

UME Test Facilities for Oil Flow Measurement up to 300 m³/h

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Abstract

National Metrology Institute of Turkey, UME, has completed the new oil flow rate measurement systems. In this article, UME primary and secondary oil flow measurement systems will be described briefly. Oil flow laboratory was designed for the calibration, testing, and type approval of liquids other than water. It utilizes flow meters with the flow rates up to 300 m³/h and capable of testing of valves and pumps.

There are two 1 m³ and one 4 m³ oil reservoirs in the laboratory for different flow rate measurements with various type of oil. Three stainless steel pumps with the frequency converters can supply flow rates from 0 up to 300 m³/h. Pumps have capability of supplying required flow to calibration system directly or send oil to tower head tanks, which are located on the top of the tower, with capacities of 4, 2 and 1 m³. This system aims to decrease system measurements error due to pressure pulses created the tower is about 35 m from the laboratory floor level. Oil can be heated up to 80 °C by using heat exchangers.

There is three test lines on the oil flow rate measuring system as: Large Test Line (DN 300), Medium Test Line (DN 100) and Small Test Line (DN 50).

There are three weighting-time oil flow measurement systems and one of them has dead weight tester with 2.5 tons, 1 ton and 150 kg. DN 300, DN 100 and DN 50 ultrasonic type reference flow meters with the maximum capacities 250 m³/h are also placed on the systems. The uncertainties of all the reference flow meters are about 0.2 percent.

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

There are two oil drainage system transfer pumps and packaged type oil separator with the level controllers. This system is used to clean the oil flow measurement systems.

Feeding, and controlling of the oil flow to the measuring lines and testing of the flow meters are being performed by the automation systems.

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

INTRODUCTION TO UME TEST FACILITIES FOR HYDROCARBON LIQUID FLOW MEASUREMENT

The new UME oil flow rate measurement systems have been completed to cover the full range of industrial need of the country. With the new systems, UME oil Flow Measurement Laboratories' capacity is upgraded up to 300 m³/h. System consist of three subsystems:

- Large Test Line,
- Medium Test Line,
- Small Test Line

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

1. Testing and Calibration for Oil flow meters

2. Hot Oil meter testing
3. Type approval testing for Oil flow meters, valves, armatures and pumps

1. TESTING AND CALIBRATION FOR OIL FLOW METERS

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

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

All the equipments for liquid feeding and Flow control system and flow rate measuring systems are explosion-proof

1.1. Liquid feeding and Flow control system

As seen from **Figure-1.1** (Oil Flow Feeding and Flow Control System) there are three

measuring lines and each has a collecting tank inside the laboratory. There are three stainless steel screw type pumps with the frequency converters with the max flow capacities of 5, 20 and 300 m³/h for the low viscosity liquids (viscosity ≤ 20 mPa.s). Pumps are constructed to feed the calibration system directly or to pump the oil from the reservoir to the tanks, which are located at the top of the tower. Tower oil tanks has capacities of 1, 2, and 4 m³. The height of the tower oil tanks is about 30 m from the laboratory floor level. A heating system is also designed in these systems. All the tanks have level sensors,

The Piping of the liquid feeding and flow control systems, oil tanks, valves, armatures, etc. are shown Schematically on **Figure-1.1**

There are 3 Main test line on the oil flow rate measuring system:

- Large Test Line (DN -300),
- Medium Test Line (DN-100),
- Small Test Line (DN-50),

Before and after the test line there is a junction, which gives the possibility to connect test line in any desired combination.

2.1 Flow rate measuring Systems

2.1.1 Large Test Line:

As shown from **Figure 2.1** the large test line's diameter is DN400. There is an ultrasonic reference flow meter on the line. Measuring range of this flow meter is 0- 250 m³/h. There are two possibilities to flow the oil through the test section, either directly from the pumps or from the tank tower. After reference flow meter and testing meter oil can run either directly to the reservoir tank or to weighting tank through the diverter and then to the reservoir tank. There is one-size diverter on the test line fill the 2.5 tons capacity of weighting system. The measuring range of the weighting system can be seen on **Figure-2.4**.

2.1.2 Medium Test Line:

As shown from **Figure 2.1** the medium test line's diameter is DN100. There is an ultrasonic reference flow meter on the line. Measuring range of this flow meter is 0- 50

m³/h. There are two possibilities to flow the oil through the test section, either directly from the pumps or from the tower tank. After reference flow meter and testing meter oil can run either directly to the reservoir tank or to weighting tank through the diverter and then to the reservoir tank. There is one-size diverter on the test line to fill the 1- ton capacity of weighting system. Weighting system has 1-ton dead weight masses to calibrate load cell at any time. Using this weighting system small and large test lines' load cells can be calibrated. The measuring range of the weighting system can be seen on **Figure-2.4**.

2.1.3 Small Test Line:

As shown from **Figure 2.1** the small test line's diameter is DN50. There is an ultrasonic reference flow meter on the line. Measuring range of this flow meter is 0- 10 m³/h. There are two possibilities to flow the oil through the test section, either directly from the pumps or from the tower tank. After reference flow meter and testing meter oil can run either directly to the reservoir tank or to weighting tank through the diverter and then to the reservoir tank. There is one-size diverter on the test line fill the 150-liters capacity of weighting system. The measuring range of the weighting system can be seen on **Figure-2.4**.

2.2 Weighting System with diverter

There are three weighting systems at the end of the flow measuring lines, with the capacities of 2.5-tons, 1-ton and 150 kg respectively. Flow rate capacities for each weighting system can be seen on **Figure-2.1** and **Figure-2.4**. There is a coriolis type density meter on each line, to obtain density information for the volume flow rate measurements. There are three diverters on the oil flow measuring system, the biggest is DN300 connected with 2.5-tons weighting tank, the medium is DN100 connected with 1-ton weighting tank and the small is DN50 connected with 150 kg weighting tank Also all measuring test lines can be connected each other and can be feed any weighting tank and any diverter.

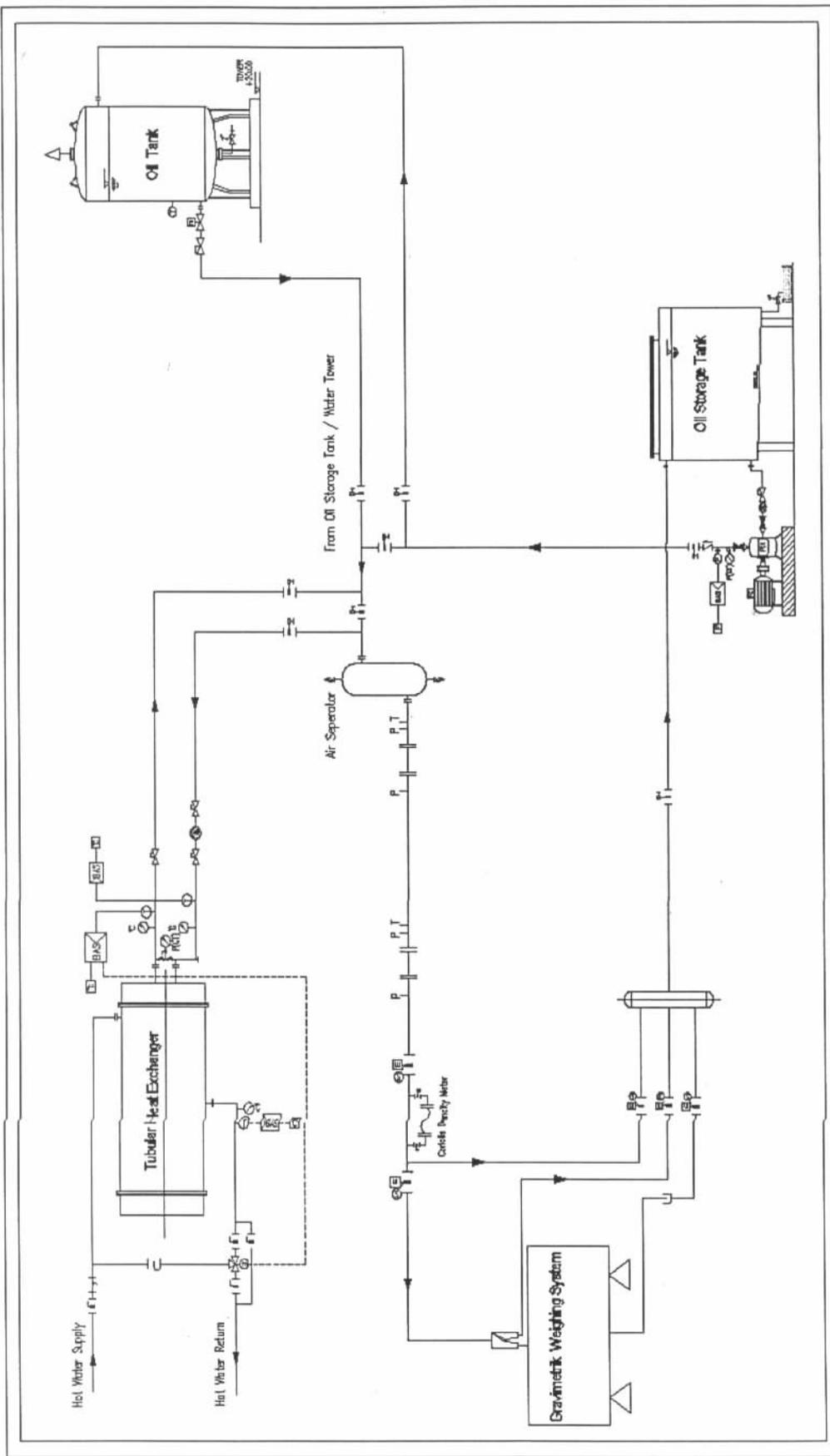


Figure -1.1 Oil Flow Feeding and Flow Control Systems

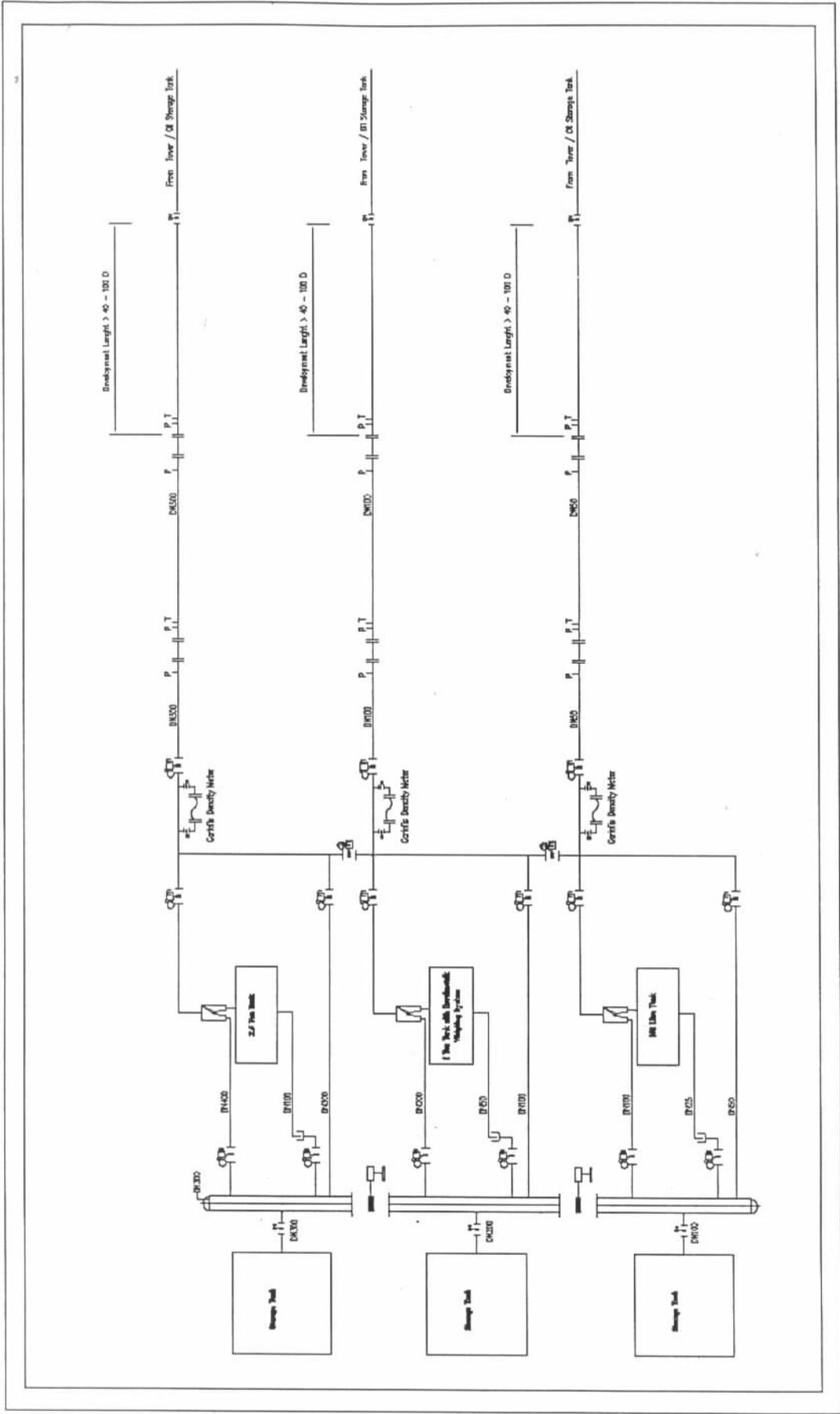


Figure -2.1 Oil Flow rate Measuring Systems

2.3 Estimated uncertainty calculation for Weighting –Time Measuring system

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

Table 2.3

Test system: 1 ton

Density: 998 kg/m³

Flowrate: 40 m³/h

Diversion time: 80 s

MASS

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-2.3

2.4 Tracibility Chain for oil Flow Measuring System

As seen from Figure – 2.4, UME Oil Flow measuring system is directly traceable to Primer SI units, which can be obtained from UME labs as primary standards. Thus UME Oil 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 on the Figure – 2.4.

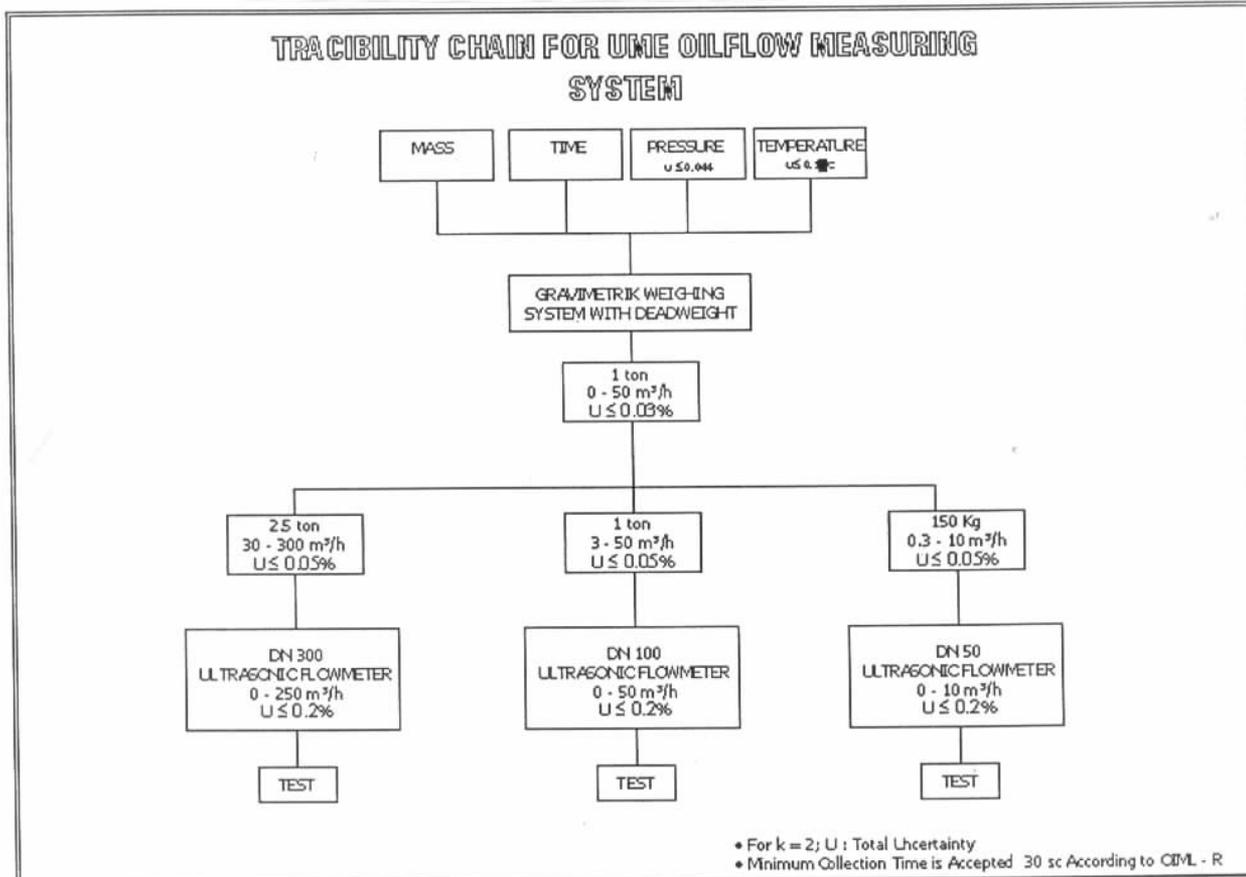


Figure –2.4 Tracibility Chain for UME Oil Flow Measurement

2.5 System Automaton flow chard

The above diagram (Figure-2..5), 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.

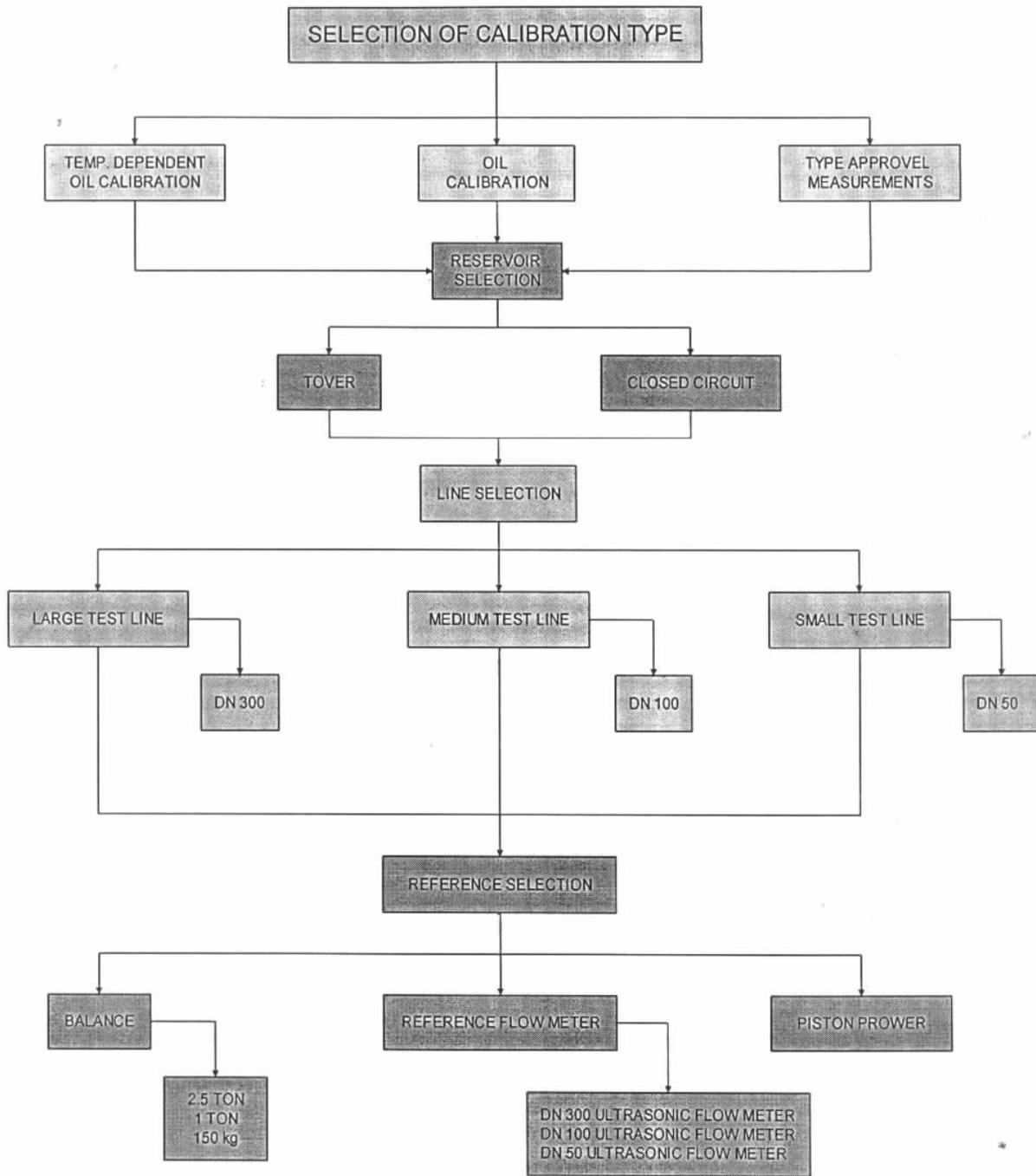


Figure-2.5 System Automation Flow chard

2. HOT OIL METER TESTING AND CALIBRATION EQUIPMENT

There are two heating equipments for oil heating line. First heating system heats the incoming domestics hot water and outgoing hot water heats the oil up to 80 °C through the shell and tube- types heat exchanger. There is a

proportional oil temperature-controlling unit on the system.

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

For the type approval testing we have:

- For the endurance test, we will use water-testing system, which has 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.
- There are Temperature and Pressure transducers all the lines

4. CONVLUSION

The new UME oil flow measurement systems were briefly explained in this paper. UME primary and secondary oil flow laboratory was designed for the calibration, testing, and type approval of oil flow meters with the flow rates

up to 3 00 m³/h. There are three tower tanks, which are located on the top of the tower, with capacities of 4, 2, and 1 m³ that oil flows through to test section and the height of the tower tank is about 30 m. from the laboratory floor level. There are three test lines on the oil flow rate measuring system, Large Test Line (DN 300), Medium Test Line (DN 100) and Small Test Line (DN 50).

There are three weighting-time oil flow measurement systems and one of them has dead weight tester with 2.5 tons, 1 ton and 150 kg. Estimated total expanded uncertainties are about 0.05 percent. Also there are three ultrasonic type reference flow meters placed on the systems, DN 300, DN 100 and DN 50 with the maximum capacities 250 m³/h. The expanded uncertainties of all the reference flow meters are about 0.2 percent.