Blasting Under a Bucket-Line Dredge

by Wes Bender

A few times in my blasting career I have been asked what situation worried me the most from a liability standpoint and also how much explosive was involved. The inquiring person generally assuming it would have been a fairly large blast. They are somewhat amazed when I tell them that I probably had the most concern and did the most analysis and computation in a situation where I detonated a little less than two pounds.

Back in the early '80s, I got a call from Yuba Placer Gold near Marysville California and was asked if I could assist in freeing a bucket-line dredge at Hammonton that was quite firmly stuck to the bottom of its pond.

For those not familiar with a bucket-line dredge, it is a very large floating dredge that uses a continuous chain of buckets running on a frame called a ladder (similar to a chain saw, except running in the opposite direction). A sprocket at the inboard end of the ladder drives the line of buckets. The far end of the ladder, containing an idler sprocket, is lowered to the bottom of the pond where the buckets dig the material and carry it up along the top of the ladder where it is dumped for processing as the buckets go over the top. There is an additional inverted idler on the underside of the ladder to handle some of the weight and to keep the buckets clear of the bottom until they reach the digging point. Yuba Consolidated Gold Fields dredge #21 was the last of several that had worked at Hammonton through the years and was 500 feet long, 110 feet tall and approximately 70 feet wide. It had a bucket line consisting of 150 to 180 18 cubic foot capacity interconnected manganese steel buckets that weighed a little over 2000 lbs each. Several months before they called me, the bucket line had been taken apart on top of the ladder to provide some slack so that they could do some repairs on one of the idler's bearings. Company procedures required that each end be buck-strapped with wire rope prior to separating the bucket line. The portion passing over the outboard end had been fastened properly, but the decision was made to hold the rest of the buckets temporarily by applying the hydraulic brake at the drive sprocket. Unfortunately, at some point in the process the hydraulic pressure bled off and two thirds of the bucket line went over the drive sprocket and wound up on the bottom of the pond, tangled like so much huge bicycle chain. Efforts to pull it up from the other end, complicated by the buckets facing in the digging direction, were not successful. Divers had been utilized, but could do nothing with the bulk that the tangled line of buckets represented.

It was important that the company salvage as many buckets as possible. On the property was another dredge that had been retired in 1967 and would yield quite a few usable buckets, but 70 or so of the buckets from YCGF #21 had to be salvaged to make it operational. The point where they wished to sever the bucket-line was down in the mud and silt of the bottom. The divers could not separate the buckets themselves without being crushed or badly injured when they came apart, hence the phone call to me to investigate the possibility of using explosives to accomplish the task.

The first question was whether the bucket-line could reliably be separated with explosives. They had a representative bucket on deck and, after making some basic measurements, it appeared feasible, but was going to require some careful calculation. The distance between the blast point and the bottom of the hull was thought to be about 75 feet. The company president, who had once been a Navy Seabee, authorized me in writing to use an explosive charge of up to 10 lbs to do the job. A careful measurement by the diver and this writer revealed that the actual straight line distance between the bucket to be cut and the nearest point on the hull was only 54 feet.

It is quite easy to calculate how much explosive is required to blast apart various metal shapes, but knowing how little you must use underwater to keep from sinking a $7.5 million dredge, built in 1937 out of 3/8" plate steel, was another matter entirely. To compound the problem, I figured that 10 lbs was possibly not enough to adequately sever both sides of a bucket's connecting ears. If one knew how much pressure the hull could withstand, it would be a simple matter of using Cole's formula for pressures generated by underwater detonations to determine a safe charge weight. We didn't know how much the hull could take and I didn't care to base my calculations on a best guess.

In attempting to find some way of reducing the explosive charge weight, it was suggested that one side of the bucket connection could be cut with an air arc by the divers and the other side would still hold OK. Buckets had been found running that way in several instances. This would reduce my problem by half, but I still wanted to reduce the pressure as much as possible. No one seemed to know just how much of the 3/8" plate steel remained after 45 years in the water or how strong it was and there wasn't a reasonable means of finding out. The only leaks that had been encountered through the years were at the bolts that held the hull’s plates together. When one was found to be leaking, it was fixed by simply welding a pipe nipple over the nut on the inside of the hull and screwing a cap on it.

I searched for other similar blasting situations and was fortunate to find an article by Ing. Bob de Raadt of the Netherlands where he provided some basic calculations and safety factors for the blasting of ice around dredges. This was in the *Proceedings of the Sixth Conference on Explosives and Blasting Techniques,* ISEE, 1980, pg 117.

Using some of de Raadt's calculations and increasing his safety factors to cover differences in my situation such as depth of charge, the fact that it was directly below the dredge and the age of the dredge, I determined that I could probably safely detonate 2-1/2 lbs at 54 feet without damaging the hull. In order to increase the efficiency of the charge, however, I elected to fabricate a shaped charge. This also allowed me to reduce the weight to slightly less than 2 lbs. The product I selected, a Hercules' seismic dynamite (Vibrogel 3P), has a specific gravity of 1.43 g/cc and a velocity of 22,150 ft/sec which is reasonably close to the TNT on which de Raadt based his calculations. The product comes packed in a plastic cartridge from which I cut the threaded ends. I fabricated the shaped charge using a slightly modified piece of brass corner molding from the local hardware store. After inserting the molding, I removed the explosive from within its included angle. I provided for a proper offset to focus the energy, inserted a carefully located detonating cord pigtail and sealed the unit.

I then added iron tie wires for fastening the charge to the bucket. The tie wires were arranged so that the charge would readily assume a correct orientation when they were tightened. I also fabricated a dummy unit for diver training purposes.

We had the lead diver attach the dummy charge to the bucket on deck several times while blindfolded and wearing thick gloves. I made sure he understood the importance of fastening it in the right location and orientation. He would not be able to see through the muck and mud surrounding the bucket at depth, hence the need for him to know by feel where to place the charge. When we were satisfied that he could install it properly and after one side of the connecting ears on the selected bucket had been cut, we sent him down to fasten the shaped charge. I had marked the detonating cord down line for length so that I could determine that it was at the expected depth. After the diver was out of the water, the company officials wanted to shoot it immediately, but I insisted on waiting until the diver came out of the decompression chamber which was fastened to the deck. (I could probably live with sinking their dredge, but not with having the diver go down with it.) As a safety precaution, several large pumps were put in place inside the hull and men were stationed where they could inspect the interior of the hull immediately following the detonation.

After the diver was out of the decompression chamber and all personnel alerted, I attached an electric blasting cap to the cord, lowered it into the water and detonated it. The resounding thump on the hull resulted in a lot of big eyeballs on those persons on board, but the bucket line swung free and a cheer went up from the assembled company personnel, divers and dredge consultants. It had been several months since the dredge was free to move and their relief was evident. An inspection of the interior of the hull disclosed only one small leak around a bolt which was promptly fixed using their usual method. Although I was fairly confident in my calculations, there is always that nagging apprehension and I was finally able to breathe a sigh of relief too.

(As happens with a lot of projects, I have looked back on this one and realize that I didn't bill them nearly enough for the job I did nor for the risk involved.)

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As Paul Harvey said, "and now for the rest of the story." In early February of 2003, Tim Hurley e-mailed me with a link to a Sacramento Bee newspaper article. It seems that the unattended YCGF dredge #21 had sunk mysteriously in the early morning hours of Monday, January 27, 2003. It is believed to be lying on its side in 120 feet of water. Apparently it will not be raised in the foreseeable future as its sister dredge, YCGF #18, is being brought back from Bolivia to replace it. And now you know the rest of the story.....

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(Author's note: For a more recent update, a few years later a contractor was brought in and managed to salvage the remains of YCGF dredge #21. Its current status is not known.)