

# HYDRO PAM

Comprehensive solution  
for Hydro Power Stations

Ductile iron pipe  
for renewable  
energy

PAM commitment  
for sustainable  
development



## Water, fire, iron and energy

### HYDROPAM

Hydraulic energy produced by the force of water flowing downwards inside a pipe is transformed by a turbine connected to a generator into electricity; this can be rapidly transported and does not produce any waste or pollution. Today, hydroelectricity is still the cheapest form of energy in terms of production costs, and ranks high among the renewable energies.

Compared with traditional fossil fuel power plants, a 1MW hydroelectric power station can supply around 630 homes with electricity and prevents the emission of around 2,500 t of CO<sub>2</sub> into the atmosphere each year.

Many European countries are investing in hydraulic technologies to meet the 20% target set by the European Union for 2020.

For decades, SAINT-GOBAIN PAM has been a major player in the development of the hydroelectric sector, supplying ductile iron mains for penstock pipelines.

**Starting from an upstream reservoir, HYDROPAM passes water to the turbine installed downstream. Depending on the difference in height and the flow rate, the pipeline can be subjected to high pressures at the lowest point.**

The robustness of ductile iron, combined with its exceptional resistance to pressure and abrasion, make HYDROPAM mains the ideal solution, boasting an excellent service record that goes back over a century.

Available in DN 60 to 2000, built to last and 100% recyclable, HYDROPAM mains are laid directly in trenches and have a life cycle that often exceeds a hundred years.





## QUALITY ASSURANCE AND ENVIRONMENT

### ISO 9001

The quality management system introduced by PAM has been certified as complying with EN / ISO 9001 by the independent third party (Bureau Veritas Certification). This involves specific internal rules concerning the design, manufacture and sale of ductile iron products in accordance with high quality standards.

A ductile iron pipe system is a 100% recyclable product.

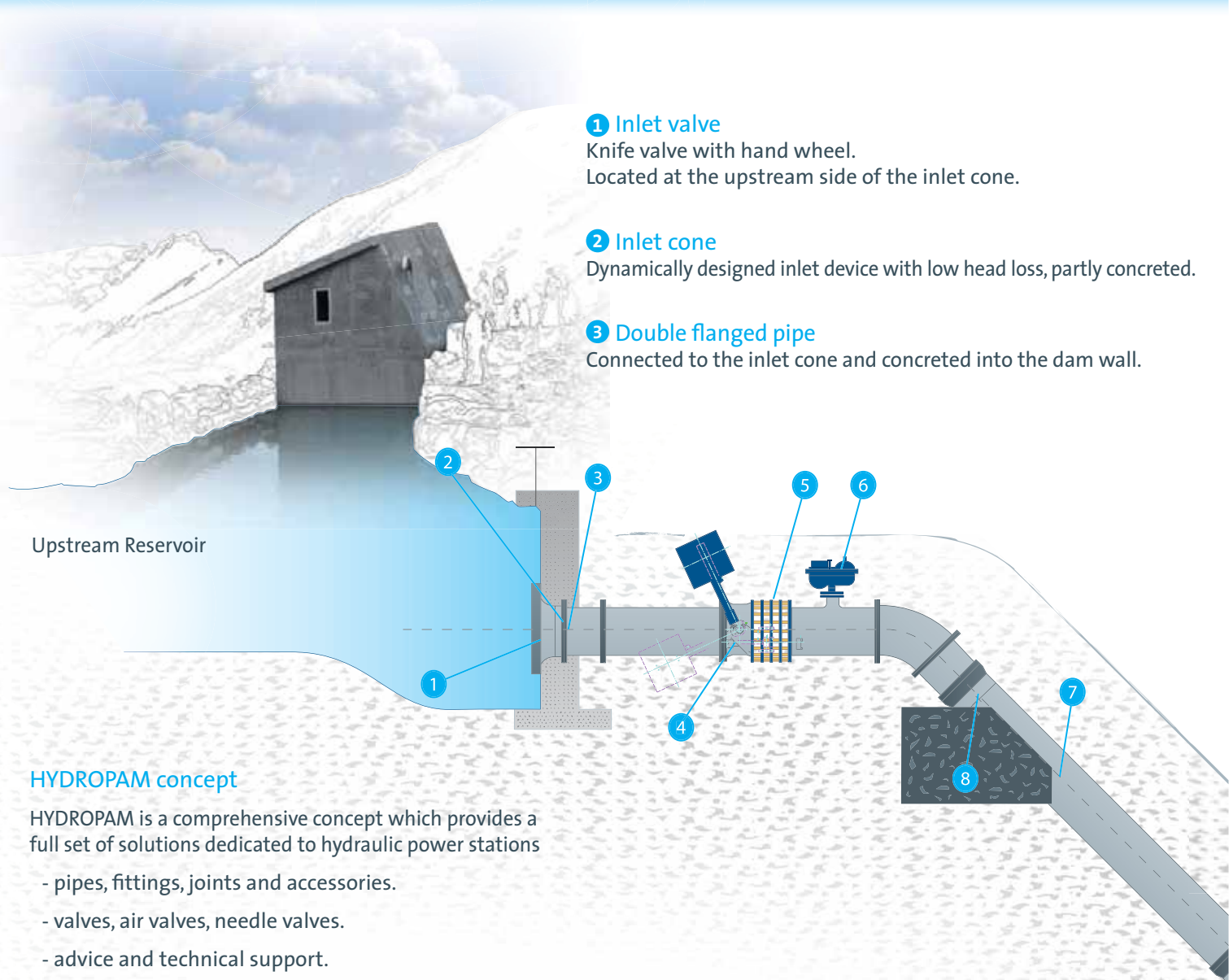


### ISO 14001

The PAM's environmental management system complies with ISO 14001 Standard







## 1 Inlet valve

Knife valve with hand wheel.  
Located at the upstream side of the inlet cone.

## 2 Inlet cone

Dynamically designed inlet device with low head loss, partly concreted.

## 3 Double flanged pipe

Connected to the inlet cone and concreted into the dam wall.

## HYDROPAM concept

HYDROPAM is a comprehensive concept which provides a full set of solutions dedicated to hydraulic power stations

- pipes, fittings, joints and accessories.
- valves, air valves, needle valves.
- advice and technical support.

## 4 EUROSTOP emergency valve

A counterweighted butterfly valve installed to prevent damage caused by pipeline failure. This safety device works without any external energy supply and shuts down when the maximum allowable flow rate is exceeded. The flow rate can be detected by a paddle system supplied on request.

## 5 Self-restrained dismantling joint

Dismantling joint for adjustment, easy installation and dismantling.

## 6 Automatic air valve (triple function VENTEX)

The air valve ensures safe filling of the pipe and exhausts entrapped air to the atmosphere. The valve prevents negative pressure in the pipeline when the water is drained out. A gate valve upstream of the air valve is an option for servicing the air valve, even if a gate valve is already present in the body.

## 7 Ductile iron pipes

The pipes are supplied in different pressure classes with or without self anchoring joints, depending on the static pressure and the slope.

## 8 Anchoring device

Anchor for clamping the pipeline to stable soil.

## 9 Needle valve for draining

Safety needle valve used for controlled draining or synchronous discharge of pipelines under high pressure without cavitation.

## 10 EUROSTOP butterfly valve

Keeping the valve closed prevents any static pressure building up on the guide blades of the turbine as well as any leakage.

# ■ DUCTILE IRON PIPE PERFORMANCES

The properties of ductile iron pipes, fittings and accessories are in conformity with EN 545 Standard.

## Main properties of ductile iron



Yield tensile (*), Rp 0.2	300 MPa
Tensile strength, Rm	420 MPa
Elongation after fracture, A	10 % for DN 60 to 1000, 7 % for DN 1100 to 2000
Modulus of elasticity	$1,7 \times 10^5 \text{ N/mm}^2$
Coefficient Thermal expansion	$1,1 \times 10^{-2} \text{ mm/m } ^\circ\text{C}$
Density	$7,05 \text{ g/cm}^3$

(\*) 270 MPa when A  $\geq$  12 % for DN 40 to 1000 or A  $\geq$  10 % for DN  $>$  1000

## ■ Stable mechanical properties over time:

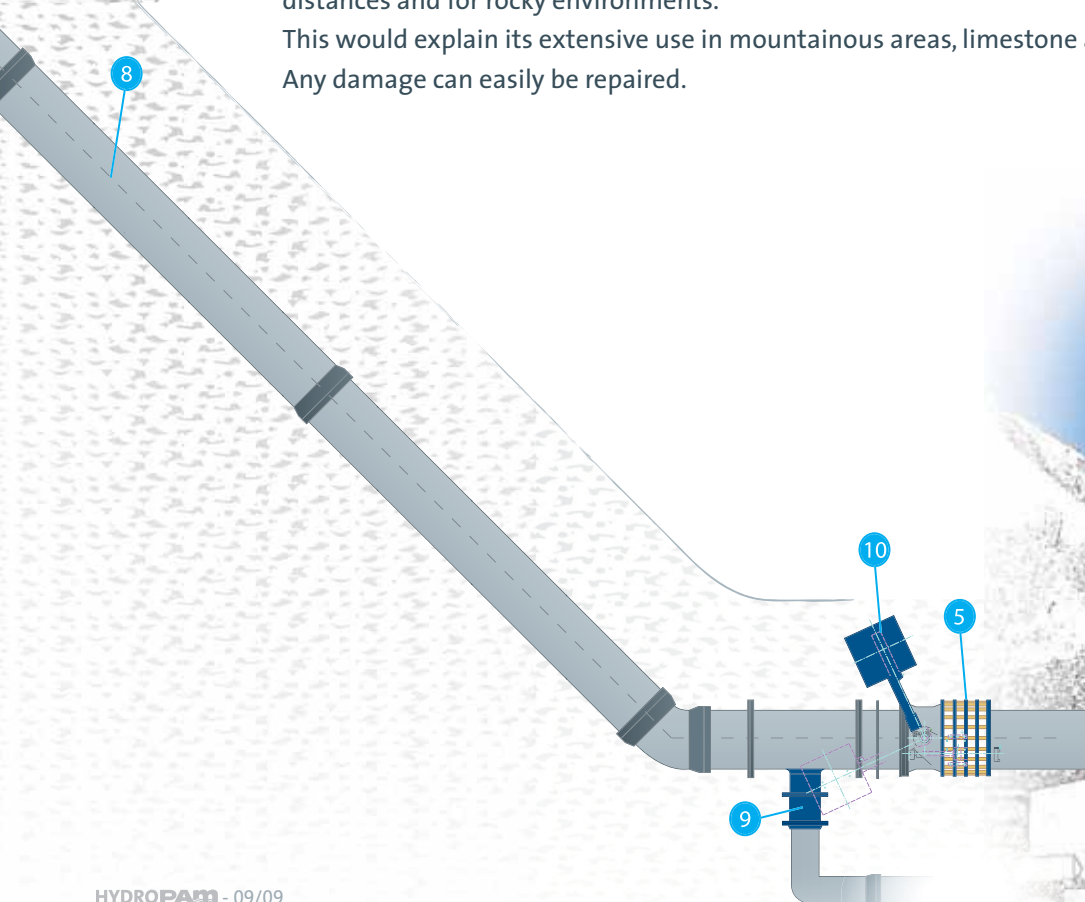
These mechanical characteristics remain constant throughout the service life of the buried pipeline. A high stiffness level makes ductile iron pipe less dependant on the quality of soil embedment. Ductile iron pipes have a high capacity to withstand poor laying conditions.

## ■ Impact and point loading:

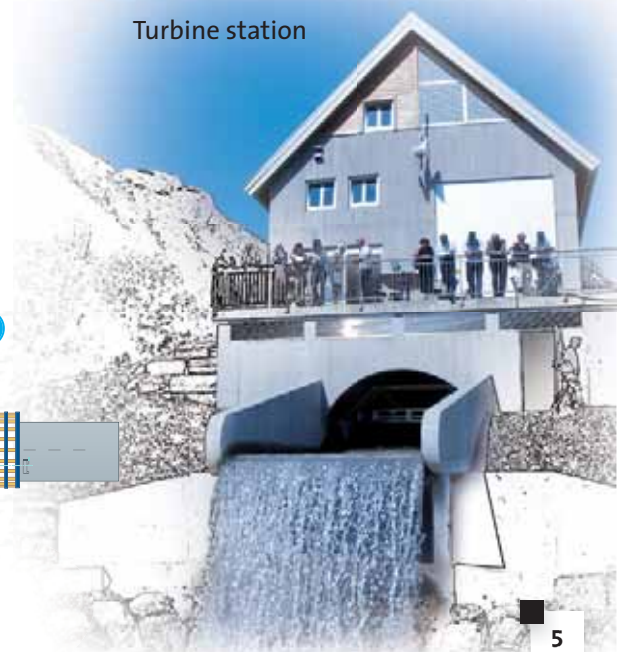
Although pipeline laying procedures require avoiding or limiting as much as possible impacts with the pipe, zinc coated ductile iron is well known to be the most resistant and suitable for transport over long distances and for rocky environments.

This would explain its extensive use in mountainous areas, limestone areas, etc.

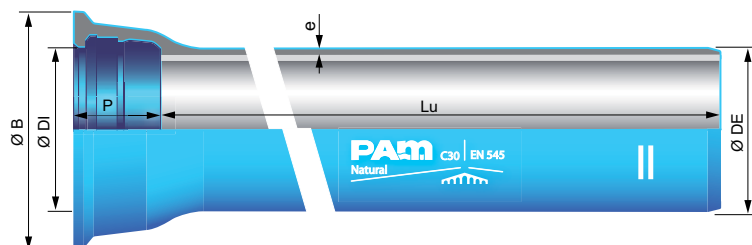
Any damage can easily be repaired.



Turbine station



PAM offers a complete range of pipe diameters from DN 60 up to DN 2000 completed by a comprehensive range of fittings and accessories. See the Pam catalogue "Water mains".



## Pipes and fittings with STANDARD joint

DN	Lu m	Angular deflection	PFA bar		PFA bar		PFA bar		PFA bar		PFA bar		PFA bar	
60	6,00	5	c40	64	k9	85	k10	85	k11	100	k12	*	k13	*
80	6,00	5		64	85	85	100	*	*					
100	6,00	5		64	85	85	100	*	*					
125	6,00	5		64	85	85	100	*	*					
150	6,00	5		62	79	85	97	100	100					
200	6,00	5		50	62	71	80	90	99					
250	6,00	5		43	54	61	70	78	86					
300	6,00	5		40	49	56	63	70	78					
350	6,00	4	c30	35	k9	45	k10	51	*k11	58	*k12	65	*k13	71
400	6,00	4		32	42	48	55	61	67					
450	6,00	4		30	40	45	52	57	63					
500	6,00	4		30	38	44	49	55	60					
600	6,00	4		30	36	41	46	51	56					
700	6,96	4		-	k9	34	k10	38	*k11	43	*k12	48	*k13	53
800	6,95	4			32	36	41	46	50					
900	6,95	4			31	35	40	44	48					
1 000	6,96	4*			30	34	38	43	47					
1 100	8,19	4			29	32	37	41						
1 200	8,19	4			28	32	37	41						
1 400	8,17	3			28	31	35	39						
1 500	8,16	1			27	30								
1 600	8,16	3			27	30								
1 800	8,15	2,5			27	30								
2 000	8,13	2			26	29								

PFA = Allowable operating pressure  
please refer to next section «design safety factor» for pressure definitions

\* = please consult PAM

## Pipes are delivered with the following protections systems:

**Coating:** a layer of metallic zinc ( ZINALIUM for NATURAL pipe range), applied by electric arc spray gun, and covered with a pore sealer layer. High resistance to impact from transport, handling, storage and backfill.

**Lining:** a layer of cement applied by centrifugal process, (blast furnace cement for potable water or high alumina cement for sewage). The mortar is spun at high speed, giving good lining compaction, then cured to optimum mechanical strength.

The spinning process has the advantage of producing a smooth internal surface layer consisting of very fine particles, giving:

- Excellent abrasion resistance against raw waters with solid particle content (e.g. sand)
- Excellent resistance against mechanical and chemical cleaning operations
- Very good resistance to longitudinal bending and ovalisation .

**Fields of application** are in accordance with EN545 annex D and E.

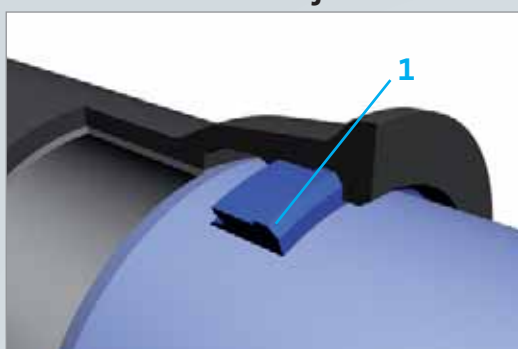
PAM can supply special coating for specific applications: please refer to the PAM catalogue





The STANDARD joint has been used for many decades all over the world. Assembly is easy, safe and quick. As the assembly operation needs no welding and coating repair, this push-fit joint is greatly appreciated by contractors when environmental conditions are difficult: winter time, presence of water in the trench bottom, no access for digger, limited time for working, etc. Ductile iron pipe joints are fully tested in accordance with the requirements of EN 545 against positive internal and external pressures, negative pressure, and cyclic pressure.

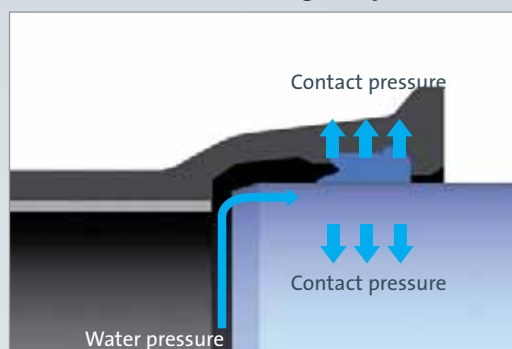
## STANDARD joint



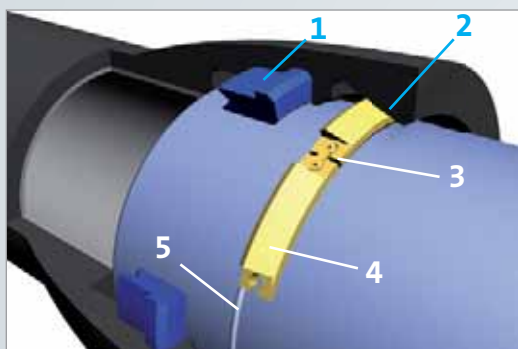
### STANDARD joint:

The STANDARD joint is a flexible push-in joint. The seal is provided by radial compression of the EPDM rubber gasket (1). Contact pressure between gasket and metal increases as the water pressure increases.

## A self water tighted joint



## UNIVERSAL Ve joint



### UNIVERSAL Ve joint:

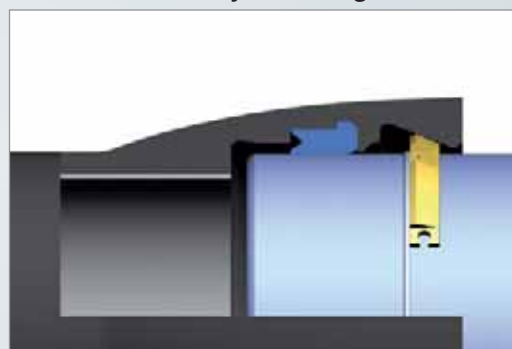
Leak tightness is ensured by an EPDM rubber gasket (STANDARD joint) (1) in one chamber. The anchoring (axial force transmission) takes place through a mechanical arrangement comprising:

- weld bead (5) on the pipe spigot (factory applied), segmented anti-slippage locking rings (3+4), (with a curved external profile)
- second chamber (2) in pipe socket (with spheroidal internal profile)
- self anchoring function is obtained by confining the locking ring between the external chamber of the socket and the weld bead (5) present on the spigot of the pipe

### The UNIVERSAL Ve joint combines the advantages of a flexible socket joint and a welded joint:

- self tightening design: the contact pressure between gasket and metal increases as the water pressure increases
- high resistance to traction stress
- fully rotational locking system: the UNIVERSAL Ve joint is designed to accept angular deviation even under axial tension: the curved exterior of the locking ring (3+4) acts like a pivot on the spheroidal internal profile of the second chamber (2). Suitable for ground movements

## Easy anchoring



### Ductile iron pipe joints make the laying operations cheaper and easier:

- simple and fast assembly on site (even when difficult trench or bad weather conditions)
- use of standard field equipment on site: crowbar, mechanical winches or digger bucket, according to diameter or accessibility in the trench
- flexible joint, suitable for ground movements
- no coating repair after assembly
- no welding operation, no sophisticated equipment
- avoids installation of concrete anchor blocks (for bends, tapers, tees, blank flanges)

## Safety Butterfly valve

DN 150-1600 PN 10-16-25

DN 1800-2000 PN 10-16

High-speed control system types: mechanical-magnetic-ultrasonic

Open-close system types: manual - electrical



Picture showing mechanical high-speed control and manual oleo dynamic system

Range

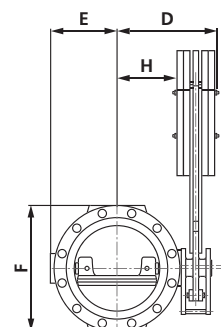
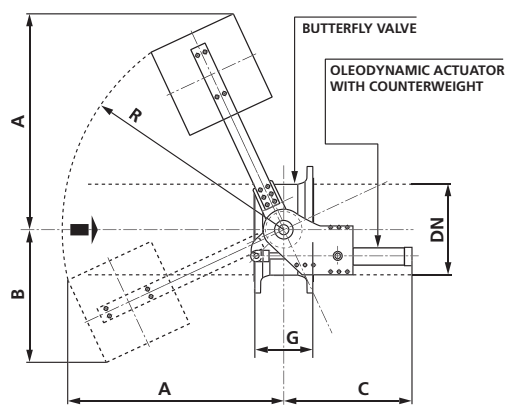
	PFA/PN		
DN	10	16	25
150			
200			
900			
1600			
2000			

For the high-speed control sensor magnetic/induction type or ultrasonic type please contact us

For electrical open-close manipulation please contact us

For other pressure types please contact us

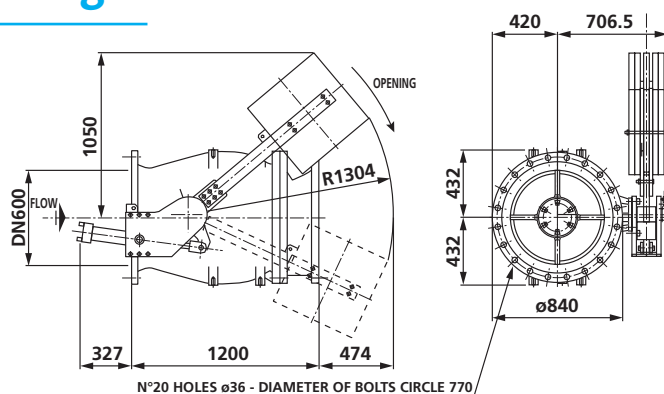
PN 10										
DN	A	B	C	D	E	F	G	H	R	Weight
150	653	411	446	352	152	285	210	111	667	190
200	653	411	446	382	181	340	230	141	667	203
250	653	411	446	441	216	400	250	200	667	226
300	653	411	446	465	240	455	270	224	667	246
350	757	467	533	544	259	505	290	208	777	382
400	757	467	533	595	330	565	310	259	777	416
450	991	604	548	657	354	615	330	316	1020	604
500	991	604	548	682	379	670	350	341	1020	632
600	1272	788	772	722	433	780	390	446	1304	899
700	1272	788	772	813	504	895	430	537	1304	1054
800	1520	939	809	926	596	1015	470	585	1560	1672
900	1520	939	809	975	642	1115	510	634	1560	1868
1000	1768	1090	979	1151	712	1230	550	710	1815	2987
1200	1768	1090	979	1162	850	1455	630	721	1815	3428
1400	1982	1208	1163	1359	962	1675	710	768	2040	5042
1500	1982	1208	1163	1410	1013	1785	750	819	2040	5403
1600	1982	1208	1163	1462	1065	1915	790	871	2040	6000
1800	2196	1326	1459	1796	1250	2115	870	915	2265	9318
2000	2196	1326	1459	1891	1345	2325	950	1110	2265	10723



## Needle valve for synchronous discharge

DN 100-900 PN 10-16-25

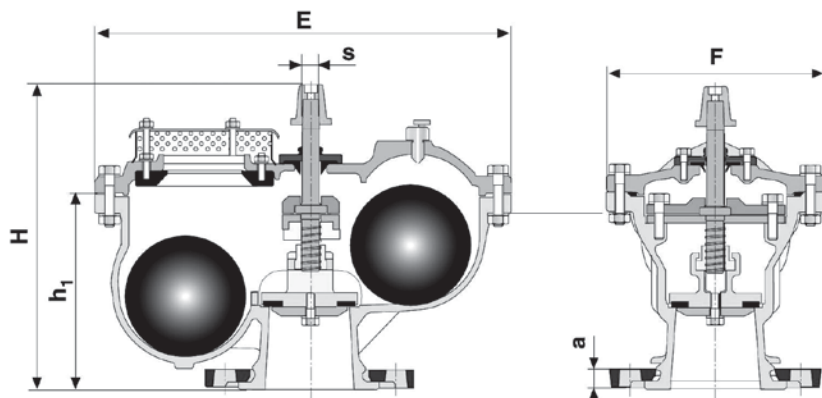
DN 1000 PN 10-16





## Automatic air valve triple function

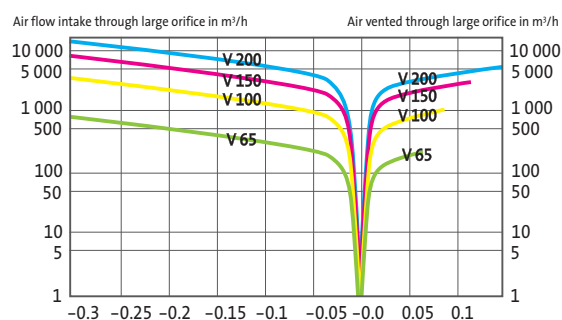
Ventex type DN65-200 PN 10-16-25



Filling - emptying function

DN	E	F	H	h <sub>1</sub>	a	s	Weight
65	390	200	258	165	20	15,3	24
80-100	467	244	300	215	20	15,3	40
150	656	405	492	285	24	18,5	115
200	737	448	580	330	29	20,7	170

To material types please contact us  
Other pressure or coating types please contact us



## Self-restrained dismantling joint

DN40-2000 PN 10-25

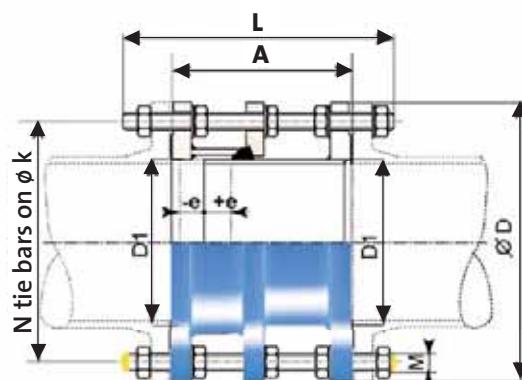
PN 10					Tie Bars					
DN	A	Ø D	Ø D <sub>1</sub>	Ø K	N	M	L	Weight	+ e	- e
40	200	150	49	110	4	M16	330	11	30	30
50	200	165	61	125	4	M16	330	13	30	30
60	200	175	76	135	4	M16	330	14	30	30
65	200	185	77	145	4	M16	330	15	30	30
80	200	200	90	160	8	M16	330	21	30	30
100	200	220	116	180	8	M16	330	22	30	30
125	200	250	142	210	8	M16	330	28	30	30
150	200	285	171	240	8	M20	330	37	30	30
200	280	340	222	295	8	M20	430	53	40	40
250	280	395	276	350	12	M20	430	72	40	40
300	280	445	328	400	12	M20	430	81	40	40
350	280	505	360	460	16	M20	430	109	40	40
400	280	565	411	515	16	M24	450	150	40	40
450	330	615	462	565	20	M24	530	180	50	50
500	330	670	514	620	20	M24	530	206	50	50
600	330	780	617	725	20	M27	550	264	50	50

Dimensions in mm

Weight in Kg



For other material types please contact us  
For other pressures or coating types please contact us  
For DN 700 to 2000, please contact us



PAM's technical teams are ready to assist the client at any stage of the project, from information on our ductile iron products and their use through to technical assistance at the beginning of pipe laying.

PAM experts can support customers, consultants and contractors for:

- Soil survey analysis and corrosion protection
- Hydraulic design and buried pipe engineering
- Pipe system designing
- Laying operations
- Logistic arrangements (transportation by ship, truck, storage, etc.)

PAM is also represented by local distributors that can propose equipment and immediate services during pipeline installation (pipe cutting, on-site logistics arrangements, after sales services, etc.)

## ■ Design Safety Factor

Long term safety of buried pipelines will be achieved if, at the design stage, it is possible to know with a fair degree of confidence:

- the properties of the pipe material and of the pipe itself, as laid down in the standards and guaranteed by the manufacturer;
- the loads which the pipeline will be subjected to, as determined by adequate design methods.

### • Resistance against pressure:

Ductile iron Pipes are designed to withstand pressure according EN545 STANDARD annex A:

**PFA** = calculated with the minimum tensile strength divided by 3 (safety factor 3)

**PMA** = 1,2 PFA

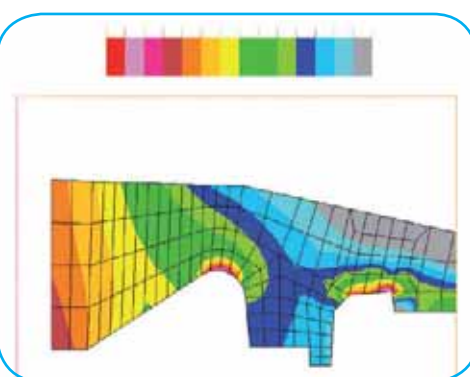
**PEA** = PMA+ 5 bar

Where:

- PFA = (Allowable operating pressure) internal pressure, excluding water hammer, that a component can safely and continuously withstand under permanent hydraulic service
- PMA = (Allowable maximum operating pressure) maximum internal pressure, including water hammer, that a component can safely withstand during service
- PEA = (Allowable test pressure) maximum hydrostatic pressure that can be applied onsite to a newly laid component.

### • Resistance against earth loads:

S = Typical stiffness for ductile iron pipes are set out in EN545 standard, Annex C, Table C.1. They clearly explain why the laying conditions are not so critical for ductile iron pipes compared to other materials.

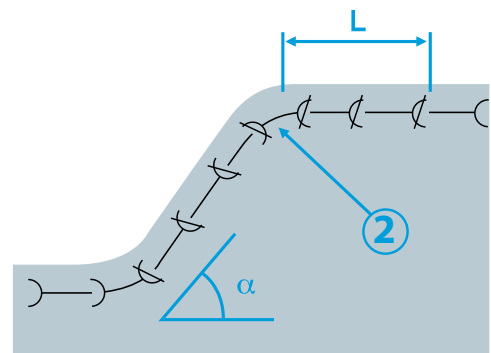
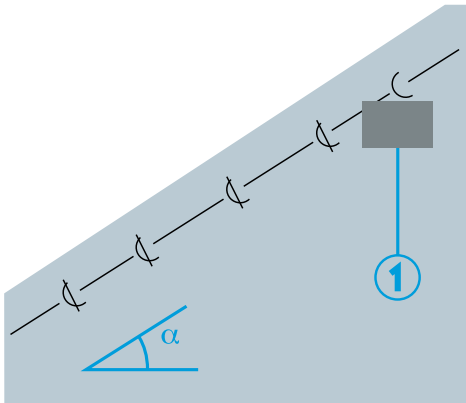


Minimum Stiffness for ductile iron pipe  
EN545 K9

DN	S
400	72 000 N/m <sup>2</sup>
800	30 000 N/m <sup>2</sup>
1200	20 000 N/m <sup>2</sup>
2000	16 000 N/m <sup>2</sup>

## ■ Steep inclines

Beyond a certain angle, the friction between a pipeline and the ground is insufficient to hold the pipeline in position: a buried main needs to be anchored when the incline exceeds an angle dependent on pipe dimension, soil characteristics and laying conditions. The longitudinal gravitational movement then has to be counteracted by the use of concrete anchor blocks for each pipe, or better, by the use of anchored joints or by a combination of both techniques.



In addition, a section of self-anchored pipes should be anchored either by an anchor block situated behind the socket of the leading pipe ① or by an additional self-anchored length (L) installed in the flat section behind the uppermost bend ②.

The maximal axial force is supported by the first self-anchored joint below the block. This force is a function of the gradient and the length of the anchored section. The maximum permissible length is therefore defined by the strength limit of the self-anchored joint.

The main should be laid downhill starting from the highest point, so that the self-anchoring system is fully engaged and tensioned.

Please contact the technical department of PAM or refer to PAM tools.





## ■ Hydraulic flow capacity

The equivalent surface roughness,  $k$ , of a pipeline depends not only on pipe wall smoothness, but also and more importantly on the number of bends, tees and branches, pipeline profile irregularities, and the development of internal bio film.

Experience has shown that  $k=0.1$  mm is a reasonable value (whatever the internal lining) for distribution mains, and slightly less (0.06 to 0.08 mm) for large mains with a small number of fittings per kilometre.

Any comparison of flow capacity of pipe material based on a different roughness coefficient would be a very theoretical speculation.

The reason is the following; head loss is the sum of 3 effects:

- a) Water friction to itself (linked to the water viscosity =  $2.51/Re^{1/2}$ )
- b) Water friction on the pipe wall (linked to the roughness =  $k / 3.71 D$ )
- c) Local changes to flow (bend, joints, etc)

Internal water friction (term a) is the main part of the head loss. Water friction on the pipe wall (term b), depending only on material roughness, is much less (evaluated at 7% max of term a for a cement-lined ductile iron pipe).

The actual internal diameter of the pipe is the most important parameter: for a given flow rate, each 1% less in diameter is 5 % more head loss, and for a given head loss (gravity main) each 1% less in diameter is 2.5 % less in the resultant flow rate

**Therefore, special attention has to be paid to the influence of the hydraulic internal diameter of the pipe.**

PAM uses software to evaluate the different cases. Please contact PAM.



# ■ PAM LIBRARY AND SOFTWARE TOOLS

PAM proposes a selection of documentation and software for the attention of consultants and contractors:

## ■ Library



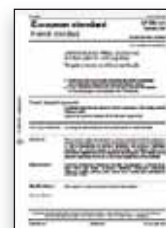
A 450-page "User's Guide" or CD ROM providing clear information and detailed application procedures for PAM products.

A series of teaching and operational instruction sheets to be used on site



"Self-anchoring solutions for ductile iron pipes": a comprehensive guide to explain the concept of anchor joints and the different existing technologies.

A full experienced, coherent and recognised European Standard System, EN545



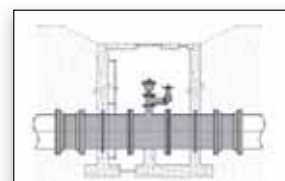
## ■ Software



**PAMCAD:** design and dimensioning software to make the work of designers and consultants easier, providing the range of PAM product software for dimensioning of:

- butterfly safety valves
- needle valves
- air valves

**PAMKIT:** design software to design standardized solution for air release, drainage and shutoff, and to provide logistic benefits. Reference shall also be made to the relevant national regulations and standards when applicable.



**PAMTC:** assistance using in-house calculations tools dedicated to :

- Pipe laying in steep incline
- Dimensionning concrete blocks
- Dimensionning self-anchored length
- simulating Head losses

■ Reference shall also be made to the relevant national regulations and standards when available.





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for Hydro Power Stations

Ductile iron pipe  
for renewable  
energy

PAM commitment  
for sustainable  
development



Every year, over 100 projects are manufactured by SAINT-GOBAIN PAM for hydraulic power stations and delivered in Europe and worldwide.



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