

Introducing UME Diverters' and Weighing Systems for Water and Hydrocarbon Flow Measurement

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Abstract

This article describes fundamental design, technical aspects, measurement and internal calibration principals of weighing-time flow measurement systems with the diverters for water and Hydrocarbon liquids, which are newly established at UME Fluid Mechanics Laboratories.

At the UME Fluid Mechanics Laboratories, there are four weighing-time flow measurement systems with the capacities of 30 tons, 5 tons, 1 tone with dead weight tester and 10 kg for water and three weighing-time flow measurement systems with the capacities of 2.5 tons, 1000 kg with dead weight tester and 150 kg for Hydrocarbon liquids. There are five diverters on the weighing-time flow measurement systems with the diameters of 600, 400, 200, 100 and 15 mm for water and three diverters on the weighing-time flow measurement systems with the diameters of 300, 100 and 50 mm for Hydrocarbon liquids.

Key words: Weighing-time water Flow measurement, Water Flow Standard, diverter and calibration

INTRODUCTION TO UME DIVERTERS' AND WEIGHING SYSTEMS FOR WATER AND OTHER LIQUIDS FLOWRATE MEASUREMENT

New UME liquid flow measurement laboratories have five diverters on the weighing-time flow measurement systems with the diameters of 600, 400, 200, 100 and 15 mm for water and three diverters on the weighing-time flow measurement systems with the diameters of 300, 100 and 50 mm for liquids other than water.

Both of the diverters with diameter of 600 mm and 400 mm fill the same weighting system, which has the capacity 30 tons. The diverter with diameter of 200 mm is for the 5 tons capacity weighing system and with diameter of 100 is for 1 tone capacity weighing system. 10 kg capacity weighing system uses the smallest diverter, diameter of 15 mm.

In the Hydrocarbon liquids laboratory, the diverter with the diameter of 300 mm fills 2.5 tons capacity tank, the 100 mm of them fills 1 tone capacity tank and the smallest one, 50 mm, fills 150 kg capacity tank.

1. BASIC SPECIFICATIONS OF GRAVIMETRIC TEST SYSTEMS

All the weighing-time test systems have these parts:

1. Test lines
2. Stainless steel weighing tank
3. Load-cell balance (placed below the weighing tank)
4. Diverter
5. Measuring Instruments (Pressure, Temperature, Level)
6. Ball / Butterfly valves with pneumatic actuators
7. Collectors and pipelines for the other sets.

2. 1 TON CAPACITY WEIGHING-TIME WATER / OIL FLOW MEASUREMENT SYSTEM WITH DEAD-WEIGHT TESTER MACHINE

As shown from figure 1, flow measurement diverting system consist of:

1. Transformation Tube
2. Nozzle,
3. Diverter,
4. Load-cell balance,
5. Weighing tank,
6. Dead Weight Tester,
7. Calibration Pump.

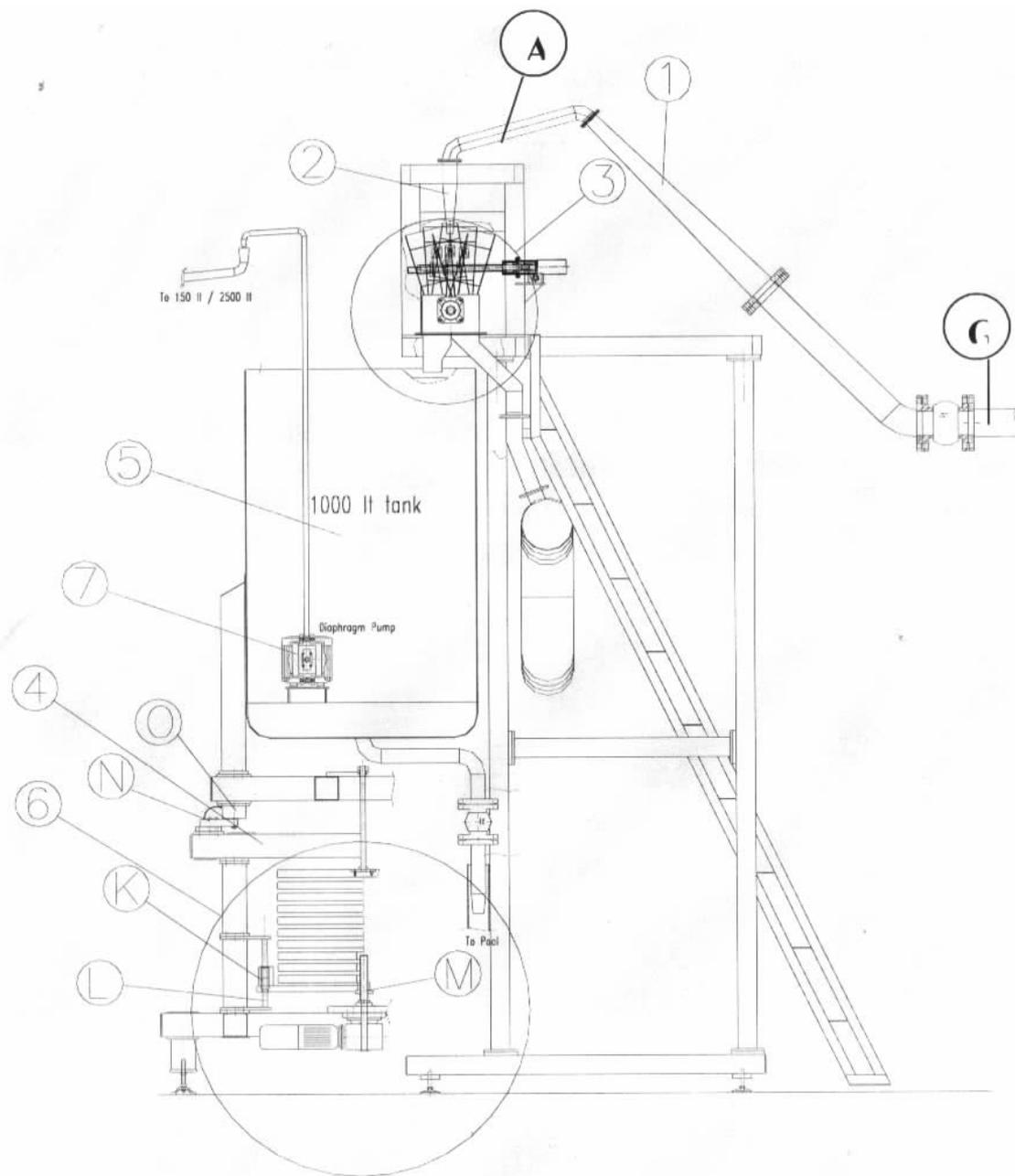


Figure 1. 1 ton capacity weighting-time flow measurement system with dead weight tester.

2.1. Transformation Tube:

Test lines (G) are connected to the transformation tube (1). The transformation tube forms the flow to the rectangular cross-section water jet (Figure 1).

2.2. Nozzle:

The transformation tube is connected to the nozzle (2) with a rectangular cross-sectioned feeding tube (A). Nozzle has a stable

rectangular cross-section. The nozzle directed the flow in to the diverter as a free water jet.

2.3. Diverter:

Diverter diverts the flow into the weighing tank or turning lines to the main pool.

Diverter (figure 2) consists of a stationary support (B) and a rotary blade (C). Stationary support is fixed to the main support frame (D) of the diverting system.

Rotary blade is pivoted on a horizontal axis (E). Rotary blade diverts the water jet with a sharpened diverting edge (F) into a bifurcated conduit (H). Rotary blade is acted by a precision ball-screwed motion mechanism (I).

The motion mechanism is controlled by a servomotor (J) and driver. Servomotor includes a high resolution (13 bit per revolution) encoder. The jog mode of the servo driver allows adjusting and determining the center position of the sharpened diverting edge and the nozzle.

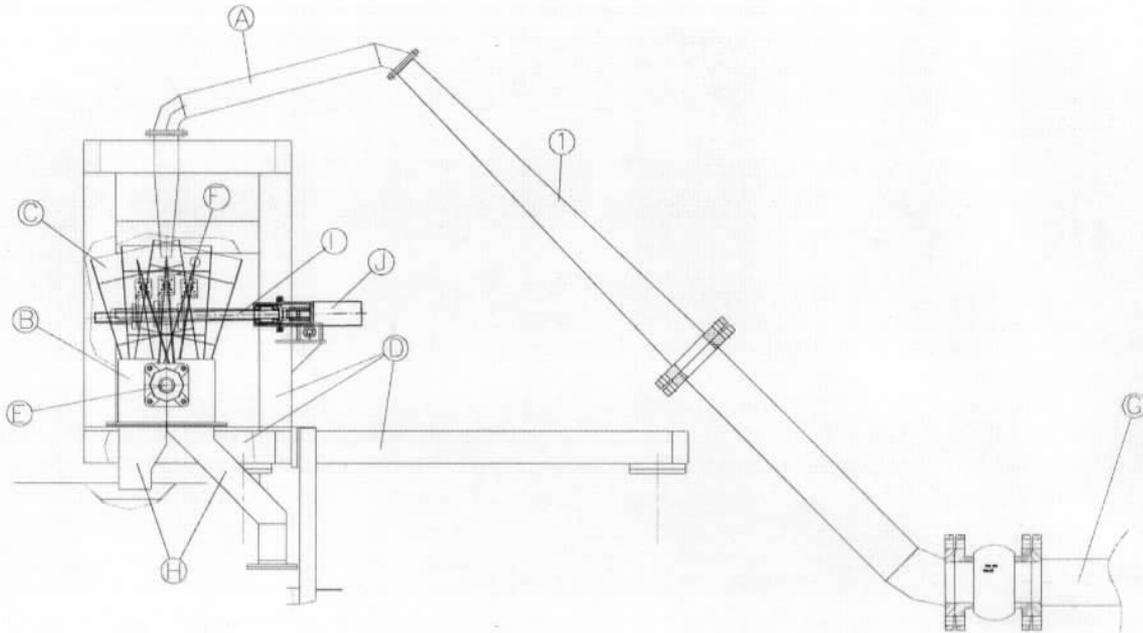
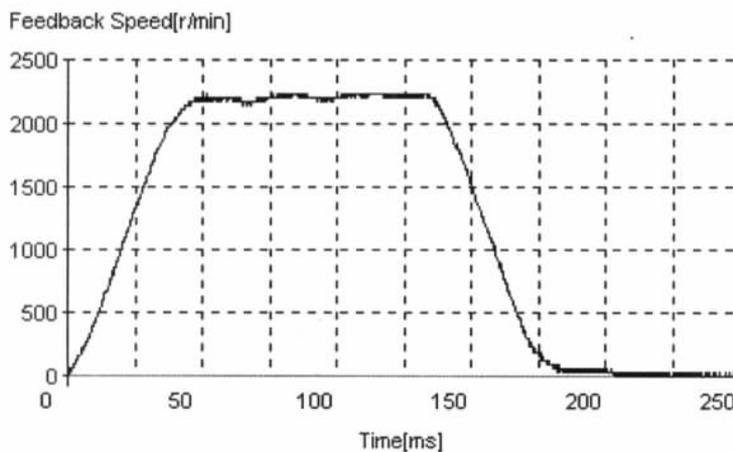


Figure 2. Diverter design.



Graph 1. Speed-time graph of 100 mm diverter.

Input/output delay times of PLC and servo driver are as follows:
On/off and off/on delay time of servo driver input: 1 ms (max)

On/off delay time of PLC output: 1 ms (max)
Off/on delay time of PLC output: 0.3 ms (max)
On/off and off/on delay time of servo driver input: 1.8 ms (max)

On/off and off/on delay time of servo driver
output: 0.8 ms (max)

2.4. Load Cell Balance:

Load cell balance is placed below the weighing tank. The balance is made of 316 Stainless steel and has 3 stainless steel load cells. The load cells are fixed with elastic kits. Technical specifications of each load cells according to in actual force value (%):

- Repeatability error : 0,01 %
- Hysteresis error : 0,06 %
- Interpolation error : 0,005 %
- Relative zero error : 0,002 %
- Temperature effect on output:
0,01%/10 K
- Temperature effect on zero:
0,01%/10 K
- Creep in 15 minute : 0,003 %
- Resolution error : 0,002 %

Specifications of the load cell amplifier, which is used for signal converter, are as follows:

Accuracy class	: 0.01 %
Input sensitivity	: 0,5 μ V/digit
Measuring range	: 1-160 mV/V
Digital Filters	: 0,-10 Hz
A/D converter speed	: 5-20 ms
A/D converter internal resolution:	16.000.000
Linearization points	: 6
Temperature range	: -20/+70 °C

2.5. Weighing Tank:

Weighing tank is made of 316 Stainless steel. Weighing tank is on the load cell balance and has temperature and level measurement on. This tank is placed below the diverter and stores the liquid during the testing time. The required liquid mass for testing is diverted and forwarded to the weighing tank through a conduit. The conduit must not contact to the tank and not effect the weighing.

2.6. Dead Weight Tester:

Flow measurement system is equipped with a dead- weight tester machine. Dead- weight tester machine has 10 pieces 100 Kg calibrated masses (1). Calibrated masses are made of Stainless steel and are hung to the load cell balance, one by one by a moving table. The moving table is guided by the linear bearings (K) and rods (L). It is acted by a precision ball-screwed motion mechanism (M). Calibrated masses are hung to the load-cell balance (4) according to the calibration procedures of

balance automatically. The calibration is able to procure check and verification of the balance for each 100 kg more step by step until 1000 kg.

Calibrated masses are unloaded before starting test. Principle of load cell balance calibration with the 10 equal piece of dead weight is explained below:

1. Pre - loading: First of all, load cell balance is pre - loading with the maximum capacity (%100 of the tank) of the tank for three times. On this pre-loading period it is better to load the dead weights in one time instead of each by each (part loading). The full load data should be taken after 60-90 sec duration. Similar with the full load data, empty load data should be taken after 60-90 sec duration from unloading. To finish the pre-loading operation same operation should be repeated for 3 times.

2. 1. Serial Loading: After completion of pre-loading, the serial loading begins with 10% of the full load. Then the loading continue in order to increasing load side as 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of the total. After the empty load data, test loads increase and the part load data's are taken in each 10% load segment. The load is unloading after full load data test, then empty load data taken. All the part, full and empty load data's should be taken after 30 sec duration.

3. 2. Serial Loading: The first part of the 2.serial loading is exactly the same with the 1.serial loading. After the full load (100% load) data which is taken after 30 sec duration, loads are not unload and loading is continue in order to backward loading side because of the hysteria. This means that after full load data (100% load), test loads decrease as 90%, 80%, ..., 10%, and 0%. After 30 sec duration from empty load, empty load data is taken to finish the 2.serial loading.

4. 3. Serial Loading: Calibration procedure is the same with the 2.serial loading. After that all the data's that we get from this and previous steps are used for calculation

2.7. Calibration Pump:

The calibration pump is fixed on the weighing tank with the pipes (until the dripping reduction) and included the tare weight of the tank. The pump forwards the incontestable quantity of fluid to the other weighing systems. This process provides check, verification and calibration of the other balances.

3.CONCLUSION

Diverters and weighting-time measurement systems of new UME liquid flow measurement laboratories were briefly explained in this paper. There are four weighting-time water flow measurement systems with 30 tons, 5 tons, 1 tone with dead weight tester and 10 kg. Also there are three weighting-time hydrocarbon flow measurement systems with 2.5 tons, 1

tone with dead weight tester and 150 kg. Estimated total expanded uncertainties are about 0.05 percent.

Diverters in new UME laboratories are designed as 600, 400, 200, 100 and 15 mm size for water, 300, 100, 50 mm size for hydrocarbon liquids. Transition time of diverters is established as 150 ms for big ones, 50 ms for small ones.