

# REVIEW OF WEIGHING TECHNOLOGY FOR GOLD 400 TR.OZ. BARS

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LBMA

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# HISTORY

## **Rounding rules established by LBMA as part of London Good Delivery**

- round down to nearest 0.025 tr.oz.
- stay at 0.025 tr.oz. if bar weight greater by 0.002 tr.oz. otherwise round down
- applies to both electronic and equal arm balances

## **Equal Arm Balances used for weighing gold bars in London up to 2013**

- Electronic balance testing started in 2004
- Report of successful Sartorius gold balance test in 2010
- Specifications for electronic balances established in 2013

# CURRENT PRACTICE

## TIGHT BAR MASS MEASUREMENT - VAULTS

For bars with mass close to rounding point 0.025 tr.oz.

Must be 0.002 tr.oz. above the rounding point to be rounded to 0.025 tr.oz.

Example 1

Displayed mass: 421.125 tr.oz. – rounded to 421.100 tr.oz.

Example 2

Displayed mass 421.128 tr.oz. – rounded to 421.125 tr.oz.

Example 3

Displayed mass 421.127 tr.oz. – could be 0.126 or 0.128 ( $\pm 0.001$  tr.oz. uncertainty)

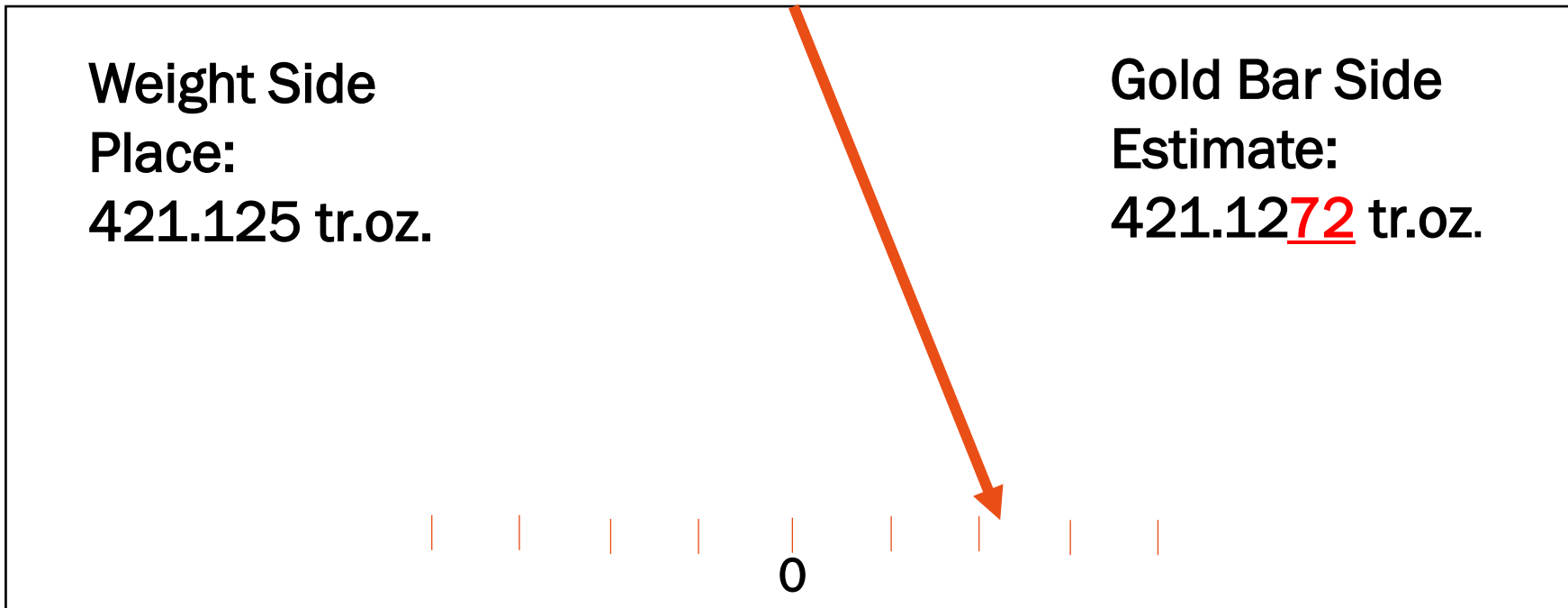
Use Equal Arm Balance to verify electronic balance measurements

# EQUAL ARM BALANCE



# EQUAL ARM BALANCE - INDICATOR

Analogue Scale – gives extra information; each division 0.001 tr.oz.  
Estimate between divisions for extra significant figure 0.0002 tr.oz.



# **CURRENT PRACTICE**

## **TIGHT BAR MASS MEASUREMENT - VAULTS**

### **Issues with Equal Arm Balances**

- very few equal arm balances being used**
- difficult to find and maintain skilled service personnel**
- accuracy dependent on calibrated set of weights**
  - frequently used**

# OPTIONS AVAILABLE

## Current Electronic Balances – 6 significant figures

### Mass Comparator

- 2 extra decimal places in tr.oz.
- 8 significant figures for 400 tr.oz. bars
- Requires AB substitution comparison with calibrated weights
- Draft enclosure required

## New Generation Electronic Balances for Gold Bars

- 1 extra decimal place in tr.oz. (divisions 0.01 g or 0.0003 tr.oz.)
- 7 significant figures for 400 tr.oz. bars

# MASS COMPARATOR

## Summary of Experiments at Royal Canadian Mint, November 2022

Mettler Toledo XP26003L

Readability: 1 mg or 0.000 01 tr.oz.

5 decimal places in tr.oz.

8 significant figures for 400 tr.oz. bars

Capacity: 26 kg

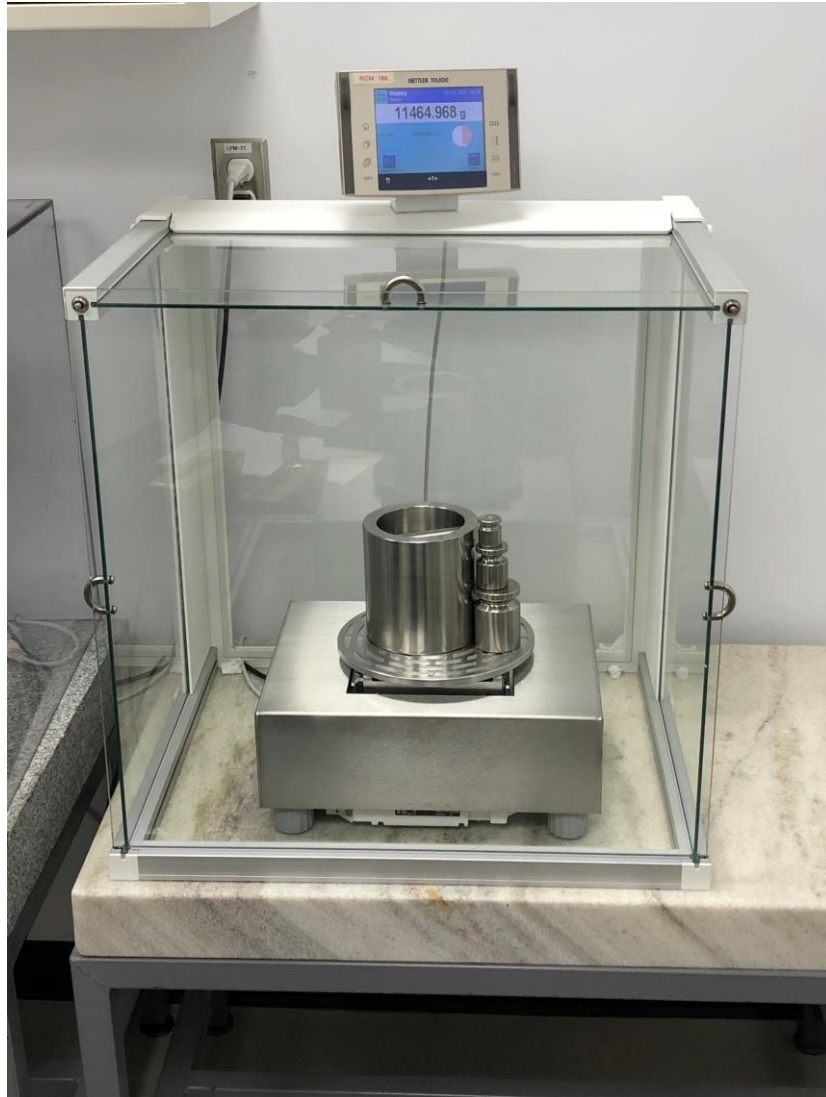
5 replicate AB substitution comparisons

A - Gold bar

B – Stainless Steel weights (RCM working set)



# MASS COMPARATOR: METTLER TOLEDO XP26003L



# SUMMARY OF MASS COMPARATOR MEASUREMENTS

Wt Bar (g)	Wt Ref (g)	Diff (g)	Ave Diff (g)	Bar Mass (ozt)	Uncert (ozt)
11265.354	11264.965	0.3890			
11265.354	11264.966	0.3880			
11265.350	11264.965	0.3850	0.3866	<b>362.19047</b>	<b>0.00036</b>
11265.351	11264.965	0.3860			
11265.350	11264.965	0.3850			

$$BarMass = \frac{(ref\_mass) + (ave\_diff)}{31.1034768g(ozt)^{-1}} \quad Uncert = 2\sqrt{(Uncert_{Measure}^2) + (Uncert_{ref}^2)}$$

# SIMULATED TIGHT BAR MASS MEASUREMENT

Based on gold bar measurements by mass comparator

Bar Number	Nominal mass values, tr.oz.	Mass Comparator values, tr.oz.	Rounded Value, tr.oz.
A	400.127	400.12617 ± 0.00035	400.100
B	410.527	410.52747 ± 0.00036	410.525

# NEXT GENERATION ELECTRONIC BALANCES

- **Capacity 15 kg**
- **Readability = 0.01 g**
- **Readability = 0.0003 tr.oz.**
- **7 significant figures**
- **Last digit useful for assessing the rounding point for tight bars**
- **Mass in tr.oz displayed or calculated from g units in spreadsheet**

# NEXT GENERATION GOLD BALANCE

7 significant figures

Measurement #	Mass Value, g	Mass values, tr.oz.	Average, tr.oz.
1	12499.92	401.8818	
2	12499.93	401.8821	401.8820 ± 0.0003
3	12499.93	401.8821	

Data courtesy of Sartorius

# EXAMPLE OF MEASUREMENT READOUT

## Next Generation Gold Bar Balances, Simulated numbers

Bar	Nominal Mass, tr.oz.	Measured Mass, tr.oz. n=3	Rounded Mass, tr.oz.
A	398.252	$398.2516 \pm 0.0003$	398.225
B	426.577	$426.5773 \pm 0.0000$	426.575

# OPTION COMPARISON

	Next Generation Gold Balances	Mass Comparator
Significant Figures	7	8
Readability, tr.oz.	0.000 3	0.000 01
Capacity	15 kg	26 kg
Approximate Cost	\$\$	\$\$\$\$
Weighing Time per bar n=3	1-2 min	10-15 min

# CONCLUDING REMARKS

## Several Mass Measurement Options for “tight bars”

- **Mass Comparators**
- **Next Generation Gold Bar Electronic Balances**
  - Bullion Weighing Kit
  - Draft Enclosure
  - Computer & spreadsheet for mass calculation
- **Replicate measurements to be sure ( $n \geq 3$ )**



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