Application of advanced fishing techniques

A.C.G. Nagelhout, T.E. Esser, M. Jongsma, T.W. Bakker

Well Engineering Partners B.V.
Tynaarlose straat 68, 9481 AE Vries, The Netherlands

This paper describes how a complex fishing job was carried out using a crane, Coiled Tubing, a newly designed fishing tool and a floating mud cap.

Introduction

NEDMAG INDUSTRIES Mining & Manufacturing produces magnesium chloride in the northwestern part of The Netherlands. Presently, only four out of NEDMAG's ten (operating) caverns produce bischofitic brine with a total production capacity of 100 m^3/hour. The other producing wells yield lower grade carnallitic brine from the carnallite deposits on top of the bischofite.

Each well is completed with a fresh water injection and brine production tubing. Inside the production tubing a dilution tubing is hung off. Into the annulus of the dilution and production tubing, fresh water is injected to dilute the produced brine in order to prevent crystallisation.

Starting 1995, the dilution tubing in wells TR-7 and TR-8 disintegrated and fell down in pieces of different lengths. Both wells were only completed in 1991.
The jointed 2 3/8" dilution tubing has flush connections (Atlas Bradford FL4-S) to minimise annular friction losses due to the narrow clearance. Over the years the annulus clogged up due to deposition of fines and probably in combination with corrosive products. Even after occasional acid treatments, the problem persisted.

Due to the limited effect of having a too shallow dilution point, with low injectivity, and because the fallen down pieces of tubing formed flow restrictions, a clear need existed to remove the segmented dilution tubing from both wells. The fishing operation for both wells took place in April and May 1999.

Approach

A dedicated team of petroleum engineers and workover specialist was formed in January 1999 to carefully investigate the situation in both wells and to assess the different options on how to retrieve the segmented and damaged tubing pieces. From an operator's point of view, it was essential that the production point remained where it was because of the specific high quality of the bischofite layers currently being mined. Pulling out the complete production tubing was not an option since that would imply an extensive workover operation while using heavy equipment with the likelihood of encountering numerous problems and risking loosing the productive zones. The strategy therefore was to fish the dilution tubing and to use cost effective and fit for purpose equipment and tools.

Initial situation

TR-8

From its original length, 1755 m, only 128 m hung underneath the hanger, see also figure 1.

The rest was fallen down, presumably into 5 different pieces, some pipe ends for several centimeters wedged into each other. The fact that tubing ends were slit into each other was established by downhole camera footage in 1997, until a depth of 1365 m. Afterwards, a tubing length of 1075 meter fell down.

TR-7

Initially, 1712 m 2 3/8" dilution tubing was hung off, inside the 3 ½" production tubing. The production point is at 1908 mAH. Wireline measurements showed that 1005 meter was still attached to the hanger.

Well control

Closed in well head pressures are approx. 100 bar. Because fallen tubing was wedged several centimeters into each other, bridge plugs could not be run through. In addition, the caverns could not be bled off for operational reasons, therefore another method had to be found to remove the pipe open ended. The found solution was to use a floating mudcap, i.e. to pump heavy mud (density s.g. 2.0) into the production tubing until the wellhead pressure was reduced to atmospheric. Laboratory tests were performed to ensure that the mud did not settle out as a function of time and temperature. The base fluid of the mud was carnalitic brine with barites added (1,35 kg/l) and polymers to enhance its carrying capacity (3,5 g/l).

If during the fishing operation the well would start to flow, the well would be closed in using BOP's and stabbing valve and mud would be bullheaded until the well became under control again. With this system of primary and secondary barriers, well control could be achieved under all circumstances.

Crane

The approach to remove the hanger and attached tubing was by using a mobile crane. Once the hanger was freed, tubing would be pulled out to maximum length, hung off in a slipbowl and laid down.

Coiled tubing

Essential for choosing the right equipment was that it should allow for running through the 2 3/8" tubing with a fishing tool, so to free stuck tubing. Since segments of tubing had fallen, the pulling strength of the couplings was assumed to be greatly reduced. Downhole video footage showed that tubing was separated at connections and that tubing ends were wedged into each other. If a stuck tubing length would be pulled at, the weakened connections could give away leading to numerous roundtrips.

The only equipment available with a work string which could pass this small sized tubing was Coiled Tubing (CT). The beneficial advantage of CT is its relatively high tripping speed, but a disadvantage is its inherent limited downhole pulling capacity, i.e. 45 klbs for a 1.5"coil.

Fishing tools

To fish the 2 3/8" tubing, a special flowrelease spear was designed. This spear was made to pass through the tubing while an abrasive roto-cutter was attached to its bottom.

The advantage of this set-up is that tubing could be cut if stuck.

Crane assisted operation

Used equipment included BOP's (5 1/8") with 2 3/8" Rams, support frames and work platform, slipbowl with slips and pipe clamps, 90 T crane, pump and tanks.

In many cases, corrosion and erosion weakened the flush connections. At the outside of the top section, the tubing was covered with a thick layer of deposits.

The floating mudcap worked although it remained stable for only several hours. Apparently, the interface between the mudcap and brine was not stable enough since lighter brine percolates upward leading to a reduction of the net density of the mudcap. When the well came in, the BOP's had to be closed. New mud was then pumped to regain well control. Later, more polymer was added to the mud (up to 7 g/l) which significantly improved the stability of the mudcap.

Coiled tubing fishing operation

In addition to the crane assisted operation other equipment used was a riser, CT injector (100 klbs pull) and reel with 1.5" coiled tubing and CT BOP's (1.5" Rams).

The followed fishing tactic was to locate top fish, to enter the fish with the spear until hold up, pull up 2 meter, set the spear, check if fish is stuck by pulling up, set down, release spear, set spear at top of fish and pull fish out of hole. Once the fish was hung off in the slip Rams, the well was killed and the fish removed by crane.

One of the problems encountered was that the inside of the tubing was eroded. The original ID of the 2 3/8" tubing was 48.7 mm but the measured ID from the bottom of the first fish was 53.2 mm. This piece of pipe came from a depth of 1540 m, which was 500 meter below the last dilution point. Apparently, non-diluted brine has an erosive effect on tubing.
Another complication was that with increasing depth, retrieved tubing was more split from initially ca. 20 cm to 130 cm (figure 3).

Because in TR-8 a single piece of tubing with a length of over 1075 m had dropped almost 500 meter on top of other pieces, the situation was far worse than in TR-7.
This long fish was first retrieved from TR-8. Its underside was split over 50 cm.
Next fishes consisted of just single lengths, or worse, of joints wedged completely into each other. Fishing small lengths was complicated by the fact that their weight was negligible compared to the string weight of the coil.

In some cases, tubing which was wedged into each other was strongly eroded. This resulted in pipe halves split over their entire length with wall thickness reduced to almost nothing. The halves sat around other lengths of tubing. In some cases four (!) pipes were found to be wedged into each other over a distance of several meters. See figure 2.
After the last fish was removed, a lead impression block (LIB) was run (69 mm) on wireline in both wells to check if the 3 ½" was empty until the XN-nipple. Running a smaller LIB (32 mm), which passed the XN-nipple and stood up at previously identified hold up depths, followed this.

In total 18 fishes were retrieved from both wells needing 50 roundtrips.

Conclusions
The approach of forming a dedicated, multi-skilled team to tackle the difficulties and to select fit for purpose equipment resulted into a successful and cost effective fishing operation.

Using advanced techniques such as newly designed fishing tool and floating mud cap made it possible to fish severely damaged tubing from a controlled well.

Acknowledgements
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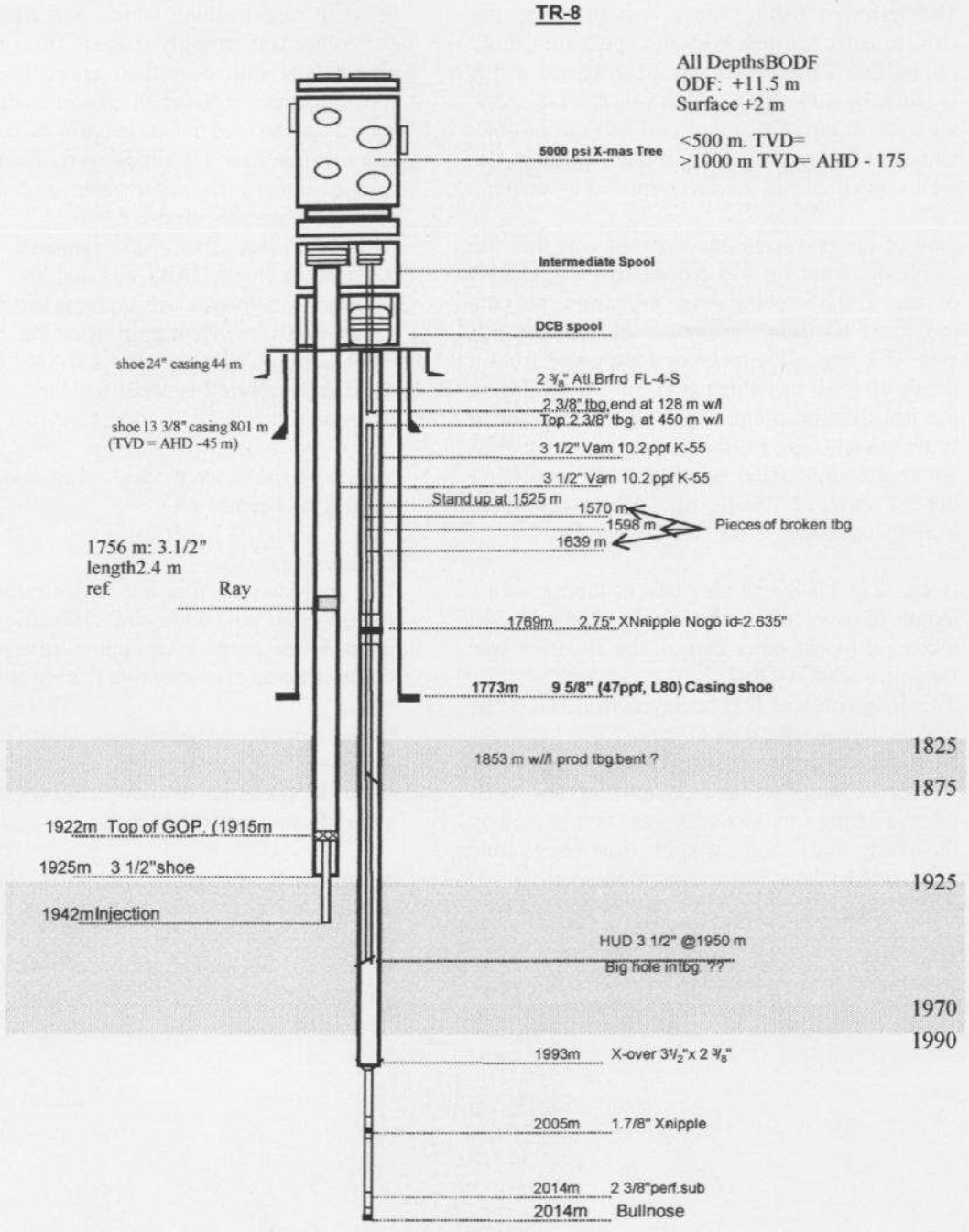

Figure 1. Well schematic of TR-8 before fishing.

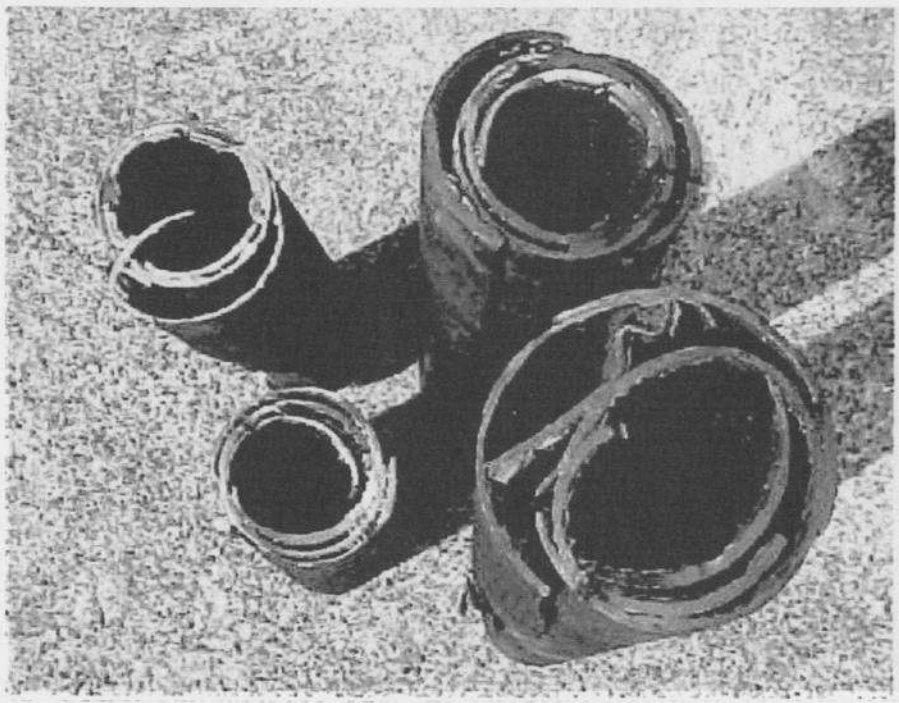

Figure 2. Cross-sections of severaledged and split fishes.

Figure 3. Typical bottom side of retrieved fish.