

Gold Losses and Control in Gold Jewellery Manufacture

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Introduction

The manufacture of carat gold jewellery inevitably gives rise to scrap materials, residues, gold-containing wastes and, what is somewhat ambiguously called, 'gold losses'. Losses may include scrap and residues, which are overlooked or are considered too low-grade to treat, but also comprise the often too-readily accepted working losses and pilferage and theft. Losses also include gold that is "given away" to the customer when product is sold at slightly above the minimum weight or assay specification.

Any loss of gold will have an adverse impact on costs and, hence, on the profitability of a business. Consequently, there should be a strong incentive to reduce and control losses by sensible, cost-effective and efficient waste collection and recovery procedures, by the use of sound, controlled production processes and, above all, by efficient metal control procedures within the workplace.

The aim of this paper is to define losses, to try and identify those areas of the manufacturer's activities which contribute towards losses and to emphasise the importance of controlling these activities in ways which both minimise the losses and allow their measurement. In this way "known" losses can be targeted and factored into the economics of the business. Tight control in these areas also enables the manufacturer to recognise when "unexpected" or "unknown" losses occur. It is important to make this distinction. *Known losses* are understood, predictable and largely controllable; they are an element of the manufacturing cost of jewellery and are built into the price. *Unknown losses* are unpredictable and uncontrollable; they need to be the subject of immediate investigation and can have a major adverse effect on the business.

This paper will deal chiefly with losses and their occurrence in a mass production factory environment, but the advice and comments apply equally well to the small goldsmith's workshop. In such traditional workshops, all too often, gold losses tend to be higher due to the manual nature of the work and the generally poorer housekeeping and control.

Definition of Gold Losses

At any instant in time, the gold in a workplace (factory, workshop, department, etc.) comprises gold as raw material, work in progress, finished stock, scrap for recycling and low-grade or contaminated scrap and waste for recovery on or off site.

The quantity of gold in a factory or workshop is normally measured periodically at an **inventory**. An inventory is a critical part of the control of gold in a workplace. There should be at least one major inventory every year when the workplace closes, all equipment is stripped down and cleaned and the drains, exhaust systems, walls, roof, floors, working clothes, etc. are thoroughly washed and cleaned to recover any gold. All metal-containing items should be weighed and, if appropriate, sampled and analysed.

Unfortunately, it may be some time after such a major inventory that the figure for gold content becomes available but that figure then becomes the basis of future calculations. Hence, at any instant in time the theoretical gold content of the workplace is:

$$\text{GOLD AT LAST INVENTORY} + \text{GOLD TAKEN IN} - \text{GOLD SHIPPED OUT}$$

By comparing the actual value with the theoretical value, the gold losses are determined.

Depending on the size of the workshop or factory and the degree of

control being exercised, inventories will be carried out in some form or another on quarterly, monthly, weekly and even a daily basis. It is common practice to conduct some form of daily check whereby individual jobs or groups of jobs are monitored sufficiently closely to allow any significant unknown loss to be recognised early enough to institute immediate remedial action. Simple weighing operations tend to be the basis for this control but analysis, inspection and counting can also play a part.

Reporting of percentage gold losses can be a contentious issue. On an annual basis, one would normally report losses as a percentage of shipments. This means that well-managed, high-yield operations that generate low levels of scrap and operate good housekeeping will have lower levels of loss than less efficient operations where re-work is a regular feature and where there is poor control and collection of dusts, filings, etc. Overall, loss levels of less than 1% should be attainable for most workplaces that have a high standard of housekeeping. However, it is not unknown to hear of levels of 5-10%, or even greater, being quoted! Surely, a frightening prospect for any business. Every gram of gold lost is profit lost. Typical levels of losses will be discussed later.

It should be obvious that the determination of gold losses requires a detailed knowledge of the total weight of gold coming into the factory, be it gold bars, carat gold alloy or scrap bought in, and the total weight of gold jewellery (or other products) shipped to customers plus any scrap or waste sold or sent out for refining.

For internal purposes within a workplace, a knowledge of the typical losses associated with individual operations (e.g. melting and casting,

pickling, wire drawing, polishing, assembly and soldering, etc) helps considerably in maintaining tight control and focusing on where effort is best directed to reduce losses.

Procurement of Raw Materials

One might expect that this area of the business would be relatively straightforward as far as losses are concerned, but this is not the case. Procuring gold might involve the purchase of:

- i) fine gold bars (tola bars, kilo bars, good delivery bars),
- ii) fine gold grain,
- iii) scrap gold alloy for remelting,
- iv) scrap or concentrate for refining prior to use,
- v) semi-finished carat gold alloy (casting grain, sheet, strip, wire, tube etc) for making directly into finished product.

Every purchase is a potential source of gold loss and it is essential to adhere to strict guidelines to ensure no loss is incurred.

Firstly, all raw materials should be purchased to an **agreed specification**. This subject has been discussed more fully elsewhere (1) but essentially the specification should comprise form of material (size, shape etc), purity requirements (overall impurity levels, any specific impurity restrictions), identification (reference, weight, packaging etc.) and certification.

For gold bars, grain and semi-finished products, there should be 100% checking of the weight, taking care to ensure that all material, particularly grain, is completely dry, heating in an oven at 200-300°C if necessary prior to weighing. Periodic sampling and analysis should be carried out to check conformance to specification. The degree to which materials should be tested depends particularly on the supplier. A well-established, highly-reputable supplier would be checked rather less-frequently than a new, less well-known one. There are known instances where ‘good delivery’ gold bars of 99.5% minimum purity have assayed at below 99.5% gold!

For scrap material and refinables, there must be 100% testing by melting, sampling and analysis, and weighing of the cast product. Even scrap gold jewellery which bears a “hallmark”, as required in certain countries such as Britain, should be treated in this way as there are several reasons why it could contain less gold than expected. For example, the use of lower caratage or base metal solder, incorporation of a

small steel spring in the bolt ring on chains, the effects of repairs etc. These observations also apply to internally – produced scrap as it is all too easy to mix different qualities – or caratages – of scrap unintentionally.

Having established the gold content of purchased material, it is important to be clear about the quantity which is “booked in” (or ‘booked out’ in the case of a supplier) to avoid any later confusion. For material which is melted and analysed, it is a straightforward case of the weight of cast metal multiplied by the gold assay. However, if purchasing, for example, 99.99% gold kilo bars, then a reputable supplier may well supply bars which are up to 50mg overweight and analyse at 99.992% gold to ensure meeting the minimum requirements. Nominally, the customer has received 1000g of fine gold. The specification calls for a minimum of 1000g x 99.99%, i.e. 999.9g of fine gold. In the above example, the customer has supplied 1000.05g at a gold content of 99.992%, i.e. 999.97g of fine gold. The customer, therefore, has the possibility of booking in 999.9, 999.97 or 1000g of fine gold. It needs to be clearly understood that, although small, there are real differences and a consistent approach needs to be taken. For a major manufacturer of small bars, there can be significant loss of gold involved over many thousands of bars. The author is aware of one example where the annual loss was estimated at over 2kg gold for this reason.

Another example, which has, perhaps, more relevance and impact, is the purchase of carat gold in the form of semi-finished product. In this case, the alloy manufacturer will have to make up the gold alloy, say 18ct gold, to a level of typically 75.1% to ensure meeting the minimum requirements. His products are likely to assay in the range 75.0 to 75.2% with the average close to 75.1%. It is common practice for a supplier to negotiate a price with his customer based on the 75.1% gold he uses in the initial alloy make-up, while guaranteeing to his customer that the assay will always exceed 75.0%. The customer once more has a choice of booking into stock three different gold levels. Thus, for a quantity of 10kg of 18ct gold sheet with an average assay of 75.15% gold, he can book in:



Figure 1 - Collection of dusts from workbenches should be part of a daily routine.

- i) the specification minimum requirement - $10,000\text{g} \times 75.0\%$ i.e. 7,500g
- ii) the quantity the customer is paying for - $10,000\text{g} \times 75.1\%$ i.e. 7,510g;
- iii) the actual quantity the customer receives - $10,000\text{g} \times 75.15\%$ i.e. 7,515g

Again, it is important that a consistent approach is taken.

Melting and Casting

All manufacturers who cast carat gold will realise that used investment, crucibles, moulds and casting dies and slags, fluxes and any other residues will contain traces of gold. However, recognising the fact, determining the quantity and recovering the metal are very different issues, especially as the metal tends to be present as discrete, unevenly-distributed particles.

The subject of recoveries from investment casting has been fully dealt with by Schneller (2), who categorised used investment into three classes. The first was described as casting dirt and consisted of investment from the inside of the casting machine and material scraped from the pouring cup of the flask prior to quenching. Secondly, he identified quench tank material, the investment 'mud' obtained from quenching cast flasks in water. The final type was wash tank material produced after castings had been cleaned with a high pressure water hose. Schneller's work particularly looked at the relationship between particle size of the crushed residual material and the gold content. He concluded that most of the gold is contained in the largest particle size fractions and that there are significant quantities of gold recoverable.

Used melting crucibles from investment, static or continuous casting can be a significant source of gold with metal being retained on inside surfaces or absorbed into the crucible walls. After every casting operation, a crucible should be inspected and scraped clean and, when finally discarded, it should be crushed and the particulate material treated for gold recovery. Close inspection of individual crushed crucibles may be rewarding with the possibility of individual particles being picked out with tweezers.

Any refining or recovery operations involving melting of alloy using fluxes, where slags are generated, need to be carefully monitored and the slags ideally crushed and treated for metal recovery. Gold alloy particles can be trapped in slags that are too viscous, for example.

Moulds can be a source of gold recovery and should be inspected after use. Continuous casting machines, often using graphite dies, need continual cleaning to collect trapped metal residues which not only need to be recovered but can cause contamination of future alloy charges if left in-situ.

Casting of metal can give rise to splashing, especially if hand pouring into a relatively small mould opening or centrifugally casting. Splashing can also result from melting damp metal, for example, casting grain containing moisture or trapped water. It is also a wise precaution to allow for the possibility of crucibles fracturing during melting or casting. The life of a crucible is not easily predictable and many casters will have experienced a "run-out" when the crucible fails and deposits its contents over the bottom of a furnace or onto the workplace floor. Some form of collection tray can save a lot of effort and metal loss.

One would not expect a significant evaporation of gold during melting, unlike the very visible losses of zinc and cadmium in some gold alloys, but there is no doubt that some evaporation does occur and, in a well-

managed operation where extraction systems are linked to each melting station, there will be metal condensing on the inside of extraction pipes. Periodic cleaning and testing is a necessary part of good metal control. If, for any reason, fine particulate or powdered material is being melted, there is a risk of physical ejection of metal.



Figure 2 - Retain and wash workers clothes and cleaning cloths.

It is usual practice to quench statically cast ingots in a water tank, while production of grain involves pouring molten metal into water. Care has to be taken when disposing of the water: only after settlement and particle recovery should the water be discharged to waste.

Ingots or castings are often “cleaned” before being subjected to further operations, for example, by the use of high pressure water hoses on castings, and the milling, turning or shaping of cast ingots to improve the surface quality and assist in subsequent working. These operations should all take place within the confines of a Melts Department and be regarded as part of Melting and Casting for the purposes of metal control. Recovery of turnings, millings, etc needs to be controlled and the scrap carefully segregated for further use. Some mixing of scrap is probably inevitable and contamination with cutter material (such as abrasive) is a possibility. Therefore, re-use of such scrap without refining, (or at least melting and analysis), is of questionable value.



Figure 3 - The use of hoods, with suction fans and filters around polishing and buffing wheels is of great benefit.

If at all possible, the area of a workplace or factory dealing with melting and casting should be physically separated from the rest of the operations. There are two major reasons for this. Firstly, melting generates a lot of heat with associated air movement and dust circulation. This will make subsequent production of high quality mill product in this environment very difficult. Secondly, control of metal is aided if metal is transferred into and out of a Melts Department without additional operations. This is especially the case if crucibles tend to be used for many castings. Regular cleaning of the area also becomes a lot more manageable if it is a smaller self-contained location rather than the whole workshop or factory.

All cast metal should, ideally, be sampled and assayed before further processing. It is important to be aware of low or high assaying alloy as early as possible in a sequence of manufacturing operations so as to be able to make the correct decision for its disposition before putting further and, possibly, wasted work into the alloy. Thus, if an 18ct gold ingot or casting tree is being produced, the alloy is likely to be made up at 75.1% gold content and an acceptable spread of analysis in the product might be 75.03 to 75.15%. Assay values below this range run the risk of the customer (or marking authority if an external agency has to test conformance to 18ct standards) rejecting the alloy for failing to meet the minimum requirements, while assay values above the range may mean giving away a significant amount of gold. In the latter case, before rejecting the alloy and re-making by adding a small amount of base metal to reduce the gold content, the costs of this exercise need to be compared with the cost of giving away the excess gold. The reasons for the divergence of the assay from the nominal value also need to be investigated to try and avoid future occurrences. These reasons might include:

- i) Use of scrap material which was rich or deficient in gold
- ii) Weighing-out errors
- iii) Loss of base metal during melting due to volatilisation
- iv) Segregation in the alloy (especially true of nickel-

- containing alloys)
- v) Poor (dirty) sample for analysis
- vi) Inaccurate analysis

Metal Working Processes

The basic working procedures - sheet rolling, rod rolling, wire drawing, tube drawing, cupping, blanking, stamping, chain making, etc. - can all give rise to waste or scrap product and, hence, potential metal losses. It is important for the business to try and recognise where this can occur so as to minimise the extent of waste generation and to collect it when it does occur.

With sheet rolling, edge cracking is a common feature and small pieces of metal can become detached and lodge in the rolling mill. Blisters, surface inclusions and pores can result in the formation of laps and subsequently flakes, which readily become detached. “Alligatoring” (i.e. splitting down the centre of an ingot during rolling) can lead to small metal particles falling out. Rod rolling will often give rise to fins forming and breaking away on subsequent passes. Wire and tube drawing are usually preceded by a pointing operation, often by filing in the case of wire. Points frequently break off during drawing while wire breaks can lead to lengths of wire being discarded. Lubricants, particularly in wire drawing, accumulate gold dust and should be regularly cleaned or changed. Blanking and stamping can give flashing and discrete pieces of waste; chain-making generates slivers of wire, especially during setting up procedures. These are just a few examples of the ways in which routine working operations can be a source of small but significant pieces of metal which are likely to become detached from the work and lost. They can be readily collected or, if becoming lodged in the equipment, recovered periodically at workplace shutdowns (inventories). Collecting all this waste is extremely important in the context of reducing metal losses and of metal control.

In association with such metal working operations is a variety of heat-treatment processes. These also need to be monitored for recoveries. Annealing, especially where many small pieces or loose-lying components pass through on a belt,

can result in individual items becoming trapped or lodged in the belt mechanism or in the internal parts of a furnace. Periodic dismantling of the equipment can be rewarding and is essential prior to disposal of scrap furnaces. Continuous wire or strip annealing furnaces often require threading up and the initial and final parts of a continuous coil of material may be discarded. For some operations, quench tanks are used to achieve high cooling rates after annealing or as part of a special heat treatment. There may be metal residues accumulating in the water.

Assembly, Cleaning and Finishing Operations

Cutting, finishing, filing, shaping and soldering at the workbench and grinding and polishing on buffing wheels all give rise to particulate gold alloy, filings or dust. These can drop onto a workbench or floor or may be fine enough to become airborne and finally settle on work surfaces, ledges, walls, floors and ceilings and workers' clothes, skin and hair. The dust may even be inhaled. A large jewellery factory in India has calculated that they lose up to 3 kg of gold per year through workers breathing in gold dusts whilst working. This, however, is very small compared to the other sources of losses.

Machine polishing and cleaning, such as tumbling, ultrasonic cleaning, wet scratch brushing etc, will generate particles in the fluid medium with the consequent risk of disposal of either down a drain or in spent liquid waste. Used gold-containing solutions from electroplating cells, from electroforming or from acid stripping operations have to be treated to recover any gold. Joining or soldering operations can produce small pieces of scrap and residues, especially when using solder powders and when hand soldering using individual pieces of solder. Finally, rags, tissues and cloths are frequently used to wipe down work areas. These will contain some gold particles.

Collection of dust from workbenches should be part of a daily routine, as should sweeping the surrounding floor areas. It helps if the floors are designed for easy cleaning. Gold particles can become engrained in wood and 'dirt' floors and, of

course, in carpets and rugs. It has been practice in some jewellers to take up wooden floors every five to ten years for incineration and gold recovery, the recovered gold more than paying for a new floor. Airborne dust has to be recovered by regular washing of floors, walls and ceilings and by routine washing of workers clothes. Many manufacturers insist on their workforce changing into special overalls and footwear on entering the workplace and these are retained in the factory for periodic cleaning.

Of course, rather than trying to recover all the gold from the places where it settles, it is better to try and capture it at source. The use of hoods, fitted with suction fans and filters, around workbenches and particularly around motorised grinding, polishing and buffing wheels is of great benefit. Such equipment is readily available and cost-effective.

On the cleaning side, traps or settling tanks should be fitted to all sinks and drains and the residues collected regularly. Wash water from walls, ceilings, benches etc. should also be collected and held in settling tanks. Gold-containing solutions all have to be treated for recoveries while cleaning rags, brushes, cloths and grinding papers are all sources of gold (and potentially of losses).

The treatment of these materials has been discussed in *Gold Technology*, issue no 21, April 1997 (3).

These points have a lot of relevance to the **typical traditional workshop** as found in many countries, particularly in hot climates, where there are open windows and doorways and ceiling fans. Many workshops are not designed or maintained for efficient collection of filings, dusts, particles and wastes in sinks and drains. Floor surfaces are often poor and damaged, walls have ledges, pipes and trailing wires, so dusts and filings get entrapped and difficult to recover. Open windows allow air-borne dusts to escape, often encouraged by ceiling fans, whilst workers walk dusts and filings that are on the floor out into corridors and into the streets on the bottom of their bare feet, along with those in the air on their clothes and in their hair. Polishing and buffing wheels do not have hoods and extraction with filters fitted, so polishing dusts become air-borne and

settle everywhere. This is a major source of losses in many workshops. Acids, cleaning solutions and wash waters are tipped into the sink or drains and washed away.

Simple measures to minimise these losses can be very cost-effective. Put in a good ceramic tiled floor and walls to facilitate easy cleaning, put in extraction hoods with filters and regularly clean and sweep. Consider installing air conditioning with filters fitted so the windows do not have to be wide open. Insist workers change their clothing and shower before going home. The costs of such measures will pay for themselves many times over.

Material Testing

During, and at the completion of, the manufacturing processes it is normal practice in many factories to carry out tests to ensure conformance with product specification requirements, particularly assaying to check gold content. This testing might comprise gold assaying, full chemical analysis, mechanical property measurements or metallographic testing. Most testing is destructive and is carried out on a sample of alloy or product. The resulting scrap might be in the form of a fire assay cornet, a solution in the case of chemical analysis, pieces of material after mechanical testing, residues after grinding and polishing metallographic samples and residual scrap from the products after removal of a sample. All has to be collected and accounted for before allocating to the appropriate recovery procedure. This is an area which can get overlooked and frequently attracts less attention and security than the direct manufacturing departments.

Shipping of Finished Jewellery and Materials

When discussing the procurement of gold onto a manufacturing site, it was emphasised that the amount of gold recorded as received could be either the amount called for in the purchase specification, the quantity paid for or the amount actually received. These may all be slightly different. A similar situation applies to shipments. It may not be easy to assay every item shipped (some may contain components from several batches of metal) but it is important to avoid the possibility of shipping more gold than the customer is paying for and to take a consistent approach to recording the weight of gold shipped. Overcarated jewellery involves 'give away' losses for which payment is not received. Some 'give away' loss is inevitable if the producer is trying to ensure all jewellery meets the minimum requirements of caratage.

The logical approach is to record the composition of each shipment at its make-up level, recognising that, in reality, there will be a spread around the nominal figure. Difficulties start to arise when significant quantities of scrap are recycled and the composition is assumed to be the nominal level when it is actually slightly different. This is one reason for restricting the amount of scrap used to produce ingots or castings. Ideally, all recycled scrap should be premelted and analysed to ensure correct make-up. Another difficulty is where lower carat solders are used, so that it is almost impossible to determine the true gold content of a piece of jewellery without extensive assaying.

In addition to the shipment of product to customers, there are various categories of refinable material which the manufacturing jeweller may choose to send off-site to a refiner for recovery of gold. These would comprise dirty or mixed scrap for refining directly, dried sludges and refractory wastes which need to be smelted and refined and finally burnables such as rags, papers, clothes and boots, wood etc which requires incineration followed by smelting and refining. In shipping this material, two principles should be followed. Firstly, as much concentration of the waste and scrap as possible should be conducted on site as transport costs and refining costs are directly related to the weight of the shipment. Secondly, accurate sampling and analysis of the shipments is desirable so as to negotiate the metal returns from the refiner from a position of strength! It is not always possible to achieve these requirements and so rough estimates may be the best that can be done using a knowledge of the processes and of the in-house losses. For large shipments of refinables, it may be worthwhile 'witnessing' the initial treatment and sampling at the refiners and taking samples for independent analysis. However, this depends largely on the quantity of gold in the material as it is only sensible to pay for low grade material to be refined when the returns significantly exceed the costs. If a decision is taken to dispose of gold-containing waste on economic grounds, then that constitutes a known loss of gold which becomes part of the manufacturing costs.

As said before, the treatment of the wastes and residues has been covered in *Gold Technology*, No 21 (3).

Security

No discussion of losses in the gold jewellery manufacturing industry is complete without considering security. At one end of the spectrum is a factory with a secure perimeter and 24-hour camera surveillance to stop break-ins, and with metal-detecting arches and hand-held metal detectors to prevent unauthorised metal leaving the workplace. At the other end of the scale is the small four-or-five person workshop with only the most rudimentary of checks.

The subject is a highly contentious one, especially when it is perceived that the system may treat some people less onerously than others. However large or small the company, there needs to be a **clearly defined and understood security policy** in place and it needs to treat everyone from the managing director and most distinguished visitor down to the humblest of employees in exactly the same way. In other words the procedure must be fair and be seen to be fair. The procedure should cover the **routine or random searching of employees and visitors** leaving the premises, actions to be taken if and when any metal is detected and actions to be taken when a metal loss is reported within the workplace. There should also be clear guidelines over the metal allowed into the workplace (for example, jewellery worn by employees and visitors and product or raw material being delivered), and also on the dispatch of product or refinables. One area of concern has often been employees bringing personal jewellery items into the workplace for repair, an activity that has to be banned or very carefully controlled. Access to the site by security, delivery or collection vehicles should also be very clearly controlled with driver identification an important issue.

When metal is reported missing within a workplace, the Head of the Security Department, (or the individual responsible in the case of a small factory), should be the first person to be notified and should take immediate charge of the ensuing investigation. An investigation should pursue two routes, one a physical search, and the second a thorough check of the paperwork. These checks should be conducted by pairs of individuals under the direction of Security. Frequently, a loss is resolved as a transaction error occurring as material is issued to a department or returned after working. A variety of schemes is used in the smaller workshop to try and counter gold losses and two examples are given:

- i) Metal is issued to a team leader who may be in charge of six operators making hand-made jewellery. He is allowed a working loss of, say, 2% for his team's work and, if the finished

items show a loss above 2%, the team has to pay for the shortfall while the team can keep (and sell back at the end of the month) any net gain.

- ii) The much sought after job of vault keeper can be secured by payment of a financial bond. Any metal losses are paid for out of this bond.

Perhaps the most difficult part of the Security investigator is knowing when to call in the local police authorities, but most police would welcome being called in sooner rather than later (unless it becomes a frequent event!) and it is no bad thing for the police to be seen on the premises from time to time.

It must be emphasised that working in a gold jewellery factory or workshop that has a lax attitude to security presents the workforce with a strong temptation to steal. It is human nature! The golden rule is to minimise any such temptation. Keep a tight control and be seen to do it.

Metal Control

Generally speaking, metal is secured in a vault or safe at the end of a working day and issued for working purposes at the start of the following day. However, essential to the control of metal is that all the gold-containing raw materials, work in progress, finished items, scrap etc., whether in a vault or on the shop floor, must be

identifiable at all times. This identification should take the form of a stock card or a job card, uniquely numbered or bar coded, and including the weight of the item with a signature accompanying the last entry. In addition, at all times every item must be the responsibility of one person when being worked on, e.g. production supervisor, team leader, operator, laboratory head, etc. If these two principles are followed, then metal control becomes relatively straightforward. Typically, difficulties arise when metal is transferred from one person or department to another. Ideally, every transfer is accompanied by a weighing operation witnessed by the transferer and their recipient, the latter of whom signs the appropriate document to accept the metal. In some workshops or factories, all transfers take place via the vault and stockkeeper. This ensures good control but lengthens the time involved. Whether on the workshop floor or in the vault, the transfer takes place at an instant in time in the presence of both parties. Metal lying about on a workshop floor, having been released by one department and awaiting collection by a second department, is asking for trouble. There must be clear "ownership" of all metal at all times.

Metal control records need to be maintained regularly, certainly on a daily basis. The more sophisticated

systems will interface with a computer to give instant metal balances by area, product etc as long as, of course, accurate data are fed in as transactions occur. This is a discipline that frequently is not followed and so the value of the metal control system is very much lessened. Such a system working well can flag up unexpected losses (or gains) almost as they happen and so it becomes a major security tool. It is obviously much more likely that a metal loss will be resolved quickly if it is identified early. These systems do need to be regarded with some care. Keying errors will probably account for most of the initial metal balance discrepancies while the opportunities for collusion and fraud should not be over-looked. It does happen!

Levels of Losses in a Factory or Workshop

An often asked question is "What is an acceptable gold loss in a workshop or factory?" It is easy to answer this by saying 0%! A more difficult question to answer is "What is a typical gold loss?" as this depends on a number of factors:-

- The factory or workshop premises: How well designed they are for recovery of filings, dusts, liquid wastes, etc. How easy they are to clean. A modern, purpose built factory will be easier to clean and recover scraps and wastes than an old workshop in old premises not designed for jewellery manufacture.



Figure 4 - Good floor surfaces facilitate easy cleaning.

- The type of manufacture: Is it predominantly mass production processes by machine or manual goldsmithing? Is it mainly casting or stamping? Is polishing done by hand on buffing wheels or in tumblers or other machines? Is scrap recycled? Are scraps and wastes refined in-house or sent to an external refinery.
- The type of jewellery manufactured. Plain gold or gem set. Traditional Indian or modern western style. The caratage of the jewellery also has an influence.
- Is the equipment old or modern, is it well maintained and regularly cleaned?
- What is the management attitude to controlling losses? Are there good housekeeping practices? How well trained is the workforce?

In Europe, for example, most factories will have gold losses of well under 3%. A good factory will be closer to 1%. For example, one factory specialising in investment cast jewellery with machine polishing achieves slightly less than 1% loss.

In many Developing Market countries, loss figures tend to be much higher with some modern, apparently well run factories achieving only about 3%. Many factories with a blend of machines for stamping, casting and finishing and much manual assembly at the workbench have higher losses up to 10% and the traditional workshops can be often higher than this. Much of this is due to poor housekeeping practices in premises not designed for easy cleaning and collection of scraps and wastes. There are no traps fitted to sinks and drains, no extraction with filters fitted to

polishing wheels, work areas are not suitable and so on. Also, there is less control on caratage so that there is more 'give away' loss by overcarating.

Recently, a survey of gold losses in Indian jewellery manufacture has been undertaken. This shows that losses tend to be higher for the production of studded gold jewellery compared to plain gold jewellery. Chain producers have the lowest losses, as one might anticipate.

Calculate how much each 1% loss is costing your business! Manufacturers cannot afford to be complacent. The reduction of losses must be a continuous process with the aim to reduce losses to less than 1%. To do this, one needs to monitor each production stage and each workshop bench. Discover where the highest losses occur and take remedial action.

Concluding Remarks

In this presentation, the paper has attempted to discuss how the full range of activities in a manufacturing jewellery operation, from purchasing through production to selling and shipping, can all contribute to metal losses. The observations apply equally to the largest and smallest operations

The collection and recovery of wastes and residues is an important part of keeping losses under control, but the cost of recovery has to be set against the value of gold contained before embarking on potentially expensive recovery operation. By far the best way to minimise losses is to try and eliminate them at source. Much can be achieved by good housekeeping, employee education and the purchase of fairly simple waste

collection equipment (exhaust systems, settling tanks, rudimentary crushing equipment etc.).

Equally important, in all the consideration given to losses, is the necessity for having an effective metal control system. It should be simple to follow and understand, maintained up to date at all times and capable of giving early warning of the unexpected losses which can have such great impact on a business.

However unpalatable it may be, security of gold on the business premises has to be a major consideration. Losses do occur as a result of theft and fraud and they are often the most difficult to identify. The most trusted employee may be systematically contributing to loss by theft. Do not make it easy; keep a tight control.

Finally, if losses are high, take action now to start reducing them. Set targets for their reduction, say 1% or maybe 0.5% per year and implement plans to achieve them.

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