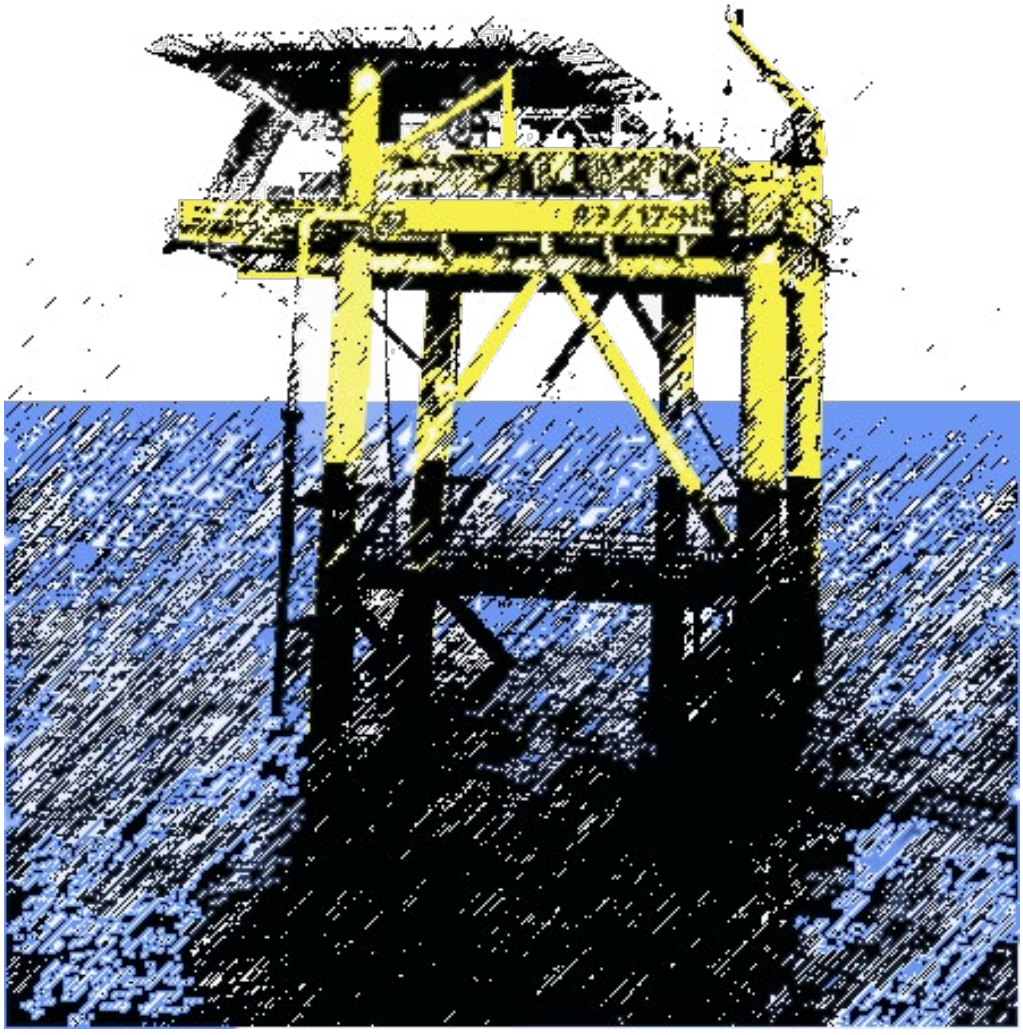
New Technology Concept

Thru-Tubing Cement Bond Logging
Before and After Cementation



OILFIELD INNOVATIONS

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Thru-Tubing Cement Bond Logging Before and After P&A Cementing

by Clint Smith[a] and Bruce Tunget[b]

Abstract

May companies advocate the requirements of cement bond logging and, during the Aberdeen OGA Hackathon in June 2016, ConocoPhillips stated in the end-of-the-day summary that through-tubing-logging was the "holy grail" needed for rigless abandonment.

Oilfield Innovations have patented a thru-tubing cement bond logging new technology usable before and after placing a thru-tubing cement P&A plug.

"*Catch-22*" for new technology companies comprises the members of the "group" of Oil and Gas Producers who do not invest in new technology and do not use new technology until it has already been used by another member of said "group" … which, effectively, prevents the development of new technology.

In our industry, developing new technology is very difficult to near impossible, which is why Oilfield Innovations have also patented the Figure 1 market for testing new technology in the relatively risk-free environment of a well where the reservoir has been isolated so that a well P&A can be used to develop new technology.

Producers own a well and its liabilities and, within regulatory requirements, can do as they wish; however, in their own self-interests and at no additional cost, Producers could allow Universities to work with Service Providers who wish to rent their partially abandoned wells for testing of new technology.

Like OGIC and OGTC matching funding, the rental of the partially abandoned well could fund University research to develop the through tubing logging before and after cementation described on the following pages and, thus, break through the "*Catch 22*" new technology barrier.

Spikes can connect tubing to casing to allow an array of cement bond logging transmitters and receivers of wavetrain acoustic signals to measure cement bonding before and after P&A plugging, wherein testing and refinement over time within partially plugged wells could develop the technology.

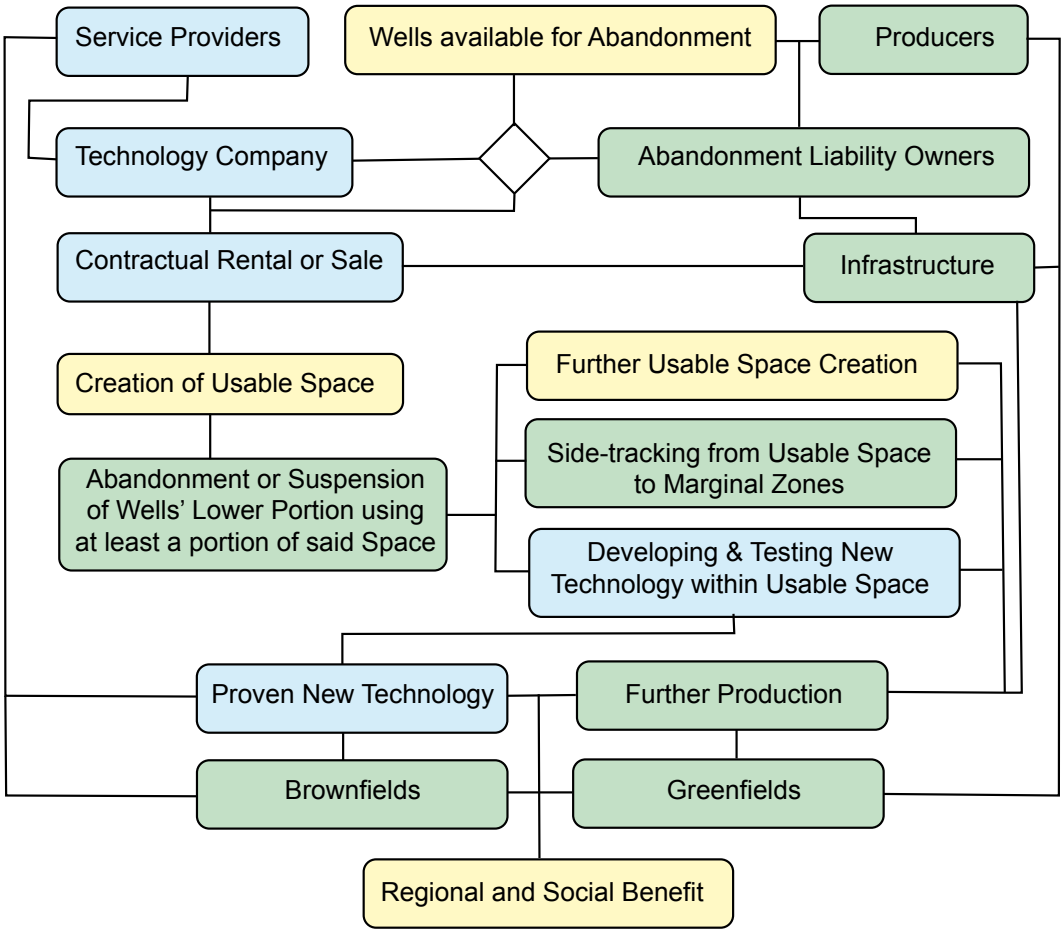

Figure 1 - UK or Scottish University Research Funding Patent

Thru-Tubing Logging before P&A Plugging

Current logging technology is not able to log through multiple casings (Moeinikia, 2014)[63] and the legal liability of potential P&A leakages drives a need to measure the quality of in situ cementation.

Vibration of unsecured tubing within casing prevents conventional cement bond logging tools from accurately sending and receiving acoustic pulses.

Securing the tubing by spiking it to the casing prevents such vibration and connects transmitters and receivers of acoustic logging signals with the casing to measure bonding of in-situ cementation.

Significant upside potential for a method of logging through tubing and/or multiple casings before setting a P&A plug is exemplified by industry's desire to leave the tubing in place, whereby if the results of logging through tubing showed poor or lacking cement the tooling could be pulled and a rigless repair carried out.

The left of Figure 2 shows the well bore before P&A begins, while the right side shows the installation of an array of logging tools using driven spikes to secure the tubing and engage the transmitters and receivers to the casing wall.

Driving spikes through the tubing using, for example, the Figure 5 Gator Perforator can mechanically secure the tubing and connect a logging tool to the casing to send and/or receive acoustic pulses and measure the casing's bond to in-situ cement.

An array of transmitters and receivers can be connected by and run on wire that can be used to transmit data and initiate, for example, an explosive charge that drives mechanical spikes through the tubing into the casing.

An array of sending and/or receiving tools connected to the spikes sends waves of acoustic signals, or wave-trains (Smolen, 1996)[132], through the tubing to vibrate the casing. Like conventional bond logging, attenuation of the acoustic pulse indicates that surrounding cementation and strata are bonded to the casing as shown in Figure 4.

Spacing of the logging tool spikes and configuring the array to send and receive acoustic wave-trains can be used to provide the coverage of conventional logging tools, which require movement.

Data transmission signals can be transmitted to surface through wire, memory gauge, fluids within the well or the tubing or casing walls extending to surface, after which the received data can be deciphered to measure the quality of in situ cement over a 100-ft (30m) tubular section.

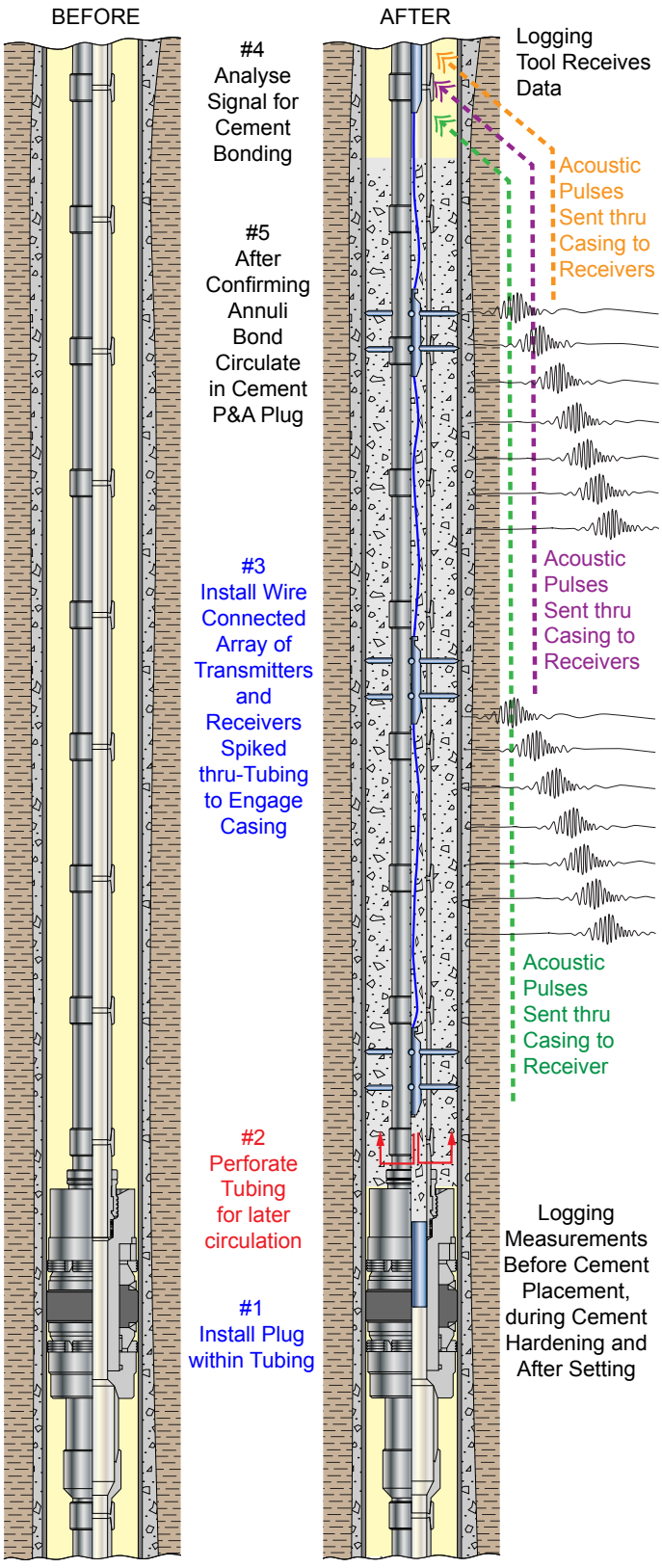

Figure 2 - Through Tubing Cement Bond Logging Rig-Equivalent Work-scope P&A Plugging

After analysing the data and confirming the bonding of cement to the casing, a cement plug could be circulated into the well using the in-situ tubing or, alternatively, the inner logging tools could be pulled, leaving the spikes, and a Perf

& Wash method could be used for repair. Alternatively, a rigless pulling and jacking unit could pull the tubing for conventional repair or casing milling with a drilling rig could be planned.

Logging after Placing a P&A Plug

The method can also be used for logging after placing P&A cement plugs, as shown in Figure 3, by measuring bond quality and sending a data transmission signal through the wall of the casing to surface or a cable connecting the cement embedded logging tool array to a retrievable memory gauge above the cement plug or to a transponder that sends data transmission signals through well fluids above the plug.

The method of confirming bonding after placing a P&A plug can be accompanied by calibrating in situ cement bonding measurements before placing the plug by either logging through a compaction or cross-cut window (see accompanying document) or through-tubing, as shown in Figure 2, with further measurements by an embedded array of logging tools after cement is placed to confirm the P&A plug itself was correctly placed.

Placing loggings tools in a compaction or cross cut window using an array of transmitters and receivers that can be engaged to the casing with spikes or gauge hangers to transmit and receive wave-train acoustic pulses through casing (see Figure 4) can measure bond quality after a repair and/or placement of the P&A plug, wherein data transmission signals can be sent from the in-situ array after cement has hardened.

Cement bond logging after placing a P&A plug can be used after cement repairs like Perf & Wash, Shred & Wash or more conventional perforating and squeezing of cement into annuli behind the casing to confirm that a repair was successful.

Accordingly, the legal liability for any future leakages from well abandonment can be avoided by measuring and proving that a good P&A plug was placed and subsequent leakages could only have been caused by natural forces.

Proving that an Operator fulfilled its legal "as-low-as-reasonably-practicable" requirement is important in subsea environments where future leakages can be visible as bubbles or slicks on the ocean surface and, also, in onshore fracked well P&A where proving that the well is not leaking into drinking water formations may be of critical importance.

Development Path

Obviously, cement bond logging is a complex topic and would take a number of years to perfect. Accordingly, the above described new technologies could be developed in conjunction with a University using the patented process described in Figure 1 for using well P&A for new technology development.

Oilfield Innovations can provide additional information on the possible development paths for our P&A technologies should the reader be interested.

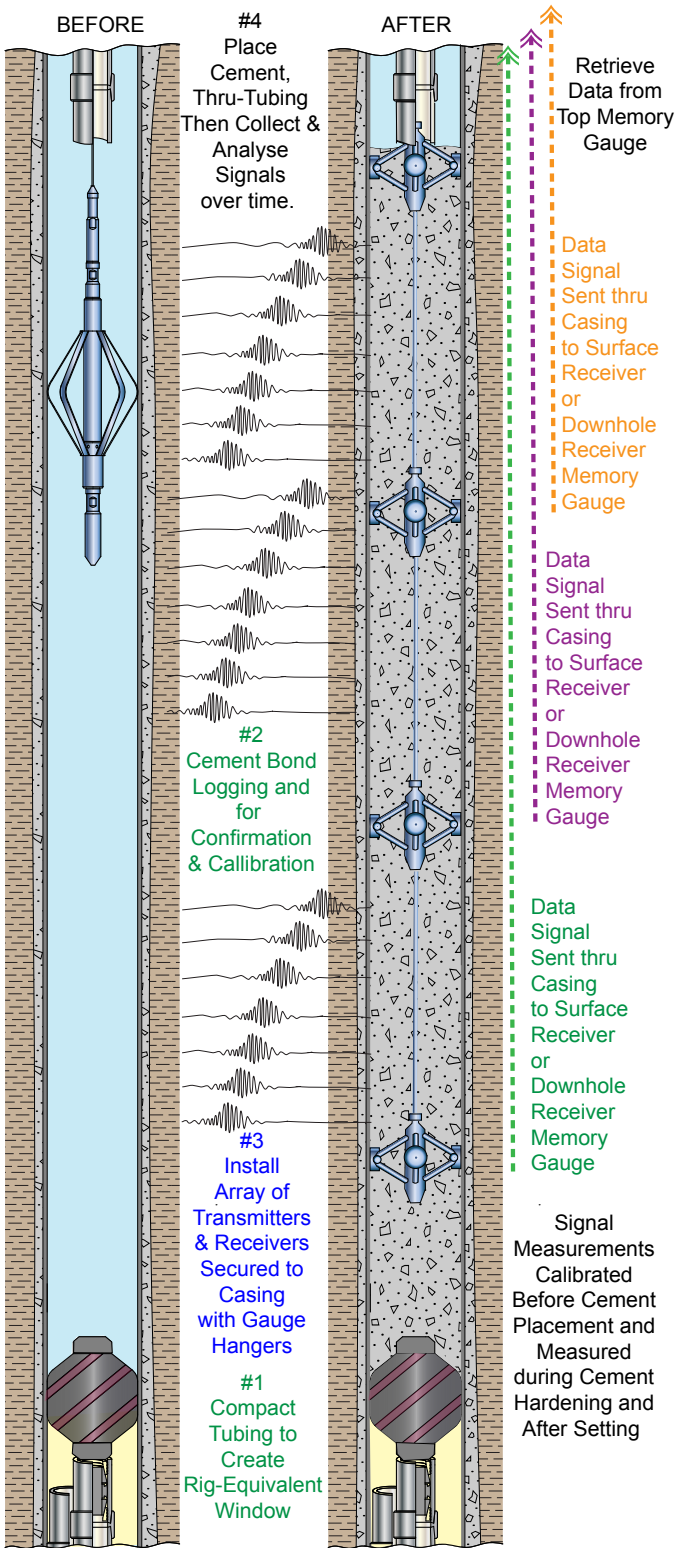

Figure 3 - Cement Bond Logging after Rig-Equivalent Work-scope P&A Plugging

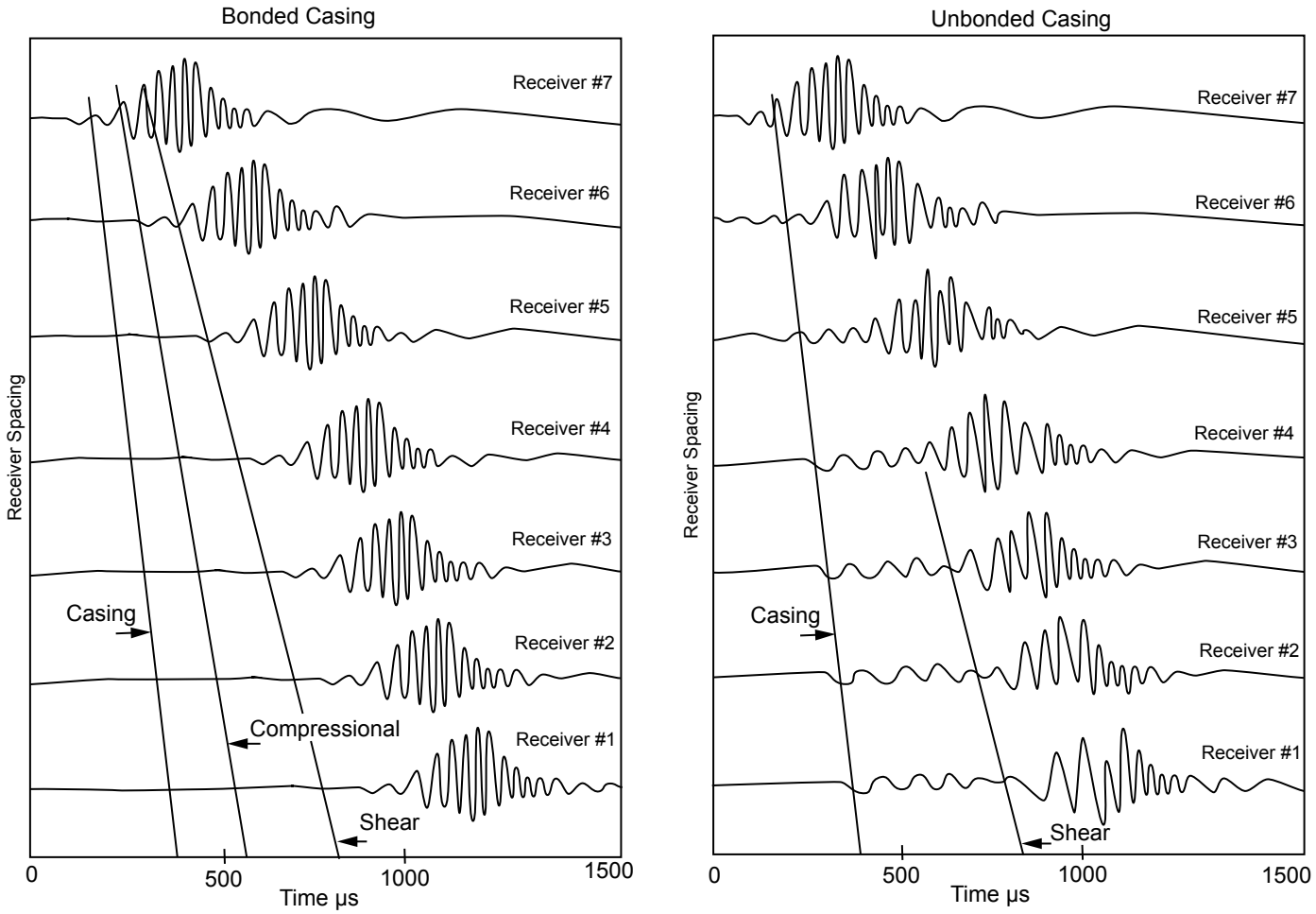

Figure 4- Wavetrain recorded at each receiver with an array type tool (Smolen, 1996)[132]

Further Information

The citations within this prospectus are part of our Universally Compliant Plug and Abandonment Prospectus on our website. Please see the citations numbers in that document. For additional information or further queries please contact Clint Smith or Bruce Tunget at the below email addresses.

Notes and references

[a] *Clint Smith is Professional Engineer in the State of Texas, began working in the Drilling, Intervention and Well Operations in 1978 and lives in Houston, Texas, USA; Curriculum Vitae (CV) available upon request; clint@oilfieldinnovations.com*

[b] *Bruce Tunget earned a PhD. and MSc in Mineral Economics and a BSc in Mineral Engineering from the Colorado School of Mines, is a Chartered Financial Analyst, began working in Drilling, Intervention and Abandonment Operations in 1982 and lives in Aberdeen, Scotland; Curriculum Vitae (CV) available upon request; bruce@oilfieldinnovations.com*

† Various photograph have been taken from the following cited references.

‡ Footnotes.

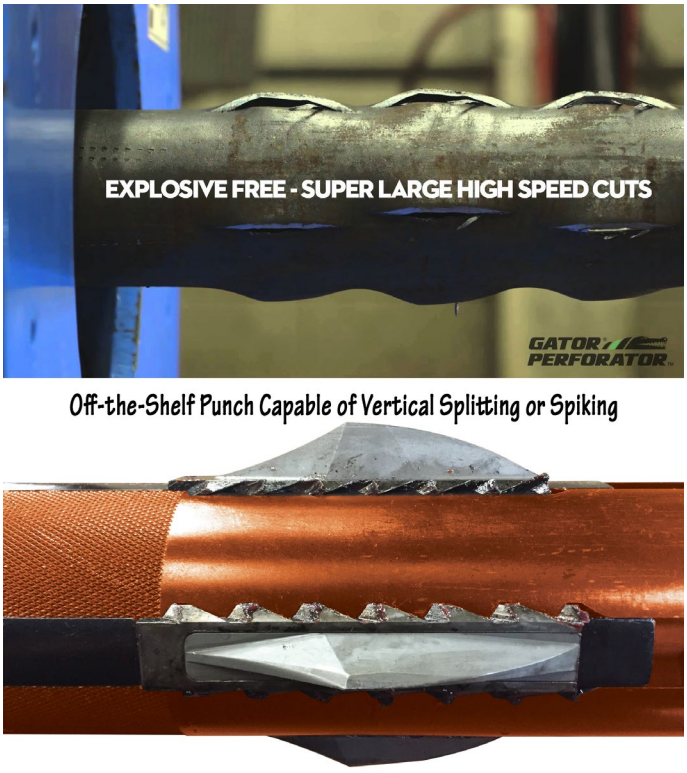

Figure 5 - Gator Perforator® (Source: Website)