

METAL PURITY TESTER PS 200/2000/X/AU



GRAVIMETRIC METHOD
USING AN ELECTROMAGNETIC
MEASURING SYSTEM

Use of advanced measuring technique in jewellery industry, realized in a form of a balance PS/X/AU series, has become an indispensable requirement for precise determining mass and density of various metals, and in particular alloyed metals. It is particularly important for the technological purposes. Appropriate selecting of the components enables preparing a lasting, effective and valuable product.

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1. Introduction

Pure gold is a relatively soft material, susceptible to abrasion and scratching. Durability of consumer goods made of gold results from other metals added to the pure gold. Thus, the alloy receives a desired colour, hardness and surface elasticity even in long time of use.

Creating alloys based on gold is a relatively common phenomenon, therefore there occurs a need to determine pure gold quantity in the alloy. Content of gold in the alloy is known as its purity. There are two methods for determining gold purity: in carats and per mille. Both methods use weighing process to determine the amount of pure gold contained in alloy sample.

Per mille (parts per thousand) determine the quantity of pure gold units contained in a 1000 units of the tested alloy. If the alloy contains 50 % of pure gold then its purity class is 500. The per mille relation is demonstrated by the so called gold purities:

- 1 purity class 960 contains 96,0% of pure gold
- 2 purity class 750 contains 75,0% of pure gold
- 3 purity class 585 contains 58,5% of pure gold
- 4 purity class 500 contains 50,0% of pure gold
- 5 purity class 375 contains 37,5% of pure gold
- 6 purity class 333 contains 33,3% of pure gold

Determining gold purity in carats, is carried out by specifying number of gold parts in 24 parts of the tested alloy. Therefore, pure gold is a 24-carat one, as 1 carat is 1/24 of a single weighing part of gold contained in the tested alloy.

- 24-carat – purity 1000 (in practice the highest achieved purity is 999 or 999,9)
- 23-carat – purity 958
- 22-carat – purity 916
- 18-carat – purity 750
- 14-carat – purity 585
- 12-carat – purity 500
- 10-carat – purity 417
- 9-carat – purity 375
- 8-carat – purity 333

The method of determining quantity of alloyed gold by weighing enables partial process automatization, mainly by application of an electronic balance. Making use of balance's advanced features enables designing a clear and proved methodology, as in case of a precision balance PS 200/2000/X/AU series.

2. Measuring technique used in jewellery, balance PS 200/2000/X/AU series

A jewellery balance PS/X/AU series is required to implement a precise measuring technique enabling accurate determining mass and density of different metals and their alloys. It is particularly important due to the technological purposes. Appropriate selecting of components is a condition for obtaining a lasting, effective and valuable product. Apart from precise weighing process, the technique requires speed and ergonomics, both ensured by the balance PS/X/AU series.

The advanced technology used in the balance PS/X series is ensured by a graphic alphanumeric display providing excellent communication with the balance in optional situations.

The automatic internal adjustment system guarantees measuring accuracy independently on ambient conditions. The system features specific algorithms triggering adjustment on temperature changes and time.



A feature distinguishing the balance PS 200/2000/X/AU series from other weighing instruments is the function of weighing with different accuracy, depending on mass of a sample to be tested. The balance features two weighing ranges, thus it enables determining mass of small samples with high accuracy (1 mg) or of relatively large samples with lower accuracy (10 mg).

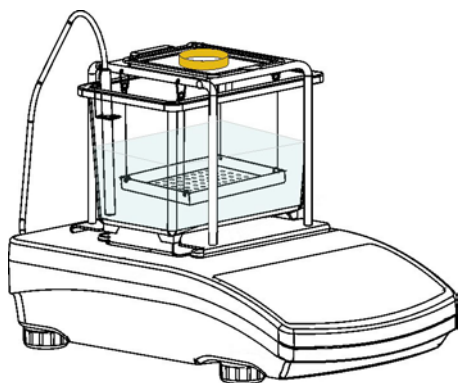


A dedicated application of the balance PS 200/2000/X/AU series is intended to testing precious metals by determining the following parameters of a tested sample:

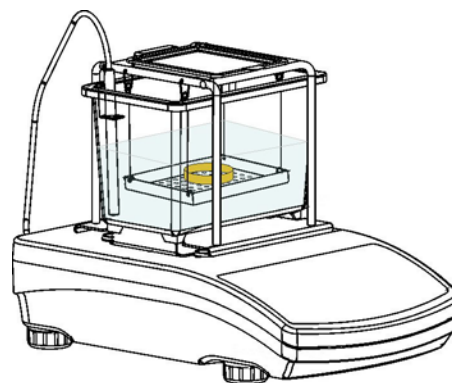
- Pure gold content in a tested sample;
- Content of gold alloyed with silver and copper;
- Content of platinum alloyed with nickel and palladium;
- Density of other metals and ready goods.

3. Measuring method

The measuring method is intended to determine mass of a tested sample by differential weighing. First a sample to be tested is weighed "in the air", and afterwards in a liquid. The obtained data is used to calculate density of the tested sample, its volume and portion of alloyed components.

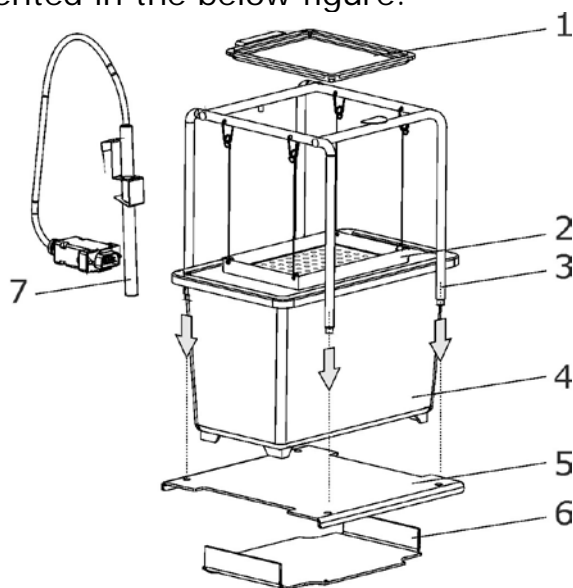


Weighing in the air



Weighing in liquid

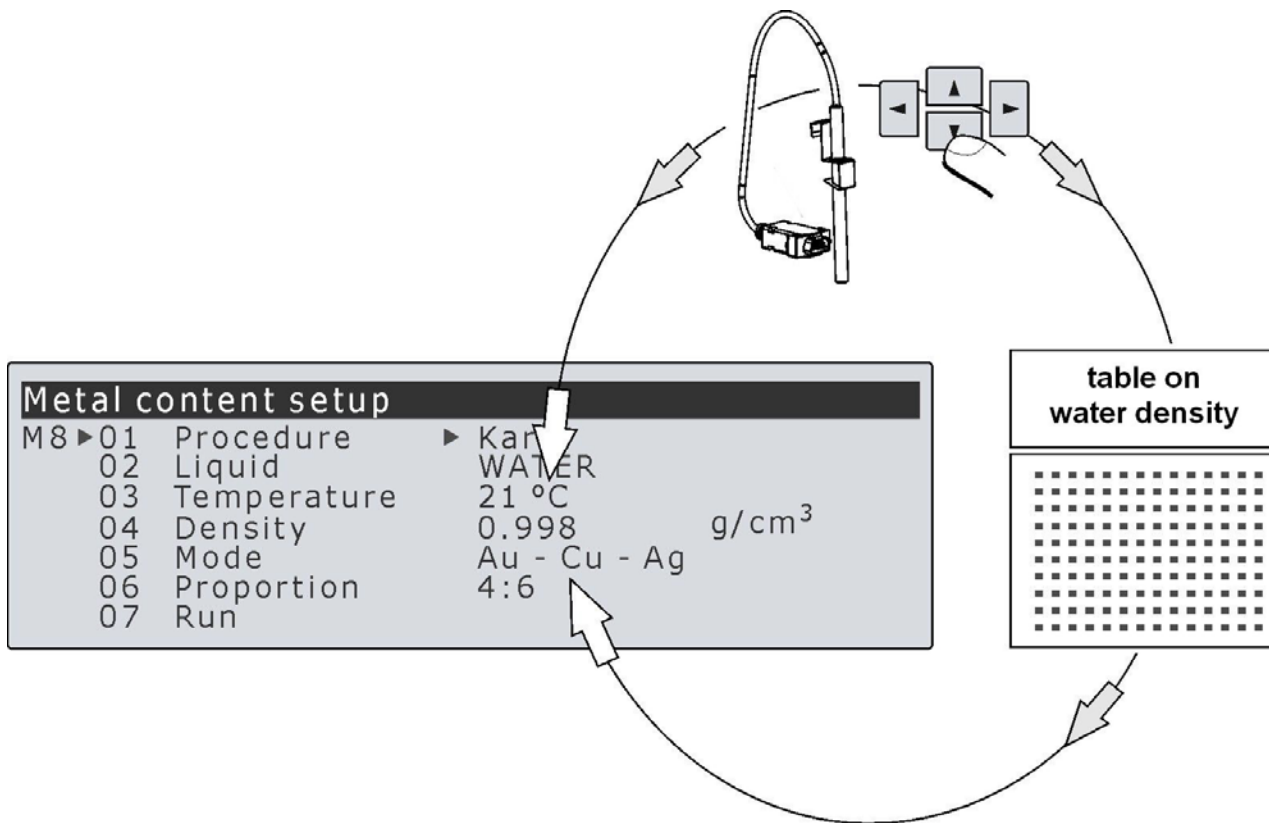
The measurement can be carried out on assembling a dedicated metal purity determining kit, presented in the below figure.



- 1 – top pan of the metal purity kit
- 2 – bottom pan of the metal purity kit
- 3 – rack
- 4 – container for liquid
- 5 – rack basis
- 6 – container basis
- 7 – control thermometer with a holder

3.1. Temperature measurement

The balance PS/X/AU comes standard with an external thermometer intended to online determining of liquid (water) temperature value.



The balance holds in its memory a table on a relation between water temperature and its density. During the measuring process, water temperature is automatically controlled by the balance (through the plugged control thermometer) and converted into the density value. It is one of the elements of Good Manufacturing Practice (GMP). Precise determining of water temperature may have significant influence on determining carat content or alloy content of weighed sample with small mass.

In case the control thermometer is not plugged to the balance, water temperature value should be entered to balance memory manually (a user should measure water temperature using another control thermometer).

4. Testing purity of gold and alloyed gold

Gold – basic information

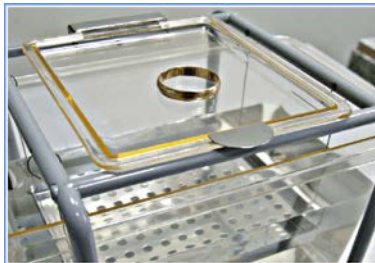
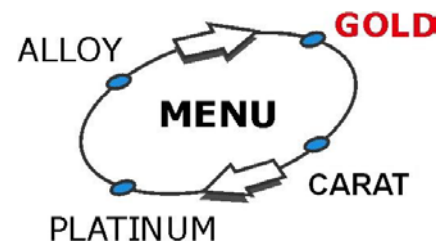
Chemical symbol [Au]. Specific gravity 19,3 g/cm³. Melting point 1062,4° C. Pure gold is a metal of bright yellow colour, very soft, malleable and forgeable, with hardness of 2,5 in the Mohs scale.

Testing pure gold using a balance PS 200/2000/X/AU series can be carried out within the carat content rating from 9 K to 24 K. This test does not focus on type of metal alloyed with gold. Gold purity expressed in carats is demonstrated in the below table.

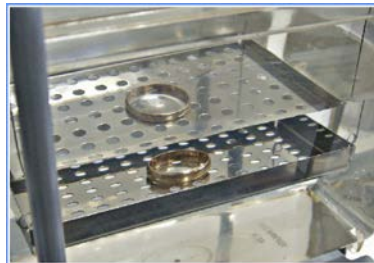
[K]	24K	23K	22K	18K	14K	12K	10K	9K
% Au	100%	95,8%	91,6%	75%	58,5%	50%	41,7%	37,5%

Testing procedure:

1. Select mode,
2. Weigh sample to be tested on the top pan,
3. Weigh tested sample on the bottom pan,
4. Balance display indicates measurement result.



Weighing in the air



Weighing in liquid



Test result

After completing the testing process, the balance generates a report to be printed on a connected printer. The report comprises two sections. The first one includes modifiable elements on GLP parameters:

- operator name, (optional sequence of alphanumeric characters)
- project name, (optional sequence of alphanumeric characters)
- date
- time

The second section contains the result of gold purity testing procedure. An example of a report is presented below.

Date	: 09/01/2013
Time	: 10:56:36
User Id	: Martin
Project Id	: Ring
Balance Id	: 321876
Metal content	
Procedure	: Gold

Air:	3.08[4] g
Water:	2.85[3] g
Temperature:	22 °C
Density:	13.321 g/cm ³
Volume:	0.232 cm ³
Percent:	61.94 %
Karat:	14.87 K

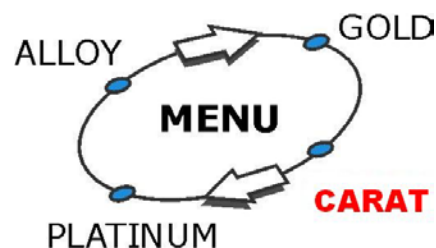
Alloyed gold testing process

The components most frequently occurring in the alloyed gold are copper, silver, and also nickel, platinum, palladium, manganese and zinc. Adding silver to gold changes its colour from gold from yellow through yellow-green to white. Adding copper causes colour change from yellow through yellow-red to red. If silver and copper are both added to the gold, they cause a large increase in the hardness and strength. Therefore, data on alloy composition is very important. Testing gold alloys should be carried out very precisely, as enabled by the metal purity tester **PS 200/2000/X/AU** series. The instrument is designed to test three types of gold alloys:

- gold – copper (Au / Cu)
- gold – silver (Au / Ag)
- gold – copper – silver (Au / Cu / Ag)

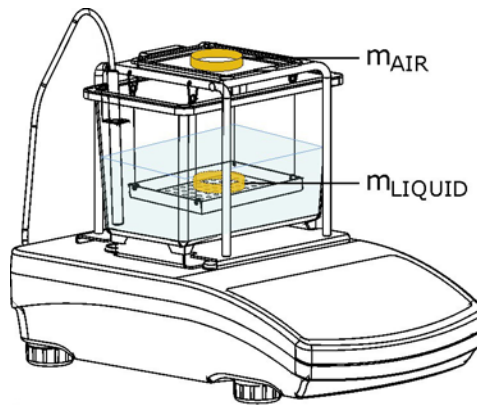
Testing procedure:

1. Select mode,
2. Select type of alloy to be tested
3. Weigh sample to be tested on the top pan,
4. Weigh tested sample on the bottom pan,
5. Balance display indicates measurement result,
6. Balance automatically generates a report to be printed on a plugged printer.



The content of the report is the same as in case of testing gold purity.

In case of two-component alloy it is sufficient to weigh the tested sample in the air and in the liquid.



In case of three-component alloy, an operator should additionally specify the ratio of alloying elements (ligatures).

Menu	Au	Cu	x	RATIO	
	Au	Ag	x		
	Au	Cu	Ag	Cu	Ag
				4	6
				5	5
				6	4
				7	1

Below table presents alloy density in relation to gold purity.

Gold purity	Au % content	Alloy density [g/cm ³]			Sample density [g/cm ³]
		Cu /Ag	Cu	Ag	
24 K	100 / 100	19,32	19,32	19,32	19,13 ÷ 19,51
22 K	91,6 / 100	17,73	17,63	18,06	17,45 ÷ 18,24
20 K	83,4 / 100	16,42	16,19	16,94	16,03 ÷ 17,11
18 K	75,0 / 100	15,24	14,99	15,96	14,84 ÷ 16,12
14 K	58,4 / 100	13,38	13,04	14,30	12,91 ÷ 14,44
10 K	41,7 / 100	11,91	11,54	12,96	11,42 ÷ 13,09

5. Testing platinum class

Platinum – basic information

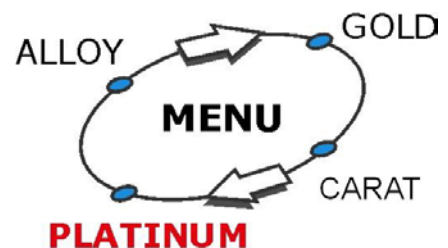
Chemical symbol [Pt], its colour is white with a shade of grayish-blue, and excellent metallic sheen. Platinum specific gravity is 21,5 g/cm³. The melting point approximately 1780°C. Due to its softness and high price, platinum is used in a few alloys: with gold, palladium or iridium. The feature which is platinum technological advantage (softness) is unfortunately its usable defect. Jewellery made of platinum is not durable. Only mixing with alloyed additions increases its usability in jewellery industry. Below table demonstrates alloy density dependent on platinum class.

Platinum class [PT]	% content of alloyed platinum	Alloy density [g/cm ³]		Sample density [g/cm ³]
		Nickel	Palladium	
1000	100 / 100	21,45	21,45	21,24 ÷ 21,66
950	95,0 / 100	20,04	20,64	19,84 ÷ 20,85
900	90,0 / 100	18,80	19,88	18,61 ÷ 20,08
850	85,0 / 100	17,71	19,18	17,53 ÷ 19,38
800	80,0 / 100	16,73	18,53	16,56 ÷ 18,72
750	75,0 / 100	15,86	17,92	15,70 ÷ 18,10

Due to technological and economical purposes (platinum is an expensive material) the quantity of alloying elements has to be precisely monitored. Appropriate selection of the elements enables obtaining platinum of different classes. Testing process with use of the metal purity tester PS 200/2000/X/AU series guarantees fast and accurate method for testing products made of platinum.

Testing procedure:

1. Select mode,
2. Select type of alloy to be tested
3. Weigh tested sample on the top pan,
4. Weigh tested sample on the bottom pan,
5. Balance display indicates measurement result,



After completing the testing procedure, the balance displays measured platinum class. Below please see an example of a printout from determining platinum class.

Date : 08/01/2013
Time : 14:12:01
User Id : Martin
Project Id: Ring
Balance Id: 321876
Metal content
Procedure: Platinum Pt-Pd

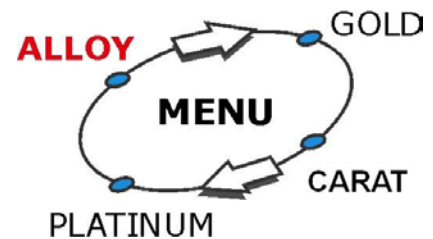
Air: 46.33[8] g
Water: 43.30[8] g
Temperature: 22 °C
Density: 15.259 g/cm³
Volume: 3.037 cm³
Percent: 48.28 %
Karat: 482.84 PT

6. Determining percent content of major alloy component in a tested sample

This software option enables analyzing an optional two-component or three-component alloy. Before initiating the measuring process, a user should enter the density values of metals forming the alloy. Additionally, in case of a three-component alloy, a user has to specify data on minor metal constituents used in the alloy to be tested.

Testing procedure:

1. Select mode,
2. Select alloy type to be tested, (2 or 3 components)
3. Enter density value of metals forming the alloy to be tested,
4. In case of a 3-component alloy specify ratio of the minor alloying elements (2 and 3),
5. Weigh tested sample on the top pan,
4. Weigh tested sample on the bottom pan,
5. Balance display indicates measurement result,
6. Balance automatically generates a report to be printed on a plugged printer.



In case of 3-component alloy, a user has to specify the ratio of minor metal alloying elements.

Menu	Alloy 1	ρ [g/cm ³]	?	RATIO	
	Alloy 2	ρ [g/cm ³]	?	Alloy 2	Alloy 3
	Alloy 3	ρ [g/cm ³]	?		
				4	6
				5	5
				6	4
				7	3
				8	2

Metal content setup				
M8	▶01	Procedure	Alloy	
	02	Liquid	WATER	
	03	Temperature	22°C	
	04	Density	0.998	g/cm ³
	05	Alloy type	▶AL-3	
		Run		

Metal content setup				
M8	▶05	▶01	Alloy type	AL-3
		02	d1	8.000 g/cm ³
		03	d2	2.700 g/cm ³
		04	d3	2.00 g/cm ³
		05	Ratio	▶8:2

Balance menu on testing alloys

An example of a report from testing density of a 3-component alloy:

Date	: 09/01/2013
Time	: 12:36:20
User Id	: ADMIN
Project Id:	Element no 4
Balance Id:	321876
Metal content	
Procedure:	Alloy AL-3

Air:	97.05[2] g
Water:	72.91[7] g
Temperature:	22 °C
Density:	4.012 g/cm ³
Volume:	24.189 cm ³
Percent:	54.16 %

7. Accuracy in testing purity of precious metals

The main issue while testing precious metals using weighing method is the dispersion of indications. Testing the same sample for multiple times may result in relatively high dispersion of obtained results. The dispersion may occur due to errors in weighing the tested sample in the air and/or in the liquid. Therefore, a user should observe specific principles that are outlined in the below points:

1. Prepare a balance for testing procedure

A balance should be plugged to mains much earlier before starting the measuring process. Generally it is assumed that the 30 minutes time is sufficient. Detailed information on balance operation is provided in the documentation attached to a balance (most likely the user manual).

2. Prepare a sample for testing procedure

A sample to be tested should be clean, i.e. it has to be free from any dirt or grease. Dirty sample surface is more susceptible to the adhesion of air bubbles when weighing in liquid.

3. Temperature and liquid surface tension

Liquid temperature stability is one of the crucial criterion. If assumed that the liquid is stored in the testing room, it can be assumed that its temperature is stable. Liquid at a temperature significantly different from the room temperature requires stabilization.

4. Ambient conditions of testing process

A balance is a relatively precise measuring device, therefore it requires appropriate operating conditions. In case of the metal purity tester PS 200/2000/X/AU series it is sufficient to ensure temperature stabilization in the range of a few Celsius degrees. Change rate of the ambient conditions does not affect the determining process due to its speed and character. (differential weighing).

5. Weighing in the air

Place the sample to be tested on the center of the top weighing pan. The measurement can be disturbed by air movement. It is caused by the design of the metal purity determining kit that does not feature an anti-draft shield. This issue may be significant in case of weighing with the accuracy of 1 mg.

6. Weighing in liquid

The amount of liquid in the container should be sufficient to fully cover the immersed sample to be tested. Therefore, it should consider the diversity of tested substances. After placing a tested sample in the liquid pay special attention to any air bubbles attached to the surface of the sample. It is primary factor determining successful completion of the testing procedure. It is assumed that the operator carrying out the testing process recognizes and eliminates such phenomena.

7. Liquid surface tension

Surface tension is a physical phenomenon occurring at the meeting point of the liquid surface of a solid, gas or other liquid, so that the surface under tension will behave like an elastic membrane. This phenomenon results from the cohesion forces occurring between liquid molecules. The surface tension between two phases can be reduced by adding the surface active substances, so-called. surfactants.

On contact of two phases there are also other forces acting on liquid particles than those acting on the inside. Therefore, the liquid surface forms a concave meniscus. These phenomena occur in micro level and their effect on determining density of a sample is negligible.