VACUUM MASS TRANSPORT FOR MASS METROLOGY AT NIST

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Abstract: With the anticipated redefinition of the kilogram in 2018, the transport and handling of masses under vacuum will become an important part of the new *mise en pratique* for the unit of mass. At the National Institute of Standards and Technology (NIST), a custom mass transport vehicle (MTV) and vacuum load locks have been constructed to move masses under vacuum between various measurement apparatus.

1. INTRODUCTION

The kilogram remains the last fundamental unit in the International System of Units (SI) which is defined by a physical artifact. The kilogram is currently defined as the mass of the International Prototype Kilogram (IPK) which is a platinum-iridium alloy cylinder maintained at the International Bureau of Weights and Measures (BIPM) in Sevres, France. The IPK is stored under normal atmospheric conditions and all of the mass comparisons used to disseminate the unit of mass are done at atmospheric pressure.

This scenario is expected to change in 2018 with the redefinition of the kilogram based on Plancks Constant. The unit of mass will then be realized using watt balance or X-ray crystal density (Avogadro) experiments. This will enable any research group throughout the world to independently realize the unit of mass at any level if they have sufficient technical expertise and equipment. Both of these experimental methods are explicitly designed to operate in vacuum. Consequently, the *mise en pratique*, or practical instructions for the dissemination of the unit of mass, must now include for the first time the handling and manipulation of masses in vacuum. Maintaining a mass measured in a vacuum under vacuum is important since the effective mass will change when exposed to air due the adsorption of water and other materials onto its surface.

2. VACUUM MASS TRANSPORT AT NIST

When the kilogram is redefined, the unit of mass at NIST will be realized with the NIST-4 watt balance.[2] Once a primary standard mass is created with the watt balance, it must be kept in vacuum as it moves between a variety of other locations including a vacuum mass storage facility, a plasma cleaning station, and vacuum mass comparators. Eventually, the unit of mass needs to be transferred to a mass in air. This will be done at NIST with the Magnetic Suspension Mass Comparator (MSMC) which will directly compare a mass in vacuum with a mass in air. In order to transport a primary standard mass and other working mass standards in vacuum between these various measurement apparatus, a custom mass transport vehicle (MTV) has been constructed. The masses are transferred from the MTV into the various apparatus through vacuum load lock systems.

2.1. Mass Transport Vehicle

The MTV, shown in Fig. 1, is essentially a mobile vacuum chamber. It is created from a stainless steel 4-way cross. On the front is a gate valve and on the back is a door with a glass viewport. The MTV is equipped with a wide range vacuum gauge and small getter pump. The getter pump can be battery operated while the MTV is being moved. The vacuum chamber is mounted on an aluminum frame with casters.

An interior cutaway view of the MTV can be seen in Fig. 2. The mass in the MTV rests on a slotted platform which has circular indentations cut into the top to match the diameters of common kilogram artifacts. The mass transfer platform is mounted on a small linear vacuum translator. On the top of the chamber are three triangular wedges mounted on another linear vacuum translator which prevents the mass from tipping while in the MTV.

2.2. Vacuum Load Locks

In order to transfer a mass to and from the MTV while maintaining the mass under vacuum, each experimental apparatus has a vacuum load lock. The main body of each load lock is 6-way cross which is isolated from the experimental vacuum chamber by a gate valve. The MTV connects to the load lock with a ISO band clamp flange which can be sealed or unsealed with a single bolt. The MTV is brought up to the same height as the load lock by a series of lifts and ramps. When the MTV is attached to a load lock a small turbo pump evacuates the load lock until the pressure is low enough to safely open both the MTV and load lock gate valves.

Once the MTV and load lock are open to the main vacuum chamber, a mass transfer fork on the end of a long vacuum linear translator can transfer the mass from the MTV to a mass transfer platform located in the center of the load lock. Then a second mass transfer fork attached on a second vacuum linear translator perpendicular to the first can transfer the mass into the main vacuum chamber.

3. CONCLUSIONS

A vacuum mass transport system at NIST has been constructed and is comprised of mass transport vehicles and vacuum load locks. This vacuum mass transport capability will be essential for the dissemination of the kilogram at NIST when the unit is eventually redefined in 2018.

REFERENCES

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[2] E. J. Leaman, et al, "A Determination of the Local Acceleration of Gravity for the NIST-4 Watt Balance," in IEEE Trans. On Instrumentation and Measurement, vol. 64, pp. 1663-1669, 2015.

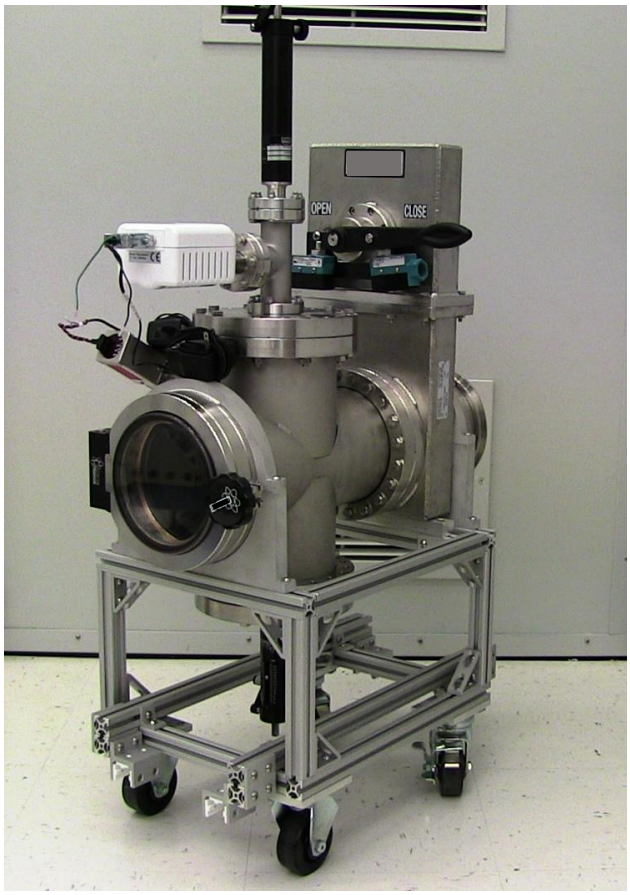

Fig.1. *Mass transport vehicle.*

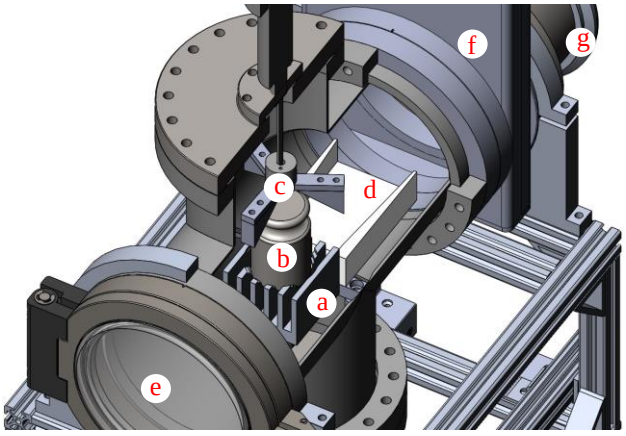

Fig. 2. *Cutaway view of the interior of the MTV. a.) slotted mass platform, b.) 1 kg mass, c.) upper mass support, d.) alignment ramp, e.) viewport/door, f.) gate valve, g.) band clamp flange.*