Operating Instructions

HM 162  Modular
Flow Channel
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Operating Instructions

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

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

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1 Introduction

Modular flow channel HM 162 is basic unit for wide-ranging experimentation possibilities in open flumes such as weirs, overflows, sluices, oceanography and offshore engineering such as measurements on waves and also coastal protection measures, e.g. dyke construction and beach simulation. It is designed for research and training purposes.

The basic unit with a length of 5 m can be extended up to a length of 15 m by adding 2.5 m long modules. The modules have glass side walls, thereby guaranteeing an almost complete view into the measuring section.

<table>
<thead>
<tr>
<th>Measuring length [m]</th>
<th>Flow cross section</th>
<th>Total length [m]</th>
<th>Tank contents [l]</th>
</tr>
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<tbody>
<tr>
<td>5.0</td>
<td>309 450</td>
<td>8.75</td>
<td>2200</td>
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<tr>
<td>7.5</td>
<td>309 450</td>
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<td>4400</td>
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<tr>
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<td>309 450</td>
<td>16.25</td>
<td>4400</td>
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<tr>
<td>15.0</td>
<td>309 450</td>
<td>18.75</td>
<td>5500</td>
</tr>
</tbody>
</table>

The tanks which are made of fiberglass-reinforced plastic are also modular and extendible. When connected to each other and the flow channel, these guarantee a closed water cycle and a sufficient water supply. The installation site of the tanks can be freely selected, thereby guaranteeing a high level of adaptability to existing local conditions. Once filled, the flow channel is independent of the water mains. A centrifugal pump, two shut-off valves and also a magnetic-inductive flow meter are integrated in the water cycle.

At a maximum flow rate of approx. 135 m³/h, flow velocities of 1.2 m/s are reached under a maximum flow cross section.
A **incline adjustment facility** enables the channel to be steplessly adjusted in the longitudinal direction from + 1/40 to - 1/200 by way of a manual adjustment fixture in order to, for example, compensate for flow losses or simulate a natural gradient.

Experiments in the following subject areas are possible with the modular flow channel HM 162 in conjunction with the wide range of **G.U.N.T. accessory units**:

**Flow in open flumes:**
- Flow rate
- Pressure, pressure ratios
- Flow velocity and velocity profile
- Influence of the wall shape (Venturi channel)
- Influence of the roughness (flow bed)
- Flow number
- Natural gradient
- Accelerated or delayed flow
- Sediment transport
- Application of the energy and continuity equation
- Measurements on various resistance bodies
- Lifting and drag forces

**Weirs of different designs:**
- Overflow and rise level
- Damming and submersion line
- Hydraulic jump
- Outflow processes under weirs
- Change in the flow state
- Outflow and outflow quantity with siphons (siphon weirs)
Measurements on waves
- Height (amplitude)
- Length (frequency)
- Forces
- Absorption of wave forces
- Velocity
- Different wave forms
- Wave breaking on coastal structures
- Wave reflection
- Behaviour of structures in the seaway
Hydraulic experiments on open flumes, for example rivers and channels, are made in order to make statements for improving shipping or to optimise coastal protection measures. Knowledge of forces and behaviour of waves in the offshore area are just as important.

The modular flow channel HM 162 covers these and other areas of scientific experiments of a hydraulic and flow-related nature. The flow channel is characterized by the following features:

- Modular design of channel by way of prefinished and preassembled elements allows easy and quick assembly at the installation site.
- Every element has adjustment screws for the purpose of precise adjustment of all levels.
- Two stainless steel guide tubes serve as rails for holding and positioning measuring units. A scale indicates the precise position.
- A separate main support separates the supporting function from the hydraulic function, thereby preventing leaks due to deformation during operation.
- Very precise and exact adjustment of the incline by way of high-quality spindle lifting gears.
- In the working area, no transverse supports disturb the continuous movement of measuring units etc.
- The transparent sides of the working area are made of hardened glass which is particularly resistant to scratching and abrasion, does not discolor and is easy to clean.
- The floor of the working area is stainless steel. This guarantees a smooth, even surface without complicated adjustment work.
Fittings which reduce and smooth the flow are integrated in the intake element made of resistant fiberglass-reinforced plastic, so that an even and calm flow is guaranteed. The accommodation of a wave generator is also provided for.

There is an adjustable overflow weir in the fiberglass-reinforced outflow element. The diversion of the water to the outflow tank is splash-protected.

The continuation of the flow cross-section in the inflow and outflow elements extends the working area.

The modular tanks are made of resistant fiberglass-reinforced plastic, thereby guaranteeing high strength and a long service life, combined with a low weight.
2.1 Structure of the system

The flow direction is shown by arrows in Fig. 2.1. The tanks are connected to each other by hoses, diameter DN 200. In longer channels, this allows as many tanks to be connected in series as are required to provide the desired water quantity.
2.2 Function of the flow channel

The storage tanks contain twice as much water as is needed to fill the flow channel up to its maximum water level.

The water is transported by the pump from the outflow tanks through the pressure line and into the intake element. Here, the flow rectifier provides calm, even flow. The associated damping plate floats on the water surface, thanks to its density which is lower than that of water.

The water now flows through the actual working and measuring area of the flow channel which is shut off by a permanently, fitted, adjustable overflow weir. The water level rises here up to the preset height of the overflow weir. The flow rate can be regulated very precisely at the shut-off valve (2) and read off on the magnetic-inductive flow rate meter.

Float switches are installed in the intake and outlet elements so that the water does not rise above the maximum level of 450 mm. When this water level is reached, these switches interrupt the power supply to the pump, thereby preventing the channel overflowing.

The water flows back into the discharge tank from the outflow element and is distributed to the other tanks from here.
2.3 Components

2.3.1 Pump unit

The pump unit consists of a base plate for securely setting up and fixing in the substrate and a centrifugal pump with a flanged-on three-phase motor, onto which are flanged a shut-off valve DN 125 with lever on the suction side and a shut-off valve DN 100 with gears and handwheel on the pressure side. The flow rate is adjusted at the pressure-side shut-off valve during subsequent operation.

The pump motor is connected in a star-delta circuit. The bearings of the motor have permanent lubrication. The pump is designed for the transport medium "cloudy water". During sediment transport, it must be ensured that the solid proportion does not exceed 10% of the water volume. The grain sizes must be kept as small as possible, but maximum $D=2\text{mm}$.

2.3.2 Flow rate meter

A magnetic-inductive flow rate sensor is installed in the pressure line to the intake element. This sensor type has the advantage that no pressure losses occur due to flow obstruction. The sensor has a current output of 4...20 mA. It is set to a measuring range of 0-150 m$^3$/h. The digital display alternately shows (every 10 sec.) the current flow rate in m$^3$/h and the total flow rate in m$^3$. 
2.3.3 Incline adjustment

The incline adjustment facility (5) is realised by two spindle lifting gears with trapezoidal spindles connected in parallel. Actuation is via a handwheel. So that the handwheel can be turned with minimum force application and to enable an exact incline to be set, the spindle performs a travel of 0.25 mm per crank revolution. A scale with the exact incline ratios is installed under the handwheel at the front. **Caution:** Only adjust the incline as far as shown on the scale range. The incline adjustment facility is designed as a pendulum support. In order to enable it to function over an extended period, **lubricating nipples** were installed on the joints. These **joints** must be **lubricated at annually** with the aid of a grease press.

2.3.4 Fixed bearing

The fixed bearing (14) has two lubricating nipples on the fork heads on its top rotation point, just like the incline adjustment facility. These must also be **lubricated at annually** with the aid of a grease press.
2.3.5 Intake element with flow rectifier

The water entering the intake element first flows through two perforated plates lying one on top of the other and offset. The flow is homogenized here. The water then impacts against a damping plate, the density of which is less than that of water. It floats on the water surface and diverts the water current. It cannot spray any water upwards. The water now continues to flow calmly and without eddys into the nozzle section, where the flow is evenly accelerated. The contour of the nozzle section was calculated so that a constant velocity profile is guaranteed over the entire intake cross section. The same water level is present everywhere and the pressure is constant transverse to the flow direction.

![Diagram](image)

Fig. 2.5: Slowing the intake flow
2.3.6 Modular center element

Modular center elements HM 162.10 are used to vary the measurement length of the G.U.N.T. flow channel HM 162. They can also be retrofitted in already existing channels, because all components required for an extension are present with this module. The elements have a length of 2.5 m and the flow cross section of 309 mm (width) x 450 mm (depth).

The transparent sides of the measuring area are made of hardened glass which is particularly resistant to scratching and abrasion, does not discolor and is easy to clean. The base is made of stainless steel. Measuring supports with threaded holes (M8) are arranged in each element at intervals of 1250 mm. These supports are used to accommodate fittings such as the beach simulator, weirs etc., as well as for holding measurement sensors and transformers. These sensors and transformers can be fitted in the measurement connections provided for this purpose with a female
thread G 1/2”. So that no water escapes during operation, the measuring supports have ball valves which are only opened as required. The ball valves have hose grommets for accommodating hoses which can be connected to a pressure gauge panel. The center elements are supplied preassembled.

2.3.7 Switch box

All switching units required for operation are located in the cover of the switch box. Before any operation, it should be ensured that all switches are set to 0/Off and that the emergency stop switch is not pressed. If it is engaged in the switched state, the interlock can be released by pulling forward the knob.

The cam switch for pump operation must always first be set to the “star” symbol before being switched to the “delta” symbol. The reverse sequence would possible cause the fuse to spring out because the start-up current is too high in the case of delta switching.

If a wave generator is installed (e.g. HM 162.41), the motor of the wave generator and the rotational speed can also be switched and adjusted from here. The rotational speed gives the stroke frequency of the wave generator and is adjustable via a 10-gear helical potentiometer. The maximum rotational speed is 114 rpm, corresponding to 1.9 Hz.
2.3.8 Overflow weir

So that different water levels can be set in the working area of the flow channel, an adjustable overflow weir was provided in the outflow element. A flap, the incline of which can be adjusted, which is on swivel bearings at the base of the outflow element, is supported by a threaded rod. An adjustable star nut provides for simple shortening or lengthening of the threaded rod, and this changes the incline.

In order to create very low water levels, the overflow weir was provided with two rectangular openings. In the normal condition, the openings are each closed with a plate, but this can be easily removed by unscrewing 6 knurled screws. If the overflow weir is to be completely folded down, always remove the upper plate in order to guarantee a sufficient flow rate.

The overflow weir is sealed by rubber beads towards the side walls of the outflow element.
In addition, the overflow weir, in conjunction with the wave generator HM 162.41, is used to generate waves. This necessitates removal of the threaded rod. Instead, the push rod of the wave generator is locked in the holder of the threaded rod.

2.4 Putting the system into and out of operation

All necessary work steps for fault-free, carefully operation of the modular flow channel HM 162 are outlined below. The flow channel should always be set up and assembled by trained personnel from the G.U.N.T. company, otherwise perfect functioning cannot be guaranteed.

We urgently discourage assembly by third parties, because the function and safety could be put at risk in the event of incorrect assembly.

2.4.1 Putting into operation

- Ensure that all switches on the control section of the switch box (9) are set to 0 (Off).
- Ensure that the ball valve in the lower part of the intake element (7) is closed.
- Close all ball valves on the measuring supports in the base of the center elements (see Section 2.3.6).
- If the system is set up correctly, the tanks can be filled with water via a hose.
- **Caution: Maximum filling level approx. 3 cm below the upper edge of the tank.**
- Check that all tanks are evenly filled with water.
- Check tank connections for leaks.
- Set the incline adjustment facility (5) to the required incline ratio.
- Open the shut-off valve (13) on the suction side. It is open when the closing lever is in the longitudinal direction with respect to the flow.
- Close the shut-off valve (2) on the pressure side. It is closed when the arrow on the front points to the 0° mark of the 90° scale.
- Set the main switch to 1.
- Move the cam switch for the pump to the star setting and run up the pump. When the pump has reached operating speed, switch over to the delta setting.
- Slowly open the shut-off valve (2) and set the required flow rate.

2.4.2 Putting out of operation

- Set the main switch to OFF
- Reduce the incline adjustment facility to the ratio -1/40
- Open the shut-off valve on the pressure side. Water flows through the pressure line back into the tank.
2.4.3 Shutting down

- Set the main switch to OFF
- Decrease the incline adjustment facility to the ratio 1/40
- Connect an outflow hose to the hose grommet of the ball valve at the lowest point of the intake element.
- Open the ball valve. The remaining water in the channel and pipeline now drains off.
- Remove the cover of the tank and place a submersible pump into the recess in the base of the tank.
- Ensure outflow
- Pump the tanks empty with the submersible pump
- **Caution**: Submersible pumps must not be allowed to run dry over an extended period. Therefore, do not leave the pump unattended during pumping-off.
2.5 Maintenance and care

A few instructions on the maintenance and care of the modular flow channel HM 162 are outlined below which can guarantee and extend perfect, fault-free operation of the system for many years:

- The joints of the incline adjustment facility and of the fixed bearing must be lubricated at annual intervals with the aid of a grease press at the lubrication nipples provided for this purpose.

- Spindles of the incline adjustment facility must be wiped off with an oil-impregnated cloth as required (for example when a rust film has formed).

- The agent FLUID FILM of the Hodt Korrosionsschutz company is recommended as a general rust and corrosion protection agent. This lanolin-based agent should be sprayed on all metal parts requiring special and permanent corrosion protection, and then wiped off. This work must be carried out when the first signs of corrosion appear.

- Always keep the tanks covered, because light encourages the growth of algae.

- Clean the disks with a mild cleaning agent. Algae growth can be removed with the aid of razor blades.

- Clean all fiberglass-reinforced plastic parts with a mild cleaning agent. Never use abrasive agents for cleaning.
The following information relating to work safety must be borne in mind when handling the modular flow channel HM 162:

- **DANGER**: Take care when opening the control cabinet and reaching into the electrical systems.
  There is a risk of an electric shock.
  Have repairs carried out only by skilled electricians.

- **DANGER!** Never reach into the crank disk while the wave generator is in operation.
  Injuries would result.

- **DANGER!** Never work under the flow channel during operation.
  There is a risk of injury from falling objects.

- **DANGER!** Never adjust the incline adjustment facility beyond the stated range.
  There is a danger that a support could slip away under load.

- **CAUTION!** Store the system in a frost-free place.
  There is a risk of frost damage.
  Empty the system if there is a frost risk.
- **CAUTION!** Fill the tank up to max. 3 cm below the upper edge. There is a risk of overflowing.

- **CAUTION!** Take care when working in the working area of the centre elements, particularly with heavy tools. There is a risk of breaking the glass.

- **CAUTION!** Check the tanks, pump and connecting lines regularly for leaks. Large amounts of water can escape unnoticed if there are leaks.

- **CAUTION!** Never leave the system running unsupervised. Users must be instructed about the system’s technical features, particularly its safety characteristics.

- **CAUTION!** When operating with sediment, never use grain sizes of more than D=2 mm. This would destroy the centrifugal pump.
4 Theory and Experiments

4.1 Structure

Many accessory units are available for the modular flow channel HM 162. Certain subject areas such as overflow weirs, flow rate measurements, wave propagation etc. can only be investigated in conjunction with these accessory units.

For this reason, the relevant theoretical background covered by an accessory unit is listed in the experiment instructions for the relevant accessory unit. These also contain numerous notes on experiments, as well as work sheets or other work material for instruction.

4.2 Didactic Information

The theory contained in the experiment instructions for the accessory units follows a certain didactic order, i.e. the understanding of certain phenomena requires certain basic knowledge, e.g. the comprehension of energy dissipation in stilling pools requires knowledge of the difference between subcritical and supercritical flow.

If you would like to have a continuous didactically tailored course on the principles of hydraulic engineering, we therefore recommend that for teaching purposes, you keep approximately to the order laid down in the following pages for the accessory units. The separate combined blocks have a thematic coherence.
## HM 162 Modular Flow Channel

<table>
<thead>
<tr>
<th>Accessory for HM 162</th>
<th>Subject areas been covered</th>
</tr>
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<tbody>
<tr>
<td>.30 Plate weirs</td>
<td>- Flow in open channels</td>
</tr>
<tr>
<td>.31 Broad crested Weirs</td>
<td>- Weir systems</td>
</tr>
<tr>
<td>.32 Free Overflow spillway</td>
<td>- Measuring weirs</td>
</tr>
<tr>
<td>.37 Spillway dissipation</td>
<td>- Measuring of flow rates in open channels</td>
</tr>
<tr>
<td>.35 Toe blocks</td>
<td>- Difference between overflow/underwater weir</td>
</tr>
<tr>
<td>.33 Crump weir</td>
<td>- Stilling pools</td>
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<tr>
<td>.51 Venturi Flume</td>
<td>- Dynamic / static pressure</td>
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<tr>
<td>.34 &quot;Ogee&quot;-weir</td>
<td>- Profiles of weirs</td>
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<tr>
<td>.36 Syphon spillway</td>
<td>- Cavitation-phenomena</td>
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<tr>
<td>.40 Radial Gate</td>
<td>- Contraction of outflow stream</td>
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<tr>
<td>.45 Culvert Fittings</td>
<td>- Intake and outflow losses</td>
</tr>
<tr>
<td>.46 Flow Splitters</td>
<td>- Pillar build-up</td>
</tr>
<tr>
<td>.39 Roughened Bed Sect.</td>
<td>- Wave types</td>
</tr>
<tr>
<td>.42 Simulation of beach</td>
<td>- Wave velocity</td>
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<td>.43</td>
<td>- Breaker types</td>
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<td>.44</td>
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<td>.48</td>
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5 Appendix

5.1 Technical Data

<table>
<thead>
<tr>
<th>Basic Apparatus:</th>
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</thead>
<tbody>
<tr>
<td><strong>Main dimensions:</strong></td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td>Range of measuring</td>
</tr>
<tr>
<td>Depth</td>
</tr>
<tr>
<td>Height</td>
</tr>
<tr>
<td>Cross-section of flow</td>
</tr>
<tr>
<td>Width</td>
</tr>
<tr>
<td>Depth</td>
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<tr>
<td>Weight empty</td>
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<tr>
<td>full</td>
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<table>
<thead>
<tr>
<th>Center element:</th>
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<tbody>
<tr>
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<tr>
<td>Height</td>
</tr>
<tr>
<td>Weight empty</td>
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<table>
<thead>
<tr>
<th>Tank:</th>
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<td>Depth</td>
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<tr>
<td>Height</td>
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<tr>
<td>Weight empty</td>
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<tr>
<td>max. Volume</td>
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<table>
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<tbody>
<tr>
<td>1x magnetic-inductiv</td>
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<tr>
<td>Diameter</td>
</tr>
<tr>
<td>Range of measuring</td>
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<td>Class of accuracy</td>
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<th>Incline adjustment facility:</th>
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<tbody>
<tr>
<td>2x trapezoidal spindles</td>
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<tr>
<td>Max. lifted load</td>
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<tr>
<td>Stroke per turn</td>
</tr>
</tbody>
</table>
Components
1 pce. centrifugal pump
output height 14 m  
(1.4 bar)
max. flow rate 220 m³/h
Voltage 3x400 V
Frequency 50 Hz
Power 5.5 kW
Speed 1450 min⁻¹
Suction/pressure side DNS 125/
DND 100

1 pce. Shut-off valve w. gear
and hand wheel DN 100
1 Stk. Shut-off Valve w.
lever DN 125