

UME TEST FACILITIES FOR WATER FLOW MEASUREMENT UP TO 3 000 m³/h

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Abstract

National Metrology Institute of Turkey, UME, has completed new water flow rate measurement systems. In this article, UME primary and secondary water flow measurement systems will be described briefly. Water flow laboratory was designed for the calibration, testing, and type approval of water flow meters with the flow rates up to 3 000 m³/h and testing of the valves and pumps.

There is a 5m x 20m x 3m water reservoir inside the laboratory, filled with soft water. Several stainless steel pumps with the frequency converters exist in the system. The flow capacities are 20 to 1000 m³/h. Pumps are constructed either to feed the calibration system directly or through the constant pressure head tanks. The head tanks had capacities of 50,15 and 5 m³ and located at the top of the tower. The height of the tower is 35 m from the laboratory floor level.

There are 5 Main test line on the water flow rate measuring system as: Large Test Line (DN -250, 400, 600), Medium Test Line (DN-200, 150, 125), Small Test Line-1 (DN-100, 80, 65,50), Small Test Line- 2 (DN-40, 32, 25, 20), Small Test Line- 3 (DN-15, 10, 5).

There are four weight-time water flow measurement systems as; 30 tons, 5 tons, 1 tone with dead weight tester and 20 kg Estimated total expanded uncertainties of weighting systems are in 0.05% range. There is also one volume-time flow measurement sub-system with the capacity up to 100 m³/h in the system. DN 400 and DN 250 Electromagnetic reference flow meters are located on the systems, with Capacities up to 2500 m³/h. DN 150, DN 80, DN 32 and DN 15 Turbine type flow meters with the minimum flow capacities 0.6 m³/h are also placed in the system. The uncertainties of all the reference flow meters are around 0.2 percent.

All the measuring lines, before the weighting systems were connected from one to others with the actuator valves and controlled by automation system.

There are two water-feeding pumps and tanks with the water temperature controllers, operating independently from the water reservoir that supplies hot, and cold water to the measuring line.

Key words: Weighting-time water Flow measurement, Water Flow Standard, head tank, calibration, and traceability

INTRODUCTION TO UME TEST FACILITIES FOR WATER FLOW MEASUREMENT

The new UME water flow rate measurement systems have been completed to cover the full range of industrial need of Turkey. UME water Flow Measurement Laboratories' capacity is from 0 to 3000 m³/h. This capacity established with five main systems;

- Large Test Line,
- Medium Test Line,
- Small Test Line-1,
- Small Test Line- 2
- Small Test Line- 3

The test facilities of the water flow measurement system was constructed mainly for three purposes:

1. Testing and Calibration for water flow meters

2. Cold and hot water meter testing
3. Type approval testing for water flow meters, valves, armatures and pumps

1. TESTING AND CALIBRATION FOR WATER FLOW METERS

UME testing and calibration facilities for water flow measurements were constructed in two parts:

- Liquid feeding and Flow control system
- Flow rate measuring System

1.1. Liquid feeding and Flow control system

As seen from **Figure-1.1**, there is a 5m x 20m x 3m water reservoir inside the laboratory, filled with soft treated water. There are several stainless steel pumps with the frequency converters. The flow capacities of the pumps are between 20 to 1000 m³/h. Pumps are

constructed to feed the calibration system either directly or through the head tanks, which are located at the top of the tower. Tank capacities are 50, 15, and 5 m³. The height of the tower is 35 m from the laboratory floor level. There is a water heating circulation system, reservoir water level sensor, filtering system and chlorine dosing unit on top of the reservoir.

The Piping of the liquid feeding and flow control systems, head tanks, valves, armatures, etc. are shown as PI diagram in **Figure-1.1**

1.2. Flow rate measuring Systems

There are 5 Main test line on the water flow rate measuring system:

- Large Test Line,
- Medium Test Line,
- Small Test Line-1,
- Small Test Line- 2
- Small Test Line- 3

1.2.1. Large Test Line:

As shown from **Figure 1.2**, the large test line has three different diameter sizes of measuring line as DN600, DN400 and DN250 mm, which comes from the same collector. There are two magnetic reference flow meter on the DN 250 and DN 400 measuring lines and measuring range of these flow meters are 0 to 1500 m³/h and 0 to 2500 m³/h respectively. There are two possibilities to flow the water through the test section, either directly from the pumps or from the head tank that is on the tower. After reference flow meter and testing meter water can run directly to the pool or through the diverter and weighting tank and then to the reservoir. There are two different size diverters on the test line, one is for the DN250 and DN400 lines, and the other is for DN600 line. Both of them fill the same weighting system, which has the capacity 30 tons.

1.2.2. Medium Test Line:

As shown from **Figure 1.2**, the medium test line has three different diameter sizes of measuring line, DN200, DN150 and DN125 mm, all feeding from the same collector. There is a turbine reference flow meter on the DN 150 measuring lines. Measuring range of this reference flow meter is 60- 600 m³/h. There are two possibilities to flow the water through the test section, either directly from the pumps or from the head tank that is on the tower. After

reference and testing meters water can run directly to the pool or through the diverter and weighting tank to the reservoir. There is one-size diverter on the test line fill the 5 tons capacity of weighting system. The measuring range of the weighting system can be seen on **Figure-1.5**

1.2.3. Small Test Line-1:

As shown from **Figure 1.2**, the **Small-1** test line has four different diameter sizes of measuring line, DN100, DN 80, DN65 and DN50 mm, all feeding from the same collector. There is a turbine reference flow meter on the DN 80 measuring lines and measuring range of this reference flow meter is 10- 100 m³/h. There are two possibilities to flow the water through the test section, either directly from the pumps or from the tower head tank. After reference flow meter and testing meter water can run directly to the pool or through the diverter and weighting tank to the reservoir. There is one-size diverter on the test line fill the 1 tons capacity of weighting system. This weighting system has got 1-ton dead weight masses to calibrate weighting load cell at any time. Using this weighting system medium and large test lines' weighting load cells can be calibrated.

1.2.4. Small Test Line-2:

As shown from **Figure 1.2**, the **Small-2** test line has four different diameter sizes of measuring line as DN40, DN 32, DN25 and DN20 mm, which comes from the same collector. There is a turbine type reference flow meter on the DN 32 measuring lines and measuring range of this reference flow meter is 3- 30 m³/h. We have two possibilities to flow the water through the test section, either directly from the pumps or from the head tank that is on the tower. After reference flow meter and testing meter water can run directly to the pool or through the piston prover to the reservoir. The piston prover's measuring capacity is 0.030- 103 m³/h

1.2.5. Small Test Line-3:

As shown from **Figure 1.2**, the **Small-3** test line has three different diameter sizes of measuring line as DN15, DN 10 and DN5 mm, which comes from the same collector. There is a turbine type reference flow meter on the DN 15 measuring lines and measuring range of this reference flow meter is 0.6- 6 m³/h. We have

two possibilities to flow the water through the test section, either directly from the pumps or from the head tank that is on the tower. After reference flow meter and testing meter water can run directly to the pool or through the diverter and weighting tank to the reservoir. There is one-size diverter on the test line fill the 10 kg capacity of weighting system. Measuring capacity of this system is about 0.001-2 m³/h.

1.3. Weighting system with diverter

There are four weighting system at the end of the flow measuring lines. The capacities of

them are 30 tons, 5 tons, 1-ton and 10 kg. Flow rate capacities for each weighting system can be seen on **Figure -1.5**. And there are five diverters on the water flow measuring system, two of them (DN600, DN400) connected with 30-tons tank, one of them (DN200) connected with 5-tons tank, one of them (DN100) connected with 1-ton tank and the last (DN15) connected with 10 kg tank. Also all measuring test lines can be connected each other and can be feed any weighting tank and any diverter.

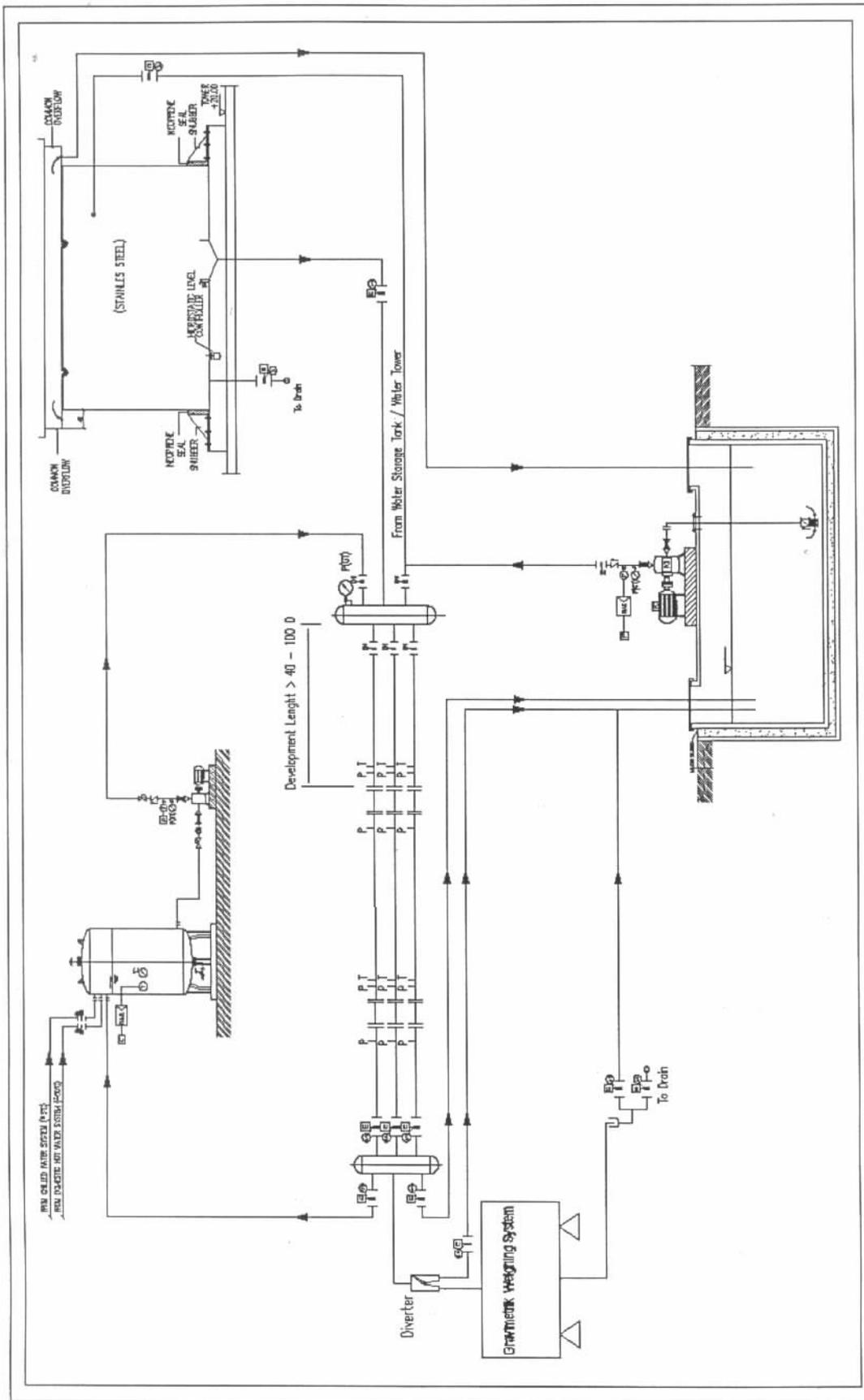


Figure -1.1 Water Flow Feeding and Flow Control Systems

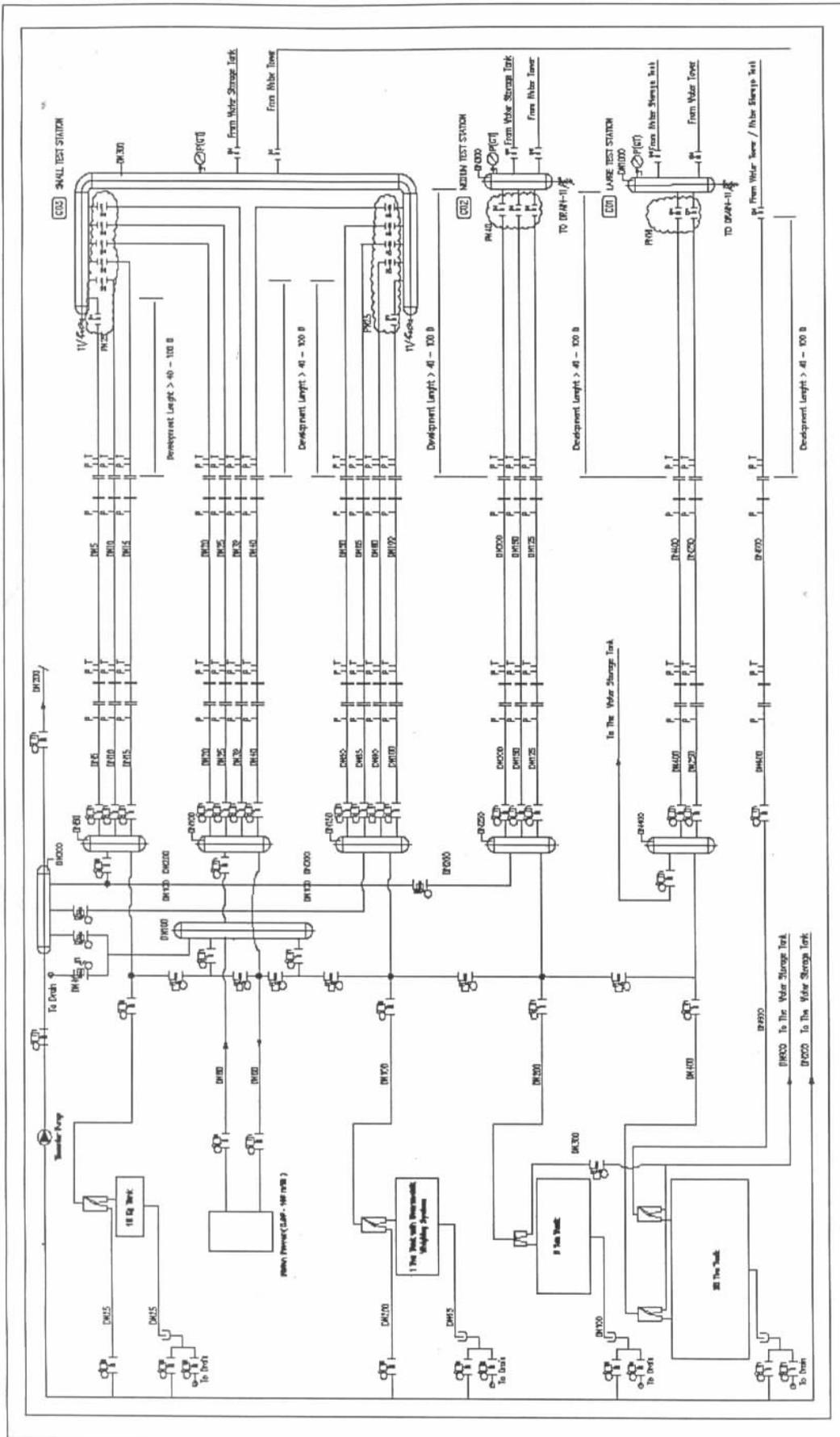


Figure -1.1 Water Flow Rate Measuring Systems

1.4: Estimated uncertainty calculation for Weighting –Time Measuring system

Estimated uncertainty calculation for Weighting –Time Measuring System for 1 ton can be seen on Table 1.4

Test system: 1 ton
Flowrate: 40 m³/h
MASS

Density: 998 kg/m³
Diversion time: 80 s

Symbol	Source of uncertainty	Value ± g	Probability distribution	Divisor	c _i	u _i (W _x) ± g	u _i (W _x) ± %
W _s	Calibration of standard weights	50	Normal	2,00	1	25,0	
S _D	Discrimination of weigh scale	50	Rectangular	1,73	1	28,9	
S _L	Linearity of weigh scale	100	Normal	2,00	1	50,0	
S _T	Temperature stability of weigh scale	50	Rectangular	1,73	1	28,9	
S _R	Repeatability of weigh scale	100	Normal	2,00	1	50,0	
u _c (W _x)	Combined uncertainty		Normal			81,67	0,0092
U (W _x)	Expanded uncertainty		Normal (k=2)			163,34	

DENSITY

Symbol	Source of uncertainty	Value ± kg/m ³	Probability distribution	Divisor	c _i	u _i (D _x) ±kg/m ³	u _i (D _x) ± %
D _{TX}	Calibration of density transducer	0,050	Normal	2,00	1	0,025	
D _T	temperature compensation	0,025	Rectangular	1,73	1	0,014	
D _P	pressure compensation	0,005	Rectangular	1,73	1	0,003	
D _S	long term stability	0,050	Rectangular	1,73	1	0,029	
u _c (D _x)	combined uncertainty		Normal			0,041	0,0041
U (D _x)	expanded uncertainty		Normal (k=2)			0,082	

TIME

Symbol	Source of uncertainty	Value ± ms	Probability distribution	Divisor	c _i	u _i (T _x) ±secs	u _i (T _x) ±%
T _C	Calibration of timer	0,1	Normal	2,00	1	0,000	
T _D	Discrimination of timer display	10	Rectangular	1,73	1	0,006	
T _T	temperature stability of timer	0,2	Rectangular	1,73	1	0,000	
T _{DIV}	diverter operation repeatability	20	Normal	2,00	1	0,010	
u _c (T _x)	combined uncertainty		Normal			0,012	0,0144
U (T _x)	expanded uncertainty		Normal (k=2)			0,024	

Total- Flowrate Measurement

symbol	Source of uncertainty	Probability distribution	u _i (Flow) ±l/s	u _i (Flow) ±%
u _c (T _x)	Combined uncertainty (Flow)	normal	0,0016	0,018
U (T _x)	Expanded uncertainty (Flow)	Normal (k=2)	0,0032	0,036

TABLE – 1.4

1.4. Tracibility Chain for Water Flow Measuring System

As seen from Figure – 1.5, UME water Flow measuring system is directly traceable to Primer SI unite which can be obtained from UME labs. Thus UME water Flow measuring system is the National Standards. There is one gravimetric measuring system with dead

weights tester; dead weights get their tracibility from the mass laboratory and using these dead weights, all the balances can be calibrated either directly or indirectly on place. So using this balances reference flow meters can be calibrated. The calibration range and estimated uncertainty for k=2, can be seen from Table 1.4.

TRACIBILITY CHAIN FOR UME WATER FLOW MEASURING SYSTEM

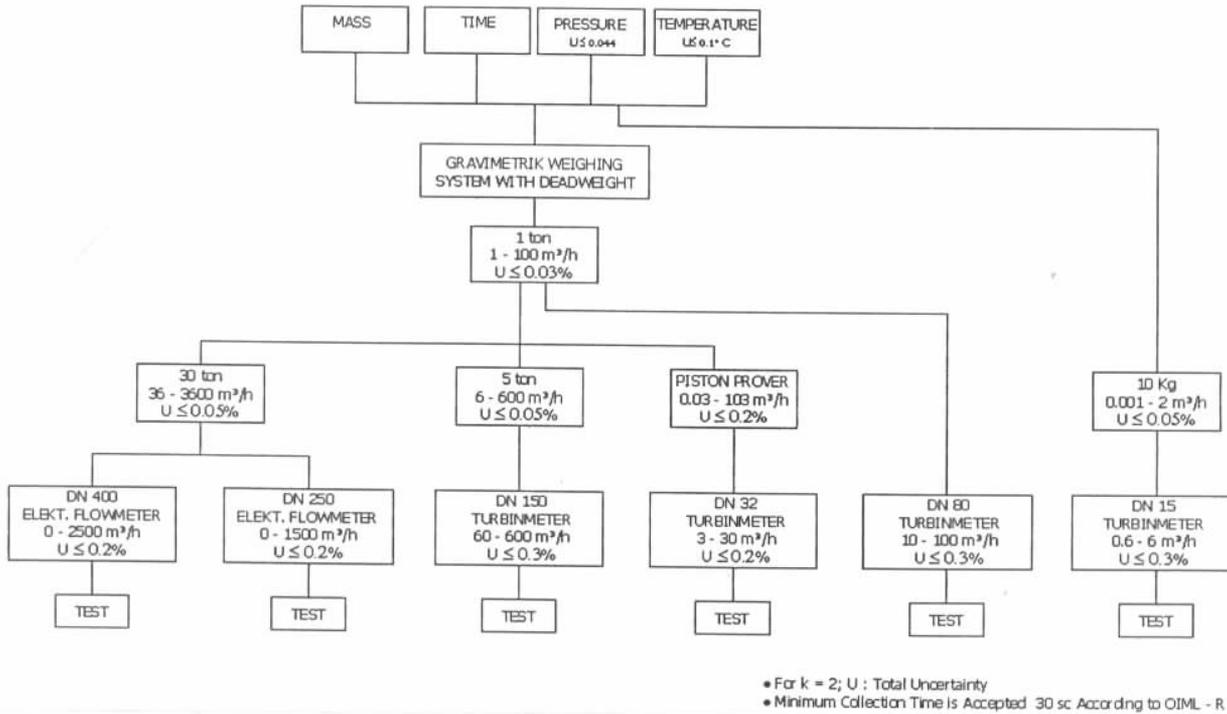


Figure -1.5 Tracibility Chain for UME Water Flow Measurement

1.5. System Automaton flow chard

The diagram (Figure-1.6), describes the automation of UME Hydraulic Laboratory system for carrying out calibration and type approval testing according to different scenarios. Automation aims, eliminating errors, which is coming from human factor and achieving less uncertainty. The automation system is PLC based and operated by a real time user interface program. So every step of

operation can be seen on computer display and can be recorded by computer.

Computer operator at the beginning of testing selects required measurement and testing procedures. After selection of the operation steps, computer operates valves, pumps, timer and weighting system and stores data. In order to achieve different flow rates the computer runs the pumps and valves by means of PID through PLC.

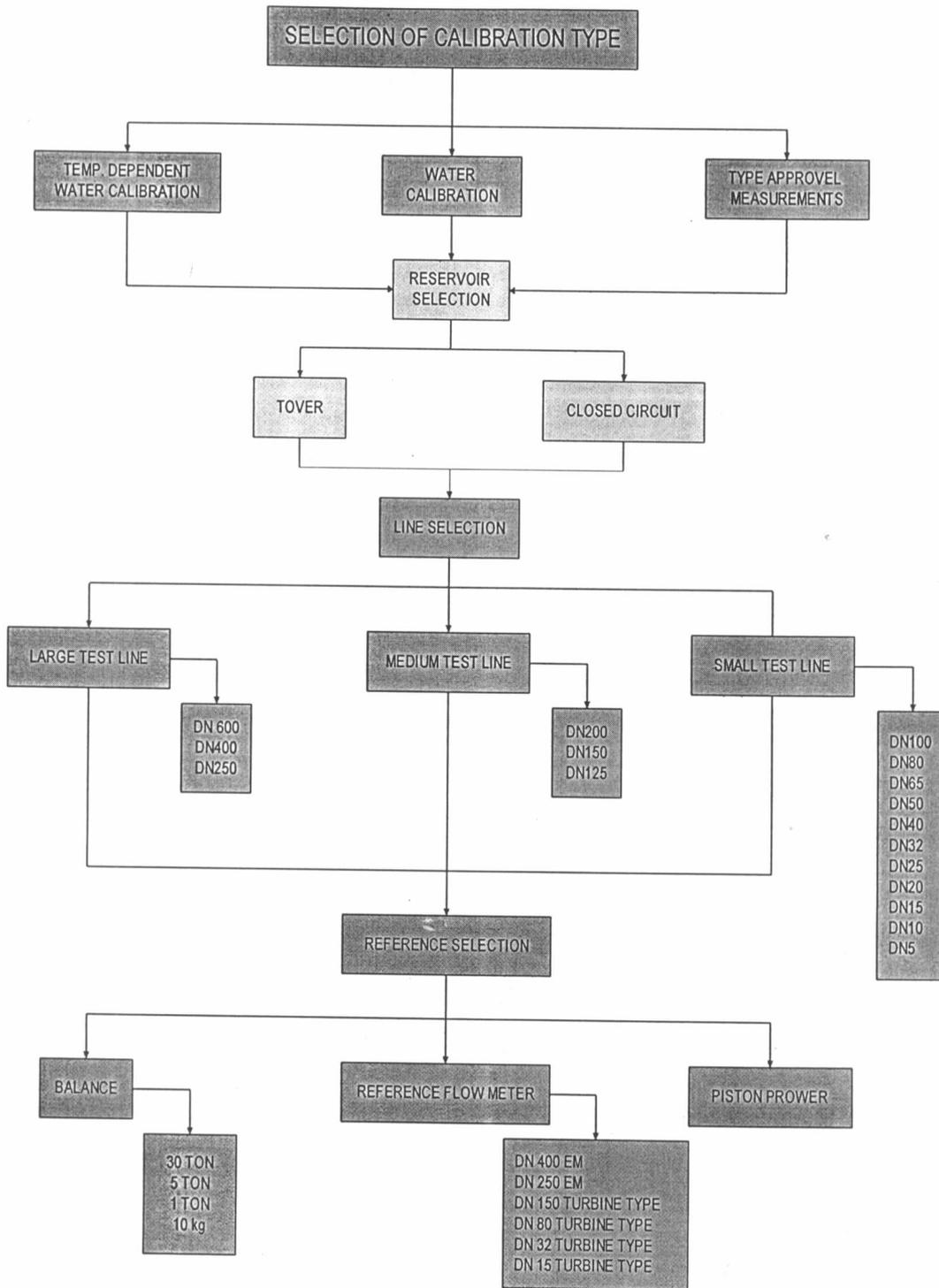


Figure-1.6 System Automation Flow chard

2. COLD AND HOT WATER METER TESTING AND CALIBRATION EQUIPMENT

There are two tanks with the capacities 2-tons and 4-tons and two different capacities pumps with the frequency controller are being used for cold and hot water feedings elements that are on the closed circuit. 5 °C - Cold water and 50 °C - hot water is being supplied from general usage. Also in the hot water tank there is heating element with controller and temperature can be increased up to 80 °C. Both systems can feed all the medium and small measuring test lines.

3. TYPE APPROVAL TEST FACILITIES FOR WATER FLOW METERS, VALVES, ARMATURES AND PUMPS

For the type approval testing following systems are designed:

- Cold and hot water meter testing and calibration equipment, which are explained under the heading number-2.
- For the endurance test, there are two different capacities pumps with the frequency controller and time controlled 3-way valves with the counters.
- There are three high-pressurized pumps with the frequency controller for the static and dynamics pressure and leakage testing.
- Temperature and Pressure transducers all the lines

4. CONCLUSION

The new UME water flow measurement systems was briefly explained in this paper. UME primary and secondary water flow laboratory was designed for the calibration, testing, and type approval of water flow meters with flow rates up to 3 000 m³/h and testing of the valves and pumps. There are three head tanks, located at the top of the tower, with capacities of 50, 15, and 5 m³. Water flows from the head tank through to test section at a constant pressure. The height of the tower is 35 m from the laboratory floor level. There are 5 Main test line on the water flow rate measuring system: Large Test Line (DN -250, 400, 600), Medium Test Line (DN-200, 150, 125), Small Test Line-1 (DN-100, 80, 65,50), Small Test Line- 2 (DN-40, 32, 25, 20), Small Test Line-3 (DN-15, 10, 5). There are four weighting-time water flow measurement systems with 30

tons, 5 tons, 1 tone with dead weight tester and 20 kg. Estimated total expanded uncertainties are about 0.05 percent. Also there are six-reference flow meters on the systems, DN 400 and DN 250 Electromagnetic flow meters with Capacities of 2500 m³/h and DN 150, DN 80, DN 32 and DN 15 Turbine type flow meters with the minimum flow capacities 0.6 m³/h. The expanded uncertainties of all the reference flow meters are about 0.2 percent.