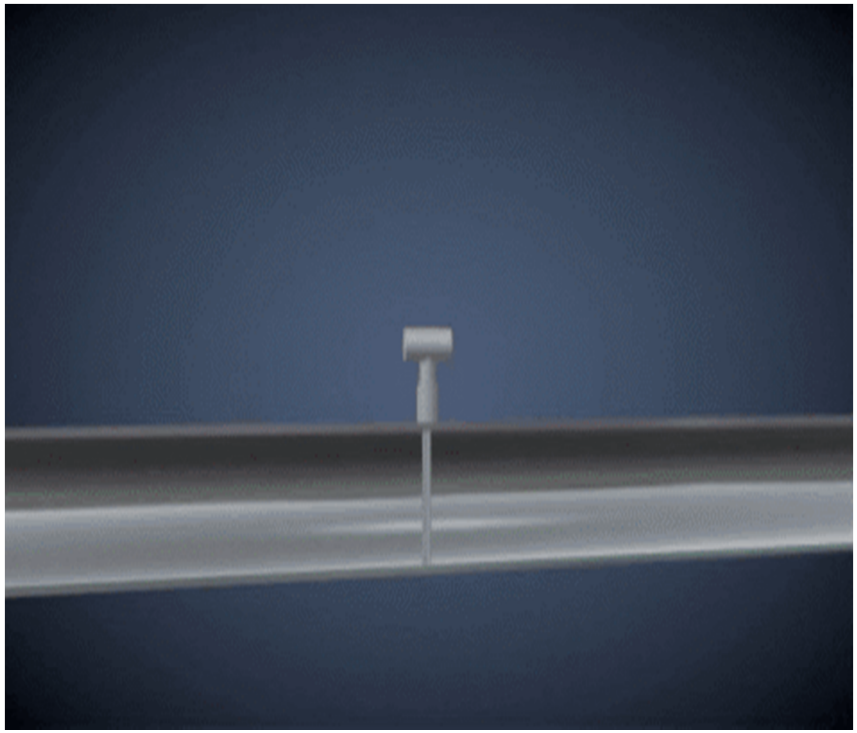
Pitot tube based on mean square error algorithm for gas-liquid mixed phase flow gas flow measurement

28th June, 2019

Content

Background

Determine the fluid flow by measures the differential pressure with the velocity in the oncoming flow and back flow of the sensor

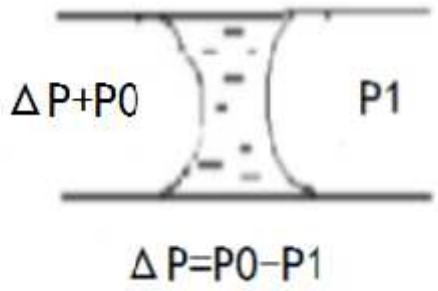


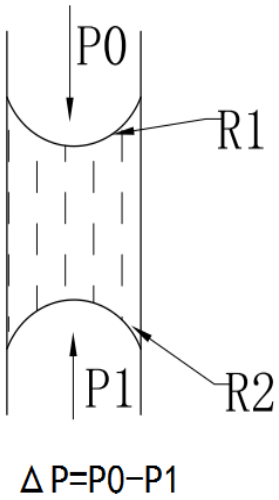
formula：

$$v = k\sqrt{\frac{2\Delta P}{\rho}}$$

Water film formation mechanism(1)

$$\Delta P = \begin{cases} 2\alpha(1/R_1 - 1/R_2) & \text{horizontal installation} \\ 2\alpha(1/R_1 - 1/R_2) + \rho g h & \text{vertical installation} \end{cases}$$



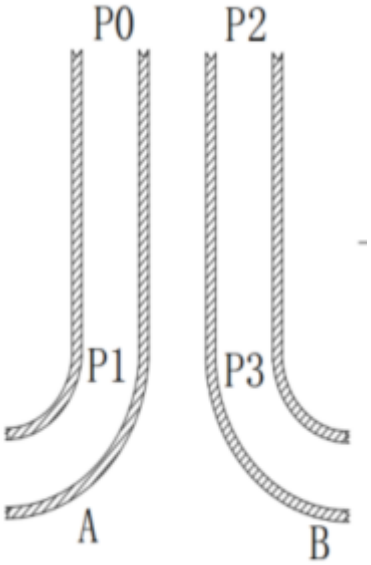


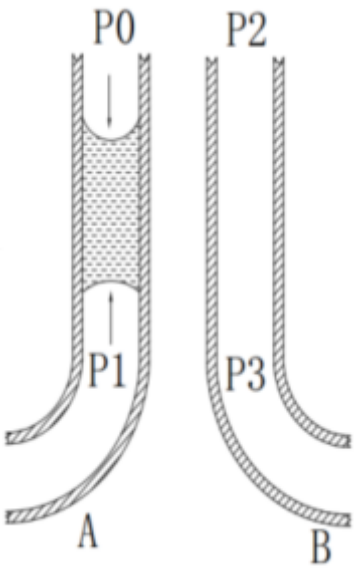
Horizontal installation

Vertical installation

Water film formation mechanism(2)

For example, operating temperature at 45℃, pressure is 0.3Mpa, and velocity is 5.34m/s in the pipeline. 10mm thick water film produced in the total pressure capillary and the radius of curvature of the two side of water film is 3mm and 5mm.

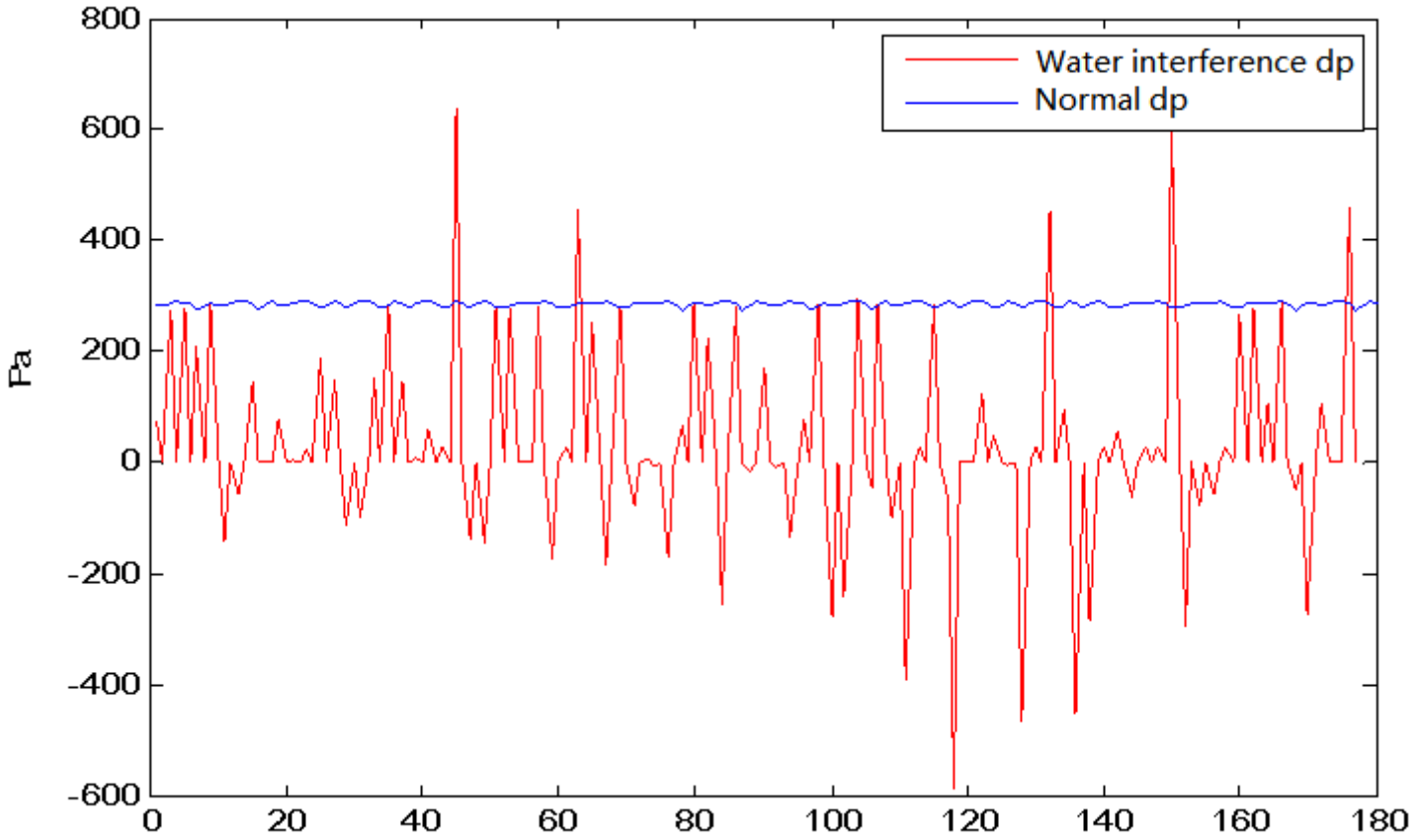




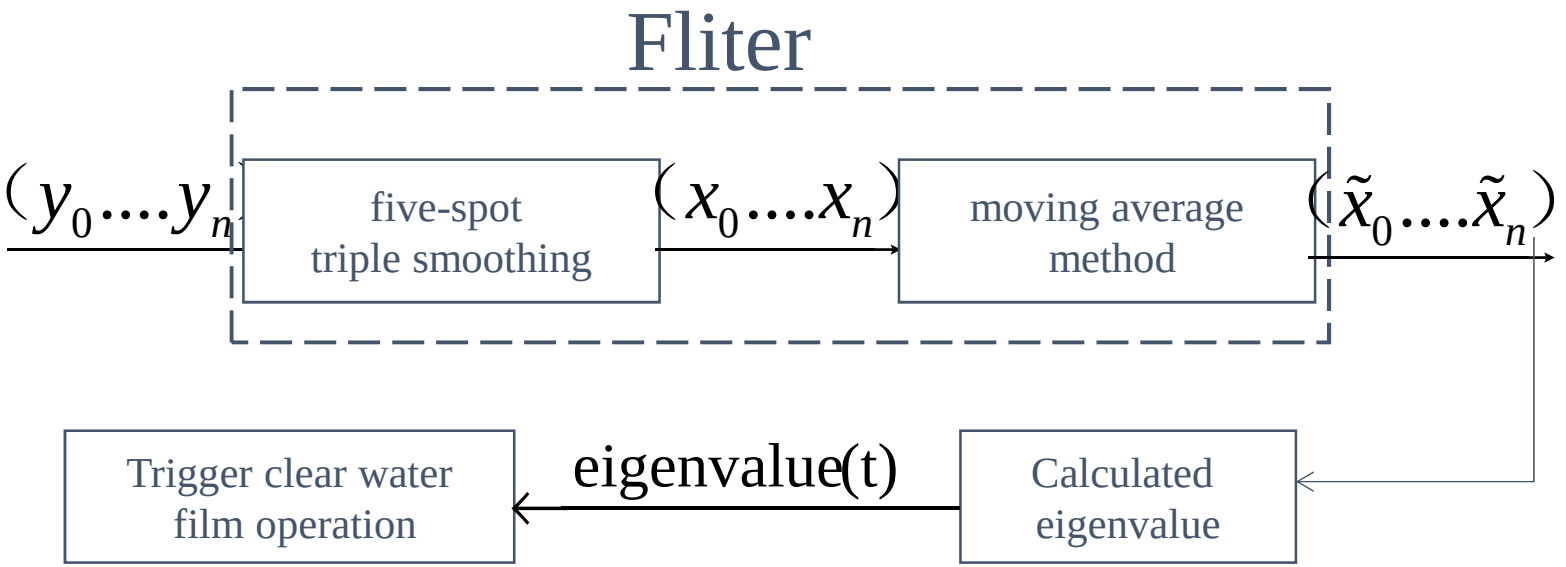
$P = P0 - P2 = 150Pa$

$P = P0 - P2 = 30Pa$

Water film formation mechanism(3)



Water film eigenvalue extraction and recognition



S1：The dp sequence (y1, y2.....yn) acquired every second is filtered to obtain a sequence (x1, x2.....xn);

S2:calculating the eigenvalues of the sequence of (x1, x2, ... xn) according to the mean square error formula;

S3:Judging the feature value t and the feature threshold T0 for water film recognition.

S4：Trigger clear water film operation

Water film eigenvalue extraction and recognition – Signal filtering(1)

1） five-spot triple smoothing

$$x_0 = 1/70(69y_0 + 4y_1 - 6y_2 + 4y_3 - y_4) \quad (1)$$

$$x_1 = 1/35(2y_0 + 27y_1 + 12y_2 - 8y_3 + 2y_4) \quad (2)$$

$$x_2 = 1/35(-3y_0 + 12y_1 + 17y_2 + 12y_3 - 3y_4) \quad (3)$$

$$x_3 = 1/35(2y_0 - 8y_1 + 12y_2 + 27y_3 + 2y_4) \quad (4)$$

$$x_4 = 1/70(-y_0 + 4y_1 - 6y_2 + 4y_3 + 69y_4) \quad (5)$$

Water film eigenvalue extraction and recognition

–Signal filtering(2)

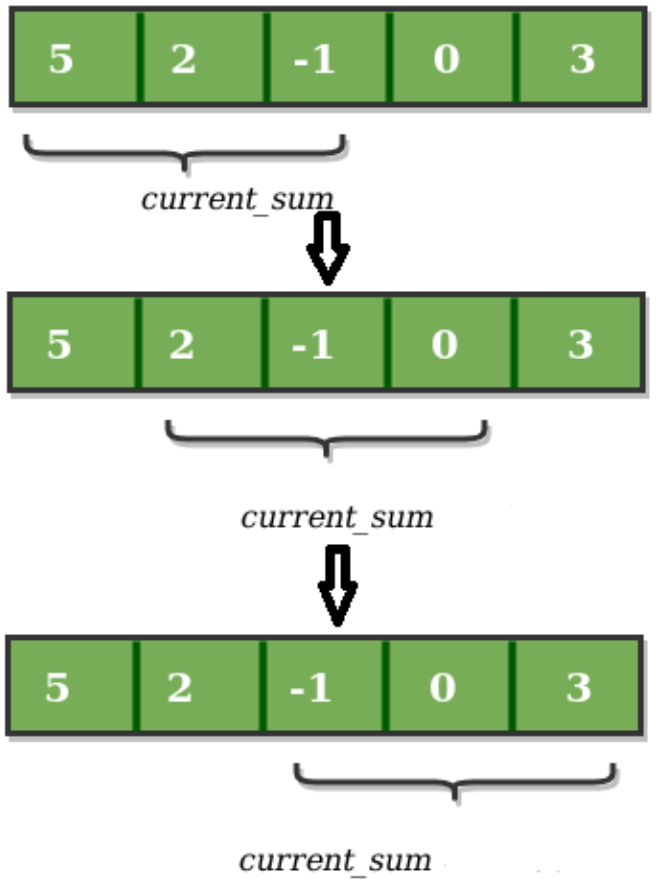
2） moving average method

$$\tilde{x}_0 = (x_0 + x_1 + \ldots + x_{m-1}) / m$$
$$\tilde{x}_1 = (x_1 + x_2 + \ldots + x_m) / m$$
$$\tilde{x}_2 = (x_2 + x_3 + \ldots + x_{m+1}) / m$$
$$\tilde{x}_n = (x_n + x_{n+1} + \ldots + x_{n+m-1}) / m$$

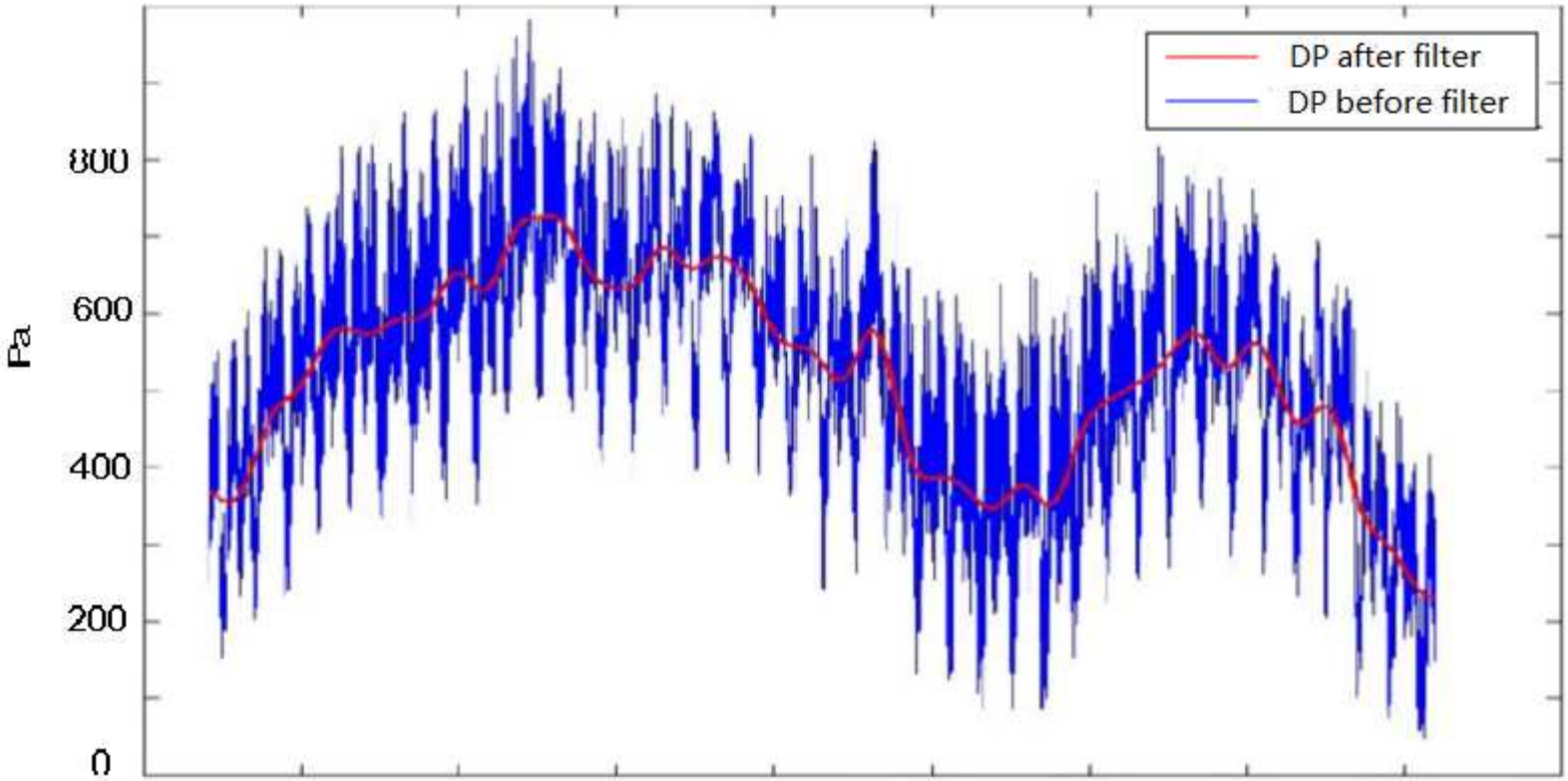
In this：

m: moving average number of sequences

$\tilde{x}_n$: filter value of moving average of the point *n*



Water film eigenvalue extraction and recognition-filtering effect



Water film eigenvalue extraction and recognition

Formula for eigenvalues :

$$\overline{x} = \frac{1}{N} \sum_{i=1}^{N} \tilde{x}_i \quad (1)$$

$$t = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (\tilde{x}_i - \overline{x})^2} \quad (2)$$

$$moist = \begin{cases} N & t < T0 \\ Y & t \geq T0 \end{cases} \quad (3)$$

In the formula:

t:eigenvalue

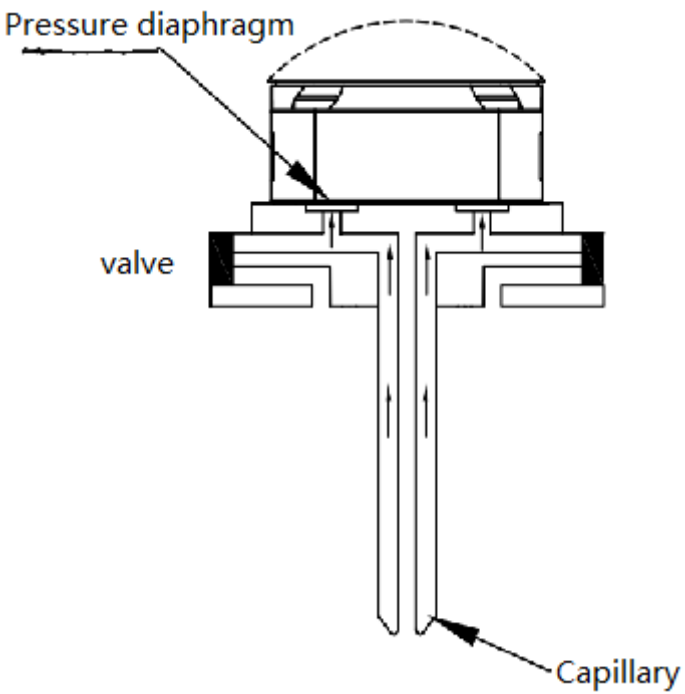
$\overline{x}$:DP sequence average

N:Number of dp sequences

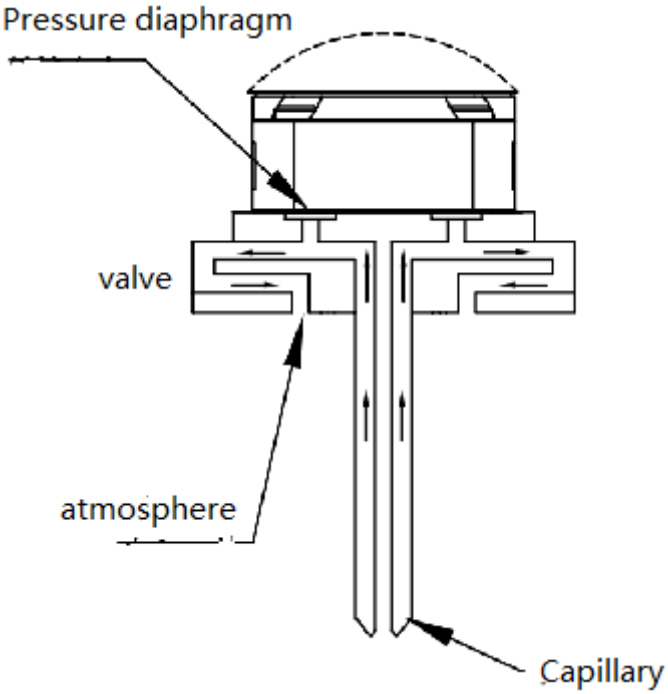
$\tilde{x}_i$: point i data

T0 : eigenvalue threshold

Water film remove



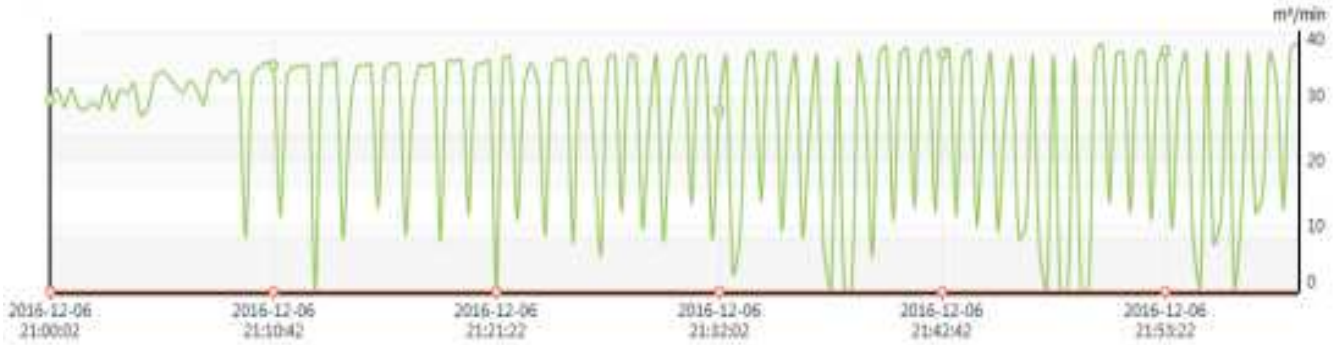
Normal status



Water film eliminated

Experimental result

Under water influence other type pitot tube flowmeter flow measuring curve：



Under water influence Comate pitot tube flowmeter flow measuring curve：

Product

Excellent in:

◆2.0%RD high accuracy

◆Capable of working where there is vibration

◆Supports online pressure installation

◆High sensitivity

◆Measure range:1~30m/s （volume）

Thank You for your attention!
Any question?

Email: guyu@comatemeter.com