Development of Vibration Tube Liquid Density Meter Standard

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Introduction

Vibration tube liquid density meter（on line）is used widely in the fields of industrial production, the international oil trade settlement, and hyrocarbon flow standard facility.To solve the problem of vibration tube liquid density meter calibration it is the tusk for Xinjiang Institute of Measurement & Testing Technology(XJMT) to establish standard facility.

Design & expriment

The principle of standard facility of vibration tube liquid densty meter on line is shown in figure 1. Opening pipeline valve and circulation pump, the liquid is entered in the density meter from bottom to top. After all air bubble in the system is eliminated, then hold temperature of liquid of circulatory system is constant. When the temperature and pressure stability, and determination of the density of the fluid and the vibration period. The value about density and vibration period of fluid is measured, after temperature and pressure of system on stability. According to the test of density range, choose more than 5 kinds of different density of material experiment, measureing the density value by standard density meter group, and measureing frequency value by frequency meter.

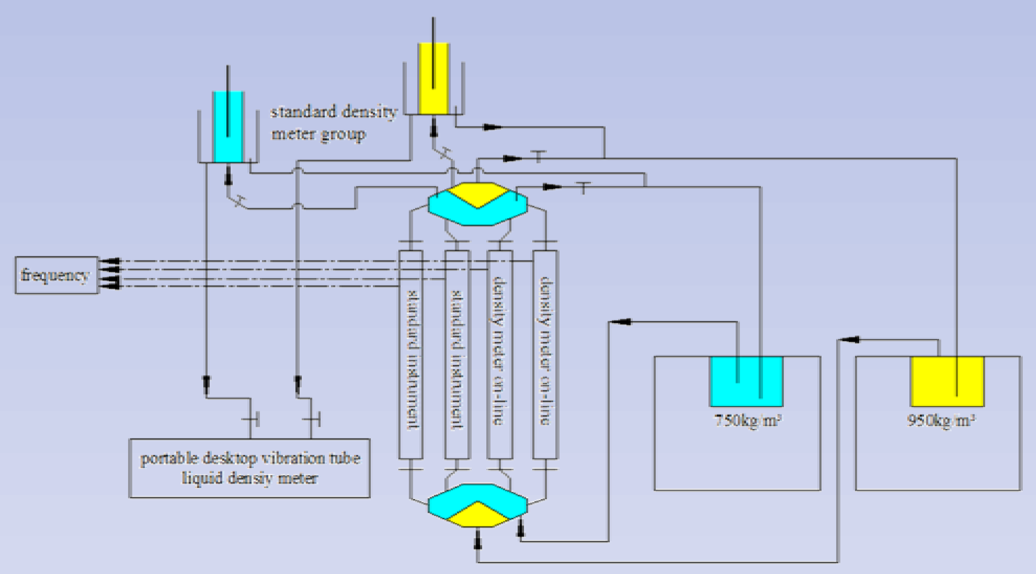

Figure1: Calibration layout for liquid density e reflection at larger durations

The arrangement of standard facility is showed in figure2. The fluid through thermostatic bath, vibration tube density meter (from bottom to top), overflow cylinder, get back to the thermostatic bath finally. The role of the overflow cylinder is keep a continuous flow of liquid, at the same time, measuring temperature, density and vibration frequency.

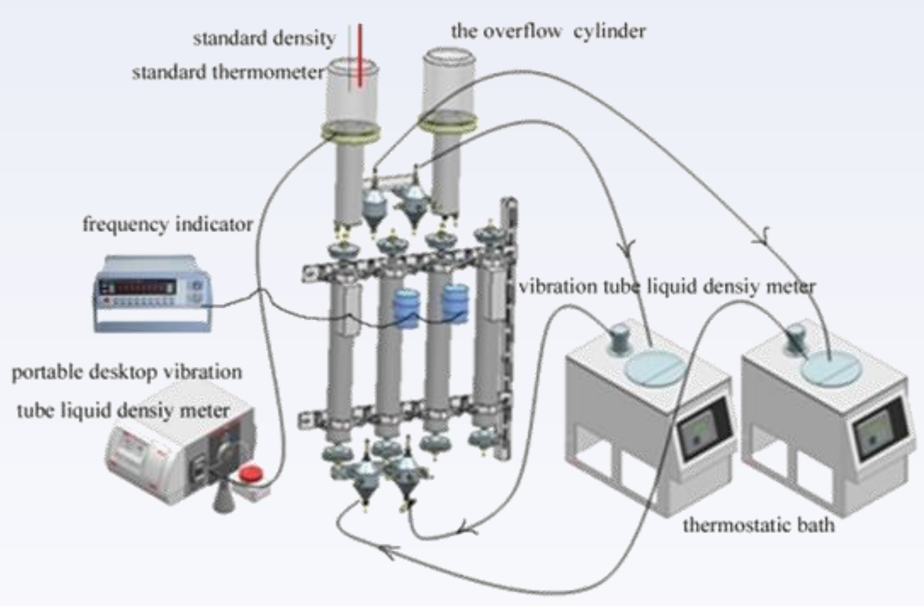

Figure 2: Standard facility layout

Considering installation characteristics of the vibration liquid density meter (installed in horizontal or vertical), working structure as follows figure 3.

On the left side for vertical installation, balancing standard meter method, the rotatable workbench is on the right and can be installed vertically, also can be installed horizontally.

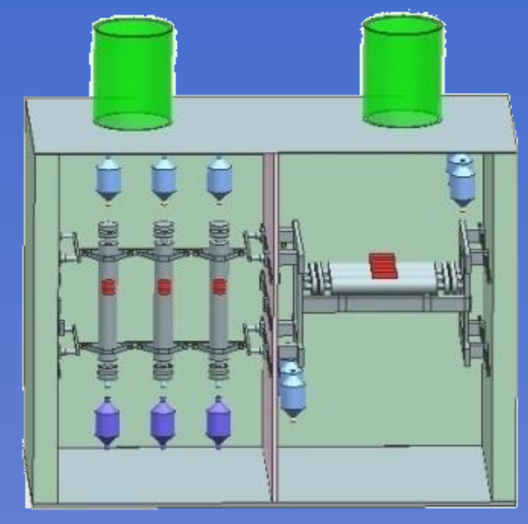

Figure 3: Workbench layout

Temperature correction

Values transfer for tube liquid density meter, the standard measurement is standard density group, so the final density meter values should corrected.

$$\Delta\rho_1 = \rho_a \times \beta \times (20 - t_{cylinder}) \qquad \Delta\rho_2 = r \times (t_{cylinder} - t_{average})$$

$$\rho = \rho_a + \Delta\rho_1 + \Delta\rho_2 + \Delta\rho_s + \Delta\rho \qquad \rho_t = \rho_T[1 + K_{18}(t-20)] +_{19} (t-20)$$

Where, $\Delta\rho_1$ is corection value of standard density meter, ρ_a is indicating value of standard density meter, β is volume expansion coefficiency of glass. $\Delta\rho_2$ is corection value of standard density meter, r is temperature coefficient of fluid denstiy.

Pressure correction

Because of the vibration tube liquid density meter actual working pressure is different with verification, so need to pressure correct for density.

$$\rho_{ps} = \rho_0 \times (1 + F \times p_i)$$

$$\rho_p = \rho_t \times (1 + K_{20} \times p\ ) + K_{21} \times p$$

Where, each virbration period value $T_{average}$ are obtained by pressure experiment, to the fitting formula, calculating the density $\rho_{Taverage}$ each pressure point.Depending on the liquid and table, getting liquied compressibility F and density ρ_0 under standard atmospheric pressure.

Uncertainty evaluation

When using the standard density meter (or portable desktop vibration tube liquid density meter) for calibration to vibration tube liquid density meter on line, the evaluation of uncertainty budget is showed as Table 1.

Table 1: Uncertainty budget

source	$u(x_i)$ (kg/m³)	Combined standard uncertainty	Combined expanded uncertainty
repeatability of density	0.02		
Indication of meniscus	0.009		
Stanadard density meter	0.02		
Indication of frequency	0.0029	u_c=0.05 kg/m³	U=0.1kg/m³ k=2
Sacle interval of thermometer	0.0058		
Temperature variation of liqued	0.012		
Fitted curve	0.04