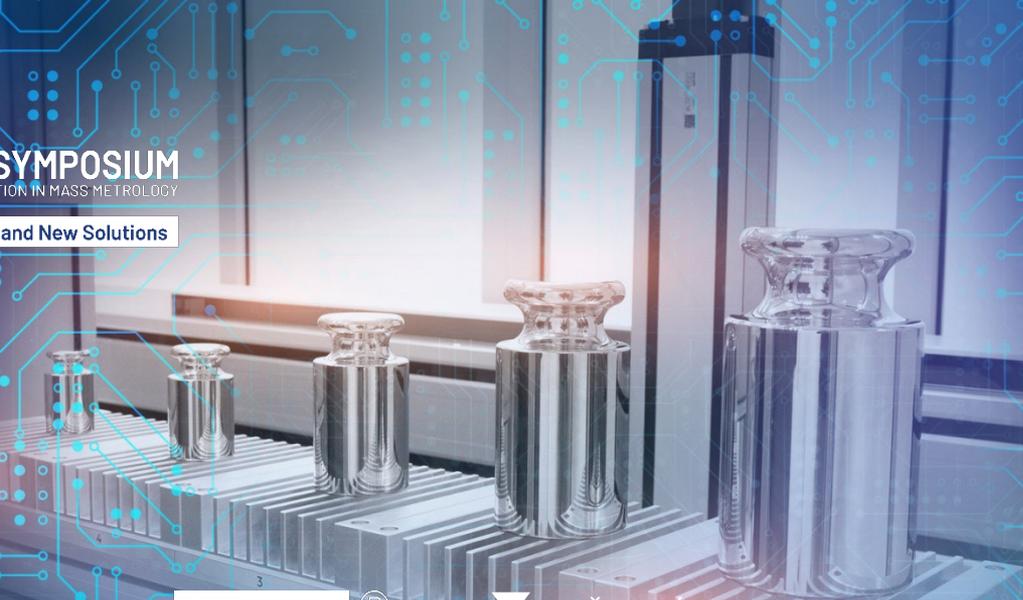




**METROLOGY SYMPOSIUM**  
DIGITALIZATION AND AUTOMATION IN MASS METROLOGY

Third Edition: Future and New Solutions



ČESKÝ  
METROLOGICKÝ  
INSTITUT

**Measuring station for comparison of mass standards at a constant atmospheric pressure or negative pressure of  $10^{-6}$ mBar**



16-18.04.2024, Radom, Poland



## METROLOGY SYMPOSIUM

DIGITALIZATION AND AUTOMATION IN MASS METROLOGY

Third Edition: Future and New Solutions



Presenters

### Tadeusz Szumiata PhD., D.Sc.

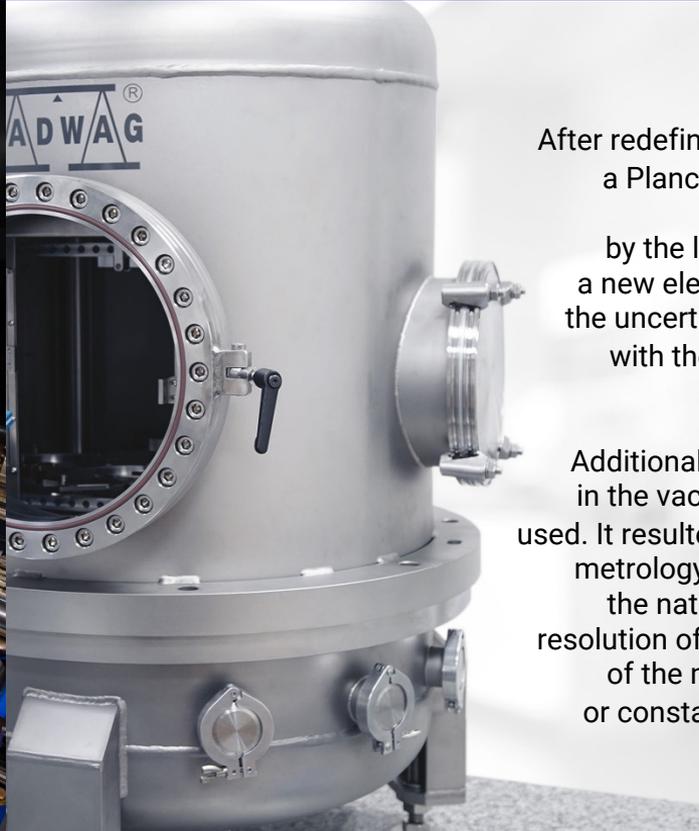
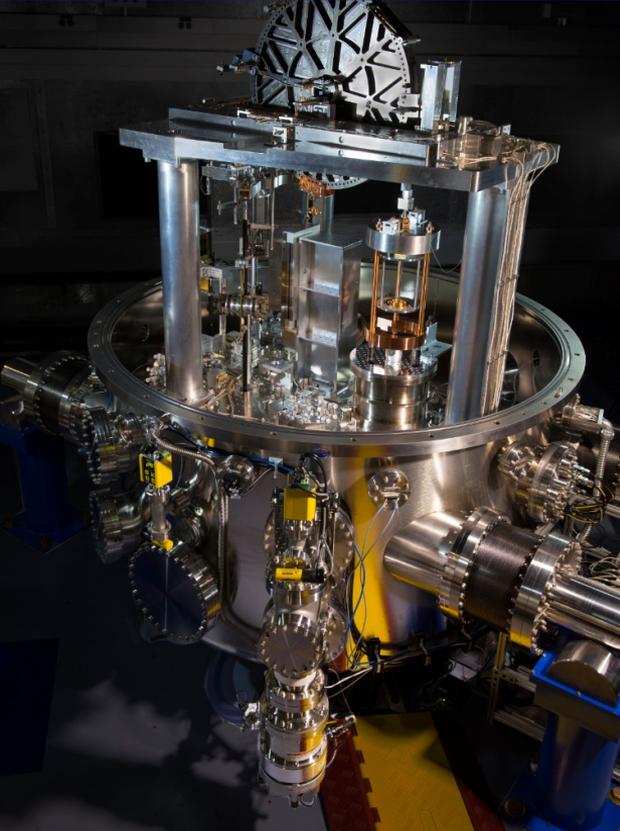
A professor at the University, the Head of the Department of Physics of the Mechanical Faculty at the Kazimierz Pułaski University of Radom



### Michał Solecki PhD Eng.

A mass comparator manager for technical issues

# Why a vacuum comparator?



After redefinition of the kilogramme unit and based it on a Planck constant, the measurement carried out on the Watt (Kibble) scale was approved by the leading-edge experiment. Due to introducing a new element (measurement on the Watt scale) into the uncertainty budget, the kilogramme is determined with the worse uncertainty than it had place before the redefinition.

Additionally the measurements were to be carried out in the vacuum setting because of the interferometers used. It resulted in the necessity of equipping the national metrology institutes in a new comparator to deal with the national kilogramme standards with the higher resolution of 0,1  $\mu\text{g}$  (in order to decrease the uncertainty of the measurement), equipped also in the vacuum or constant pressure chamber (constant air density).

# The extension variants of the constant pressure comparator



## AVK-1000.5Y.CP

Automatic Constant Pressure  
Mass Comparator



## AVK-1000.5Y

Automatic Vacuum Mass Comparator  
equipped with pumps



## AVK-1000.5Y.LLS

Automatic Vacuum Mass  
Comparator equipped with pumps  
and Load-Lock System



# AVK-1000.5Y.CP

## Automatic Constant Pressure Mass Comparator

**AVK-1000.5Y.CP** is a constant-pressure comparator (constant air density) with a maximum load capacity of **1 kg**.

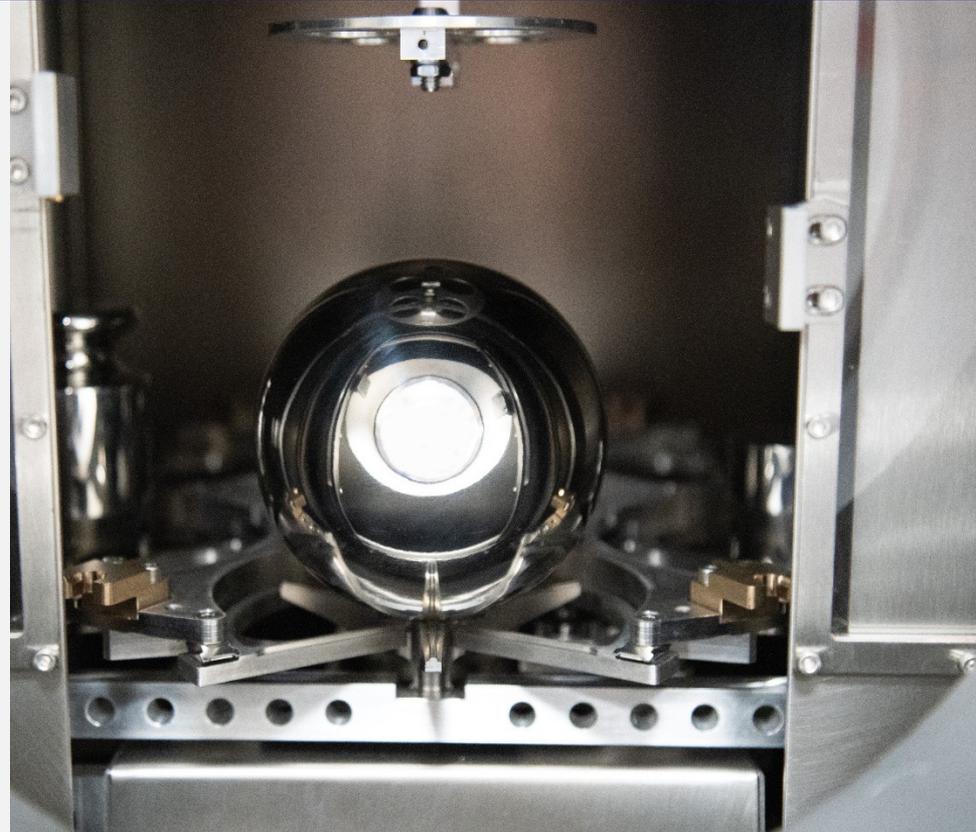
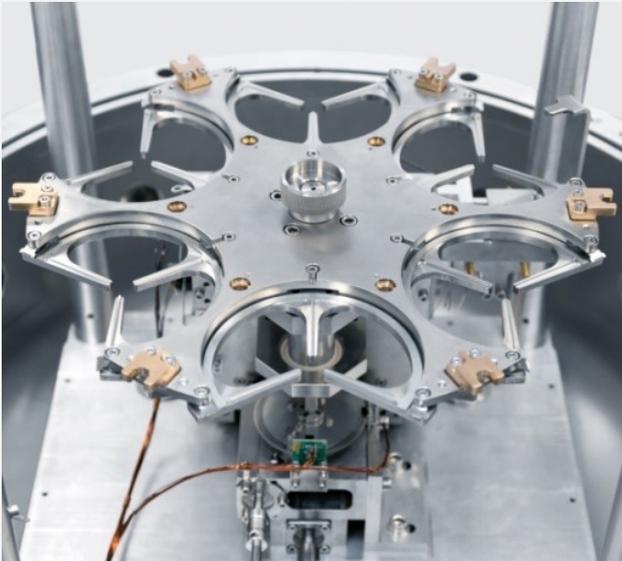
It is supplied with a **6-position mass standard magazine**, a self-centring suspended weighing pan and automatic external adjustment with a (replaceable) standard weight.

The comparator can also be used to compare silica hemispheres with a diameter from 40 to 100 mm, as well as cylindrical standards of  $\varnothing$  (22-95)x110.

Model	Maximum capacity	Readability	Standard repeatability	E0	E1	E2	F1	F2
AVK-1000.5Y.CP	1002 g	0,1 $\mu$ g	1 $\mu$ g	100 g - 1 kg				

# Main advantages of the AVK-1000.5Y.CP comparator

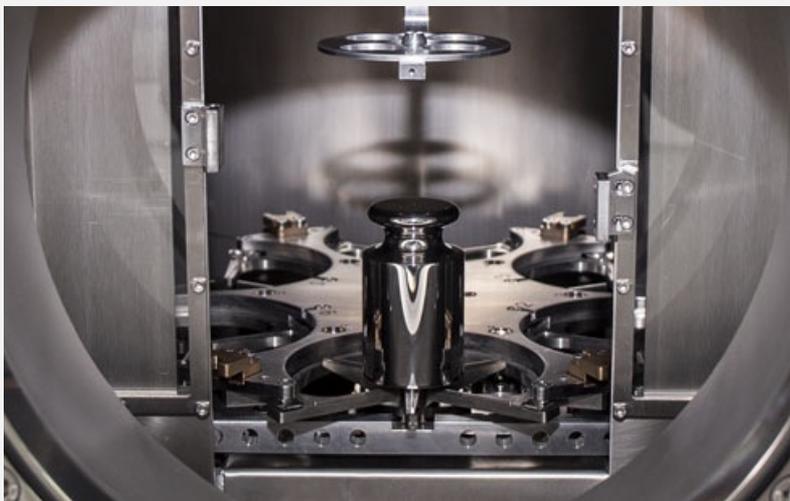
**6-position mass standard magazine** for calibration  
of cylindrical standards  $\varnothing$  (22-95)x110 and silica  
hemispheres with a diameter from **40**  
to **100 mm**



# Main advantages of the AVK-1000.5Y.CP comparator

## Self-centring suspended weighing pan

Elimination of a non-centricity error thanks to the use of a special suspended weighing pan.





# AVK-1000.5Y

## Automatic Vacuum Mass Comparator equipped with pumps

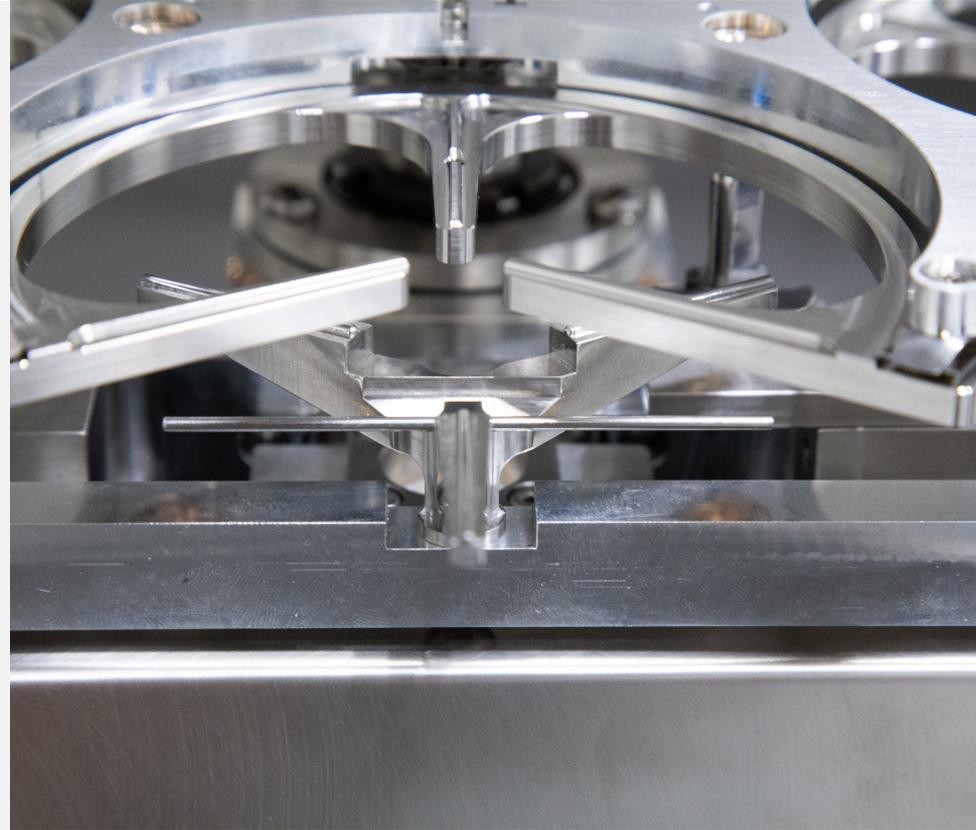
The constant-pressure comparator can be equipped with a first-level vacuum pump and turbomolecular pump as well as a vacuum meter.

The comparator has advantages of the constant-pressure comparator, can generate a vacuum of **10<sup>-6</sup> mBar**, and allows performing comparison in the vacuum.

Model	Maximum capacity	Readability	Standard repeatability	E0	E1	E2	F1	F2
AVK-1000.5Y	1002 g	0,1 µg	0,5 µg	100 g - 1 kg				

# Main advantages of the AVK-1000.5Y comparator

The automatic calibration mechanism with potential replacement of the adjustment weight for a lower-mass weight in order to check sensitivity of the comparator.



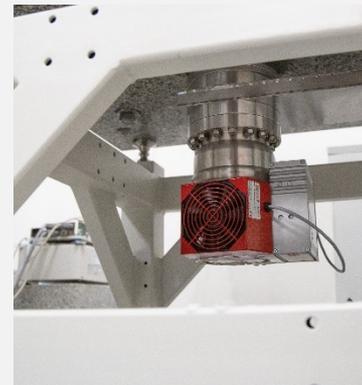
# Main advantages of the AVK-1000.5Y comparator

It is possible to perform comparison  
in the atmosphere of inert gases.



Vacuum of up to  $10^{-7}$  mBar.

The comparator is equipped with **2 pumps**  
(first-level vacuum pump and turbomolecular  
pump), as well as a high-class vacuum meter.





# AVK-1000.5Y.LLS

## Automatic Vacuum Mass Comparator equipped with pumps and Load-Lock System

The vacuum comparator can be additionally equipped with a “LOAD LOCK” system. It is responsible for feeding mass standards and is supplied with a separate pump unit that allows generating a vacuum similar to the one that is present in the main chamber. Thanks to lower volume of the loading chamber, similar vacuum can be generated a way faster (around 4 hours). Afterwards it is possible to load or unload one mass standard from the main chamber.

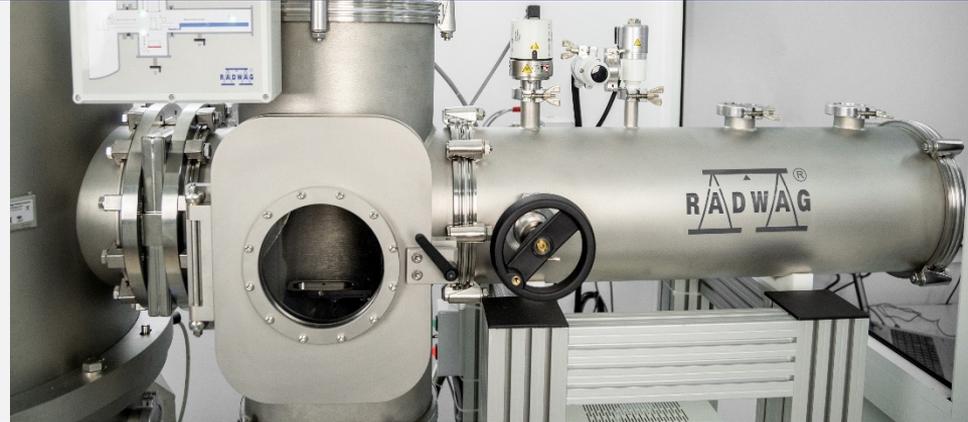
The RADWAG’s original “LOAD LOCK” system allows loading the standard from the main chamber into the special vacuum container and transferring the mass standard in the vacuum.

Model	Maximum capacity	Readability	Standard repeatability	E0	E1	E2	F1	F2
AVK-1000.LLS	1002 g	0,5 µg	0,5 µg	100 g - 1 kg				

# Main advantages of the AVK-1000.5Y.LLS comparator

## LOAD LOCK system

The comparator is supplied with a special mass standard feeder with a separate pumping unit.



## Vacuum containers

The **LOAD LOCK** system is used to load and unload a mass standard from a dedicated container that allows transferring and storing the mass standard in the vacuum.

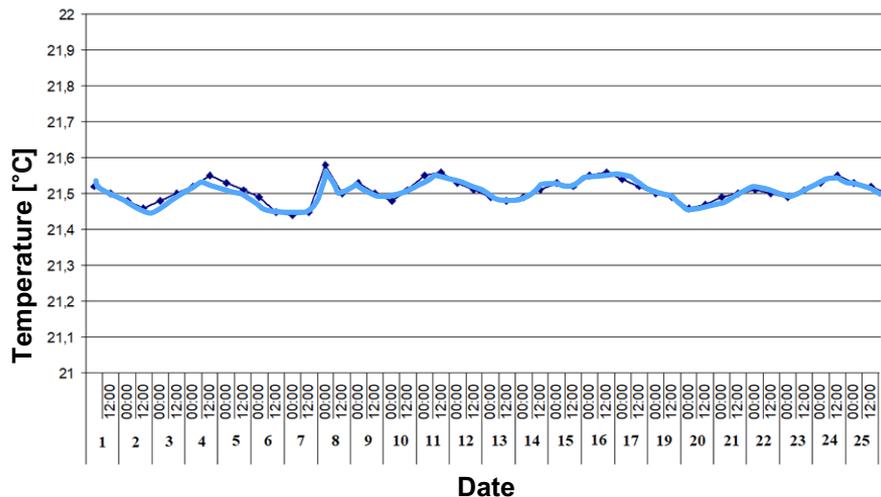


# Environmental requirements for using the vacuum (constant-pressure) comparator

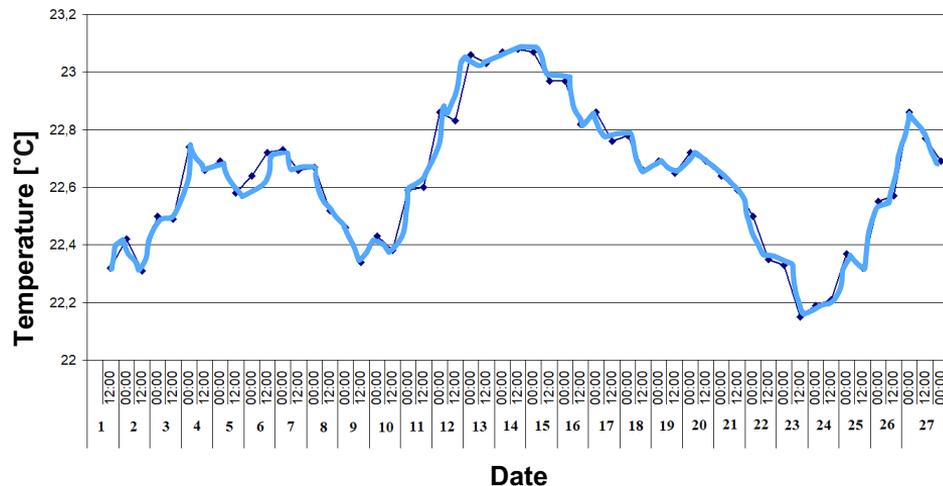
In view of its enormous reading unit (**10 billion units**), the **vacuum comparator** requires specific ambient conditions.

The temperature and vibrations are the main factors influencing the repeatability and final results.  
Temperature fluctuations:  $<0,1^{\circ}\text{C}/24\text{h}$ .

Correct temperature distribution



Incorrect temperature distribution

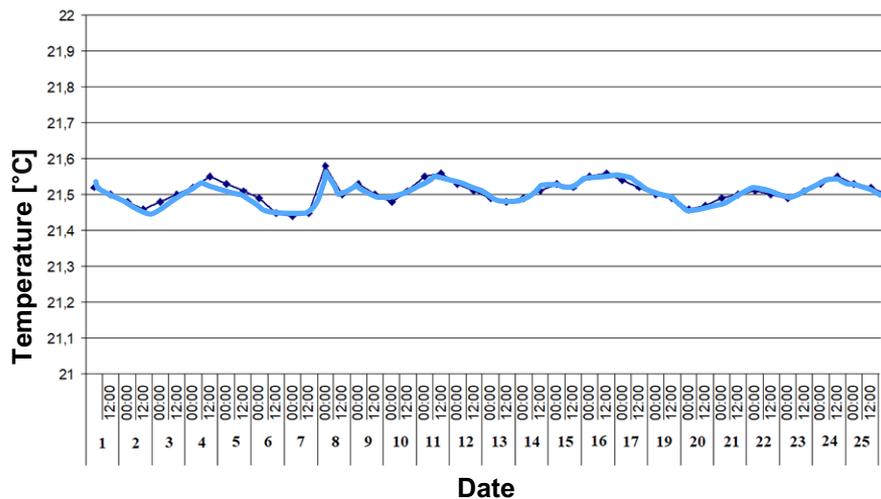


# Environmental requirements for using the vacuum (constant-pressure) comparator

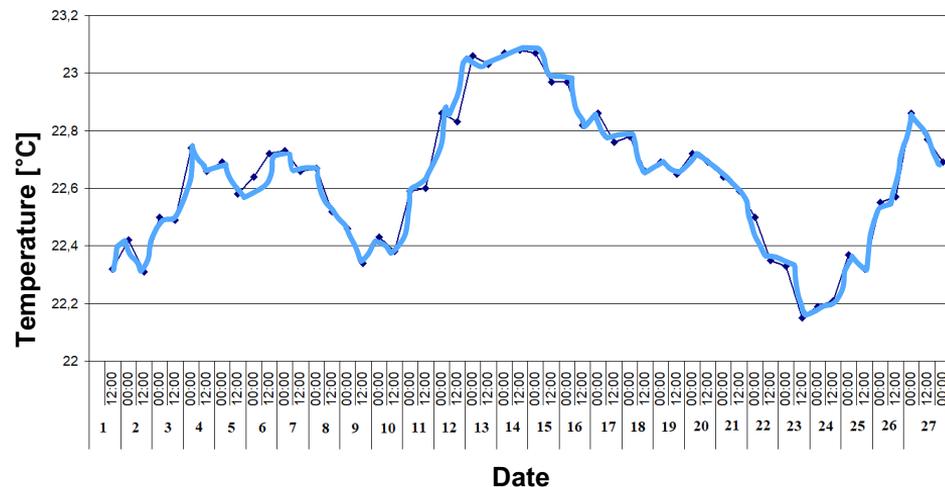
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Correct temperature distribution



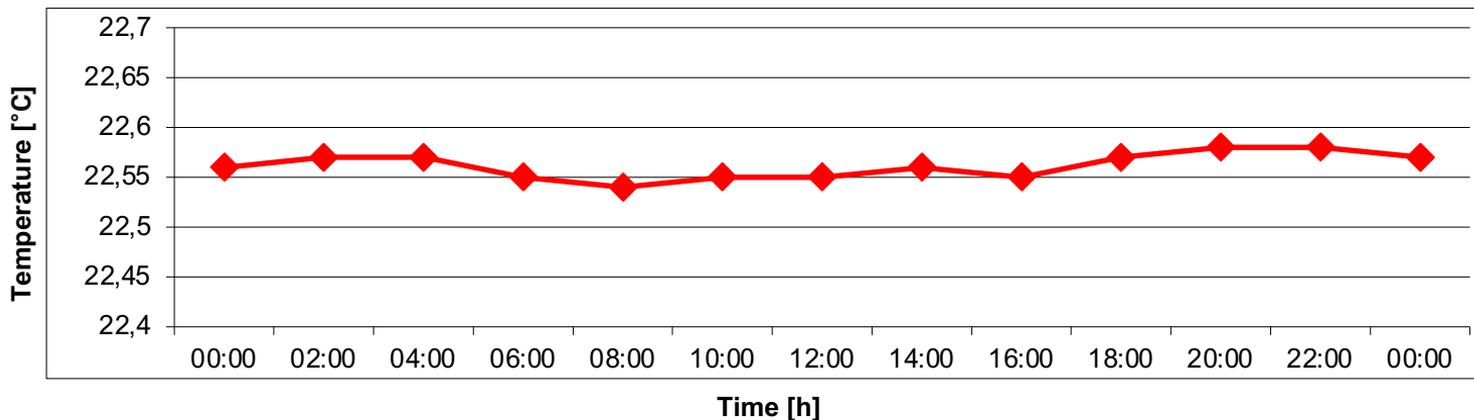
Incorrect temperature distribution



# AVK 1000.5.CP

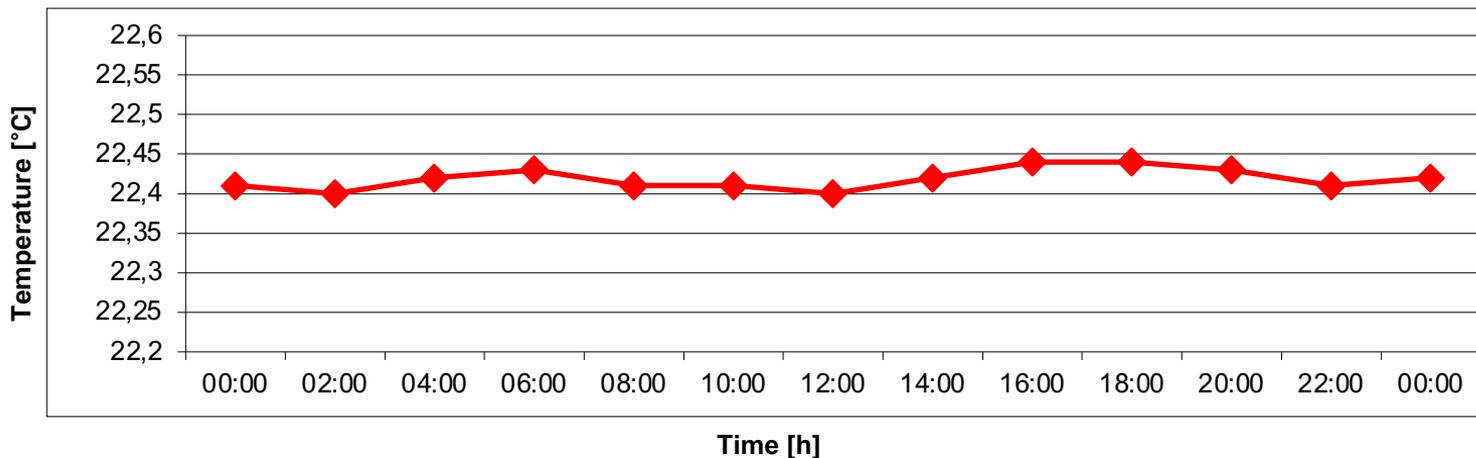
## comparator repeatability results

Mass	MEASUREMENTS					Average
	1 SD [ $\mu\text{g}$ ]	2 SD [ $\mu\text{g}$ ]	3 SD [ $\mu\text{g}$ ]	4 SD [ $\mu\text{g}$ ]	5 SD [ $\mu\text{g}$ ]	SD [ $\mu\text{g}$ ]
1000 g	0,86	0,52	0,43	0,92	0,74	0,694
500 g	0,34	0,77	0,6	0,83	0,54	0,616
200 g	0,63	0,32	0,29	0,69	0,7	0,526
100 g	0,26	0,55	0,5	0,42	0,63	0,472



# AVK 1000.5.LLS comparator repeatability results

Mass	MEASUREMENTS					Average
	1 SD [ $\mu\text{g}$ ]	2 SD [ $\mu\text{g}$ ]	3 SD [ $\mu\text{g}$ ]	4 SD [ $\mu\text{g}$ ]	5 SD [ $\mu\text{g}$ ]	SD [ $\mu\text{g}$ ]
1000 g	0,46	0,32	0,37	0,3	0,48	0,386
500 g	0,27	0,44	0,4	0,31	0,45	0,374
200 g	0,39	0,32	0,25	0,45	0,3	0,342
100 g	0,36	0,21	0,17	0,4	0,36	0,3



# Installations and implementations

Vacuum comparator  
with the LOAD LOCK  
system **AVK 1000.5Y.LLS**

Installation site:  
**GUM Polish NMI**  
Warsaw, Polska

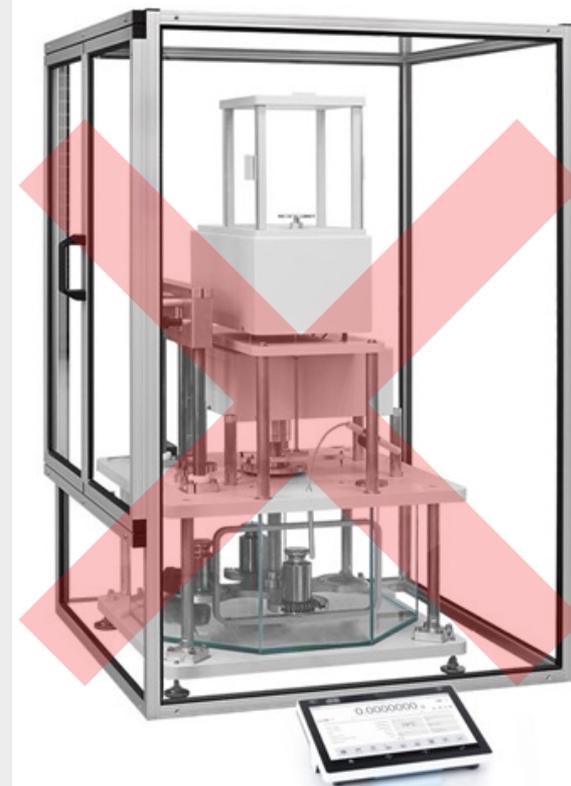
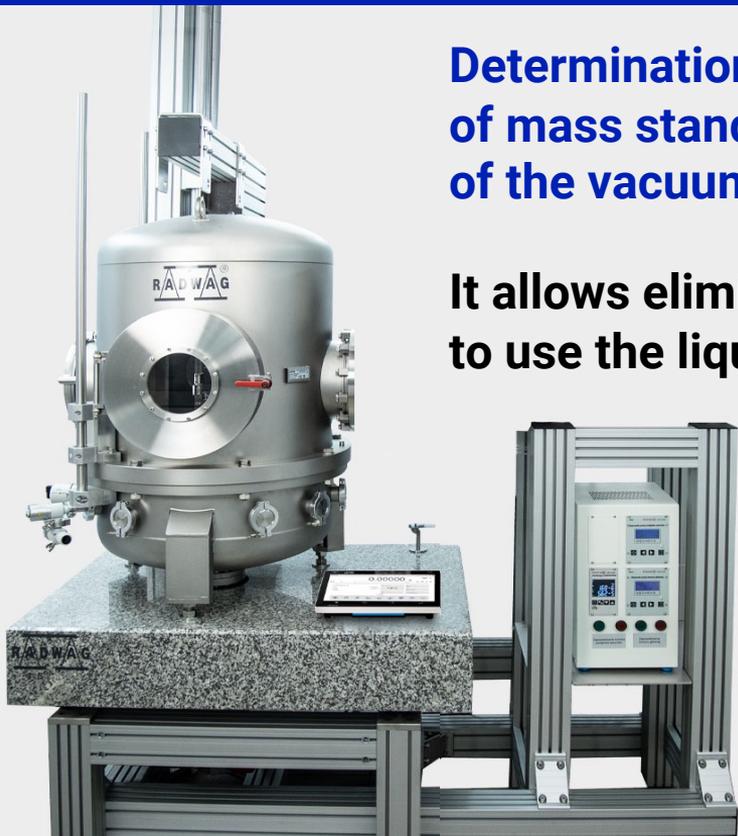


Andrzej Hantz  
Head of Department of Mechanics and Acoustics, Central Office of Measures

# Special application of the vacuum comparator

**Determination of density/volume  
of mass standard with the use  
of the vacuum comparator.**

**It allows eliminating the need  
to use the liquid comparator.**





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**Thank you for  
your attention**

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