

## Fluid Flow Calibration Facilities in India- A Case Study

Battal Singh, Mohit Kaushik, Shally Sharma & Avijit Das

National Accreditation Board for Testing and Calibration Laboratories (NABL)  
Plot No. 45, NABL House, Sector -44,  
Gurgaon -122002, Haryana, India

Email: [battal@nabl.qcin.org](mailto:battal@nabl.qcin.org)

### ABSTRACT

Fluid flow is a very critical parameter used in various applications such as process control in industries (cement plants, paper industries); nuclear, thermal and hydro-electric power generation; manufacturing of drugs and pharmaceuticals, fertilizers, beverages, distilleries, petrochemicals; safety and health hazards and in aviation, agricultural, irrigation and dairy plants *etc.* Therefore, various types of flowmeters such as magnetic flow meters, turbine flowmeters, Coriolis mass flow meters, vertex flowmeters, differential pressure type flowmeters, ultrasonic flowmeters, pitot tubes, dry gas meters, air volume samplers, weirs, flumes, current meters, anemometers, *etc.* are used for the accurate and precise measurement of fluid flow parameters. These parameters are collected fluid mass, collected fluid volume, mass flow rate, volume flow rate and velocity. These measurements are required for control, indication, alarm and tariff purposes.

In India, there were little awareness about Fluid Flow about 15-20 years. Also installation of Fluid Flow Laboratories requires huge funding. Therefore, there were only a few Fluid Flow Laboratories at that time and most of them were either in Govt. Sectors or private sectors having flowmeters manufacturing. Now with increasing awareness and upgraded technical capabilities, large numbers of flowmeters manufacturers are coming in the market. These manufacturers are now investing money in establishing flowmeters testing and calibration laboratories for improving the quality of their products and services and also saving money and time in getting them tested and calibrated from other fluid flow laboratories. The establishments of these laboratories have greater impact in their business and some of the flowmeters

manufacturers are posing tough competitions to the MNCs. These manufacturers are exporting flowmeters to other countries on very competitive prices and also establishing laboratories on turnkey basis, thus earning and saving foreign currency and contributing towards Indian economy.

In the present paper, the briefs of these fluid flow laboratories and their effects on their flow business are discussed.

### 1. INTRODUCTION

Fluid flow calibration can be done by gravimetric and volumetric methods. These are primary methods. The flowmeters can be also calibrated by comparison method.

Flow can be simply defined as flow of mass or volume per unit time means a quantity of mass or volume flowing per unit time. Flow can be differentiated either liquid mass flow rate or volume mass flow rate and it can be expressed as

$$\text{Mass Flow Rate } q_m = \frac{m}{t} \quad (1)$$

$$\text{Volume flow rate } q_v = \frac{q_m}{\rho} = \frac{m}{t \cdot \rho} \quad (2)$$

Where  $m$  is the mass of liquid through the MUC during a time interval of  $t$  and  $\rho$  is the liquid density at the MUC location.

Flow elements can be differentiated into two categories differential pressure based flow elements (i.e. orifice plate, flow nozzle,

venture, pitot tube etc.) and direct measuring flow elements (magnetic flow meters, coriolis mass flow meters, vortex flow meters etc.).

In case of differential pressure based flow elements flow can be measured with the help of discharge coefficient  $C_d$  and differential pressure by putting these values in the formula. The formula is different for different flow elements like orifice plate, flow nozzle, venture, pitot tube etc.

Discharge coefficient, defined for an incompressible fluid flow, which relates the actual flow rate to the theoretical flow rate through a device, and is given by the formula for incompressible fluids

$$C = (q_m \sqrt{1 - \beta^4}) / (\pi/4 * d^2 * \sqrt{2Dp \rho}) \quad (3)$$

Where,

$C$  - discharge coefficient

$q_m$  - mass flow rate

$d$  - diameter of flow element

$\beta = d/D$

$D$  - diameter of the pipe

$D_p$  - differential pressure

$\rho$  - density of fluid used for calibration

## 2. NEED OF FLUID FLOW CALIBRATION

About 25 to 30 years back, the calibration of differential pressure based flow element was not in use particularly in India and it was assumed that only by putting the values in formula flow rate can be calculated but how one can ensure the correctness of the computed flow rate based on the various values to be put in the formula. The accuracy of differential pressure based flow element is always in the doubt because only by putting the value of differential pressure can never be assured. There are many other parameters which needs to be ensured.

The only way to ensure the accuracy of the formula was calibration of flow element either in liquid or air or oil medium based on the requirement of flow element i.e. the orifice plate, flow nozzle, venture are fitted in the pipe in proper direction or not, pressure tapings are proper or not. It has been noticed that direction of flow element in the pipe or flanges is not proper and the resulted flow by putting differential pressure in the formula will definitely produce the result and as per the physical dimension the produced result will be

accepted by the user but these results can never be in the agreement of the required result just because of the reverse direction of the flow element. Similarly pressure tapings are having great impact over the measurement of flow, if there is any obstruction/burr inside the pressure tapping of the flow element the differential pressure produced by flow element will be less as compared to the required value and the value of flow will be different. In this situation, actual calibration of flow element can ensure the accuracy of the flow element. When actual calibration of the flow element is done the discharge coefficient measured with the help of formula given above (eq. 1) can be compared with theoretical discharge of particular type of flow element. If the result of actual calibration and theoretical discharge coefficient are within the permissible limit then only the flow element can be used to measure the flow rate of any process. During the time of calibration, the upstream and downstream straight length needs to be taken care to ensure the authenticity of the calibration results.

In new era, the calibration of flow elements became necessary to ensure the quality of the various processes. The deviation of flow can cause a big loss either to the customer or manufacturer. For example if some company is selling the steam to the various customers for production of electricity the accuracy of the flow nozzle is required 0.25% and it can only be ensured with the help of wet flow calibration.

## 3. SCENARIO IN INDIA

**The calibration laboratories in India can be differentiated in following categories:**

### 3.1 NMI (National Metrology Institute)

Presently, National Physical Laboratory, New Delhi, India (NPLI) is providing Calibration Facility upto 100 mm for wet flow calibration and the expanded uncertainty of the system at 2000 kg collection mass is 0.06% at  $k=2$ . The upgradation of old water flow calibration facility upto 200 mm is under process.

The Gas Flow Calibration System has been established in the flow range 10 sccm (standard cubic centimeter per minute) to 1000 slm (standard litre per minute) with expanded uncertainty of 0.2% at  $k=2$ .

### 3.2 NABL Accredited laboratories

There are more than 20 NABL accredited laboratories in India . FCRI Palakkad , Kerla is the first accredited govt. laboratory in India and having very good facility of fluid flow calibration in all the fields i.e. water flow , gas flow and oil flow with CMC at par to some of the advanced NMIs of the world.

Rockwin Flow calibration laboratory is second fluid flow calibration laboratory after FCRI and first from private sector, having calibration facility in all the fields water, gas and oil calibration. Table 1 shows the facilities available for fluid flow calibration with range and CMC.

**Table 1. Fluid Flow Laboratories and their flow range & uncertainties**

Lab Name	Parameter	Range	CMC
Fluid Control Research Institute, Palakkad, Kerala	Flow Rate (near ambient condition) <sup>§</sup>	0.75 ml/min to 650 l/min	0.10 % to 1.0 %
	Mass flow rate <sup>§</sup> (water) t/h	Upto 1 t/h to 2500 t/h	0.030 % to 0.050 %
	volume flow rate <sup>§</sup> (Water) m <sup>3</sup> /h	Upto 1 m <sup>3</sup> /h to 2500 m <sup>3</sup> /h 2500 m <sup>3</sup> /h to 4500 m <sup>3</sup> /h 3500 m <sup>3</sup> /h to 15000 m <sup>3</sup> /h	0.050 % to 0.100 % 0.150 % 0.5%
	mass flow rate <sup>§</sup> (oil) t/h	Upto 0.8 t/h to 500 t/h	0.020 % to 0.040 %
Rockwin Flow Calibration Laboratory, Ghaziabad, U.P.	volume flow rate <sup>§</sup> (Media Water)	0.05 m <sup>3</sup> /h to 3500 m <sup>3</sup> /h	0.18 % to 0.08 %
	volume flow rate <sup>§</sup> (media air)	0.8 m <sup>3</sup> /h to 2500 m <sup>3</sup> /h	0.27 % to 0.3%
	volume flow rate <sup>§</sup> (media oil)	0.2 lpm to 250 lpm	0.22 % to 0.23 %
Godrej & Boyce MFG. Co. Ltd., Lawkim Motors Group, Mumbai, Maharashtra	Fluid Flow Flow rate <sup>§</sup> (Air & N <sub>2</sub> )	5 sccm to to 100 sccm 100 sccm to 100 slm	0.40 % rdg to 0.40 % rdg 0.34 % rdg to 0.48 % rdg
Yadav Measurements Private Limited, Udaipur, Rajasthan	flow rate by volume <sup>§</sup> (air)	a) 0.016 to 0.040 m <sup>3</sup> /h Volume range: 0.001 m <sup>3</sup> to 0.01 m <sup>3</sup>  b) 0.040 to 6.6 m <sup>3</sup> /h Volume: 0.01 m <sup>3</sup> to 0.08 m <sup>3</sup>	0.62%  0.001 m <sup>3</sup> to 0.01 m <sup>3</sup>  0.19 % 0.011 m <sup>3</sup> to 0.08 m <sup>3</sup>
Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai, Maharashtra	volume flow rate (water)	1.5 m <sup>3</sup> /h to 240 m <sup>3</sup> /h	0.20%
	mass flow rate (water)	1500 kg/h to 240000 kg/h	0.22%
The Automotive Research Association of India, Pune, Maharashtra	volumetric flow meters <sup>§</sup> (media-air)	10 LPM to 30 LPM 30 LPM to 100 LPM 100 LPM to 200 LPM	1.5 % 1.05 % 1.02 %
Belz Calibration Laboratory, Belz Instruments Pvt. Ltd., Faridabad, Haryana	flow rate <sup>§</sup> (medium of calibration–n <sub>2</sub> )	1 LPM to 3 LPM 3 LPM to 43 LPM	1.41 % 0.58 %
	volume flow rate <sup>§</sup> (medium of calibration liquid–	3 m <sup>3</sup> /h to 80 m <sup>3</sup> /h 80 m <sup>3</sup> /h to 1450 m <sup>3</sup> /h	1.53 % rdg 0.90 % rdg

	water)		
Centre for Calibration, Nagman Instruments & Electronics (P) Ltd , Chennai, Tamilnadu	mass flow rate (water)	240 kg/hr to 360000 kg/hr	0.11%
	volume flow rate (water)	0.24 m <sup>3</sup> /h to 360 m <sup>3</sup> /h	0.14%
Northlab (India) Pvt Ltd., Chennai, Tamilnadu	Rotameters	1.5 lpm to 5 lpm	5.9 % rdg
	Air flow meters	5 lpm to 15 lpm	1.9 % rdg
Krohne Marshall Flow Calibration Laboratory, Pune, Maharashtra	fluid volume <sup>§</sup> (water)	0.2 m <sup>3</sup> 22.5 m <sup>3</sup>	0.014 % to 0.07 %
Syscon Calibration Centre Pvt. Ltd., Bangalore, Karnataka	air flow meters	2 ml/m to 50l/m	1.43% of rdg to 1% of rdg
Autometers Energitec Flow Calibration Lab., Noida, U.P.	turbine meters,	0.5 m <sup>3</sup> /h to 25 m <sup>3</sup> /h	0.26%
	positive displacement flow meters <sup>§</sup> (with conditioned air as medium)	25 m <sup>3</sup> /h to 4000 m <sup>3</sup> /h	0.55%
Electonet Equipments Calibration Laboratory ,Electonet Equipments Pvt. Ltd., Pune, Maharashtra	mass flow rate <sup>§</sup> (media water)	560 kg/hour to 300000 kg/hour	0.2%
	volumetric flow rate <sup>§</sup> (media water)	0.56 m <sup>3</sup> /hour to 300 m <sup>3</sup> /hour	0.2% to 0.25 %
C & I Calibration Pvt. Ltd., Jaipur, Rajasthan	mass flow rate <sup>#</sup> (medium : liquid)	Up to 725 kg/min.	0.06 % rdg.
	volume flow rate <sup>#</sup> (medium : liquid)	5 m <sup>3</sup> /h to 70 m <sup>3</sup> /h	0.36 % rdg to 0.81% rdg
Sigma Test & Research Centre, Delhi	gas flow <sup>§</sup> measurement – rotameter (medium nitrogen gas)	3 lpm to 5 lpm 5 lpm to 15 lpm 15 lpm to 50 lpm	0.1 lpm 0.16 lpm 0.49 lpm
Ecotech Instruments-Centre for Calibration Services, Greater Noida, U.P.	flow measuring devices medium –air near ambient condition	0.6 m <sup>3</sup> /min to 1.4 m <sup>3</sup> /min	2%
Star-Mech Controls (India) Pvt. Ltd. (Calibration Division), Pune, Maharashtra	volumetric flow rate <sup>§</sup> (water)	5 m <sup>3</sup> /h to 500 m <sup>3</sup> /h	0.50%
	mass flow rate <sup>§</sup> (water)	5000 kg/h to 500000 kg/h	0.50%
Envirotech Calibration Laboratory (A Division of Envirotech Instruments Pvt. Ltd.), Delhi	air flow rate <sup>§</sup>	35 LPM to 100 LPM	1.06 %
		0.6 m <sup>3</sup> /min to 1.5 m <sup>3</sup> /min	0.41 %
Spectro Analytical Labs Ltd., Greater Noida, U.P.	mass flow controller <sup>§</sup>	3 SLM to 50 SLM	0.4 %
	rotameters / flow meters <sup>#</sup> (flow rates)	0.1 LPM to 30 LPM	1.5 %
		3 LPM to 50 LPM	0.4 %
SBEM Flow Laboratory, Pune, Maharashtra	Liquid volume Flow rate <sup>§</sup>	1.5 m <sup>3</sup> /hour to 220 m <sup>3</sup> /hour	0.5 %
Gail India Ltd., Hazira Meter Prover Facility,	Natural gas flow <sup>§</sup>	10 m <sup>3</sup> /hr to 80 m <sup>3</sup> /hr >80 m <sup>3</sup> /hr to 260 m <sup>3</sup> /hr	2.08 % 0.69 %

Surat, Gujrat		>260 m <sup>3</sup> /hr to 800 m <sup>3</sup> /hr 800 m <sup>3</sup> /hr to 6600 m <sup>3</sup> /hr	0.41 % 0.36 %
Manas Liquid Flow Calibration Laboratory ,(A Division of Manas Microsystems Pvt. Ltd.), Pune, Maharashtra	Volume flow rate <sup>s</sup> (water flow)	0.2 m <sup>3</sup> /hour to 250 m <sup>3</sup> /hour	0.28 % to 0.25%
Minco India Pvt. Ltd., Goa	Discharge Coefficient Value (Media : Water) Orifice Plate	400 LPM to 2000 LPM 400 LPM to 2000 LPM	0.67 % 1.44%

Overall there are 23 accredited laboratories and facility of calibration can be judged by seeing their accredited scope. Only 13 laboratories having air flow calibration facility and 12 laboratories having water flow calibration facility. On the other hand only 2 laboratories are having oil flow calibration facility. The laboratories having oil flow

calibration facility are FCRI and Rockwin flow calibration laboratory.

### 3.3 Applicant Laboratories

Table 2 shows the list of laboratories who have applied for NABL accreditation.

**Table 2. List of Laboratories applied for NABL Accreditation**

Lab Name	Parameter	Range	Applied CMC
Calibration Laboratory, Hydraulic Department Surat Municipal Corporation, Surat, Gujarat	mass flow rate (water) t/h	Upto 200 t/h	0.29%
	volume flow rate (water) m <sup>3</sup> /h	Upto 200 m <sup>3</sup> /h	0.24%
	mass (water)	Upto 2500 kg	0.21%
	volume (water)	Upto 2.5m <sup>3</sup>	0.19%
ENDRESS+HAUSER FLOWTEC (INDIA) PVT. Ltd., Aurangabad, Maharashtra	mass flow rate (water) t/h	1.8 kg/h to 1.2t/h 0.4t/h to 40 t/h	0.05% 0.05%
	volume flow rate (water) m <sup>3</sup> /h	1.8dm <sup>3</sup> /h to 1.2 dm <sup>3</sup> /h 0.4 dm <sup>3</sup> /h to 40 dm <sup>3</sup> /h	0.05% 0.05%
	mass (water)	0.4 kg to 10 kg 20kg to 400 kg	0.05% 0.05%
	volume (water)	0.4dm <sup>3</sup> to 10 dm <sup>3</sup> 20 dm <sup>3</sup> to 400 dm <sup>3</sup>	0.05% 0.05%
Lata Envirotech Services-Centre for Calibration Lab., Greater Noida, U.P.	mass flow rate (air) lpm	0.1 lpm to 5 lpm 6 lpm to 10 lpm 11 lpm to 100 lpm	0.78% 0.48% 0.53%
	volume flow rate (air)	0.6 to 1.4 m <sup>3</sup> /min	0.48%
	velocity (air) m/s	3 m/s to 25 m/s	1.89%
	volume (water)	10 l to 5000 l (0.01 m <sup>3</sup> to 5 m <sup>3</sup> )	0.56%
Raychem RPG Gas Flow Meter Calibration Laboratory, Pune, Maharashtra	volume flow rate (gas) m <sup>3</sup> /h gas flow meters	0.25 m <sup>3</sup> /h to 2500 m <sup>3</sup> /h	0.25 m <sup>3</sup> /h to 1 m <sup>3</sup> /h: 0.45% 1 m <sup>3</sup> /h to 2500 m <sup>3</sup> /h: 0.45%
Micro Precision Products Pvt. Ltd., Palwal, Haryana	mass flow rate (water) t/h	0.8t/h to 25 t/h 5 t/h to 125 t/h 50 t/h to 700 t/h 300 t/h to 1700 t/h	0.10% 0.10% 0.10% 0.071%
	volume flow rate	0.8 m <sup>3</sup> /h to 25 m <sup>3</sup> /h	0.10%

	(water) m <sup>3</sup> /h	5 m <sup>3</sup> /h to 125 m <sup>3</sup> /h 50 m <sup>3</sup> /h to 700 m <sup>3</sup> /h 300 m <sup>3</sup> /h to 1700 m <sup>3</sup> /h	0.10% 0.10% 0.07%
	mass (water)	100 kg to 400 kg 300 kg to 1500 kg 1500 kg to 7000 kg 5000 kg to 17000 kg	0.10% 0.10% 0.05% 0.07%
	volume (water)	100 L to 400 L 300 L to 1500 L 1500 L to 7000 L 5000 L to 17000 L	0.10% 0.10% 0.05% 0.071%
M/s Perfect Calibration Centre Pvt. Ltd., Kancheepuram, Tamilnadu	volume flow rate (water) m <sup>3</sup> /h	3 m <sup>3</sup> /h to 80 m <sup>3</sup> /h 180 m <sup>3</sup> /h to 1250 m <sup>3</sup> /h	1.65% rdg 0.96% rdg
	ford/zahn/sheen cup	Size cups 2,3,4	1.5 % rdg
Raychem RPG Calibration laboratory, Pune, Maharashtra	volume flow rate (gas) m <sup>3</sup> /h gas flow meters	0.016 m <sup>3</sup> /h to 2.5 m <sup>3</sup> /h	Qmax to 0.1 Qmax: 0.54% 3Qmin to Qmin: 1.23%
Hydraulic turbine R & D laboratory, AHEC IIT Roorkee, Uttarakhand	volume flow rate (water)	100 to 916 l/s	0.1%

At present 8 laboratories in applicant stage, their scope of accreditation and claimed CMC can be seen from the Table 2. Out of 8 laboratories 3 laboratories have applied for air flow calibration and 5 laboratories applied for water flow calibration. None of them applied for oil flow calibration.

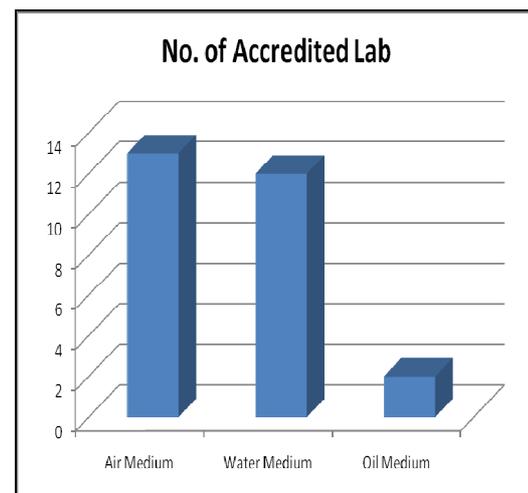
### 3.4 Non-Accredited Laboratories

- I. IIT-Chennai
- II. IIT-Delhi
- III. IIT-Kanpur
- IV. SGS-Mumbai

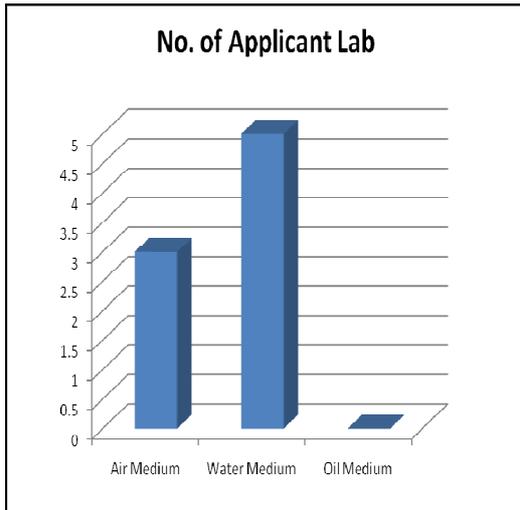
## 4. CONCLUSION

There are total 23 accredited and 8 applicant laboratories in India whereas there are few non-accredited laboratories also working in the field of fluid flow calibration. Figure 1 shows the segregation of fluid flow laboratories. There are almost 800 calibration laboratories in India and almost 100 new applications received in the field of calibration in all the discipline of calibration. The overall percentage of fluid flow accredited and applicant laboratories is 2.9% and 8% respectively. The overall picture of fluid flow calibration laboratory is not impressive because overall growth of calibration laboratories is more than 20% and share of fluid laboratories comparatively is very less. The fluid flow calibration field still needs attention for development. Out of 4 non-accredited laboratories 3 are from govt.

department and they can be persuaded for accreditation. Figure 2 shows the distribution of Fluid Flow Laboratories in India. From Figure 2, we conclude that most of the flow laboratories are in northern, southern and western parts of country. No fluid flow laboratory exists in Eastern regions. Also most of the laboratories are concentrated in particular cities of the regions. India is such a big country, therefore, we need more fluid flow laboratories in whole country apart from special need in eastern region to take care of growing demands in flow calibration.



(a)



(b)

**Figure 1. Plots showing segregation of Fluid Flow Laboratories**

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## REFERENCES

1. ISO 4185, *Measurement of liquid flow in closed conduits – Weighing methods*, 1<sup>st</sup> edition, pp 1-21, 1980.
2. ISO 9368-1, *Measurement of liquid flow in closed conduits by weighing methods – Procedure for checking the installations, Part 1: static weighing system*, 1<sup>st</sup> edition, pp 1-22, 1990.
3. ISO 5168, *Measurement of liquid flow in closed conduits – Procedure for the evaluation of uncertainties*, 2<sup>nd</sup> edition, pp 1-65, 2005.
4. JCGM 100, *Evaluation of measurement data – Guide to the expression of uncertainty in measurement*, 1<sup>st</sup> edition, pp 1-134, 2008.
5. ISO 5167, Part-1 to Part-5, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*, 2016.
6. NABL Website and Records (<http://www.nabl-india.org>)



Figure 2. Distribution of Fluid Flow Laboratories in India .

## **Presenting author Biodata**

**Name** : Battal Singh  
**Designation** : Joint director  
**Company** : NABL-India  
**Qualification** : M.Sc.(physics), MS Quality Management,  
pursuing PhD.  
**Area of Expertise** : calibration



**Significant Achievements:** Worked in the calibration field dimension, pressure, thermal electro-technical etc. for more than 20 years. Established fully automatic fluid flow calibration laboratory at Micro precision products Pvt. Ltd. Faridabad (A WIKA Group , Germany). Assessor in the field of calibration and conducted various assessment before joining NABL.

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