

Peak Analysis for Cement Evaluation (PACE™) Service

ADVANCED CEMENT EVALUATION PROVIDING A MORE COMPLETE DESCRIPTION OF ANNULAR CONTENTS

OVERVIEW

The Halliburton Peak Analysis for Cement Evaluation (PACE™) service is an advanced waveform analysis that provides a more thorough investigation of the wellbore annular regions than previous methods. Extending beyond the casing-to-cement interface, details regarding cement-to-formation bonding character are investigated with increased detail. Understanding potential deep channeling may help prevent unwanted fluid production, misinterpretation of hydrocarbon volumetrics, and may lead to optimized reserves recovery.

The new PACE service is ideal for assessing the composition of annular contents from standard cement bond acoustic (CBL), as well as radial and segmented-type sensors. Additionally, LWD and longer-spaced openhole acoustic tools can be used for bond assessment purposes in casing above the primary openhole objectives. Data from any service provider may be used to provide a complete cement evaluation product.

The resulting answer product depicts multiple regions starting in the primary casing string, continuing within the annulus, and extend to the formation for a robust cement bond evaluation. These are typically presented as four sections in the ALLPLOT image in the PACE service log presentation. Radial or segmented bond tool processing provides a circumferentially oriented set of results or shells, giving more representative descriptions of annular contents and phase distribution.

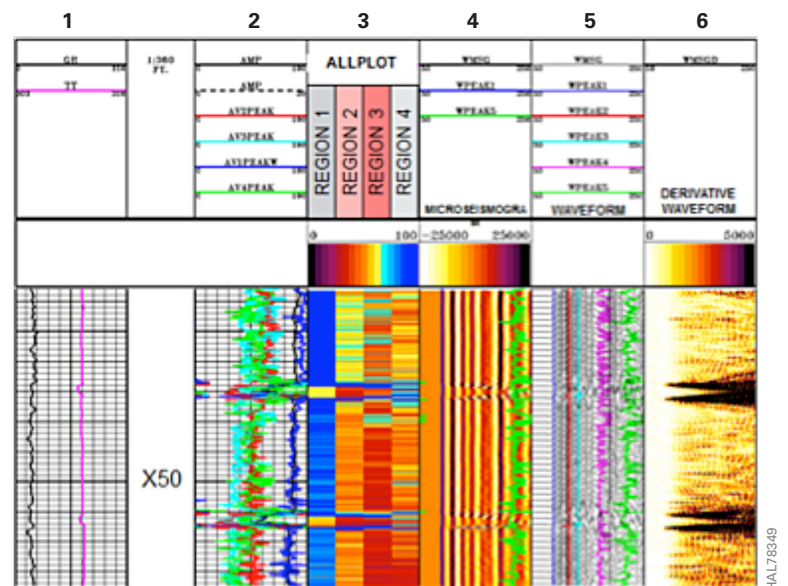
VALUE

- » More accurate description of cement bonding at multiple depths of investigation
- » Provides enhanced analysis of the cement-to-formation bonding that can be overlooked in standard cement evaluation methods

BENEFITS

- » Provides better decisions on squeeze cement requirements
- » Allows optimized production and reserves recovery

PACE Service Processed CBL Acoustic Waveform Composite



- 1) Track 1 presents depth correlation (GR) and quality control (TT)
- 2) Track 2 contains standard CBL pipe amplitude and relative bonding quality indicators from the individual PACE service regions providing a quick interpretation view of cement quality and placement
- 3) Track 3 shows the relative bonding quality of each of the regions that represent concentric shells extending outward from the primary casing
- 4) Track 4 includes the raw MSG refracted waveform (X-Z) and shows the beginning of region 1 (blue trace) and the ending of region 4 (green trace) covering the time-based acoustic waveform analysis
- 5) Track 5 presents the raw MSG waveform (X-Y) and includes the peak-based boundaries for the four PACE service regions
- 6) Track 6 displays the ACE derivative waveform, which can be used for micro-annulus detection where applied pressuring is not feasible, such as those encountered with open perforations in the evaluation interval

- » Complements the benefits provided from ACE™ advanced cement evaluation in complex cementing applications for all service providers of cement evaluation logging services
- » Reduces the customer's operational expenses and contributes to the bottom line by helping to eliminate unnecessary remedial cement operations

SEGMENTED PACE SERVICE SOLUTION OVERVIEW

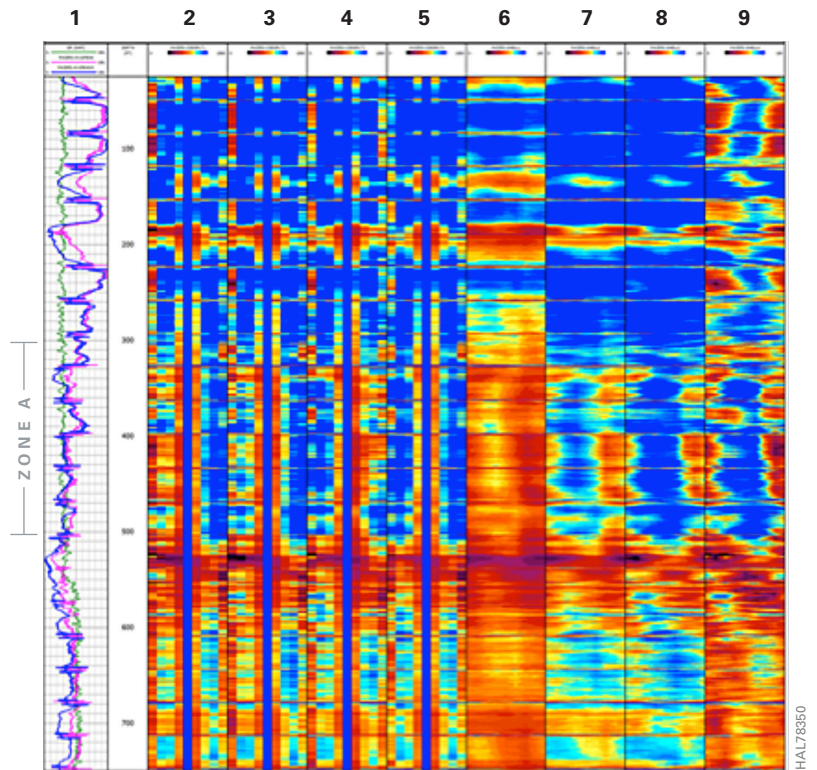
Segmented PACE service results demonstrate a more complete evaluation of radially segmented acoustic waveforms and provide details of the annular contents in an oriented concentric shell basis. This example demonstrates a cement-coated casing with degraded bonding deeper in the wellbore between the cement sheath and formation in the interval X300 to X500 (Zone A). Standard field log presentation leads to the interpretation that a good bond exists due to pipe amplitude responses in legacy interpretation methods in similar cases. This holds true as well in basic cement mapping techniques common to the industry.

With the PACE service method, the relative bonding evaluation is expanded to deeper depths of investigation than legacy interpretation methods. The displays in tracks 2 to 5 are slices through the wellbore at 45° circumferential spacing derived from segmented bond tool responses. The center of the individual tracks display the wellbore shaded in dark blue and show opposing sensor analysis for four regions in each individual measured sector direction. These cross-sectional views show the same four regions as a normal PACE service display with region 1 including nearest casing responses, while region 4 is further away, including the near-formation responses at the edges of the track.

The four tracks furthest to the right display circumferential shell cement mappings for four increasing depths of evaluation starting in track 6 representing the casing string of interest, which is region 1 of the segmented tracks 7, 8, and 9, and evaluate increasingly deeper positioned shells derived from the PACE service analysis.

As can be seen in these deeper shells in the interval X300 to X500 (Zone A), the cement bonding is not of the quality seen in the nearest shell against the inner casing. Here, the PACE service determines isolation issues not observed in other common cement evaluation techniques.

PACE Service Processed Segmented Acoustic Waveform



- 1) Track 1 presents depth correlation (GR) and average cement bond index results
- 2) Track 2 displays receivers 1 and 5 in a cross-wellbore slice display of the individual four PACE service regions
- 3) Track 3 displays receivers 2 and 6 in a cross-wellbore slice display of the individual four PACE service regions
- 4) Track 4 displays receivers 3 and 7 in a cross-wellbore slice display of the individual four PACE service regions
- 5) Track 5 displays receivers 4 and 8 in a cross-wellbore slice display of the individual four PACE service regions
- 6) Track 6 displays the innermost PACE service region 1 shell derived from all oriented receivers
- 7) Track 7 displays the second nearest PACE service region 2 derived from all oriented receivers
- 8) Track 8 displays the second furthest away PACE service region 3 derived from all oriented receivers
- 9) Track 9 displays the furthest away PACE service region 4 derived from all oriented receivers

For more information, contact your local Halliburton representative or visit us on the web at www.halliburton.com

Sales of Halliburton products and services will be in accord solely with the terms and conditions contained in the contract between Halliburton and the customer that is applicable to the sale.

H012427 2/17 © 2017 Halliburton. All Rights Reserved.