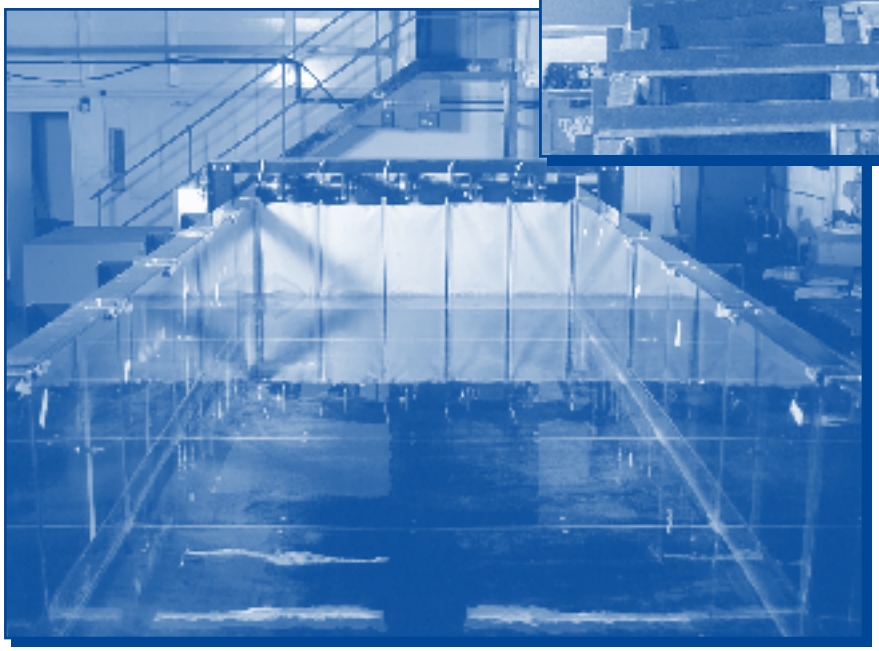
armfield

S6MkII
issue 12

LABORATORY FLUMES AND CHANNELS FOR HYDRAULIC TEACHING/RESEARCH STUDIES



- *Standard Flumes*
- *Special Flumes, Tanks and Basins*
- *Ancillary Equipment*
  - *Sediment Transport Facilities*
  - *Mono and Random Wave Makers*
  - *Instrumentation*

Applied Hydraulics and Hydrology

Introduction

Armfield has been designing and supplying open channel facilities to hydraulic laboratories throughout the world for over 40 years.

This brochure describes the range of channel designs available from Armfield, from which research/teaching personnel may wish to request specific quotations depending on their field of interest.

Usually channels are of rectangular prismatic section. The dimensions of the working cross-section and length are the principal features which determine both the functional suitability and the cost of a channel.

Depending on customer requirements, channels can be designed to incorporate the following alternative features:

- *fixed bed or variable slope*
- *self-contained or laboratory supplied water*
- *open circuit or re-circulating sediment load*
- *choice of working section materials (glass, metal, wood)*
- *inclusion of a wave generator and beach*
- *instrumentation systems for flow, velocity, level, etc.*
- *sediment sampling*

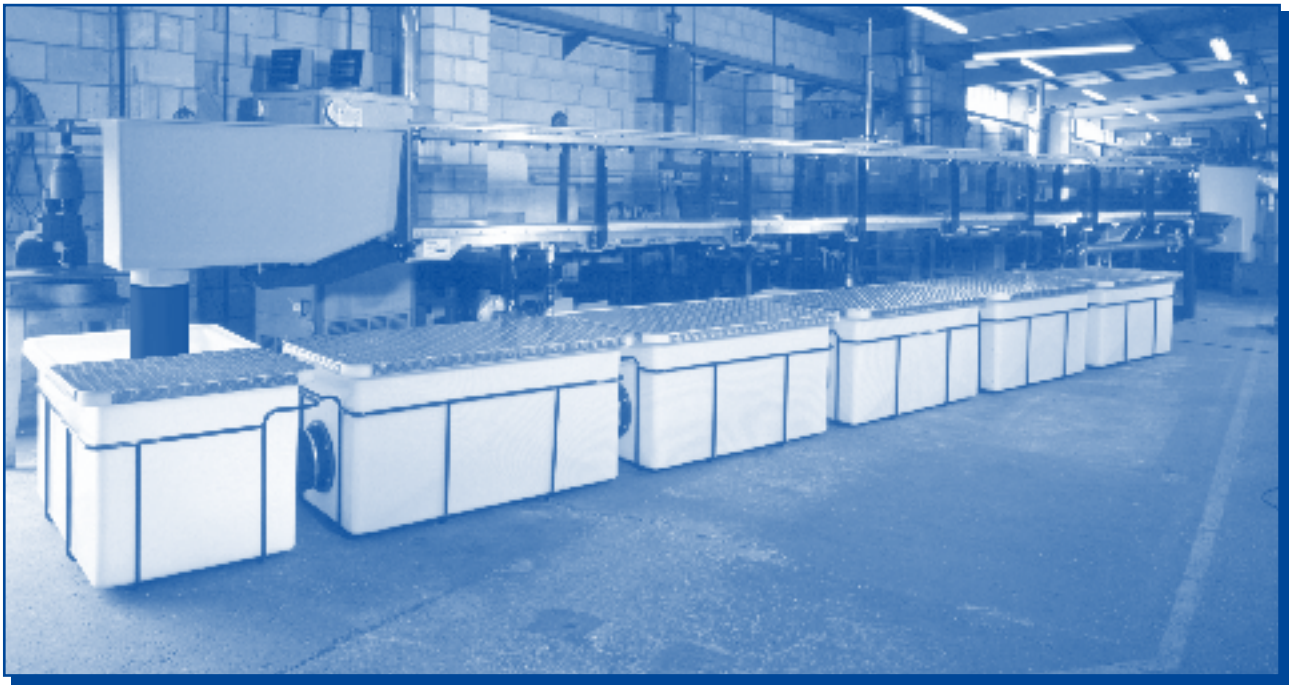
The Key Features of an Open Channel Facility

Because of the physical size and the general heavy nature of the construction, it is easy to forget that a flume is an instrument and in many instances required to have a high level of integrity regarding both its working dimensions and ability to achieve repeatable results.

Armfield acknowledge the necessity for accuracy, precision and repeatability. These are cornerstones of the design, manufacture and final installation.

Dimensions

The critical dimensions of a flume are the working length and cross-section (width and depth). Working length also means usable length. All too often the turbulent entry conditions require a substantial portion of what would be described as the working section before suitable flow conditions prevail. Armfield flumes are designed such that the working length is maximised. The overall dimensions of the flume are also minimised through careful design of the inlet and outlet conditions and sensible use of the space underneath the flume and immediately adjacent.



S6MkII flow channel complete with its own service system

Materials of Construction

The materials of construction are of paramount importance, not only for the durability and longevity required of an expensive piece of equipment, but also suitability for purpose. Many flumes are used for sediment transport studies and therefore the materials in contact with the sediment must have abrasion resistance. In such instances it is standard practice for Armfield to incorporate stainless steel on the bed of flumes.

Clarity of flow visualisation is an essential ingredient, particularly if laser doppler anemometry or sophisticated photography is involved. Even potable water will abrade a surface but water containing harsh particles, such as sediment, will quickly damage any soft material. This is why all Armfield flumes are constructed with toughened glass viewing panels, whether these be small portholes or full length working sections. Toughened glass is also used as a safety feature. In the unlikely event that a glass panel shatters, it will not break into dangerous sharp shards but into small relatively harmless cubes.

Wherever possible the more basic components in contact with water are made of non-corroding materials, such as plastic or GRP. Pumps are usually cast iron but where sediment is involved we recommend the use of special pumps, typically glass lined. Where wood or a composite material is chosen for the base and/or sides of the flume, these are carefully treated to protect against water ingress.

Set-up and Assembly

Armfield flumes, whether a standard product or customised, are built on a modular principle. This allows them to be delivered to site in pre-fabricated, manageable sections. The designs are such that in most cases with help from the instruction manual, clients are able to assemble and commission the equipment without the need for our skilled staff. However this is always an option, and Armfield are happy to submit a quotation for installation, commissioning and, where appropriate, basic training.

Ease of Use

Experimentation can be a time-consuming and tedious business. Quite often long periods are required in order to gather sufficient meaningful data. It is at these times that the user appreciates equipment that has been carefully designed from an ergonomic viewpoint.

Armfield incorporates many features to ease the life of the operator. All controls on a single floor mounted console. Electrical options for driving valves, jacking systems and weirs. Direct reading flow meter instrumentation, with digital readout at the control console. Powered instrument carriages offering three way axes. A sensible working height that provides comfortable access to the working section.

S6MkII control console

Uniform Flow

Within the limited confines of a laboratory flume it is critical that the best possible working conditions are achieved as quickly as possible after the flow enters the working section. Much hinges on the entry conditions and particularly the means used to settle and direct the flow as it enters the inlet tank and is re-directed into the working section.

Inlet Tank Design

The inlet tank design generally adopted as standard by Armfield is the consequence of 40 years of experience coupled with comprehensive model test work. The result is a carefully shaped tank, with profiling to both the side walls and base, whilst remaining compact in its length, an essential ingredient to minimise the waste of laboratory space. Within the tank various stilling devices are incorporated.

Level Control - The Outlet Weir

Of equal importance is the method of controlling the level within the flume. This is usually done through a weir at the discharge end. Many options exist but most frequently Armfield utilise either an adjustable overshot tilting weir or, for more complex flow conditions, a venetian blind weir with either vertical or horizontal slats.

Water Supply

Traditionally hydraulic laboratories were constructed with underfloor sumps and elevated header tanks linked with a ring main. Modern laboratories rarely enjoy these facilities. Armfield are, however, able to supply flumes either in a non self-contained configuration, where they can be serviced from an existing header tank and discharge to a laboratory sump, or as fully self-contained facilities, where floor mounted reservoirs, pumps, pipework, valves and flow meters are incorporated, including, where appropriate, re-circulating loops for sediment transport.

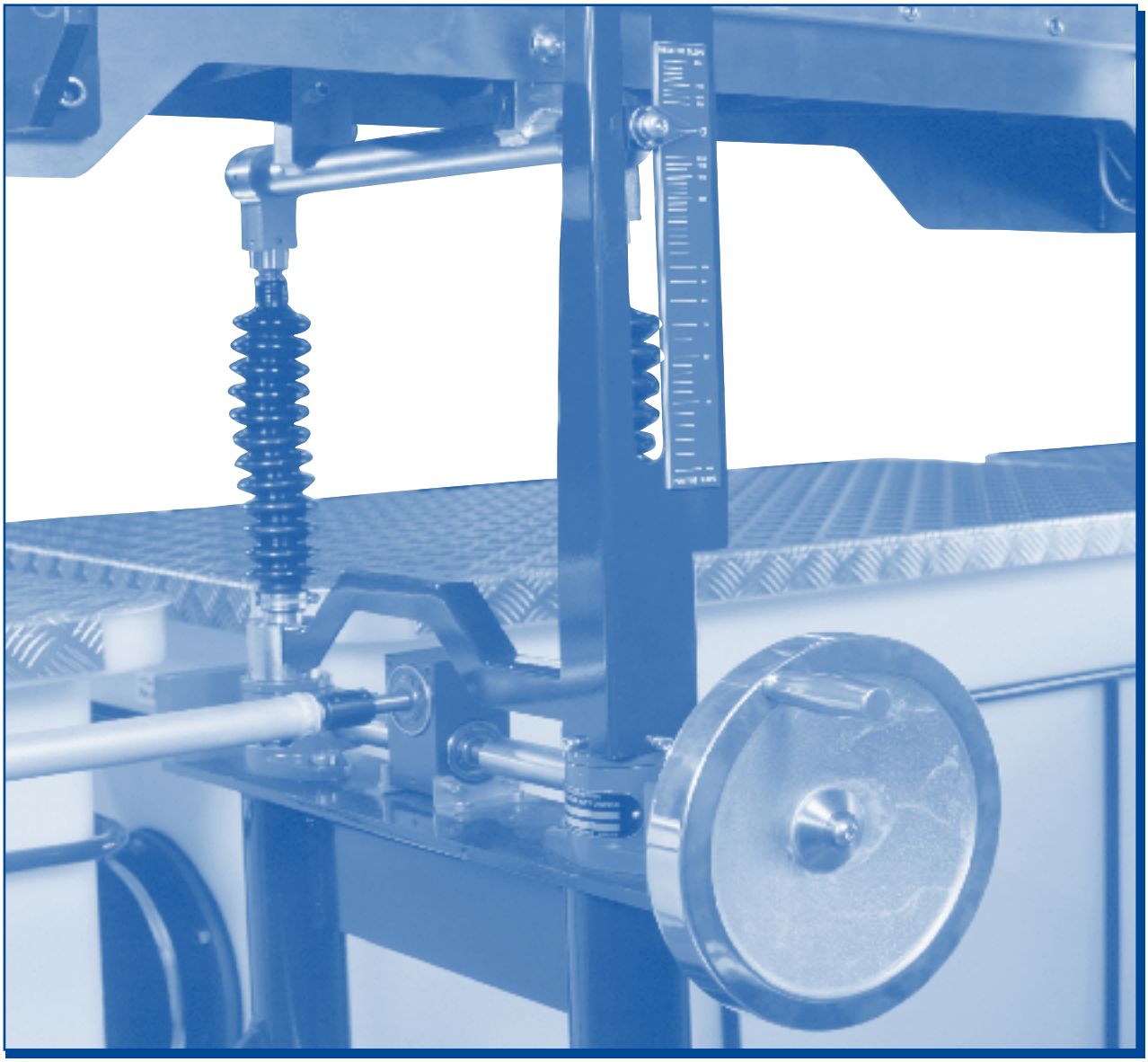
Occasionally flumes are required that meet both requirements. These can also be supplied.

Major Design Features

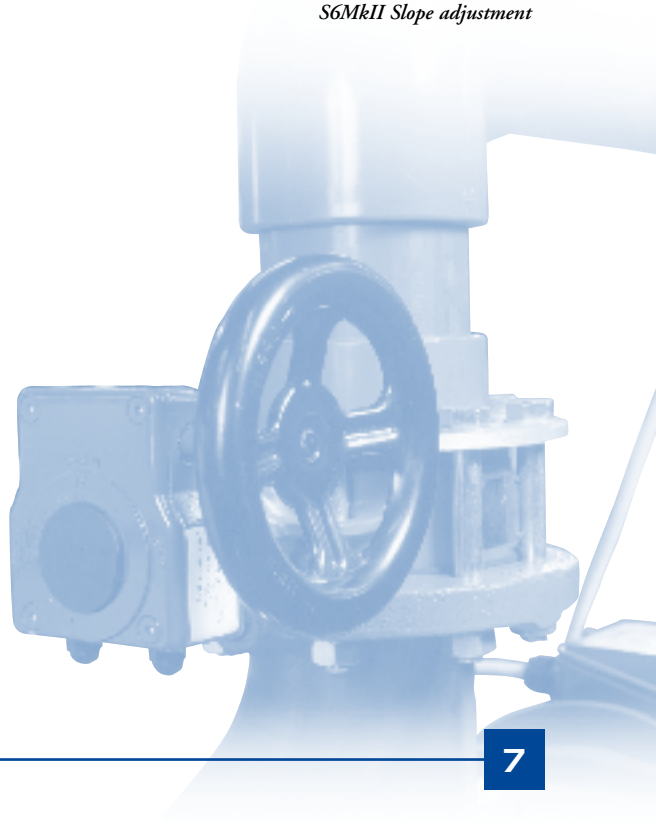
There are numerous design features associated with Armfield channel facilities, many are unique. The following list is not exhaustive. Not all features are appropriate to every channel.

- *Accurate for education and research*
- *Extremely stable design, no user adjustments required to the flume bed*
- *Floor space requirements reduced to a minimum*
- *Fabricated high precision stainless steel channel bed*
- *Can be readily converted to closed-loop recirculation for sediment transport studies*
- *Precision screw jacks provide accurate slope adjustment with minimum effort (powered jacks available as an option)*
- *Designed for ease of visibility:- toughened glass sides; slimline side supports; comfortable viewing height. etc.*
- *Adjustable instrument rails with positioning scales are fitted over the whole working length*
- *Fully profiled inlet tank fitted with stilling and smoothing devices*
- *Discharge tank with adjustable overshot weir and draft tube to avoid splashing and reduce noise*
- *Modular construction - supplied in pre-glazed sections for rapid and easy assembly on site*
- *Wave generation options, both regular and random - the end tanks acting as basins extending the working length*
- *Standard flumes have a comprehensive range of accessories, instruments and models available*
- *Standard flumes have non-corroding durable GRP tanks throughout*
- *Transverse members have been eliminated throughout the working length*
- *Transparent sides are of toughened glass, which is extremely strong, abrasion resistant, dimensionally stable, does not discolour or scratch and is inherently safe*
- *Working section is fully adjustable, enabling extremely accurate setting*
- *Substantial underframes reduce load deflections to a minimum*
- *Close tolerances specified and achieved.*

S6MkII
Detail showing side support with instrument rail and side wall adjustment system



S6MkII Slope adjustment

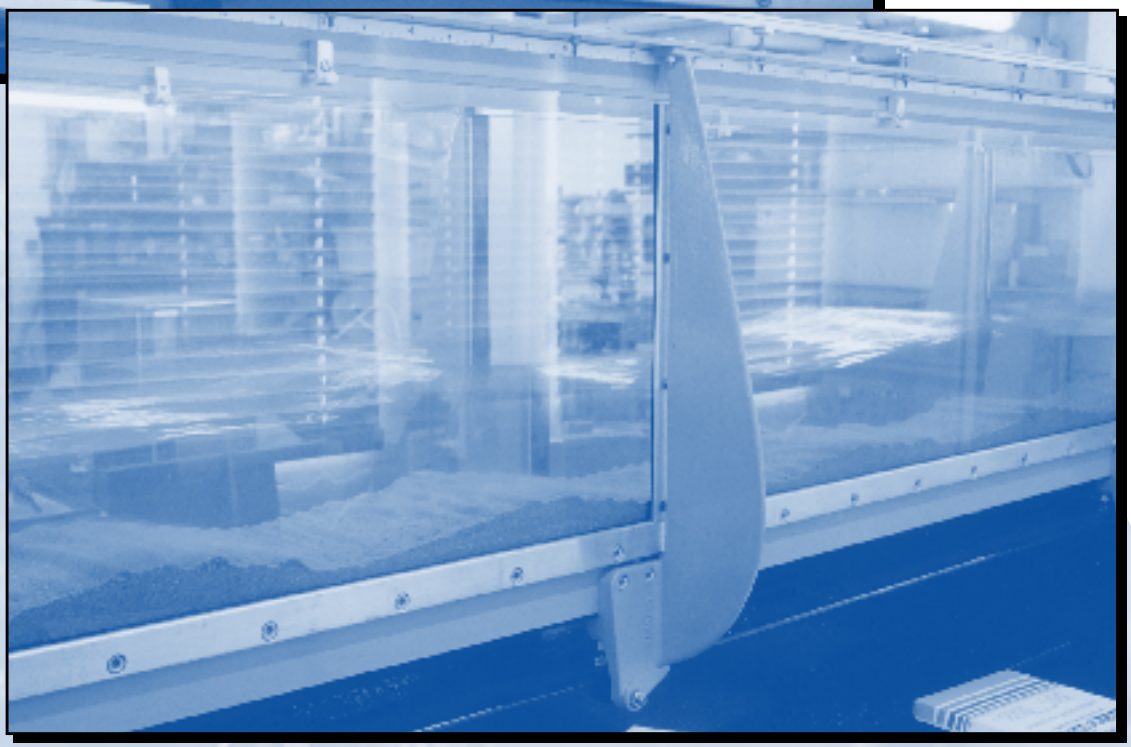


Standard Flumes

Armfield offer a design, manufacture and installation service for special channel facilities of all types and sizes. Their reputation and expertise has developed through the evolution of standard products. By this we mean high quality flumes offered to a standard design.

History and experience has shown that there is an optimum cross-section that will fill a great majority of educational and research needs. Those dimensions are a width of 300mm and a depth of 450mm (these are internal working dimensions).

The length of a flume is dictated by many factors. Common amongst them are experimental requirements, space availability and cost. Standard Armfield flumes are therefore available as modular units.



S6 MK II Glass Sided Tilting Flumes

Description

A glass sided tilting flume with fabricated all stainless steel bed. A working cross-section of 300mm wide by 450mm deep and available in standard working lengths of 5m, 7.5m, 10m and 12.5m. Longer lengths are available to special order in increments of 2.5m.

Completely self-contained and comprising the working section, moulded inlet and discharge tanks, a series of sump tanks, a pump, an electronic flow meter, a jacking system and a control console.

The channel section is fully glazed with large clear panels of toughened glass. This is coupled with careful design of the side support profiles to provide excellent visibility and allow flow visualisation of the full working height of the flume. The glass panels are sealed using a rubber "U" section compressed by an aluminium alloy clamping strip. The flume bed is manufactured to high tolerances and designed with an integral web support frame to give the flume a high degree of rigidity and stability. Rigid dowelled joints are used to connect the sections. The overall strength and rigidity of the design allows excellent stability figures to be achieved and eliminates the need to provide adjusting screws or to perform periodic setting up of the flume to maintain its specification. No underframe or support structure other than jacks is necessary.

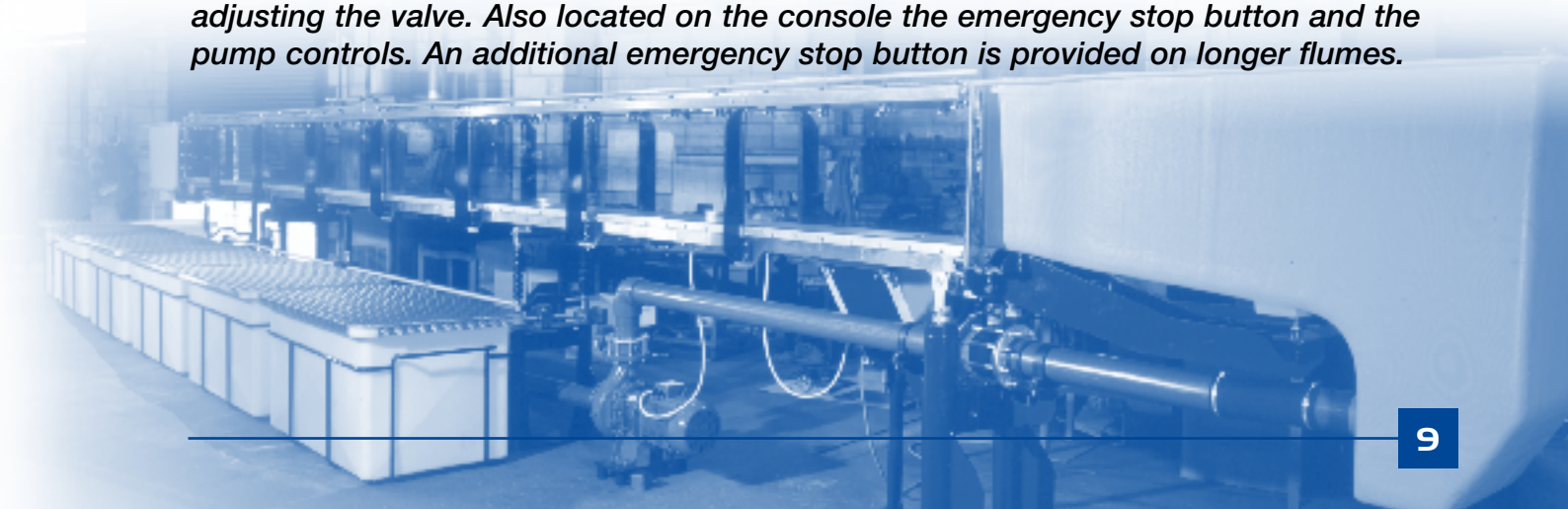
Instrument rails are provided along the entire working length of the flume and a continuous scale calibrated in millimetres is provided along the length of one of the rails. Adjustable screws allow the track to be set level and true.

Excellent velocity profiles are achieved in the working section by careful shaping of the inlet tank and by the incorporation of stilling and smoothing devices. Operating water levels are maintained by an overshot tilting weir located in the discharge tank. Both end tanks are made from tough non-corroding GRP.

Water circulation is by a centrifugal pump mounted beneath the flume channel, drawing water from a series of interconnected non-corroding sump tanks mounted on the floor and running alongside the flow channel. All interconnecting pipes and fittings are made of non-corroding materials.

The flow is regulated using a manually adjusted valve. Flow rate is measured using an electro-magnetic flow meter and displayed on a digital readout located on the control console.

The control console is mounted on a pedestal and located in a convenient position for the installation, such that it is easily accessible and the flow rate can be read whilst adjusting the valve. Also located on the console the emergency stop button and the pump controls. An additional emergency stop button is provided on longer flumes.



The flume is tilted using a jacking system - a single jacking station on 5m flumes. Flumes up to 12.5m have two jacks interconnected by a geared drive. A slope indicator is provided.

Electrical jacking is available as an optional extra, including a control box with up/down inch buttons plus an additional emergency stop button. Electronic limit switches disable the electrical device at the maximum and minimum extent of travel.

Technical Details

Width	*300mm*
Depth	*450mm*
Length overall is	*As ordered (multiples of 2.5m)* ***Note:*** *length 3.25m longer than the working section defined*
Walls	*Toughened glass*
Bed	*Exclusively fabricated from stainless steel*
End tanks	*GRP (Glass Reinforced Plastic)*
Sump tanks & pipework	*PVC (Polyvinylchloride) & PE (polyethylene)*
Pump	*Close-coupled centrifugal*
Flow regulation valve	*Hand wheel operated butterfly*
+ve slope	*1:40 max (1.4º)*
-ve slope	*1:200 max (0.28º)*
Flow meter	*Electro-magnetic*
Maximum flow rate	*30 Litres/sec*
Bed stability	*<1.0mm (typical) at 400mm water depth*
Side wall stability	*<0.5mm (typical) at 400mm water depth*

Ordering Specification S6 Flume

- ***A self-contained glass sided tilting flume for fluid mechanics laboratory experiments, project work and research activities***
- ***The flume working channel is assembled from modular sections of 2.5m length. A wide choice of standard lengths are available from 5m upwards***
- ***The flume cross-section is 300mm wide by 450mm deep***
- ***A fabricated high precision stainless steel bed provides excellent strength and rigidity, eliminating the need for a separate underframe. No adjustments other than the jacking stations are necessary in order to set up and maintain the equipment, achieving typical bed deformations better than 1mm***
- ***Each flume incorporates a discharge tank fitted with an adjustable overshot weir and draught tube to avoid splashing and noise***
- ***An electro-magnetic flow meter is incorporated as standard***
- ***A comprehensive range of optional accessories and instruments is available to supplement the capabilities of the basic flume***
- ***Closed-loop recirculation is available as an option for sediment transport studies***

See inside back page for ordering options.

Experimental Models & Instrumentation

A comprehensive range of experimental models and measuring instruments is available for selection. These provide the basis for a large number of practical experiments in open channel flow including the use and operation of regulating and gauging structures.

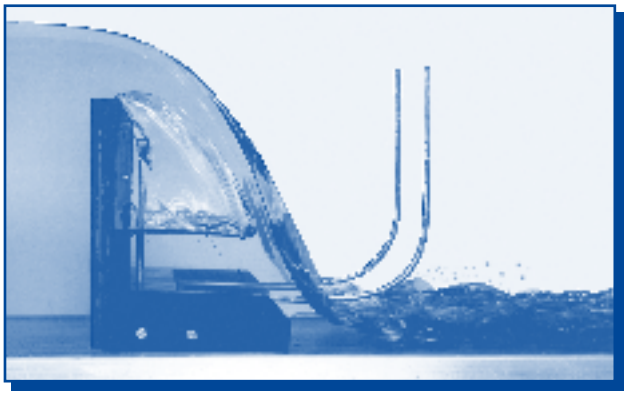
Wherever possible non-corroding materials have been used to reduce maintenance time and increase the working life of the models.

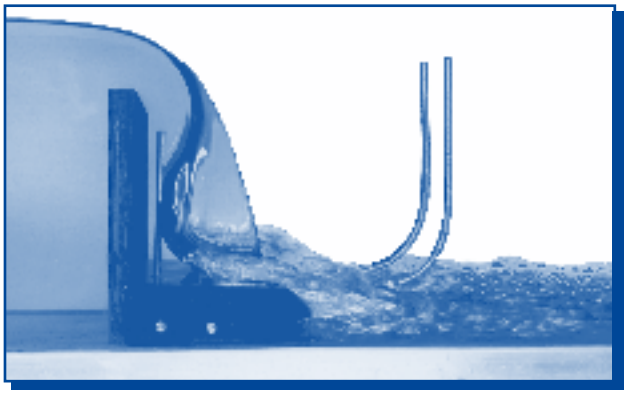
S6-20: Plate Weirs - (Stainless steel)

- *screw operated adjustable undershot weir*
- *rectangular overshot weir plate*
- *`V´ notch weir*

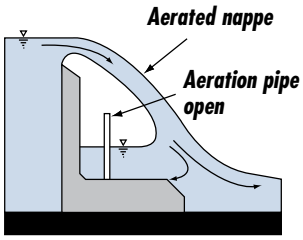
S6-21: Broad Crested Weirs - (GRP)

- *rectangular sharp cornered weir*
- *rectangular streamlined weir*

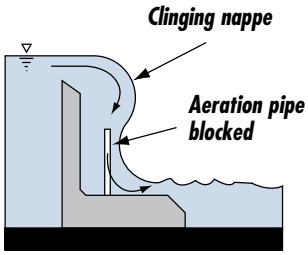




S6-20: Rectangular overshot weir - in operation (above) and theory (right)



Stable conditions are obtained for the rectangular weir by exposing both upper and lower surfaces of the nappe to atmosphere, air being admitted below and immediately downstream of the weir crest. Vent pipes are utilised to replenish lost air through entrainment with the falling water ***(Fig. 1)***



Should air loss occur then a vacuum will be created causing the nappe to adhere to the downstream face of the weir. This condition is associated with an increase in discharge, instability of flow behaviour and is incompatible with accurate flow measurement ***(Fig. 2)***

S6-21: Broad crested weir - in operation (above) and theory (right)

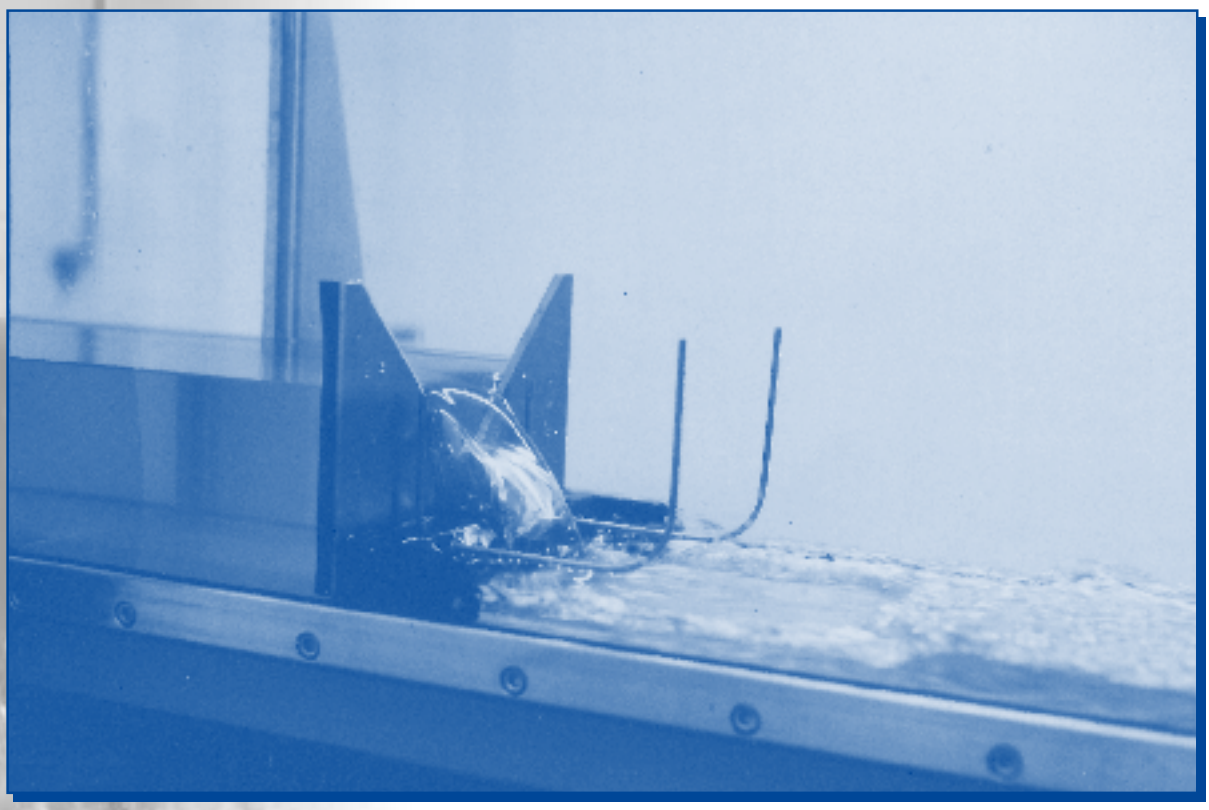
Broad Crested Weir

$$Q = 1.704 C_d b H^{3/2}$$

$$C_w \approx 0.85 \text{ to } 0.9$$
$$h_d \geq 0.67\, h_u$$
$$h_a \geq 0.40\, h_u$$

This type of weir is commonly used in the gauging of discharge in open channels, particularly where accuracy and reliability are required to be combined with ease of construction and maintenance.

Shown is a traditional streamlined hump in operation, which may be compared with the crump weir.



S6-20: 'V' notch weir

S6-22 Venturi Flume - (GRP)

A set of GRP mouldings for installation in the channel section to form a venturi flume.

S6-23: Ogee Weir & Manometer Board - (GRP)

Eight pressure tappings (2 upstream, 5 downstream, 1 at apex) complete with multi-tube piezometer board.

S6-24: Dam Spillway Models - (GRP)

Complete with the following interchangeable downstream sections:

- *spillway toe*
- *roller bucket toe*
- *apron with removeable energy dissipator*

S6-25: Syphon Spillway - (Acrylic)

Complete with adjustable breather tube.

S6-26: Self-regulating Syphon - (Acrylic)

S6-27: Roughened Beds - (GRP)

Two sections of different roughness. Each consists of three modules arranged to cover a 2.5m length.

S6-28: Vibrating Pile

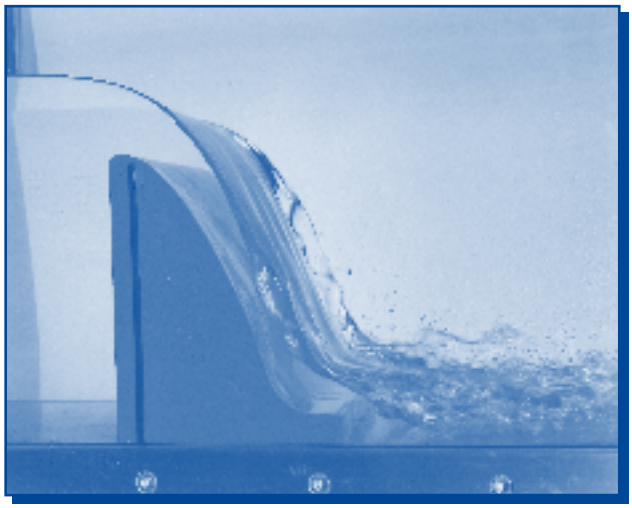
For the study of vortex shedding by piles and tall structures.

S6-29: Lift & Drag Balance & Models - (GRP)

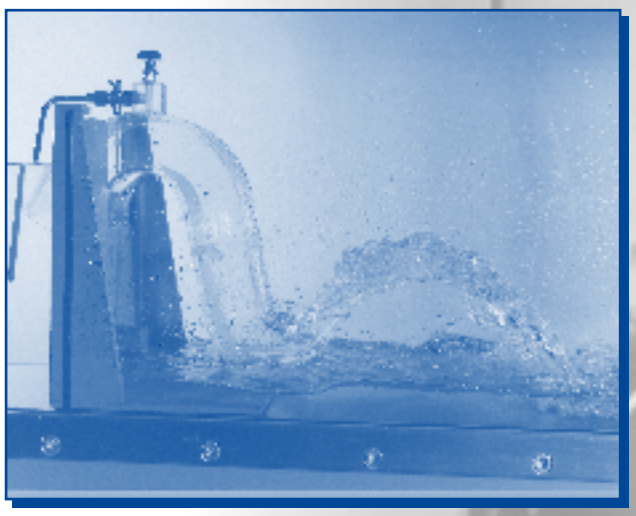
Three models - large and small diameter cylinders and an aerofoil section.

S6-30: Pitot Tube & Manometer Board - (GRP)

Complete with traversing carriage and vernier height adjustment, and an inverted paraffin water manometer for magnification of small pressure differences.



S6-23: Ogee weir



S6-25: Syphon spillway

S6-31: Crump Weir - (GRP)

Single pressure tapping at apex, complete with piezometer tube.

S6-32: Parshall Flume - (GRP)

One of the most widely used standing wave flumes; allows comparison of head-flow characteristics with those published in the literature.

S6-33: WSC Flume - (GRP)

Developed by Washington State College, this trapezoidal flume conforms more closely to natural channel sections and passes sediment even more freely than the Parshall Flume.

S6-35: Wave Generator

Simple, regular, flap-type generator designed to be mounted on the flume discharge tank.

S6-36: Beach

Wave absorption beach for use with S6-35 or S6-45 to reduce the effect of reflected waves.

S6-37: Zagni Flow Monitoring System

Consists of a free standing manometer board and instrument carriage fitted with Pitot tube and interconnecting tubing. This system may be used to establish the basic parameters of fluid flow in the channel including, invert slope, surface profiles, pressure profiles and velocity profiles.

S6-40: Instrument Carrier

Both longitudinal and transverse movement and position lock.

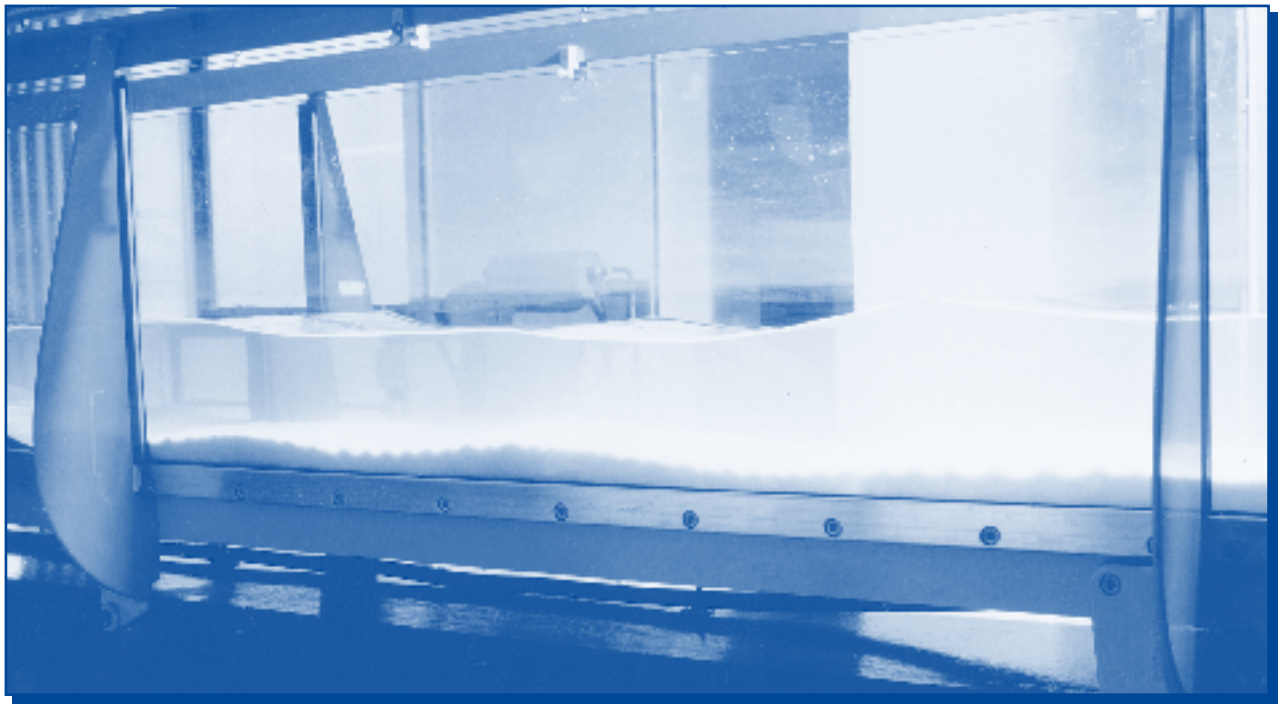
S6-42: Velocity Meter and Mountings

Velocity probe and digital meter, complete with mounting attachments to channel.
Range 0.6. to 3m/sec.

H-1/2/3: Hook & Point Gauges

Designed to be mounted on S6-40.

S6-45 Random Wave Maker



This machine utilises the base hinge weir in the discharge tank of the Armfield S6 Flume as the paddle. The S6-45 Control box interfaces with a personal computer (not supplied by Armfield) via a serial interface.

Wave generation software

- *Regular waves*
- *Irregular waves - filtered white noise*
- *Irregular waves - Fourier series*
- *User defined wave generation techniques*

This is an advanced software package designed to simulate long crested sea conditions. It can generate Regular, Irregular and Solitary waves.

It is capable of running on any Windows compatible-PC with a free serial interface.

Installation is by means of an installation program. Following installation it allows all the relevant dimensional details of the paddle to be entered and saved in a file.

The experimental transfer function can be entered and saved for a range of water depths.

Wave height and period requirements are entered at full (prototype) scale together with the model scale being used.

When it is running, the parameters of the generated sea state and a real time graphical display of the paddle movement are shown on screen.

For more information on S6-45 request data sheet S6-45 provisional

Special Tilting Flumes

Many areas of study require or are enhanced by using flumes with a tilting capability. This mostly translates into positive slope but sometimes there is the requirement for negative slope.

The most important aspect of a tilting flume is retaining the integrity of the working section, i.e., maintaining tolerances.

To achieve this requires an extremely rigid design which ensures almost no deflection regardless of load or tilt. Design of the jacking system is crucial in guaranteeing this.

The general construction of such flumes is similar to the tilting flume described at S6 MKII.

Dimensions can be modified to suit requirements.

Jacking Systems

Tilting flumes need jacks to raise and lower them. The need for stability and the size and weight of the installation make this element of crucial importance.

Various options are available, including chain drive and hydraulic lift. None, however, give the degree of repeatable accuracy achievable with screw jacks driven through shafting and gear boxes. The Armfield choice.

Long flumes need a series of jack stations carefully linked to avoid distortion of the main frame.

On larger flumes, or where exceptional degrees of slope are involved, a pivot mechanism at each station ensures a vertical aspect to the jacks at all times.

Other features include indicators for setting slope, soft "bearings" to limit noise, electric drives (optional) and detection systems permitting operation only if all jacks move together.

Not all applications require a flume to be tilting. In many cases it is sufficient for the unit to have a fixed horizontal position. In such cases the options for construction are increased. The most flexible arrangement being a wood/composite and glass panelled knock-down form.

Wood/Composite and Glass Panelled Construction

Flumes of this type are invariably fixed bed, as the structure does not lend itself to the rigidity required for tilting. The knock-down format is particularly suited for research facilities where future projects may require flow channels of different proportions. The knock-down design provides for optimum flexibility in the assembly of the flume, inlet and outlet tanks, service pumps and pipework.

The walls are made of varnished plywood or composite materials and glass panels which are interchangeable. A special jointing compound, which remains plastic, is watertight and bonds itself to the glass or wood/composite, seals the panels which are themselves supported by mild steel channel sections. These sections are spaced at regular intervals and support the flume bed and side walls through adjustable jacking studs. It is therefore possible to level and align the flume with the utmost accuracy.

Steel Bed and Glass Wall Construction

Similar in construction to the tilting flume described at S6 Mk II, these flumes do not require the sophisticated underframe or jacking system of a tilting flow channel. Instead, they sit on simple 'A' frames, whilst the accuracy of the working section continues to be maintained at the same high levels prescribed for all other flow channels.

Sediment Transport

Studies involving bed movement are increasingly relevant, frequently based around environmental issues. A topic notoriously difficult to study in the field lends itself to detailed study using a flow channel in the controlled environment of a laboratory.

Recirculating Sediment Systems

Frequently in experimentation there is the need for erosion and/or deposition. This requires the circulation of sediment. For this configuration a flow channel requires a recirculating loop enabling the water containing sediment in suspension to be recirculated. Armfield flow channels can be designed to incorporate such loops, the pipework being designed to ensure the sediment stays in suspension and does not settle out within the system.

Sediment is abrasive and this makes the selection of materials of particular importance. Pumps are usually lined with glass, valves are reduced to a minimum and flow metering is via electro-magnetic flow meters that do not require any components within the flow. Flow visualisation areas must be of toughened glass and stainless steel is essential on the base and in tanks.

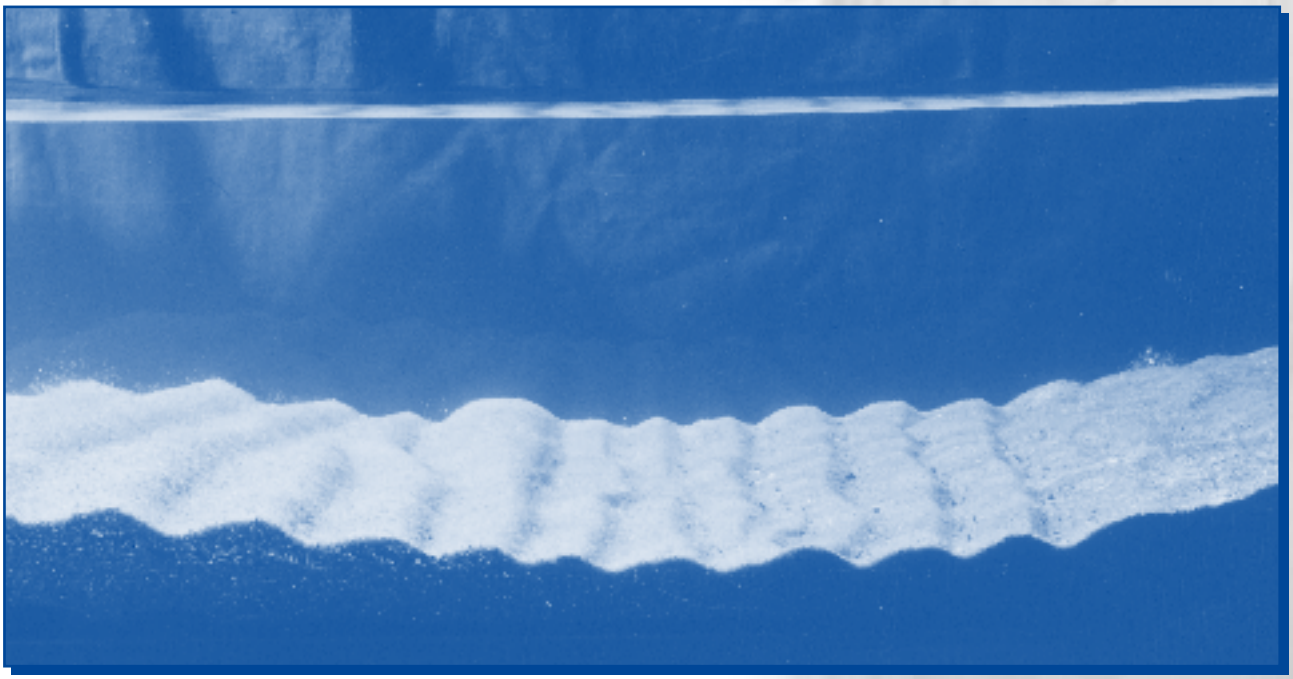
Non-Recirculating Systems

These tend to be more complex and require that sediment be collected after discharge, either through a settling tank or hydro-cyclones.

Ancillary Hardware

These typically include sediment feeders and sediment samplers.

Armfield have in-depth experience of all these options and are happy to advise on supply.



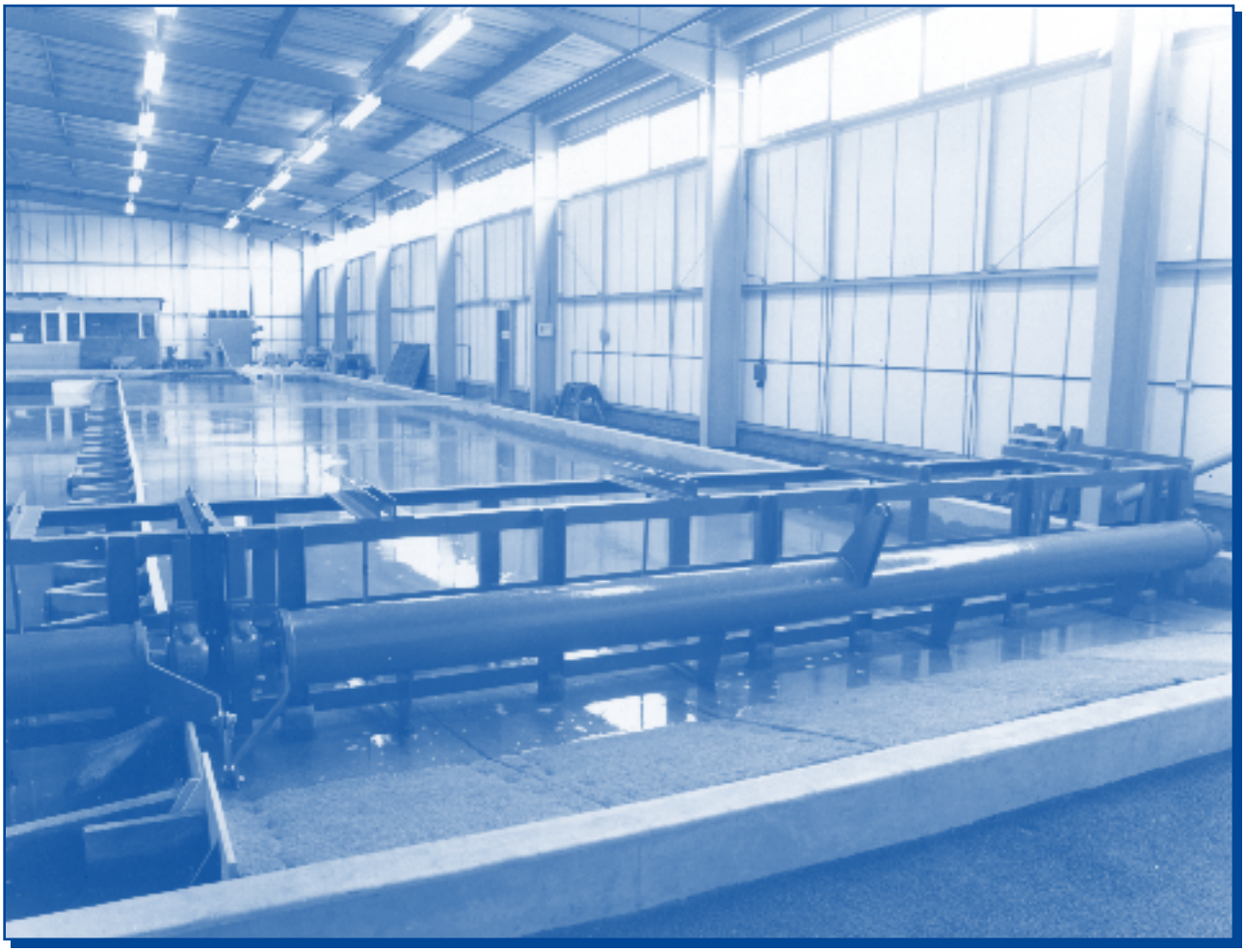
Wave Generators

Wave generation and the effects of waves are significant areas of study. Wave generators themselves can range from simple mechanical systems for regular waves through multi-paddle random generating systems that may be computer controlled. For many applications, particularly coastal models and flume studies, long crested and directional random waves are sufficient to model the sea state. For offshore studies and some shallow water problems multi-directional components are required.

In flumes or open channels, such as described in this brochure, there are a number of different types of wave maker that are appropriate. For small scale laboratory installations electrically driven piston machines are available. Where larger flumes are involved hydraulic powered piston machines and for deeper water, wedge type wave makers. Flumes may be used to study breakwaters, sea walls and beach behaviour, or for fundamental research.

Multi-element wave makers recreate complex short crested waves. Many wave makers of this type have hinge-flap type paddles and are used, for example, in offshore sea basins where models of oil and gas rigs are tested. For shallow water piston mechanism is the preferred mechanical option.

Whatever the application Armfield can supply a complete system designed to suit your particular requirements.



Instrumentation

A selection of instruments is available for use in flumes, channels and basins:-

H1-1 to H1-11	*Vernier Hook & Point Gauges*
H12-1 to H12-7	*Manometers including water, pressurised, water-mercury*
H12-8 to H12-9	*Portable Pressure Meters*
H30-1H to H30-3H	*Pitot Tubes*
H32	*Turbulence/Velocity Meter*
H33 to H33-11	*Velocity Probes, Digital Indicator and Data logger*
H40-1-1 to H40-2-3	*Wave Probe Systems*

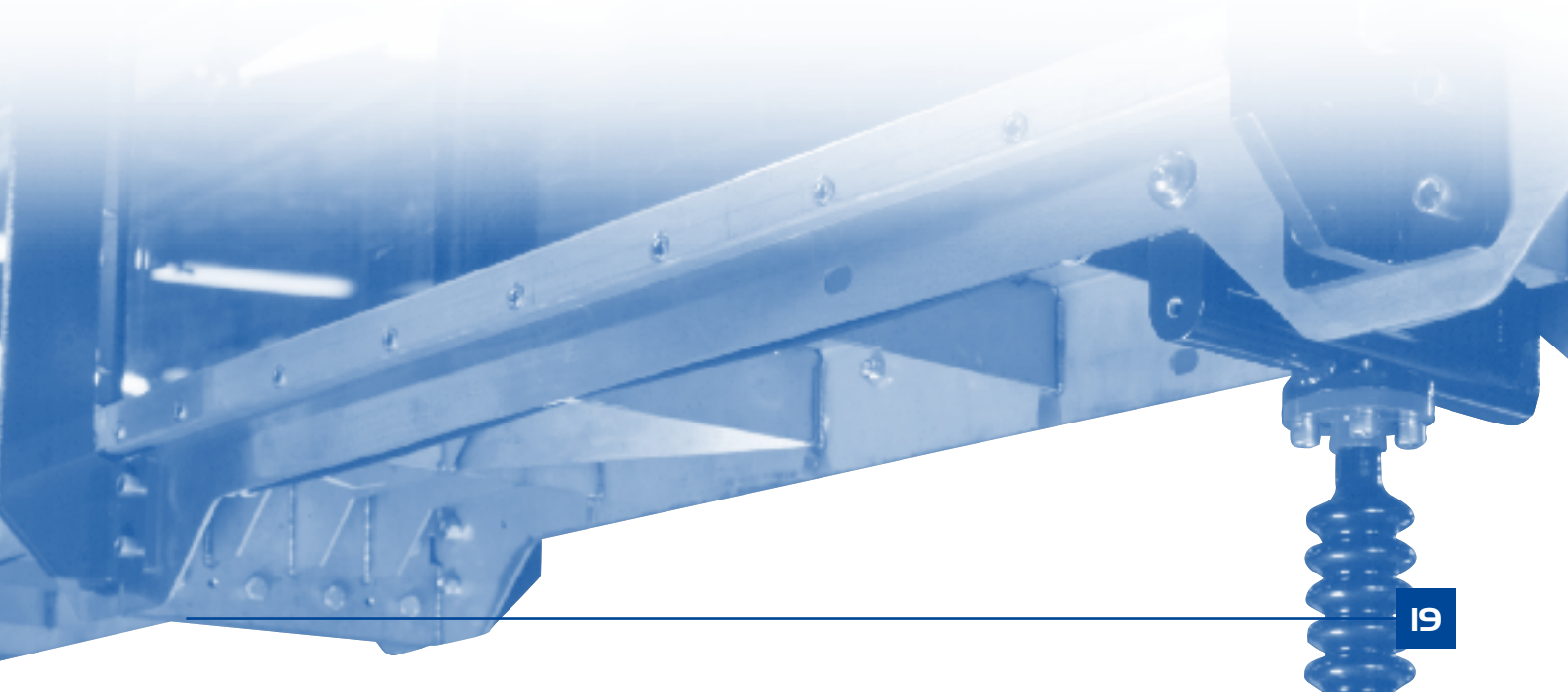
Individual detailed catalogues available on request.

Ordering options S6MkII

S6 MkII - 5.0m	*Basic self contained flume (no electrics)*
S6 MkII - 7.5m	*Basic self contained flume (no electrics)*
S6 MkII - 10m	*Basic self contained flume (no electrics)*
S6 MkII - 12.5m	*Basic self contained flume (no electrics)*
S6 MkII - C	*415V/3ph/50Hz - Basic electrics comprising control console & pump*
S6 MkII - D	*208V/3ph/60Hz - Basic electrics comprising control console & pump*
S6 MkII - E	*380V/3ph/50Hz - Basic electrics comprising control console & pump*
S6 MkII - F	*220V/3ph/60Hz - Basic electrics comprising control console & pump*
S6 MkII - SL	*Sediment loop for any of the above flumes*
S6 MkII - 14 - 1	*Powered jacks for 5.0m or 7.5m flumes*
S6 MkII - 14 - 2	*Powered jacks for 10m or 12.5m flumes*

Shipping Specifications S6MkII

Available on request



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Specifications may change without notice.
iss12/5k/0206/TRG.