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Precious Metal Losses in Refineries. Where Did the Gold Go?

Speakers:

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Summary:

Losses of precious metals during the refining is an issue of constant concern for refiners. Losses can be small, leading to minor adjustments in the financial statements, or catastrophic, leading to the bankrupting of an organization. In his presentation, Michael listed some of the reasons for precious metals losses as variability in sampling, weights and assays, transactional errors vs technical losses, known vs unknown losses, stocktake errors, and theft, and advises that an improved evaluation needs to be provided for incoming materials.

Speaker 1:

Good morning everybody, and hello to everybody here from the East Coast of the United States. My topic today is *Precious Metal Losses in Refineries* which I've subtitled *Where Did the Gold Go*? Losses of metal in a refinery are not always about gold but, regardless, precious metal losses are an issue that many, or shall I say most refineries deal with at some time, even the best-run refineries have experienced these issues. It is when they are large that they are problematic and, of course, of great consternation and concern. We don't like to talk about them publicly, but metal gains and losses are a regular course of our business in a refinery and what I hope to present in this talk is a systematic way to look at them and some suggestions as how to reduce them, or at least understand them going forward. So, the agenda for today is to talk a little bit about the uniqueness of precious metal control in a refinery, and then to talk about inventory – the book versus the physical number. I want to talk about the built-in variability in the physical inventory results, and then I want to talk about the way I look at losses, where we have known losses and unknown losses.

So, let's start off by talking about inventory control. In a regular manufacturing operation, inventory control is a fairly straight and forward matter. There's the recording of the incoming and outgoing material, and then when you do a stock take in an existing refinery, you're taking piece counts and you may be checking some weights. It's a fairly straightforward operation. However, in a precious metal refinery, it is a lot more complicated. We don't know what's coming in, we want to make sure what's leaving, so we've got to assay the incoming material and we got to analyse the outgoing material. Material changes form and composition as it moves through the refining process. It comes in as an ingot which turns into a molten metal, and then might end up in solution form as electrolytes and eventually as precipitated powder. So, its composition and form are changing throughout the refining process and, as we know, in a precious metal refinery, metal goes everywhere.

So, when we do a physical inventory in a refinery, there are two governing – what I call – governing inventory equations. The first one is calculating what we call the book number. This is the calculated Work in Progress number – or so-called book number. That's the number from the previous physical inventory, the previous Work in Process number, and then we add the incoming material during the present time period, minus the outgoing time period. And then we do another physical inventory, and then we calculate the gain and the loss. And the gain or the loss is the difference between the present physical inventory results, minus the book number.

And let me give you an example that might help you, sort of, make sure you follow these equations. For example, here we have a previous work inventory was 25,000 ounces. We had 200,000 ounces of incoming material during the period, and then we had 210,000 outgoing. So, our book number should be, the difference should be a WIP number of 15,000. We then do a physical inventory, we come up with 14,000 of gold in the refinery, minus the book number of 15,000, and we end up with 1000-ounce loss. And that's how we determine our loss. And, of course, when we have a loss of this type, and of this magnitude, the question is no longer 'where did the gold go?' The question tends to get phrased in this way: ('Where did the *&^*()@# gold go?').

When we have losses, it is a cause for great stress, distress, and expensive investigations. Auditors get involved. It's a lot of sleepless nights for managers and outside consulting firms get brought in and it tends to cause a lot of issues. And sometimes the causes are found, but often it's a cause for large financial adjustments, insurance claims, and management turnover. And I sometimes council operations in inventory management, their job security tends to last from one physical inventory to the next. It's very important that we understand these losses.

So, when I look at the losses, I look at them in two ways. I look for transaction losses, and the transaction losses are basically there's been a data entry problem, there's been a calculation error. When this occurs, this can lead to a problem with either the incoming or the outgoing number, and when there's an error in the incoming and outgoing number, of course, there's going to be a physical gain or loss that can be determined. And, you know, in terms of transaction errors, these are these often called accounting errors, and they are embedded in the accounting system, in the ERP. And they can occur because it's a double-booked transaction or perhaps, you know, a shipped material that hasn't been booked into the system.

But my focus in this presentation are the so-called technical or physical losses that actually result in metals disappearing. A question I'm often asked is 'what are typical losses in a refinery?' There's really not a typical loss, every refinery is different. So, here's how I look at, sort of, what I call acceptable losses, and it's driven by this table.

In this first column I have metal accountability, then I have metal loss. And when I talk about metal accountability, you know, I'm talking if we have metal accountability of 99.9%, the metal loss would be 1%. And, in terms of dollar terms of incoming, say for every ounce of incoming material, a 1% loss on a $1500 gold, would be a loss of $15. Similarly, for silver at $15 an ounce, that would represent a 15-cent loss if we have a 1% loss. So, for gold, an acceptable number I believe is 0.01% loss. We've got accountability of 99.99%, and so we've got a 0.1% loss. That's about a 15-cent loss for gold that might be refined for $3 or $4 all-in costs, so 15 cent loss per ounce might be considered acceptable. For silver, the equivalent number is a 0.1% loss, and so we've got 99.9% accountability, and that translates as about 1 ½ cents or rounded up here to about 2 cents an ounce. So, this is a loss that might be considered acceptable for something we might be refining for 20 or 30 cents an ounce all-in.

So, my view of precious metal accountability, we need to be good enough for gold to have 99.99% accountability, and for silver 99.9% accountability. But – and this is a very important 'but' okay – this assumes that the metal loss number is a fixed number. It is not a fixed single number. It is a number with built-in noise and variability, but we treat it as fixed in order to book a single number into the accounting system. We need to be aware that the metal loss number is derived from measurements, that have variability. If there was no variability, we would not have any settlement rules, settlement negotiations or umpire labs.

So, we need to take into account that every number, every sample, every weight, and every assay is an average, it is not an absolute result. As a result, our physical inventory number has built-in noise and variability, and it has a standard deviation. For example, if we were to take a regular fire assay which we've repeated a couple hundred times, we'd get a distribution of results, scattered around the mean,

with a normal distribution. Of course, we can't run hundreds of repeats, we can only run past three or four replicate samples. Hopefully, they are clustered close enough together, so we believe that they're scattered around the mean. So, bear in mind the same thing happens to our physical inventory number, so we do need to take into account the built-in variability in the physical inventory number.

Could we have the next slide please? So, take into account there's this built-in variability in weight sampling, assaying, and variation. We need to take into account that errors in measurements propagate. The physical inventory results are results of a series of variable numbers. So, the inventories in measurement propagate, and it takes a combination of calculus and statistics to determine the error in the final result. So, coming back to the point that the physical inventory number is not an absolute, it is a number with built-in variability and noise. And sometimes this built-in variability is larger than we care to admit. Preliminary calculations show the variability can vary and depends on the refinery and their operations, but we are seeing numbers from 0.01% to 0.5%. using a standard error as a calculation, and that's a fair amount of variability in the physical inventory results. But for accounting purposes we need to pick a single number, as accounting folks are not interested in a number with an error rate. Well then that’s not a useful result. So, what I draw out of this is that we need to be circumspect in booking inventory gains or losses. If they’re within the error range of the book number, I would be disinclined to book an inventory loss or gain. Remember this year's inventory pickup could yield a loss in a future inventory.

So, let's have a look at these technical losses, there’s two types. There's what I call the known losses. Known losses, we're aware of them, we know where they are coming from, we can calculate what they are, and typically they are unrecoverable. Unknown losses, on the other hand, are typically discovered after a physical inventory or stock take is done and, of course, they are difficult to calculate. So, let's have a look at some of these known precious metal losses, and many of you are familiar with these. They are contaminant losses – for example, gold in silver. If you're refining a lot of silver, there always tends to be 5 to 7 PPM of gold in that silver. And, if you've got a lot of silver leaving your refinery, over time, there's a fair amount of gold that is leaving with that silver, so that's what I call contaminant losses. Then there is denominated purity or giveaway. For example, we might refine gold to 99.995%, but we can only sell it for 99.99% purity, so there's a little bit of gold that we're giving away every time, and when we refine a lot of gold, that accumulates over time.

There's weight rounding or overages on final products. We don't sell final products exactly at say 31.1 or 3 ounces of gold in every log. We tend to be a little bit over to make sure that we don't have any errors. So that weight rounding is a known precious metal loss. There’s of course another known precious metal loss is precious metals below the payable limits in subcontracted material. And then, of course, there is the contracted retention of metals in subcontracted materials. And then, of course, as we've heard from Mario just previously, there’s trace amounts of precious metals that end up in wastewater, or even in airborne discharges from refineries. So, these are all known precious metal losses.

The unknown losses are a little bit more troublesome. And the way I look at them and investigate them is I’d look at the two governing equations for physical inventory. So, these losses occur because there's been an error in the previous Work in Process inventory, so that could lead to a gain or a loss. There could be an error in the present inventory, and that could lead to a loss from the present inventory – if there’s been a mistake, that can result in a gain or loss. Of course, then there can be errors in the received incoming materials. We've incorrectly evaluated incoming materials so that could result in a physical gain and loss. Or, of course, we could have an error in our outgoing materials, or perhaps we even have theft, so our outgoing material is incorrect. So, if we're looking at how unknown losses can occur, I look at them – to summarize – we can have an incorrect value from the previous physical inventory. We can have an incorrect value from the most recent physical inventory. We can have an incorrect evaluation of incoming materials, errors in outgoing materials, and I even like to look at theft completely differently because it's such an enormous problem in refineries.

So, let's have a look in a little bit more detail at the first two. These are all issues associated with physical inventory determining stock-taking in the refinery, and stock-taking in a refinery is a difficult operation. We have to stop our normal course of business; we have to skip for a few days and clean up our plant. We have to find all the precious metal-containing materials, which are in all sorts of forms. We need to consolidate them, treat them, sample them, analyse them. So, in refineries, it’s a complicated operation. And oftentimes problems are encountered because we did not find all the material in the refinery. Equipment has been incompletely cleaned out because we have reactors to deal with, we have piping to

deal with, we have ductwork, and we have filters. And if we don't completely clean out these pieces of equipment, we experience precious metal losses. And I've experienced great losses of precious metals in every one of these cases. I have found material hung up in filters, lining reactor walls, in pipework, and in ductwork, I've been there and seen it all. Another problem that might occur during a stock take is simply incorrect weights that have been put into the system. During a physical inventory, we're weighing materials, and that's why it's important, you know, that we make sure that the, you know, incorrect weights aren't assigned to lots. So, it's good to have a process and a procedure where at least you'll have duplicate weights, and you have both a weigher and a checker that are, you know, verifying results. It's never a good idea to send a lone operator off to the far corners of the plant to weigh materials and then, you know, to bring back those unchecked weights and to enter them into a system.

Another way we could have an error during stock take is through poor sampling practice. Lots of errors during a physical inventory are created by poor sampling practice. For example, many refiners don't like to precipitate the gold or silver out of concentrated electrolytes in order to determine the precious metal contents. I know why. It takes time, it is expensive, and then you have to make up fresh electrolytes to restart your operation. Instead, they resort to solution sampling which is fraught with problems. There is the homogeneity of the concentrated solution, the presence of sludges, and then the problems of determining weight and volume determination. When you have large volumes of solution, the potential for error grows.

Another problem is created by by-products, for example, Miller salts that are non-homogenized. These heterogeneous materials can be very difficult to analyse. For example, Miller salts contain small and sometimes large particles of gold, and when you are faced with a physical inventory time of 30 or 40 barrels of unprocessed salts, there is a big problem, as to how you'll get a reliable number for the precious metal content of the material. Another problem I've seen is tracking materials after the stock take. After the inventory stock take, there are materials that have to be processed when the operations start up in order to determine their precious metal content. For example, there's metal that has to be melted and sampled. These materials have to be tracked separately, and their by-products, the slags from the melt generate sub lots that need to be tracked separately as well. So, when you have poor tracking, you can get errors happening.

The single best solution I have come across to reduce stock take related errors is to keep your Work in Process inventories as low as possible because there's less to evaluate, there's a smaller chance of errors, and of course, lower carrying costs. Sometimes this is easier said than done. Materials accumulate because equipment breaks down, and we focus on moving higher-grade materials through our plants in order to keep carrying costs down. And, as a result, lower-grade materials sometimes accumulate in our plants.

So, let's turn to the incorrect evaluation of incoming material. Sampling on incoming materials can be problematic. High-grade materials we typically melt and sample, and when we've got high iron materials coming into our plants, it's very difficult to homogenize those materials in a melt. They do segregate into two phases and it can be very difficult to get a reliable sample from the melt. Low-grade materials, we know the complications of analysing this. We go through incineration, crushing, grinding screening, blending, and sampling procedures. And, after all of that, if we're not applying good sampling practices, we are compromising the results.

Analytical errors also occur in evaluating incoming materials. There can be simple weighing errors, there can be incorrect calibrations and procedures that are applied in the assay lab. I have also seen straightforward sample mix-ups in labs. Many labs have good LMS systems now, and checking of results, but errors still do occur that can result in the incorrect evaluation of incoming material. Like you can have incorrect evaluations in incoming material, you can have incorrect evaluations in outgoing material. For example, in outgoing material, you could have incorrect weights, shipment weights, you know, being in a facility where the wrong number of bars were shipped and wasn't recorded correctly. So, you can have errors in what you are shipping out. There can be errors in outgoing materials. For example, there can be evaluation errors. Many refiners subcontract materials to smelters and sometimes these materials aren't analysed correctly. They are sent out unprepared, and it's never a good idea for a refinery to send out unprepared materials to subcontracting because that's when errors can occur.

The other potential errors in outgoing material that can occur, of course, are process losses. You know, you can have material ending up in plant trash. I've investigated a precious metal loss where we found materials literally in the food waste that had left the refinery. And you might ask yourself, 'well how did

that occur?' But, of course, you can have scrubbers fail, and you can have material leaving the plant through the Air Treatment Systems, or you can have a failure of a wastewater treatment plant. And, again, this does occur. Mario pointed out today that there's gold in sewage sludge, so it's important to realize that losses can occur there.

Theft is an ongoing problem in all refineries. We spend a lot of time, money, and effort to try to deter that. I really can't address it today – that's a whole presentation by itself – but it is important, and we need to work hard to reduce them.

So, I've covered a lot of material today, and I'd like to summarize where we've been and some of the key points. The first thing to remember: that physical inventory results that we end up booking, we've got to understand that because there is a variability in the sampling, weights, and assays that go into that number, there is variability in their gain or loss number. There are transaction errors and technical losses. Transaction errors are typically accounting losses, technical losses are actual physical losses. And then, in the technical losses, I've broken them down into known versus unknown losses. Stock take errors do occur, and the best way to reduce stock take errors is to keep Work in Process inventories low. We can always work to improve the evaluation of our incoming materials and make sure we are applying the right analytical methods, and make sure we've got the correct weights, and make sure the right procedures are used. We've got to watch our outgoing materials. And, again, that means, you know, what we are sending out of the refineries plus, you know, the inadvertent losses through theft.

I do apologize for having to gloss over so many of these important issues. I have certainly not done much justice to many of them, but in the interest of time, I've had to cut this short. I could go on for this topic for hours. So, I do have a more detailed white paper that I could share with you, so just reach out to me via email, which you can find in the conference attendee list. Thank you very much for your time and attention.

Speaker 2:
Okay, Mike! Yeah, thanks for that. It's a scary thought that – I think you made the point that a manager's career could end between one stock take and the next stock take.

Speaker 1:
Yes

Speaker 2:
Which is a scary thought. And, also, when you're trying to explain to an auditor that analytical chemistry isn't an exact science… you'll get some funny looks. One thing I just wanted to say, you talked about analytical errors and you talked about sampling errors, but they're not the same, are they? They are different orders of magnitude?

Speaker 2:
I did not mean to mute myself then. I don't know how that happened but anyway. Yes, sampling errors are very different from analytical errors. For example, if we were to sample the same low-grade material five or six times, you would get an average result with variability associated with it.

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