13.17.08 RBC FLUME

OPERATING INSTRUCTIONS

Contents

1. Introduction..1
2. The flumes of Eijkelkamp Agrisearch Equipment..1
3. Principles of discharge-measuring flumes...2
4. Selection and location of the flume..3
5. Measurements using the flume...4
6. Maintenance and measuring problems...5

Appendices

Appendix 1: References...5
Appendix 2: RBC Flume 13.17.08 Data..6
Appendix 3: Explanation of program output for computed rating table..........7
Appendix 4-5: data from computer program FLUME......................................8
Appendix 4: Rating table RBC flume 13.17.08..8
Appendix 5: Discharge graph...14

1. Introduction

For the management of irrigation systems it is important that the quantity of water flowing through canals can be measured accurately. In the field of irrigation this is called discharge (flow rate). Discharge is the amount of water flowing through a canal at a certain place at a certain time. The flow rate is usually expressed in litres per second or cubic meters per hour.

The flow rate data are used for the design and monitoring of irrigation canals. This allows for the design of an efficient water distribution system in which a surplus or waste of water is avoided as much as possible. The flow rate is measured frequently in particular at canal splitting or separation structures. At section level it is important to know the flow rate in order to determine whether the crop receives sufficient water.
These operating instructions give brief information on how to use the RBC flume. For detailed information on flumes is referred to literature as listed in appendix 1.

2. The flumes of Eijkelkamp Agrisearch Equipment

Flumes are designed in different types and sizes. Eijkelkamp Agrisearch Equipment offers a trapezium shaped RBC (Clemmens et al. 1984) flume for four flow rate ranges (0.16 - 9.0; 0.93 - 50; 1.55 - 86 and 2.0 - 145 l/s). Compared to the WSC and the Parshall flumes the RBC flume is the most accurate. Compared to other shapes, the trapezium shaped flumes have two more important advantages:
- ❒ Accurate for a wide range of flow rates;
- ❒ Fits better in canals which often are trapezium shaped by design (more reliable flow pattern upstream of the flume and inside the flume).

The RBC flumes are designed mainly for use in furrows or other small earthen canals. All flumes can be equipped with a data logger and a pressure sensor.
This allows for automatic measuring (or activation), storage and reading.

P.O. Box 4, 6987 ZG Giesbeek, the Netherlands
T +31 313 88 02 00
F +31 313 88 02 99
E info@eijkelkamp.com
I www.eijkelkamp.com

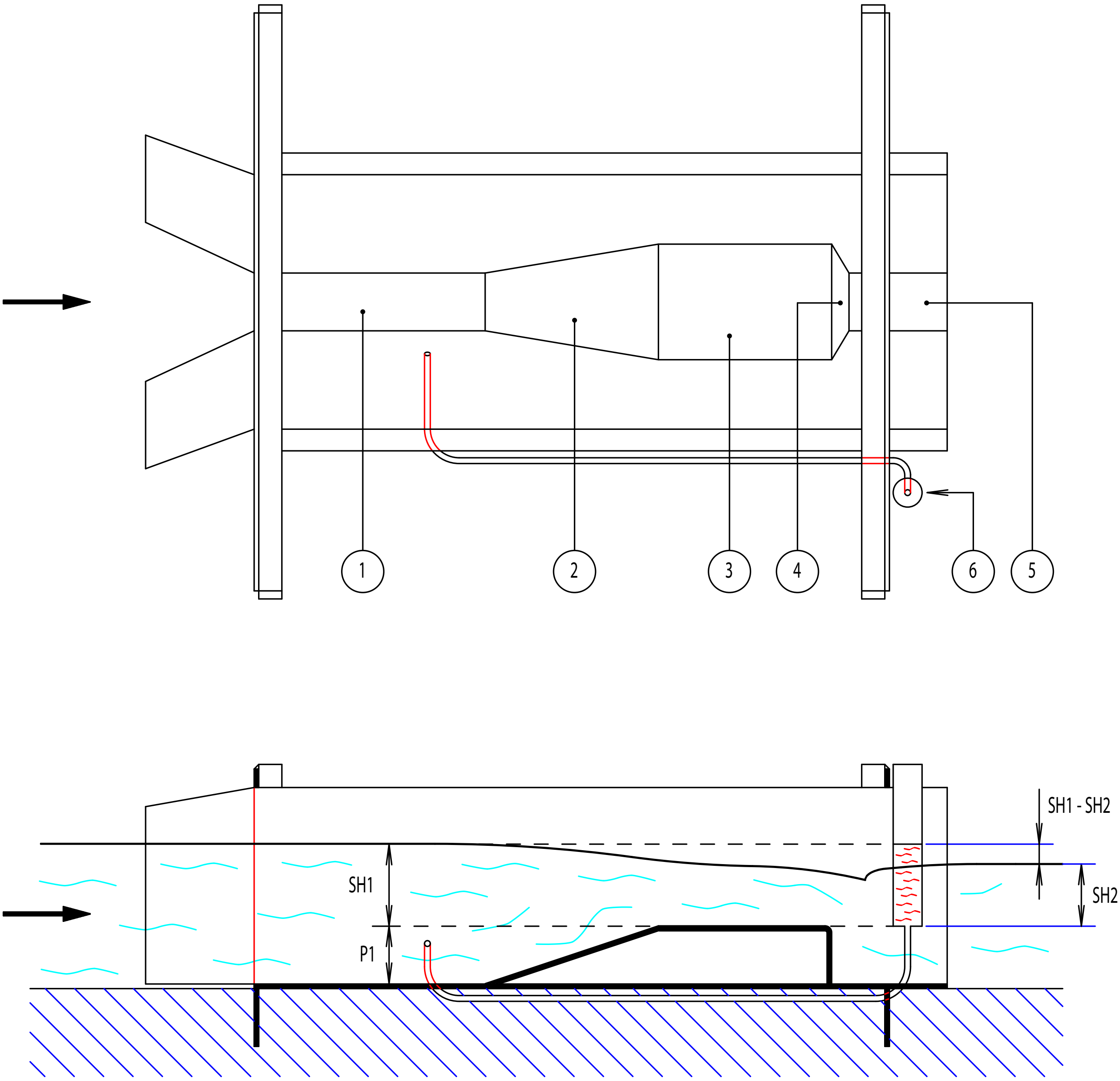


Fig. 1. Top view (above) and side view of the flow profile in the RBC flume.

3. Principles of discharge-measuring flumes

For field measurement of the flow rate in small, usually earthen, irrigation canals, discharge-measuring flumes can be applied. Discharge-measuring flumes for small canals usually are compact and easy to use and transport.

A discharge-measuring flume is illustrated in figure 1 and consists of:

1. Approach section.
2. A converging section in which the speed of the water increases.
3. A throat section, a sill where the speed is increased further.
4. The throat section discharges into a diverging outlet where the flow rate is reduced to its original value. The Eijkelkamp flume has an abrupt transition: the diverging section has a length of 0 cm.
5. A tail water section where the water level is controlled by flow downstream.
6. A measuring tube (stilling well).

In figure 1, the mechanism of a discharge-measuring flume is illustrated:
Water enters the approach section of the flume (1) as indicated by the arrow. The converging section (2) causes an increase of the flow rate in the flume. This flow rate is further increased in the throat section (3). The diverging section (4) of the Eijkelkamp flume has a length of 0 cm, so the water drops immediately to its original value.
The increase of the flow rate causes a reduction of the water level in the tail water section (5), and results in a drop in water stage (SH1 - SH2) inside of the flume. By constructing a flume in this way, the theoretical preconditions are realised allowing the flow rate to be determined by only measuring the water level (SH1) in the flume.
The water level is measured using a stilling well, which has its inlet upstream of the flume. The measured water level is referenced to the sill level (P1).

The sill-referenced water level is converted to discharge or flow rate, using tables or graphs.
The relation between water level SH1 and flow rate (specific to the 13.17.08 Eijkelkamp RBC flume) is given in appendices 4 and 5.
Data in this table and graph are determined using the computer program FLUME (1993), which is developed for assisting in the design and calibration of flumes. For instance, FLUME gives information on the required head loss needed to create optimal measuring conditions.
It can also be used for predicting the flow rate through the flume.
An explanation of the output parameters of the FLUME software is given in appendix 3.

If an automated flume is used, and data are already stored in (spreadsheet importable) files, it is much more convenient to calculate the flow rate in stead of using tables or graphs.

Based on the regression line of the graph in appendix 5, the following equation is used for the
13.17.08 Eijkelkamp flume
(formula for the operating range SH = 46 (Q = 5.212) till SH = 311 (Q = 145.344):

$$Q = 0.0000004 \cdot (SH1)^3 + 0.0011 \cdot (SH1)^2 + 0.1358 \cdot (SH1) - \sqrt{(SH1)} + 3.488$$

With Q (discharge) in litres per second
and SH1 (sill referenced water level) in millimeter.

4. Selection and location of the flume

Selection

Before starting discharge measurements the best type of flume for the chosen application has to be selected.
Usually, from a point of view of economy as well as accuracy, the smallest possible type of flume is selected for the flow rate measurement in a canal. As a general rule this is a flume with a top width of approximately 1/3 or ½ times the width of the canal. As no flow rate measurements are possible without a water-level head, a flume must be used which allows the passage of the 'estimated' flow and which provides the required sill-referenced head. The following table can be used as an indication of the discharge capacity of the flume and the required sill-referenced head.

flume type (art. no)	minimum flow (l/s)	maximum flow (l/s)	required head (SH1 - SH2) (mm)
13.17.02	0.16	9.0	20
13.17.04	0.93	50.0	40
13.17.06	1.55	86.0	50
13.17.08	2.00	145.0	60

In addition of the type of flume, also the type of data registration has to be selected: manually versus automatically.
In case of an automated flume, the sill-referenced water level is recorded using a very accurate pressure sensor connected to a data logger.
Advantages of automatic registration over a manual determination of the flow rate are:

- ❐ Maximum and minimum values are recorded in relation to time, from which the response rate of the discharge can be deduced.
- ❐ Average discharge rates as well as the cumulative discharge are accurately determined by continuous recording.
- ❐ Automatically recording flow rates is less time consuming and is very convenient in remote areas.
- ❐ High flow rates during rain periods can selectively be recorded.

Location

The flume is placed in the centre of the flow with the stilling well located at the end of the tail water section. The supply flow should preferably be straight and without any head over a substantial distance (a distance of 10 times the average channel width).

The channel bed in the approach section to a certain extend must not be porous because:

a. all the water must flow through the flume in order to obtain reliable measurements.
b. the flume can be undercut and will subside by erosion.

Erosion of the supply channels must be limited in order to prevent pollution or blockage of the flume. The flume must be installed level in vertical as well as in horizontal direction in order to avoid that the flow profile (and thus the measurements) is influenced. If the flume is not installed level in the longitudinal direction then this can easily yield a measuring error of 3%. The vertical direction yields a less important error (approximately 0.5%). Placing the flume upright in the vertical direction of flow of the water can be realised by holding the upstream side of the flume parallel to the water surface. In the longitudinal direction a level can be used.

Both sides of the flume must be sealed (filled up with earth) to prevent water from flowing along side of it. The effluent water must be able to run off unobstructedly and should not hinder the influent water. The flume should not be placed at a depth at which it disappears under the water level (submerged condition). Installing the flume too shallow is not a real problem as the water will soon accumulate in front of the flume (damming up) and an equilibrium water level will soon establish itself.

In case of an automated flume, the pressure sensor protrudes from under the flume. This should be taken into account when installing the flume in order to avoid damaging the sensor. The complete stilling well can be demounted as to facilitate installation. The data logger is placed on a separate mounting base which allows to read the data logger without having to stand in the canal.

5. Measurements using the flume

After the flume is placed into the canal, the conditions as described in chapter 4 are met and the water level in the flume has become in equilibrium with the new situation, discharge measurements can be started. As already described, using the Eijkelkamp RBC flume, only the sill-referenced water level has to be measured to determine discharge.

The water level in the approach section of a flume can be measured in several ways:

- ❐ Graduation fitted on the side of the approach section.
- ❐ Level measurement via surface level measurement (for instance ultrasonic).
- ❐ Level measurement applying a stilling well.

In the Eijkelkamp RBC flumes, the stilling well is used for measuring the water level without the need to measure inside the flume itself and disturbing the level in the process (wave action caused by current and wind). The still also dampens water level fluctuations caused by longitudinal flowing water in the flume. The passage towards the stilling well is provided in the wall of the approach section under the sill height. In order to avoid blocking by debris or sediment, the opening is located slightly raised from the bottom of the flume.
After the water level has been measured in the stilling well and referenced to the sill height, the discharge is determined, either by using the table in appendix 4, the discharge graph in appendix 5 or the formula in chapter 3.

The frequency of measurements, or the time interval between successive measurements, completely depends on the user wished application of the flume.
If one wants to make a continuous registration of the discharge rate of a natural stream, it is important to carry out measurements at the same points of time, as to minimise the effect of natural daily discharge fluctuations.
If one wants to determine maximum discharge rates after heavy rainfall, the frequency of measurements will be low during dry periods, but very high during splash rains.

6. Maintenance and measuring problems

Inside the flume and the stilling well pollution in the form of sediment, waste, algal growth, weeds etc. may accumulate in time. For this reason the flume and in particular the stilling well and the supply must be checked for pollution frequently. In case of blockage of the supply towards the measuring opening this line can be blown through. In case of measuring problems with the automated flume the pressure sensor should be handled with care. The sensor can only sustain limited over pressure. By slackening the lower ring of the stilling well the sensor can be demounted for cleaning.

To prevent damage of the sensor this must be removed when temperature drops below zero.

If the flume is not working properly, or if there is any doubt regarding the flow profile or the installation, the necessary flow profile can be obtained by raising the entire flow a small amount. Or if that is not feasible, the same result may be obtained by lowering and cleaning the canal for a short distance downstream so that the water may flow freely away below the flume.

Appendix 1: References

Bos, M.G. (editor). 1989. Discharge Measurement Structures . Third revised version. ILRI Publication no. 20. The Netherlands.

Bos, M.G. and J.A. Replogle. 1984. Flow Measuring Flumes for Open Channel Systems. A Wiley-Intersience Publication. John Wiley & Sons. New York.

Bos, M.G. (editor). 1976. Discharge Measurement Structures. Published in co-operation with ILRI and Wageningen Agricultural University, Department of Hydraulics and Irrigation. Publication no. 161.

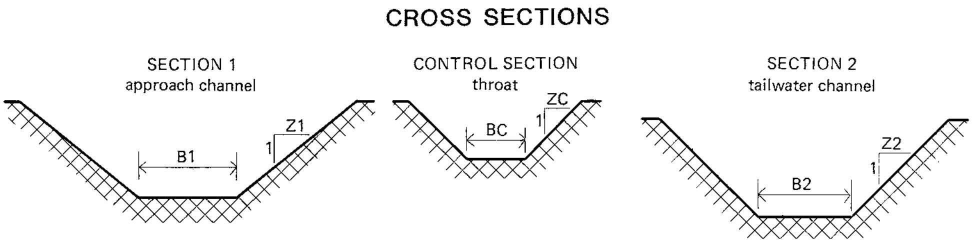
Clemmens, A.J., M.J. Bos and J.A. Replogle. 1993. FLUME Design and Calibration of Long-Throated Measuring Flumes. Version 3. ILRI Publication no. 54. The Netherlands. Including 1 HD disk.

Eijkelkamp. Operating Instructions 13.17.10.06 Flume Software.

Withers, B. and S. Vipont. 1988. Irrigation: Design and Practice. BT Batsford Limited. Londen.

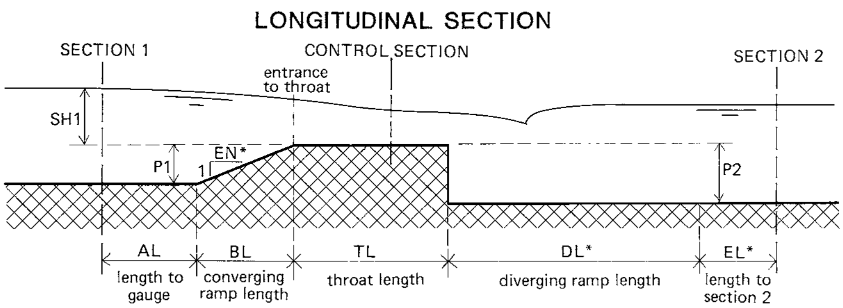
Appendix 2: RBC Flume 13.17.08 Data

Cross section data:



Approach channel, simple trapezoid:	Bottom width	B1	=	.150 m
	Side slope	Z1	=	.500 : 1
Throath section, simple trapezoid:	Bottom width	BC	=	.300 m
	Side slope	ZC	=	.500 : 1
Tailwater channel, simple trapezoid:	Bottom width	B2	=	.150 m
	Side slope	Z2	=	.500 : 1

Longitudinal section data:



SH1	=	Sill-referenced head		
AL	=	Distance between converging ramp and gauging station	=	0.150 m
BL	=	Converging ramp length	=	0.474 m
TL	=	Throath length	=	0.450 m
P1	=	Sill height relative to approach channel	=	0.150 m
P2	=	Sill height relative to tail water channel	=	0.150 m
EN*	=	Converging transition ratio (hor./vert.)	=	3.000:1
DL*	=	Diverging ramp length	=	0
EL*	=	Length to section 2	=	3.125 m
SH2	=	Sill-referenced head in tail water section		
SH1-SH2=		Head loss		
RK	=	Absolute roughness height of material	=	0.0001 m

An * indicates that these data are not specified by the user

Appendix 3: Explanation of program output for computed rating table

Column	Value	Description
1	SH1 = h_1	The sill-referenced head. This is the head measured at the gauging station for determining discharge.
2	Q	The predicted flow rate for the given h_1.
3*	FR1 = Fr_1	The Froude number of the flow in the approach channel. This value should be less than 0.5 in all cases and less than 0.45 when the approach conditions are not totally smooth.
4	H1/TL = H_1/L	The ratio of energy head to throath length. The head, h_1, over which rating can be reliably computed is limited to $0.075 < H_1/L < 0.75$
5	CD = C_d	Discharge coefficient, the ratio between actual and ideal flow.
6	CV = C_v	The velocity coefficient which is computed for reference purposes only. It is the ratio between flow based on energy head, H_1, and water depth h_1
7	DH = DH	This is the required energy loss across the flume, $H_2 - H_1$. This may differ from the required difference in water levels, $Dh = h_2 - h_1$
8	Y2 = y_2	This is the maximum flow depth in the tail water channel for which there is no influence of this depth on the Q - h_1 relationship, $y_2 = h_2 + p_2$
9	ML	This is the modular limit defined in terms of the ratio of downstream to upstream energy heads, H_2/H_1, at the limit between modular and nonmodular flow. Modular flow exists when the Q - h_1 relationship is not affected by the flow in the tail water channel.

* = the Froude number F1 at the gauging station is defined as:

$$Fr_1 = \frac{v_1}{\sqrt{(gA_1/B_1)}}$$

with:

v_1 = the average flow velocity at the gauging station
g = the acceleration due to gravity
A_1 = the cross sectional area perpendicular to the flow
B_1 = the water surface width at the gauging station.

The Froud number gives an indication for the expected turbulence. When there is a rapid change in depth of flow from a low to a high stage, the water level will rise abruptly, creating a hydraulic jump, visible through its turbulence. The higher the Froud number, the higher the turbulence.
To obtain a relatively smooth water surface for which the elevation can be determined accurately, the Froud number should not exceed 0.5.

For channels with high sediment loads, the Froude number should be kept high in order to prevent sedimentation.

APPENDIX 4-5 DATA FROM COMPUTER PROGRAM FLUME

Appendix 4: Rating table RBC flume 13.17.08

SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI MM	Q LIT/SEC	FR1	H1/TL	CD	CV	DH MM	Y2 MM	
25.0	1.946	.042	.056	.9291	1.007	7.9	166.9	.685
26.0	2.074	.044	.058	.9319	1.008	8.1	167.7	.689
27.0	2.204	.046	.060	.9345	1.008	8.3	168.5	.693
28.0	2.337	.049	.063	.9369	1.009	8.5	169.3	.696
29.0	2.474	.051	.065	.9391	1.009	8.7	170.1	.700
30.0	2.613	.053	.067	.9412	1.010	8.9	170.9	.704
31.0	2.755	.056	.069	.9432	1.011	9.1	171.7	.707
32.0	2.900	.058	.072	.9450	1.011	9.3	172.5	.711
33.0	3.047	.060	.074	.9467	1.012	9.5	173.3	.714
34.0	3.198	.063	.076	.9482	1.012	9.7	174.1	.717
35.0	3.351	.065	.078	.9498	1.013	9.9	174.9	.720
36.0	3.506	.068	.081	.9512	1.014	10.0	175.8	.724
37.0	3.665	.070	.083	.9526	1.014	10.2	176.6	.727
38.0	3.826	.072	.085	.9538	1.015	10.4	177.4	.730
39.0	3.990	.075	.088	.9550	1.016	10.5	178.3	.733
40.0	4.157	.077	.090	.9561	1.016	10.7	179.1	.736
41.0	4.326	.079	.092	.9572	1.017	10.8	180.0	.739
42.0	4.498	.082	.094	.9582	1.018	11.0	180.8	.741
43.0	4.672	.084	.097	.9591	1.018	11.1	181.6	.744
44.0	4.849	.087	.099	.9601	1.019	11.3	182.5	.747
45.0	5.029	.089	.101	.9609	1.020	11.4	183.4	.750
46.0	5.212	.091	.104	.9616	1.021	11.5	184.2	.752
47.0	5.397	.094	.106	.9624	1.021	11.7	185.1	.755
48.0	5.584	.096	.108	.9632	1.022	11.8	185.9	.757
49.0	5.774	.098	.110	.9640	1.023	11.9	186.8	.760
50.0	5.967	.101	.113	.9647	1.024	12.1	187.7	.762
51.0	6.162	.103	.115	.9654	1.024	12.2	188.5	.765
52.0	6.360	.106	.117	.9660	1.025	12.3	189.4	.767
53.0	6.560	.108	.120	.9667	1.026	12.4	190.3	.770
54.0	6.763	.110	.122	.9673	1.027	12.5	191.2	.772
55.0	6.969	.113	.124	.9678	1.027	12.6	192.1	.774
56.0	7.177	.115	.127	.9686	1.028	12.8	192.9	.776
57.0	7.387	.117	.129	.9691	1.029	12.9	193.8	.779
58.0	7.600	.120	.131	.9696	1.030	13.0	194.7	.781
59.0	7.816	.122	.134	.9701	1.030	13.1	195.6	.783
60.0	8.034	.124	.136	.9706	1.031	13.2	196.5	.785
61.0	8.255	.127	.138	.9710	1.032	13.3	197.4	.787
62.0	8.478	.129	.141	.9715	1.033	13.4	198.3	.789
63.0	8.703	.131	.143	.9719	1.034	13.5	199.2	.791
64.0	8.932	.133	.145	.9722	1.034	13.5	200.1	.793
65.0	9.162	.136	.148	.9726	1.035	13.6	201.0	.795
66.0	9.396	.138	.150	.9730	1.036	13.7	201.9	.797
67.0	9.631	.140	.152	.9734	1.037	13.8	202.8	.799
68.0	9.869	.142	.155	.9739	1.038	13.9	203.7	.800
69.0	10.110	.145	.157	.9743	1.039	14.0	204.6	.802

SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI	**Q**	**FR1**	**H1/TL**	**CD**	**CV**	**DH**	**Y2**	
MM	**LIT/SEC**					**MM**	**MM**	
70.0	10.353	.147	.159	.9745	1.039	14.1	205.5	.804
71.0	10.599	.149	.162	.9750	1.040	14.1	206.4	.806
72.0	10.847	.151	.164	.9752	1.041	14.2	207.3	.808
73.0	11.098	.154	.166	.9755	1.042	14.3	208.2	.809
74.0	11.351	.156	.169	.9759	1.043	14.4	209.1	.811
75.0	11.607	.158	.171	.9763	1.043	14.4	210.1	.813
76.0	11.865	.160	.174	.9766	1.044	14.5	211.0	.814
77.0	12.126	.163	.176	.9769	1.045	14.6	211.9	.816
78.0	12.389	.165	.178	.9772	1.046	14.7	212.8	.817
79.0	12.654	.167	.181	.9774	1.047	14.7	213.7	.819
80.0	12.923	.169	.183	.9777	1.048	14.8	214.7	.821
81.0	13.193	.171	.185	.9780	1.048	14.9	215.6	.822
82.0	13.467	.173	.188	.9783	1.049	14.9	216.5	.824
83.0	13.742	.176	.190	.9785	1.050	15.0	217.4	.825
84.0	14.020	.178	.193	.9788	1.051	15.0	218.3	.826
85.0	14.301	.180	.195	.9790	1.052	15.1	219.3	.828
86.0	14.584	.182	.197	.9793	1.053	15.2	220.2	.829
87.0	14.870	.184	.200	.9795	1.053	15.2	221.1	.831
88.0	15.158	.186	.202	.9798	1.054	15.3	222.1	.832
89.0	15.449	.188	.205	.9800	1.055	15.3	223.0	.834
90.0	15.742	.190	.207	.9802	1.056	15.4	223.9	.835
91.0	16.037	.192	.209	.9804	1.057	15.4	224.9	.836
92.0	16.336	.194	.212	.9806	1.058	15.5	225.8	.838
93.0	16.636	.197	.214	.9808	1.059	15.5	226.7	.839
94.0	16.939	.199	.217	.9811	1.059	15.6	227.7	.840
95.0	17.245	.201	.219	.9813	1.060	15.6	228.6	.841
96.0	17.553	.203	.221	.9815	1.061	15.7	229.5	.843
97.0	17.864	.205	.224	.9816	1.062	15.7	230.5	.844
98.0	18.177	.207	.226	.9818	1.063	15.8	231.4	.845
99.0	18.493	.209	.229	.9820	1.064	15.8	232.4	.846
100.0	18.811	.211	.231	.9822	1.064	15.9	233.3	.847
101.0	19.132	.213	.233	.9824	1.065	15.9	234.2	.849
102.0	19.455	.215	.236	.9826	1.066	15.9	235.2	.850
103.0	19.781	.217	.238	.9827	1.067	16.0	236.1	.851
104.0	20.109	.219	.241	.9829	1.068	16.0	237.1	.852
105.0	20.440	.221	.243	.9831	1.069	16.1	238.0	.853
106.0	20.773	.223	.246	.9832	1.069	16.1	239.0	.854
107.0	21.109	.225	.248	.9834	1.070	16.1	239.9	.855
108.0	21.448	.227	.250	.9836	1.071	16.2	240.9	.856
109.0	21.789	.228	.253	.9837	1.072	16.2	241.8	.858
110.0	22.132	.230	.255	.9839	1.073	16.2	242.8	.859
111.0	22.478	.232	.258	.9840	1.074	16.3	243.7	.860
112.0	22.826	.234	.260	.9842	1.075	16.3	244.7	.861
113.0	23.177	.236	.263	.9843	1.075	16.4	245.7	.862
114.0	23.531	.238	.265	.9845	1.076	16.4	246.6	.863
115.0	23.887	.240	.268	.9846	1.077	16.4	247.6	.864
116.0	24.246	.242	.270	.9848	1.078	16.5	248.5	.865
117.0	24.607	.244	.272	.9849	1.079	16.5	249.4	.866
118.0	24.971	.246	.275	.9850	1.080	16.5	250.4	.867

SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI	Q	FR1	H1/TL	CD	CV	DH	Y2	
MM	LIT/SEC					MM	MM	
119.0	25.337	.247	.277	.9852	1.080	16.5	251.3	.868
120.0	25.702	.249	.280	.9852	1.081	16.6	252.2	.868
121.0	26.074	.251	.282	.9853	1.082	16.6	253.2	.869
122.0	26.448	.253	.285	.9854	1.083	16.6	254.1	.870
123.0	26.824	.255	.287	.9856	1.084	16.6	255.0	.871
124.0	27.203	.256	.290	.9857	1.085	16.7	256.1	.872
125.0	27.585	.258	.292	.9858	1.085	16.7	257.0	.873
126.0	27.969	.260	.295	.9860	1.086	16.7	258.0	.874
127.0	28.355	.262	.297	.9861	1.087	16.8	259.0	.875
128.0	28.749	.264	.300	.9863	1.088	16.8	259.9	.876
129.0	29.141	.266	.302	.9865	1.089	16.8	260.9	.876
130.0	29.495	.267	.304	.9852	1.089	16.8	261.9	.877
131.0	29.890	.269	.307	.9853	1.090	16.8	262.8	.878
132.0	30.287	.270	.309	.9854	1.091	16.9	263.8	.879
133.0	30.687	.272	.312	.9854	1.092	16.9	264.7	.880
134.0	31.090	.274	.314	.9855	1.093	16.9	265.7	.880
135.0	31.495	.276	.317	.9856	1.093	16.9	266.6	.881
136.0	31.903	.277	.319	.9856	1.094	17.0	267.6	.882
137.0	32.313	.279	.322	.9857	1.095	17.0	268.6	.883
138.0	32.726	.281	.324	.9858	1.096	17.0	269.5	.883
139.0	33.141	.282	.327	.9858	1.097	17.0	270.5	.884
140.0	33.559	.284	.329	.9859	1.097	17.0	271.4	.885
141.0	33.980	.286	.332	.9859	1.098	17.1	272.4	.886
142.0	34.403	.287	.334	.9860	1.099	17.1	273.3	.886
143.0	34.829	.289	.337	.9861	1.100	17.1	274.3	.887
144.0	35.257	.291	.339	.9861	1.101	17.1	275.3	.888
145.0	35.688	.292	.342	.9862	1.102	17.2	276.2	.888
146.0	36.121	.294	.344	.9862	1.102	17.2	277.2	.889
147.0	36.557	.296	.347	.9863	1.103	17.2	278.1	.890
148.0	36.996	.297	.349	.9864	1.104	17.2	279.1	.890
149.0	37.438	.299	.352	.9864	1.105	17.2	280.1	.891
150.0	37.882	.301	.354	.9865	1.106	17.3	281.0	.892
151.0	38.328	.302	.357	.9866	1.106	17.3	282.0	.892
152.0	38.777	.304	.359	.9866	1.107	17.3	282.9	.893
153.0	39.229	.305	.362	.9865	1.108	17.3	283.9	.894
154.0	39.684	.307	.364	.9866	1.109	17.3	284.9	.894
155.0	40.141	.309	.367	.9867	1.110	17.3	285.8	.895
156.0	40.600	.310	.369	.9867	1.110	17.4	286.8	.896
157.0	41.063	.312	.372	.9868	1.111	17.4	287.7	.896
158.0	41.527	.313	.374	.9869	1.112	17.4	288.7	.897
159.0	41.995	.315	.377	.9869	1.113	17.4	289.7	.897
160.0	42.465	.316	.379	.9870	1.113	17.4	290.6	.898
161.0	42.938	.318	.382	.9871	1.114	17.4	291.6	.899
162.0	43.413	.319	.384	.9871	1.115	17.5	292.5	.899
163.0	43.891	.321	.387	.9872	1.116	17.5	293.5	.900
164.0	44.372	.322	.389	.9873	1.117	17.5	294.5	.900
165.0	44.856	.324	.392	.9873	1.117	17.5	295.4	.901
166.0	45.342	.326	.394	.9874	1.118	17.5	296.4	.901
167.0	45.830	.327	.397	.9875	1.119	17.5	297.4	.902

SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI	Q	FR1	H1/TL	CD	CV	DH	Y2	
MM	LIT/SEC					MM	MM	
168.0	46.322	.329	.400	.9875	1.120	17.5	298.3	.902
169.0	46.816	.330	.402	.9876	1.120	17.5	299.3	.903
170.0	47.312	.332	.405	.9876	1.121	17.6	300.2	.904
171.0	47.811	.333	.407	.9877	1.122	17.6	301.2	.904
172.0	48.313	.334	.410	.9878	1.123	17.6	302.2	.905
173.0	48.818	.336	.412	.9878	1.124	17.6	303.1	.905
174.0	49.325	.337	.415	.9879	1.124	17.6	304.1	.906
175.0	49.835	.339	.417	.9880	1.125	17.6	305.1	.906
176.0	50.348	.340	.420	.9880	1.126	17.6	306.0	.907
177.0	50.863	.342	.422	.9881	1.127	17.6	307.0	.907
178.0	51.381	.343	.425	.9881	1.127	17.6	308.0	.908
179.0	51.902	.345	.427	.9882	1.128	17.7	308.9	.908
180.0	52.425	.346	.430	.9883	1.129	17.7	309.9	.909
181.0	52.952	.347	.433	.9883	1.130	17.7	310.8	.909
182.0	53.480	.349	.435	.9884	1.130	17.7	311.8	.910
183.0	54.012	.350	.438	.9884	1.131	17.7	312.8	.910
184.0	54.546	.352	.440	.9885	1.132	17.7	313.7	.911
185.0	55.083	.353	.443	.9886	1.133	17.7	314.7	.911
186.0	55.622	.355	.445	.9886	1.133	17.7	315.7	.912
187.0	56.165	.356	.448	.9887	1.134	17.7	316.6	.912
188.0	56.710	.357	.450	.9887	1.135	17.7	317.6	.913
189.0	57.257	.359	.453	.9888	1.136	17.7	318.6	.913
190.0	57.808	.360	.455	.9888	1.137	17.8	319.7	.913
191.0	58.361	.361	.458	.9889	1.137	17.8	320.7	.914
192.0	58.917	.363	.461	.9890	1.138	17.8	321.6	.914
193.0	59.476	.364	.463	.9890	1.139	17.8	322.6	.915
194.0	60.037	.366	.466	.9891	1.139	17.8	323.6	.915
195.0	60.601	.367	.468	.9893	1.140	17.8	324.6	.915
196.0	61.168	.368	.471	.9893	1.141	17.8	325.5	.916
197.0	61.737	.370	.473	.9894	1.142	17.8	326.5	.916
198.0	62.309	.371	.476	.9894	1.142	17.8	327.5	.917
199.0	62.884	.372	.479	.9894	1.143	17.8	328.4	.917
200.0	63.462	.374	.481	.9895	1.144	17.8	329.4	.918
201.0	64.043	.375	.484	.9895	1.145	17.8	330.4	.918
202.0	64.626	.376	.486	.9896	1.145	17.9	331.4	.918
203.0	65.212	.377	.489	.9896	1.146	17.9	332.3	.919
204.0	65.800	.379	.491	.9896	1.147	17.9	333.3	.919
205.0	66.392	.380	.494	.9897	1.148	17.9	334.3	.920
206.0	66.986	.381	.497	.9897	1.148	17.9	335.2	.920
207.0	67.583	.383	.499	.9898	1.149	17.9	336.2	.920
208.0	68.183	.384	.502	.9898	1.150	17.9	337.2	.921
209.0	68.786	.385	.504	.9899	1.151	17.9	338.2	.921
210.0	69.391	.386	.507	.9899	1.151	17.9	339.1	.922
211.0	70.000	.388	.509	.9900	1.152	17.9	340.1	.922
212.0	70.610	.389	.512	.9900	1.153	17.9	341.1	.922
213.0	71.224	.390	.515	.9901	1.153	17.9	342.1	.923
214.0	71.841	.391	.517	.9901	1.154	17.9	343.0	.923
215.0	72.448	.393	.520	.9900	1.155	17.9	344.0	.923
216.0	73.070	.394	.522	.9901	1.156	17.9	345.0	.924

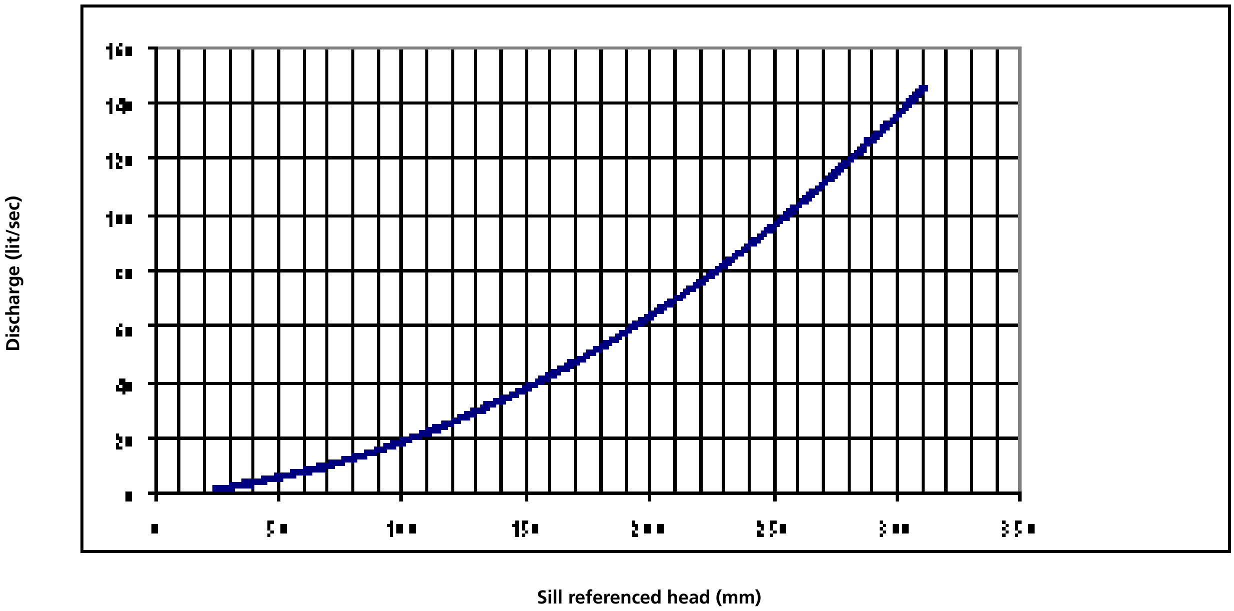
SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI	Q	FR1	H1/TL	CD	CV	DH	Y2	
MM	LIT/SEC					MM	MM	
217.0	73.695	.395	.525	.9901	1.156	17.9	346.0	.924
218.0	74.322	.396	.528	.9902	1.157	17.9	346.9	.924
219.0	74.953	.398	.530	.9902	1.158	17.9	347.9	.925
220.0	75.586	.399	.533	.9903	1.158	17.9	348.9	.925
221.0	76.222	.400	.535	.9903	1.159	17.9	349.9	.926
222.0	76.861	.401	.538	.9904	1.160	17.9	350.8	.926
223.0	77.502	.402	.540	.9904	1.160	17.9	351.8	.926
224.0	78.147	.404	.543	.9905	1.161	17.9	352.8	.927
225.0	78.794	.405	.546	.9905	1.162	17.9	353.7	.927
226.0	79.444	.406	.548	.9906	1.163	18.0	354.7	.927
227.0	80.097	.407	.551	.9907	1.163	18.0	355.7	.928
228.0	80.753	.408	.553	.9907	1.164	18.0	356.7	.928
229.0	81.412	.410	.556	.9908	1.165	18.0	357.6	.928
230.0	82.073	.411	.559	.9908	1.165	18.0	358.6	.929
231.0	82.738	.412	.561	.9909	1.166	18.0	359.6	.929
232.0	83.405	.413	.564	.9910	1.167	18.0	360.6	.929
233.0	84.075	.414	.566	.9910	1.167	18.0	361.5	.930
234.0	84.747	.416	.569	.9909	1.168	18.0	362.5	.930
235.0	85.423	.417	.572	.9912	1.169	18.0	363.5	.930
236.0	86.102	.418	.574	.9912	1.170	18.0	364.5	.930
237.0	86.783	.419	.577	.9913	1.170	18.0	365.5	.931
238.0	87.467	.420	.579	.9913	1.171	18.0	366.4	.931
239.0	88.155	.421	.582	.9914	1.172	18.0	367.4	.931
240.0	88.845	.422	.585	.9915	1.172	18.0	368.4	.932
241.0	89.537	.424	.587	.9915	1.173	18.0	369.4	.932
242.0	90.233	.425	.590	.9916	1.174	18.0	370.3	.932
243.0	90.932	.426	.593	.9917	1.174	18.0	371.3	.933
244.0	91.633	.427	.595	.9918	1.175	18.0	372.3	.933
245.0	92.338	.428	.598	.9918	1.176	18.0	373.3	.933
246.0	93.045	.429	.600	.9919	1.176	18.0	374.2	.933
247.0	93.755	.430	.603	.9918	1.177	18.0	375.2	.934
248.0	94.468	.431	.606	.9918	1.178	18.0	376.2	.934
249.0	95.184	.432	.608	.9919	1.178	18.0	377.2	.934
250.0	95.902	.434	.611	.9920	1.179	18.0	378.1	.935
251.0	96.624	.435	.613	.9920	1.180	18.0	379.1	.935
252.0	97.349	.436	.616	.9921	1.180	18.0	380.1	.935
253.0	98.076	.437	.619	.9921	1.181	18.0	381.1	.935
254.0	98.807	.438	.621	.9922	1.182	18.0	382.0	.936
255.0	99.540	.439	.624	.9922	1.182	18.0	383.0	.936
256.0	100.276	.440	.627	.9923	1.183	18.0	384.0	.936
257.0	101.015	.441	.629	.9923	1.184	18.0	385.0	.937
258.0	101.757	.442	.632	.9924	1.184	18.0	385.9	.937
259.0	102.502	.443	.634	.9924	1.185	18.0	386.9	.937
260.0	103.250	.444	.637	.9925	1.186	18.0	387.9	.937
261.0	104.001	.445	.640	.9926	1.186	18.0	388.9	.938
262.0	104.755	.446	.642	.9926	1.187	18.0	389.8	.938
263.0	105.511	.447	.645	.9927	1.188	18.0	390.8	.938
264.0	106.271	.449	.648	.9927	1.188	18.0	391.8	.938
265.0	107.034	.450	.650	.9928	1.189	18.0	392.8	.939

SILL REFER. HEAD	FLOW RATE	FROUDE NO.		DISH. COEFF.	VELOC. COEFF.	REQ'D HEAD LOSS	MAX. T-WATER DEPTH	MODULAR LIMIT
SHI MM	Q LIT/SEC	FR1	H1/TL	CD	CV	DH MM	Y2 MM	
266.0	107.799	.451	.653	.9928	1.190	18.0	393.7	.939
267.0	108.568	.452	.655	.9929	1.190	18.0	394.7	.939
268.0	109.339	.453	.658	.9930	1.191	18.0	395.7	.939
269.0	110.114	.454	.661	.9930	1.192	18.0	396.7	.940
270.0	110.891	.455	.663	.9931	1.192	17.9	397.7	.940
271.0	111.671	.456	.666	.9931	1.193	17.9	398.6	.940
272.0	112.454	.457	.669	.9932	1.194	17.9	399.6	.940
273.0	113.241	.458	.671	.9932	1.194	17.9	400.6	.941
274.0	114.030	.459	.674	.9933	1.195	17.9	401.6	.941
275.0	114.822	.460	.677	.9933	1.196	17.9	402.5	.941
276.0	115.617	.461	.679	.9934	1.196	17.9	403.5	.941
277.0	116.415	.462	.682	.9935	1.197	17.9	404.5	.942
278.0	117.216	.463	.684	.9935	1.198	17.9	405.5	.942
279.0	118.020	.464	.687	.9936	1.198	17.9	406.4	.942
280.0	118.828	.465	.690	.9936	1.199	17.9	407.4	.942
281.0	119.638	.466	.692	.9937	1.199	17.9	408.4	.942
282.0	120.451	.467	.695	.9938	1.200	17.9	409.4	.943
283.0	121.267	.468	.698	.9938	1.201	18.0	410.6	.943
284.0	122.086	.469	.700	.9939	1.201	18.0	411.6	.943
285.0	122.908	.470	.703	.9939	1.202	18.0	412.6	.943
286.0	123.733	.471	.706	.9940	1.203	18.0	413.6	.943
287.0	124.561	.472	.708	.9940	1.203	18.0	414.5	.944
288.0	125.391	.473	.711	.9939	1.204	17.9	415.5	.944
289.0	126.226	.473	.714	.9940	1.205	17.9	416.5	.944
290.0	127.063	.474	.716	.9940	1.205	17.9	417.5	.944
291.0	127.903	.475	.719	.9941	1.206	17.9	418.5	.945
292.0	128.746	.476	.722	.9941	1.206	17.9	419.5	.945
293.0	129.592	.477	.724	.9942	1.207	17.9	420.4	.945
294.0	130.441	.478	.727	.9942	1.208	17.9	421.4	.945
295.0	131.293	.479	.729	.9943	1.208	17.9	422.4	.945
296.0	132.149	.480	.732	.9943	1.209	17.9	423.4	.946
297.0	133.007	.481	.735	.9944	1.210	17.9	424.4	.946
298.0	133.868	.482	.737	.9945	1.210	17.9	425.3	.946
299.0	134.733	.483	.740	.9945	1.211	17.9	426.3	.946
300.0	135.600	.484	.743	.9946	1.211	17.9	427.3	.946
301.0	136.470	.485	.745	.9946	1.212	17.9	428.3	.947
302.0	137.344	.486	.748	.9947	1.213	17.9	429.3	.947
303.0	138.221	.487	.751	.9947	1.213	17.9	430.3	.947
304.0	139.100	.488	.753	.9948	1.214	17.9	431.2	.947
305.0	139.983	.488	.756	.9948	1.214	17.9	432.2	.947
306.0	140.869	.489	.759	.9949	1.215	17.9	433.2	.948
307.0	141.758	.490	.761	.9949	1.216	17.9	434.2	.948
308.0	142.649	.491	.764	.9950	1.216	17.9	435.2	.948
309.0	143.544	.492	.767	.9950	1.217	17.9	436.1	.948
310.0	144.442	.493	.769	.9951	1.217	17.9	437.1	.948
311.0	145.344	.494	.772	.9951	1.218	17.9	438.1	.949

Appendix 5: Discharge graph

Discharge graph RBC flume 13.17.08

(formula for the operating range SH = 46 (Q = 5.212) till SH = 311 (Q = 145.344):
$Q = 0.0000004 \cdot (SH1)^3 + 0.0011 \cdot (SH1)^2 + 0.1358 \cdot (SH1) - \sqrt{(SH1)} + 3.488$



Technical data can be amended without prior notification.

Eijkelkamp Agrisearch Equipment is not responsible for (personal damage due to (improper) use of the product.

Eijkelkamp Agrisearch Equipment is interested in your reactions and remarks about its products and operating instructions.