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Validation of a variable bell jar pressure as a method for primary generation of absolute pressure in the range from 100 Pa to 5 kPa

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Abstract

Generation of absolute pressure with a pressure balance is commonly done by enclosing the space above weights with a bell jar and evacuating it with a vacuum pump. Residual pressure in a bell jar is usually of the order of few tens of Pa to few Pa, depending on the effective pumping speed. Its value is added to a calculated pressure of the gravitational force of the piston and weights to obtain the generated absolute pressure. By connecting to the absolute pressure balance a precise and stable pressure gauge with sufficient resolution it is easy to observe that small changes of residual pressure in a bell jar generate a corresponding change in a pressure reading of the gauge. Unfortunately the lowest absolute pressure which can be generated by a pressure balance of conventional design is determined by the tare weight of the piston and some small additional weights necessary for sufficient minimum free rotation time and it is in the pressure range starting at 3 kPa and up to 5 kPa.

Keywords: Absolute pressure, primary generation of pressure, validation, variable bell jar.

Introduction

It has been already discussed by Dadson et al [1] how to generate any required pressure below the normal operating limit of a pressure balance by varying the residual pressure in a bell jar.

Recently Woo and Choi [2] described a special "in-vacuum" automatic weight loading mechanism for the pressure balance and a measurement setup with a precise barometer and a pressure controller. They have showed that the precision of their setup is sufficient for calibration of a 10 torr FS capacitance diaphragm gauge, but they did not validate the method by comparing it with another independent method for realization of absolute pressure.

We have tested a much simpler setup with a conventional absolute pressure balance; precise quartz crystal based auxiliary pressure gauge and a manual system for adjusting pressure in a bell jar in the range from 100 Pa to 5 kPa. Pressure balance is operated with a fixed weight load (equivalent to Po = 30 kPa at zero bell jar pressure) and without venting the bell jar to atmosphere. Auxiliary pressure gauge has been calibrated prior to measurements with the same

pressure balance in a limited part of working range from 28 kPa to 37 kPa. Our method relies first of all upon the stability and resolution of the pressure gauge, which is used to determine the changes in generated pressure in the range 30 kPa < P(i) < 35 kPa, caused by variable bell jar pressure Pr(i). It can be calculated to a first approximation as Pr(i) = P(i) - Po. Appropriate corrections for changes of the piston temperature and weight buoyancy effect shall be also taken into calculations.

Conclusions

Here it is described our measurement setup, detailed uncertainty analysis and validation procedure. Accuracy of the new method was evaluated by comparison with a conical piston balance standard, which is in addition to the ultrasonic or laser interferometer manometers, the most accurate standard gauge in the presented range. Maximum relative difference of the new method and conical piston balance was from 0.3% at 100 Pa to 0.016% at 5 kPa.

In conclusion the method is relatively simple and can be a good alternative to static expansion systems, which are used in several national metrology institutions to realize pressure scale below the lower limit of pressure balance.

References

[1] Dadson R. S., Lewis S. L., Peggs G. N., The Pressure Balance, Theory and Practice, HMSO, London (1982), page 192.
[2] Woo S. J., Choi M. I., Metrologia **42**, (2005), S193-S196.