DISCOVER WITH armfield

S SERIES: APPLIED HYDRAULICS & HYDROLOGY

LABORATORY FLUMES AND CHANNELS FOR HYDRAULIC TEACHING/RESEARCH STUDIES

FEATURING

> *Standard Flumes*
> *Special Flumes, Tanks and Basins*
> *Ancillary Equipment*

- *Sediment Transport Facilities*
- *Mono and Random Wave Makers*
- *Instrumentation*

NEW

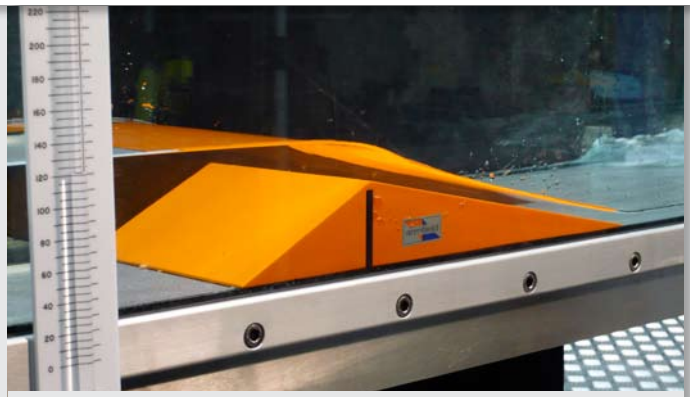
New research flumes available as standard

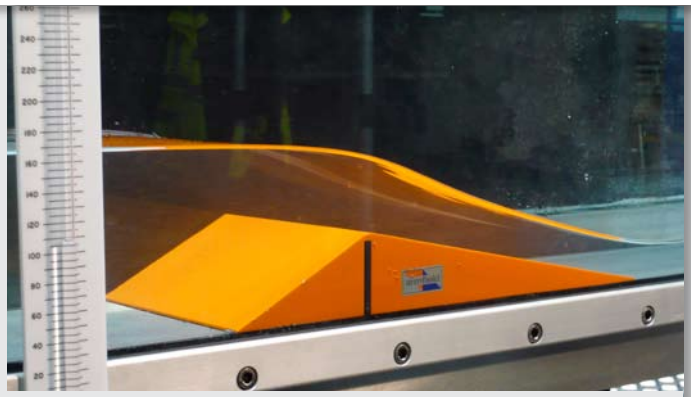
BM TRADA CERTIFICATION ISO 9001:2008 UKAS QUALITY MANAGEMENT 012

EXTENDED WARRANTY 2 years 2YR WARRANTY ON ALL ARMFIELD PRODUCTS

The latest version of this data sheet is available at:
www.armfield.co.uk/flumes

ISSUE 1





Crump weir

INTRODUCTION

Armfield has been designing and supplying open channel facilities (sometimes referred to as flumes) to hydraulic laboratories throughout the world for over 50 years.

This brochure presents the full range of channels/flumes available from Armfield, both teaching & research, Standard & special.

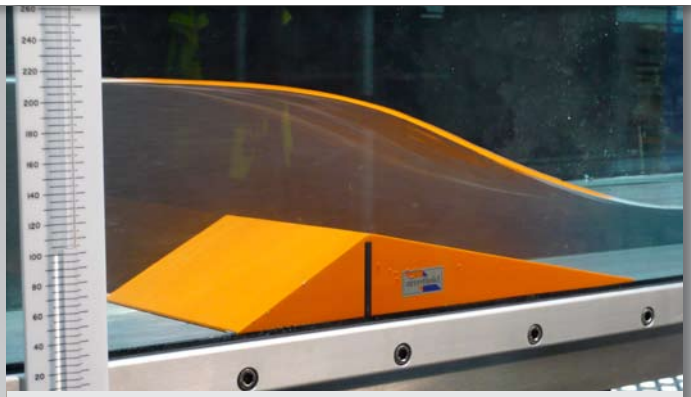
There are also general comments about the design, flexibility & accuracy of flumes in order to assist those embarking on the specifying & purchase of flumes for advanced studies or research.

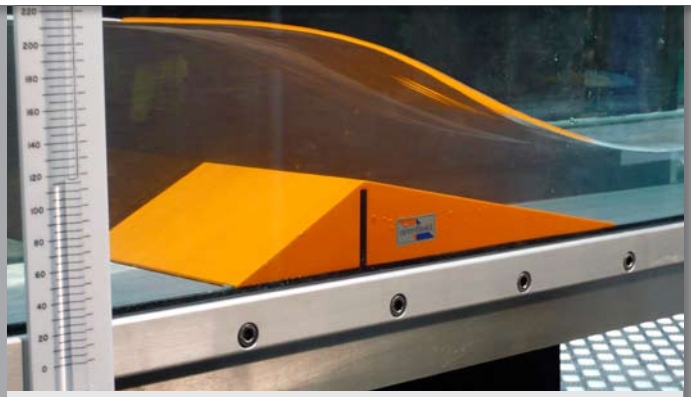
Usually channels are of rectangular prismatic section. The dimensions of the working cross-section and length are the principal features which determine both the functional suitability and the cost of a channel.

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*

10M Research Flume - Purdue University, USA





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, GRP, or stainless steel. 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.

S6MkII model mounting system

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 some 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 & computer linked data gathering.

Typical 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 50 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.

S6MkII - Upstream of the Trapezoidal plate weir

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.

Detail of slope scale, and slope control Inch buttons with Emergency Stop. Electronic slope also indicated on the main control console - inset

Gearboxes at each jacking point ensures accuracy of the tilting channel bed and the benefits of ease of operation.

JACKING SYSTEMS

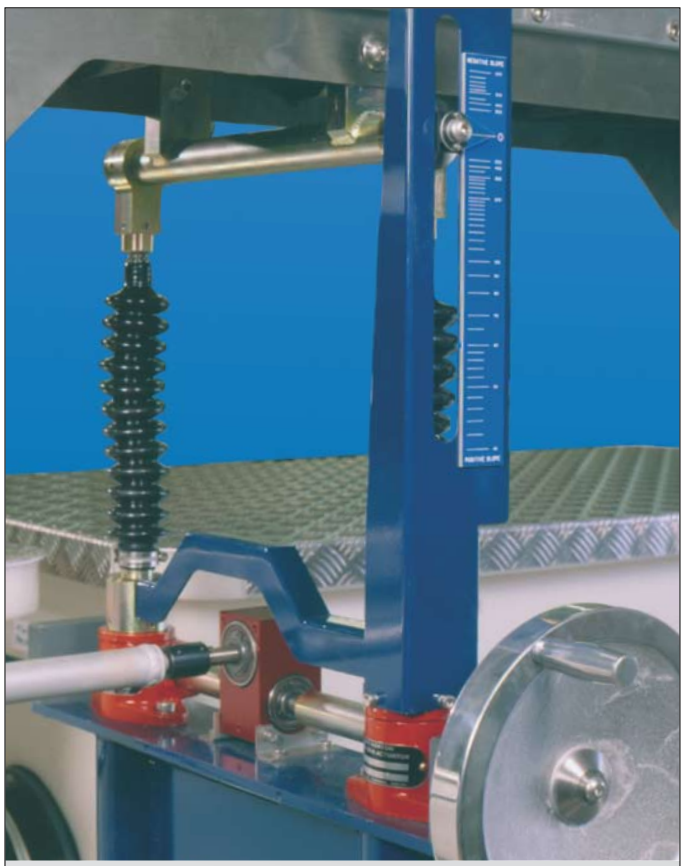
Tilting flumes need jacks to raise and lower them. The need for stability and the size and weight of the installation make this element of crucial importance.

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.



S6MkII Jacking station

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 except in flumes with a smaller cross section. 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 sometimes faced with stainless steel 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.

SEDIMENT TRANSPORT

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.

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.

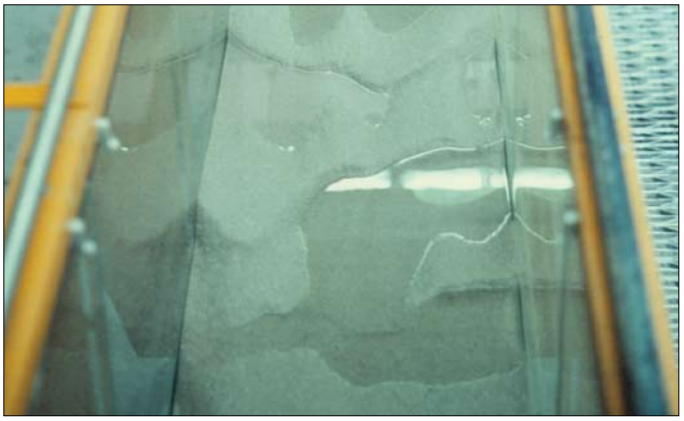
NON-RECIRCULATING SYSTEMS

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

ANCILLARY HARDWARE

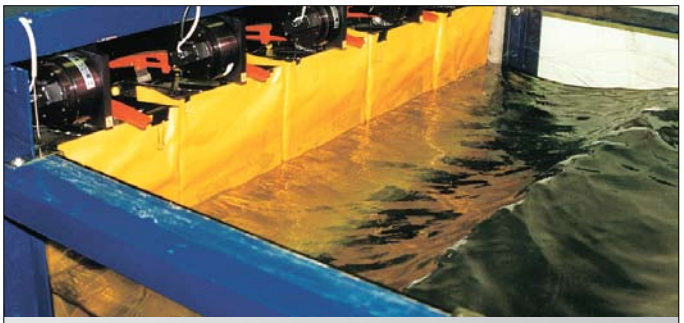
These typically include sediment feeders and sediment samplers.

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



Exeter University - UK

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.



Multi paddle, computer driven random wave maker

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.

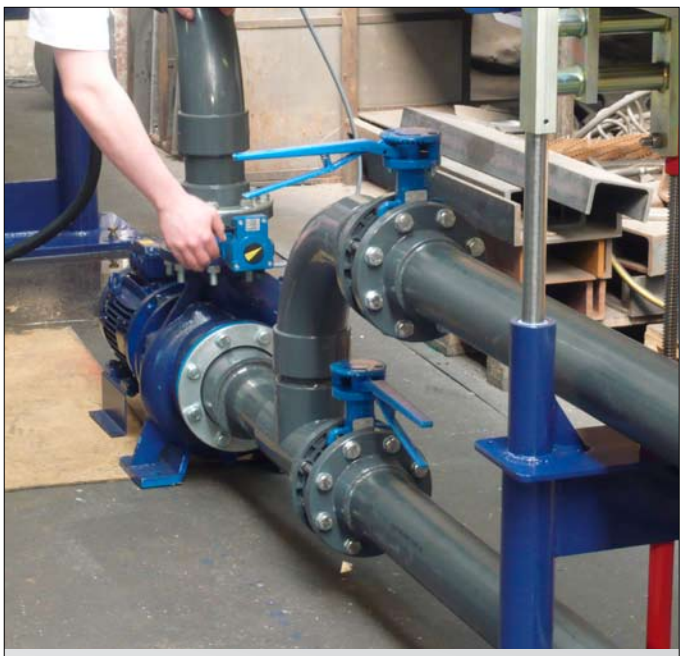
Whatever the application Armfield can supply a complete system designed to suit your particular requirements.

Associated British Ports - UK

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*



Typical pump/pipework configuration

Detail showing side support and side wall adjustment system

- > *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 thus extending the working length*
- > *Standard flumes have a comprehensive range of accessories, instruments and models available*
- > *Non-corroding, durable materials used througout for water contacting surfaces*
- > *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*

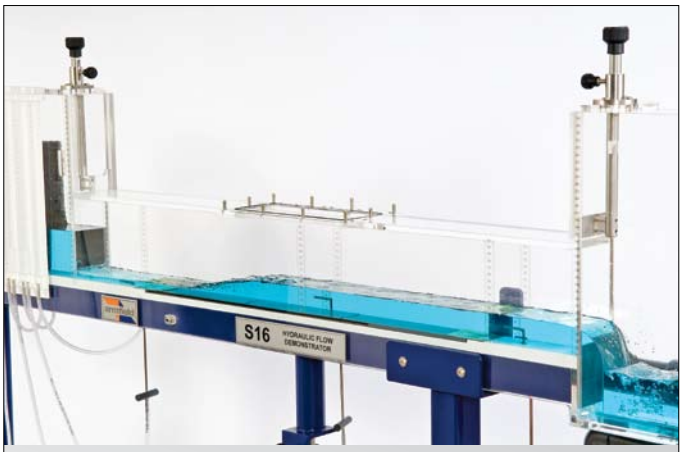
F1-19 FLOW CHANNEL

F1-19

A Simple channel supplied as an accessory to the popular demonstration facility F1-10 Hydraulics Bench. The channel introduces students to the characteristics of flow in an open channel at an elementary level.

For more information see data-sheet
URL: www.armfield.co.uk/f1

S16 HYDRAULIC FLOW DEMONSTRATOR



S16

This unique facility demonstrates flow through both open channels and closed conduits. It has an elevating bed section and models of various hydraulic structures.

For more information see data-sheet
URL: www.armfield.co.uk/s16

Laser PIV System H41 for flow visualisation
(S16 flume compatible)
URL: www.armfield.co.uk/h41

C4MKII MULTIPURPOSE TEACHING FLUME

C4MkII shown with F1-10 Hydraulics Bench

This versatile teaching flume has been specifically designed to demonstrate the principles of Fluid Mechanics when applied to engineering structures in open channel flow. Available in 2.5m or 5.0m lengths and with a wide range of accessories.

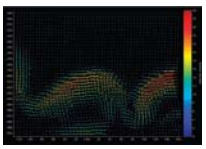
For more information see data-sheet
URL: www.armfield.co.uk/c4

S8 SEDIMENT TRANSPORT DEMONSTRATION CHANNEL

S8 shown with accessories and typical bed-form (Inset)

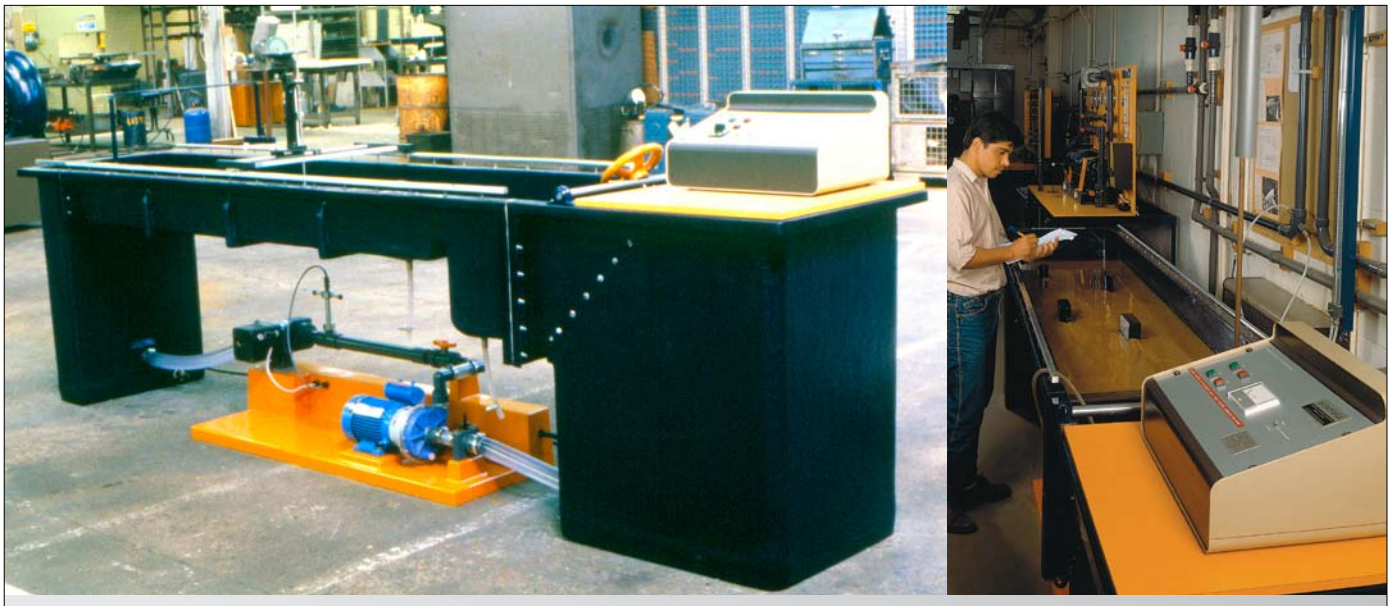
This teaching facility allows the demonstration of the full range of bedforms that arise in a mobile bed as the flow and/or slope are increased. The equipment is portable and therefore may be used in the classroom as well as in the laboratory.

For more information see data-sheet
URL: www.armfield.co.uk/s8



Laser PIV System H41
For flow visualisation
(S8 & S16 flume compatible)
URL: www.armfield.co.uk/h41

S2 MOBILE BED AND FLOW VISUALISATION TANK



This unit may be used in two principal fields of study. The first involves detailed investigation of mobile bed situations, The second, two dimensional flow visualisation.

For more information see data-sheet
URL: www.armfield.co.uk/s2

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 are a number of optimum cross-section dimensions that will fill the great majority of educational and research needs.

Armfield now offer a range of standard cross sections in both tilting & fixed bed configuration.

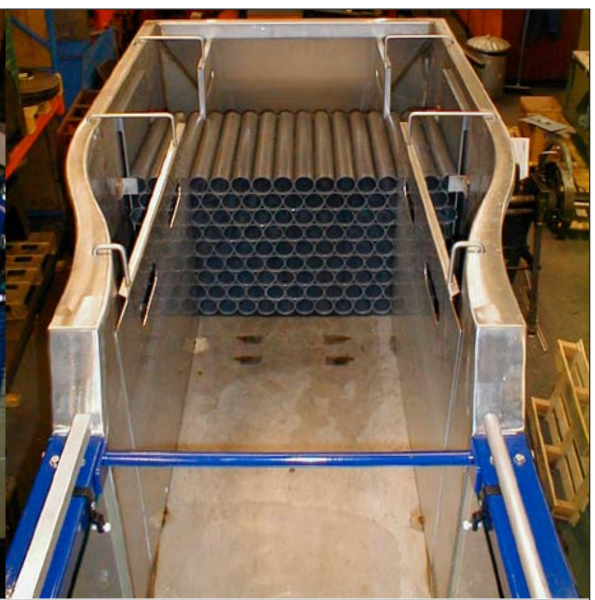
These are:

300mm wide x 450mm deep (S6MkII) Tilting only
600mm wide x 600mm deep (S20 & S21)
1000mm wide x 1000mm deep (S22 & S23)

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 ranging from 5M to 15M in increments of 2.5M

Loughborough University flume during construction.

Stilling device



Flow profiler

S6 MK II GLASS SIDED TILTING FLUMES

10m working section. The end tanks actually extend the effective length of the flow channel beyond this. S6 MkII Glass sided Tilting Flume

DESCRIPTION

If the requirement is for a flume suitable both for teaching & project/research work then the very popular S6MkII has to be the flume of choice, offering high levels of dimensional accuracy, a wide selection of models & accessories & formatting in various configurations.

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, & 15m. 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.

A computer control and data logging package is also available. See S6MkII-50 & S6MkII-90.

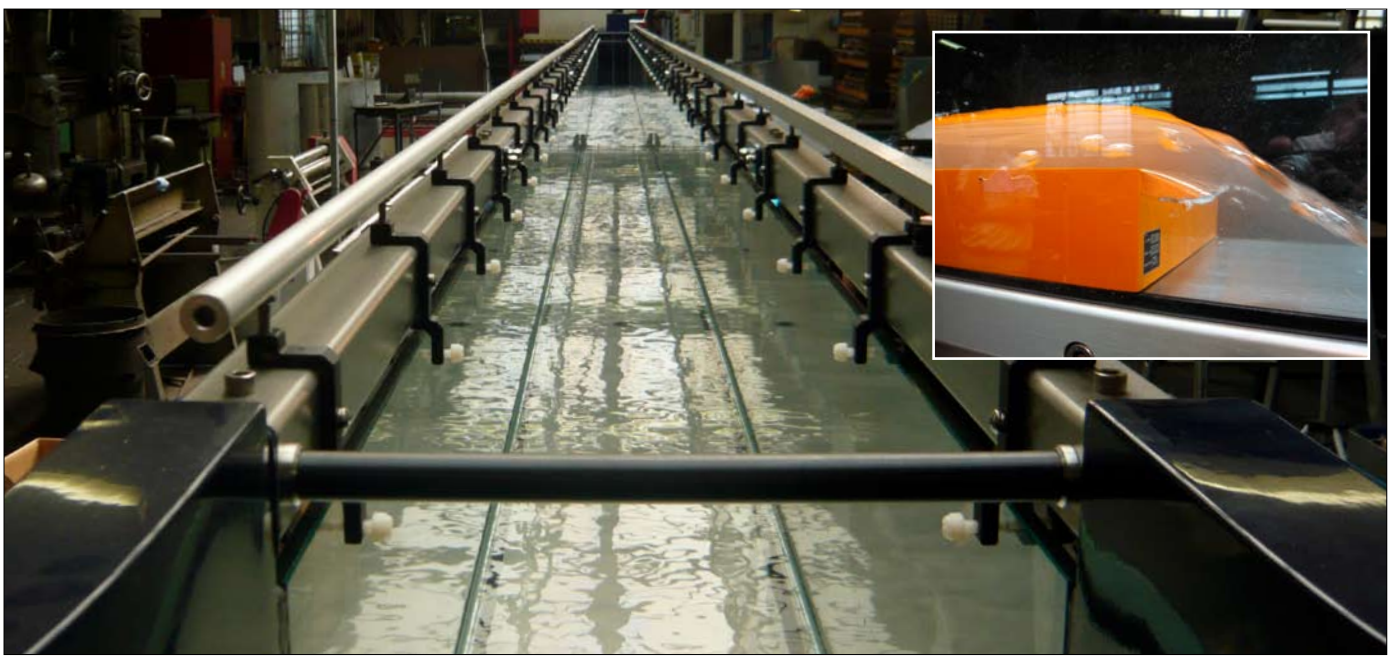
The flume is tilted using a jacking system - a single jacking station on 5m flumes. Flumes up to 15m have two or three jacks interconnected by a geared drive. A slope indicator is provided.

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.

S6MkII view from outflow end showing sump tank arrangement

TECHNICAL DETAILS

Width	*300mm*
Depth	*450mm*
Length	*As ordered (multiples of 2.5m) Note: overall length is 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 *-ve slope*	*1:40 max (1.4°)* *1:200 max (0.28°)*
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*



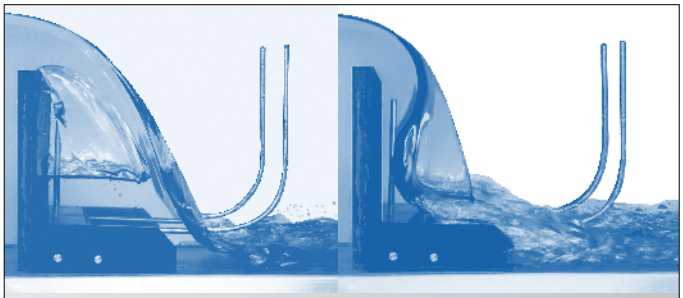
EXPERIMENTAL MODELS & INSTRUMENTATION

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.

V-notch, Sutro and Rectangular plate weirs
Trapezoidal and Sharp Crested weirs also included with the S6-20.

S6-20: PLATE WEIRS - (STAINLESS STEEL)



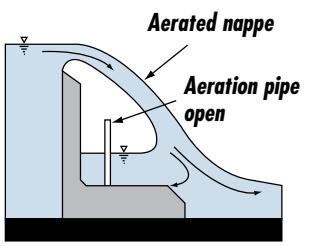
S6-20: Rectangular overshot weir - in operation

> screw operated adjustable undershot weir

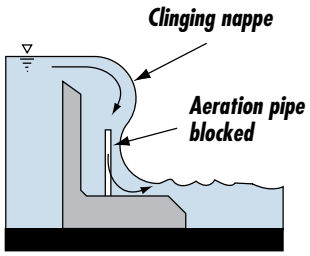
> mounting block, for a range of interchangeable plate weirs that are included in the supply:

- *Sharp crested weir (with aeration pipe)*
- *Rectangular notch weir*
- *Trapezoidal notch weir*
- *90° vee notch weir*
- *60° vee notch weir*
- *Sutro notch weir (linear proportional weir)*

User can fabricate & fit other weir types.



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)***

S6-20: Rectangular overshot weir - theory

S6-21: BROAD CRESTED WEIRS - (GRP)

> rectangular sharp cornered weir

> rectangular streamlined weir

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.

S6-21: Broad crested weir - theory

S6-21: Broad crested weir - in operation

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)

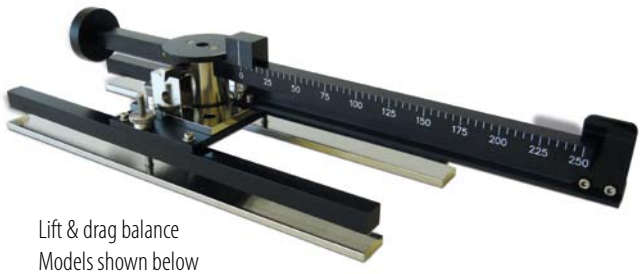
Three models - large and small diameter cylinders and an aerofoil section.

S6-30: PITOT TUBE & MANOMETER BOARD - (GRP)

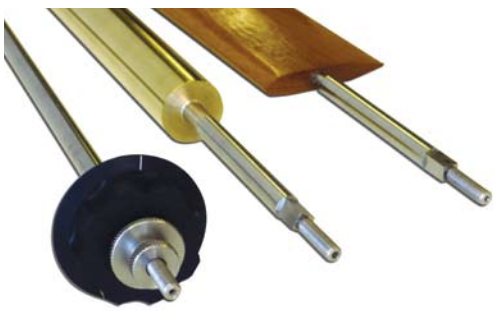
Complete with traversing carriage and vernier height adjustment, and an inverted paraffin water manometer for magnification of small pressure differences.

Ogee weir & manometer board

Roughened beds



Lift & drag balance
Models shown below



A selection of S6MkII accessories

EXPERIMENTAL MODELS & INSTRUMENTATION

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 SYSTEMS

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.

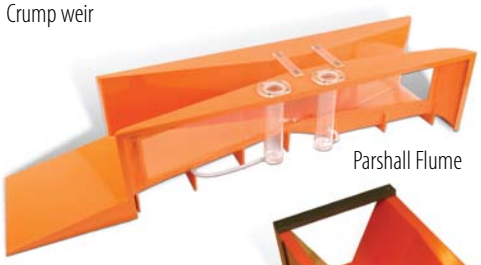
S6-42: VELOCITY METER AND MOUNTINGS

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.

Crump weir



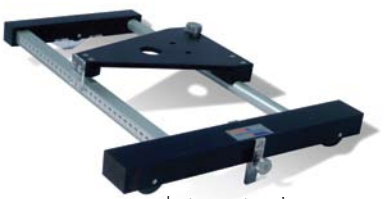
Parshall Flume

WRC Flume

Artificial Beach

Zagini Flow Monitoring Systems

Hook & point gauge



Instrument carrier

A selection of S6MkII accessories

S6-MKII-50 SOFTWARE CONTROL AND DATA ACQUISITION PACKAGE

The S6-MkII-50 Software Control and Data Acquisition package includes an inverter within the control console for electronic speed control for the flow channel pump. It also includes the S6-MkII-90 data logging and instrumentation system.

The S6-MkII-50 option must be specified at time of order, and cannot be retrofitted to existing flumes. The S6-MkII-90 Datalogger can be added at any time and can be retrofitted to existing S6-MkII Flumes.

CONTROL FUNCTIONS:

- *Inverter speed control of circulating pump, either by front panel control or from a PC. When using PC control the pump speed can be set in a PID loop to maintain a constant flow rate.*
- *Control of powered jacking system to set specific slope of bed.*

S6-MKII-90 data logging and instrumentation system
Front and rear of the console

DATA LOGGING AND INSTRUMENTATION SYSTEM (S6-MKII-90) FUNCTIONS

(Included with S6-MkII-50 and available independently)

- *Electronic inclinometer to measure slope of bed*
- *Electronic manometer to measure:*

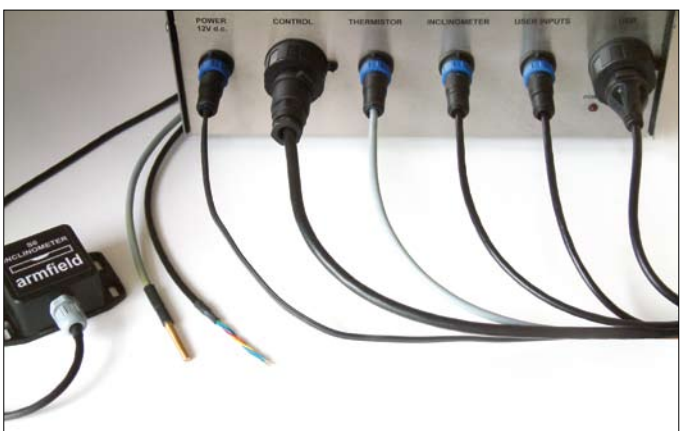
  Pressure distribution at 10 locations, Range: ±690mm H_2O (+/- 1 psi) e.g. bed tappings or tappings on hydraulic structures such as S6-23 Ogee weir.

  and

  Single low range differential pressure sensor, Range 0 to 254 mm. H_2O (0 to 10”), e.g. for use with S6-30 Pitot tube.

- *2 Voltage input channels for use with their instrumentation, Range: ± 5Volts. e.g. for use with S6-42 Velocity meter and H40 Wave probe. (These voltage inputs can be scaled to engineering units in the software).*
- *Thermistor sensor to measure water temperature, Range 0-50°C.*
- *USB interface and software included to allow data logging of the above parameters. The software includes sophisticated sampling, calibration and graph plotting facilities including the ability to save or export the data in Microsoft Excel format.*

Essential Requirement: Windows PC with USB port. *(not supplied by Armfield).*



Rear of the console showing:
Main connections, S6 Inclinometer, Thermistor and lead for user inputs.

S6-45 RANDOM WAVE MAKER

Controls for S6-45 Random Wave Maker

This machine utilises the base hinge weir in the discharge tank of the Armfield S6MkII 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.

GENERATED SEA STATES

Regular waves
This method of signal generation enables regular monofrequency waves to be produced with a specific height and period.

Irregular waves - filtered white noise method
This method of signal generation is based on the principle of digitally filtered white noise and is generated in real time. Three sources of white noise are available based on either a single shift register, multiple shift registers or random numbers with a Gaussian distribution. The white noise source is generated and passed through a digital filter to produce the required position demanded signal for the paddle.

The characteristics of this filter are obtained by performing a Fast Fourier transformation based on the spectral shape that has been selected.

The advantage of this method is that it creates sequences which can be varied from a few seconds to several years whilst only requiring enough memory to hold the sea state parameters.

This ability to create long non-repeating sequences is of great importance when testing models which have a non-linear response. Extensive tests have been carried out which demonstrate that the waves produced using this system are realistic and that they do fit the statistical theories for ocean waves.

The data inputs required are:

- *model scale*
- *spectral shape*
- *sequence length*
- *sequence start condition*
- *run time*

The sequence start condition is a very useful feature because it allows exactly the same random sequence to be generated each time as this is essential for comparative tests.

Besides allowing the user to completely define the spectral shape, many standard shapes are available including:

- *Pierson-Moskowitz*
- *JONSWAP*
- *ITTC*
- *1SSC*
- *Darbyshire Coastal*
- *Darbyshire Ocean*
- *Neuman*

Irregular waves - Fourier series method

This method is equivalent to the summation of sine waves of different frequencies and amplitudes to reproduce the specified energy spectrum.

In fact the output time series is produced by carrying out an inverse Fourier Transform of the spectral amplitudes after applying the appropriate Transfer Function.

Two options are provided. In the first the frequency components are produced with random phase. In the second the components have random phase and amplitude.

The technique is not suitable for producing signals in real time so the required values are computed and stored in a file. This is read by a 'playback' program when the waves are to be generated. Once created these files may be kept and used repeatedly.

A single FFT operation cannot produce a time series of infinite length and the limit in this system has been set to 2048 points. Longer sequences are available however, made by carrying out a number of FFTs and merging the individual sequences together to create one of the length which the user has requested.

This method provides all the spectral types which are available from the filtered white noise method.

SPECIFICATIONS

General
Output signal ± 10 volts

Standard sea states available:

> *Pierson-Moskowitz*
> *JONSWAP*
> *ITTC*
> *ISSC*
> *Darbyshire Coastal*
> *Darbyshire Ocean*
> *Numan*

Sea states may be defined by:

> *Windspeed*
> *Wind speed and Fetch*
> *Wave frequency and height*
> *Frequency*
> *16 Ordinates of spectral density*

Random waves may be based on:

> *White noise with single or multiple shift registers or random numbers, all with variable test length*

> *Fourier series with variable or fixed amplitude, and with variable test length*

> *User defined techniques*

Transfer Functions:

> *Automatic recompilation of the paddle demand signal with changing Transfer Function*

> *Interpolation of Transfer Function between defined frequencies*

NB

This basic random wave maker concept can be applied to all our large flumes. Paddle configurations can vary to siut the application.

Ask for details & a quotation.

NEW

GLASS SIDED TILTING AND NON-TILTING STANDARD FLUMES FOR RESEARCH

These larger Flumes are considered research facilities and so it needs to be noted that most of the models and accessories available for the S6-MkII are not available for these flumes. The exception are the Wavemakers. We can offer Wavemakers for these flumes to special order.

In construction the tilting versions are very similar in design and performance to the S6-MkII range. However due to their increased size there are certain design differences that reflect the greater loads being transported and the higher flow rates offered.

These differences comprise bed manufacture i.e. mild steel, laminated with stainless steel on the wetted side, a rigid supporting underframe and the end tanks are manufactured from stainless steel.

The other major differences relate to the capacity of these bigger units. The standard units do not have floor mounted reservoir tanks. Instead they incorporate closed loops for re-circulation. These loops are designed as standard to accommodate sediment transport as a feature. In addition flow is controlled via the pump(s) where at least one pump has variable speed control.

The jacks are electronically driven via 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.

The non-tilting options have generally the same performance criteria to the tilting options but their method of construction is lighter and more flexible. The working section is of a proven design and utilizes a steel framework robust enough to support the weight of water. The sides are toughened glass and the base is constructed from marine plywood faced with stainless steel or can be toughened glass where visualisation is required. The sections are suspended within the steel frame. Section sizes are approximately 2.5m long making them easy to manhandle during construction or at any time in the future.

One of the features of the non-tilting design is the ability to modify the flume in various ways at a later date.

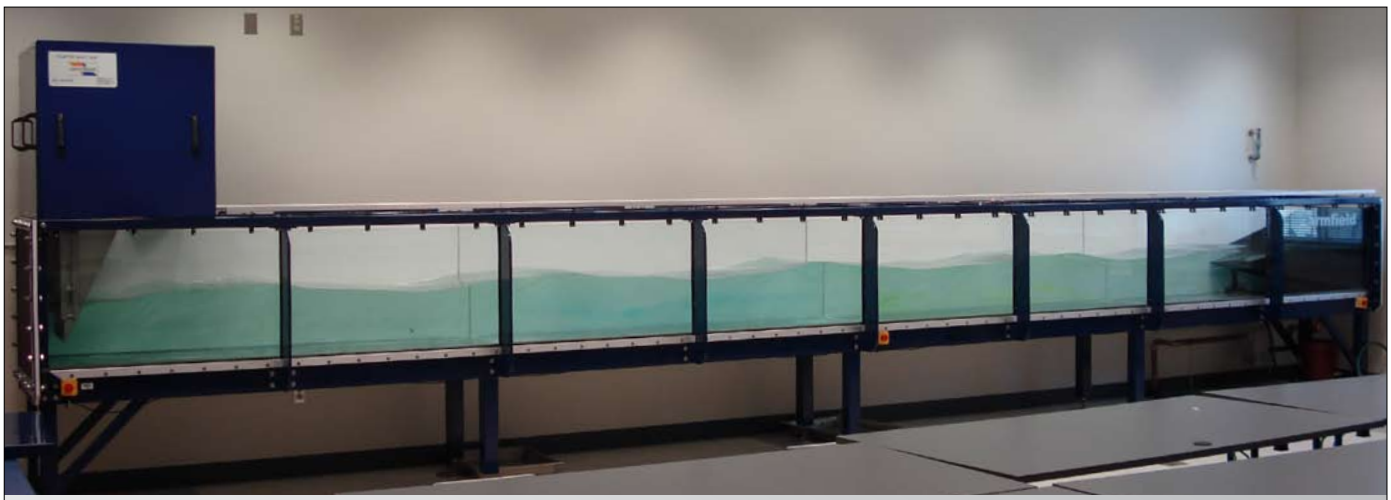
For example:-

- *> Increase the length*
- *> Re-configure the dimensions*
- *> Add viewing panels in the base*

Unlike the tilting versions which come in pre-glazed 2.5m modules the non-tilting versions are flat-packed for assembly at site.

Both tilting and non-tilting are available for service from an existing laboratory supply or as advised above with a fully self-contained capability.

They are available in standard working lengths of 5m, 7.5m, 10m, 12.5m, and 15m. Longer lengths are available to special order in increments of 2.5m.



10m Wave tank

TECHNICAL DETAILS

	S20/S21	S22/S23
Working width	600mm	1000mm
Working depth	600mm	1000mm
Working length	As ordered (Multiples of 2.5m)	As ordered (Multiples of 2.5m)
Walls	Toughened glass	Toughened glass
Bed-tilting versions	Mild-steel laminated with stainless-steel	Mild-steel laminated with stainless-steel
Bed non-tilting versions	Marine Plywood laminated with stainless-steel or glass	Marine Plywood laminated with stainless-steel or glass
End tanks	Stainless-steel	Stainless-steel
Pump(s)	Close-coupled centrifugal	Close-coupled centrifugal
Slope (tilting only)	1:40 max (1.4°) + ve 1:200 max (0.28^) - ve	1:40 max (1.4°) + ve 1:200 max (0.28°) - ve
Flow meter	Electro-magnetic	Electro-magnetic
Maximum flow rate	120 L/sec	180 L/sec
Bed stability	<1.0mm (typically) at 540mm water depth	<1.0mm (typically) at 900mm water depth
Side wall stability	<0.5mm(typically) at 540mm water depth	<0.5mm(typically) at 900mm water depth
Maximum particle size when circulating sediment	3mm diameter	3mm diameter

WAVE TANKS

Using the same methods of construction as used by the non-tilting flumes Armfield can offer wave tanks of similar dimensions with or without water circulating and with simple mono wavemakers or sophisticated random machines.

Further details on application.

ORDERING OPTIONS

S6 MkII flumes - cross section 300mm wide x 450mm deep

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 -15m	*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*

NEW

New research flumes - available as standard

S20/S21 flumes - cross section 600mm wide x 600mm deep

S20 - 7.5m	*Basic flume - Tilting (no services)*
S20 - 10m	*Basic flume - Tilting (no services)*
S20 - 12.5m	*Basic flume - Tilting (no services*
S20 - 15m	*Basic flume - Tilting (no services)*
S20 - SERV(5/10)	*Service system - 7.5m to 10m*
S20 - SERV(12/15)	*Service system - 12.5m to 15m*
S21 - 7.5m	*Basic flume - Non-Tilting (no services)*
S21 - 10m	*Basic flume - Non-Tilting (no services)*
S21 - 12.5m	*Basic flume - Non-Tilting (no services)*
S21 - 15m	*Basic flume - Non-Tilting (no services)*
S21 - SERV(5/10)	*Service system - 7.5m to 15m*

S22/S23 flumes - cross section 1000mm wide x 1000mm deep

S22 - 7.5m	*Basic flume - Tilting (no services)*
S22 - 10m	*Basic flume - Tilting (no services)*
S22 - 12.5m	*Basic flume - Tilting (no services*
S22 - 15m	*Basic flume - Tilting (no services)*
S22 - SERV(5/10)	*Service system - 7.5m to 10m*
S22 - SERV(12/15)	*Service system - 12.5m to 15m*
S23 - 7.5m	*Basic flume - Non-Tilting (no services)*
S23 - 10m	*Basic flume - Non-Tilting (no services)*
S23 - 12.5m	*Basic flume - Non-Tilting (no services)*
S23 - 15m	*Basic flume - Non-Tilting (no services)*
S23 - SERV	*Service system - 7.5m to 15m*

POWER OPTIONS S20/21 & S22/23 FLUMES

Must be decided when ordering

C	*415V/3Ph/50Hz*
D	*208V/3Ph/60Hz*
E	*308V/3Ph/50Hz*
F	*220V/3Ph/60Hz*

INSTRUMENTATION

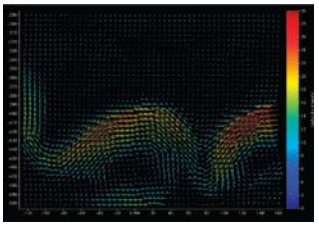
A selection of instruments is available for use in flumes, channels and basins:-

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*
H33 to H33-11	*Velocity Probes, Digital Indicator and Data logger*

H33
URL: www.armfield.co.uk/h33

H40-1-1 to H40-2-3 Wave Probe Systems

H41 Laser PIV System *(Suitable for S8MkII & S16 size flumes only)*



URL: www.armfield.co.uk/h41

Hydraulic Instruments (H series) data sheet available on request.

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