# Value Addition Using Cement Evaluation by Ultra Sonic Imaging Tool In Upper Assam Oil Fields

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## Summary

Primary objective of cement sheath evaluation logs is to determine whether the production, injection and other critical zones are hydraulically isolated. Many types of logs have been used to evaluate the placement of cement in the casing to formation annulus. Each logging tool has provided a significant advancement in the identification of cement placement and zonal isolation. During 1960s Cement Bond Log (CBL) was developed and in the 1980s Cement Evaluation Tool (CET) was introduced to measure the acoustic impedance of the material in contact with the outside of the casing.

The Ultra Sonic Imager (USI) tool, a second-generation tool, and uses the same basic measurement physics as the CET. The main improvements are in the signal processing for more accurate and consistent answer of acoustic impedance and the use of a single rotating transducer and receiver to provide complete casing coverage. Another improvement of the USI is the presentation of a color map, which allows the interpreter of the log to quickly identify the problems in the cement sheath. Since its introduction, USI tool has proved to be a superior cement evaluation tool that overcomes most of the problems found with the well bore constraints and interpretation of other cement bond logging tools.

Ultra Sonic Imaging Tool in combination with CBL has been used in few wells to evaluate cement behind casing in the Assam Oil fields. The importance of cement evaluation is very critical in these reservoirs as they are thin sand stone beds (< 7m.) separated by thin shale /clay beds (1-8m). Some times months of rig time is wasted without any injectivity resulting in futile cement squeeze jobs due to false prediction of poor isolation on CBL. Few case studies of USIT and CBL logs are presented in this paper. USI logged in Assam fields is discussed in this paper. USIT helped in determining the nature of cement behind the casing in the object of interest. It further helped in deciding the feasibility, validity and necessity of a cement squeeze. This turns out to be a cost saver by saving rig time and optimizing the oil production.

## Introduction

Oil & Natural Gas Corporation (INDIA) has drilled many wells for exploration and exploitation of hydrocarbon from shallow marine Upper Paleocene – Lower Eocene clastic reservoirs of Assam oil fields. The depth of wells is ranging from 2500-5500 meters. The thickness of upper Paleocene – lower Eocene formations ranges approximately 80 meters nearer to Himalayan foothills in North Bank to approximately 230 meters in the South Bank of Brahmputra . These formations contain oil & gas bearing sand reservoir particularly in South Bank. The reservoir consists of thin nature of reservoir, it is of utmost importance to critically evaluate the cement behind the casing, Asses the quality of isolation of Hydrocarbon bearing zones and analyze the production behavior of the wells. Many types of logs have been used to evaluate the placement of cement in the casing to formation annulus. Each logging tool has provided a significant advancement in the identification of cement placement and zonal isolation.

Temperature log was in use to detect the cement top and Cement bond log (CBL) is in use to evaluate the cement behind the casing The CBL can give an overall idea about cement to formation and casing to cement bond. USIT provides azimuthally image of the cement around the casing. It gives detailed map of material distribution: solid, gas, and debonded cement.

## Method

The Ultra Sonic Imager (USI) tool is a wire line tool for cement evaluation and corrosion detection by ultrasonic principle. A rotating ultrasonic transducer gives full coverage of the casing at high resolution. The principle is based on making a small area of the casing resonate in thickness-mode. The transducer excites the casing resonance by repeatedly emitting short pulses of ultrasound at normal incidence to the casing, and the same transducer detects the echoes reflected from the casing. Analysis of the echo gives four measurements: internal radius, rugosity, casing thickness and cement acoustic impedance. The cement impedance indicates cement quality, its presence and placement. Good cement has higher impedance (as it causes a rapid damping of the resonance) than poor cement or drilling fluids.

USIT enables two measurements: i. Cement evaluation ii. Casing evaluation - corrosion and wear. Field results show that channeling, contaminated cement, light cement and gas can be diagnosed and that external hardware such as centralizers can be detected. The corrosion measurements can detect mechanical wear, corrosion and deposits.

## USIT Presentations and images

Several presentations are available to address specific applications. The color red indicates negative conditions. For example. Red curves represent outputs for tool eccentering, minimum amplitude, maximum internal radius, minimum thickness, gas index, and so on. Increasing intensity of red in the images represents increasingly negative conditions such as low amplitude, metal loss and the presence of gas in the cement map
The following log presentations are available from USI recording,

## Fluid properties presentation

1. Log of fluid velocity (FVEL), acoustic impedance of fluid (AIBK) and thickness of reference calibrator plate (THBK).
2. Visual indicator from which to select cement logs parameters.

## Cement presentations

1. Cement measurement and lateral casing profile.
2. Synthetic bond index and minimum, maximum and average values of acoustic impedance
3. Two cement images- one with and one without impedance thresholds

## Corrosion presentation

1 Casing profile
2 Casing reflectivity (AWBK)
3 Casing internal check (IRBK)
4 Thickness image (THBK)
5 Internal and external radii curves.
Average and maximum thickness curves

## Acoustic impedance images

Two acoustic impedance images are presented. One on linear scale and one with thresholds. Corresponding to the acoustic impedance of gas and mud.

**Linear color scale**
White < 0.5 Mrayl
Color from yellow to brown represent steps of 0.5 Mrayl
Black < 8Mrayl

**With thresholds**
Red < 0.3 Mrayl(acoustic impedance indicates gas)
Blue < 2.6 Mrayl (acoustic impedance indicates fluid)
Yellow <3 Mrayl

Color from yellow to brown represent steps of 0.5 Mrayl and indicate solids (usually cement)
Black < 8Mrayl

These thresholds can be varied for conditions such as light cement (where lower acoustic impedance indicates lower fluid cutoff) and heavy mud (with a higher fluid threshold cutoff)

## Amplitude images

The amplitude image, derived from the amplitude of the main echo of each waveform, represents the reflectivity of the internal surface of the casing. The image is normalized with respect to the maximum value at a given depth, and all points are presented in terms of attenuation from the maximum amplitude at that depth. Normalized minimum amplitude (AWMN) and maximum amplitude (AWMX) curves are plotted.

**Linear color scale**

1. Black = low signal (-6 db)
2. Color from dark red to white represent steps of 0.5db.
3. White + high signal (0 db)

## Diagnostic images

**Internal radius images**

The internal radius Image shows the variations around IRAV the average radius at each depth. Two color scales are used—blue to white for internal radii less than IRAV and white to red for internal radii greater than IRAV. Each color step represents 0.008 in

### Thickness images

The thickness image shoes the variations around THAV the average value of the thickness at each depth. Two color scales are used—red to white for thickness less than THAV and White to blue for thickness greater than THAV

### Alternate images

that plot internal radius and thickness versus API specifications of the casing are available

## USIT advantages over CBL-VDL

1. USIT provides azimuthal image of the cement around the casing.

   It gives detailed map of material distribution: solid, liquid, gas and debonded cement. It detects narrow channels. (1.2") With sonic tools such as in CBL-VDL logs, lack of azimuthal resolution makes it difficult to distinguish channeling from poor cement
2. USIT not only evaluates Cement quality but also Corrosion if run in corrosion mode.
3. Easier interpretation and less ambiguity than CBL-VDL. Some of the cases are:
   - CBL does not distinguish between free gas and free liquid present behind the casing. It reads high for both the cases. USIT clearly distinguish between the two.
   - CBL shows poor bond in the presence of liquid micro annulus. USIT Microdebonding* logic clearly distinguishes microdebonded cement from poor bond.

   Micro annulus removes the shear coupling and gives a response similar to fluid behind the casing. Reflections from hard formations or second casing strings and early arrivals through "fast" formation pose additional problems and often invalidate the measurements.
4. Casing inspection in the same pass. USIT provides extra information about the casing geometry for corrosion and damage evaluation.

The ultrasonic pulse-echo method of logging was developed to combat the limitations of the sonic method. For the purpose of cement evaluation it is recommended to run USIT along with other sonic tools the data from which complements, strengthens and under certain circumstances is the only way to identify cement quality in the well.

## Discussions of field examples

Some examples of USIT logged in Assam oil fields have been provided below which helped in assessing the performance of this tool in multi faceted logging environments. The objective is to select an interval, based on cement evaluation from USIT and CBL-VDL, that is hydraulically isolated in the formation and which will support the formation fluid production in respective wells.

### WELL NO. G- A (fig-1)

Well was drilled as a development well with an objective to test Miocene prospects. After lowering final casing (5.5inch). CBL was recorded, CBL amplitude was varying between 18 mV to 60 mV indicating bad cement, USIT was run to check the cement integrity, As the CBL shows poor bond in the presence of liquid micro annulus. USIT microdebonding logic clearly distinguishes micro bonded cement from poor bond, and it was observed that the recommended zone was isolated from the water-bearing zone.

It was decided not to do a cement squeeze job and go ahead with the perforation plan and test the recommended zone after six months. Rate of liquid flow increased with 14% USIT helped in determining the nature of cement behind the casing in the object of interest. The perforated object flowed oil initially @ 95 cubic meters per day with 0.5 % water cut. Cost of well was recovered by six-month production.

By interpreting the USIT data it was decided not to go for cement squeeze. , Minimum nine rig days, cost of logging operations, secondary cement job were saved.

### WELL NO. R -B (fig-2)

Well was drilled as a development well for exploitation from Miocene prospects. After final casing CBL –VDL recorded which showed poor cement. Block cement was carried out and USIT with CBL-VDL was

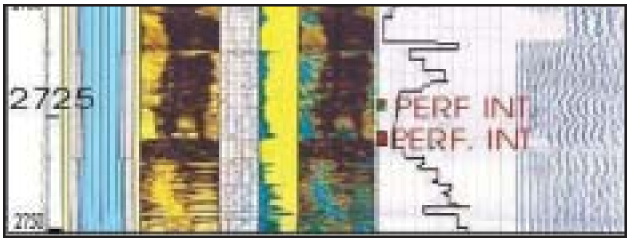


**Fig. 1:** USIT & CBL OF WELL NO. G—A.

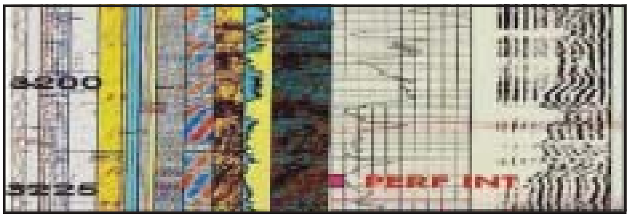


**Fig.2 :** USIT & CBL of well No R-B

recorded. CBL improved but USIT showed cement patches with closed mud channels. So the perforation was carried out without any further cement repair job, USIT helped in ascertaining the efficacy of cement repair job, which would not have been simply on the basis of CBL-VDL. On well-flowed oil @ 14 cubic meter per day with little water cut

**WELL NO. G -C (fig-3)**

Well was drilled as an exploratory well to explore Miocene prospects. CBL and USIT logs were recorded to asses cement quality in 5.5 inch casing. Micro debonded cement channel were observed. Micro annulus affects the apparent cement acoustic impedance. Even the smallest liquid – filled micro annulus causes the loss of shear coupling into the cement and a drop of approximately 20 percent in impedance, which could not be inferred from CBL log. Perforation intervals were modified in these objects and testing was carried out after perforation. Two objects flowed oil object in the interval 3224-3230m. Flowed oil with 40% - 45% water cut. (Channel above the zone up to 3212 was observed on USIT).

Determining the micro debonded cement channel could only be done on the basis of USIT logs. Modifying the perforation intervals rather than going for cement repair job gave the desired results

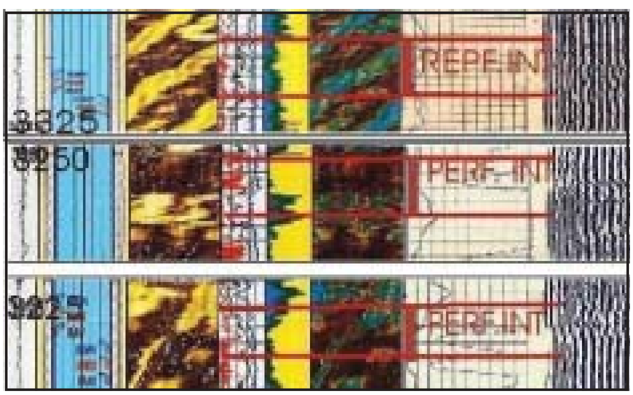


**Fig. 3. :**USIT & CBL of Well No. G-C

**WELL NO. R-D (fig-4)**

Well was drilled as a development well for Miocene prospects and CBL was recorded after final casing (5.5 inch). Well data was reviewed along with CBL –VDL data. It showed satisfactory cement behind casing. So well was taken up for production testing. However well started producing water through perforation after some oil production. USIT was run to check the cement integrity behind the casing. It showed contaminated channel in the interval 3111-3114m. Cement repair job was done in the interval 3125.5-3126.5 m. and the same object was tested. Well-started producing oil @ 40 cubic meter per day with 0.6% water cut. USIT was able to determine the reason for production and hence remedial action could be taken which enhanced oil production

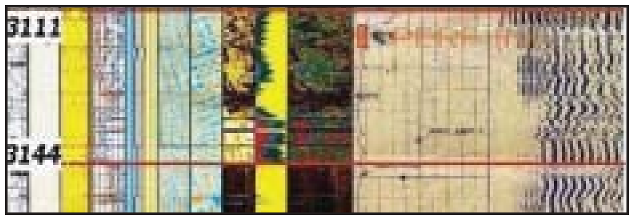


**Fig. 4 :** USIT & CBL of well No. R-D

**WELL NO. L –E (fig-5)**

Well was drilled as an exploratory well to explore Miocene prospects. After final casing CBL was recorded, it showed that objects of interest had bad cement with the amplitude varying from 10 mV to 40 mV. After evaluating the CBL-VDL data it was decided to run USIT before going for squeeze cement for cement repair. USIT was run to find out the isolation and feasibility of doing block cementing in the intervals of doubt. USIT logs were recorded from 3759.0 m – 3350.0 m. The recommended objects of interest were contaminated cement behind the casing with good isolation above &below. It was decided to go ahead with the perforation plan without block cementing repair job prior to the perforation. Four objects tested, all objects flowed oil (80 – 100 cu. M.) & gas.

**WELL NO. CM–F (fig-6)**

Well was drilled as an exploratory for exploitation of Miocene prospects. CBL and USIT logs were recorded to Asses the quality of cement. CBL in general show low amplitude indicating good cement bond. High amplitude is observed at various depths via 2910-2915m. 2840-2843m. 2837-2839 m., 2811-2812m. , 2805 -2807m. , 2799-2801m. In the section of interest. However USIT indicates harmless micro debonding against this high amplitude. Since all the

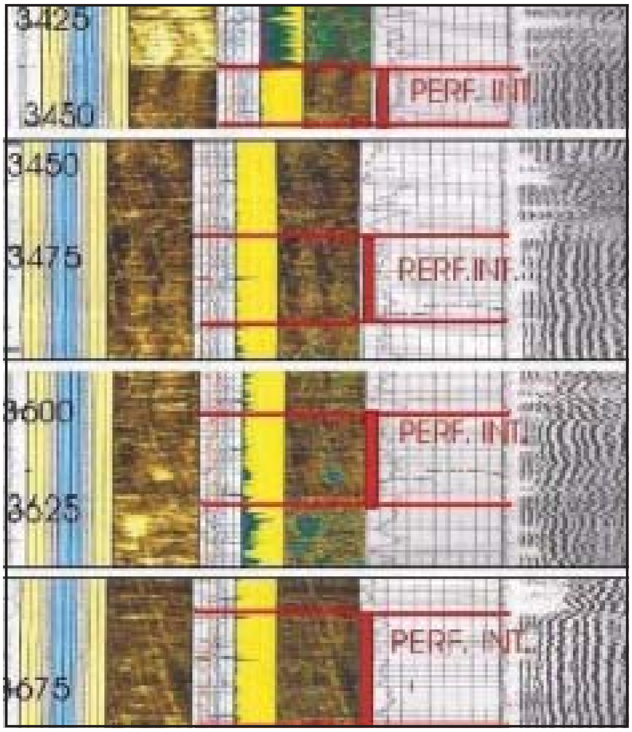


**Fig. 5. :**USIT & CBL of Well No. L-E

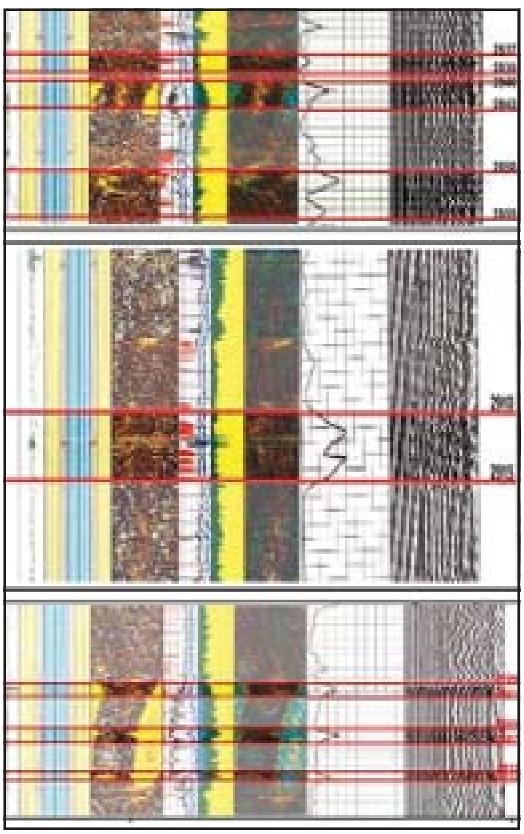

**Fig. 6. :**USIT & CBL of Well No. CM-F

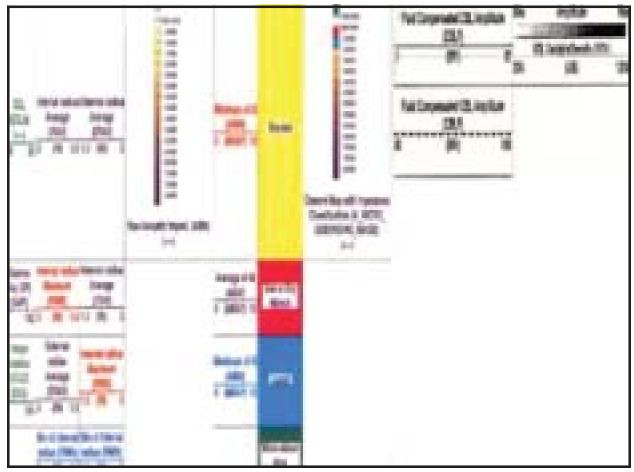

**Fig.7** : Scale of USIT & CBL

objects were isolated from the layers below and above a cement repair job was not needed.

USIT helped in ascertaining the quality of cement behind the casing and helped to decide against a cement repair job and go ahead with perforation and production. On testing all the objects produced oil with little water cut (I. e. 0.6% to 5%). Scale of the USIT log is shown in this fig.

## Conclusions

The study carried out on CBL and USIT of six wells shows good cementing zone, channel, and partial cementing zones behind casing. These can be easily identified which would have been difficult from the CBL data alone. Also it was observed that the data quality of USIT is very sensitive to tool centralization. The recording of USIT alone with CBL helps in deriving complete information on the cement bond and under some circumstances is the only way to identify the cement quality in the well.

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