VPC FIBERGLASS

PARSHALL FLUME

User Manual

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vpcfiberglass.com P 585.735.9668 F 585.735.9965

2410 N. FOREST RD · SUITE 301 · GETZVILLE, NY 14068

INTRODUCTION TO THE PARSHALL FLUME

As a fixed hydraulic structure, a Parshall Flume is utilized for measuring sub-critical water flow in open channels. Developed to aid in the measurement of irrigation, this flume can now be found in the following uses:

- ❑ Sanitary sewage (piped & treatment plant)
- ❑ Industrial effluent
- ❑ Irrigation / water rights
- ❑ Storm Water
- ❑ Mine discharge /dewatering
- ❑ Cooling water discharge
- ❑ Dam seepage
- ❑ Landfill Leachate

STANDARDS

The design and discharge characteristics of the Parshall flume have been standardized in:

- ❑ ASTM D1941 – 91 (2013) Standard Test Method for Open Channel Flow Measurement of Water with the Parshall flume.
- ❑ ISO 9826: 1992 Measurement of Liquid Flow in Open Channels – Parshall and SANIIRI Flumes
- ❑ JIS B 7553 Parshall Flume Type Flowmeters

ACCURACY

While accounting for practical considerations such as approach flow, installation and dimensional tolerance, free-flow accuracy of Parshall flumes in field conditions is usually within +/- 5%.

DIMENSIONS

Refer to the Master Dimensions Chart or specific Parshall flume drawings for reference

DIMENSIONAL TOLERANCES

ASTM D1941 requires that Parshall flume dimensions be within 2% of nominal, while JIS B7553 requires tolerances of +/- 1 to 1.5% depending upon flume size.

Outside of these ranges, Parshall flumes should be replaced, or field rated as they are non-conforming.

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POINTS OF MEASUREMENT

Located in the converging section of the flume, indicated on relevant drawings, is the primary, free flow, point of measurement (Ha). This is 2/3 length of the converging section wall 'a' *upstream* of the throat.

Hb, a secondary point of measurement, is used for determining the submergence of a Parshall flume. Close to the junction of the throat and the discharge section, this is found in the throat of the flume. To avoid submerged flow applications, measurements should be taken.

FLOW EQUATIONS

For free-flow conditions, the level to flow equation for the Parshall flume can be expressed as:

$$Q = K H_a{}^n$$

Where:

Q = free flow rate
K = flume discharge constant (determined by flume size/units)
H_a = depth at the head measuring point (feet/meters)
n = discharge exponent (determined by flume size/units)

US Units: Cubic Feet Per Second (CFS), Gallons Per Minute (GPM), or Millions of Gallons per Day (MGD)
Metric Units: Liters per Second (L/S), or Cubic Meters per Hour (M3/HR)

FREE FLOW EQUATIONS FOR PARSHALL FLUME		
Flume Size	**Cubic Feet per Second (CFS) (K)**	**Discharge Component (n)**
1 in	0.338	1.55
2 in	0.676	1.55
3 in	0.992	1.55
6 in	2.06	1.58
9 in	3.07	1.53
1 ft (12 in)	4	1.522
1.5ft (18 in)	6	1.538
2 ft (24 in)	8	1.55
3ft (36 in)	12	1.566
4 ft (48 in)	16	1.578
5 ft (60 in)	20	1.587
6 ft (72 in)	24	1.595

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7 ft (84 in)	28	1.601
8ft (96 in)	32	1.607
10ft (120 in)	39.38	1.6
12ft (144 in)	46.75	1.6

SUBMERGED FLOW

The submergence ratio is the ratio of the downstream depth at the secondary point of measurement, Hb, to the depth at the primary point of measurement, Ha.

Corrections must be made to the flow equation when a flume becomes submerged. The ratio must be calculated to determine when these conditions should be made.

$$S = H_a / H_b$$

SUBMERGENCE TRANSITION

A submergence transition (St) is when unrestricted water flow shifts to submerged into one of slowed velocity discharge. Below is the submergence transitions for a given flume's size which must be corrected for submergence effects.

1 to 3 inch	**50 %**
6 to 9 inches	60 %
1 to 8 foot	70 %
10 to 50 foot	80 %

FOUDE NUMBERS FOR FLUMES

The Parshall flume is a sub-critical flume, which operates by accelerating slow, sub-critical flow to a subcritical state through the restriction of water flow as it passes through the flume. This particular flume restricts through contracting side walls and a dropping floor.

Fr < 1, flow is sub-critical
Fr = 1, flow is critical
Fr > 1, flow is super-critical

The Froude number should generally not exceed 0.5. Standing surface waves may form above this number. The Froude Number equation is below:

$$F_r = V / (gD)^{1/2}$$

Where:
F_r = Froude Number
V = Average velocity of liquid in a channel (feet/second or meters/section)
g = Acceleration due to gravity (32.17 ft/sec^2 or 9.81 m/sec^2)
D = hydraulic depth exponent

D = cross-sectional area of flow / top width

INSTALLING A PARSHALL FLUME

Consider the following when selecting your installation site -

FLUME LOCATIONS

- ❑ Allow the flumes flat converging section to be level from front-to-back and side-to-side. It should also be centered in the flow stream.
- ❑ The flume should be centered in the flow stream, to allow no bypass.
- ❑ A 1:4 (rise:run) slope should be formed in the flume, so as to set the flume above the floor of a channel. Greater slopes should be avoided to avoid turbulence as the flow separates.

UPSTREAM OF THE FLUME

- ❑ Flow MUST be sub-critical when entering the flume. If it is super-critical, a hydraulic jump must be formed well upstream of the flume. Upstream energy absorbers and tranquilizing racks must be used.
    - Hydraulic jumps should be forced to occur at least 30 Hmax upstream of the flume.
- ❑ For flow entering a flume, the Froude Number should not exceed 0.5 and never exceed 0.99. Above 0.5, surface turbulence may occur.
    - For a flume to accurately measure flow, that flow must be sub-critical (Fr<0.99)
- ❑ The flow entering the flume should be smooth, tranquil, and well distributed across the channel. The approaching channel should be straight to encourage uniform velocity profiles. Flows should be conditions if they are surging, turbulent, or unbalanced. Any dips or bends upstream of the flume must be far upstream to ensure a well distributed and non-turbulent flow.
- ❑ Open channel (non- full pipe) flow must be present under all flow conditions.
- ❑ EPA recommendations for upstream channel runs are conservatively the same as long throated flume – 25 throat widths.
- ❑ ASTM D1941 indicates that 10 to 20 times the throat width will usually meet the necessary inlet conditions. As a general guideline, a straight upstream approach length of 10-20 times the throat width will meet these entrance conditions.

- 10 throat widths may be used where the throat width of the flume is larger than half of the width of the approach channel.
- 20 throat widths should be used where the throat width of the flume is less than half the width of the approach channel.

- ❑ When a Parshall flume is connecting to pipes, an influent converging section end adapter and appropriately sized pipe stub is required. The influent pipe connection should be straight and without bends for 15 to 25 pipe diameters. The greater the pipe size, the lower the allowable slope. Incoming pipe slope should remain between 1% - 2%.
- ❑ Wing Walls should be formed to direct a smooth flow into the flume when channels are wider than the flume inlet.
- ❑ The upstream channel should be clear of vegetative growth.

DOWNSTREAM OF THE FLUME

- ❑ To prevent flow from backing up into the flume, effectively slowing discharge, the downstream channel must be of sufficient size and configurations. The channel must be clear of vegetative growth and debris collection.
- ❑ When flow out of the Parshall flume is returning to a channel, the EPA recommends that the channel be straight and unobstructed for 5-20 throat widths –
  - Free spilling of the flume can eliminate this requirement.
- ❑ When a Parshall flume is connecting to pipes, an effluent diverging section end adapter and appropriately sized pipe stub is required.
- ❑ The influent pipe connection should be straight and without bends a minimum of 5 pipe diameters.
  - The effluent pipe must be at least as large as the influent pipe. The slope should be greater than, or equal to the influent pipe slope.
- ❑ Wing walls or bulk heads should be used as a flat extension when a channel is wider than the outlet of the flume.

INSTALLING YOUR FLUME

Once a site has been selected, the flume must then be installed correctly:

- ❑ The upstream floor of the flume should be set high enough so that the flume does not operate under *submerged flow* conditions.
- ❑ The outlet of the flume should be set at or above (ideally) the invert of the outlet channel/pipe to help transitions out of the flume.
- ❑ The flat floor of the converging section must be set upstream. Ensure the floor is level by using a level on the floor of the flume, not the top.
- ❑ Ensure your flume is braced internally during installation to prevent distortion.
- ❑ The flume must not float out of its intended final position during installation.

FOR MORE INFORMATION ON HOW TO INSTALL PLEASE SEE: INSTALLATION GUIDE

BRACING THE FLUME

Most Parshall flumes ship with dimensional bracing (angle or tube) at the top of the flume. The bracing should be left on the flume until the installation has been completed.

If the flume is set in concrete, the bracing should be removed once the installation has been completed. For installations where the flume is free-standing or otherwise not set-in concrete the bracing should be left in place. If the racing is removed, verify the dimensional accuracy of the flume after the removal.

HOW TO MAINTAIN A PARSHALL FLUME

Parshall flumes should be periodically inspected and maintained. Starting 6 months after installation and each following year, inspect the channel in which the flume is installed; the flow entering and exiting the flume; the flume itself.

FOR MORE INFORMATION ON MAINTANENCE PLEASE SEE: OPERATIONS & MAINTANENCE

CHANNEL INSPECTION

- ❑ Upstream channel banks should be clear of vegetation and debris.
- ❑ Any hydraulic jump should be at least 30 times the maximum head (Hmax) upstream of the flume.
- ❑ All of the flow must go through the flume.

FLOW INSPECTION

- ❑ Flow entering the flume should be tranquil and well distributed. Turbulence, poor velocity profile, or surging should not be present.
- ❑ The Froude (Fr) number should be 0.5. Flows greater than unit (Fr=I) will not provide an accurate measurement.
- ❑ As the Froude number increases so does surface turbulence.
- ❑ Flumes accelerate sub-critical flow (Fr < I) to a supercritical state (Fr I>).

FLUME INSPECTION

- ❑ Flumes must be level from front-to-back and from side-to-side.
- ❑ Flow surfaces are to be kept clean of surface buildup or algal growth. Scrubbing or a mild detergent can be used.

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