METROLOGY SYMPOSIUM

DIGITALIZATION AND AUTOMATION IN MASS METROLOGY

Third Edition: Future and New Solutions

RADWAG

ČESKÝ METROLOGICKÝ INSTITUT

Measuring station for testing other physical parameters of mass standards as per OIML R111 (density, volume and magnetism)

METROLOGY SYMPOSIUM

DIGITALIZATION AND AUTOMATION IN MASS METROLOGY

Third Edition: Future and New Solutions

Presenters

Agnieszka Żukowska M.Sc., eng.

A deputy head of the measuring laboratory

Tomasz Jędrzejewski M.Sc., eng.

A head of the measuring laboratory

RADWAG ČMI Český metrologický institut **16-18.04.2024**, Radom, Poland

Introduction

Center for Metrology, Research and Certification

Measuring Laboratory

– accredited since 2004 r.

ilac-MRA

PCA Polskie Centrum Akredytacji >o< WZORCOWANIE

AP 069

Accredited according to ISO 17025:2017

Electronic balances

Mass standards

Piston pipettes

Design of the new RADWAG laboratory

Laboratory advancement and many years of experience with research influence of environmental conditions for working of mass comparators resulted in building a professional headquarters of the RADWAG's Measuring laboratory.

Why to determine density as per OIML R111

Nominal mass	r_{min}, r_{max} (10^3 kg/m^3)							
	Weight class (for M_3 class, no value has been determined)							
	E_1	E_2	F_1	F_2	M_1	M_{1-2}	M_2	M_{2-3}
≤ 100g	7,934...8,067	7,81...8,21	7,39...8,73.	6,4...107	≤ 4,4	≤ 3,0	≤ 2,3	≤ 1,5
50 g	7,92...8,08	7,74...8,28	7,27...8,89	6,0...12,0	≤ 4,0			
20 g	7,84...8,17	7,50...8,57	6,6...10,1	4,8...24,0	≤ 2,6			
10 g	7,74...8,28	7,27...8,89	6,0...12,0	≤ 4,0	≤ 2,0			
5 g	7,62...8,42	6,9...9,6	5,3...16,0	≤ 3,0				
2 g	7,27...8,89	6,0...12,0	≤ 4,0	≤ 2,0				
1 g	6,9...9,6	5,3...16,0	≤ 3,0					
500 mg	6,3...10,9	≤ 4,4	≤ 2,2					
200 mg	5,3...16,0	≤ 3,0						
100 mg	≤ 4,4							
50 mg	≤ 3,4							
20 mg	≤ 2							


INTERNATIONAL RECOMMENDATION

OIML R 111-1
Edition 2004 (E)

Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3

Part 1: Metrological and technical requirements

Poids des classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} et M_3

Partie 1: Exigences métrologiques et techniques

OIML R 111-1 Edition 2004 (E)

OIML

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

The density of the material used to make mass standards in [kg/m^3] as per **OIML R-111-1** Table 5.

The material density requirements have been introduced so that deviation of 10% from the air density of 1.2 kg/m^3 does not result in the error exceeding ¼ of the value of the maximum permissible error (MPE).

Why to determine magnetism as per OIML R111

Weight class	E_1	E_2	F_1	F_2	M_1	M_{1-2}	M_2	M_{2-3}	M_3
Maximum polarization m_oM (μT)	2,5	8	25	80	250	500	800	1600	2500

Maximum polarisation values as per OIML R-111 Table 3

Weight class	E_1	E_2	F_1	F_2
m ≤ 1 g	0,25	0,9	10	-
2 g ≤ m ≤ l0 g	0,06	0,18	0,7	4
20 g ≤ m	0,02	0,07	0,2	0,8

Maximum susceptibility as per OIML R-111 Table 4

The maximum durable magnetisation (polarisation) and magnetic susceptibility have been established in a way that they generate the change of contractual mass lower than 1/10 of the value of maximum permissible error (MPE) for the test weight in the magnetic fields on weighing pans.
If both polarisation and susceptibility values are lower than values specified in the tables, the component of uncertainty caused by the standard magnetism can be considered as negligible.


INTERNATIONAL RECOMMENDATION

OIML R 111-1
Edition 2004 (E)

Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3

Part 1: Metrological and technical requirements

Poids des classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} et M_3

Partie 1: Exigences métrologiques et techniques

OIML R 111-1 Edition 2004 (E)

OIML

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

AGV-8-1000.5Y

Automatic comparator for determination of density and volume of mass standards

The automatic **AGV-8/1000** comparator determines density and volume of mass standards in the E0 and E1 class as per the OIML R111.

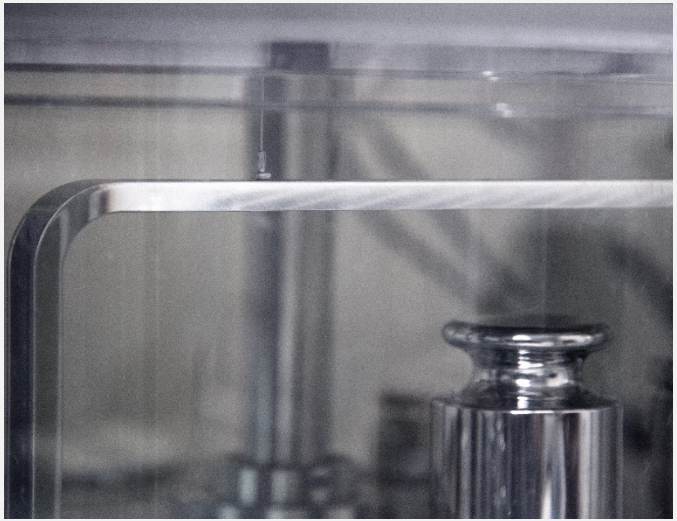
It is known for top precision and stability of measurements from 1 g to 1 kg.

Model	Maximum capacity	Readability	Repeatability [max]	E0	E1
AGV-8/1000	1110 g	0,01 mg	0,05 mg	1 g - 1000 g	1 g - 1000 g

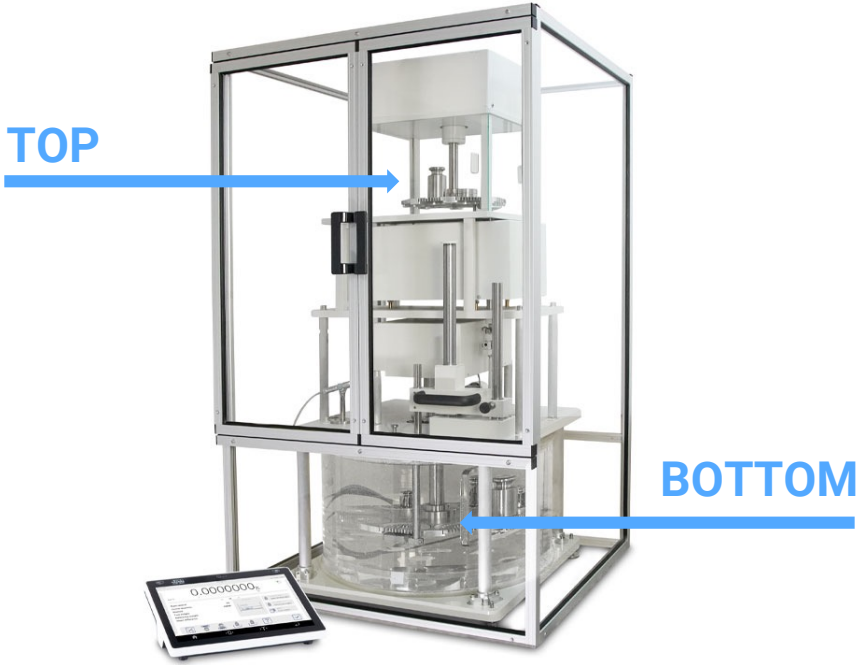
Main advantages of the AGV-8/1000 comparator for determination of density and volume

Self-centring suspended weighing pan

The weighing pan suspended on wires with a diameter of 0.3 mm allows minimising non-centricity errors and eliminates the impact of surface tension of the liquid.

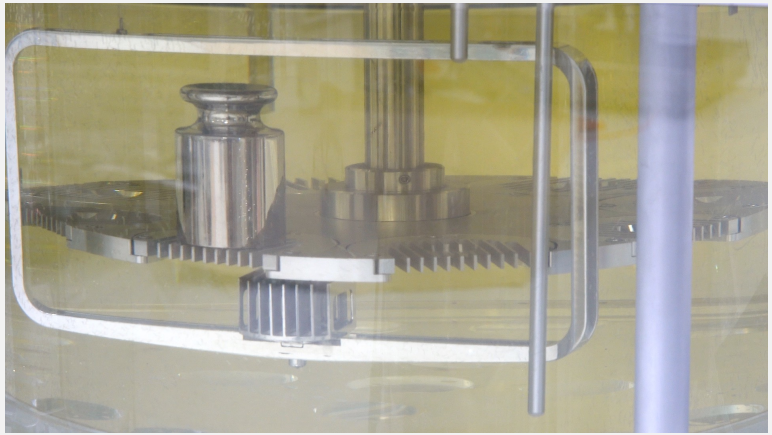


Main advantages of the AGV-8/1000 comparator for determination of density and volume



Dual automatic machine with a 8-position mass standard magazine

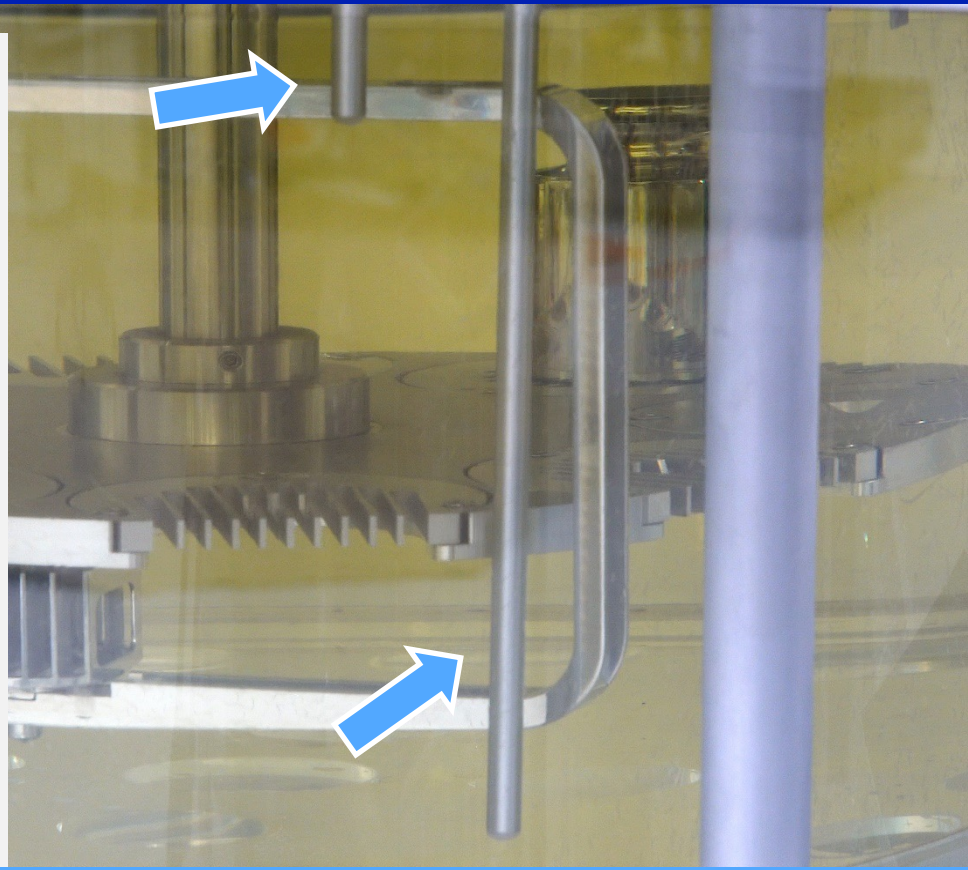
The machine is equipped with an **8-position** mass standard **magazine** located in the tank with DODECAN liquid as well as an additional „ballasting" automatic device synchronised with the feeder immersed in the liquid.



Main advantages of the AGV-8/1000 comparator for determination of density and volume

Temperature measurement in 3 spots

The device is equipped with a high-quality thermometer with a reading unit of **0,001°C** and three temperature sensors. Thanks to measuring in 3 spots of the tank (at the bottom, in the centre, at the surface), it is possible to establish the difference and, if necessary, mix and balance the temperature of liquid in the tank. Otherwise incorrect results of the density measurement would be obtained.



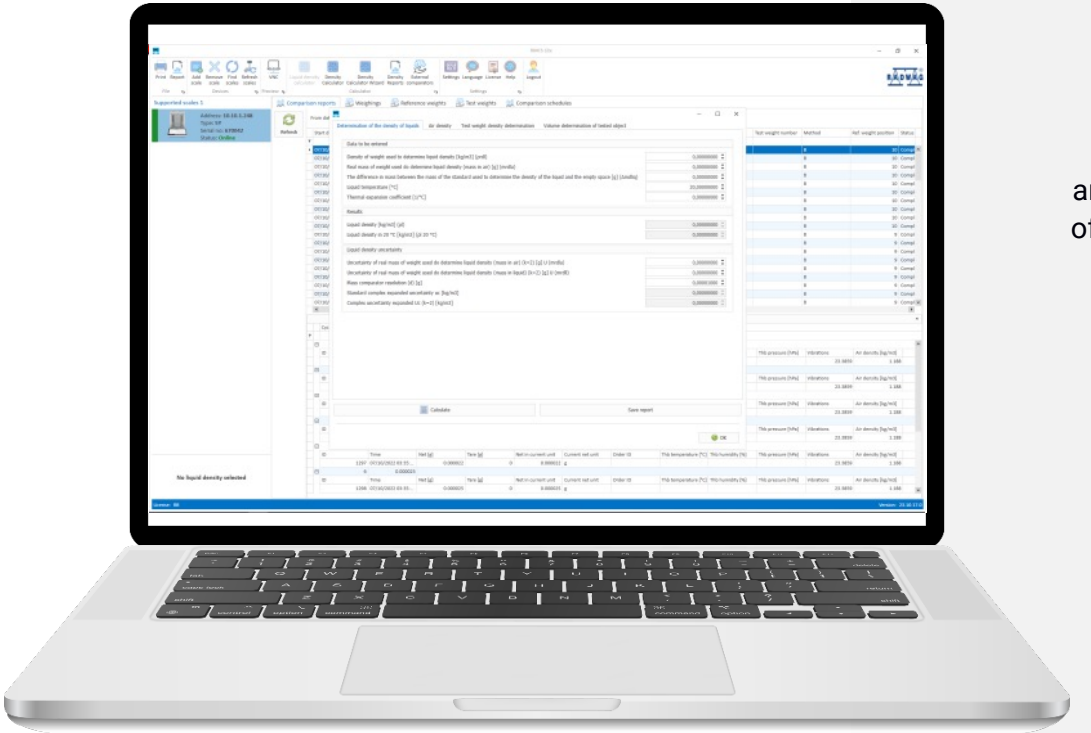
Main advantages of the AGV-8/1000 comparator for determination of density and volume

Mass standard feeder

The automatic **AGV-4/1000** comparator is supplied with a special arm used to feed and remove mass standards or silica hemispheres from the magazine, which substantially improves operation.

Thanks to a special structure of the insert, the comparator offers a wide measuring range (from 1 g to 1 kg) and is adapted to comparing silica hemispheres.

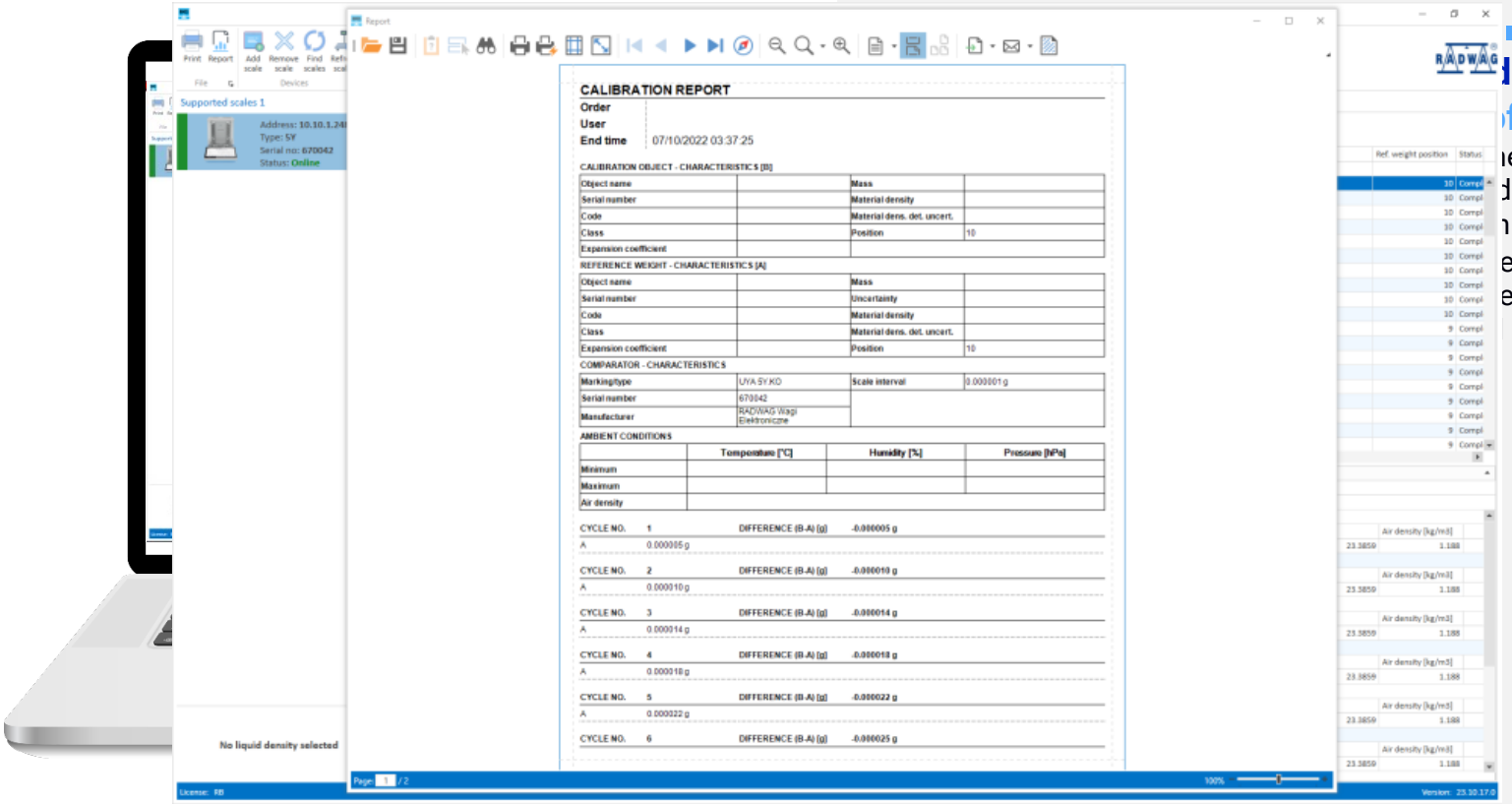
Main advantages of the AGV-8/1000 comparator for determination of density and volume



Dedicated density determination software

The software of the machine allows determining mass standard density and calculating the uncertainty with the use of an A method as per the recommendation of **OIML R111.** It also allows determining (checking) the liquid density.

Main advantages of the AGV-8/1000 comparator for determination of density and volume



lensity
ftware

ıe allows
d density
ı the use
endation
ermining
density.

Validation of calculations by NPL UK

NPL ASSESSMENT OF RADWAG AGV-8/1000 AUTOMATIC VOLUME COMPARATOR

STUART DAVIDSON, KEVIN DOUGLAS, SASKIA BURKE

NPLML - COMMERCIAL

FEBRUARY 2022

6.7.4 Result at 20 grams

Table 10 gives the results for the determination of the density of a 20 gram mass standard. The density of the reference standard was 7887.65 kg/m³.

Table 10: Accuracy of density measurement at 20 g

Measured Density	Calculated uncertainty	Mass Standard Density	Mass Standard Density Unc.	Difference
kg/m³	kg/m³	kg/m³	kg/m³	kg/m³
7 964.948	1.402	7 964.3	0.74	-0.6

6.7.5 Summary of results

Table 11 summarises the results for density determination of weights from 1 kilogram to 20 grams.

Table 11: Summary of density measurement results

Nominal mass value	Measured density	Calculated uncertainty	Density error	Volume difference (ref – test)
g	kg/m³	kg/m³	kg/m³	cm³
1000	8 049.981	0.133	-0.441	1.381
500	7 793.201	0.217	-0.201	-0.538
200	7 868.686	0.382	-0.686	0.036
100	7 879.886	0.706	+0.114	0.041
20	7 964.948	1.402	-0.648	0.024

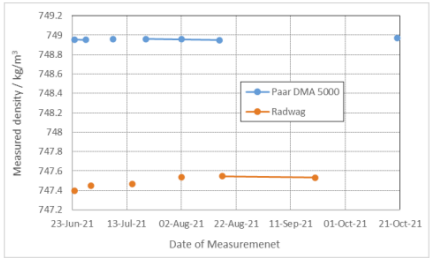
Although the density error exceeds the calculated uncertainty in two cases once the uncertainty on the density of the reference weight is taken into account only the error at 1 kilogram is greater than the combined uncertainty. There does not seem to be a correlation between the error in the density measurement and the volume difference between the reference and test weights.

6.8 DETERMINATION OF LIQUID DENSITY

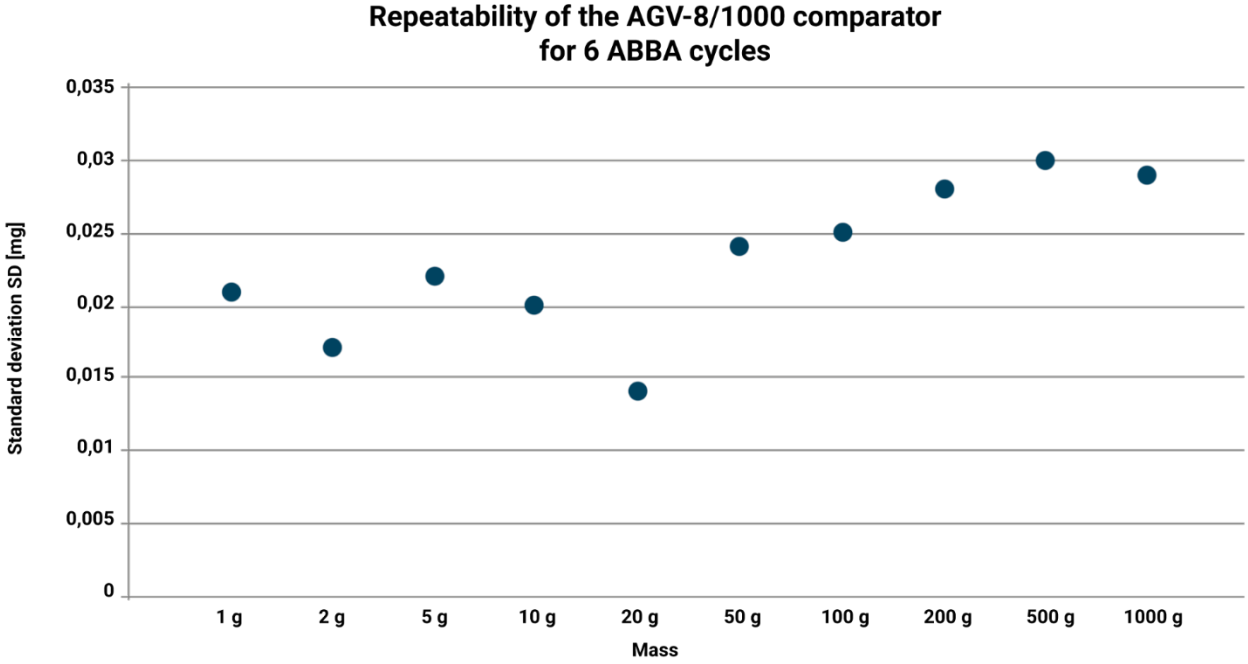
Throughout the assessment period the density of the liquid in the comparator was measured using the standard procedure for liquid density determination outlined by Radwag, (i.e. the hydrostatic weighing of a 100-gram weight). In parallel, 5 mL samples of the liquid were taken from the bath and the density of each sample was determined in a calibrated Paar DMA 5000 density meter. A summary of all the measurements is given in Table 12 and the results are plotted in Figure 2.

Table 12: Results of density determination on the Radwag comparator and in the Paar DMA 5000 density meter

Paar DMA 5000		Radwag comparator	
Date	Determined liquid density	Date	Determined liquid density
	kg/m³		kg/m³
21 June 21	748.949		
24 June 21	748.954	24 June 21	747.397 4
28 June 21	748.951		
		30 June 21	747.450 3
08 July 21	748.957		
		15 July 21	747.467 2
20 July 21	748.961		
2 Aug 21	748.958	2 Aug 21	747.536 3
16 Aug 21	748.950		
		17 Aug 21	747.545 8
		20 Sept 21	747.531 8
20 Oct 21	748.968		
Av.	**748.956**		**747.488 1**
SD	**0.006**		**0.059**



AGV-8/1000 comparator repeatability results



SM-UYA Susceptometer

The susceptometer by **RADWAG** is used to measure magnetic susceptibility and magnetisation of E1-class weights or lower-class weights as per OIML R111. In view of its modular structure, once the suitable module has been disassembled, **the susceptometer** can be used as a mass comparator or balance/scale.

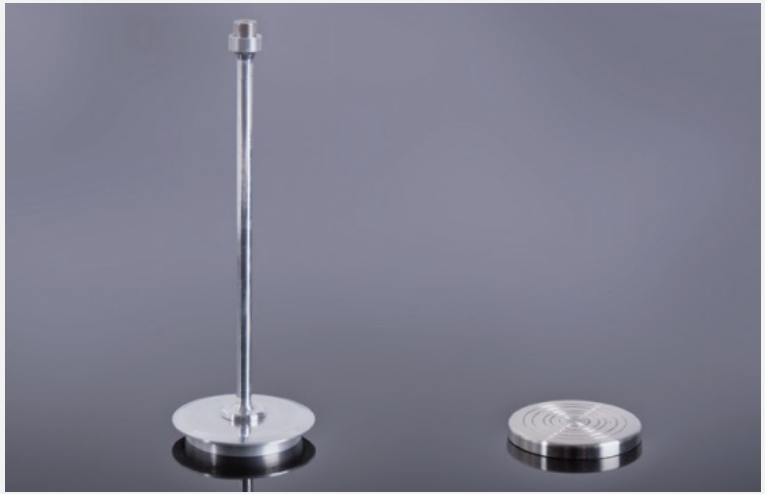
Model	Obciążenie maksymalne	Dokładność odczytu	Powtarzalność [max]	Obciążenie maksymalne	E0	E1	E2	F1	F2
SM-UYA 6.5Y.KO	6,1 g	0,1 ug	0,4 ug	50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg
SM-UYA 2.5Y	2,1 g	0,1 ug	0,35 ug	50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg
SM-MYA 5.5Y	5,1 g	1 ug	1,6 ug	50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg
SM-MYA 11.5Y	11 g	1 ug	2,5 ug	50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg	1 g - 50 kg

Main advantages of the SM susceptometer

Modular structure

In view of its modular structure, after disassembling the module, the **susceptometer** can be used as a mass comparator or balance/scale, depending on the model.

Thanks to the structure of weighing pans, they can be easily replaced and it is possible to easily switch from the **susceptometer** mode to the weighing or comparing mode.



Main advantages of the SM susceptometer

The magnetic susceptibility and residual magnetism measurements

The SM susceptometer by RADWAG is used to test magnetic properties of mass standards (E1, E2, F1, F2 class). The machine offers 3 different working heights, from the bottom of the standard to the centre of the magnet. The recommended distance of the mass standard from the magnet depends on the class of the standard. The test result is the magnetic susceptibility and polarisation, that is residual magnetism.

Special designs

SUSCEPTOMETER

The special design of the **susceptometer** for checking environmental samples and soil samples. The machine allows checking the content of metals in the soil and filters for air quality testing.


METROLOGY SYMPOSIUM
DIGITALIZATION AND AUTOMATION IN MASS METROLOGY
Third Edition: Future and New Solutions
Thank you for your attention
www.radwag.com