GOLD BARS WORLDWIDE
www.goldbarsworldwide.com
TECHNICAL REPORT
Supplement 2014

HOW CAST GOLD BARS ARE MANUFACTURED

BACKGROUND INFORMATION

Cast gold bars are normally produced directly from gold that has been melted.

However, the way in which melted gold is used in their manufacture can vary.

This supplement describes in outline some typical methods for manufacturing three types of cast bars:

(1) **Large** cast bars with approximate weights.
(2) **Small** cast bars (1000 g or less) with specific weights.
(3) **Long** flat cast bars, notably for the manufacture of minted bars.

It can be noted that most refiners apply their own variations. In addition, many now automate some or all of the manufacturing process, some through computer-controlled robots.

Cast gold bars can range in weight from 400 oz to 1/2 oz.

Heraeus
Germany

LARGE CAST BARS

As large cast bars (e.g. London Good Delivery '400 oz' and COMEX Division Good Delivery '100 oz') are usually manufactured to an approximate weight, the method of manufacture normally varies from that adopted for small cast bars with a specific weight (e.g. exactly 1000 g).

Refined gold at the required purity for casting (i.e. pouring) into large bars is usually taken directly in the form produced by the refining method (e.g. in melted form following pyrometallurgical chlorination, or as cathode deposits following electrolysis).

- The gold is melted in bulk in a large **'holding' crucible** which may contain as little as 450 oz or as much as 30,000 oz. Induction furnaces are normally used to melt the gold.

- By tilting the "holding" crucible, a relatively small amount of gold, between 450 oz and 2,000 oz, is then poured into a pre-heated **'transfer' crucible**.

Pouring melted gold into a transfer crucible.

The Perth Mint
Australia

At this stage, dip samples (containing about 1/2 oz gold) for assaying purposes may be taken, using a steel ladle or a glass vacuum tube.

- Using a gantry if necessary, melted gold in the 'transfer' crucible is then poured through a soft gas flame into a pre-heated and dressed **bar mould** (generally cast-iron) of the required size (e.g. 400 oz, 100 oz).

The mould, during pouring, is positioned on a **balance**. When the balance records the required weight of gold, the pouring ceases.

Pouring melted gold into a 400 oz bar mould.

Metalor
Switzerland

- Within seconds following completion of the pouring, the mould is then tilted so that the bar drops into a tank of water for immediate cooling. This procedure is known as **'quenching'**. Alternatively, the bar is allowed to cool gradually in the mould through natural exposure to the air.

- The bar is then placed on a table for **cleaning** with a soft cloth to remove any stains, and **weighed.**

- Approved bars are then **marked**, where required, with the refiner's official stamp/certification mark, a serial number, the precisely assayed purity of the batch of gold from which the bar was made, and sometimes the weight.

Markings may be applied manually, working dies for each mark or group of marks being hammered onto each bar individually. A template (i.e. a stencil indicating the areas for marking) is normally used. Alternatively, bars may be inserted into a press which applies some or all of the markings simultaneously.

It can be noted that, in the case of London Good Delivery '400 oz' bars, the weight is not usually marked on the bar.

Assaying procedures during manufacture vary among refiners. Assays are normally taken while the gold is in the 'holding' crucible and/or the 'transfer' crucible.

Induction Tunnel Systems

In April 2013, the London Bullion Market Association (LBMA) approved the use of induction tunnel systems in the manufacture of London Good Delivery 400 oz bars.

The system involves the melting of gold grains in a flameless tunnel that derives its heat from induction.

400 oz bars cooling in their bar moulds.

The Perth Mint
Australia

Newly-made 400 oz bars.

Prioksky
Russia

An automated machine that uses Flameless Tunnel® technology to produce up to 150 x 400 oz bars per 8-hour shift.

IKOI
Machine Manufacturer
Italy

Assaying laboratory.

Valcambi
Switzerland

SMALL CAST BARS

To produce small cast bars (1000 g or less) with a specific weight, refined gold, which has been assayed at the required purity, is normally converted into two basic forms: **granules** and/or **small cut pieces** (including thin strips if needed).

- Gold in one or both of these forms is placed on the **balance** and weighed, the amount adjusted until precisely the required weight of gold is recorded.
- When placed on the balance, the gold is contained in either a **crucible** or a **bar mould**, dependent on the method of manufacture,

Usually, the amount of gold weighs slightly more than the required bar weight. This is done to compensate for any minor anticipated gold loss in the manufacturing process (e.g. vaporization, remains in the crucible), as well as to ensure that the final bar weight is not less than the specified weight to be marked on the bar.

Although most small cast bars are manufactured to a specific weight, it can be noted that in some countries they are also manufactured with approximate or variable weights.

Traditional method: Pouring melted gold into a bar mould
This method is still used by many manufacturers.

- The gold is placed in a **crucible** that is appropriate in size to the volume of gold.
- The crucible is then put into an induction or resistance element **furnace** for melting at a controlled temperature of around 1200°C.

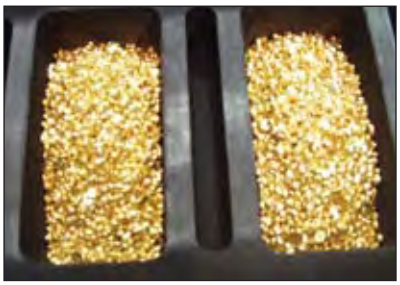
If the temperature is too high, gold losses may occur; if too low, premature surface solidification may result in a poor surface appearance. The melting time depends on the furnace used. An **induction** furnace, which relies on an electro-magnetic frequency to induce heat, melts the gold rapidly within a few minutes. A **resistance element** furnace, which relies on heat being radiated from an element such as a rod, melts the gold over a longer period.

It can be noted that, although no longer widely practised, a furnace may also be heated, or the gold melted directly, through the use of gas, oil or charcoal.

Care is taken to avoid contamination of the gold. For example, part of the furnace lining or rust on the tongs transferring the crucible could fall into the crucible.

- The melted gold is then poured rapidly, without spilling, into the appropriate **bar mould** (generally, cast-iron) which has been pre-heated and dressed with carbon smoke or graphite.

Where pre-heating of the mould is excessive, causing the dressing to evaporate or burn off, small unsightly cavities may subsequently appear on the base surface of the bar.



Bar moulds with a kilo of gold granules prior to melting.

The Perth Mint
Australia

Pushing a group of bar moulds into an induction furnace.

The Perth Mint
Australia

Newly-made kilobars.

Johnson Matthey
USA

While pouring takes place, a soft gas flame (around 800 – 900°C) is normally directed into the mould so that the top surface is the last part of the bar to solidify. This ensures not only that the top surface is smooth in appearance but also that any residual contaminants are burned off during the pouring process.

- As also occurs in the manufacture of many large bars, the mould is then tilted so that the bar drops into a tank of water for immediate **cooling**.
- The bar is removed from the tank, placed on a table, **cleaned** and **weighed**.
- If the bar weighs slightly more than the required bar weight, excess gold is normally removed through **filing**; if slightly less, the bar is rejected and melted down.

Tanaka (Japan) is generally acknowledged as the first accredited refiner to automate the manufacture of cast bars.

Modern method: Melting gold in bar moulds

This method enables many small cast bars to be manufactured at the same time. Most major manufacturers have automated the procedures.

- The gold is placed in a **bar mould** of the required size.
- Several moulds, grouped together, are then fed into an **induction furnace** for melting at a controlled temperature of around 1200°C.
- When the gold has melted, the moulds are then pushed gradually through a **cooling tunnel**.
- When the moulds exit the tunnel, the bars are removed, **cleaned** and **weighed**.

Manufacturing small cast bars in bulk.

Metalor
Switzerland

As occurs in the traditional method, any excess gold is removed through filing, normally using a linishing machine. Excess gold is usually taken from one of the corners of the bar.

Markings

Approved bars are **marked**, as required, with the designated weight, purity, official stamp/certification mark and serial number.

A hydraulic press normally applies some or all of the marks simultaneously. Alternatively, marks may be applied manually, working dies for each mark or group of marks being hammered onto each bar individually.

If a serial number is required, the number is normally applied by inserting each bar into a machine that stamps it with a sequential number.

Applying official stamps and other markings to small cast bars.

The Perth Mint
Australia

Assaying

Assaying procedures before and after manufacture can vary among refiners. Normally gold used in the original form of granules and cut pieces has been assayed precisely before bar manufacture takes place. Randomly selected bars may also be assayed.

LONG FLAT CAST BARS

Long flat cast bars, notably for the manufacture of minted bars, can be produced in two ways, either from cast iron moulds in a pack or from a continuous casting machine.

Traditional: Cast iron moulds in a pack
The cast iron block is recessed to provide a mould which gives the required width, thickness and length of the cast bar stock.

A number of moulds are then clamped together vertically so that the flat base of one mould forms the side of the neighbouring mould. The melted gold is then poured into the open end of each mould in turn. When the gold has solidified, the moulds are unclamped and the bars removed.

Modern: Continuous casting machine
The more modern method is to produce bar stock of the required width and thickness on a continuous basis using a continuous casting machine.

This machine consists of a graphite block (the die), through which an orifice is machined to the width and thickness of the required bar stock. This orifice is attached to the aperture of a graphite crucible in which the gold at a specified purity is melted, normally by induction heating or resistance element heating. The die is also clamped between two cooling blocks through which water is passed.

A starter bar, machined to fit the channel in the die, is inserted into the orifice as far as the crucible, while the other end is clamped into the withdrawal mechanism. When the melted gold has reached the required casting temperature, the process is started by pulling the starter bar out of the die in a series of short pulling movements.

As the bar is drawn through the die, the gold gradually solidifies, emerging as a cast bar which is then cut to the required length (excluding the starter which is removed). Gold in the form of granules or cut pieces of large bars is added to the crucible at intervals to maintain continuous production.

Source: Based on information kindly provided by **The Perth Mint (Australia).**

A continuous casting machine producing flat cast bars from melted gold.

After rolling, they can be used to produce minted bars.

Rand Refinery
South Africa

A box of small cast bars ready for shipment.

PAMP
Switzerland

400 oz bars for the international market.

Rand Refinery
South Africa

Cast 500 g bars.

Heraeus
Germany

Refer to disclaimer on website: www.goldbarsworldwide.com