

## Tender Document for LBMA Reference Material AuRM6

### Introduction

The LBMA has previously sponsored the production and sale of AuRM3, a gold reference material (RM) at the 995% Au purity level. This RM has sold out and a replacement is required.

The next phase of this project is now commencing. It will again be led by Dr Mike Hinds, a consultant for the LBMA, who is working with the LBMA Referees Group to complete this project.

This will be a single RM suitable for both Spark-Optical Emission Spectrometry and X-Ray Fluorescence analysis.

### Composition

Table 1. Concentrations of Proposed Gold Reference Material AuRM6,  
Concentrations in ppm

Element	Target Concentration	Desired Variation in Element Homogeneity Within Material,
Ag	4000	$\pm 30$
Cu	500	$\pm 5$
Pd	250	$\pm 3$
Pt	250	$\pm 3$
Au %	99.5%	

$\pm$  one standard deviation

Note: AuRM6 does not contain all the elements that were in AuRM3 because these other elements are contained within AuRM4 and AuRM5.

### Form

Standard dimension: Disks of 25 mm diameter x 6 mm thickness.

Mass  $\approx$  41 g

### Quantity

60 units (excluding those judged defective or used for homogeneity testing)

### Manufacturing and Analytical Testing

See the Request for Quotation and Questionnaire (attached)

## Quotation

Good Delivery Refiners interested in being contracted to produce AuRM6 should submit their quotation and replies to the Request for Quotation and Questionnaire to the LBMA Chief Technical Officer, by email at [gdl@lbma.org.uk](mailto:gdl@lbma.org.uk) by Friday 28 November 2025

29<sup>th</sup> September 2025

## Request for Quotation and Questionnaire

Objective: The objective of this project is to produce a gold reference material (RM) with set amounts of impurity elements homogeneously distributed within the material. The final product will be approximately 60 individual sub-samples cut from the homogenized cast block. The material will be tested for element homogeneity (15 pieces will be used). Shavings from each of the 15 selected pieces will be sent out to approximately 10 laboratories for analysis. The sub-samples will have a mass of  $\approx 41$  g and have the following approximate disk dimensions: diameter 25 mm x thickness 6 mm. Note: a disk shape is preferred for AuRM6.

The responses to the questions in this document will enable the Referees' Group and the LBMA to select the manufacturer for this project. The general evaluation weighting for each section is given below.

Experience 20%

- 1) What experience does your group have in manufacturing the type of reference material the LBMA Reference Material Project requires (see attached Table 1). Please list recent accomplishments with dates. What form was the end product (disk, rod, bar, granules)?

Number and qualifications of staff who will be working on this project? How many years of experience do these people have?

Indicate the elements that you have experience in adding to gold.

Equipment 20%

- 2) We require  $\approx 4.5$  kg of gold RM to be cast. It is recognized that the final amount of reference material produced will be reduced because of losses in the casting, milling, and cutting stages. Do you have the equipment to do this?

- 3) Please specify casting equipment (include size, shape and material of the mould), rolling device, milling device, polishing device (paper type used), annealing equipment, and cutting equipment (specify cutter type and thickness) that you have available to use. The inclusion of pictures of the equipment would also be very helpful.
- 4) What is the maximum amount that you can safely cast and handle in a single piece?

Time for Manufacturing and Logistics 20%

- 5) How long will it take to produce the reference material and complete the element homogeneity testing (steps “a” to “h” in Question #7)? From receipt of order to final product and given your company’s workload how many weeks would this project take?
- 6) Describe the procedures involved in shipping gold reference materials from your facility to the LBMA or another laboratory outside your country. How often has this occurred over the past 2 years?

Costing for Proposed Manufacturing/Testing Methodology 20%

- 7) Give a cost estimate (in \$US) for the work and shipping (material and labour excluding the cost of precious metal) for the production of the AuRM6 reference material. Please provide the costing with a breakdown if possible. The project would require the following steps in the prescribed order (see table below):

<b>Manufacturing Steps</b>	<b>Cost (\$US)</b>
Initial Casting <ol style="list-style-type: none"> <li>a. Melting the metal matrix with the addition of elements at the concentration levels by induction melting and cold casting (preferably in vacuum). See attached tables for elements and concentrations.</li> </ol>	

<p>b. Determine whether elements are near target concentrations by sampling the cast block at two opposite ends determining element concentrations by ICP-AES, ICP-MS, or other equivalent method. The samples must also be cleaned to avoid surface contamination.</p>	
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<p>Bar Preparation</p> <ul style="list-style-type: none"> <li>c. Anneal the cast bars at 800°C, under argon or nitrogen for a minimum of 2 hours. This is to homogenize the elements in the metal matrix and to remove thermal stress from casting.</li> <li>d. Mill the cast block for the following reasons: to remove uneven surfaces, to remove the outer layer of metal, and to make the large faces parallel for rolling.</li> <li>e. Roll the milled block to 6 mm thickness</li> <li>f. Re-annealing at 400°C, under argon or nitrogen for a minimum of 2 hours to minimize grain size</li> </ul>	
<p>Standard Preparation</p> <ul style="list-style-type: none"> <li>g. Cut into sub-sample pieces (41 g) and label. Dimensions to be decided by Steering Committee. An identifying label “LBMA AuRM6” must be engraved onto the side of each piece.</li> </ul>	
<p>Homogeneity Test</p> <ul style="list-style-type: none"> <li>h. Conduct the homogeneity test for element homogeneity by spark AES or spark ablation ICP-AES as described in Appendix 1. The data from the homogeneity analysis must be sent via the LBMA to the Steering Committee, which will decide if the material can be considered as sufficiently homogeneous.</li> </ul>	
<p>Preparation and Distribution of Shavings for Analysis</p>	

<ul style="list-style-type: none"> <li>i. If the materials are determined to be homogeneous then shavings must be taken from different pieces must be combined for analysis. The shavings must be cleaned in 50% hydrochloric acid for 60 minutes, washed several times, and then dried (under clean hood conditions).</li> <li>j. Divide, weigh, package, and send shavings in 11 separate containers each containing 25 g to the LBMA for subsequent distribution to 10 assayers worldwide (to be nominated by the Steering Committee). These should be sent to the LBMA which will purchase them at the current gold price.</li> <li>k. The individual pieces must be weighed, labelled, packaged, and shipped to the LBMA. The price will be calculated as the total of the ruling gold price x the fine gold weight of the RMs and the quoted manufacturing cost (including the cost of shipping the RMs to the LBMA's designated vault in London).</li> </ul>	
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8) Do you have an alternative approach to making the reference materials that differs from the one outlined above? The end product must have very small grain sizes that can be used with Spark - Atomic Emission Spectrometry. Please describe the different steps and provide a quotation for that approach.

Reference Material Storage

10%

- 9) Will the manufacturer consider maintaining possession of the gold used to make AuRM6 and have the LBMA purchase the gold as sales occur.

Communication

10%

- 10) The manufacturer must communicate effectively with the Project Lead or delegate throughout the process. What means would be most effective for you to communicate? We would expect bi-monthly updates on the manufacturing process at a minimum.
- 11) Please include any other relevant factors that this document does not address.

**From experience from previous reference materials, we offer the following points for consideration when manufacturing the reference material:**

- To achieve the specified concentration levels and reduce the risk of element volatilization, vacuum melting should be used.
  - Vacuum melting systems have physical constraints due to limited chamber size, which restricts the allowable shape and size of the casting molds.
  - Given the mold height limits, using cylindrical or rectangular molds results in castings with a thick cross-section. Recommend water cooled copper molds if possible.
  - Such thick castings are prone to segregation due to the uneven cooling between the inner and outer regions—even when cooled promptly.
- Continuous casting is acceptable provided the desired elements are retained at the target concentrations and homogeneously distributed.
- Rolling out such castings to the desired thickness introduces risks of cracking and internal defects.
- To form the final product, outer surface machining and cutoff processing are required, causing significant material loss.
- If a batch is rejected, the machining scrap cannot be reused as feedstock nor as evaluation samples for subsequent lots.
- Additional length is required for work holding during machining, further reducing yield.

## Appendix 1

### Homogeneity Testing Procedure

- a) Take 15 pieces from the total number of cut pieces in a systematic manner as shown in Diagram 2 below and label (on the side edges). This is necessary for the Analysis of Variance Test (ANOVA) using a randomized block design for determining homogeneity.
- b) Prepare both top and bottom surfaces of each selected piece for Spark – Atomic Emission Spectrometry solid sample analysis.
- c) There are 30 test sites, considering the top and bottom surfaces of each of the 15 selected pieces. Analyse each of these test sites in random order (provided by Steering Committee).
- d) Re-surface each piece (top and bottom) and re-analyse in a different random order
- e) Repeat d) for a total of 90 analyses for each element.
- f) Send the data electronically to the Steering Committee for evaluation.
- g) It may be necessary to verify the homogeneity test by another laboratory. This will be decided by the Referees Group and the LBMA.
- h) Verification of element homogeneity is critical to the project and analysis of variance to be calculated by Steering Committee. If the material is not homogeneous for one or more elements, then the material may have to re-annealed and/or re-cast and re-tested for element homogeneity.

Diagram 2, Diagram of a cast reference material cut into pieces (numbered) after rolling and annealing.

Nominal number of pieces – will depend on amount cast, weight after milling, dimensions of the cast block, rolled thickness, and final dimensions of the pieces.

1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21
22	23	24
25	26	27
28	29	30

31	32	33
34	35	36
37	38	39
40	41	42
43	44	45
46	47	48
49	50	51
52	53	54
55	56	57
58	59	60
61	62	63
64	65	66
67	68	69
70	71	72
73	74	75
76	77	78
79	80	81



Gray filled pieces – taken for homogeneity testing