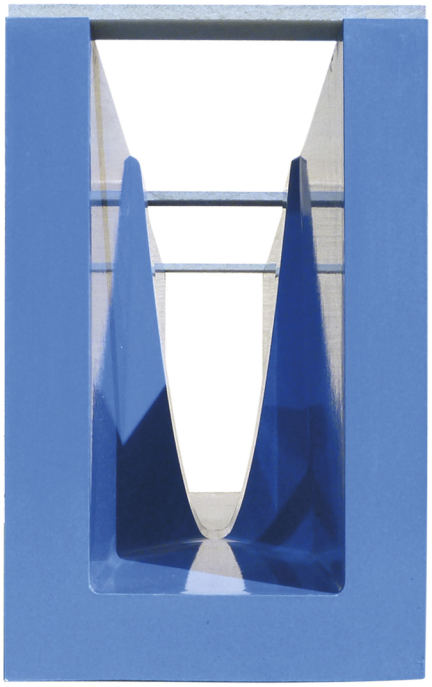
Open channels, exponential Venturi.
DEBITFLO CHANNELS



Channel types: I - II - III - IV - V - VI - VII

USER MANUAL

BAMO INTERNATIONAL
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SUMMARY

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Inspection on delivery: In the presence of the delivery person, check that the Venturi is in good condition.

IMPORTANT: Keep in place (do not remove) the cross bars to insure correct inner width of channel.

1. INSTALLING THE CHANNEL

The channel must be positioned horizontally (no slope), both in the longitudinal and transverse direction. Horizontality is mandatory for the Venturi channel and the approach channels(s). They all must be perfectly aligned and not show any change in the profile.

Approach channel may be realized on site with any convenient material with correct rigidity and roughness at least equivalent to Venturi channel material (polyethylene, concrete, stainless steel, etc.) It is recommended to use our ready-to-use approach channels, perfectly sized.

The approach channels are necessary for flow tranquilization to avoid turbulences in the measuring area and therefore to have correct measurements.

Directive ISO 4359 dictates for approach channel a length as a minimum of 5 times its inner width, right at the measurement area, located between 3 and 4 times the maximum of height to be measured (upstream the restriction on Venturi). In France, the minimum for approach channel length is 10 x B (Agence de l'Eau RM&C) when upstream conditions are ideally perfect (flow in the axis, without drop, etc.); See drawing page 5.

2. DESCRIPTION

The exponential Venturi channels are designed to measure flow rates in a straight open channel. When conditions of non-turbulent flow upstream of Venturi and the totally free outlet (downstream the Venturi) are respected, the height of liquid before restriction (h, upstream) is directly related to the flow rate (Q).

The originality of exponential Venturi is to combine advantages of conventional Venturi and to cover larger variations in flow. This is allowed by use of a parabolic section. This feature allows the measurement of low flow rates with accuracy, as the liquid flows through a narrow section (base of the parabolic shape). As the flow increases, the path widens to the top gradually releasing a larger flow according to the equation:

$$y = f(\chi) \quad \text{with} \quad y = Kx^z$$

As a result, this type of Venturi channel is the only one to procure accurate measurement of flow rates varying in an extreme ratio of 1 to 100. Example with type V (size 5): Continuous measurement from 3,6 m^3/h up to 360 m^3/h This ratio is usually only 1 to 20 for the open channels.

It corresponds to frequent requests from prescriptors and end-users. It is useful for measuring flows subject to large variations, either for instantaneous flow rates (quick draining of storage weirs), without risk of overflow prejudicial to industrial activity, or for network of communities during peak flow (storm rain).

There are 7 types of exponential Venturi covering (in 7 ranges) flow rates from 0.22 m^3/h up to 1440 m^3/h These glass fiber reinforced polyester channels have an extremely reduced roughness coefficient and great resistance to aggressive liquids, and, solidity is ensured by transverse stiffeners allowing a direct installation in formwork.

Calibration tables of each Venturi were verified on a hydraulic bench equipped with electromagnetic flowmeters. A study carried out by ENGEES (École Nationale du Génie de l'Eau et l'Environnement de Strasbourg) confirmed the quality and accuracy of these channels.

3. MATERIALS

Exponential Venturi and their approach channels are made of polyester isophtalique resin (glass fibre reinforced polyester), UV protected (blue RAL 5015). They are moulded with release shrinkage of less than 0.02 mm. Their design includes cross bars and stiffeners preventing any deformation until final commissioning. By their construction, these channels have an excellent resistance to wear.

Material main features:

Buckling at 243 °C	Elongation: 1.4 %	Barcol hardness: 72	Elasticity: 3.40 GPa	Compression: 46 MPa

4. LIQUIDS COMPATIBILITY

The isophthalic polyester resin has a very good resistance to hydrolysis and to acids. This resin is not compatible with organic solvents (styrène, acétone, etc.). It is nevertheless possible to adapt the channel to particular specifications: on request.

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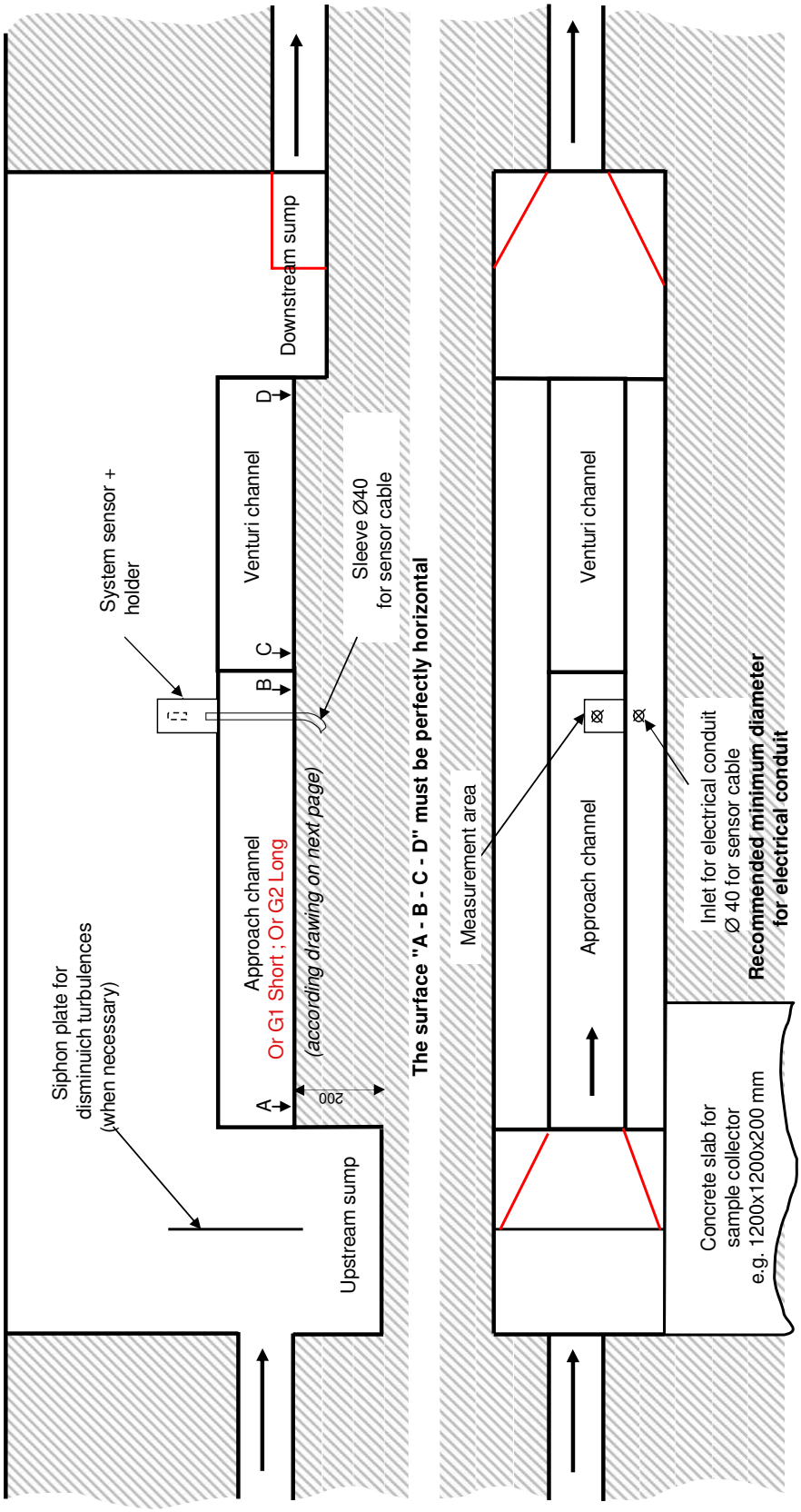
5. RECOMMENDATIONS FOR THE INSTALLATION



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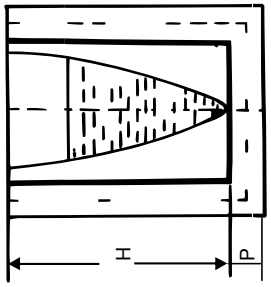
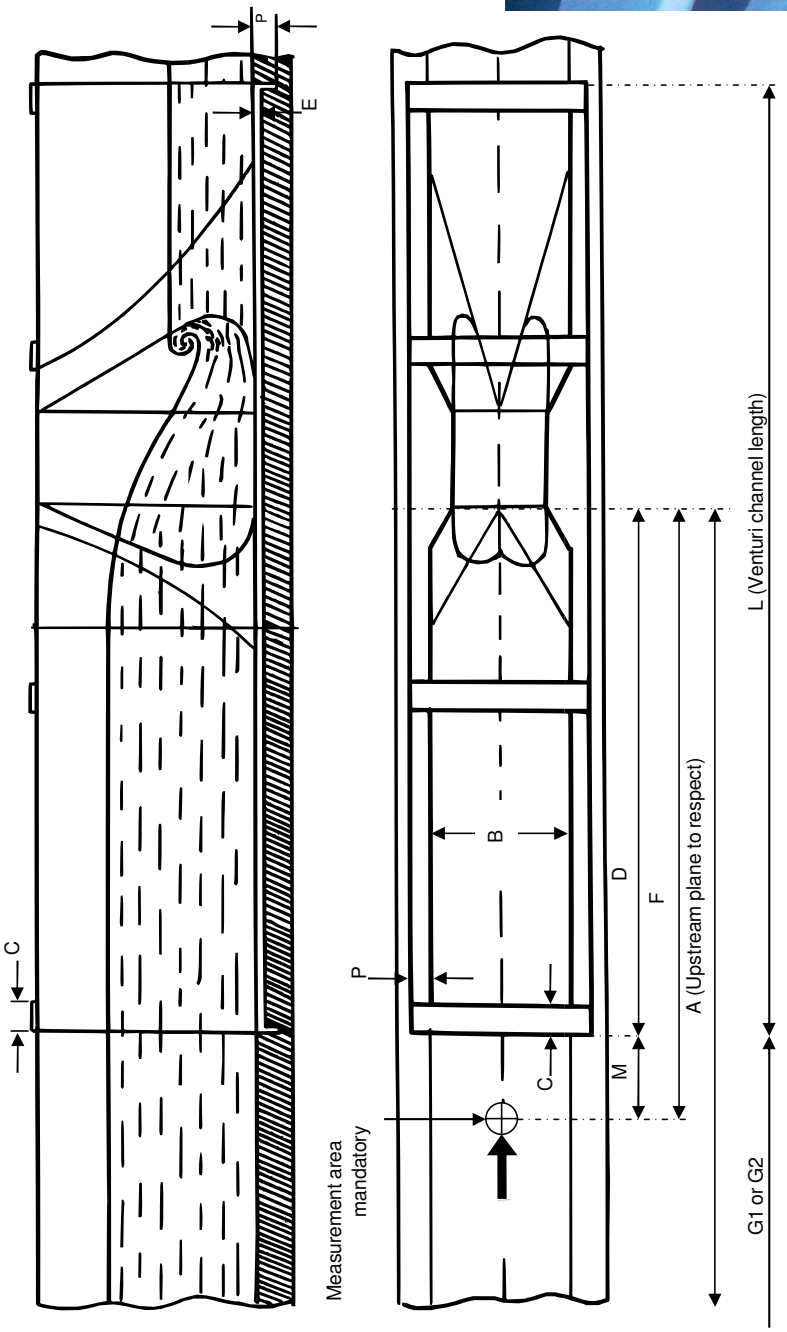
6. DIMENSIONS





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DEBITFLO CHANNELS

6.1 Approach channels SHORT MODELS

Exponential Venturi channels with SHORT approach channels (respecting the minimum of 5 B + 3 Hmax upstream restriction)

Marks	
A	Upstream distance from restriction
B	Inner width
C	Cross bars width
	Number of cross bars
D	Distance inside the channel from restriction
E	Thickness
***F**	Measuring point distance from restriction
G1	(short channel) Distance minimum upstream from Venturi channel inlet
G2	(long channel) Distance minimum upstream from Venturi channel inlet
M	Measuring point distance (upstream of Venturi channel)
H	Inner height of Venturi channel
L	Overall length of Venturi channel
P	Width of stiffeners
****R**	Lateral stiffeners number & width (type VI & VII only)
Q	Minimum flow rate
Q	Maximum flow rate

Type	I		II		III		IV		V		VI		VII	
A	945		1300		1900		2800		4200		5500		7300	
B	90		130		190		280		420		550		730	
C (W.)	25		30		40		50		80		100		140	
C (Nr)	3		4		4		4		4		4		4	
D	455		575		725		880		1080		1100		1460	
E	4		4		5		5		7		8		10	
***F**	560		700		885		1120		1400		1850		2400	
G1	490		725		1175		1920		3120		4400		5840	
G2	945		1300		1900		2800		4200		5500		7300	
M	105		125		160		240		320		750		940	
H	200		250		310		380		460		600		800	
L	750		1000		1350		1800		2500		3150		4200	
P	30		30		35		50		50		50		55	
****R**	None		None		None		None		None		1	85	2	90
	l/s	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**
Q Min.	0,06	0,22	0,12	0,43	0,25	0,90	0,5	1,80	1	3,60	2	7,20	4	14,40
Q Max.	6	22	12	43	25	90	50	180	100	360	200	720	400	1440

* Measuring area is located in the approach channel, upstream of the Venturi channel. ** see Pic. page 5

Details of approach channels SHORT type, in polyester, glass fiber reinforced, for exponential Venturi channels

Type	Inner length [mm]	Inner width [mm]	Inner height [mm]
I	490	90	200
II	725	130	250
III	1175	190	310
IV	1920	280	380
V	3120	420	460
VI	4400 (in 2 parts, each 2200 mm)	550	600
VII	5840 (in 2 parts, each 2920 mm)	730	800

6.2 Approach channels LONG MODELS

Exponential Venturi channels with LONG approach channels (respecting the minimum of 5 B + 3 Hmax on upstream restriction)

Marks	
A	Upstream distance from restriction
B	Inner width
C	Cross bars width
	Number of cross bars
D	Distance inside the channel from restriction
E	Thickness
***F**	Measuring point distance from restriction
M	Measuring point distance (upstream of Venturi channel)
H	Inner height
L	Overall length
P	Width of stiffeners
****R**	Lateral stiffeners number & width (type VI & VII only)
Q	Minimum flow rate
Q	Maximum flow rate

Type	**I**		**II**		**III**		**IV**		**V**		**VI**		**VII**	
A	945		1300		1900		2800		4200		5500		7300	
B	90		130		190		280		420		550		730	
C (W.)	25		30		40		50		80		100		140	
C (Nr)	3		4		4		4		4		4		4	
D	455		575		725		880		1080		1100		1460	
E	4		4		5		5		7		8		10	
***F**	560		700		885		1120		1400		1850		2400	
M	105		125		160		240		320		750		940	
H	200		250		310		380		460		600		800	
L	750		1000		1350		1800		2500		3150		4200	
P	30		30		35		50		50		50		55	
****R**	None		None		None		None		None		1	85	2	90
	l/s	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**	**l/s**	**m³/h**
Q Min.	0,06	0,22	0,12	0,43	0,25	0,90	0,5	1,80	1	3,60	2	7,20	4	14,40
Q Max.	6	22	12	43	25	90	50	180	100	360	200	720	400	1440

* Measuring area is in the approach channel, upstream of Venturi channel; ** See the picture

Details of approach channels LONG type, in polyester, glass fiber reinforced, for exponential Venturi channels

Type	Inner length [mm]	Inner width [mm]	Inner height [mm]
I	950	90	200
II	1300	130	250
III	1900	190	310
IV	2800	280	380
V	4200	420	460
VI	5500 (2 parts, each 2750)	550	600
VII	7300 (2 parts, each 3650 mm)	730	800

6.3 Length of approach channel: See distances G1 or G2

The short and long types of approach channels allow to correspond to most of requests.

Type		Liquid height		Point of level measuring point	Straight distance in Venturi channel	Length of approach channel		Measurement area according ISO 4359	
	Channel width	At Q Min.	At Q Max.			G1 Min.	G2 adviced	3 x H max.	4 x H max.
I	90	18 mm	162 mm	486 mm	455 mm	490 mm	950 mm	486 ... 648 mm	
II	130	24 mm	209 mm	627 mm	575 mm	725 mm	1300 mm	624 ... 832 mm	
III	190	29 mm	266 mm	798 mm	725 mm	1175 mm	1900 mm	796 ... 1061 mm	
IV	280	35 mm	338 mm	1014 mm	880 mm	1920 mm	2800 mm	1014 ... 1351 mm	
V	420	43 mm	420 mm	1260 mm	1080 mm	3120 mm	4200 mm	1260 ... 1660 mm	
VI	550	54 mm	545 mm	1635 mm	1100 mm	4400 mm	5500 mm	1633 ... 2177 mm	
VII	730	73 mm	731 mm	2193 mm	1460 mm	5840 mm	7300 mm	2194 ... 2926 mm	

7. Measurement uncertainty

The manufacturing tolerances induce the following uncertainties:

	Type I		Type II		Type III		Type IV	
	m^3/h	Uncertainty	m^3/h	Uncertainty	m^3/h	Uncertainty	m^3/h	Uncertainty
Q at 25 % H	0,93	± 3.0 %	1,77	± 2.8 %	4,36	± 2.6 %	8,65	± 2.4 %
Q at 50 % H	4,43	± 2.5 %	8,92	± 2.4 %	19,72	± 2.2 %	39,21	± 1.8 %
Q at 75 % H	11,16	± 2.2 %	22,50	± 1.8 %	48,39	± 1.6 %	96,09	± 1.4 %
At Q Max.	21,83	± 2.0 %	43,44	± 1.6 %	90,62	± 1.4 %	180,16	± 1.2 %

	Type V		Type VI		Type VII	
	m^3/h	Uncertainty	m^3/h	Uncertainty	m^3/h	Uncertainty
Q at 25 % H	19,60	± 2.0 %	39,12	± 1.5 %	78,49	± 1.0 %
Q at 50 % H	84,01	± 1.4 %	169,01	± 1.0 %	336,48	± 0.8 %
Q at 75 % H	196,83	± 1.0 %	395,00	± 0.8 %	788,41	± 0.6 %
Q Max.	360,14	± 0.8 %	721,79	± 0.6 %	1442,52	± 0.5 %

8. ACCESS AND MAINTENANCE

Depending on the nature of the liquids, it is possible that materials settle on the base and the walls. They must remain as clean as possible, it is therefore necessary to ensure accessibility to the channel for checking and cleaning operations.

If the channel is located below the level ground, it is convenient that the covering is of removable gratings, allowing a rapid visual check of the channel and facilitating maintenance operations.

It is particularly not recommended to cover the channel with a concrete slab or a non-removable cover.

9. PEOPLE SAFETY

Safety of people on site must be consider when carrying out the project to avoid any accident during future maintenance routine.

10. CORRESPONDENCE FLOW vs. HEIGHT

It is advisable to regularly check the measured flow with the value of flow from the table according to the water height at the measuring point (use the ruler installed).

10.1 TYPE I

$$Q = -0{,}19xh + 672{,}7xh^2 - 734xh^3 + 11400xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m³/h
18	0,06	0,21
20	0,07	0,26
22	0,09	0,32
24	0,10	0,38
26	0,12	0,44
28	0,14	0,51
30	0,16	0,59
32	0,19	0,67
34	0,21	0,76
36	0,24	0,85
38	0,26	0,95
40	0,29	1,05
42	0,32	1,16
44	0,35	1,27
46	0,39	1,39
48	0,42	1,52
50	0,46	1,65
52	0,50	1,79
54	0,54	1,93
56	0,58	2,08
58	0,62	2,24
60	0,67	2,40
62	0,71	2,57
64	0,76	2,74
66	0,81	2,92
68	0,86	3,11
70	0,92	3,30
72	0,97	3,51
74	1,03	3,71
76	1,09	3,93
78	1,15	4,15
80	1,22	4,38
82	1,28	4,62
84	1,35	4,86
86	1,42	5,12
88	1,49	5,38

mm CE	l/s	m³/h
90	1,57	5,64
92	1,64	5,92
94	1,72	6,21
96	1,81	6,50
98	1,89	6,80
100	1,98	7,11
102	2,07	7,43
104	2,16	7,76
106	2,25	8,10
108	2,35	8,45
110	2,45	8,81
112	2,55	9,18
114	2,66	9,56
116	2,76	9,95
118	2,87	10,35
120	2,99	10,76
122	3,11	11,18
124	3,23	11,62
126	3,35	12,06
128	3,48	12,52
130	3,61	12,99
132	3,74	13,47
134	3,88	13,96
136	4,02	14,47
138	4,16	14,99
140	4,31	15,52
142	4,46	16,07
144	4,62	16,63
146	4,78	17,21
148	4,94	17,80
150	5,11	18,40
152	5,28	19,02
154	5,46	19,66
156	5,64	20,31
158	5,83	20,97
160	6,02	21,66
162	6,21	22,35

10.2 TYPE II

$$Q = -0{,}3311xh + 735{,}1xh^2 + 80{,}7xh^3 + 6210xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m3/h
24	0,12	0,42
30	0,18	0,66
35	0,25	0,90
40	0,33	1,18
45	0,42	1,51
50	0,52	1,87
55	0,63	2,28
60	0,76	2,72
65	0,89	3,22
70	1,04	3,76
75	1,21	4,34
80	1,38	4,97
85	1,57	5,66
90	1,78	6,39
95	1,99	7,18
100	2,23	8,02
105	2,48	8,92
110	2,74	9,87
115	3,03	10,89
120	3,33	11,97
125	3,64	13,12
130	3,98	14,33
135	4,34	15,61
140	4,71	16,97
145	5,11	18,40
150	5,53	19,91
155	5,97	21,49
160	6,43	23,17
165	6,92	24,92
170	7,44	26,77
175	7,98	28,71
180	8,54	30,75
185	9,13	32,88
190	9,76	35,12
195	10,41	37,47
200	11,09	39,92
205	11,80	42,49
209	12,40	44,63

10.3 TYPE III

$$Q = -0{,}58461xh + 1156{,}085xh^2 - 1125xh^3 + 6550xh^4$$

Q [m^3/h]
h [mm]

mm CE	l/s	m^3/h
29	0,26	0,93
40	0,49	1,77
45	0,62	2,24
50	0,77	2,76
55	0,93	3,34
60	1,10	3,97
65	1,29	4,65
70	1,50	5,40
75	1,72	6,19
80	1,96	7,04
85	2,21	7,95
90	2,48	8,92
95	2,76	9,95
100	3,06	11,03
105	3,38	12,18
110	3,72	13,39
115	4,07	14,66
120	4,44	15,99
125	4,83	17,39
130	5,24	18,86
135	5,67	20,40
140	6,11	22,01
145	6,58	23,69
150	7,07	25,44

mm CE	l/s	m^3/h
155	7,58	27,28
160	8,11	29,19
165	8,66	31,18
170	9,24	33,25
175	9,84	35,42
180	10,46	37,67
185	11,11	40,01
190	11,79	42,44
195	12,49	44,98
200	13,22	47,61
205	13,98	50,34
210	14,77	53,18
215	15,59	56,13
220	16,44	59,19
225	17,32	62,37
230	18,24	65,66
235	19,19	69,08
240	20,17	72,63
245	21,20	76,31
250	22,25	80,12
255	23,35	84,07
260	24,49	88,16
263	25,19	90,68
266	25,91	93,26

10.4 TYPE IV

$$Q = -1{,}535xh + 1537{,}5xh^2 - 834xh^3 + 2820xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m3/h
35	0,50	1,80
40	0,65	2,35
50	1,02	3,68
60	1,47	5,30
70	2,00	7,21
80	2,61	9,41
90	3,30	11,89
100	4,07	14,67
110	4,93	17,74
120	5,86	21,10
130	6,88	24,76
140	7,98	28,71
150	9,16	32,98
160	10,43	37,55
170	11,79	42,43
180	13,23	47,64
190	14,77	53,17
200	16,40	59,03
210	18,12	65,24
220	19,95	71,80
230	21,87	78,72
240	23,89	86,02
250	26,03	93,69
260	28,27	101,76
270	30,62	110,24
280	33,09	119,14
290	35,68	128,46
300	38,40	138,24
310	41,24	148,48
320	44,22	159,19
330	47,33	170,40
338	49,93	179,73

10.5 TYPE V

$$Q = -3{,}171xh + 2056xh^2 - 470xh^3 + 1050xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m³/h
43	1,01	3,63
50	1,37	4,93
60	1,98	7,12
70	2,70	9,72
80	3,53	12,71
90	4,47	16,09
100	5,52	19,88
110	6,68	24,06
120	7,95	28,63
130	9,33	33,60
140	10,82	38,97
150	12,42	44,73
160	14,14	50,89
170	15,96	57,45
180	17,89	64,40
190	19,93	71,76
200	22,09	79,53
210	24,36	87,69
220	26,74	96,27
230	29,24	105,25
240	31,85	114,65
250	34,57	124,47
260	37,42	134,70
270	40,38	145,36
280	43,46	156,44
290	46,65	167,95
300	49,97	179,90
310	53,41	192,29
320	56,98	205,13
330	60,67	218,41
340	64,49	232,15
350	68,43	246,36
360	72,51	261,02
370	76,71	276,16
380	81,05	291,79
390	85,53	307,89
400	90,14	324,49
410	94,89	341,59
421	100,27	360,99

10.6 TYPE VI

$$Q = -4{,}423xh + 2661{,}66xh^2 - 1360xh^3 + 1690xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m³/h
54	2,03	7,32
70	3,42	12,31
85	5,03	18,11
100	6,94	24,98
115	9,14	32,92
130	11,64	41,90
145	14,42	51,92
160	17,49	62,97
175	20,84	75,04
190	24,48	88,12
205	28,39	102,22
220	32,59	117,33
235	37,07	133,46
250	41,83	150,60
265	46,88	168,77
280	52,21	187,97
295	57,84	208,21
310	63,75	229,51
325	69,96	251,87
340	76,48	275,31
355	83,29	299,86
370	90,42	325,53
385	97,87	352,34
400	105,64	380,32
415	113,75	409,49
430	122,19	439,89
445	130,98	471,53
460	140,13	504,46
475	149,64	538,71
490	159,53	574,32
505	169,81	611,32
520	180,49	649,75
535	191,57	689,66
547	200,75	722,68

10.7 TYPE VII

$$Q = -7{,}223xh + 2873{,}2xh^2 - 766xh^3 + 770xh^4$$

Q [m³/h]
h [mm]

mm CE	l/s	m³/h
73	4,03	14,51
80	4,85	17,45
95	6,85	24,65
110	9,18	33,06
125	11,86	42,68
140	14,86	53,50
155	18,19	65,50
170	21,86	78,69
185	25,85	93,05
200	30,16	108,59
215	34,80	125,29
230	39,77	143,17
245	45,06	162,20
260	50,67	182,41
275	56,60	203,77
290	62,86	226,31
305	69,45	250,01
320	76,36	274,88
335	83,59	300,92
350	91,15	328,15
365	99,05	356,56
380	107,27	386,17
395	115,83	416,97
410	124,72	448,99

mm CE	l/s	m³/h
425	133,95	482,22
440	143,52	516,68
455	153,44	552,39
470	163,71	589,34
485	174,32	627,56
500	185,30	667,06
515	196,63	707,86
530	208,33	749,97
545	220,39	793,41
560	232,83	838,19
575	245,65	884,35
590	258,86	931,88
605	272,45	980,83
620	286,44	1031,20
635	300,84	1083,02
650	315,64	1136,32
665	330,87	1191,12
680	346,51	1247,44
695	362,59	1305,31
710	379,10	1364,76
725	396,06	1425,82
740	413,48	1488,51
745	419,38	1509,78