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VACUUM TRANSFER SYSTEM FOR LOADING THE SARTORIUS PROTOTYPE MASS COMPARATOR CCL1007

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ABSTRACT

The Vacuum Transfer System (VTS) is designed for fully automatic loading of weights into the Sartorius Prototype Mass Comparator CCL1007. The system enables the user to transfer weights from air to air/neutral gas, air to vacuum and back, as well as from vacuum to vacuum conditions. A detailed description of the technical parameters, the different operation modes and a first application will be presented.

1. INTRODUCTION

The Vacuum Transfer System (VTS) is directly connected to the mass comparator vacuum chamber via a DN200 high vacuum gate valve. For this the original quick loading door of the CCL1007 main vacuum chamber as well as the standard air to air loading mechanism mounted outside the main chamber have to be dismounted. Figure 1 shows the standard loading mechanism used for loading weights to the open CCL1007 chamber. The threaded holes around the quadratic doorway can be seen in the picture. Those holes are used for mounting the VTS gate valve using a special high vacuum adaptor.

Fig. 1. Air to air standard loading mechanism and open quick loading door mounted outside the main chamber of CCL1007

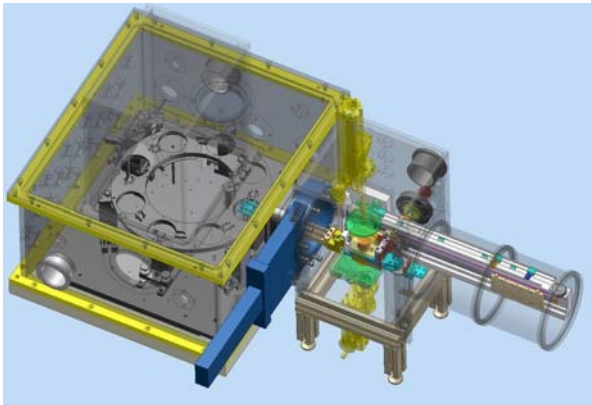

Fig. 2. Vacuum Transfer System schematic drawing

Fig. 3. Vacuum Transfer System connected to CCL1007

The VTS chamber can be evacuated independently from the CCL1007 main chamber if the gate valve is closed. The gate valve is operated manually according to the load/unload procedure description. Inside the VTS chamber a fully automatic transfer system receives the weights and transfers them to the load alternator of the Prototype Mass Comparator CCL1007. All components inside the VTS are high vacuum compliant, free of oil and optimized for low magnetic properties. The horizontal guiding for the feed arm movement is an oil free UHV compliant recirculating ball guide. The two z-axis manipulators have a dove-tail guide and spindle on the air side and a vacuum bellow.

Depending on the mode of operation the weight is placed directly on the feed arm of the transfer system or alternatively a vacuum transport container with the weight inside is placed on a vertical moveable base plate ("table"). The VTS vacuum chamber offers several ISO-KF vacuum flanges for measuring instruments like vacuum gauges or the connection of a vacuum pump system.

Fig. 4. VTS with door open for picture, cylindrical mass standard standing on the feed arm just moving into the CCL1007 main chamber (loading)

2. THE VACUUM TRANSPORT CONTAINER

A special Vacuum Transport Container VTC (Fig. 5 and Fig. 6) is used to store weights under vacuum or keep them in neutral gas. This container can be loaded to the VTS through a wide rectangular door and is opened inside the closed VTS under air, vacuum or neutral gas atmosphere by using special vacuum manipulators mounted on the VTS. The VTS and the Vacuum Transport Container are designed to load OIML-shaped weights, as well as national prototypes or silicon spheres up to 1kg. The Vacuum Transport Container has a guided spring mechanism to fix the weight inside the container.

Fig. 5. Vacuum Transport Container VTC top view with vacuum valve (blue knob), bell fixing bracket and trim weights

The contact material at the bottom and at the top of the weight is high vacuum compliant plastic PEEK to prevent contamination and scratches. The base plate and the upper holder can be changed to suit the different shapes. For different heights the spacer can be changed accordingly. The Vacuum Transport Container can be used for storing and transportation in the lab but not for shipping weights. Special shipping containers have to be used for shipping weights.

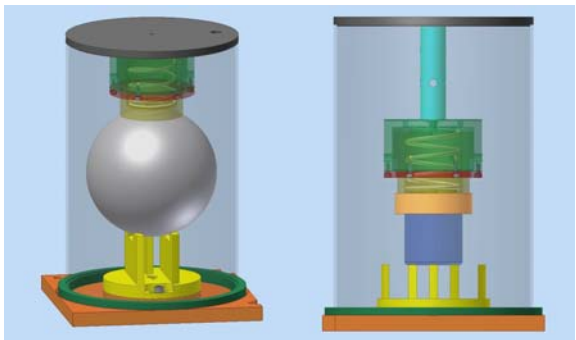

Fig. 6. Vacuum Transport Container VTC loaded with sphere (left) and loaded 1kg PtIr prototype mass standard (right), schematic drawing

3. THE MODES OF OPERATION

The VTS has several modes of operation depending on the conditions under which the weight is stored and how the CCL1007 main chamber is filled. We distinguish between moist air,

neutral gas and vacuum. Moist air means ordinary air with water, oxygen and some hydrocarbons that are always contained in air. Neutral gas means dry nitrogen, argon or any gas without undesirable contamination under normal or reduced pressure. Vacuum means high vacuum between 0.1Pa and 0.0001Pa.

The three conditions considered for the operating conditions of the CCL1007 main chamber and the storing conditions for the weight are summarized in Table 1. The loading of an artefact stored in the VTC under neutral gas into the CCL1007 main chamber evacuated to vacuum conditions is, for example, operation mode number 8. The same operation mode number is used for unloading the weight from the CCL1007 to the container.

Table 1. Operation mode summary, operation mode number depending on weighing and storing conditions

Weight stored in:	CCL1007 filled with		
	Moist air	Neutral Gas	Vacuum
Moist air	1	4	7
Neutral Gas	2	5	8
Vacuum	3	6	9

Loading weights to and unloading weights from the CCL1007 main chamber filled with moist air (operation mode numbers 1, 2 and 3 in Table 1) can be done using the standard air to air loading mechanism as well as with the VTS. The operation modes 2 and 3 given in Table 1 are practically unnecessary but nevertheless theoretically possible.

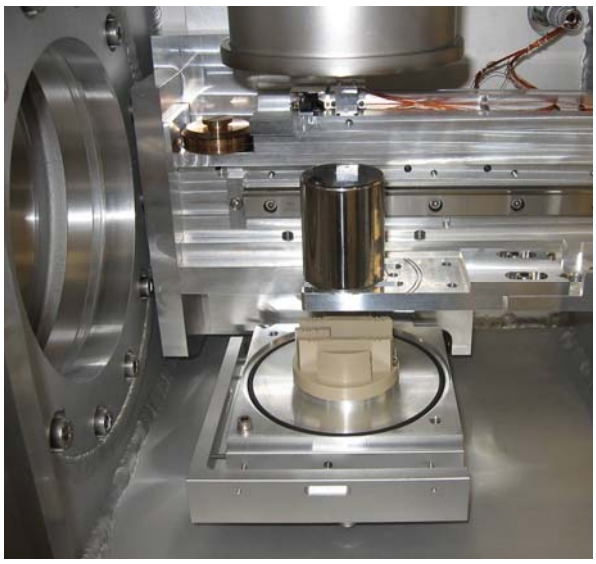

Fig. 7. Cylindrical 1kg test weight standing on feed arm, bell hanging and lifted up, table with VTC base plate fixed moved down to lowest position

The Vacuum Transfer System VTS is absolutely essential for loading and unloading weights stored under moist air if the CCL1007 main chamber is operated with neutral gas filling or evacuated to vacuum (operation mode numbers 4 and 7 in Table 1). Neither operation mode requires the Vacuum Transport Container VTC because the weight stored under moist air will be placed directly on the feed arm inside the VTS chamber.

The use of Vacuum Transfer System VTS is absolutely essential for operation mode numbers 5, 6, 8 and 9 given in Table 1 and the weights have to be stored in the Vacuum Transport Container VTC.

The loading and unloading procedure varies for all operation modes and is described in detail in the VTS operation manual. In the following we provide a detailed description of the loading procedure.

First we describe the loading of a weight stored under moist air to the CCL1007 operated under vacuum conditions (operation mode number 7 in Table 1). Once the test weight, for instance a mass standard, is placed on the feed arm inside the VTS chamber the door is closed and the vacuum pumping system for the VTS is started. After reaching the pre-vacuum of 1mbar=100Pa inside the VTS the turbo molecular pump is started. Once the high vacuum has stabilized the gate valve between the two vacuum systems can be opened. Then the control software asks for the position to which the test mass should be loaded. Loading starts by moving the feed arm into the CCL1007 main chamber through the opened gate valve (see Fig. 4).

For the loading of a weight stored inside a VTC under vacuum into the CCL1007 operated under vacuum conditions (operation mode number 9 in Table 1), first the evacuated Vacuum Transport Container with loaded test weight will be placed and fixed to the table at the upper position inside the VTS. The upper part of the Vacuum Transport Container ("bell") has to be fixed to the vertical bell lifting guide. After closing the VTS door and evacuating the VTS to high vacuum the bell can be moved up manually by turning the crank handle of the vertical bell lifting guide. The feed arm is moved by the control software below the weight standing at the Vacuum Transport Container base plate and the table can be moved down manually by turning the crank handle of the vertical guide for the table (see Fig. 7). The Vacuum Transport Container was now unloaded under vacuum conditions and the weight stands at the feed arm and is ready to be moved into the CCL1007 main chamber with the same procedure as described above for operation mode number 7.

For unloading weights from the CCL1007 under vacuum conditions into the VTC (operation mode number 9), first the VTC has to be placed into the opened VTS with the bell hanging at the upper position and the VTC base plate fixed to the table at the lowermost position. After this the VTS is evacuated to high vacuum and the gate valve can be

opened. The weight is unloaded by the control software to the position above the VTC base plate as shown in Fig. 7 and the gate valve can be closed. Then the table is moved up by manually turning the crank handle. After moving the feed arm to the rightmost position the bell can be moved down by manually turning the crank handle of the vertical bell guide. Now the VTC is closed and still under vacuum conditions. After flushing the VTS chamber with air the test weight inside the VTC is still under vacuum and was unloaded with no contact to undesirable contaminants contained in normal air.

4. THE CONTROL SOFTWARE

The complete operation of the VTS system is controlled by the software, except for the manually operated gate valve and the vertical guide for lifting the bell and table. During the automatic loading procedure the eccentricity of the weight will be adjusted on the X and Y axes by the movement of the feed arm and by the rotation of the carousel. Cylindrical shaped test weights are pre centered using a system with 3 strain gauge sensors.

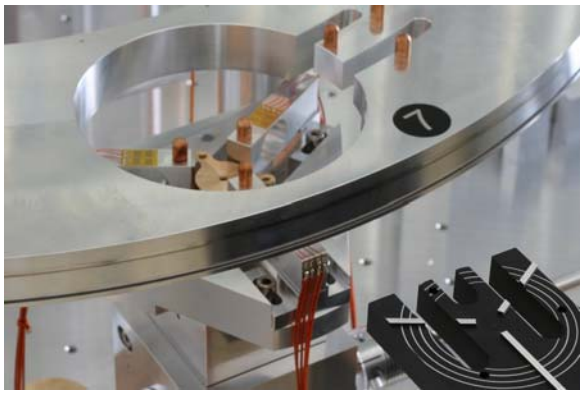

Fig. 8. Pre centering sensors below the load alternator table

The center of gravity of the cylindrical weight in relation to a centric position on the carousel can be determined with the 3 readings of the strain gauge systems (see Fig. 8). The result is a pre-centered weight on the carousel ready for the mass comparison procedure. Spheres are directly placed to the load alternator leaving out the centering procedure.

The software permanently checks the position of the manually operated gate valve, the bell position and the table position for security reasons. The feed arm will only be moved if the gate is actually open and the bell and table are out of the way. If, for example, the gate is closed, the software will not move the feed arm of the transfer system. The status of the positions is displayed using traffic lights (see Figure 9).

5. THE VACUUM PUMPING SYSTEM

The pumping system for the VTS is completely

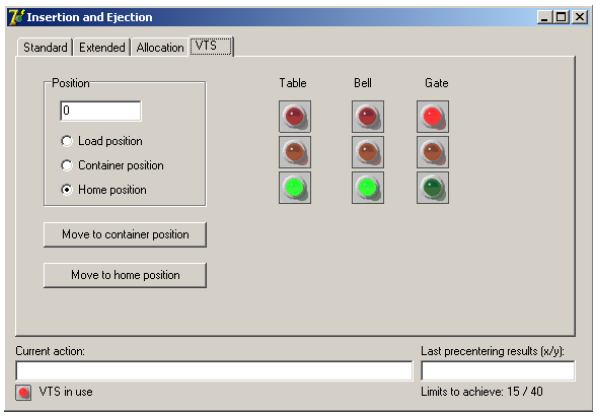

Fig. 9. Software showing that the gate valve is closed, the table is down and the bell is up

independent of the pumps for the CCL1007 main chamber if the gate valve between the two vacuum chambers is closed. The pumping system consists of the pre vacuum scroll pump and the turbo molecular pump. The pumping speed of the system was chosen to allow convenient operation. The primary pressure of 100Pa necessary for starting the turbo molecular pump is reached after less than 10 minutes. A vacuum of 0.1Pa is normally reached 10 minutes after starting the turbo molecular pump. There are several valves to control the evacuation process. It is also possible to connect the Vacuum Transport Container to the pumping system for separate evacuation.

6. SUMMARY

The VTS was jointly developed by Sartorius, the Institute of Process Measurement and Sensor Technology at Ilmenau Technical University and SIOS Messtechnik GmbH. It allows the CCL1007 to run permanently under vacuum or neutral gas conditions avoiding the opening of the quick loading door for changing the test weights. Furthermore, it is now also possible to keep the test weights outside the CCL1007 under vacuum or neutral gas by using the Vacuum Transport Container. This container can be opened inside the VTS to keep normal atmosphere away from the test weights. This will open up many application possibilities for high level mass metrology. One VTS system was installed at the BIPM/France in 2009, another one at PTB/Germany end of last year.

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