

Appendix A: Agendas for Inactive and Active Mine Visits

Osino Mine Site Visit - Inactive & Active 1/23/2020 & 1/29/2020

Reminders:

Mercury can contaminate the washer and/or pollute sewage. Throw all clothing that came in contact with liquid mercury in the trash. If mercury is visible on the clothing take it to your local household hazardous waste collection site for disposal. Wash clothing or other items that were exposed to mercury vapor during the cleanup, but did not get mercury directly on them.

Things to look for

How they handle mercury

The general process

Materials

Where they get materials from

Equipment

Observations of miners

Process Questions

- The hose inlet to the chanfan has many outlets, are they plugged up at the end or do they lead to other parts of the process?
- Weir or 2 different heights in the shoot from the grinder to the sluice? Purpose?
- Velocity of the water down the sluice?
- Clarify 30 meters or 30 minutes for the duration of sluicing?
- How do you get the gravel from the carpet to the plastic bowl for mixing?
- How many people are working on each machine?
- How much mercury is being used per team per shift?
- How long do you use a handkerchief for? Do you wash them or reuse them?
- How do you contain the excess mercury you squeeze out of the handkerchief?
 - Where do you put the excess mercury?
 - Where do you put the amalgam before burning?
 - What do you transport the unrefined gold in?
- Only sell unrefined gold to PMMC?
 - What is the process to become an authorized seller?

Workday Questions

Batch process every 8 hours or continuous process?

Same people working each shift or do the miners rotate shifts?

Can we see any other mines?

Osino Mine Site Visit - Inactive & Active
2/20/2020

Cost Analysis Questions

1. Do you think that mercury is bad for your health?
 - a. Have you or someone you know felt the side effects of mercury?
2. If you could have a device to protect you from mercury, would you use it?
3. How much would you be willing to spend on a device that protects you from mercury?
4. How much do you make on an average day of mining?
5. Would you share a device for the burning of mercury with other miners?
 - a. Would you share the cost?

Introduce the device to the miners

1. What do you think of this device?
2. What benefits or drawbacks do you see in a device like this?
3. How much would you pay for this?
4. If you knew this cost 300 GHS, how long would it take you to pay for this?

Appendix B: Agendas for Workshops

Initial Deep Dive with Miners University College of Agriculture and Environmental Studies - Bunso 1/29/2020

Goal:

Engage with the miners to begin prototyping designs to mitigate exposure to mercury for themselves and the environment.

Agenda:

1. Introductions of us and the miners
 - a. Small talk - how are the kids? Coronavirus, isn't it wack?
 - b. Maybe an icebreaker
2. Explanation of our project and goals
 - a. Outcome of project
 - b. Outline parameters
 - i. Economically viable
 - ii. Mercury reclamation
 - iii. Health and safety
3. Small group discussions
 - a. Break into small groups containing miners and students to begin thinking about prototyping
 - b. Use questions to prompt them to give us information thinking about what
 - c. Use paper and drawings to help facilitate
 - d. Go over design requirements

Design questions to ask:

- What would you like to change about the process right now?
- What problems do you see with the mining process?
 - Improvements that can be made to the mining process
- Would being able to reclaim the mercury be an incentive to use the device?
- What would make you want to use this device?
 - Incentives that you would like to see to go out of your way to use this device?
- Do you think a device would be useful?

Design Considerations:

- Interface between flame and amalgam will increase duration burning time
 - Can create a small hole to allow contact
- If putting device together needs tools that miners have
 - Repairs

- Estimate operator cost and repair cost
- Portable
- Miners need to see amalgam burning to know when to stop

Deep Dive with Miners
University College of Agriculture and Environmental Studies - Bunso
2/04/2020

Goal: Come up with a couple of designs with the miners and do a shopping trip for materials. We need to come prepared with potential designs of our own, material knowledge, and mercury oxide research. Bring measuring tools.

Agenda:

1. Design discussion
 - a. Based on our last meeting
 - i. Go over design requirements
 - ii. Talk about priority
 - iii. Would you change anything about this?
 - b. Design collaboration
 - i. Both designs planned by our team to get input and go over to their designs they've thought of
 - ii. More hands on/drawing
 - iii. Defining critical dimensions
 - iv. Multiple design ideas (exhaust vs condense)
2. Materials discussion
 - a. Go over potential materials to use based on our mercury research to verify it's what they understand about gold and mercury
 - b. What materials fit the design needs?
3. Gloves
 - a. Maddie will coordinate
4. Shopping
 - a. For materials

Notes:

Questions:

- Video of mercury burning process?
- Can the design use electricity?
 - Alternatively, hand crank?

Length of Exhaust:

- i) Rao: How can we calculate minimum height for condensation?
 - (1) No way to calculate it, depends on a whole lot of things
 - (2) Unnecessary fancy simulation would be needed

- (3) Find through testing
- (4) The length of exhaust can be variable, and just make tube longer leaving other measurements constant
- (5) Maybe coil tubing trial and error

Appendix C: Device Questionnaires for Miners

GOAL: Get feedback on devices using our design requirements.

- a. Interview style to get feedback on device
- b. Gather info on how we can improve prototype and take note of visual observations.

Name: _____

Date: _____

Prototype _ Questions

Requirement	Description	Met/ Not Met	Comments
Partnership and adoption	Device must be designed with miners as equal partners so that it will be readily integrated into their practices.		
Personal Safety - vapor - Vapor	Device must protect users from exposure to mercury vapor during the burning of amalgam.		
Environmental Safety	Device must protect the surrounding environment from mercury or vapor.		
Materials & Fabrication	Device must be manufactured using local materials and fabrication techniques.		
Integration - Heating	Device must be comparable in procedure and effectiveness to current practices. Device allows for direct heating of amalgam from blowtorch.		
Integration - Visual	Device must be comparable in procedure and effectiveness to current practices. Device must		

	allow miners to check on the amalgam while it is being burned.		
Durability	Device must be able to withstand the wear and tear from basic operation or drops/accidents on the mine site.		
Portability	Device should be easily transportable between different mine sites and the miners home without damage.		
Repairs	Device must be easy for miners to repair using locally available materials.		
Affordability	Device should be relatively inexpensive to manufacture and repair.		
Reclamation	Device can reclaim mercury for later use.		
Personal Safety - contact - Contact	Device protects miners from skin contact with mercury during hand mixing phase		
Replication	Device can provide economic opportunity through manufacture and sale		

USAGE:

1. What are your thoughts on the device?
2. Did you like the device?
3. What would you change about the device?
4. Was the device easy to use?
5. How easy was it to place “gold mercury” in the device?

6. How easy was it to put the blowtorch in the hole?
7. Did this device greatly affect your mining process?

OBSERVATION:

8. Did the flame have direct contact with the “gold mercury”?
9. Did you take the torch out to see “gold mercury”
 - a. How often?
10. How long did you wait for the” gold mercury” to cool?
11. Did you see vapor in the exhaust?
12. Did the gold change color?
13. Were you satisfied with the color of the gold?
14. Did you see liquid mercury?
 - a. At what point?
 - b. How many minutes did it take until you saw the liquid mercury?

PROTECTION:

15. Did you notice any leaks (vapor) in the device?
16. Did you see any leaks (vapor) in the device?
17. Were you able to redirect the smoke?

Appendix D: Operations Safety & Maintenance Manual



OPERATIONS, SAFETY AND MAINTENANCE MANUAL

These materials will be translated into Twi by the Okyeman Environmental Foundation and distributed along with retorts. This manual was modeled after “Using Retorts to Reduce Mercury Use, Emissions, and Exposures in Artisanal and Small-Scale Gold Mining” created by the U.S. Department of State and the United Nations Industrial Development Organization (UNIDO).

The citation is as follows.

Richard M., Moher P., Rossin R., and Telmer K. (2014). Using Retorts to Reduce Mercury Use, Emissions and Exposures in Artisanal and Small Scale Gold Mining: A Practical Guide, (Version 1.0), Artisanal Gold Council. Victoria, BC. ISBN 978-0-9939459-2-2

Introduction

The purpose of the manual is to facilitate the implementation and usage of the retort made in 2020 with miners in Osino, Ghana. This document has been designed to help guide the use of this retort for Artisanal and Small-Scale Gold Miners (ASGM). It provides guidance for individual miners and mining communities and for any agencies trying to replicate this design. One of the key messages in the guide that has not often been clearly described is that retorts, although simple in design, have operational requirements that must be followed to avoid increasing human and environmental exposure.

What is a retort?

Retorts are used around the world to help prevent breathing in dangerous mercury vapours. A gold mercury amalgam is placed in the retort and burned. The mercury turns into vapor and the retort cools and condenses the vapor back into liquid mercury. However, retorts are not perfect and do not collect 100% of the mercury, so safety precautions must be made when using them.

The Osino Retort (2020)





Galvanized Steel Plate

Number	Device Description
1	Outlet of condensation coils
2	Door on burning vessel for transport of amalgam
3	Condensation coils
4	Blowtorch entry spout

Safety and Usage Precautions

- The device is made of galvanized steel. Before the retort is used for the first time, burn wood or paper in the burning vessel [2]. This will allow the zinc coating from the galvanized steel to burn off. This will prevent the mercury from bonding with the zinc layer. Also, during this initial burn the user should and check for any leaks in the device.
- The galvanized steel plate will wear down at a faster rate because of its direct contact with the blowtorch. This will result in the galvanized steel to change to regular steel at a faster rate. When steel reacts with the sponge gold, a change in the gold color may occur. To prevent this, cover the steel plate with clay or soot to prevent damage to the steel plate.
- If any leak is suspected, DO NOT burn gold-mercury. Take the retort to the welder to be fixed.
- DO NOT place the outlet pipe [1] in water, this will cause an EXPLOSION
- DO NOT use the retort around women or children
- DO use a retort outdoors to avoid vapours depositing on indoor surfaces.
- DO NOT store the retort and the clothes of the user indoors
- DO NOT open the retort door [2] before it is completely cool to the touch, or mercury vapour will escape. Note that there will always be some mercury vapour that escapes when a retort is opened but this will be minimized by cooling the retort.
- DO place wet towels around the coiled pipe [4] to promote condensation

How to use your retort safety

1. Place the retort in its designated area for use. This should be outside.
2. Cover the galvanized steel plate with soot or clay to prevent degradation.
3. Place gold-mercury on the galvanized steel plate, open the door on the device [2], and place the galvanized steel plate in the device
4. Close door [2]and secure the door latch
5. Soak rags or t-shirts with water and wrap them around each coil [4]
6. Turn the blowtorch on and place the blowtorch in the circular opening of the spout [3]
7. Heat the gold mercury amalgam until all of the mercury is evaporated. This time may vary based on the size of the gold-mercury amalgam.
8. Turn the blow torch off
9. Wait for the retort to cool. Cooling it with water is okay, but don't open the retort door [2] while it is still hot. If you do, mercury vapours will escape and contaminate you
10. Open the door [2] and remove the galvanized steel plate from the device

11. Check your sponge gold color to guess if all the mercury is gone. If not, then use the retort again.

Maintenance

- Make sure to burn a piece of paper or wood in the device before using it for the first time. This ensures the zinc coating is burned off as it may react with the mercury, or affect the quality of the sponge gold product
- You may use a wire brush to clean the spout and the outlet pipe. DO keep this brush with the retort outside of your house.
- Use alcohol to clean the burning vessel to remove any oils. Make sure to let the alcohol evaporate for around 30 mins before burning gold-mercury.
- DO NOT store the retort and your working clothes indoors
- DO NOT open the retort before it is completely cool to the touch, or mercury vapour will escape.
- Galvanized steel typically has a lifetime of 20-25 years when in heavy-duty use. Replace your retort after around 20 years to ensure it works properly.
- The steel plate may wear out faster than the rest of the retort, so make sure to replace it if you notice the metal degrading, as this may affect the sponge gold product quality

Appendix E: Structural Failure Analysis

In normal use, the device does not undergo any significant loads or stresses that could cause structural damage. Given the nature of mining environments, there is some risk of wear such as drops or dents.

Using dents up to 2% of pipe diameter as an acceptable threshold, and assuming a drop height of 2 meters, a failure analysis was conducted for a section of the outlet piping and the main house. The device is made of galvanized steel, which has a Young's Modulus of 200 Gpa. Measured values are outlined below.

Device dimensions

Pipe diameter	0.0338 m
Pipe thickness	0.00254 m
House diameter	0.1016 m
House thickness	0.00127 m
Device mass	3.5 kg

Acceptable dent threshold

Pipe	0.00068 m
House	0.0020 m

Modeling the device as a spring, the equation $k = 2 * W * H / D^2$ can be used to find the minimum equivalent spring constant k required in N/m, where W is the weight of the device in kg, H is the drop height in m, and D is the allowable deformation in m.

Spring constant required

Pipe	3.0×10^8 N/m
House	3.4×10^7 N/m

Young's Modulus can be used as a spring constant for the purpose of analysis. The equation $F / A = E * d / D$, where F is the impact force kd , A is the relevant area (wall thickness * length, assuming a 1 in length of pipe), d is the allowable deformation, and D is the original diameter. By substituting and solving for k , $k = E * A / D$, this value can be compared against the previously calculated value.

Spring constant calculated

Pipe	$3.8 * 10^8 \text{ N/m}$
House	$6.4 * 10^7 \text{ N/m}$

Thus, the materials selected are appropriate for reasonable accidental damage the device may expect to undergo.

Appendix F: Miner Final Interview Results

How do you feel about the project?

I learned how to use mercury and how to prevent mercury poisoning

Did you like working with us?

I liked it! I feel like I can now take charge and can advise my friends and family on safe mercury use

Did you feel like we were partners?

Yes we were friends! By coming to the restaurant, showing each other ideas, going to the mine site.

[he feels like we spent time together and built a relationship]

Did you feel your ideas were heard?

Yes

How did you feel, working with Americans?

I liked it. You are always learning and producing ideas. You always ask for details and ask questions. You do your research to see if something works.

What are your hopes for the future?

Now I know how to demonstrate the device to other people and miners. I can educate my friends so they can be safe

How has your view of scientists changed from this experience?

I like that you did research to [support your claims]. We show what we say we will do.

Overall?

I feel mature in devices and using mercury. I can educate others on the topics and show them how to be safe.

Appendix G: Final Design Specifications and Technical Drawings

