Vacuum Transfer Equipment for M-one

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Abstract. The dissemination method after redefinition of mass unit will be changed from Planck constant to primary mass standard and from primary mass standard to secondary mass standard. The measurement of weights under vacuum will replace the measurement of weights in air. M-one manufactured by Mettler-Toledo company is a product for measuring the mass of an object under vacuum. In order to transfer weights from vacuum vessel to M-one, a vacuum transfer equipment (VTE) is developed by National Institute of Metrology, China (NIM). A multistage manipulator system is designed to transfer weight under vacuum between VTE and M-one. The experimental results show that the performance of VTE is efficient for transferring the weights under vacuum.

1. Introduction

The 26th General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM) will be coming at the end of this year. That means the redefinition of mass unit will be approved on the meeting of CGPM. According to the requirement of *Mise en pratique*-kg, the dissemination after redefinition of mass unit is also important for the revolution of mass unit. The classic dissemination of mass unit is carried out in air. The new method for dissemination from Planck constant to primary mass standard and from primary mass standard to secondary mass is implemented under vacuum.

Watt balance that is an equipment for measuring the Planck constant will be used to determine the mass value of primary mass standard under vacuum after redefinition of mass unit. To ensure the stability of primary mass standard, the dissemination from primary mass standard to secondary mass standard may be carried out under vacuum. CCL1007 manufactured by Sartorius company and M-one manufactured by Mettler-Toledo company can measured the weights under vacuum. But the old M-one only includes Load lock parts and mass measurement parts, it is not used to transfer the weights from vacuum vessel to vacuum chamber of M-one.

According to the structure character of M-one, the vacuum transfer equipment developed by NIM is introduced in this paper. It may transfer silicon sphere, cylinder weights and OIML weights under vacuum.

2. Structure of Vacuum Transfer Equipment

M-one installed at NIM that includes Load lock, mass comparator and vacuum chamber. Load lock is used to transfer the weights from air to vacuum. Mass comparator in the vacuum chamber is usually used to measure the mass of the weights in air or under vacuum. Based on the structure of Load lock, the VTE on the top of Load lock is designed as shown in figure 1.

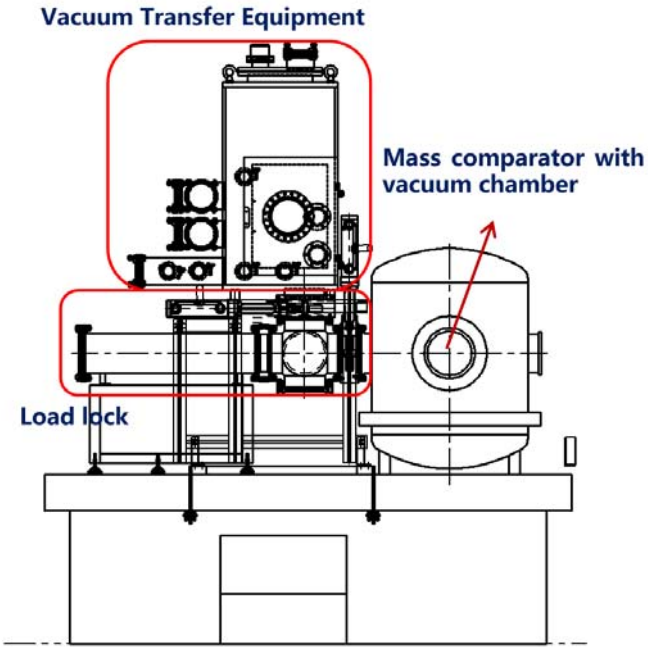

Figure 1. M-one with vacuum transfer equipment

VTE is consisting of a vacuum chamber, a horizontal motion manipulator, two vertical motion manipulators, displacement sensor, high definition camera, vacuum measurement system and double stage vacuum pump system. The internal structure of VTE is shown as figure 2. The first vertical motion manipulator is used to lift or fall a vacuum vessel under vacuum. Then the horizontal motion manipulator is used to move a weight to the second vertical motion manipulator. The second vertical motion manipulator is used to lift or fall the weight from the vacuum chamber of VTE to Load lock of M-one. The vacuum degree of the vacuum chamber is usually 0.1 Pa, which is the working vacuum degree. A high definition camera is installed on the top of the vacuum chamber. It is used to monitor during the move.

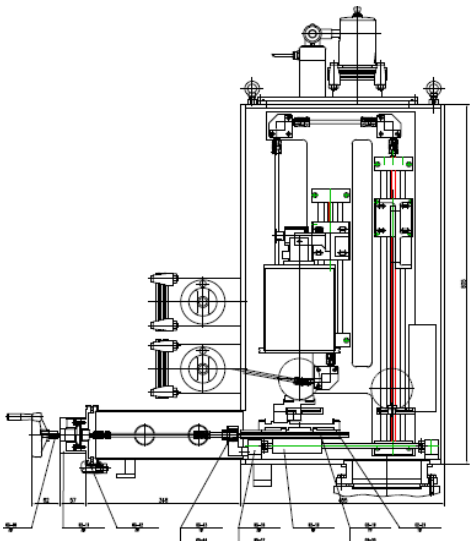

Figure 2. the internal structure of VTE

2.1. The vacuum chamber

The structure of the vacuum chamber is shown as figure 3. It is consisting of main body and manipulator areas. The observation windows are located at the top of the vacuum chamber and at the front of the vacuum chamber respectively. The size of the vacuum chamber is 810 mm × 335 mm × 695 mm (length × width × height).

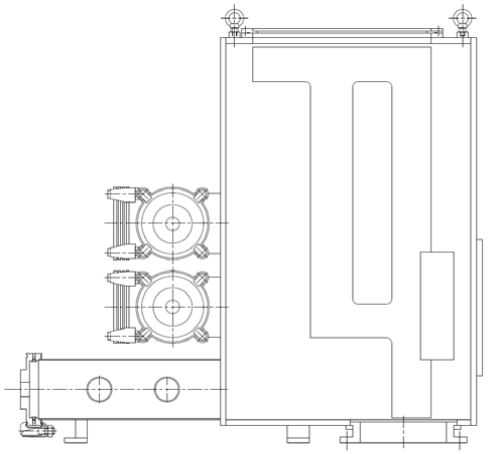

Figure 3. the structure of vacuum chamber

2.2. The horizontal motion manipulator

The structure of the horizontal motion manipulator is shown as figure 4. The maximum distance of the horizontal stroke is 205 mm. The maximum carrying capacity is 15 kg. The end of the horizontal motion manipulator depends on the auxiliary limit of the displacement limit system to ensure the accurate transfer of the weight.

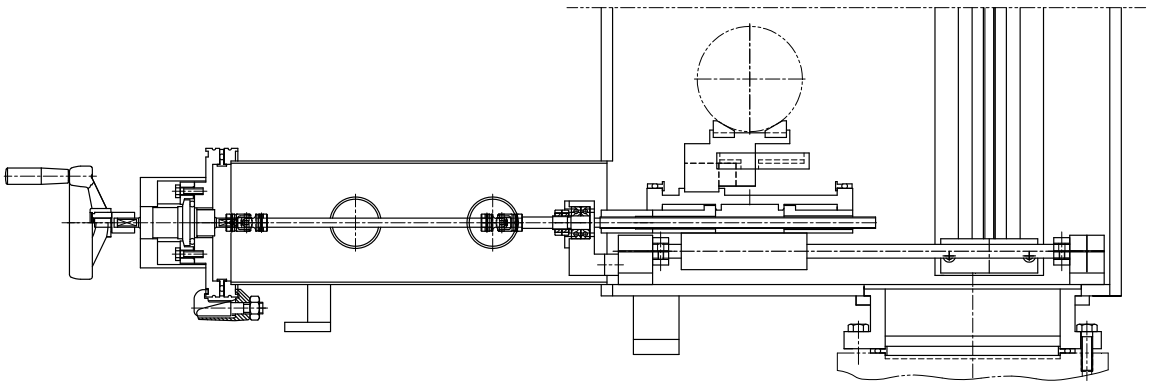

Figure 4. the structure of the horizontal motion manipulator

2.3. Two vertical motion manipulators

Two vertical motion manipulators located in the vacuum chamber are shown as figure 5. One of them is used to lift or fall the vacuum vessel. Another is used to move the weights between the vacuum chamber and Load lock.

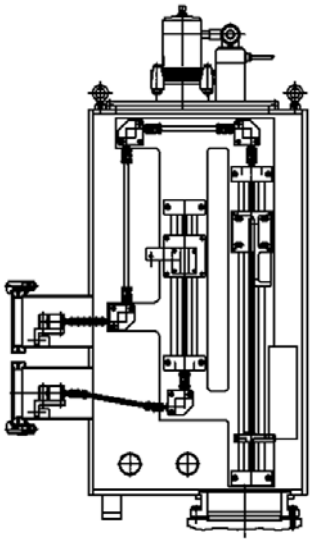

Figure 5. the structure of two vertical motion manipulators

3. Experiment and analysis

The vacuum results after moving the weights from vacuum vessel to M-one are shown as table 1. 6 OIML weights of 1 kg are the transferring samples. The maximum standard deviation is 0.00069 mg. The minimum standard deviation is 0.00013 mg. The results show that he performance of VTE is efficient for transferring the weights under vacuum.

Table 1. The measurement results under vacuum

Place B	Place A	Indication error (mg)	Standard deviation (mg)
P2	P1	-0.03681	0.00031
P2	P1	-0.03658	0.00036
P3	P1	-0.06883	0.00028
P3	P1	-0.06838	0.00041
P4	P1	0.02024	0.00033
P4	P1	0.02069	0.00044
P5	P1	-0.07756	0.00014
P5	P1	-0.07755	0.00017
P6	P1	-0.65535	0.00047
P6	P1	-0.65496	0.00037
P3	P2	-0.03214	0.00025
P3	P2	-0.03241	0.00028
P4	P2	0.05715	0.00028
P4	P2	0.05692	0.00022
P5	P2	-0.04074	0.00029
P5	P2	-0.04115	0.00028
P6	P2	-0.61857	0.00024
P6	P2	-0.61838	0.00009
P4	P3	0.08927	0.00025
P4	P3	0.08876	0.00031
P5	P3	-0.00869	0.00033

P5	P3	-0.00829	0.00059
P6	P3	-0.58634	0.00025
P6	P3	-0.58635	0.00025
P5	P4	-0.09757	0.00032
P5	P4	-0.09763	0.00042
P6	P4	-0.67548	0.00042
P6	P4	-0.67541	0.00013
P6	P5	-0.5775	0.00033
P6	P5	-0.57762	0.00024
P1	P1	0.00031	0.00045
P1	P1	-0.00002	0.00034
P1	P1+s	-1000.01	0.00044
P1	P1+s	-1000.01	0.00041
P2	P1	-0.00013	0.00016
P2	P1	0.00011	0.00029
P2	P1+s	-1000.01	0.00026
P2	P1+s	-1000.01	0.00024
P3	P3	0.00012	0.00028
P3	P3	-0.0003	0.00046
P3	P3+s	-1000.01	0.00069
P3	P3+s	-1000.01	0.0002
P4	P4	0.00014	0.00027
P4	P4	-0.00014	0.00041
P4	P4+s	-1000.01	0.00033
P4	P4+s	-1000.01	0.00034
P5	P5	0.00007	0.00028
P5	P5	0.00009	0.00038
P5	P5+s	-1000.01	0.00035
P5	P5+s	-1000.01	0.00032
P6	P6	0.00002	0.00018
P6	P6	0.00028	0.00034
P6	P6+s	-1000.01	0.00053
P6	P6+s	-1000.01	0.00041

4. Conclusions

The vacuum transfer equipment is developed by NIM. It is a necessary conjunction point between vacuum vessel and M-one. A multistage manipulator system is designed to transfer weight under vacuum between VTE and M-one. The experimental results show that the performance of VTE is efficient for transferring the weights under vacuum.

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