

Experiment Instructions

HM 160.31 Broad Crested Weir

G.U.N.T. Gerätebau GmbH

P.O. Box 1125

D-22881 Barsbüttel • Germany

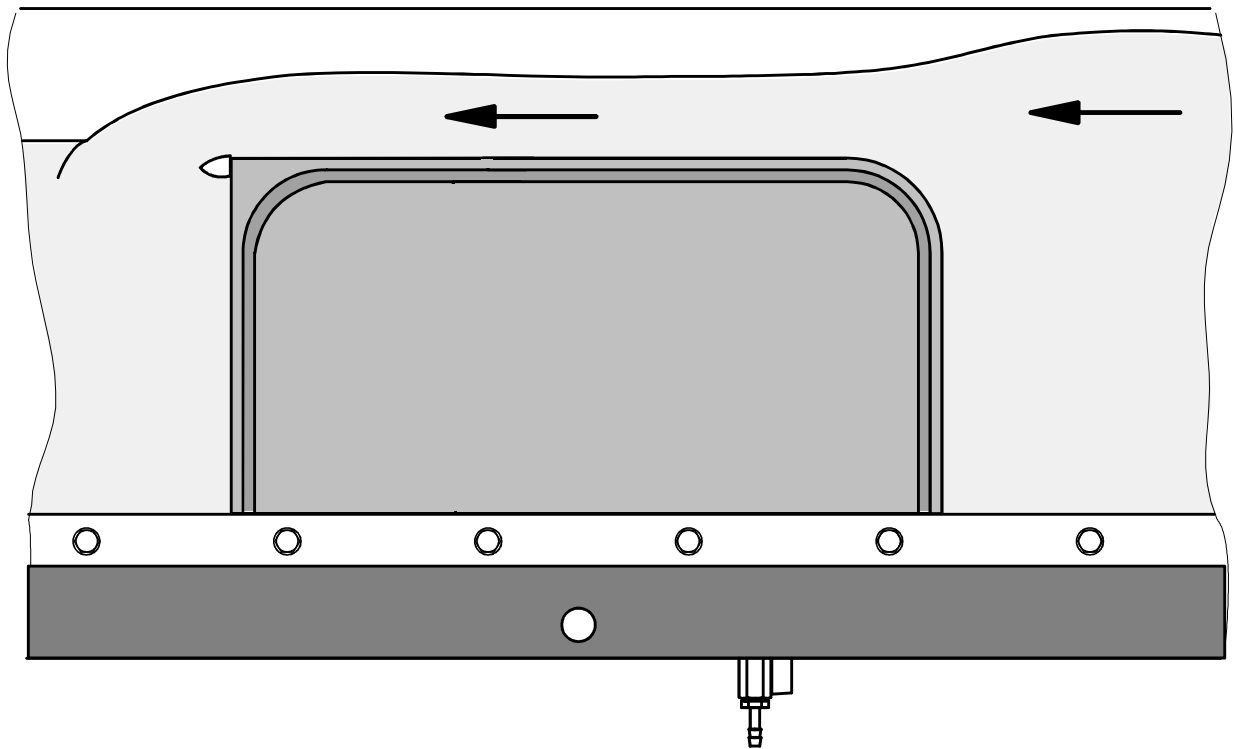
Phone (040) 670854-0

Fax (040) 670854-41

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



All Rights reserved G.U.N.T. Gerätebau G.m.b.H., Barsbüttel 02/97



Experiment Instructions

Please read and follow the safety comments before the first installation!

This apparatus is ment to be used only for Education, Teaching or Research.

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



Table of Contents

1	Introduction.	1
2	Unit description.	2
2.1	Components.	2
2.2	Assembly	2
3	Safety	3
3.1	Protection of the unit	3
4	Theory and experiments.	4
4.1	Terms.	4
4.2	Purpose of dams	4
4.3	Weirs	5
4.3.1	Transition from overflow weir to underwater weir	5
4.3.2	Design of weirs	6
4.3.3	Broad-crested weir	7
4.3.4	Additional experiments	8
5	Appendix	9
5.1	Technical data	9

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



1 Introduction

The **HM 160.31 broad-crested weir** accessory unit serves to demonstrate hydraulic processes in weirs and barrage systems in relation to overflow weirs (complete overflows) and overflowed underwater weirs (incomplete overflows). Reproducible experiments of a qualitative and quantitative nature can be performed.

The broad-crested weir gate has a square edge on one side and a rounded edge on the other. By appropriate positioning of the flow, the flow burble as a function of the rounding of the edge can be investigated.

The HM 160.31 broad-crested weir accessory unit is designed for installation in the laboratory flow channel.

The following **topics** can be covered with the accessory unit:

- Inflow and outflow processes on the broad-crested weir
- Comparison of complete and incomplete overflow
- Flow burble and cavitation
- Flow metering on the broad-crested weir
- Borderline between subcritical and supercritical flow states on the broad-crested weir

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



2 Unit description

The **HM 160.31 broad-crested weir accessory unit** is made from robust plastic and can be inserted very easily into the HM 160 laboratory flow channel and fixed by a screw. The broad-crested weir is adapted to the laboratory flow channel in terms of its shape and size.

2.1 Components

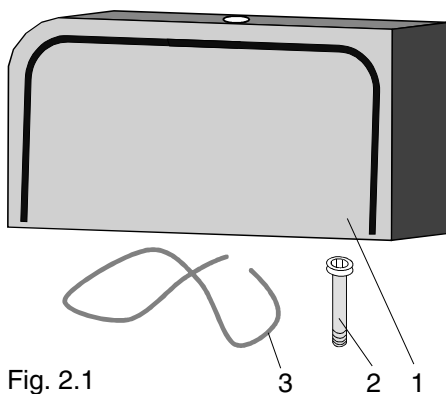


Fig. 2.1

The overflow weir comprises the following components:

- **Weir body** with rounded edge and squared edge (1)
- **Hexagon socket screw M6** (2)
- **Plastic sealing tube** (3)

2.2 Assembly

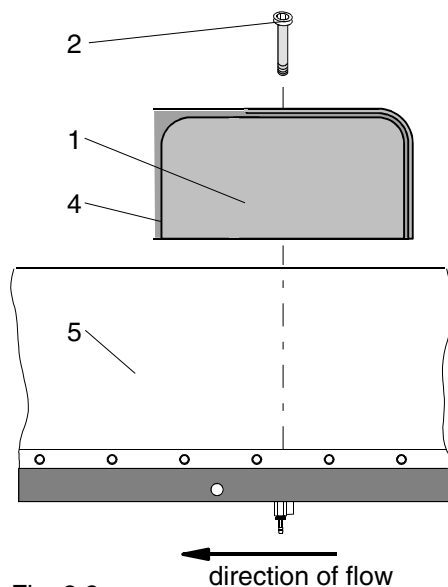


Fig. 2.2

- Insert the plastic sealing tube into the two side grooves (4); cut them to size as necessary
- Insert the broad-crested weir (1) in the desired direction relative to the flow in the flow channel (5) and secure it on the channel bed with the M6 hexagon socket screw (2)
- The weir can be secured at a variety of different positions

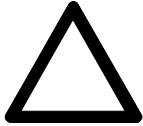
Important! Do not perform the assembly when water is flowing, to prevent the screws from being swept away by the flow.

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



3 Safety

3.1 Protection of the unit



ATTENTION

- **IMPORTANT!** After assembly do not leave any tools or tubes lying in the flow channel! They will be swept away by the flow and may get into the pump!



ATTENTION

- **IMPORTANT!** Do not perform assembly and disassembly when water is flowing! Screws or the like may be swept away by the flow and get into the pump.

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



4 Theory and experiments

4.1 Terms

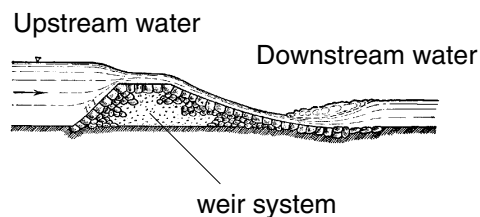


Fig. 4.1

The term **weir or barrage system** covers all installations in the bed of a water course intended to bring about an artificial raising of the upstream water level. **Upstream water** is the segment of the water course between the barrage system and the inlet; the segment downstream of the barrage system is termed the **downstream water**.

A barrier serving primarily to raise the upstream water level is termed a **weir**. If it is constructed to hold water and to compensate for the outflow, it is termed a **dam or barrage**

4.2 Purpose of dams

- Increase water depth of the natural river course
This is primarily for the benefit of **shipping**, to provide sufficient water depth even at low water on the river.
- concentrate the natural river gradient at one point

This purpose is important wherever the natural gradient of the river is to be exploited for **power generation** (e.g. hydroelectric power stations).

- Reduce fluctuation of the water level

If water is conducted away from the course of the river in artificial channels (e.g. for irrigation purposes), fluctuations in the natural water level are to be prevented from affecting the channels, in order to ensure the **amount of water removed** is kept as **constant** as possible.

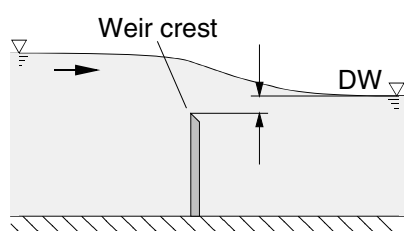
HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



- High-water protection

Dams and barrages offer the possibility of equalising the seasonal fluctuations in flow of a river and storing surplus water (e.g. in reservoirs).

4.3 Weirs



Underwater weir (incomplete overflow)

Overflow weir (complete overflow)

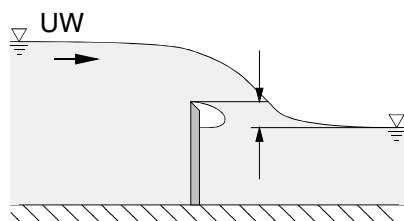


Fig. 4.2

As already mentioned, the main purpose of a weir is to raise the upstream water level.

A distinction is made between a number of different kinds of weir. An important differentiation between weirs is their classification according to the height of the crest of the weir relative to the **downstream water (DW)** level. A distinction is made between **overflow weirs** and **underwater weirs**.

Depending on the outflow volume, one and the same weir may in fact be of both categories. With a low outflow the weir acts as a overflow weir, but when the outflow is high it acts as a underwater weir, because as the outflow increases the water depth in the downstream water can rise much more quickly than in the upstream water (UW).

In a overflow weir **complete overflow** occurs; in a underwater weir **incomplete overflow**.

4.3.1 Transition from overflow weir to underwater weir

The description "underwater weir" in regard to weirs of which the crest is below the downstream water level cannot always be sustained in practical operation. Rather, a overflow weir becomes a underwater weir at the moment when a damming effect in the downstream water becomes noticeable in the upstream water.

In the case of the **broad-crested weir** being examined here, this "transformation point" can be

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



investigated if an artificial damming effect is created by inserting plastic panels in the groove provided on the outflow segment (see Operating Instructions, HM 160 multi-purpose teaching flume).

First establish a complete overflow, and then during operation insert the panels from above into the groove. Pay attention to the water level mark above the broad-crested weir.

4.3.2 Design of weirs

In an actual case, the decisive factor in constructing a **fixed weir** in a river course will be the overflow height h of the weir (always measured from the upstream water level UW). h must be measured at a sufficient distance l from the weir ($l > 4h$). If the structure height w and the weir opening width b are fixed, the hydraulic calculation is reduced to the equation $h = f(Q)$. The through-flow Q indicates the **efficiency of the overflow** at an overflow height h .

An incomplete overflow is very difficult to represent mathematically, because of the damming effect (backpressure).

For the complete overflow, neglecting the inflow speed in the upstream water, an overflow formula is produced which indicates the through-flow Q (estimation formula)

$$Q = \frac{2}{3} \mu b \sqrt{2g} \cdot h^{3/2} \tag{4.1}$$

In this, the symbols have the following meanings:

- μ Overflow coefficient, dependent on shape of structure
- b Width of the weir (in m!)
- g Acceleration due to gravity $g = 9,81 \text{ m/s}^2$
- h Overflow height (in m!)

All Rights reserved G.U.N.T. Gerätebau G.m.b.H., Barsbüttel 02/97

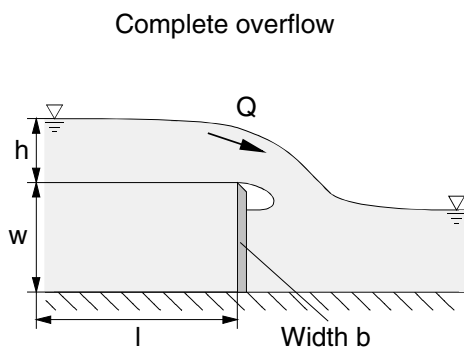


Fig. 4.3

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



4.3.3 Broad-crested weir

The broad-crested weir, as a special form of weir, has already been quite thoroughly investigated by researchers. The **top** (opposed to the direction of flow) of the weir corresponds to a **channel inlet**, while the **bottom** corresponds to an **overflow**.

The object of the following is to ascertain the through-flow of the broad-crested weir, **assuming a complete overflow** (downstream water level below weir crest), by applying the overflow formula.

For this, it is necessary to determine the overflow coefficients μ for the weir geometry under observation. Fig. 4.4 shows values ascertained by experimentation.

Example:

A value of $Q_{\text{system}}=3 \text{ m}^3/\text{h}$ was set on the system flowmeter. On the broad-crested weir with a square edge on the upstream water side the following water levels were measured:

Height of weir crest: $w = 120 \text{ mm}$
 UW 156 mm over channel bed:
 therefore $h = 156 \text{ mm} - 120 \text{ mm} \Rightarrow h = 36 \text{ mm}$
 Width of weir: $b = 86 \text{ mm}$

(We recommend gauging the water levels with the **HM 160.52 level gauge**.)

In the present case we expect an overflow coefficient of $\mu=0.5$. The resulting theoretical through-flow calculated according to the overflow formula (4.1) is:

$$Q_{\text{theo}}=2.95 \cdot 0.5 \cdot 0.086 \cdot 0.036^{1,5} =$$

$$= 0.00087 \text{ m}^3/\text{s}$$

$$\text{or } Q_{\text{theo}} = 3.1 \text{ m}^3/\text{h}$$

All Rights reserved G.U.N.T. Gerätebau G.m.b.H., Barsbüttel 02/97

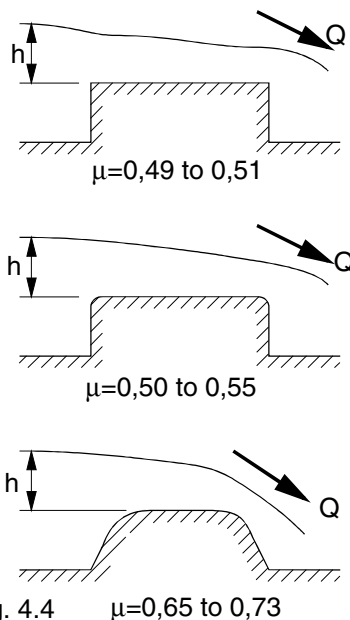


Fig. 4.4 $\mu=0,65$ to $0,73$

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



The deviation from the displayed value is

$$\text{Dev} = \left| \frac{Q_{\text{theo}} - Q_{\text{System}}}{Q_{\text{theo}}} \right| \cdot 100\% = 4\%.$$

This is a good value! Remember, when analysing errors, that the apparently so simple hydraulic problem conceals many imponderables, and that is why equation (4.1) is only an estimation formula! So do not be disappointed if you produce large deviations!

4.3.4 Additional experiments

- In both weir states - complete and incomplete overflow - take a look at the respective surface curves and compare them!
- Observe the flow burble in complete and incomplete overflow with a square-edged weir gate on the downstream water side

HM 160.31 Broad Crested Weir for Multi-Purpose Teaching Flume



5 Appendix

5.1 Technical data

Material: PVC

Dimensions:
(L x W x H) 300 x 120 x 84 mm

Radius of the round edge: 40 mm

Fixing hole for: M6