A CASE STUDY: *Halliburton developed a more efficient way to recomplete heavy oil wells in Canada*

Canadian Natural Resources increased production with novel Halliburton re-perforation method

Halliburton recompleted declining wells using extended delay fuses with jointed pipe, increasing production faster and saving money

OVERVIEW

Canadian Natural Resources Limited (CNRL), one of the largest Canadian-based oil and gas producers, used cyclic steam stimulation for heavy oil production in some of its wells. Over time, production declined due to scaling over their perforations. Normally, single-trip TCP or acidizing would be used to remedy this problem. However, both posed technical and economic challenges due to reservoir heat.

CNRL turned to Halliburton to help find an efficient, cost-effective solution. Halliburton recommended the use of time-delay fuses with jointed pipe to help re-perforate the wells and successfully implemented this technique for the first time ever. CNRL used it on several wells and, once the technique was perfected, saved up to seven days of rigtime, a 78 percent reduction.

CHALLENGE	SOLUTION
Deploy delayed fuses with jointed pipe Delayed fuses are typically used with *coiled tubing,* but due to the high temperatures of the well, special surface equipment would be required, making it less cost-effective. But using delayed fuses with *jointed pipe* meant workers needed to pull pipe quickly before the next gun went off.	**Defined process and collaboration** Halliburton and CNRL worked together to establish a well-defined process, thoroughly diagrammed the job beforehand, established clear procedures and kept lines of communication open. Once the process began, workers efficiently pulled the jointed pipe out without complications.
Reduce wellbore temperature Well temperatures ranged between 175°-190°C (347°-374°F). These high temperatures reduced the window of effectiveness for the explosives to only four to six hours. Therefore, Halliburton needed to reduce the wellbore temperature to increase time available for perforating.	**Hot spots found with logging and wellbore cooled** Halliburton conducted temperature logging beforehand to locate hot spots. Halliburton then flushed cold water through the annulus during the operation, reducing well temperatures enough to increase the time available for perforating.
Higher temperatures reduced time between fuses Normally delay fuses have a maximum of *six* minutes, but high temperatures reduced that to as little as four minutes. That severely limited the amount of time workers could safely pull the jointed pipe out before the next section of the well could be perforated.	**Tandem fuses doubled safety margin** Halliburton linked two delay fuses together, increasing the time between explosions to a maximum of *twelve* minutes. This extra time allowed workers to safely pull and remove the joints necessary to get to the next zone. In some cases three delay fuses were used in tandem to pull twenty joints.

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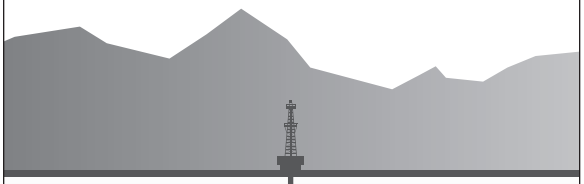

DELAY FUSES & MORE GUNS = RIGTIME SAVINGS

Halliburton experimented to find the maximum number of perforating guns that could be used safely in one trip with jointed pipe and fuse limitations.

Halliburton began with two guns per run, then went to six, nine, and eventually 12, the current limit for safe operations.

This marked the first time delay fuses and jointed pipe were used for this application. This innovative approach enabled CNRL to resume production faster and recomplete more wells. CNRL has committed to at least 30 more wells with this same process.

FIRST TIME PERFORATING USING DELAY FUSES WITH JOINTED PIPE

CNRL needed to increase production in heavy oil wells where temperatures ranged from 175°-190°C (347°-374°F). Acidizing does not work well at these temperatures and cooling down the reservoir would have been too expensive and time consuming. CNRL chose Halliburton to re-perforate these wells using jointed pipe and timed-delay fuses to increase production.

Halliburton completed perforations in just two days instead of nine, saving CNRL a week of rigtime.

~~1 week~~ **2 DAYS**

78% REDUCTION IN RIG POSSESSION TIME

Solving challenges.™

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CNRL needed increased production from heavy oil wells

Canadian Natural Resources Limited, one of the largest oil and gas producers in Canada, operates thousands of heavy oil wells in the region. These wells are much different to produce than conventional wells. CNRL uses cyclic steam stimulation (CSS) to reduce the viscosity of the heavy oil, enabling it to flow to the surface. Due to the steam-generation costs associated with this process, maintaining production was vital to CNRL.

Production declines in several wells prompted CNRL to find a method to recomplete these wells. Downhole video technology showed scaling over the ports, preventing flow. One way to stimulate production involved acidizing, but downhole temperatures that reached 175°-190°C limited the effectiveness of the acid. To make the acid effective, CNRL would have had to wait for the reservoir to cool before acidizing, which could take considerable time, and then reheat the reservoir after the treatment. CNRL wanted a more cost-effective method to restore production and decided to re-perforate the sections.

Halliburton recommended unique perforation method

CNRL turned to Halliburton to re-perforate these wells. Halliburton began by deploying two perforating guns with limited charges. This method took nine days to perforate a well with 18 zones. To save time and money, Halliburton recommended a unique solution to CNRL. Instead of using just two guns, Halliburton proposed using extended delay fuses to fire several guns, enabling perforation of more zones in one trip. This method is typically used with coiled tubing, but would have required using special surface equipment to deal with the high well temperatures. Halliburton proposed using jointed pipe, which was already on-site and could tolerate well temperatures. CNRL liked this innovative approach because of the potential time and cost savings. This marked the first time this process was used with jointed pipe.

Precise timing needed to ensure effectiveness

Deploying extended delay fuses with jointed pipe was the first challenge Halliburton faced. There were only a few minutes between guns to bring the jointed pipe up to the surface. Halliburton and CNRL worked together to establish a well-defined process. The gun string would be built with delay fuses placed between each gun, enabling multiple zones to be perforated in a single deployment. Once the first gun is fired, crews pulled tubing joints to position the next gun over subsequent intervals. This process is repeated for the remaining zones. To achieve this objective, crews thoroughly diagrammed the job beforehand, established clear procedures and kept lines of communication open to ensure success. Once the process began, workers efficiently pulled the jointed pipe out without complications.

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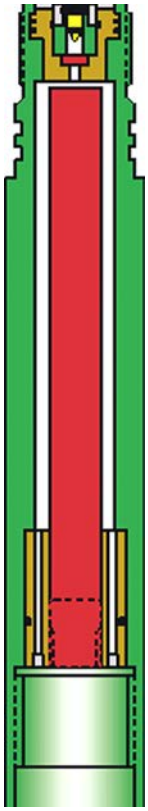

Temperature logging found hotspots in well

The high wellbore temperatures in these heavy oil wells reduced the window of effectiveness of the explosives. Normally, explosives could last downhole approximately 30 hours. But in these high temperatures, the explosives were only effective for four to six hours. Halliburton needed to reduce the wellbore temperature to increase the life span of the explosives. Halliburton conducted temperature logging beforehand to locate hot spots, develop a plan and anticipate conditions downhole. Halliburton also flushed cold water through the backside of the annulus during the operation, reducing well temperatures. This method increased operating time marginally.

Tandem fuses gave workers more time between explosions

The high temperatures of the well also reduced the extended delay fuse time from six minutes to as little as four minutes. That severely limited the amount of time workers could safely pull the jointed pipe out before the next scheduled detonation. Halliburton linked two delay fuses together, increasing the time between explosions to 12 minutes. In some cases three delay fuses were used. Even with that number reduced somewhat, workers could still safely pull and remove the joints necessary to get the guns to the next zone before the next explosion. But, the critical timing meant workers needed to be precise in the timing and amount of pipe pulled to the surface.

Delayed fuse application saved week of rigtime per well

Halliburton began testing this innovative approach with more guns to find the optimum number. With six guns, CNRL saved 50 percent of rigtime. Halliburton and CNRL then decided to increase the number again. On another well, Halliburton used nine guns, taking only two days to complete a job that once took nine. CNRL saved seven days of rigtime. This 78% reduction in rig possession time resulted in both rig cost savings and increased production. Because this method could work with high bottomhole temperatures, the reservoir did not have to be cooled down and reheated. This reduced the amount of steam and time needed to resume production.

The results of this unique application exceeded the expectations of CNRL. The efficiency enabled CNRL to get wells back into production much faster. CNRL was so impressed with the results, it committed to recompleting 30 wells with this method. CNRL also has increased the number of guns per trip to 12 and the number of zones to perforate to 25-30. This innovative process has applications for other heavy oil producers around the world.

"The time delays have worked very well. They cut our costs and increased our production."

Matt Russett,

Completions Supervisor Thermal, CNRL

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