THE LARGE WATER FLOW LABORATORY- A NEW FACILITY FOR CALIBRATING LARGE SIZE FLOWMETERS

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ABSTRACT
Ever increasing consumer demand, limitation of available resources and inadequacy of revenue are the major challenges for the water supply sector of India. These challenges are imposing stringent accountability in day-to-day operation of any water supply system especially where large quantity is dealt with. The same is the case in power stations where water is utilized for cooling circuits. This problem, to a considerable level, can be solved by using accurately calibrated/tested products. Due to lack of adequate facilities for testing / calibrating flow products, indirect methods were generally adopted. This will lead to high inaccuracies. Having an exclusive facility in India for Calibrating large size flow meters will solve this issue to a considerable level. Now, the Fluid Control Research Institute (FCRI), Palakkad has come out with a solution for this issue. FCRI has established a Large Water Flow Laboratory (LWFL) at Palakkad commissioned in the year 2012. With this new facility, flow products of size up to 2000mm can be calibrated with desired accuracy level. The maximum flow rate that can be achieved is 15000 m^3/hr. this paper will discuss salient features of the facility, operational parameters, selection of equipments and scope of coverage for calibration / testing of flow products in LWFL.

1. INTRODUCTION

Calibration / Testing of higher diameter flow products are found to be more challenging comparing to smaller size due to the facts like requirement of huge upstream / downstream straight lengths, high capacity flow sources for establishing a reasonably higher velocity in higher diameter pipes for accurate calibration etc. On the other hand, the demand for calibration / testing of higher diameter flow products are found to be increasing day by day. Hence a need has been felt to address these requirements in India and FCRI has established a Large Water Flow Laboratory (LWFL) for this purpose which has made possible, the calibration of very large size flow meters hitherto considered impossible in India. Testing of pumps with capacities up to 25000 m^3/hr and 10 bar would also become possible in LWFL.

In its essential features, the LWFL consists of a large sump, 5 pumps with a cumulative flow of 15000 m^3/hr, reference flow meters, other associated instruments and long straight lengths of test lines. Various manifolds and motorized control valves take care of flow regulation.

2. INFRASTRUCTURAL REQUIREMENTS

The NABL 106 document on “Specific Criteria for Fluid Flow Testing Laboratories” prescribes many stipulations to be followed by any laboratory in this field. The LWFL facility is designed to be fully compliant. Facilities for the normal operations in the test laboratories like compressed air supply, Water supply, oil storage, electrolyte storage etc. are adequately available. Un interrupted and steady power supply is ensured by captive generators.

3. ENVIRONMENTAL REQUIREMENTS

In all cases, it is imperative that the flow conditions at the test section be checked to ensure that the flow is sufficiently steady, the velocity distribution across the test cross-section is symmetrical and the flow is free from swirl. This is ensured by providing a very large straight length of test line to gain fully developed flow.

Working fluid must be clean and the degree of cleanliness will be determined by the type of flow meters being calibrated e.g. in turbine type flow meters the bearings can be affected, it needs greater fluid cleanliness compared to the venturi tubes.

The working liquid must be of uniform composition and temperature. These conditions are fulfilled by the impervious concrete sump, which has been embedded with water line breakers at all seam joints. The liquid temperature stability criteria must be met for the test media. In case the variation is more than ± 1 deg C/hour, results shall be corrected appropriately .The large size and capacity of the sump of over 3000 m^3 ensures that water circulation/exchange per hour is reduced to less than 5 , and the temperature rise per hour is much lower even at 15000 m^3/hr.

Density and viscosity (wherever felt necessary by laboratory) of the fluid are measured at the temperature at which the testing is performed and recorded. It is a common practice to check these variables at a recognized reference temperature in addition to the working temperature. Reference temperature of 25 deg C may be used for this purpose. For convenience, the measure of viscosity may be taken as kinematic viscosity rather than absolute viscosity.

Accurate measurement of density is essential, in case testing is based on volumetric ground. Measurement of density in liquids shall be made by equipments like hydrometer, density ball or density bottle. Fluid flow control test circuit must be such that:

a) Operation of controlling device has no effect on flow meter testing and
b) Any drop in pressure at the flow meter does not cause dissolved gases to come out of solution/ cavitation to occur.
c) Appropriate/ adequate material handling facilities like 15 ton crane, forklifts, 10 ton Mobile crane etc. are available from the point of view of safety, capacity and suitability for handling.

4. DESIGN CONSIDERATIONS OF THE LOOP

After a due survey of all relevant techno economic factors, the broad specification of the rig was finalized. It was found that flow calibration above 5000 m^/hr was a requirement. An economical upper limit was calculated as 15,000 m^/hr. The line size was chosen from 1200 mm upwards and an extreme possibility to accommodate 3m dia pipelines was also taken into account. The flow test pressure was limited to 2 bar, taking into account the large pipe diameters involved and the resulting stress considerations.

4.1. Specifications

The major specifications of this facility are as under when the NABL and the market requirements are merged:

Table 1: Major Specifications of the facility

Flow Medium	Water
Maximum discharge	15000 m3/hr
Pipe Line Size	2000mm(Design) & Ready to use1200mm
Maximum velocity	1.4m/s. in 2000mm dia.& 3.4 m/s. in 1200mm dia.
Max Line Size	3000mm Possible
Sump Dimensions	50m long x 8 m wide x 7.5 m deep
Type of Flow	Direct Pumping
Type of Pumps	Vertical turbine 5 numbers
Discharge	5000 m3/hr, 4000 m^3/hr., 3000m^3/hr, 2000 m^3/hr., and 1000 m^3/hr
Head	20m of Water Column
Type of Drive	Electrical Motor, slip ring type
Power	DG Sets,1250 KVA 2 Nos.
Uncertainty	+/- 0.5%

4.2. Major Equipments / Basic Investments

4.2.1. SUMP

The basic layout of the sump implemented at LWFL is shown in Figure 1. Based on the American National Standards for Pump Intake Design, ANSI / Hydraulic Institute Standards, the general sump design objective need to be first satisfied when considering sump design. The specific hydraulic phenomena that can adversely affect the performance of pumps when present to an excessive degree are:

- Free-surface and submerged vortices
- Excessive pre-swirl of flow entering the pump and its variations with time
- Non-uniform distribution of velocity at the impeller eye and excessive variations in velocity with time
- Entrained air or gas bubbles

The negative impact of each of these phenomena on pump performance depends on pump specific speed and size, as well as other design features of the pump. In general, large high specific speed pumps are more sensitive to adverse flow phenomena. Typical symptoms of adverse hydraulic conditions are:

- Reduced flow rate
- Reduction in developed head
- Increased power consumption
- Increased vibration and noise.

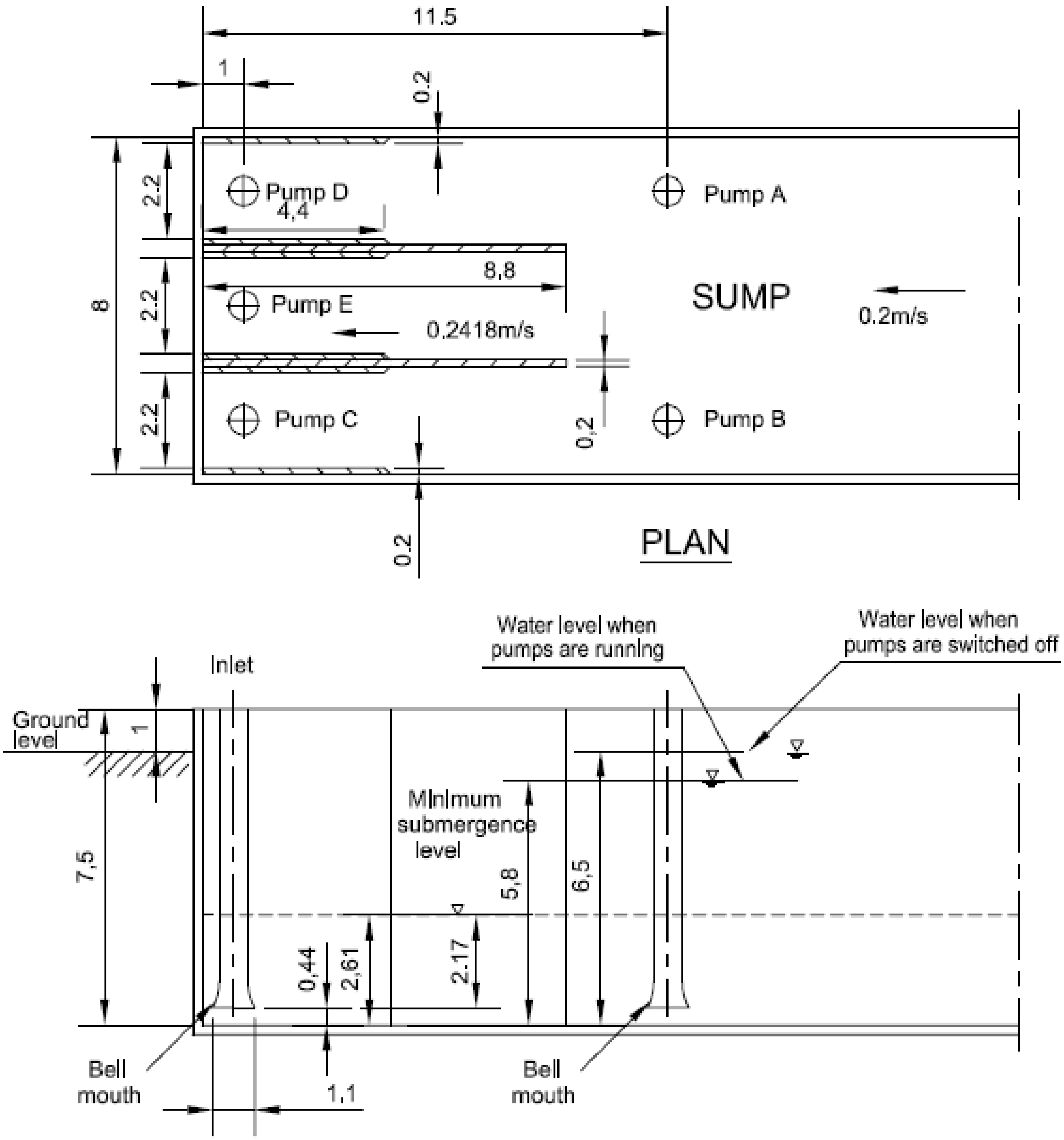

Figure 1: Sump Layout

The sump should be designed to allow the pumps to achieve optimum hydraulic performance for all operating conditions. The performance of a sump is largely determined by the characteristics of the approach flow. The direction and distribution of flow at the entrance to a sump must be based on the following considerations:

1. The orientation of the structure relative to the supply
2. Whether the structure is recessed, flush with, or protrudes beyond the boundaries of the supply
3. Strength of currents in the supply perpendicular to the direction of approach to the pumps
4. The number of pumps required and their anticipated operating combinations

The ideal conditions exist when the structure draws flow so that there are no cross flows in the vicinity of the intake structure that create asymmetric flow patterns approaching any of the pumps. The structure is oriented so that the supply boundary is symmetrical with respect to the centerline of the structure.

4.2.1.1. Sump Dimensions

The basic design requirements for satisfactory hydraulic performance of rectangular sumps include:

1. Adequate depth of flow to limit velocities in the pump bays
2. Reduce the potential for formulation of surface vortices
3. Adequate pump bay width, in conjunction with the depth, to limit the maximum pump approach velocities to 1.5 ft/s, but narrow and long enough to channel flow uniformly toward the pumps

4.2.1.2. Minimum Submergence

The Net Positive Suction Head (NPSH) available is the function of the station design and is the net head available at the eye of the impeller. The NPSH available should always be higher than that required by the pump with manufacturer recommended safety factor. The minimum submergence, should be enough to prevent strong air core vortices.

4.2.2. Pumps

Vertical turbine pumps are selected to achieve the required large quantity of operating flowrate in minimum head loss and maximum flow stability. The maximum flow rate of 15000 m^3/hr is achieved through 5 pumps of capacities 1000,2000,3000,4000 and 5000 m^3/hr respectively. This selection, though complicated was necessitated by the need to establish fixed in time but different in context flow rate to cover entire flow ranges of flowmeters. Variable speed drives were prohibitively costly and pumps had to run at in efficient regimes. By suitable switching of the 5 pumps, any flow rate between 1000 and 15000 m^3 /hr in steps of 1000 could be effortlessly achieved.15 points with in a range is more than adequate. Brief specifications of pumps employed in loop are listed in Table 2.

Table 2: Details of Pumps

Parameter	**Pump A**	**Pump B**	**Pump C**	**Pump D**	**Pump E**
Nominal Flow rate (m3/h)	1000	2000	3000	4000	5000
Delivery size (mm)	300	350	600	600	600
Suspension length (m)	7.06	7.06	7.06	7.06	7.06
Type of joint	Flanged				
Line shaft dia/shaft tube (mm)	50	60	70	80	80
Type of bearing	Antifriction				
Type of coupling for line shaft	Muff coupling				
Static load (kgs)	2500	2750	3500	400	4500
Dynamic load(kgs)	3125	3437.5	4375	5000	5625
Material of construction					
Suction bell and bowl	CI IS 210 Gr.FG260				
Impeller	Bronze				
Wearring	Bronze				
Shaft/line shaft,Head shaft	SS410				
Shaft bearing	Neoprene rubber in bronze shell				
Shaft coupling	SS410				
Shaft sleeves	SS410				
Rising main pipe	MS				
Delivery bend and sole plate	MS				
Stuffing box	CI IS 210 Gr.FG260				
Gland packing	Teflon				
Gasket&'o' rings	Rubber				
Motor rating (kW)	110	160	260	350	415
Motor speed (rpm)	1480		980		

4.2.3. Flowmeters

Four High performance Electromagnetic flowmeters of 600 mm NB accurately calibrated at WFL are used as parallel reference devices. The cumulative flowrate will flow through the device under test. The specifications of the flowmeters are as under:

Fluid	: Water
Operating pressure	: 2 bar
Operating temperature	: 10-50 deg.c
Flow velocity	: 0.3-10 m/sec.
Size	: DN 600
Accuracy	: +/- 0.2%of rdg.

4.2.4. Density and Viscosity Measuring Facilities

Density and viscosity of the fluid are to be measured at the temperature at which the testing is performed and the readings are recorded. It is a common practice to check these variables at a recognized reference temperature in addition to the working temperature. Reference temperature of 25 deg.c may be used for this purpose. For convenience, the measure of viscosity may be taken as kinematic viscosity. Accurate measurement of density is essential in case testing is based on volumetric ground. Measurement of density in liquids shall be made by equipments like hydrometer, density ball or density bottle. Provision is made for accurate determination of on line density measurements through tapping points. Calibrated and traceable hydrometers and viscometers are available. High precision Antonn Paar digital densitometer with 0.000005 g/cc resolution is available in Physical Standards Laboratory of FCRI.

4.2.5. Flow On-Off and Control Mechanism

The facility is fitted with all types of valve like NRV's, Gat valves, control valves wherever needed for isolation and regulation purposes. These can be operated from a centralized control room. The piping are equipped with Viking Johnson couplings for ease of assembly. Bolted joints are used as needed to accommodate devices under test. 1200mm pipes have been fitted to start with basic rig performance tests.

4.2.6. Input Power to Motors

The entire power requirements close to 2 MW are designed to be met with captive capacity. Two Mitsubishi generators of capacity 1 MW each are installed. These are housed in acoustically treated rooms and are provided with all sub systems including stacks. Soft LRS starters are installed to start the slip ring motors.

4.2.7. Supports and Anchoring

As the test lines may have to be altered to suit the end connections and required gaps, the pipe may have to be quickly dismantled and re assembled. Accommodation of different diameters of pipes and components is an operation requirement for commercial calibration. Keeping this in mind, heavy adjustable supports have been designed and fabricated. The 2000mm manifolds at the extremities are suitable anchored to negotiate the moment of momentum. Figure 2 shows the schematic arrangement of the loop. Figure 3 shows some photographs of the facility.

5. TRACEABILITY AND OVERALL UNCERTAINTY OF MEASUREMENTS

The CMC/BMC of this facility is expected to be better than +/-0.5% (of reading) covering the flow range, while calibrations are performed using Comparison Method. Traceability of all measurements are maintained through an un broken chain of calibration through the regular water flow laboratory, the Physical Standards Laboratory and the Electro Technical Laboratory. These are all accredited facilities within FCRI, and maintain a high level of BMC/CMC.

6. ADVANTAGES AND LIMITATIONS

It may be recalled that when FCRI was established in the late eighties, considerable foreign knowhow was required. This facility now established is a national asset, which is implemented with 100% indigenous effort. Credible and affordable flow calibration of large flow elements is deliverable. Flow meters and valves up to 2000 mm Nominal bore can be tested with this facility with 0.5% uncertainty. This can cater to almost all needs of flow meters for water industry. Comprehensive flow testing of large pumps independently by third party is a reality. The major limitation is the estimated uncertainty of +/-0.5% which though reasonable for such a huge setup, requires to be upgraded. The reason is the comparison method of Calibration. Additionally, the bridge across the sump can accommodate only 1900mm inlet pipe diameters for large turbine pumps.

Figure 2: Large Water Flow Laboratory of FCRI

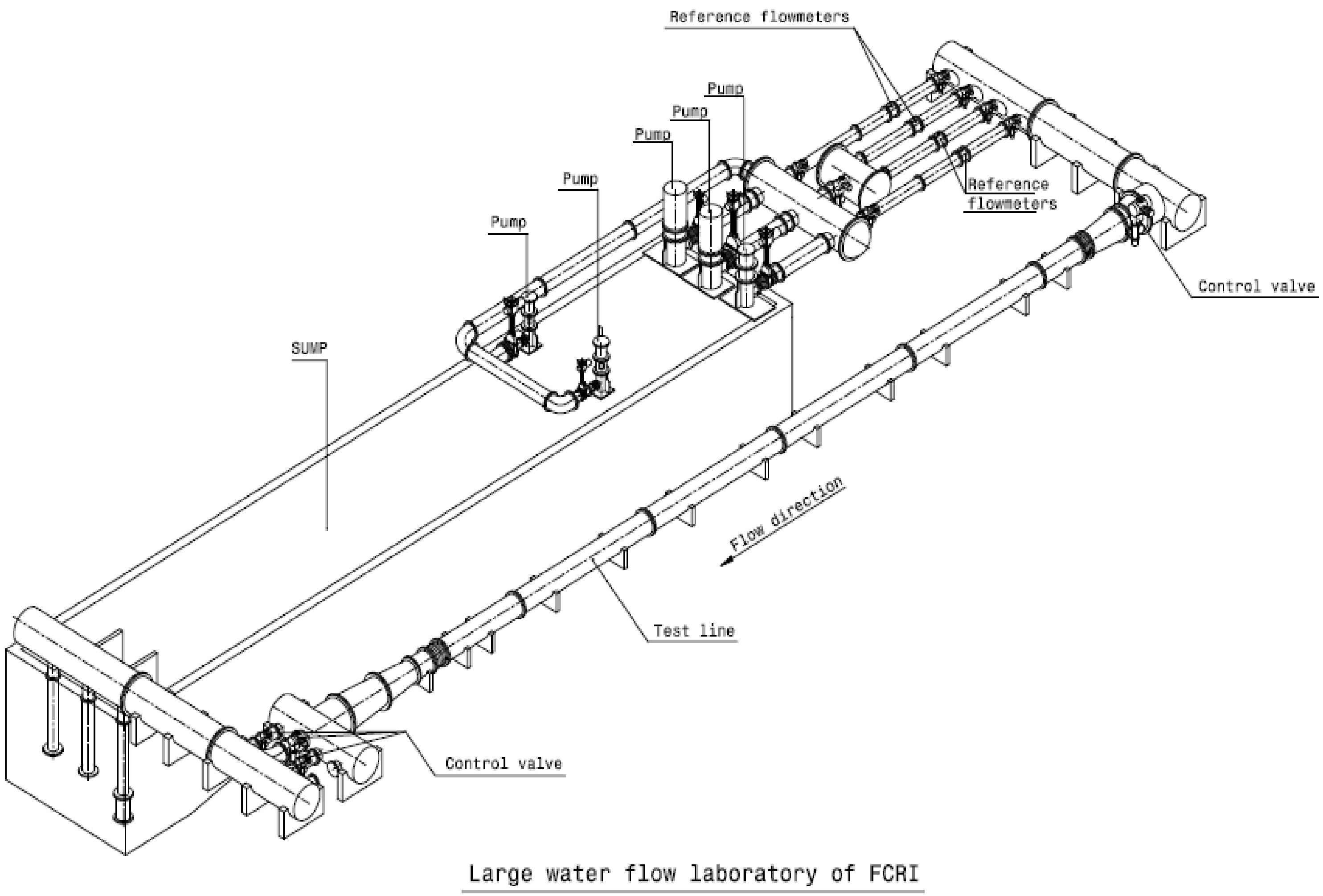

Figure 3: A Few Photographs

Photo 1: Large Water Flow Laboratory

Photo 2: 1000mm Venturi Flow Meter Under Calibration

7. SCOPE FOR FUTURE DEVELOPMENT

As a contribution to alleviating the above limitation on accuracy providing a primary static weighing method is being contemplated. A design proposal has been muted.

8. CONCLUDING REMARKS

The necessity for the establishment of a large water flow test facility, the salient features of the facility and the guiding principles adopted for the design of the facility are described. Selection criteria the major components and the details are presented. Quality assurance, traceability and future considerations are discussed. The future developmental work to improve the accuracy is also indicated.

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