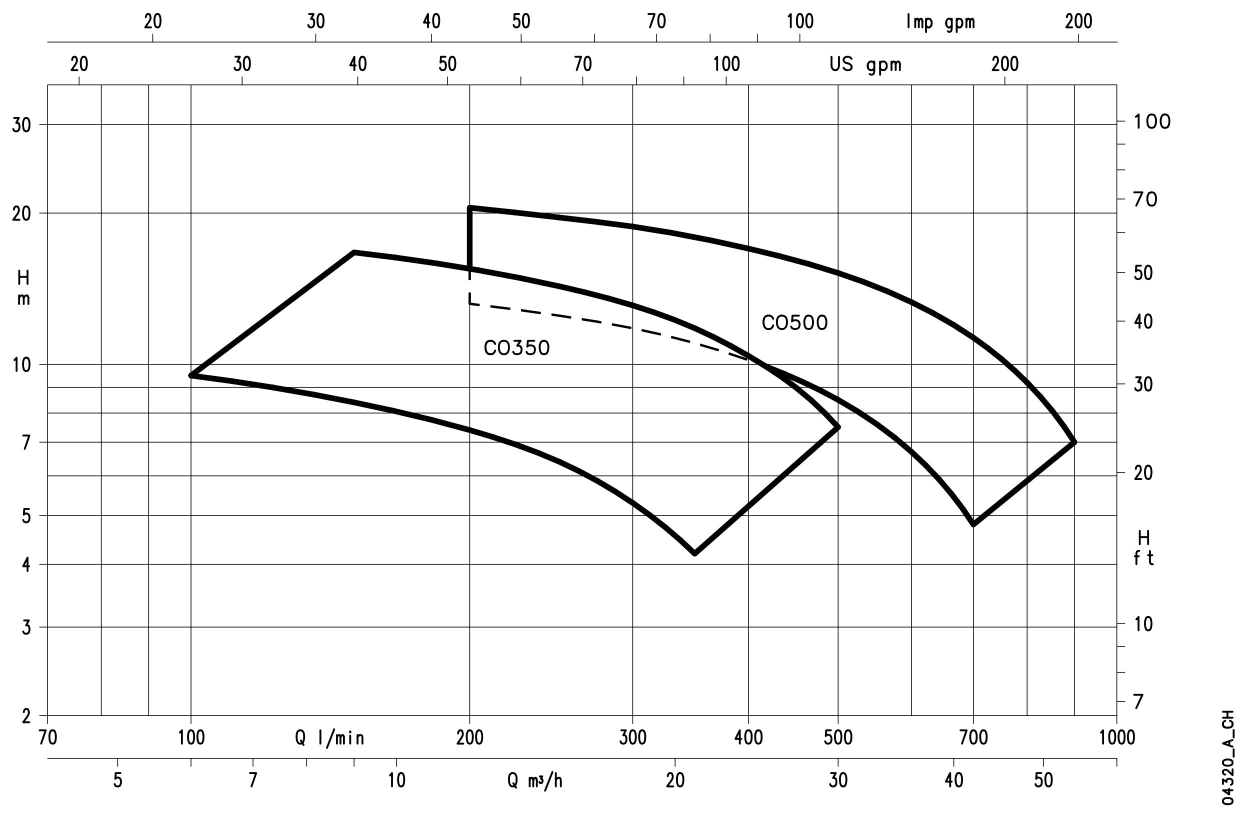
LOWARA

OPEN IMPELLER CENTRIFUGAL ELECTRIC PUMPS WITH OPEN IMPELLERS

60 Hz

CO SERIES



EDITION 03-2004

Lowara

ITT Industries
Engineered for life

Open impeller centrifugal electric pumps

CO-COM Series

LOWARA

MARKET SECTORS

CIVIL, INDUSTRIAL.

APPLICATIONS

- Washing of metal parts and/or surface treatment.
- Washing of produce in the packaging industry.
- Food industry washing equipment and systems.
- Dyeing plants and textile industry.
- Plants for the circulation and transfer of moderately viscous liquids, with light chemical aggressiveness.
- Industrial washing machines and commercial dishwashers.

SPECIFICATIONS

PUMP

- **Delivery** up to 900 l/min (54 m^3/h).
- **Head** up to 24,5 m.
- **Temperature** of pumped liquid: -10°C to 110°C for standard version.
- Maximum working **pressure**: 8 bar (PN8).
- **Suspended solids** handled up to: CO350: 11 mm. CO500: 20 mm.

MOTOR

- Asynchronous, squirrel cage rotor, enclosed construction in aluminium casing, external ventilation.
- **IP55 protection.**
- Class F **insulation.**
- Performances according to EN 60034-1.
- Maximum ambient **temperature** : 40°C.
- **Standard voltage:**
  - **Single-phase** version: 220 V, 60 Hz, 2 poles with built-in automatic reset overload protection up to 1.5 kW. For higher powers the protection must be provided by the user.
  - **Three-phase** version: 220-380 V, 60 Hz, 2 poles; overload protection to be provided by the user.
- Condensate drain plugs on all motors.
- Other voltages.

CONSTRUCTION FEATURES

- Close-coupled, single-impeller centrifugal pump with axial suction and radial delivery.
- Threaded suction and delivery ports (Rp UNI - ISO 7).
- Compact construction; adaptor for motor/pump coupling; the impeller is keyed directly to the motor shaft extension.
- Back pull-out design; no need to disconnect the pump body from the system pipes.
- **AISI 316L** stainless steel open **impeller** with four pressed vanes welded onto base disk.
- Impeller's front **wear surface** consists of a sturdy **AISI 316L** stainless steel plate welded onto the suction port.
- **AISI 316L** stainless steel **pump body and seal housing disk,** with no diffusers or cavities for easier cleaning and maintenance.
- Pump body is secured by eight screws, allowing for the rotation of the delivery port.
- **Mechanical seal:**
  Standard version: Carbon/ Ceramic faces, **FPM** elastomers.
  The other parts are made of AISI 316L stainless steel.
  "K" version: faces are made of **Silicon Carbide and Tungsten Carbide.**
  FPM elastomers.
  The other parts are made of AISI 316L stainless steel.
  FPM O-Rings.

OPTIONAL FEATURES

- Different voltages and frequencies.
- Different materials for the mechanical seal and O-rings.

- **ALL COMPONENTS IN CONTACT WITH PUMPED LIQUID ARE MADE OF AISI 316L STAINLESS STEEL**
- **MECHANICAL SEAL MADE OF SILICON CARBIDE/TUNGSTEN CARBIDE/FPM IN THE "K" VERSION**

MATERIALS

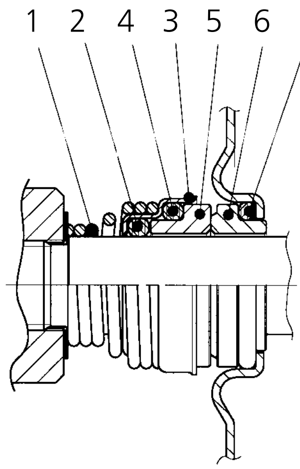
PART	MATERIAL			
		UNI	ASTM - AISI	EN - DIN
Pump body	Stainless steel	X2 CrNiMo 17-12-2	316L	1.4404
Seal housing disk	Stainless steel	X2 CrNiMo 17-12-2	316L	1.4404
Impeller	Stainless steel	X2 CrNiMo 17-12-2	316L	1.4404
Shaft extension	Stainless steel	X5 CrNiMo 17-12-2	316	1.4401
Impeller locknut	Stainless steel	X5 CrNiMo 17-12-2	316	1.4401
Fill/drain plugs	Stainless steel	X5 CrNiMo 17-12-2	316	1.4401
Fill/drain plug gaskets	FPM			
Mechanical seal	Ceramic/Carbon/FPM (Silicon Carbide/Tungsten Carbide/ FPM for CO-K versions)			
Seal shoulder washer	Stainless steel	X5 CrNiMo 17-12-2	316	1.4401
O-Rings	FPM			
Adapter	Aluminium			
Support foot	Painted steel			
Pump body fastening screws	Zinc plated steel			

CO SERIES MECHANICAL SEAL

The standard configuration has the characteristics shown in fig. 1 and table 1.

STANDARD MATERIALS (TABLE 1)

POS.	COMPONENT	MATERIAL
1	Spring	AISI 316 stainless steel
2	Shaft seal	FPM
3	Armature	AISI 316 stainless steel
4	Rotating assembly seal	FPM
5	Rotating assembly seal ring	Ceramic
6	Fixed assembly ring	Carbon
7	Fixed assembly seal	FPM



(FIG. 1)

Various alternative materials are available on request.
The special configuration has the characteristics shown in fig. 1 and table 2.
A fixed-seal design with an anti-rotation lockpin is available on request.

ALTERNATIVE MATERIALS (TABLE 2) (on request)

POS. 1-2-3-4-7	MATERIALS 5 - 6
EPDM	Ceramic - Carbon
	Ceramic - Special carbon
	Silicon carbide - Special carbon
	Silicon carbide - Tungsten carbide
	Tungsten carbide - Tungsten carbide*
FPM	Ceramic - Special carbon
	Silicon carbide - Special carbon
	Silicon carbide - Silicon carbide
	Silicon carbide - Tungsten carbide
	Tungsten carbide - Tungsten carbide*

* A version with anti-rotation lockpin is available on request.

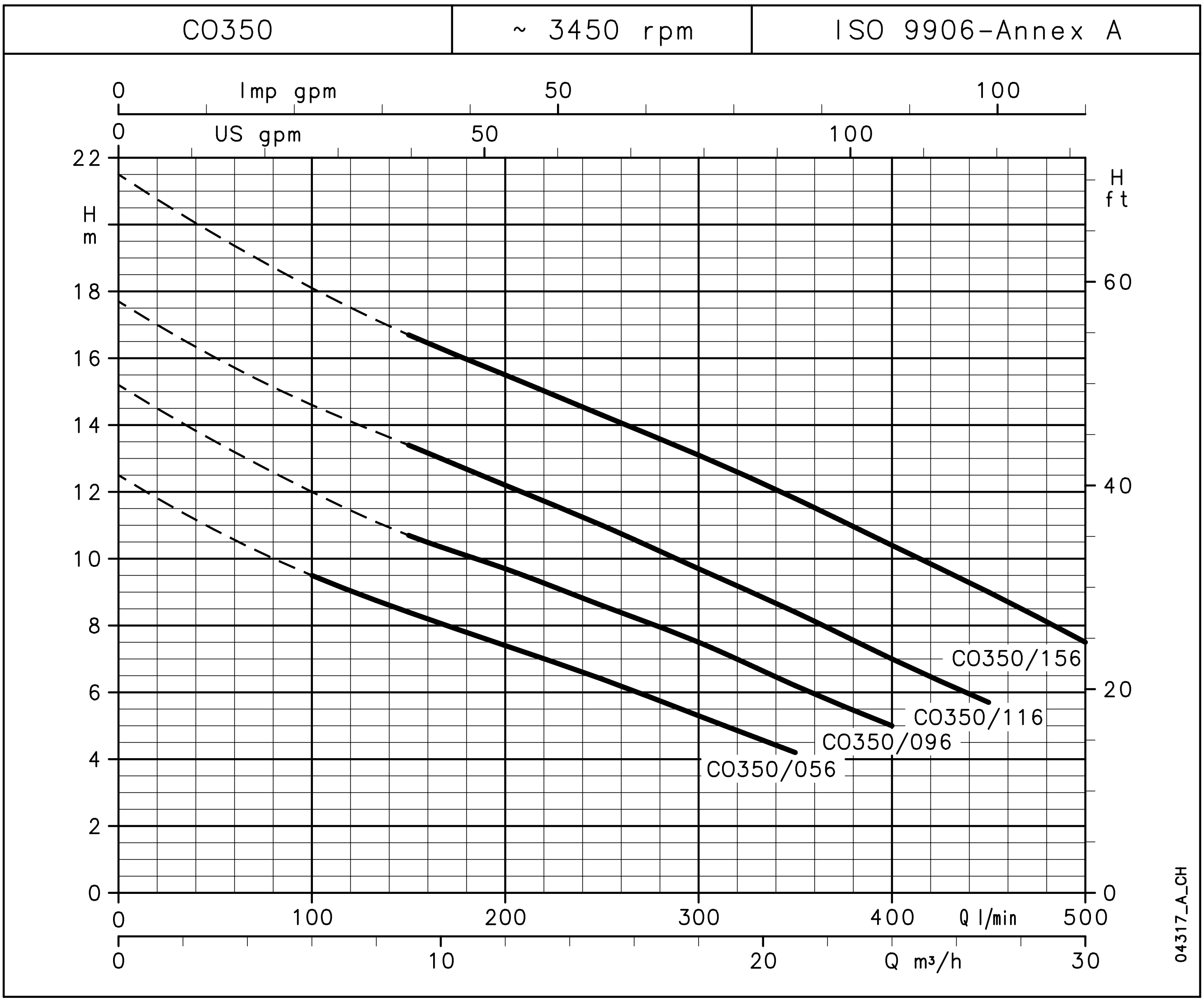
IDENTIFICATION CODE

The CO-COM series models are identified as follows:

CO M 350 / 15 6 K

- K: If present = Silicon carbide / tungsten carbide seal; Null = Alumina/graphite seal
- 6: If present = 60 Hz; Null = 50 Hz
- 15: Rated motor power in kW x 10
- 350: Rated delivery in l/min.
- M: If present = Single-phase version; Null = Three-phase version
- CO: Series of centrifugal horizontal threaded pumps with open impeller

CO350 SERIES
OPERATING CHARACTERISTICS AT 3450 rpm, 60 Hz



HYDRAULIC PERFORMANCE TABLE AT 60 Hz

PUMP TYPE	RATED POWER		Q = DELIVERY									
			l/min 0	100	150	200	250	300	350	400	450	500
			m³/h 0	6	9	12	15	18	21	24	27	30
	kW	HP	H = TOTAL HEAD METRES COLUMN OF WATER									
CO(M) 350/076	0,75	1	12,5	9,5	8,4	7,4	6,4	5,3	4,2	-	-	-
CO(M) 350/096	0,9	1,2	15,2	-	10,7	9,7	8,6	7,5	6,2	5	-	-
CO(M) 350/116	1,1	1,5	17,7	-	13,4	12,2	11,0	9,7	8,4	7	5,7	-
CO(M) 350/156	1,5	2	21,5	-	16,7	15,5	14,3	13,1	11,8	10,4	9	7,5

co350-2p60-en_a_th

ELECTRICAL DATA (60 Hz, 3450 rpm) CO350 SERIES

PUMP TYPE SINGLE-PHASE	INPUT POWER* kW	INPUT CURRENT* 220-230 V A	CAPACITOR μF / 450 V
COM350/076	1,01	4,62	20
COM350/096	1,23	5,57	25
COM350/116	1,53	7,09	30
COM350/156	2,00	9,29	40

PUMP TYPE THREE-PHASE	INPUT POWER* kW	INPUT CURRENT* 220-230 V A	INPUT CURRENT* 380-400 V A
C0 350/076	0,95	3,05	1,76
CO 350/096	1,07	3,48	2,01
C0 350/116	1,40	4,16	2,40
CO 350/156	1,86	5,51	3,18

*Maximum value in specified range

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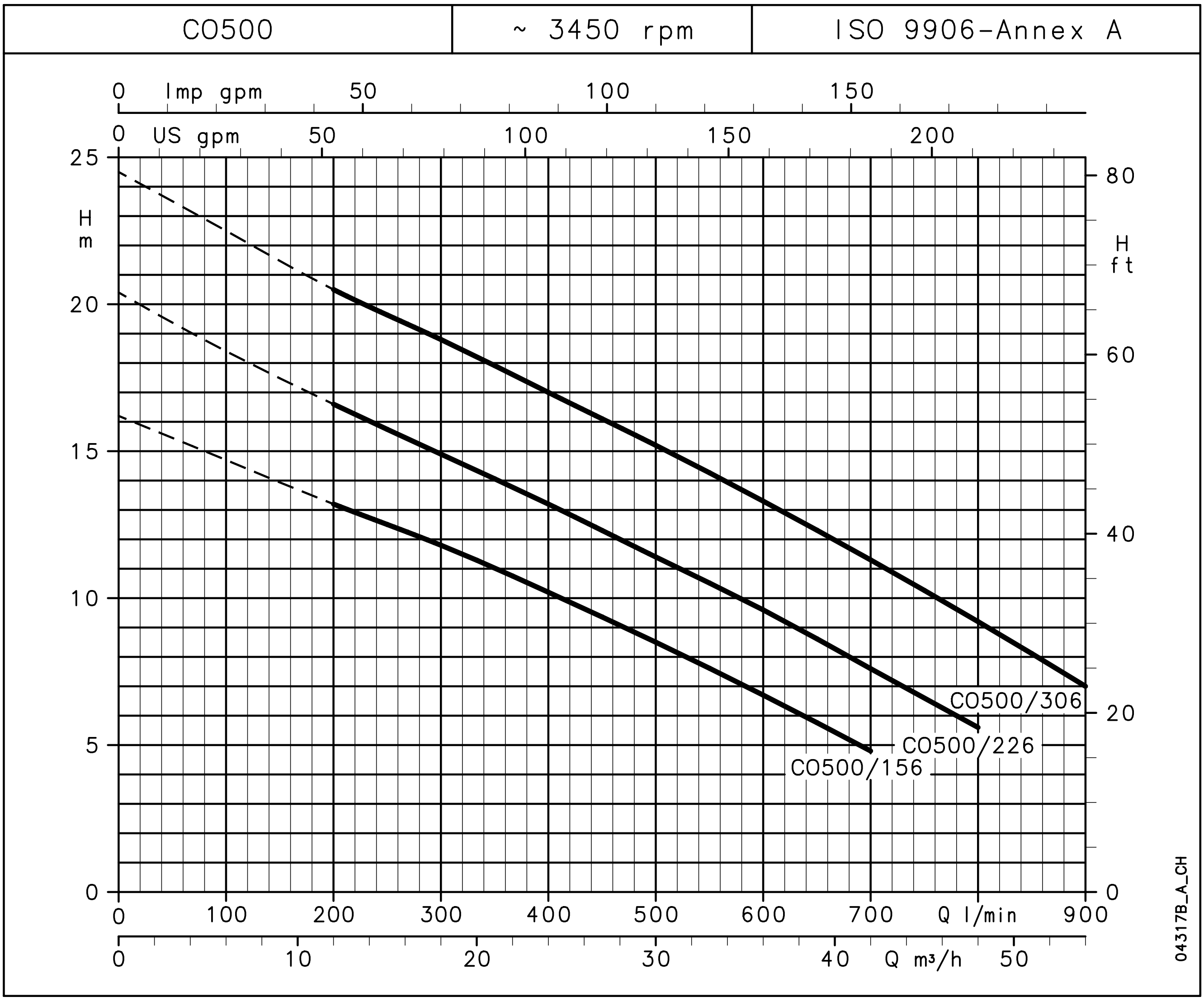
CO500 SERIES
OPERATING CHARACTERISTICS AT 3450 rpm, 60 Hz



HYDRAULIC PERFORMANCE TABLE AT 60 Hz

PUMP TYPE	RATED POWER kW	RATED POWER HP	Q = DELIVERY l/min 0 / m³/h 0	200 / 12	250 / 15	300 / 18	400 / 24	500 / 30	600 / 36	700 / 42	800 / 48	900 / 54
			H = TOTAL HEAD METRES COLUMN OF WATER									
CO(M) 500/156	2	2	16,2	13,2	12,5	11,8	10,2	8,5	6,7	4,8	-	-
CO(M) 500/226	2,2	3	20,4	16,6	15,7	14,9	13,2	11,4	9,6	7,6	5,6	-
CO 500/306	3	4	24,5	20,5	19,6	18,8	17	15,2	13,3	11,3	9,2	7

co500-2p60-en_a_th

ELECTRICAL DATA (60 Hz, 3450 rpm) CO500 SERIES

PUMP TYPE SINGLE-PHASE	INPUT POWER* kW	INPUT CURRENT* 220-230 V A	CAPACITOR µF / 450 V
COM500/156	2,04	9,45	40
COM500/226	2,71	12,7	40
-	-	-	-

PUMP TYPE THREE-PHASE	INPUT POWER* kW	INPUT CURRENT* 220-230 V A	INPUT CURRENT* 380-400 V A
C0 500/156	1,91	5,63	3,25
CO 500/226	2,55	7,53	4,35
C0 500/306	3,64	10,7	6,15

*Maximum value in specified range

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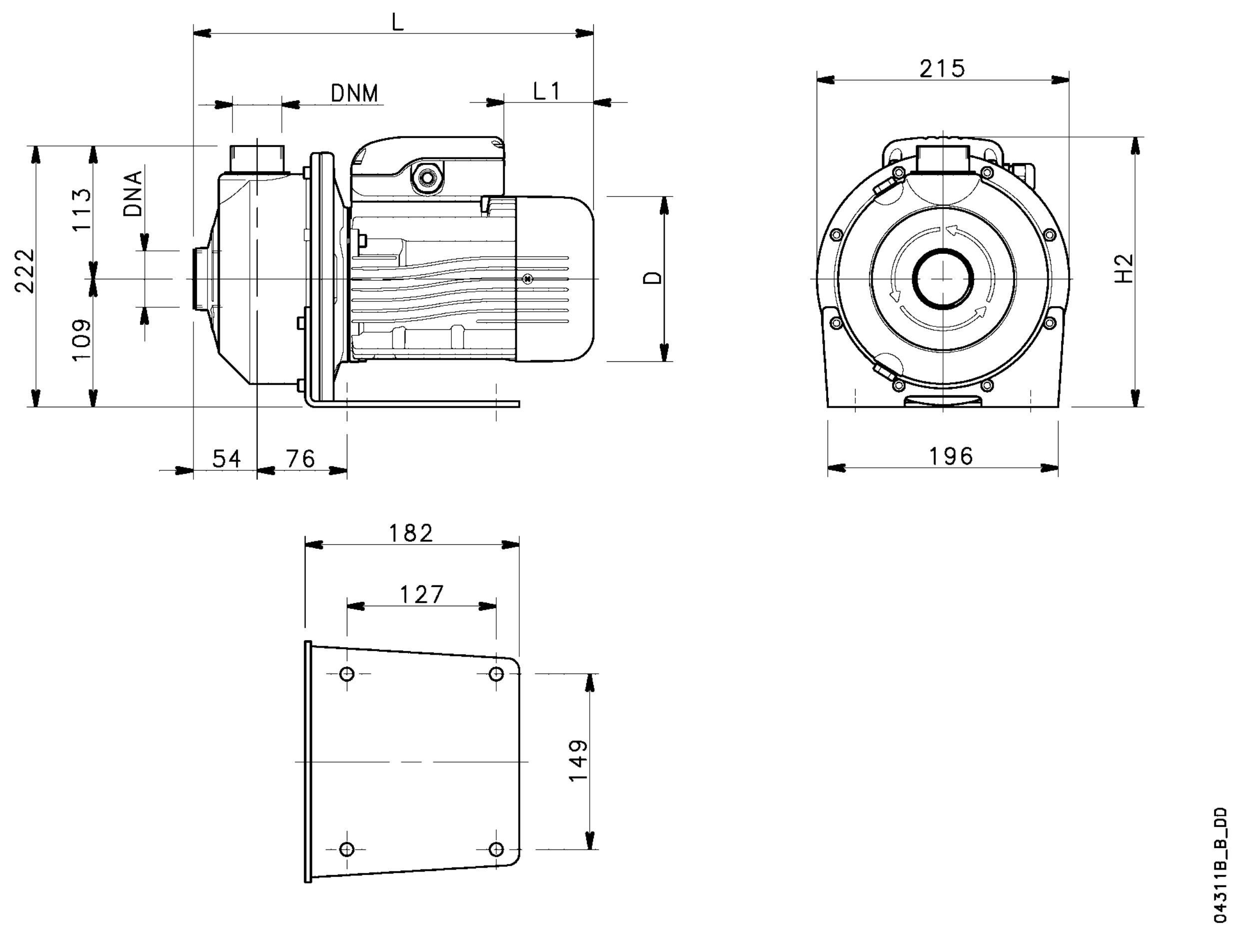
CO SERIES
DIMENSIONS AND WEIGHTS



PUMP TYPE	DIMENSIONS (mm)				DNA	DNM	WEIGHT
	D	H2	L	L1			kg
COM 350/076	140	230	339	76	Rp 1½	Rp 1¼	12,6
COM 350/096	140	239	339	31	Rp 1½	Rp 1¼	13,2
COM 350/116	156	246	385	69	Rp 1½	Rp 1¼	14,5
COM 350/156	156	246	385	69	Rp 1½	Rp 1¼	16,2
COM 500/156	156	246	385	69	Rp 2	Rp 1½	16,2
COM 500/226	176	230	416	114	Rp 2	Rp 1½	17,8
CO 350/076	140	230	339	76	Rp 1½	Rp 1¼	12,6
CO 350/096	140	230	339	76	Rp 1½	Rp 1¼	12,2
CO 350/116	156	238	385	114	Rp 1½	Rp 1¼	14,5
CO 350/156	156	238	385	114	Rp 1½	Rp 1¼	16,2
CO 500/156	156	238	385	114	Rp 2	Rp 1½	16,2
CO 500/226	156	238	385	114	Rp 2	Rp 1½	17,8
CO 500/306	176	230	416	149	Rp 2	Rp 1½	22

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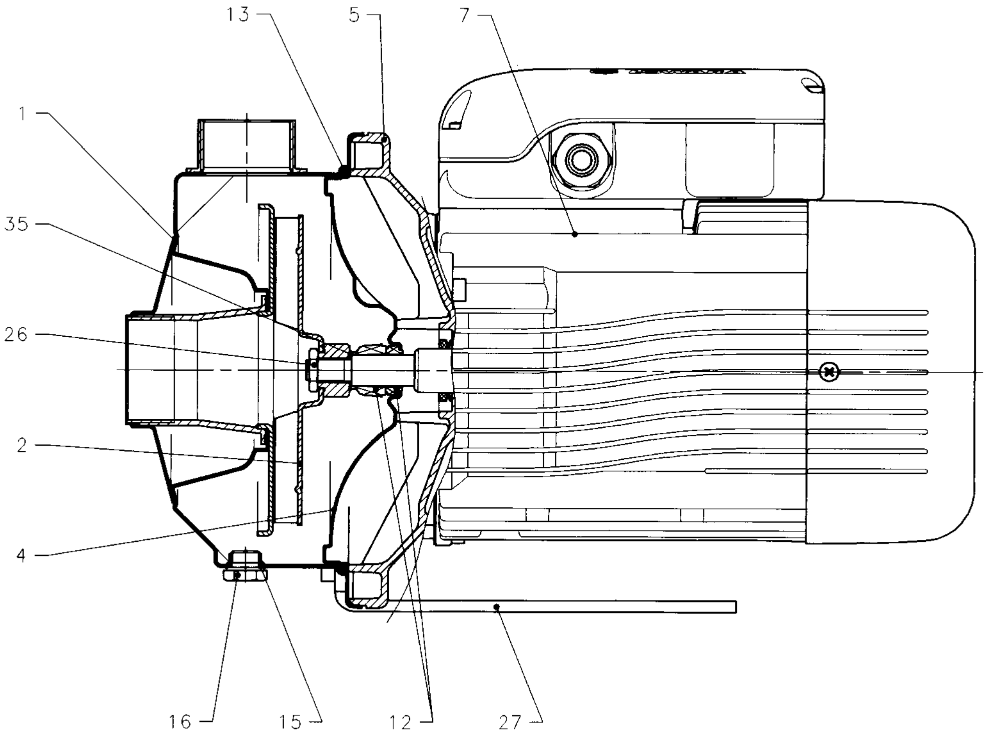
PUMP SECTION AND LIST OF MAIN COMPONENTS



N. RIF.	DESCRIPTION
1	Pump body
2	Impeller
4	Seal housing disk
5	Adapter
7	Motor
*12	Mechanical seal
*13	O-ring
*15	O-ring
16	Fill/drain plug
26	Impeller locknut
27	Support foot
35	Seal shoulder washer

* Recommended spare parts

TECHNICAL APPENDIX

TYPICAL APPLICATIONS OF CO SERIES ELECTRIC PUMPS

Water Purification:
Filtration
De-ionized water
Water treatment
Commercial and residential pools

Plastics:
Temperature control
Extrusion machines
Manufacture of polymers

Agricultural/ residential applications:
Irrigation
Greenhouses
Humidifiers
Water supply

Heating, Ventilating & Air Conditioning (HVAC)
Air scrubbers
Water re-circulation
Cooling towers
Cooling systems
Temperature control
Chillers
Induction heating
Heat exchangers
Water heating
Booster packagers

General Industry:
Spray Booths
Light chemical transfer
Booster systems

Medical:
Laser cooling
Massages
Medical chillers
Sanitary equipment

Waste Management:
Waste treatment
Pollution control

Machine Tool:
Degreasing
Parts washing
Chemical treatment
Heat treatment

Graphics:
Film washing
Cooling processes

Marine:
Water on board ships

Computers:
Washing of circuit boards
Unit cooling

Laundry:
Commercial washing

Food and Drink:
Food processing
Bottle washing
Citrus Processing
Dish washing
Brewing
Sanitary ware

CO SERIES

STANDARD CONFIGURATION:
MECHANICAL SEAL CARBON/CERAMIC O-RINGS NBR

TABLE OF COMPATIBILITY FOR LIQUIDS MOST USED

For other liquids refer to our web page www.lowara.com

LIQUID	CONCEN-TRATION	TEMPE-RATURE	DENSITY	SEAL MATERIAL RECOMMENDED	O-RING	MECHANICAL SEAL				"O" RINGS	
	%	-MIN (°C) -MAX (°C)	kg/dm³	MECHANICAL SEAL		NUMBER A	NUMBER N	NUMBER B	NUMBER P	FPM	EPDM
Acetic acid (1) CH3-CO-OH configuration code	80	-5 +70	1.05	Sil.Carbide-Tungs.Carb ÉXNA	EPDM	2	1	3	1	3	1
Citric acid H8C6O7-H20 configuration code	5	-5 +70	1.54	standard product		1	1	1	1	1	1
Hydrochloric acid (1) H Cl configuration code	2	-5 +25	1.2	ÉXNA		2	1	3	3	1	3
Water H2O configuration code	100	-5 +85		standard product		1	1	1	1	1	1
Deionized water configuration code	100	-5 +85		standard product		1	1	1	1	1	1
Demineralized water configuration code	100	-5 +85		standard product		1	1	1	1	1	1
Sea water (4) configuration code	/	-5 +25		standard product		1	1	1	1	1	1
Distilled water configuration code	100	-5 +85		standard product		1	1	1	1	1	1
Butyl alcohol C2H5-CH2-CH2OH configuration code	100	-5 +80	0.81	standard product		1	1	2	2	1	2
Ethyl alcohol (Ethanol) configuration code	100	-5 +40	0.81	ÉXPB		3	3	2	1	3	1
Methyl alcohol CH3-OH configuration code	100	-5 +40	0.79	ÉXPB		3	3	2	1	3	1
Chloroform CHCI3 configuration code	25	-5 +30	1.48	ÉXNA		2	1	3	3	1	3

LIQUID	CONCEN-TRATION %	TEMPE-RATURE -MIN (°C) -MAX (°C)	DENSITY kg/dm³	SEAL MATERIAL RECOMMENDED MECHANICAL SEAL	O-RING	MECHANICAL SEAL NUMBER A	NUMBER N	NUMBER B	NUMBER P	"O" RINGS FPM	EPDM
Freon 112 CCI2FCCLF2 configuration code	100	-5 +30	1.57	ÉXNA		2	1	3	1	1	3
Freon 113 Triclorotrifluroetano CCI2FCCLF2 configuration code	100	-5 +30	1.42	ÉXNA		2	1	3	3	2	3
Diesel oil (3) configuration code	100	0 80	0.9	standard product		1	1	3	3	1	3
Ethylene glycol CH2OHCH2OH configuration code	50	-5 +80	1.13	ÉXNA		2	1	2	1	1	1
Inks Configuration code	100	0 +80		standard product		1	1	3	3	1	3
Sodium hypochlorite (1) NaOCI Configuration code	0.5	-5 +25		Silicon Carb.- Tungs. Carb ÉXNA		1	1	2	2	1	2
Castor Oil Configuration code	100	-5 +85		ÉXNA		2	1	2	2	1	2
Mineral oil Configuration code	100	-5 -85	0.94	standard product		1	1	3	3	1	3
Caustic Soda Na OH Configuration code	25	0 +70	2.13	ÉXPB		2	2	2	1	2	1
Ferrous Sulfate FeSO4-7H2O Configuration code	20	-5 +40	2.28	ÉXPB		3	3	1	1	3	1
Fruit juice Configuration code	/	-5 +70		standard product		1	1	1	1	1	1

(X) - Positive suction head required

1 = Good compatibility
2 = Poor compatibility
3 = No compatibility

(1) Dangerous liquid (toxic, poisonous, attacks skin, irritant, etc.).
(2) Flammable and explosive liquid.
(3) Four poles versions only.
(4) The stainless steel compatibility depends on the chlorine content in relationship with the liquid temperature, a detailed analysis is necessary.

NPSH

The minimum operating values that can be reached at the pump suction end are limited by the onset of cavitation.

Cavitation is the formation of vapour-filled cavities within liquids where the pressure is locally reduced to a critical value, or where the local pressure is equal to, or just below the vapour pressure of the liquid.

The vapour-filled cavities flow with the current and when they reach a higher pressure area the vapour contained in the cavities condenses. The cavities collide, generating pressure waves that are transmitted to the walls. These, being subjected to stress cycles, gradually become deformed and yield due to fatigue. This phenomenon, characterized by a metallic noise produced by the hammering on the pipe walls, is called incipient cavitation.

The damage caused by cavitation may be magnified by electrochemical corrosion and a local rise in temperature due to the plastic deformation of the walls. The materials that offer the highest resistance to heat and corrosion are alloy steels, especially austenitic steel. The conditions that trigger cavitation may be assessed by calculating the total net suction head, referred to in technical literature with the acronym NPSH (Net Positive Suction Head).

The NPSH represents the total energy (expressed in m.) of the liquid measured at suction under conditions of incipient cavitation, excluding the vapour pressure (expressed in m.) that the liquid has at the pump inlet.

To find the static height hz at which to install the machine under safe conditions, the following formula must be verified:

$$\mathbf{h_p + h_z \geq (NPSHr + 0.5) + h_f + h_{pv}} \quad ①$$

where:

h_p is the absolute pressure applied to the free liquid surface in the suction tank, expressed in m. of liquid; hp is the quotient between the barometric pressure and the specific weight of the liquid.

h_z is the suction lift between the pump axis and the free liquid surface in the suction tank, expressed in m.; hz is negative when the liquid level is lower than the pump axis.

h_f is the flow resistance in the suction line and its accessories, such as: fittings, foot valve, gate valve, elbows, etc.

h_{pv} is the vapour pressure of the liquid at the operating temperature, expressed in m. of liquid. hpv is the quotient between the Pv vapour pressure and the liquid's specific weight.

0.5 is the safety factor.

The maximum possible suction head for installation depends on the value of the atmospheric pressure (i.e. the elevation above sea level at which the pump is installed) and the temperature of the liquid.

To help the user, with reference to water temperature (4°C) and to the elevation above sea level, the following tables show the drop in hydraulic pressure head in relation to the elevation above sea level, and the suction loss in relation to temperature.

Water temperature (°C)	20	40	60	80	90	110	120
Suction loss (m)	0,2	0,7	2,0	5,0	7,4	15,4	21,5

Elevation above sea level (m)	500	1000	1500	2000	2500	3000
Suction loss (m)	0,55	1,1	1,65	2,2	2,75	3,3

Friction loss is shown in the tables at pages 16-17 of this catalogue. To reduce it to a minimum, especially in cases of high suction head (over 4-5 m.) or within the operating limits with high flow rates, we recommend using a suction line having a larger diameter than that of the pump's suction port.
It is always a good idea to position the pump as close as possible to the liquid to be pumped.

Make the following calculation:

Liquid: water at ≈15°C y = 1 kg/dm³
Flow rate required: 30 m³/h
Head for required delivery: 43 m.
Suction lift: 3.5 m.
The selection is an FHE 40-200/75 pump whose NPSH required value is, at 30 m³/h, 2.5 m.

For water at 15°C the hpv term is $\frac{Pv}{\varsigma}$ = 0,174 m (0.01701 bar)

and h = $\frac{Pa}{\varsigma}$ = 10,33m

The Hf flow resistance in the suction line with foot valves is ≈1.2 m.
By substituting the parameters in formula ¿ with the numeric values above, we have:

$$10{,}33 + (-3{,}5) \geq (2{,}5 + 0{,}5) + 1{,}2 + 0{,}17$$

from which we have: 6.8 > 4.4

The relation is therefore verified.

VAPOUR PRESSURE

ps VAPOUR PRESSURE AND ⇐DENSITY OF WATER TABLE

t °C	T K	ps bar	ρ kg/dm³
0	273,15	0,00611	0,9998
1	274,15	0,00657	0,9999
2	275,15	0,00706	0,9999
3	276,15	0,00758	0,9999
4	277,15	0,00813	1,0000
5	278,15	0,00872	1,0000
6	279,15	0,00935	1,0000
7	280,15	0,01001	0,9999
8	281,15	0,01072	0,9999
9	282,15	0,01147	0,9998
10	283,15	0,01227	0,9997
11	284,15	0,01312	0,9997
12	285,15	0,01401	0,9996
13	286,15	0,01497	0,9994
14	287,15	0,01597	0,9993
15	288,15	0,01704	0,9992
16	289,15	0,01817	0,9990
17	290,15	0,01936	0,9988
18	291,15	0,02062	0,9987
19	292,15	0,02196	0,9985
20	293,15	0,02337	0,9983
21	294,15	0,2485	0,9981
22	295,15	0,02642	0,9978
23	296,15	0,02808	0,9976
24	297,15	0,02982	0,9974
25	298,15	0,03166	0,9971
26	299,15	0,03360	0,9968
27	300,15	0,03564	0,9966
28	301,15	0,03778	0,9963
29	302,15	0,04004	0,9960
30	303,15	0,04241	0,9957
31	304,15	0,04491	0,9954
32	305,15	0,04753	0,9951
33	306,15	0,05029	0,9947
34	307,15	0,05318	0,9944
35	308,15	0,05622	0,9940
36	309,15	0,05940	0,9937
37	310,15	0,06274	0,9933
38	311,15	0,06624	0,9930
39	312,15	0,06991	0,9927
40	313,15	0,07375	0,9923
41	314,15	0,07777	0,9919
42	315,15	0,08198	0,9915
43	316,15	0,09639	0,9911
44	317,15	0,09100	0,9907
45	318,15	0,09582	0,9902
46	319,15	0,10086	0,9898
47	320,15	0,10612	0,9894
48	321,15	0,11162	0,9889
49	322,15	0,11736	0,9884
50	323,15	0,12335	0,9880
51	324,15	0,12961	0,9876
52	325,15	0,13613	0,9871
53	326,15	0,14293	0,9862
54	327,15	0,15002	0,9862
55	328,15	0,15741	0,9857

t °C	T K	ps bar	ρ kg/dm³
56	329,15	0,16511	0,9852
57	330,15	0,17313	0,9846
58	331,15	0,18147	0,9842
59	332,15	0,19016	0,9837
60	333,15	0,19920	0,9232
61	334,15	0,2086	0,9826
62	335,15	0,2184	0,9821
63	336,15	0,2286	0,9816
64	337,15	0,2391	0,9811
65	338,15	0,2501	0,9805
66	339,15	0,2615	0,9799
67	340,15	0,2733	0,9793
68	341,15	0,2856	0,9788
69	342,15	0,2984	0,9782
70	343,15	0,3116	0,9777
71	344,15	0,3253	0,9770
72	345,15	0,3396	0,9765
73	346,15	0,3543	0,9760
74	347,15	0,3696	0,9753
75	348,15	0,3855	0,9748
76	349,15	0,4019	0,9741
77	350,15	0,4189	0,9735
78	351,15	0,4365	0,9729
79	352,15	0,4547	0,9723
80	353,15	0,4736	0,9716
81	354,15	0,4931	0,9710
82	355,15	0,5133	0,9704
83	356,15	0,5342	0,9697
84	357,15	0,5557	0,9691
85	358,15	0,5780	0,9684
86	359,15	0,6011	0,9678
87	360,15	0,6249	0,9671
88	361,15	0,6495	0,9665
89	362,15	0,6749	0,9658
90	363,15	0,7011	0,9652
91	364,15	0,7281	0,9644
92	365,15	0,7561	0,9638
93	366,15	0,7849	0,9630
94	367,15	0,8146	0,9624
95	368,15	0,8453	0,9616
96	369,15	0,8769	0,9610
97	370,15	0,9094	0,9602
98	371,15	0,9430	0,9596
99	372,15	0,9776	009586
100	373,15	1,0133	0,9581
102	375,15	1,0878	0,9567
104	377,15	1,1668	0,9552
106	379,15	1,2504	0,9537
108	381,15	1,3390	0,9522
110	383,15	1,4327	0,9507
112	385,15	1,5316	0,9491
114	387,15	1,6362	0,9476
116	389,15	1,7465	0,9460
118	391,15	1,8628	0,9445
120	393,15	1,9854	0,9429

t °C	T K	ps bar	ρ kg/dm³
122	395,15	2,1145	0,9412
124	397,15	2,2504	0,9396
126	399,15	2,3933	0,9379
128	401,15	2,5435	0,9362
130	403,15	2,7013	0,9346
132	405,15	2,8670	0,9328
134	407,15	3,041	0,9311
136	409,15	3,223	0,9294
138	411,15	3,414	0,9276
140	413,15	3,614	0,9258
145	418,15	4,155	0,9214
150	423,15	4,760	0,9168
155	428,15	5,433	0,9121
160	433,15	6,181	0,9073
165	438,15	7,008	0,9024
170	433,15	7,920	0,8973
175	448,15	8,924	0,8921
180	453,15	10,027	0,8869
185	458,15	11,233	0,8815
190	463,15	12,551	0,8760
195	468,15	13,987	0,8704
200	473,15	15,55	0,8647
205	478,15	17,243	0,8588
210	483,15	19,077	0,8528
215	488,15	21,060	0,8467
220	493,15	23,198	0,8403
225	498,15	25,501	0,8339
230	503,15	27,976	0,8273
235	508,15	30,632	0,8205
240	513,15	33,478	0,8136
245	518,15	36,523	0,8065
250	523,15	39,776	0,7992
255	528,15	43,246	0,7916
260	533,15	46,943	0,7839
265	538,15	50,877	0,7759
270	543,15	55,058	0,7678
275	548,15	59,496	0,7593
280	553,15	64,202	0,7505
285	558,15	69,186	0,7415
290	563,15	74,461	0,7321
295	568,15	80,037	0,7223
300	573,15	85,927	0,7122
305	578,15	92,144	0,7017
310	583,15	98,700	0,6906
315	588,15	105,61	0,6791
320	593,15	112,89	0,6669
325	598,15	120,56	0,6541
330	603,15	128,63	0,6404
340	613,15	146,05	0,6102
350	623,15	165,35	0,5743
360	633,15	186,75	0,5275
370	643,15	210,54	0,4518
374,15	647,30	221,2	0,3154

FLOW RESISTANCE

TABLE OF FLOW RESISTANCE IN 100 M OF A NEW AND STRAIGHT CAST IRON PIPELINE

Hr = FLOW RESISTANCE (m/100 m OF PIPELINE)
V = WATER SPEED (m/sec)

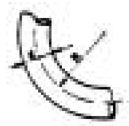
FLOW RATE m³/h	l/min.		15 ½"	20 ¾"	25 1"	32 1 ¼"	40 1½"	50 2"	65 2½"	80 3"	100 4"	125 5"	150 6"	175 7"	200 8"	250 10"	300 12"	350 14"	400 16"
0,6	10	V	0,94	0,53	0,34	0,21													
		hr	11,8	2,82	1	0,25													
0,9	15	V	1,42	0,8	0,51	0,31													
		hr	25,1	6,04	2,16	0,55													
1,2	20	V	1,89	1,06	0,68	0,41	0,27												
		hr	43,1	10,4	3,72	0,95	0,31												
1,5	25	V	2,36	1,33	0,85	0,52	0,33												
		hr	64,5	15,8	5,68	1,47	0,47												
1,8	30	V	2,83	1,59	1,02	0,62	0,4												
		hr	92	22,3	8	2,09	0,66												
2,1	35	V	3,3	1,86	1,19	0,73	0,46	0,3											
		hr	123	29,8	10,8	2,81	0,89	0,31											
2,4	40	V	3,77	2,12	1,36	0,83	0,53	0,34											
		hr	164	38,2	13,8	2,65	1,15	0,4											
3	50	V	4,72	2,65	1,7	1,04	0,66	0,42											
		hr	246	58,2	21,5	5,6	1,75	0,61											
3,6	60	V		3,18	2,04	1,24	0,8	0,51											
		hr		82	30	8	2,48	0,86											
4,2	70	V		3,72	2,38	1,45	0,93	0,59											
		hr		110	40	10,8	3,33	1,14											
4,8	80	V		4,25	2,72	1,66	1,06	0,68											
		hr		141	51,5	13,9	4,3	1,46											
5,4	90	V			3,06	1,87	1,19	0,76	0,45										
		hr			64	17,5	5,4	1,82	0,46										
6	100	V			3,4	2,07	1,33	0,85	0,5										
		hr			79	21,4	6,6	2,22	0,56										
7,5	125	V			4,25	2,59	1,66	1,06	0,63										
		hr			120	33	10	3,4	0,86										
9	150	V				3,11	1,99	1,27	0,75	0,5									
		hr				47	14,2	4,74	1,21	0,43									
10,5	175	V				3,63	2,32	1,49	0,88	0,58									
		hr				63	19	6,3	1,63	0,57									
12	200	V				4,15	2,65	1,7	1,01	0,66									
		hr				82	24,5	8,1	2,1	0,74									
15	250	V				5,18	3,32	2,12	1,26	0,83	0,53								
		hr				126	37,5	12,3	3,2	1,12	0,36								
18	300	V					3,98	2,55	1,51	1	0,64								
		hr					53	17,3	4,5	1,58	0,51								
24	400	V					5,31	3,4	2,01	1,33	0,85								
		hr					92	29,5	7,8	2,7	0,89								
30	500	V					6,63	4,25	2,51	1,66	1,06	0,68							
		hr					140	44,8	12	4,13	1,36	0,48							
36	600	V						5,1	3,02	1,99	1,27	0,82							
		hr						63	16,9	5,8	1,93	0,68							
42	700	V						5,94	3,52	2,32	1,49	0,95							
		hr						84	22,6	7,8	2,6	0,9							
48	800	V						6,79	4,02	2,65	1,70	1,09	0,75						
		hr						108	29	10	3,35	1,16	0,43						
54	900	V						7,64	4,52	2,99	1,91	1,22	0,85						
		hr						134	36	12,5	4,2	1,45	0,54						
60	1000	V							5,03	3,32	2,12	1,36	0,94						
		hr							44,5	15,2	5,14	1,76	0,66						
75	1250	V							6,28	4,15	2,65	1,70	1,18	0,87					
		hr							68	23	7,9	2,68	1	0,48					
90	1500	V							7,54	4,98	3,18	2,04	1,42	1,04					
		hr							96	32,6	11,2	3,77	1,42	0,68					
105	1750	V							8,79	5,81	3,72	2,38	1,65	1,21	0,93				
		hr							129	43,5	15	5,04	1,9	0,91	0,45				
120	2000	V								6,63	4,25	2,72	1,89	1,39	1,06	0,68			
		hr								56	19,4	6,5	2,43	1,18	0,58	0,16			
150	2500	V								8,29	5,31	3,40	2,36	1,73	1,33	0,85			
		hr								85	30	9,8	3,75	1,79	0,89	0,25			
180	3000	V								9,95	6,37	4,08	2,83	2,08	1,59	1,02	0,71		
		hr								120	42	13,8	5,3	2,53	1,25	0,35	0,15		
300	5000	V									10,62	6,79	4,72	3,47	2,65	1,70	1,18	0,87	0,66
		hr									124,9	41,3	16,74	7,81	4,03	1,34	0,54	0,25	0,13
600	10000	V										13,59	9,44	6,93	5,31	3,4	2,36	1,73	1,33
		hr										161	65	30,2	15,6	5,16	2,09	0,97	0,5
1200	20000	V														6,79	4,72	3,47	2,65
		hr														20,1	8,13	3,8	1,95
1800	30000	V															7,7	5,2	4,0
		hr															18,07	8,39	4,32
3000	50000	V															11,8	8,67	6,63
		hr															49,5	23	11,8
4500	75000	V															17,7	13	9,9
		hr															110,5	51,3	26,4
6000	100000	V																17,33	13,27
		hr																90,6	46,6

(Column heading: NOMINAL DIAMETER IN mm AND INCHES)

THE FLOW RESISTANCE MUST BE MULTIPLIED BY:
- 0.8 for stainless steel pipes
- 1.25 for slightly rusted steel pipes
- 1.7 for pipes with deposits that reduce the flow section
- 0.7 for aluminium pipes
- 1.3 for fibre-cement pipes

FLOW RESISTANCE

TABLE OF FLOW RESISTANCE OF BENDS AND VALVES IN cm OF COLUMN OF WATER

WATER SPEED	SHARP BENDS 					SMOOTH BENDS 					STANDARD GATE VALVES	FOOT VALVES	CHECK VALVES
m/sec	a = 30°	a = 40°	a = 60°	a = 80°	a = 90°	$\frac{d}{R} = 0,4$	$\frac{d}{R} = 0,6$	$\frac{d}{R} = 0,8$	$\frac{d}{R} = 1$	$\frac{d}{R} = 1,5$			
0,10	0,03	0,04	0,05	0,07	0,08	0,007	0,008	0,01	0,0155	0,027	0,030	30	30
0,15	0,06	0,07	0,10	0,14	0,17	0,016	0,019	0,024	0,033	0,06	0,033	31	31
0,2	0,11	0,13	0,18	0,26	0,31	0,028	0,033	0,04	0,058	0,11	0,058	31	31
0,25	0,17	0,21	0,28	0,4	0,48	0,044	0,052	0,063	0,091	0,17	0,090	31	31
0,3	0,25	0,30	0,41	0,6	0,7	0,063	0,074	0,09	0,13	0,25	0,13	31	31
0,35	0,33	0,40	0,54	0,8	0,93	0,085	0,10	0,12	0,18	0,33	0,18	31	31
0,4	0,43	0,52	0,71	1,0	1,2	0,11	0,13	0,16	0,23	0,43	0,23	32	31
0,5	0,67	0,81	1,1	1,6	1,9	0,18	0,21	0,26	0,37	0,67	0,37	33	32
0,6	0,97	1,2	1,6	2,3	2,8	0,25	0,29	0,36	0,52	0,97	0,52	34	32
0,7	1,35	1,65	2,2	3,2	3,9	0,34	0,40	0,48	0,70	1,35	0,70	35	32
0,8	1,7	2,1	2,8	4,0	4,8	0,45	0,53	0,64	0,93	1,7	0,95	36	33
0,9	2,2	2,7	3,6	5,2	6,2	0,57	0,67	0,82	1,18	2,2	1,20	37	34
1,0	2,7	3,3	4,5	6,4	7,6	0,7	0,82	1,0	1,45	2,7	1,45	38	35
1,5	6,0	7,3	10	14	17	1,6	1,9	2,3	3,3	6	3,3	47	40
2,0	11	14	18	26	31	2,8	3,3	4,0	5,8	11	5,8	61	48
2,5	17	21	28	40	48	4,4	5,2	6,3	9,1	17	9,1	78	58
3,0	25	30	41	60	70	6,3	7,4	9	13	25	13	100	71
3,5	33	40	55	78	93	8,5	10	12	18	33	18	123	85
4,0	43	52	70	100	120	11	13	16	23	42	23	150	100
4,5	55	67	90	130	160	14	21	26	37	55	37	190	120
5,0	67	82	110	160	190	18	29	36	52	67	52	220	140

1) Flow resistance in bends is due to the contraction of the liquid threads resulting from the change of direction: the development of the bends must therefore be included in the length of the pipeline.
2) Flow resistance in valves and gates was determined on the basis of practical tests.

VOLUMETRIC CAPACITY

litres per minute l/min	cubic metres per hour m³/h	cubic feet per hour ft³/h	cubic feet per minute ft³/min	imp. gal. per minute imp. gal./min	US gal. per minute US gal./min
1,0000	0,0600	2,1189	0,0353	0,2200	0,2640
16,6670	**1,0000**	35,3147	0,5886	3,6660	4,4030
0,4720	0,0283	**1,0000**	0,0167	0,1040	0,1250
28,3170	1,6990	60,0000	**1,0000**	6,2290	7,4800
4,5460	0,2728	9,6326	0,1605	**1,0000**	1,2010
3,7850	0,2271	8,0209	0,1337	0,8330	**1,0000**
0,1100	0,0066	0,2339	0,0039	0,0240	0,0290

PRESSURE AND HEAD

Newton per square metre N/m²	kiloPascal kPa	bar bar	pound force per square inch psi	metre of water $m\ H_2O$	millimetre of mercury mm Hg
1,0000	0,0010	1×10^{5}	$1{,}45 \times 10^{-4}$	$1{,}02 \times 10^{-4}$	0,0075
1.000,0000	**1,0000**	0,0100	0,1450	0,1020	7,5000
100.000,0000	100,0000	**1,0000**	14,5000	10,2000	750,1000
98.067,0000	98,0700	0,9810	14,2200	10,0000	735,6000
6.895,0000	6,8950	0,0690	**1,0000**	0,7030	51,7200
2.984,0000	2,9840	0,0300	0,4330	0,3050	22,4200
9.789,0000	9,7890	0,0980	1,4200	**1,0000**	73,4200
133,3000	0,1330	0,0013	0,0190	0,0140	**1,0000**
3.386,0000	3,3860	0,0338	0,4910	0,3450	25,4000

LENGTH

millimetre mm	centimetre cm	metre m	inch in	foot ft	yard yd
1,0000	0,1000	0,0010	0,0394	0,0033	0,0011
10,0000	**1,0000**	0,0100	0,3937	0,0328	0,0109
1000,0000	100,0000	**1,0000**	39,3701	3,2808	1,0936
25,4000	2,5400	0,0254	**1,0000**	0,0833	0,0278
304,8000	30,4800	3,0480	12,0000	**1,0000**	0,3333
914,4000	91,4400	0,9144	36,0000	3,0000	**1,0000**

VOLUME

cubic metre m³	litre l	millilitre ml	imp. gallon imp. gal.	US gallon US gal	cubic foot ft³
1,0000	1.000,0000	1×10^{6}	220,0000	264,2000	35,3147
0,0010	**1,0000**	1.000,0000	0,2200	0,2642	0,0353
1×10^{-6}	0,0010	**1,0000**	$2{,}2 \times 10^{-4}$	$2{,}642 \times 10^{-4}$	$3{,}53 \times 10^{-5}$
0,0045	4,5460	4.546,0000	**1,0000**	1,2010	0,1605
0,0038	3,7850	3.785,0000	0,8327	**1,0000**	0,1337
0,0283	28,3170	28.317,0000	6,2288	7,4805	**1,0000**