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AVIO® AND AVIS® GATES

Constant downstream level control in channels and reservoirs

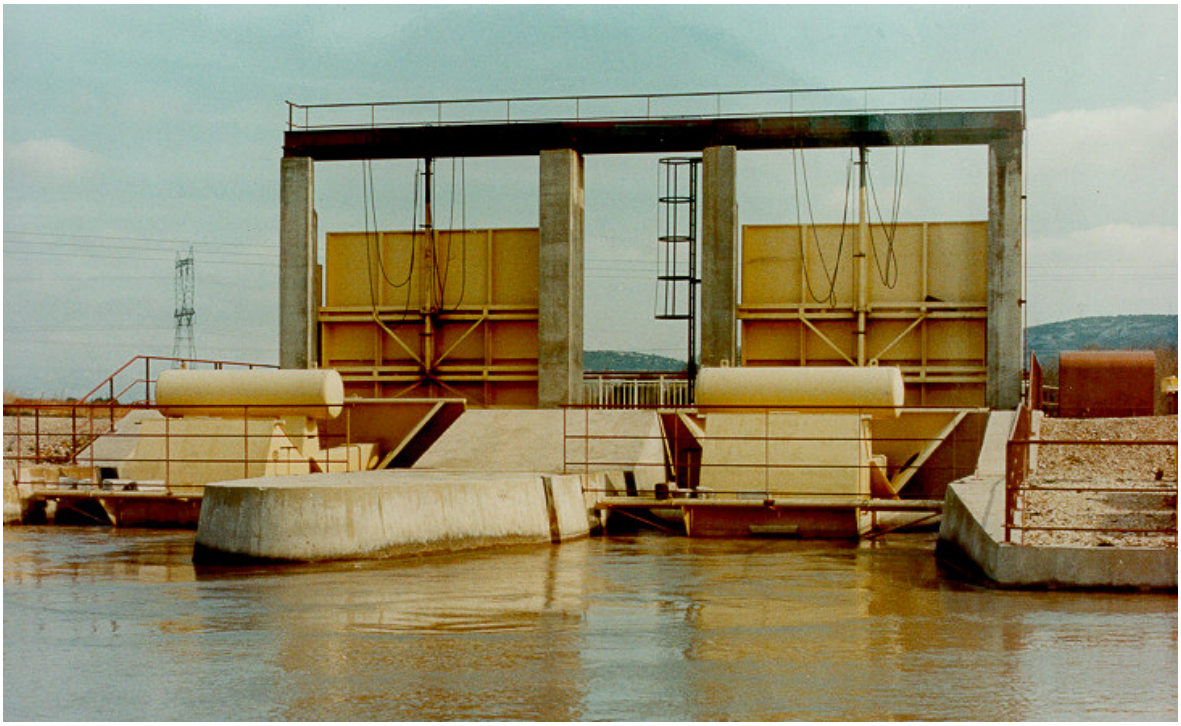
Among the solutions available to control the levels in channels and reservoirs, the AVIO® and AVIS® Automatic Gates stand out for of their simplicity.

These gates control the downstream water level, independently of their opening, upstream water level and required discharge. This feature is provided by means of a single moving part hinged around a shaft.

The lack of any kind of hoisting device has provided such excellent qualities for this type of equipment as precision, rigidity and working security, giving low cost solutions and easily implemented for the hydraulic control of free surface flow.

Downstream level control gates are divided into two groups:

- AVIO® Gates for submerged openings,
- AVIS® Gates for channel free surface flow.



AVIO® and AVIS® Gates are trademarks

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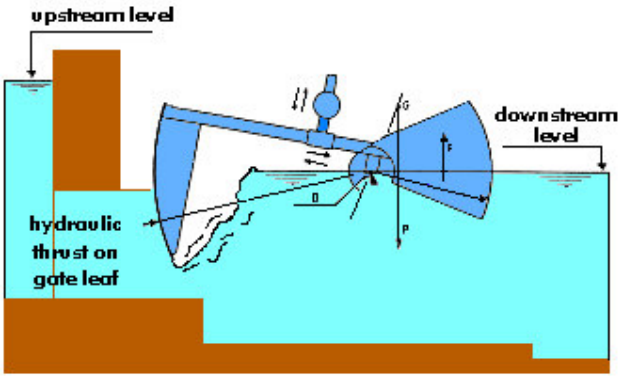
Operating principle:



As shown in the picture above, AVIO® and AVIS® Gates consist of a cylindrical plate gate leaf with trapezoidal section, a framework and its bearings, a float in shape of a toroid and a counterweight.

The hinge axis, which has to be set at the same elevation as the target downstream water level, coincides with hte geometrical centers of the gate leaf and float cylinders.

The counterweight fixed to the framework allows the center of gravity of the moving part to be placed in a position ideal for the gate balancing.

The hydraulic thrust on the gate passes through the hinge axis and does not affect the assembly equilibrium. The only torques that move the assembly are the moments due to its own weight P and the Archimedes Thrust F acting on the float.

The gate is ballasted and balanced so that these two torques above cancel each other out for all positions of the gate leaf, when the downstream water level is at the same elevation of the gate hinge axis.

When the downstream water level does not coincide with the hinge axis elevation, the equilibrium above is affected and the gate position is established as follows:

- If the water demand (s) drop, the downstream level rises and the gate closes to an intermediate position that gives a discharge equal to the downstream demand, so that the downstream level once again coincides with the hinge axis dimension, reestablishing the assembly's equilibrium.

- If the water demands increase, the downstream level drops and the gate opens to a position that allows the reestablishment of the assembly's equilibrium. This equilibrium is reached whenever the corresponding water level is the height of the gate hinge axis.

Installation

In the installation, as shown in figures (in the following page), the float is located in a fixed chamber, shich communicates with the downstream water level through a horizontal slot, at the bottom, reducing the flow oscillations.

The gate leaf, in closed position, stops up the whole trapezoidal section of the channel in an AVIS® Gate design or the steel lining opening section in an AVIO® Gate design. The trapezoidal channel section enables the gate opening and closing operations to be smooth, without any contact and consequently without any friction between the moving gate and fixed parts of the channel.

Furthermore, to avoid any locking in the gate's closed position, there is a small gap between the side edges of the gate and the steel lining opening or of the channel. Due to this gap, there is a small leakage in the closed position of the gate.

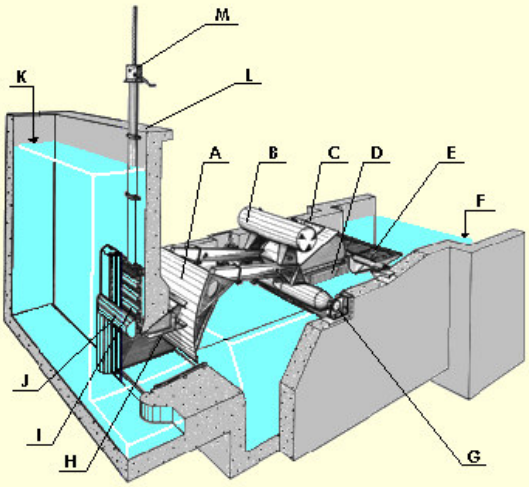
For this reason, if a low leakage is required when the gate is kept closed for long time, a maintenance gate in the upstream side, (mainly for AVIO® Gates) should be provided (a slide gate of fixed-wheel gate with hand or motor-operated hoist).

Construction

The gates are welded assemblies of steel plate, tubing and rolled shapes of carbon steel. They require precision sheet-metal work with controlled close tolerance margins so as to ensure correct operation without a hitch.

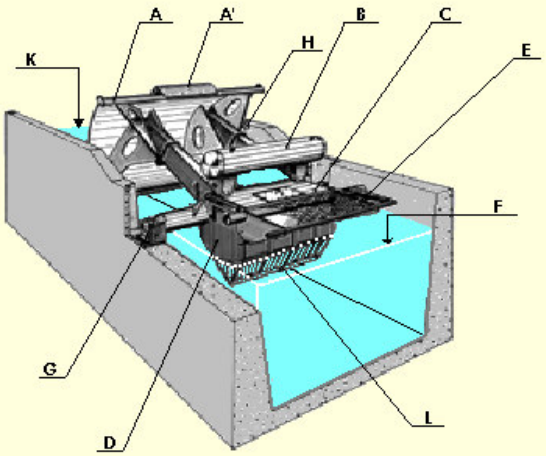
The gate construction elements, particularly the moving part, could be taken apart in order to facilitate the transport to the work site.

Typical lay-out of an AVIO® Gate



A Gate leaf
B Counterweight
C Float
D Float chamber
E Metal walkway (optional)
F Downstream water level
G Bearing
H Steel lining
I Maintenance gate
J Stream lined intake
K Upstream water level
L Control walkway
M Maintenance gate crank or motor-operated floor stand

Typical lay-out on an AVIS® Gate



A Gate leaf
A' Damping tank
B Counterweight
C Float
D Float chamber
E Metal walkway (optional)
F Downstream water level
G Bearing
H Embedded part
K Upstream water level
L Float-chamber communicating slot

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AVIO® GATE

Hydraulic characteristics

AVIO® Gates are defined by two dimensions:

- Outside float radius (r), in cm.
- Sluice cross-section area (S), in dm^2.

Gate selection

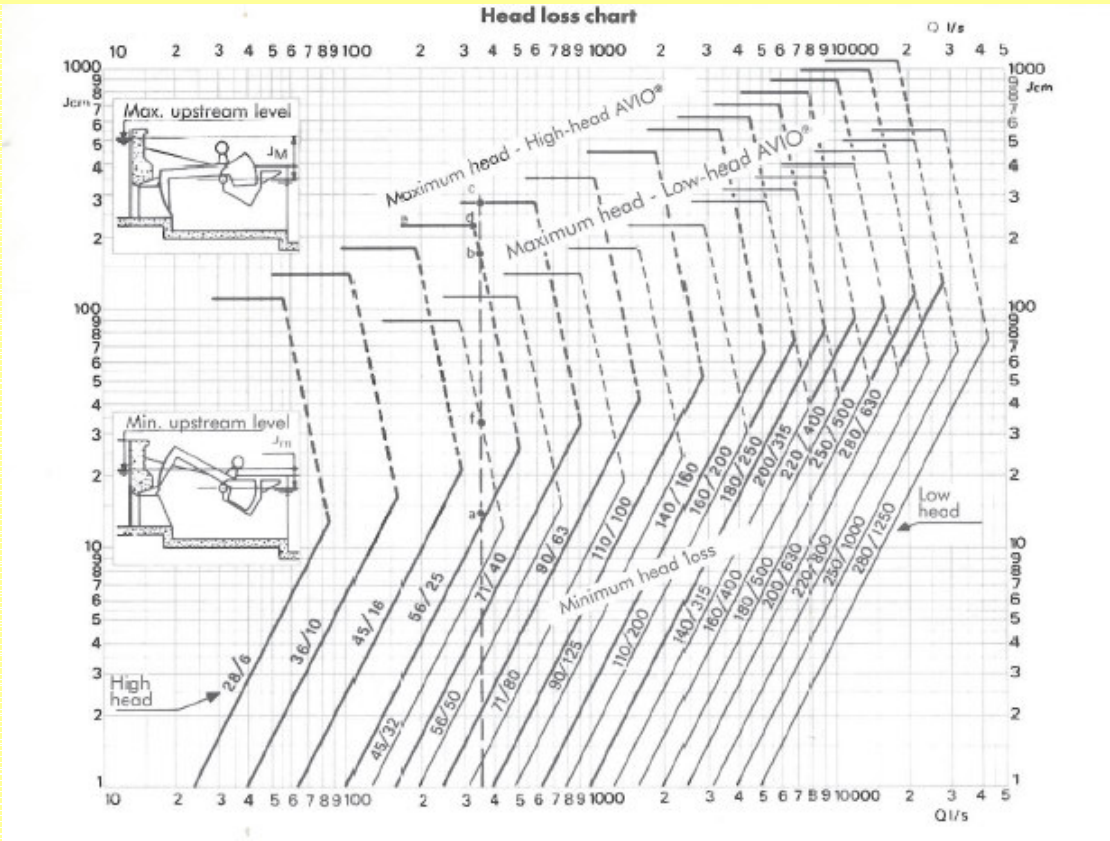
The data required to select the gate suitable for a given structure are:

- Maximum discharge Q_M [ℓ/s],
- Minimum head J_m (cm),
- Maximum head at zero discharge J_M [cm],
- Maximum head at maximum discharge J'_M [cm] (For reservoir intake $J'_M = J_M$).

Procedure

- The gate must be selected so that with maximum flow, the corresponding head loss does not exceed the available minimum head.
- The gate must withstand the maximum head at zero discharge.
- The maximum head at maximum discharge should be less than that shown on the head loss graph.
- The actual operating point should always lie below the corresponding broken line on the graph and never to the right of this line made up of three sections:

. Rising section, representing the gate head losses (flow-pressure relationship);
. A horizontal section, defining the maximum head that the gate is built to withstand;
. A falling section, represented by a broken line, which limits, the maximum head at maximum discharge, for the sake of stability.



Notes:

1 No operating points (Q, J) for gate should lie to the right of the broken line.

2 The ticker lines relate to the "high head" gates, while the thin lines relate to the "low head" (except for partial superposition for "high head" gates. For example, the head loss lines of the 110/220 gates (low head) and 160/200 gates (high head) are superposed until Jm 30cm).

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AVIS® GATES

Hydraulic characteristics:

AVIS® gates are defined by two dimensions:

- Outside float radius (r), in cm;
- Sluice width (b) at the sill height, in cm.

Gate selection:

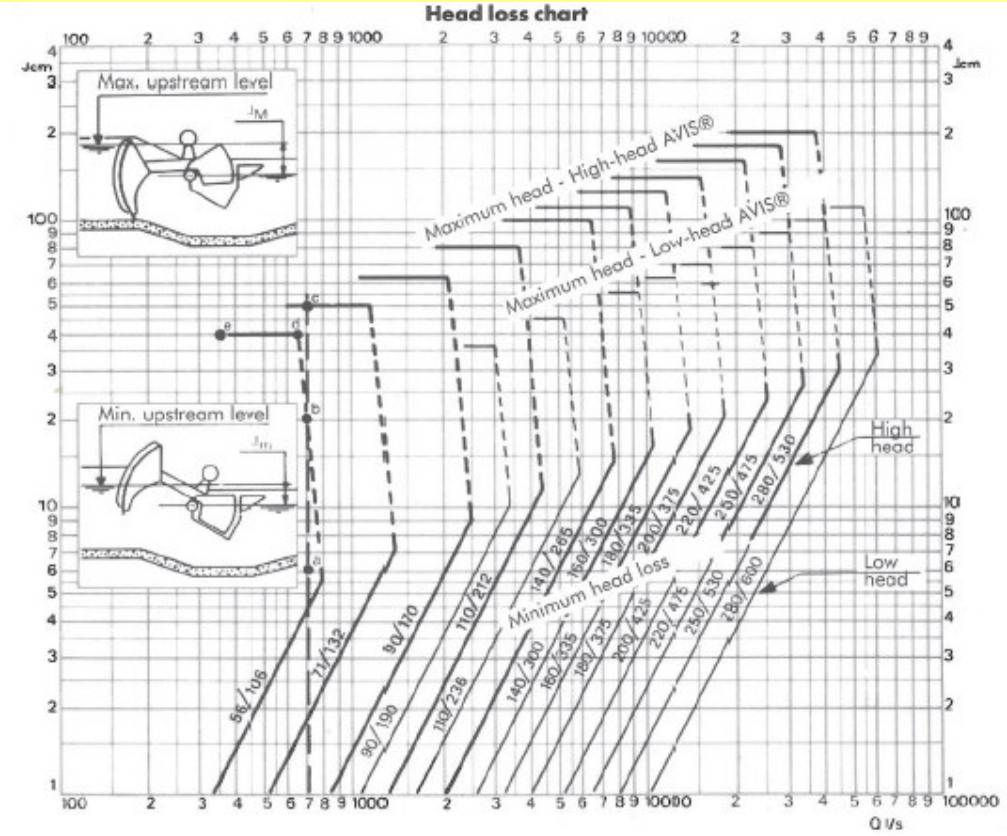
The data required to select the gate suitable for a given structure are:

- Maximum discharge Q_M [ℓ/s],
- Minimum head J_m (cm),
- Maximum head at zero discharge J_M [cm],
- Maximum head at maximum discharge J'_M [cm] (For reservoir intake $J'_M = J_M$).

Procedure

- The gate must be selected so that with maximum flow, the corresponding head loss does not exceed the available minimum head.
- The gate must withstand the maximum head at zero discharge.
- The maximum head at maximum discharge should be less than the head shown on that loss graph.
- The actual operating point should always lie below the corresponding bronken line on the graph and never to the right of this line made up of three sections:

. Rising section, representing the gate head losses (flow-pressure relationship);
. A horizontal section, defining the maximum head that the gate is dimensioned to withstand;
. A falling section, represented by a broken line, which limits, the maximum head at maximum discharge for the sake of stability.



Notes:

1 No operating points (Q, J) for a gate should lie to the right of the broken line.

2 The head losses given on the chart consider that the upstream and downstream channel sections are equal to the gate section. In case of a section restriction after the gate, we recommend considering lowering the corresponding level.

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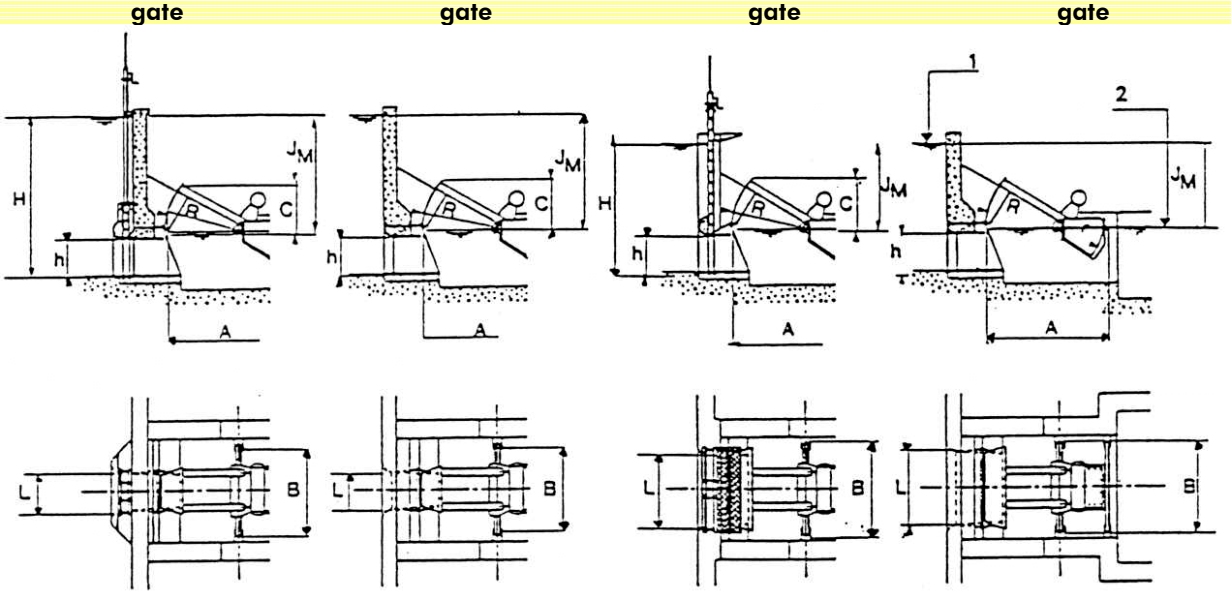
AVIO® Gate – Dimensions

AVIO® – High head (AQ) 28/6 to 90/63 | **AVIO® - Low head (BQ) 45/32 to 90/125**

With maintenance gate | Without maintenance gate | With maintenance gate | Without maintenance gate



1 – Maximum upstream level 2 – Controlled downstream level

The dimension H should be set during the design of civil works and indicated in the purchase specification.

Dimensions in cm

AVIO® r / s		Overall Dimensions					Max. Head	Size Opening		Maintenance gate			
High head	Low head	A	B	C	R	r	J_M	h	L	Type	Dimensions	(*)	Gate travel
28/6		90	70	35	50	28	112	25	25	VGSL	25 x 25	C	25
36/10		110	85	45	63	36	140	32	32	VGSL	32 x 32	C	32
45/16		140	103	55	80	45	180	40	40	VGSL	40 x 40	C	40
	45/32	140	103	55	80	45	90	40	80	VG	80 x 143	S	40
56/25		170	120	70	100	56	224	50	50	VG	50 x 50	C	50
	56/50	170	120	70	100	56	112	50	100	VG	100 x 178	S	50
71/40		210	160	90	125	71	280	63	63	VG	63 x 63	C	63
	71/80	210	160	90	125	71	140	63	125	VG	125 x 220	S	63
90/63		265	200	110	160	90	355	80	80	VG	80 x 80	C	80
	90/125	265	200	110	160	90	180	80	160	VG	160 x 280	S	80

(*) C : Gate for submerged opening
S : Channel free surface gate

VGSL Small opening slide gate
VG Slide gate
VW Fixed-wheel gate

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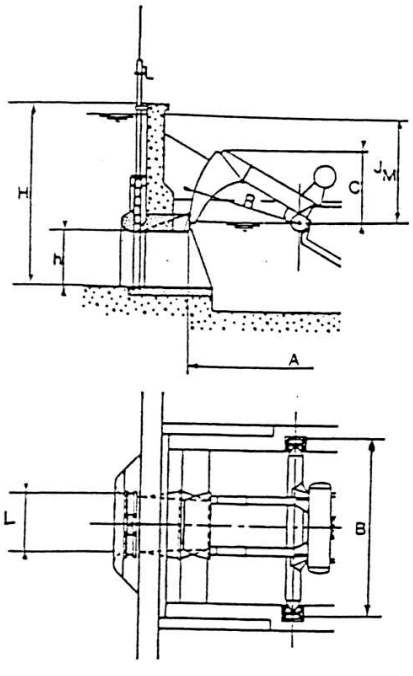
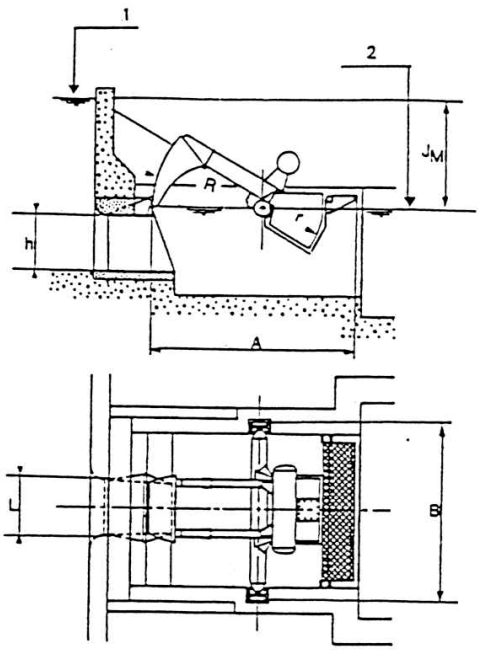
AVIO® Gate – Dimensions

High head and Low head AVIO® - 110/100 to 280/1250

With maintenance gate



Without maintenance gate



Dimensions in cm

AVIO® r / s		Overall Dimensions					Max. Head	Size Opening		Maintenance Gate			
High head	Low head	A	B	C	R	r	J_M	h	L	Type	Dimensions	(*)	Gate travel
110/100		390	320	140	200	110	450	100	100	VG	100 x 100	C	100
	110/200	390	320	140	200	110	224	100	200	VG	200 x 100	C	100
140/160		470	410	180	250	140	560	125	125	VG	125 x 125	C	125
	140/315	470	410	180	250	140	280	125	250	VG	250 x 125	C	125
160/200		520	450	200	280	160	630	140	140	VG	140 x 140	C	140
	160/400	520	450	200	280	160	315	140	280	VG	280 x 140	C	140
180/250		580	510	220	315	180	710	160	160	(**)	160 x 160	C	160
	180/500	580	510	220	315	180	355	160	315	VG	315 x 160	C	160
200/315		640	560	250	355	200	800	180	180	VW	180 x 180	C	180
	200/630	640	560	250	355	200	400	180	355	VW	355 x 180	C	180
220/400		710	635	280	400	220	900	200	200	VW	200 x 200	C	200
	220/800	710	635	280	400	220	450	200	400	VW	400 x 200	C	200
250/500		790	710	320	450	250	1000	220	220	VW	220 x 220	C	220
	250/1000	790	710	320	450	250	500	220	450	VW	450 x 220	C	220
280/630		870	800	350	500	280	1100	250	250	VW	250 x 250	C	250
	280/1250	870	800	350	500	280	560	250	500	VW	500 x 250	C	250

(*) C : Gate for submerged opening
S : Channel free water surface gate

(**) VG for J < 430 cm
VW for J ≥ 430 cm

VGSL Small opening slide gate
VG Slide gate
VW Fixed-sheel gate

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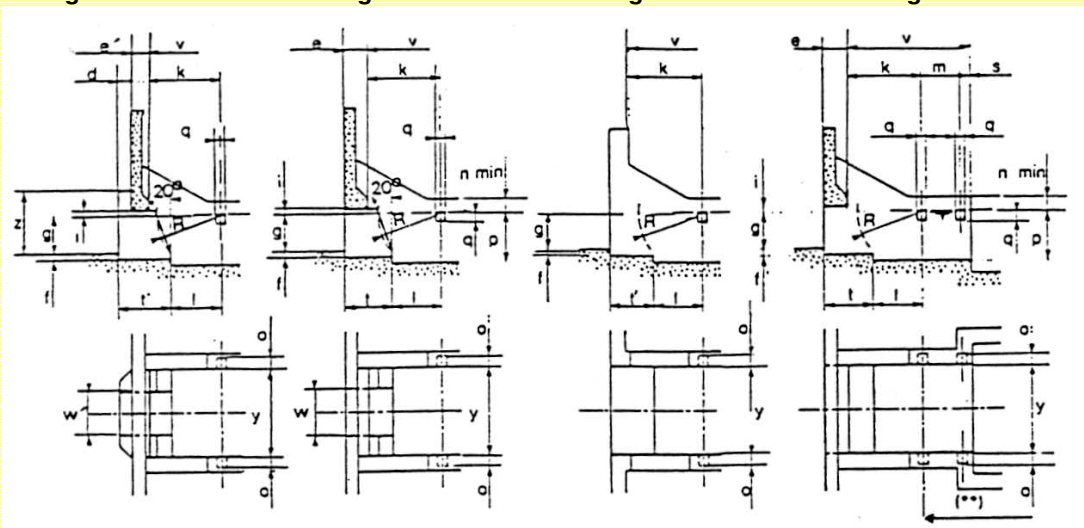
AVIO® Gate – Civil engineering structure

High head AVIO® 28/06 to 90/63 | **Low head AVIO® 45/32 to 90/125**

With maintenance gate | Withou maintenance gate | With maintenance gate | Without maintenance gate



Dimensions in cm

AVIO®		R	d (*)	e	e'	f (*)	g	i	k	l	m	n min.	o
High head	Low head												
28/6		50	17	21	15	8	30	3	58	39	32	14	10
36/10		63	17	28	20	8	37,5	4	75	49	40	17	13
45/16		80	17	37	27	8	47,5	5	93	63	50	20	16
	45/32	80	-	37	-	12	47,5	5	93	63	50	20	16
56/25		100	22	42	30	12	60	6	116	78	62	24	20
	56/50	100	-	42	-	12	60	6	116	78	62	24	20
71/40		125	22	51	35	12	75	8	145	96	78	28	26
	71/80	125	-	51	-	12	75	8	145	96	78	28	26
90/63		160	28	60	40	15	95	10	185	124	97	32	32
	90/125	160	-	60	-	15	95	10	185	124	97	32	32
110/100		200	28	75	50	15	118	14	232	157	120	40	35
	110/200	200	35	75	50	18	118	14	232	157	120	40	35
140/160		250	35	91	60	18	150	16	290	196	150	50	45
	140/315	250	40	91	60	22	150	16	290	196	150	50	45
160/200		280	40	105	70	22	170	18	325	217	173	56	50
	160/400	280	40	105	70	22	170	18	325	217	173	56	50
180/250		315	60	120	80	35	190	20	365	245	194	63	55
	180/500	315	40	120	80	22	190	20	365	245	194	63	55
200/315		355	75	135	90	35	212	22	411	278	214	71	60
	200/630	355	75	135	90	35	212	22	411	278	214	71	60
220/400		400	75	150	100	35	236	25	463	317	242	80	65
	220/800	400	75	150	100	35	236	25	463	317	242	80	65
250/500		450	75	165	110	35	265	28	521	355	271	90	70
	250/1000	450	75	165	110	35	265	28	521	355	271	90	70
280/630		500	85	182	120	40	300	32	580	390	300	100	75
	280/1250	500	85	182	120	40	300	32	580	390	300	100	75

(*) For fixed wheel gates, the froove sizes quoted provide an estimate of civil engineering structure, byt are not valid for the constructional design. A special studied drawing relative to the concrete shapes will be supplied for each order. On the other hand, the dimension W' represents the minimum width to install the emergency gate, while W allows easy installation of the AVIO® Gate steel lining.

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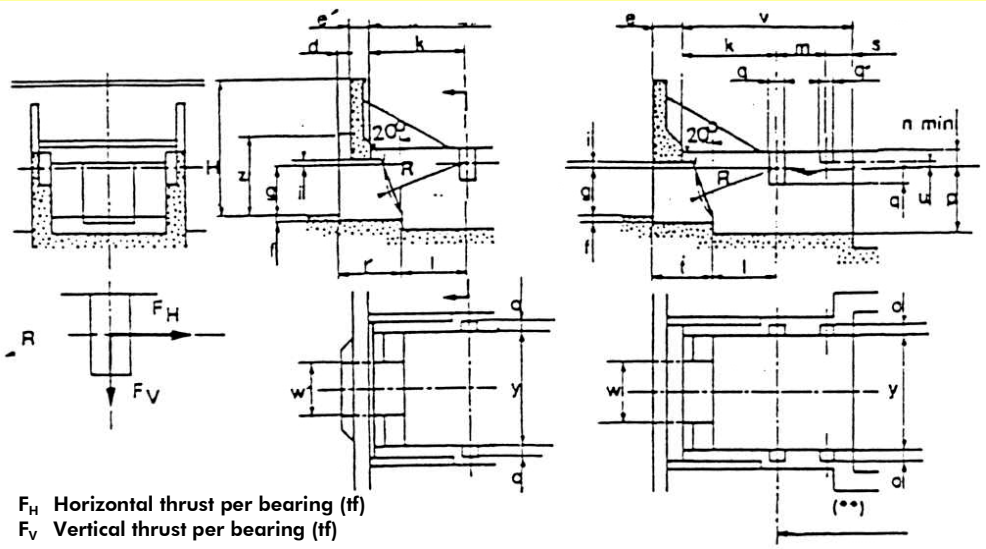
AVIO® Gate – Civil engineering structure

High head and low head AVIO® 110/100 to 280/1250



F_H Horizontal thrust per bearing (tf)
F_V Vertical thrust per bearing (tf)

With maintenance gate

Without maintenance gate

Dimensions in cm

AVIO®		p	q	q'	s	t	t'	u	v	w	w'	y	z	F_H	F_V
High head	Low head	min.									(*)		(***)		
28/6		40	10	-	10	40	51	-	100	37	41	70	41	0,1	0,1
36/10		50	12	-	12	54	63	-	127	48	48	90	48	0,15	0,1
45/16		65	15	-	15	67	74	-	158	60	56	110	56	0,2	0,2
	45/32	65	15	-	15	67	60	-	158	-	-	110	-	0,3	0,2
56/25		80	18	-	18	80	90	-	196	74	74	140	107	0,4	0,3
	56/50	80	18	-	18	80	71	-	196	-	-	140	-	0,6	0,3
71/40		100	20	-	20	100	106	-	243	95	87	180	132	0,8	0,4
	71/80	100	20	-	20	100	87	-	243	-	-	180	-	1	0,5
90/63		125	25	-	25	121	129	-	307	120	110	224	167	1,5	0,7
	90/125	125	25	-	25	121	108	-	307	-	-	224	-	2	1
110/100		160	40	40	80	150	153	0	432	150	130	280	207	3	1,5
	110/200	160	40	40	80	150	160	0	432	250	236	280	H	4	2
140/160		200	50	40	80	185	189	5	520	187	161	355	257	6	3
	140/315	200	50	40	80	185	194	5	520	312	294	355	H	7	4
160/200		224	50	40	80	213	218	10	578	210	184	400	287	9	4
	160/400	224	50	40	80	213	218	10	578	350	324	400	H	10	6
180/250		250	60	40	80	240	260	15	639	240	230	450	H	12	6
	180/500	250	60	40	80	240	240	15	639	395	359	450	H	14	7
200/315		280	70	40	80	268	298	20	705	270	250	500	H	17	7
	200/630	280	70	40	80	268	298	20	705	445	425	500	H	19	9
220/400		315	80	50	80	296	321	25	785	300	270	560	H	23	10
	220/800	315	80	50	80	296	321	25	785	500	470	560	H	26	12
250/500		355	90	50	80	331	351	30	872	330	290	630	H	32	14
	250/1000	355	90	50	80	331	351	30	872	560	520	630	H	36	17
280/630		400	100	50	80	372	395	35	960	374	330	710	H	45	21
	280/1250	400	100	50	80	372	395	35	960	624	580	710	H	50	24

(**) Identical layout for any arrangement.

(***) For high head AVIO® gates of 180/250 to 280/630 , including, and low head 110/200 to 280/1250 , including, dimension "Z" is equal to H (control walkway height, above the sill).

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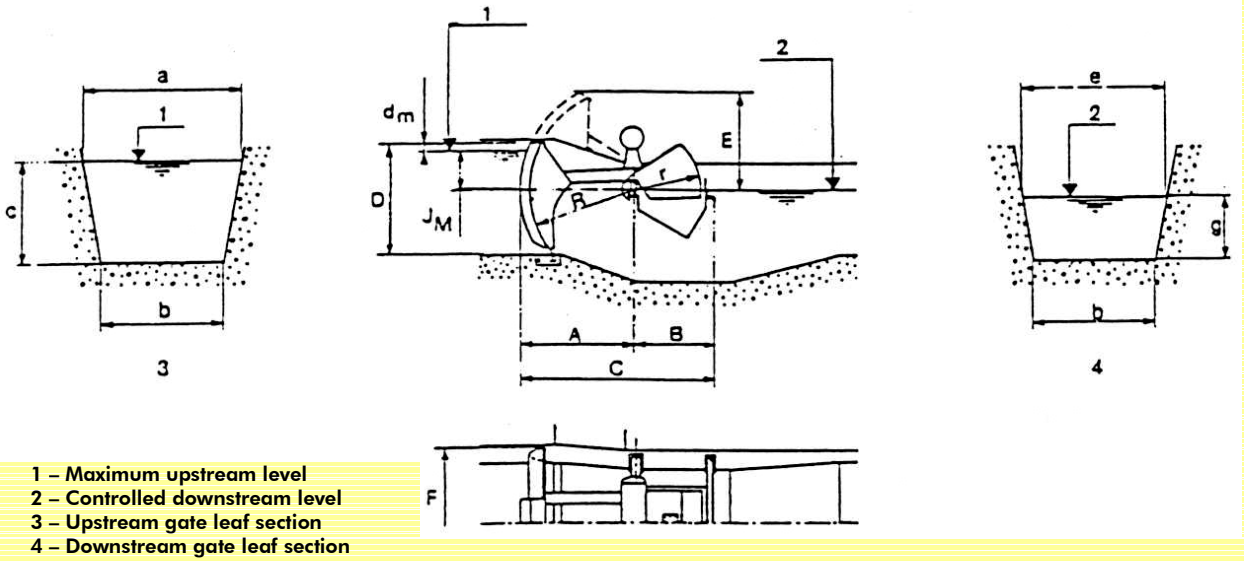
AVIS® Gate – Dimensions

AVIS® 56/106 to 90/190



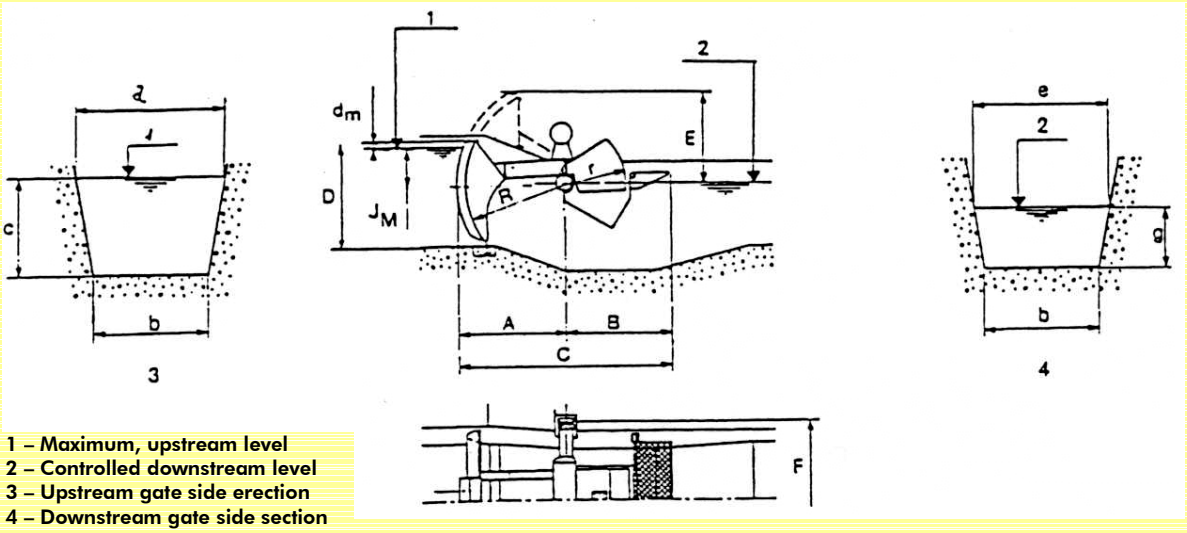
1 – Maximum upstream level
2 – Controlled downstream level
3 – Upstream gate leaf section
4 – Downstream gate leaf section

Dimensions in cm

AVIS® r/b		Overall Dimensions								Max. Head	Span Geometry		
High head	Low head	A	B	C	D	E	F	R	r	J_M	a	b	c
56/106		102	62	164	98	90	140	90	56	40	138,5	106	96
71/132		127	78	205	123,5	110	181	112	71	50	180	132	121
90/170		158	100	258	156	135	222	140	90	63	221	170	153
	90/190	180	100	280	138,5	130	237	160	90	35,5	236	190	135,5
110/212		202	190	392	196	175	286	180	110	80	277,5	212	192
	110/236	225	190	415	174	165	316	200	110	45	296	236	170
140/265		252	210	462	245	215	360	224	140	100	350,5	265	240
	140/300	282	210	492	221	205	400	250	140	56	374,5	300	216
160/300		282	233	515	275,5	240	402	250	160	110	393	300	270
	160/335	315	233	548	248,5	230	447	280	160	63	422,5	335	243
180/335		315	254	569	311	270	455	280	180	125	445	335	305
	180/375	355	254	609	276	260	505	315	180	70	476,5	375	270
200/375		355	274	629	347	300	507	315	200	140	502,5	375	340
	200/425	400	274	674	311	290	557	355	200	80	527	425	304
220/425		400	302	702	392	340	571	355	220	160	553,5	425	384
	220/475	450	302	752	348	325	631	400	220	90	590,5	475	340
250/475		450	331	781	439	380	634	400	250	180	621,5	475	430
	250/530	500	331	831	389	365	704	450	250	100	666	530	380
280/530		500	360	860	490	430	713	450	280	200	701,5	530	480
	280/600	565	360	925	435	405	793	500	280	110	748,5	600	425

AVIS® Gate – Dimensions

AVIS® 110/212 to 280/600



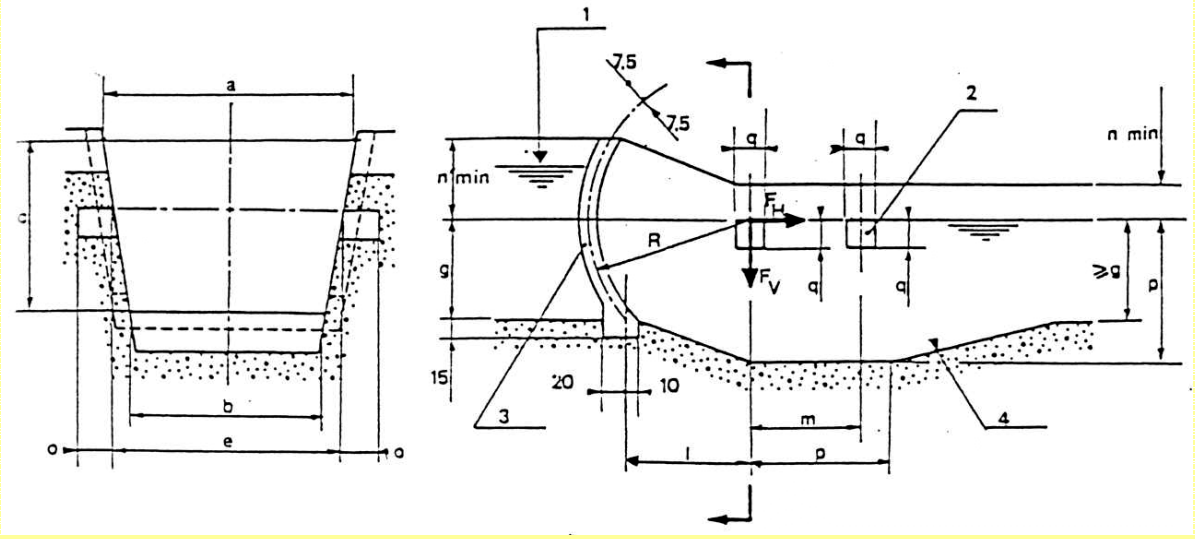
1 – Maximum, upstream level
2 – Controlled downstream level
3 – Upstream gate side erection
4 – Downstream gate side section

Dimensions in cm and section in dm^2

AVIS® r/b		Max. Head	Min. Free Board	Downstream side free section			
High Head	Low Head	J_M	d_m	b	e	g	Section
56/106		40	2	106	125	56	65
71/132		50	2,5	132	160	71	104
90/170		63	3	170	200	90	167
	90/190	35,5	3	190	224	100	207
110/212		80	4	212	250	112	269
	110/236	45	4	236	280	125	322
140/265		100	5	265	315	140	406
	140/300	56	5	300	355	160	524
160/300		110	5,5	300	355	160	524
	160/335	63	5,5	335	400	180	662
180/335		125	6	335	400	180	662
	180/375	70	6	375	450	200	825
200/375		140	7	375	450	200	825
	200/425	80	7	425	500	224	1035
220/425		180	8	425	500	224	1035
	220/475	90	8	475	560	250	1295
250/475		180	9	475	560	250	1295
	250/530	100	9	530	630	280	1625
280/530		200	10	530	630	280	1625
	280/600	110	10	600	710	315	2065

AVIS® Gate – Civil engineering structure

AVIS® 56/106 to 90/190



1 – Maximum upstream level
2 – Bearing groove depth "O"
3 – Groove depth : 15cm
4 – Maximum slope : 25%

Dimensions in cm

AVIS®		Span geometry			R	e	g	l	m	n mín.
High head	Low head	a	b	c						
56/106		138,5	106	96	90	125	56	70,5	62	24
71/132		180	132	121	112	160	71	86	78	28
90/170		221	170	153	140	200	90	107	97	32
	90/190	236	190	135,5	160	224	100	125	97	22
110/212		277,5	212	192	180	250	112	141	120	40
	110/236	296	236	170	200	280	125	156	120	25
140/265		350,5	265	240	224	315	140	175	150	50
	140/300	374,5	300	216	250	355	160	192	150	32
160/300		393	300	270	250	355	160	192	173	56
	160/335	422,5	335	243	280	400	180	215	173	36
180/335		445	335	305	280	400	180	215	194	63
	180/375	476,5	375	270	315	450	200	243	194	40
200/375		502,5	375	340	315	450	200	243	214	71
	200/425	527	425	304	355	500	224	275	214	45
220/425		553,5	425	384	355	500	224	275	242	80
	220/475	590,5	475	340	400	560	250	313	242	50
250/475		621,5	475	430	400	560	250	313	271	90
	250/530	666	530	380	450	630	280	353	271	56
280/530		701,5	530	480	450	630	280	353	300	100
	280/600	748,5	600	425	500	710	315	388	300	63

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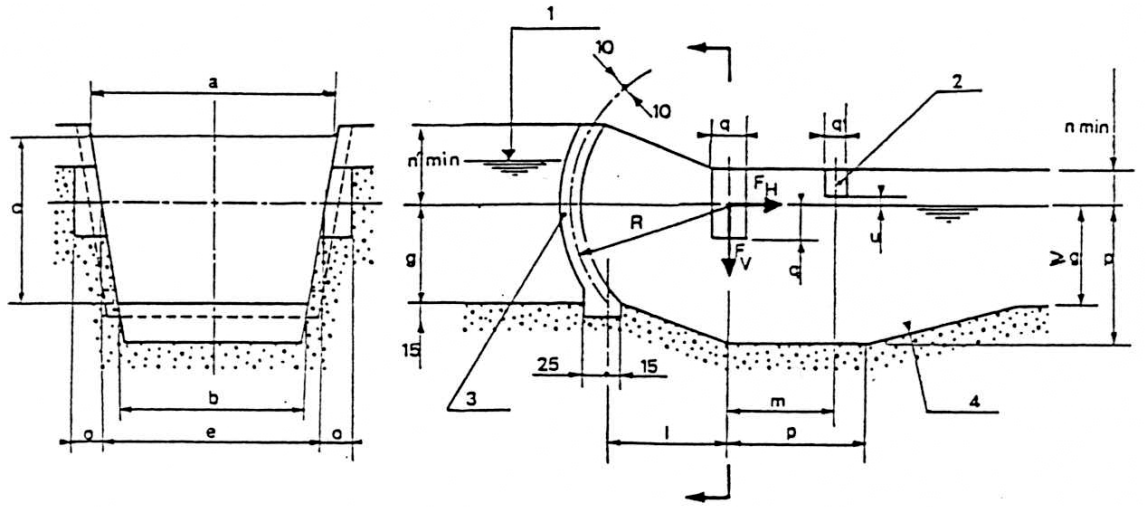
AVIS® Gate – Civil Engineering Structure

AVIS® 110/212 to 280/600



1 – Maximum upstream level
2 – Bearing groove depth "O"
3 – Groove depth : 15cm
4 – Max. slope : 25%

F_H Horizontal thrust per bearing(tf)
F_V Vertical thrust per bearing (tf)

Dimensions in cm

AVIS®		n' mím.	o	p	q	q'	u	F_H	F_V
High head	Low head								
56/106		45	20	80	18	-	-	0,5	0,5
71/132		56	26	100	20	-	-	1	0,7
90/170		71	32	125	25	-	-	2	1,5
	90/190	40	32	125	25	-	-	1,5	1,5
110/212		90	35	160	40	40	0	3	3
	110/236	50	35	160	40	40	0	2,5	3
140/265		110	45	200	50	40	5	5	4
	140/300	63	45	200	50	40	5	4,5	4
160/300		125	50	224	50	40	10	7,5	6
	160/335	71	50	224	50	40	10	6,5	6
180/335		140	55	250	60	40	15	10	8
	180/375	80	55	250	60	40	15	9	8
200/375		160	60	280	70	40	20	14	10
	220/425	90	60	280	70	40	20	13	10
220/425		180	65	315	80	50	25	20	14
	220/475	100	65	315	80	50	25	18	15
250/475		200	70	355	90	50	30	30	19
	250/530	110	70	355	90	50	30	25	21
280/530		220	75	400	100	50	35	40	26
	280/600	125	75	400	100	50	35	35	29

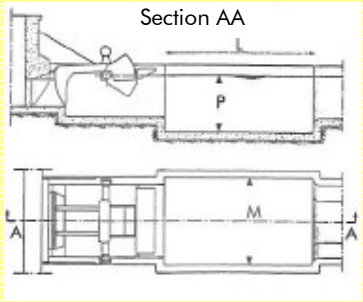
(*) The "n' min" level represents the minimum height of the channel free bank required for proper installation of the fixed parts.

Recommendations

Stilling basin

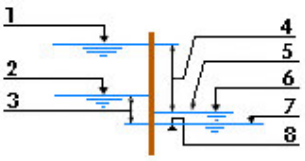
In order to reduce the work costs, facilitate their use and assure the protection of the channel banks when these are not lined, employing a stilling basin downstream from the AVIO® gates is recommended.

The basin volume, as shown in the following figure, can be calculated by the formula:
$V = L \times M \times P = 21{,}2\ Q_M\ (J_M)^{1/2}$
where L, M and P are the length, width and depth of the basin in meters, respectively. The recommended proportions of these dimensions are the following: $L \approx 3M \approx 4{,}5P$ provided that the dimensions M and P are respectively greater than the dimensions y and P_{min} as shown in the respective table (Civil Engineering Structures) and $L \approx (13{,}5V)^{1/3}$.



Level setting - decrement

For the implementation of AVIO® and AVIS® gates, the key characteristic of maintaining the downstream water level at the level of the hinge axis should be assured. The sketch in the figure below shows the water levels, at limit operating regimes, in relation to the gate hinge axis level.



1 – Max. water level for Q = 0
2 – Min. water level for Q = max.
3 – Minimum head = head losses of the gate.
4 – Maximum head.
5 – Gate hinge axis.
6 – Downstream water level corresponding to Q = 0
7 – Downstream water level corresponding to Q = máx.
8 - Decrement (level 6 – level 7)

The channel banks safe height must be at least 1/10 of the depth of the water and must be respectively increased in sections exposed to wind.

The decrement (difference between the corresponding downstream levels at Q= 0 and $Q_{max.}$) can be adjusted within certain limits, by ballast, during the balance adjusting operation at the work site. Its practical value is r/20 (r= float radius).

In certain cases, when it is necessary to provide greater operation stability, the decrement value may be increased, but without exceeding r/10.

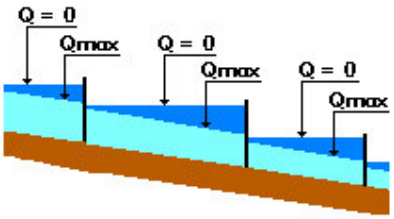
Operating reserves (stability)

The water reserves are formed of the wedges among the waterlines corresponding to Q=0 and Q = max. (shaded area of figure below). In a channel, equipped with a number of automatic in-series gates, the stability of the whole must be kept in mind, checking that the water volume of each wedge (depending on the distance (L) between two in-series gates) is greater or equal to: (Q x T)/2; where Q= Maximum discharge; T= go and return time of the waves in a certain reach:

$$T = \frac{L}{\sqrt{gh} + V} + \frac{L}{\sqrt{gh} - V}$$

where
h = (Channel section) / (Width at water level) [m]

V= (Discharge) / (Section) [m^3/s]



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