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Final Report

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CHEMICAL TRACERS IN HYBLA GOLD WORKING ROOM

by

Barbara G. Killian and John H. McQueen

ABSTRACT

Chemical tracers were placed in the working room for the Hybla Gold event to aid in diagnosing flow of high-energy gases down expanding pipes leading from the room. If post-shot reentry is made, the tracers could provide valuable knowledge concerning pipe closure, mixing of gases from various locations, and volume of gas flow into various sizes of pipes.

I. INTRODUCTION

Four different chemical tracers were placed in the $\sim 24.4 \text{ m}^3$ working room of Hybla Gold, Fig. 1. These tracers were located at various distances, on about a radial line, from the nuclear source to the throat of each of the 1-ft (0.3-m) pipes and to the 3-ft (0.9-m) pipe. The shock wave from the nuclear source will vaporize the chemical tracers and some or all of them will flow down the pipes with the vaporized fiber glass. Calculations are indicating that the 1-ft (0.3-m) pipes will be closed by the ground shock. Calculations which describe the flow of high-energy gases down expanding pipes with ablation are very dependent on the amount of gases entering the pipe and on subsequent pipe closure. Closure will stop or inhibit gases in the working room from flowing down the pipes. If a post-shot reentry is performed, examination of the locations at which tracers are found in the pipes will provide valuable information regarding: (1) pipe closure, (2) mixing of

gases from various locations, and (3) an indication of the amount of gas which flowed into each pipe.

II. CONSTRUCTION OF THE TRACERS

The tracer materials used were all laboratory grade, in excess of 99% pure, elements. Since they came in different forms, they are discussed separately below.

Gold

The gold foils available were of varying thickness. The 10-mil (2.54-mm) foils were rolled to 3 ± 2 -mil (0.76 ± 0.51 -mm) thickness so that none of the foils was over 5 mils (1.27 mm) thick.

Tracer #1	138.6 g of 3-mil (0.76-mm) Au foil
	99.7 g of 5-mil (1.27-mm) Au foil
	<u>16.1 g of 3 ± 2-mil (0.76 ± 0.51-mm) Au foil</u>
Subtotal	254.4 g of Au
Tracer #2	169.5 g of 4-mil (1.02-mm) Au foil
	<u>84.8 g of 3 ± 2-mil (0.76 ± 0.51-mm) Au foil</u>
Subtotal	254.3 g of Au
Tracer #3	254.4 g of 3 ± 2 -mil (0.76 ± 0.51 -mm) Au foil
Tracer #4	253.8 g of 3 ± 2 -mil (0.76 ± 0.51 -mm) Au foil
Total Au =	1016.9 g

For each tracer, the foils were laid out and centered (as carefully as possible due to random sizes) on a 24-x 24-in. (0.6-x 0.6-m) piece of cardboard of packing box strength. The foils were taped to the cardboard with masking tape. Another 24-x 24-in. (0.6-x 0.6-m) piece of cardboard was laid on top and masking tape was applied around the edges. Thus, each tracer can be thought of as a 24-x 24-in. (0.6-x 0.6-m) sealed sandwich.

Indium

The available indium was pressed into strips about 1.5 in. (38 mm) wide with a thickness of 3 ± 2 mils (0.76 ± 0.51 mm). It was laid in strips that spanned the 24-x 24-in. (0.6-x 0.6-m)

cardboard and taped to the cardboard. Another piece of cardboard was placed on top, and the tape was applied around the edges.

Tracer 1a	419.0 g of In
1b	427.0 g of In
2a	412.5 g of In
2b	422.5 g of In
3a	419.0 g of In
3b	418.5 g of In
4a	422.5 g of In
4b	<u>423.5 g of In</u>

Total In = 3364.5 g

Silver

The available silver was in 5-mil (1.27-mm) strips 1 in. (25 mm) wide. These were laid out as 24 strips across and taped to the 24-x 24-in. (0.6-x 0.6-m) cardboard sheet. Again, a taped sandwich was made.

Tracer #1	491.0 g of Ag
#2	484.0 g of Ag
#3	491.0 g of Ag (approximate)
#4	489.0 g of Ag (approximate)
#5	498.0 g of Ag
#6	473.0 g of Ag
#7	483.0 g of Ag
#8	<u>483.7 g of Ag (approximate)</u>

Total Ag = 3892.7 g

The total of 3892.7 g is accurate, to less than 0.1 g. Measurements of individual foils are only accurate to within about ± 0.5 g.

Bismuth

Bismuth was only available in powdered form. It was, therefore, mixed with Fosco glue and spread out over a cardboard sheet. When spread too thinly, the bismuth-glue mixture did not adhere well to the cardboard. Thus, an area of cardboard about 18 in. (0.46 m) in diameter was covered on each tracer.

Tracer #1	2025 g of Bi
#2	2033 g of Bi
#3	2027 g of Bi
#4	<u>2040 g of Bi</u>

Total Bi = 8125 g

Because of the thicker tracer formed from the Bi and because of the smaller area, it was decided to place the Bi closest to the working point (rather than the Ag as previously planned in our original proposal).

III. LOCATION OF THE TRACERS

The fiber glass bats that filled the working room were nominally 2 x 24 x 48 in. (0.05 x 0.6 x 1.2 m). Many of them were cut to fit the irregularities of the working room as shown in Fig. 2. To fill the 10-ft (3.0-m)-high working room, the fiber glass bats were stacked on edge in three layers: floor layer, middle layer, and top layer (Fig. 2). The floor layer was stacked vertically; that is, 4 ft (1.2 m) high. The middle layer was stacked horizontally; that is, 2 ft (0.6 m) high. The top layer was again stacked vertically; that is, 4 ft (1.2 m) high. A bundle of six fiber glass bats was used to obtain the 1-ft (0.3-m) dimensions indicated in Fig. 2.

Looking toward the working point (WP), the 1-ft (0.3-m) pipes all enter the working room on the "1-ft-pipe wall" (identified in Fig. 1), as shown in Fig. 3a. The pipes have a flare as they enter the working room, as shown in Fig. 3b. The "1-ft-pipe wall" is at a 5-ft (1.5-m) perpendicular distance from the WP along the centerline. The center of Pipe A is located 3 ft 10 in. (1.17 m) horizontally from the centerline and is 3 ft 10 in. (1.17 m) lower than the WP. Pipe A is the rough-walled pipe. The center of Pipe B is located 3 ft 10 in. (1.17 m) horizontally from the centerline and is 3 ft 10 in. (1.17 m) higher than the WP. Pipe B is the "smooth" pipe. The center of Pipe C is located 3 ft 10 in. (1.17 m) horizontally from the centerline and is 3 ft (0.9 m) higher than the WP. Pipe C is partially filled with water and enters the "1-ft-pipe

wall" 10 in. (0.25 m) lower than Pipe B. The flared end (5 ft, or 1.5 m) of the 3-ft pipe is centered in the 5-ft (1.5-m)-wide "3-ft-pipe wall," indicated on Fig. 1, and is centered at 2 ft 6 in. (0.76 m) below the WP (and thus tangent to the floor).

One Au tracer was located at the center of the throat of each pipe (Figs. 4a and b). It was placed 2 in. (51 mm) from the throat itself, in between the first and second fiber glass blocks.

Au tracer #1 (254.4 g) was used on Pipe A

#2 (254.3 g) was used on Pipe C

#3 (254.4 g) was used on Pipe 3-ft (0.9 m)

#4 (253.8 g) was used on Pipe B

Two In tracers were used for each pipe. For the 1-ft (0.3-m) pipes, these tracers were all placed 18 in. (0.46 m) from the "1-ft-pipe wall," and parallel to it. For Pipe A, the two In tracers were placed starting against the "right-hand wall" and extended horizontally 48 in. (1.2 m), parallel to the "1-ft-pipe wall," as shown in Fig. 4a. Their bottoms were located at a height of 14 in. (0.36 m) from the floor. For Pipe C, the two In tracers were again placed starting against the "right-hand wall" and extended horizontally, parallel to the "1-ft-pipe wall" for 48 in. (1.2 m), as shown in Fig. 4b. Their bottoms were located at a height of 72 in. (1.8 m) from the floor. For Pipe B, the two In tracers were placed starting at a horizontal distance of 1 ft (0.3 m) to the left of the centerline, Fig. 4b. They extended horizontally for 48 in. (1.2 m), parallel to the "1-ft-pipe wall," and 18 in. (0.46 m) from it, and their bottoms were located 75 in. (1.9 m) from the floor.

For the 3-ft (0.9-m) pipe, two In tracers were placed 24 in. (0.6 m) from the "3-ft-pipe wall." They started 27 in. (0.69 m) (measured parallel to the "3-ft-pipe wall") from the "back left-hand corner," as shown in Fig. 4, and extended for 48 in. (1.2 m) parallel to the "3-ft-pipe wall." Their bottoms were located 20 in. (0.51 m) from the floor.

In tracers 4a (422.5 g) and 4b (423.5 g) were used on Pipe A

2a (412.5 g) and 2b (422.5 g) were used on Pipe C

1a (419.0 g) and 1b (427.0 g) were used on Pipe B

3a (419.0 g) and 3b (418.5 g) were used on Pipe 3-ft

Two Ag tracers were used on each pipe. For the 1-ft pipes, these tracers were all placed 29 in. (0.74 m) from the "1-ft-pipe wall," and parallel to it. For Pipe A, the two Ag tracers were placed starting against the "right-hand wall" and extended horizontally for 48 in. (1.2 m), parallel to the "1-ft-pipe wall," Fig. 4a. Their bottoms were located at a height of 24 in. (0.6 m) from the floor. For Pipe C, the two Ag tracers were placed again starting against the "right-hand wall" and extended horizontally for 48 in. (1.2 m), parallel to the "1-ft-pipe wall" and 29 in. (0.74 m) from it, Fig. 4b. Their bottoms were located at a height of 72 in. (1.8 m) from the floor. For Pipe B, the two Ag tracers were placed starting at the centerline and extending for a distance of 48 in. (1.2 m), parallel to the "1-ft-pipe wall," and 30 in. (0.76) from it, Fig. 4b. Their bottoms were located at a height of 72 in. (1.8 m) from the floor.

The two Ag tracers on the 3-ft (0.9-m) pipe were emplaced parallel to the centerline. One was located 3 ft (0.9 m) from the centerline, extended for 48 in. (1.2 m), and terminated 2 ft (0.6 m) from the "1-ft-pipe wall," Fig. 4a. The other was located 4 ft (1.2 m) from the centerline, extended for 48 in. (1.2 m), and terminated 3 ft (0.9 m) from the "1-ft-pipe wall," Fig. 4a.

Ag tracers #6 (473 g) and #3 (491.0 g) were used on Pipe A
#5 (498 g) and #8 (483.7 g) were used on Pipe C
#2 (484 g) and #4 (489.0 g) were used on Pipe B
#1 (491 g) and #7 (483.0 g) were used on Pipe 3-ft

One Bi tracer was used for each pipe. For Pipe A, the Bi tracer was placed starting at the centerline, 1 ft (0.3 m) in front of the WP and 4 ft (1.2 m) from the "1-ft-pipe wall." It extended 24 in. (0.6 m) parallel to the "1-ft-pipe wall," terminating 3 ft (0.9 m) from the "right-hand wall," Fig. 4a. The bottom of this tracer was 2 ft (0.6 m) from the floor. For Pipe C, the Bi tracer was placed directly above the Pipe A Bi tracer with its bottom 72 in. (1.8 m) from the floor.

For the 3-ft (0.9-m) pipe, the Bi tracer was emplaced parallel to the centerline, 7 ft (2.1 m) from the "right-hand wall." It

started 3 ft (0.9 m) from the "1-ft-pipe wall" and terminated 5 ft (1.5 m) from it, Fig. 4a. Its bottom was located 48 in. (1.2 m) from the floor.

IV. CONCLUDING REMARKS

John McQueen designed and installed the fiber glass bundles in the working room. The tracer fabrication and installation were performed by the authors. The working room dimensions and tracer locations represent "as-built" values.

A careful review of all experimental data obtained on Hybla Gold will be performed post-shot. An assessment of whether a re-entry is desirable should be made at that time. If such a reentry is desirable and samples from the pipe region can be obtained, planning for the analyses of the chemical tracers will commence.

Fig. 1. Hybla Gold working room plan.

Fig. 2. Fiber glass bundle stacking layout.

Fig. 3a. "1-ft-pipe wall" elevation.

ONE-FOOT-PIPE FLARE

Fig. 3b. Three-foot-pipe flare.

Fig. 4a. Tracer locations in fiber glass bundles.

Fig. 4b. Tracer locations in fiber glass bundles.