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A SHAPED CHARGE SYSTEM FOR WELL CASING PERFORATING

By

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Equipment & Instrumentation
Chemical Effluents Technology
CHEMICAL RESEARCH & DEVELOPMENT OPERATION

October 6, 1958

Hanford Laboratories Operation

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Richland, Washington

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RICHLAND, WASHINGTON

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A SHAPED CHARGE SYSTEM FOR WELL CASING PERFORATING

INTRODUCTION

Water wells drilled in the Hanford Works area for water quality monitoring, water level determination and geologic information demand use of steel casing. This casing is required due to the inability of the unconsolidated sediments penetrated by the well to stand without support. It is obvious that openings in the casing must be provided to permit free communication with the water bearing formation if the well is to be useful for water quality determination, aquifer testing and water level information.

Openings (perforations) may be placed in a well casing in a number of different ways. Three methods are used rather widely. These are: (1) knife perforator; (2) jet perforator; (3) gun or bullet perforator. The knife perforator (Mills) is probably the most widely used of several mechanical methods and is the only method which has been used previously at Hanford. This device tears a narrow triangular slot in the casing through action of the drilling machine cable pulling upward on a sharpened steel blade pivoted and supported in such a way that the blade is forced through the casing. The Mills perforator makes only one perforation at a time, thus perforating a casing extensively by this means is laborious and time consuming. Quality of the perforations may be poor due to dull or broken blades. The Mills perforator requires use of the drilling rig or other heavy duty winching and hoisting equipment. Another type of perforator is the bullet or gun perforator used primarily for casing and formation perforation in oil well completion. In this method, a steel projectile is fired through the casing by a charge of gunpowder. The gun chambers are so designed that a number of charges may be placed in a carrier and fired simultaneously, thus perforating a long section of the well. The carriers are generally loaded with gun chambers in the shop prior to perforating a well, therefore only a short time is needed to perforate the well in the field. The carriers are lowered in the well, the charge ignited and the carriers removed from the well. The jet perforator utilizes the high speed gas jet from an exploding shaped charge to perforate the well casing and surrounding formation; there is no 'projectile'. The arrangement of components is practically the same as the bullet perforator, with shaped charges replacing the gun chambers. The charges are fired by a length of primacord placed through the center of the shaped charges. The primacord is detonated by an electric blasting cap.

All of the project wells were originally perforated by the Mills knife method. Recent indications are that the perforations in many of the older wells are partially plugged and in poor condition. It was also recognized that most of the wells did not contain sufficient open casing area to permit use of certain aquifer testing methods. Investigations were made to determine the advantages of the shaped charge method for re-perforating these wells.

SUMMARY

A shaped charge system originally designed for oil well aquifer monitoring was adapted for non-routine re-perforating of Hanford water wells. Tempro shaped charges developed by Jet Research Center, Arlington, Texas are utilized. The

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Each plane of charges has four charges arranged in two pairs and pressed into opposite ends of a steel tube (primary tube), and two charges pressed into separate smaller tubes (secondary charges) near cone-shaped cut ties and facing the center of the well to mate with a corresponding conical depression drilled at right angles to the axis in the primary charge. This is shown in the photograph accompanying the diagram. A hole drilled perpendicular to the primary charge axis and on the symmetrical centerline accommodated the primer of the burning star detonating the charges. The primer was made of ball bearing pressure in the inward pointing ends of all four charges of the group. The six charges of the detonating cup at the top of the barriers caused the pressure to be transmitted to the four detonators and the end of the tunnel. From the center of the tunnel, a small hole for sensitive explosive was drilled.

The structure which I built and which I have many times seen well built is a parallel-sided timber with a deep channel to run in the water and tapered up at the ends and a deep channel on each side of the channel in the center. The channel is covered by a board and put in place and water poured in a channel and is taken to the upper end of the position. The channel is 12" wide and 12" deep and the water will be kept in a channel and the first part of the water will be in the middle of the channel and the water will be in the middle of the channel around the water and the water will be in the middle of the channel.

[illegible]

Background:

Time required to perforate a well using four carriers (256 perforations) is about 8 man hours. This includes loading the carriers, transportation to well site, assembling, perforating, dis-assembling and cleaning equipment. Cost of expendable equipment is about \$1.52 per perforation. Direct comparison with cost of the Mills method is rather difficult. The Mills method may cost as little as \$0.75 per perforation if the drill rig is already set up at the well site. At least 8 man hours are generally required just to move to the site and set up the drilling machine if it is desired to re-perforate a well. For non-routine re-perforating where speed, positive perforation, high density perforation and use of light weight hoisting equipment are desired, the shaped charge method is better than the knife method.

A number of tests were performed to determine the effectiveness of well re-perforation. The rate and final extent of water level lowering in a well being pumped (drawdown) is caused by two interactions, actual lowering of the aquifer water level, which is a function of soil permeability, and by entrance or friction loss due to limited open area of the well. With a high performance aquifer and an inefficient well (poor access to the formation), a large enough quantity of water often cannot be pumped from a well to give adequate aquifer evaluation data. Well efficiency data can be obtained from well step-drawdown tests. Figures 4 and 5 show data obtained from step-drawdown tests run on two project wells before and after re-perforation. The tests were run by W. H. Bierschenk, Geochemical and Geophysical Research Operation. Well pumping rate is plotted against drawdown in water level due to well entrance loss. Well S 8-19 (Figure 4), drilled about ten years ago, is one of the older project wells. This well was initially perforated with a Mills perforator and probably contains four perforations per round with one round per foot. Well loss caused 22' of drawdown at a pumping rate of 100 gpm. A well in such condition has little utility for ground-water monitoring or aquifer testing purposes. The well was re-perforated by 192 shaped charges. As a result, drawdown due to entrance loss was only 0.6 ft. at 100 gpm and 9.6 ft. at 400 gpm. Well 26-15 is a new well, but the number of perforations (two per foot) is inadequate. Drawdown due to well loss was 14.4 ft. at 400 gpm pumping rate. As shown in Figure 5, after re-perforating with 96 charges, entrance loss drawdown was only 1.9 ft., graphically showing the increased well efficiency.

SAFETY CONSIDERATIONS

With any technique utilizing explosives, there exists a serious-accident potential. Therefore, the probability of any such accident occurring must be kept vanishingly small. This is achieved by examining each step in the operation to be certain that no mistakes are being made. Actually, most of the explosives used in shaped charge perforating are safe to ordinary handling. The shaped charges are protected by their steel case. The RDX used in the charges is so insensitive that shock from dropping, heat from fire and friction and from crushing will not cause detonation. Likewise, the PETN primacord will burn without detonating and it will safely absorb shock from a blow. The electric blasting caps are the only sensitive explosive used with this system. They contain a base load of PETN or RDX and a priming load of lead azide which is relatively sensitive. They will explode by being crushed or heated and must be protected from such treatment.

A number of precautions are taken in storing, handling and assembling the explosive components. The explosives are stored in concrete magazines, the blasting caps are stored separately from the high explosives. The caps and high explosives

are also transported in separate vehicles. The cap log wires are shunted at all times until they are placed in the cable head prior to perforating. The wire line and shooting line leads are shorted together; the truck and wire line grounded to the well casing, and the setup tested for stray electrical currents before the blasting cap is placed in the cable head. The cap is not connected if a stray current of more than 20 ma is encountered. Radio transmitter operation is not permitted near the well site during perforating, although it is highly improbable that the caps used in this application would be discharged by radio frequency energy. The assembled carrier is placed in the well as soon as possible after the cable head is connected. Personnel are clear of the carrier insofar as possible during the hoisting and lowering operation. Also, circuit and cap continuity tests are not made until the carrier is safely in the well. All procedures have been checked by an engineer from Jet Research Center, Inc., and by plant safety personnel.

CONCLUSION

The jet method of perforating standard 8" steel casing in project wells selected for testing has been employed with success in many wells to date. The method permits re-conditioning older wells whose original perforations have become closed, without the need of heavy well-drilling equipment. Other advantages include more accurate positioning of perforations in the well casing and relatively low cost. Some difficulty with the thin wall brittle Kal-Well casing may be resolved with lighter charges or by employing fewer charges per shot. Safety requirements have been established and are carefully followed.

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Sections Showing Placement of Charges

FIGURE 1
SHAPED CHARGE PERFORATORS

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FIGURE 2
ASSEMBLED CARRIER READY TO BE PLACED IN A WELL

FIGURE 3
PERFORATED TEST SECTION OF CASING

FIGURE 4
WELL LOSS DATA FOR WELL S 8-19

FIGURE 5
WELL LOSS DATA FOR WELL 26-15

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