



Wellbore Cleanout Tool – How Clean is Your Wellbore?

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ABSTRACT

The wellbore cleanout tool (WCT) is a cup tool which mechanically cleans (squeegee effect) the walls of the casing. The paper will describe the tool, procedure used and the results of WCT runs along with the lessons learned resulting in tool improvements. The WCT was run in several highly deviated wells where indirect displacement technique was used to clean the casing prior to displacing with a packer fluid. The WCT followed the traditional brushes, scraper, bit runs and chemical washes/surfactants used to displace the mud with seawater to a nephelometric turbidity unit (NTU) of 50 or less. Fluid NTU's greater than 500 were circulated out the highly deviated wells when the WCT was run to the objective depth indicating that the wall of the casing was not clean. Removal of solids from the casing is an important step for the well completion as these solids could plug the perforations reducing well productivity and could impact completion hardware installation.

INTRODUCTION

Wellbore clean up for a completion has evolved into a defined process utilizing proven mechanical, chemical and hydraulic processes. Clean completion fluids are critical to a successful completion due to the impact on formations, well productivity, and the environment for running completion tools in the well trouble free.

The literature has numerous articles justifying the need for clean packer/completion fluids. The impact of dirty completion fluids on well productivity or hindering the running and setting of completion packers is well documented in the literature and will not be covered in this paper. This paper offers another method to clean the walls of the casing of the fine solids, mud debris and mud film which may not be removed with brushes, scrapers and chemical washes. Four WCT runs are described in this paper. All WCT runs were preceded by the conventional brush and scraper run displacing the well with seawater (SW) preceded by pills, washes and spacers. The wells were circulated with seawater to the desired NTU (typically 50 or less) and the workstring with the brushes and scrapers tripped out the hole.

The workstring with WCT's and a mule shoe was tripped in the hole and the well circulated in reverse to the desired NTU's. The WCT enhances the traditional

brushes, scrapers, sweeps and washes used to clean drilling mud, mud debris and fine solids from the wellbore to accept the clean brines used as completion fluids.

WCT Description:

The WCT tools may be ran above a bit, scraper and or brush assembly. The WCT tools are designed to remove fine solids in the wellbore through wiping action (squeegee effect) using a brush and or scraper to assist in dislodging any solids from the casing wall and suspend them in the mud system. A packer cup seal unit on the WCT forces the fluids and solids below the tool into the ID of the work string. The fluid travels up the work string and is captured and returned to the mud system by one of two devices designed for the purpose of filling or circulating fluids on either a top drive or rotary rig. The purpose of placing the fluids inside the work string is to isolate the suspended solids in a smaller volume which has a higher velocity while tripping and circulating which minimizes solids dropping out.

WCT Objective:

The objective is to wipe the casing wall with the packer wiper cups to suspend and move the solids into the work string. The suspended mud solids are moved to the surface as the work string is tripped in the hole and while keeping the annulus above the WCT full of clean fluid equal in density to that in the well. This is unlike the traditional methods where the fluids are circulated down the work string and into the annulus.



Surface Equipment Description:

In order to manage the fluids returning to the surface through the work string one of two tools recently introduced to the industry should be used. Both of these units are controlled remotely from the rig floor allowing the work strings are to be tripped in the normal manner. The circulating flow - back tools were used on the four wells with the WCT.

CFT (Circulating Flow – Back Tool):

The CFT is a circulating and flow back tool mounted on the saver sub of a top drive unit. This tool when actuated will extend down to seal on the work string to allow fluid to be circulated by the rig pump or flow back to the mud system.

Down Hole Equipment Details:

The WCT consists of a unique packer cup wiper seal and a port to divert the wellbore fluid below the tool into the work string. The packer cup wiper seal is mounted on a moveable sleeve which provides for opening and closing the port below the packer cup wiper seal while closing or opening a by-pass under the packer wiper cup sleeve. The port and by-pass can not be opened at the same time as either the port is open or the by-pass is open.

The fluid flowing through the by-pass moves through an annulus between the packer cup wiper seal sleeve and the mandrel of the WCT tool and is isolated from the work string. With a balanced fluid system, this sleeve is controlled by moving the work string up or down.

While running the work string (moving down) in the hole the by-pass valve is closed and the port between the lower cup of the WCT and the work string is open. This forces any fluid below the WCT packer cup wiper seal into the work string.

With the annulus full and a balanced fluid system the port can be closed and the by-pass opened by picking up (moving up) on the work string. In this position the well can be reverse circulated to bring all of the contaminated fluid to the surface.

While reversing, all of the annulus fluid must go to the very bottom of the work string since it can not enter the work string at the WCT tool. This provides for complete displacement of the contaminated fluid with any material not circulated out of the well remaining on bottom out of harms way.

Packer Cup Wiper Seal:

Originally, a conventional packer or swab cup was used as the wiper seal. This type seal is considered mature technology as packer cups were originally used as a wellbore seal prior to 1950. They became common place in well service tools where they have been used as the seal on retrievable bridge plugs, packers and various other tools. They are still used today as the seal on

perforation wash tools and casing fill-up and circulating equipment.

Lessons learned in running the WCT found that some modifications were needed to prevent unacceptable wear and leakage of the cup seal while running in deviated wellbores. For this reason a new packer cup wiper seal system has been developed which greatly reduces the wear and improves centralization and sealing ability.

Operation:

One or more of the WCT tools are spaced out so that the upper ones will be at the top of their respective liner when the lower most tool is at the bottom of the wellbore. It is recommended that a scraper and brush be run immediately below each WCT to help suspend the solids in the mud system. The solids are then forced into the work string through the WCT port on the trip in the hole.

While running the WCT system in a well, pressure is created below the WCT. Surge pressure forces the solid laden fluid below the WCT's into the work string and to the surface. An analysis of the work string weight required (torque and drag and buckling) based on trip speed should be made as the work string weight may be insufficient resulting in the tools floating. Drill collars may be strategically placed in the work string to minimize buckling and facilitate weight transfer in a highly deviated wellbore.

The bottom port on the tool provides an opening for dirty fluid to enter the work string and move to the surface as the tool is run in the wellbore. Tripping or running the WCT in the hole shifts the mandrel which opens the bottom port and closes the tool internal by-pass.

The WCT's (10 3/4 - 9 5/8 and 7 5/8 - 7 inch tools) also have an internal by-pass which opens when the tool is hoisted approximately 5 feet. The bottom port is closed when the internal by - pass is opened.

The WCT can be short tripped which will shift the bottom port closed and open the tool internal by-pass. It is advisable to reverse circulate fluid in the work string to the surface prior to any tripping out the hole including short trips. Tripping in the hole will shift the bottom port open and close the internal by - pass. During short trips one hole volume equivalent to the largest WCT will be displaced when tripping back in the hole. Sufficient mud/completion fluid pit volume must be available.

TOOL SPECIFICATION'S – TABLE SUMMARIZING KEY TOOL DIMENSIONS

The following tables summarize key specifications for the WCT's

Application Size, inches	Tensile X 1000 lbs	Burst, psi	WCT Specifications		Connection	OD, in	ID, in	Make up Torque, ft-lbs
			Collapse, psi	Slot Flow Area, sq in				
9 5/8 - 10 3/4	546	19000	19000	4.282	4 1/2 IF(NC50)	6.4	2.375	31000
7 - 7 5/8	222	24000	24000	2.132	3 1/2 IF(NC38)	4.75	1.75	11500
5 1/2	192	27660	27070	3.14	2 3/8 IF(NC26)	3.375	1.75	3900
4 1/2 - 5	250	22365	22590	3.14	2 3/8 IF(NC26)	3.375	1.5	3900

WCT TORQUE LIMITS

Application Size, inches	Torque Limit
9 5/8 - 10 3/4	5000 ft-lbs
7 - 7 5/8	3000 ft-lbs
5 1/2	5000 ft-lbs
4 1/2 - 5	5000 ft-lbs

Actual WCT Runs:

The procedure that was used for each run was developed jointly with the operator, fluids & filtration company, and WCT personnel (OES). Since this was the first use of the WCT, a conservative approach was taken where the initial objective was to test the tool and cleaning concept.

Bit, brushes and scrapers were ran into the hole and the drilling mud was displaced to seawater using surfactant based displacement products (weighed spacer and viscous spacer) rotating and reciprocating the workstring.

A mule shoe, brush and scraper below the lower most WCT with the upper WCT spaced out to locate on the liner top were tripped in the hole. Drill collars were run in the work string in two wells to minimize work string buckling and maintain weight transfer to the tool string.

The WCT's were tripped in the hole to the desired depth at speeds to minimize tool floating. The annulus above the WCT was filled with clean seawater as the tool was run in the hole.

A circulation flow back tool (CFT) was used on the top drive to manage the wellbore fluids forced into the work string ID and forced to the surface as the WCT's are tripped in the hole. The CFT has a pneumatic cylinder and seal which lowers over the drill pipe tool joint as the work string is tripped in the hole. The CFT diverts the dirty fluid through a side outlet at the top of the tool to the appropriate part of the rig mud circulating system.

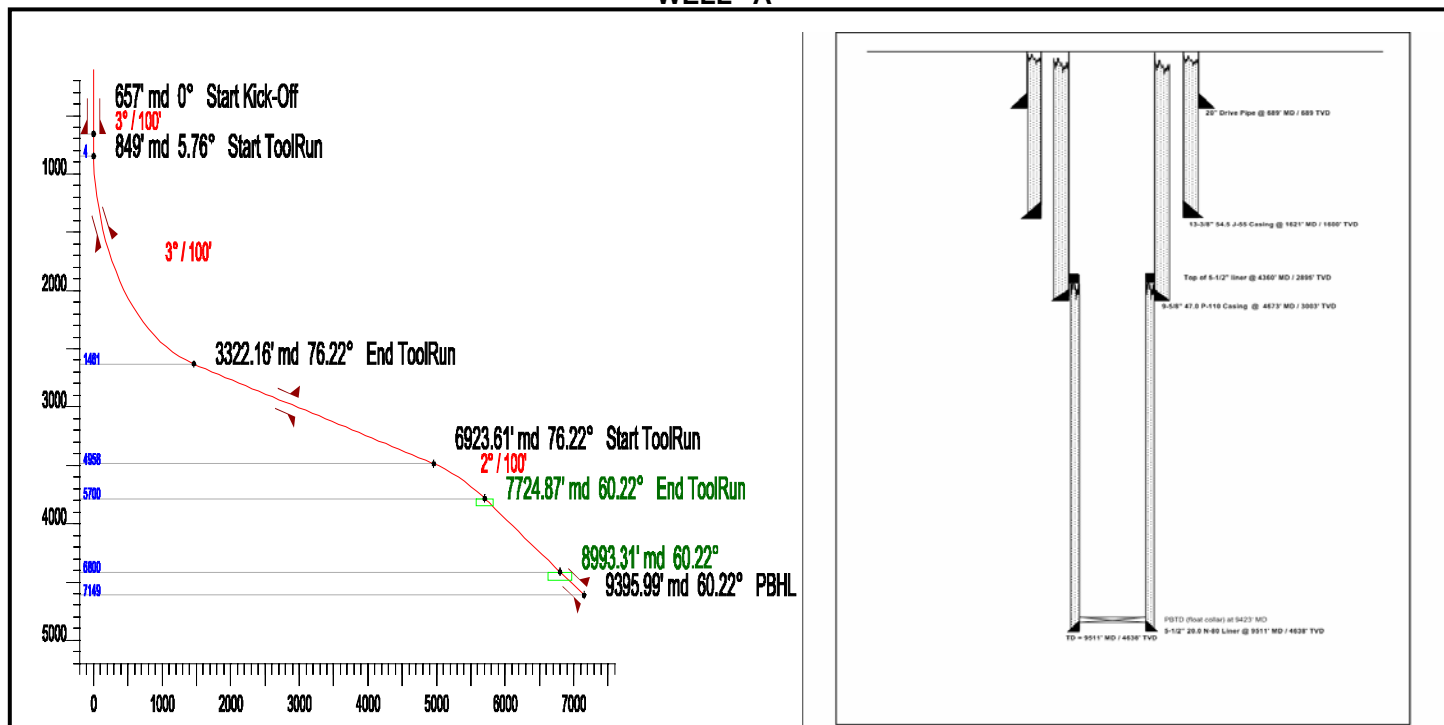
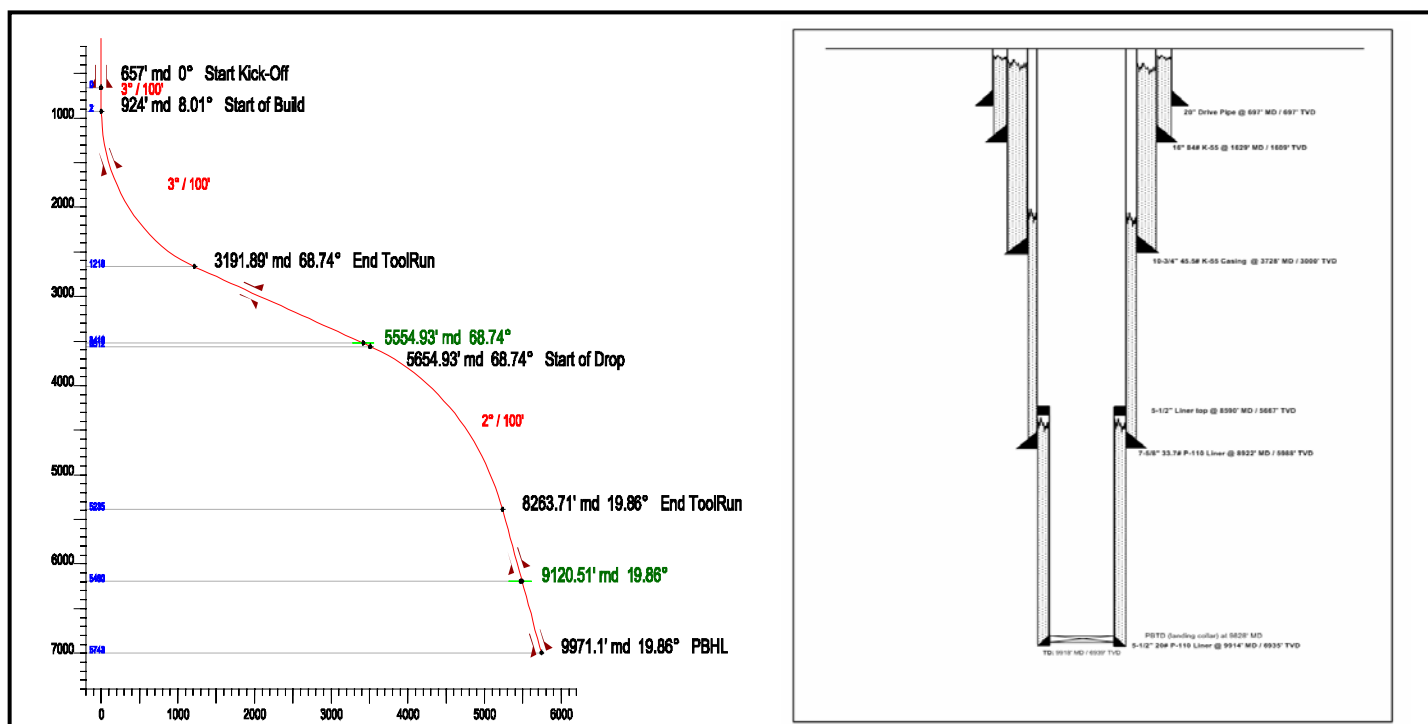
At the desired depth, the work string was raised approximately 5 feet which shifts the top WCT to the

reverse circulating position- closing the bottom port and opening the internal by pass. The annular BOP is closed and the well was reverse circulated with seawater to the desired NTU's. Once the desired NTU's were achieved with the sea water, the seawater was displaced in reverse with the completion brine.

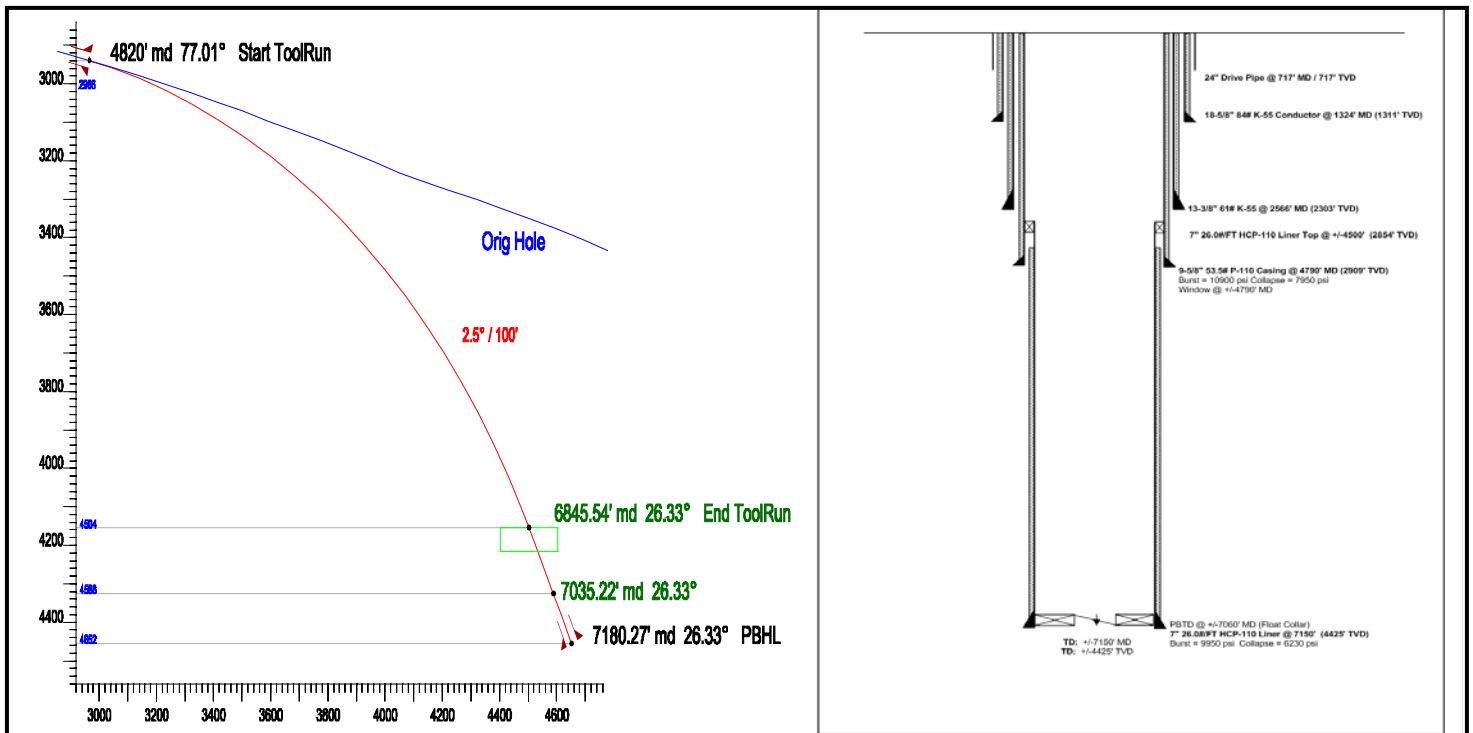
Well Summary:

Wells are summarized in the wellbore and directional sketches. All wells were deviated with angles greater than 55 degrees with production liners. WCT's spaced appropriately were run for each casing size for all wells listed. Well D ran WCT's only in the 7 inch and 5 inch casing as there is currently no 11 3/4 inch WCT. Wells "B", "C" and "D" ran a brush and scraper below the WCT in the liner.

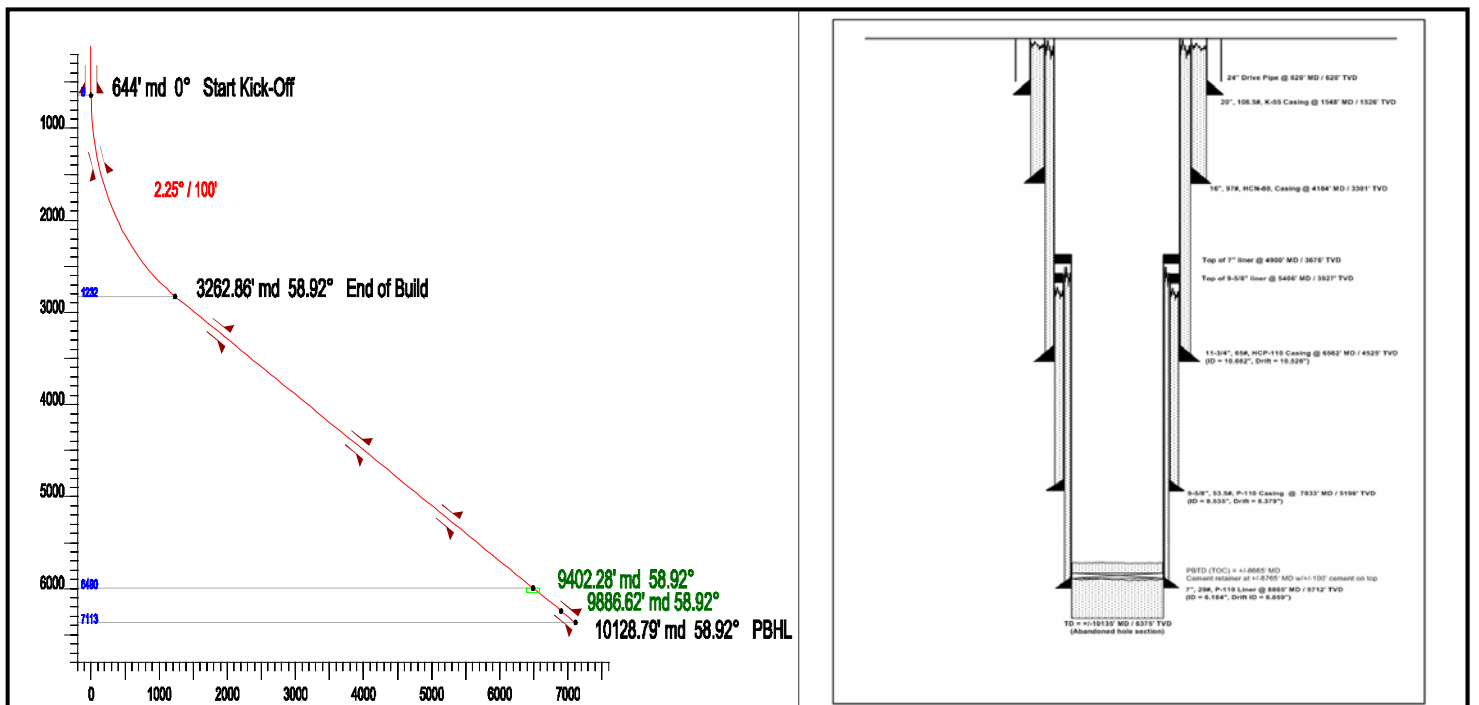
Well "C" had a tight spot at 5874 ft MD preventing passage of the 9 5/8 WCT. The WCT was laid down and the 7 inch WCT was run in the liner.

WELLS SUMMARY DATA TABLE**WELL "A"****WELL "B"**

WELL “C”



WELL “D”



DISPLACEMENTS:

All wells used indirect displacement technique to prepare the wellbore for completion. The mud was displaced with seawater on the bit, brush scraper trip and the wellbore circulated to the desired NTU's. The WCT's with a mule shoe brush and scraper below the smaller WCT was run and the well reverse circulated to the desired NTU's with the WCT's at the desired depth.

Circulation rates varied: Wells A, B, and C were displaced to seawater at 6 bpm; Wells A and B were circulated with seawater at 6 bpm while Well C was circulated with seawater at 16 bpm.

Well	Csg. in.	Flow Required for Turbulence, Fluid - BPM
A	9 5/8	SW 1.5 / CaCl ₂ 11.6
	5 1/2	SW 0.6 / CaCl ₂ 4.4
B	7 5/8	SW 1.1 / ZnBr ₂ 10.4
	5 1/2	SW 0.6 / ZnBr ₂ 5.5
C	9 5/8	SW 1.5 / CaCl ₂ 13
	7	SW 1 / CaCl ₂ 8
D	11 3/4	SW 0.3/ CaBr ₂ 23.2
	7	SW 0.2/ CaBr ₂ 8.7

BRINE DENSITIES in PPG:

Well	Density	Brine
A	10.5 ppg	CaCl ₂
B	15.8 ppg	ZnBr ₂
C	12.3 ppg	CaBr ₂
D	12.3 ppg	CaBr ₂

SW = Seawater **CaCl₂** = Calcium Chloride
ZnBr₂ = Zinc Bromide **CaBr₂** = Calcium Bromide

RESULTS OF WCT RUNS:

Fluid samples were collected at the CFT as the well was reverse circulated with seawater with the WCT's on bottom. The traditional bit, scraper and brush preceded the WCT run to displace the wellbore with seawater and circulate the seawater to 50 NTU's or less.

Picture of Fluid Samples

In reviewing the fluid samples captured as the well was reverse circulated with the WCT's at depth,

fluid cleanliness, NTU's, improved significantly on reverse circulating two hole volumes. The cup on the right is the bottoms up work string volume- 540 NTU's, the middle cup is one hole volume – 232 NTU's and the cup on the left is two hole volumes – 48 NTU's. This was the typical progression of fluid cleanliness as the wellbores were reverse circulated on all four WCT runs.

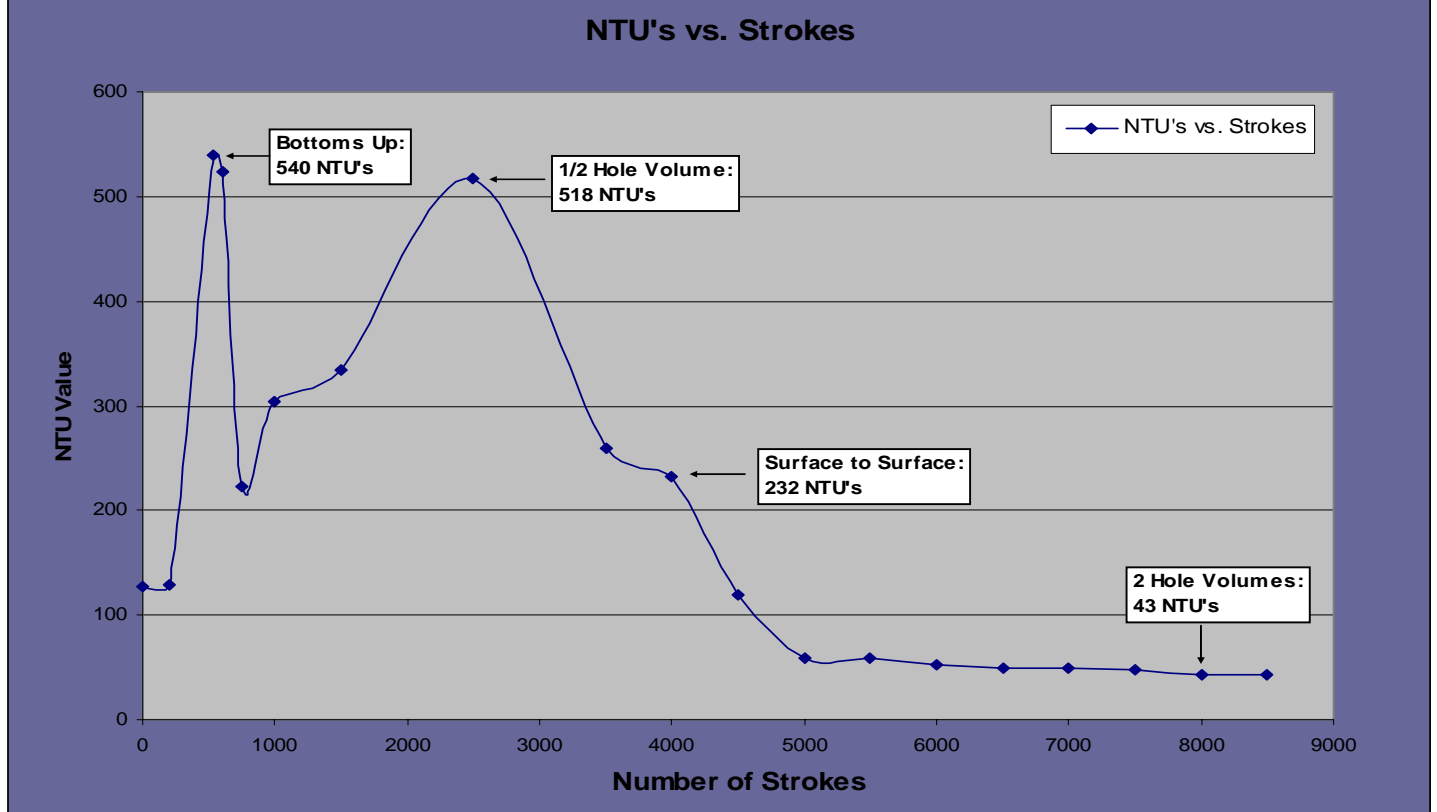
Plots #1 through #4 of NTU's versus Volume (time and or strokes) summarize the fluid cleanliness as the wellbore is reverse circulated with the WCT's at the desired depth. The seawater NTU's decreased to less than 50 after circulating two hole volumes. Completion brine NTU's were less than 20 in 3 to 6 hrs reverse circulating and filtering the brine.

Plots #1 through #4 of NTU's versus volume (time or strokes) have basically the same character on reverse circulating the wellbores. There is a spike in NTU's on bottoms up and one half hole volume with a dramatic decrease in NTU's at one hole volume.

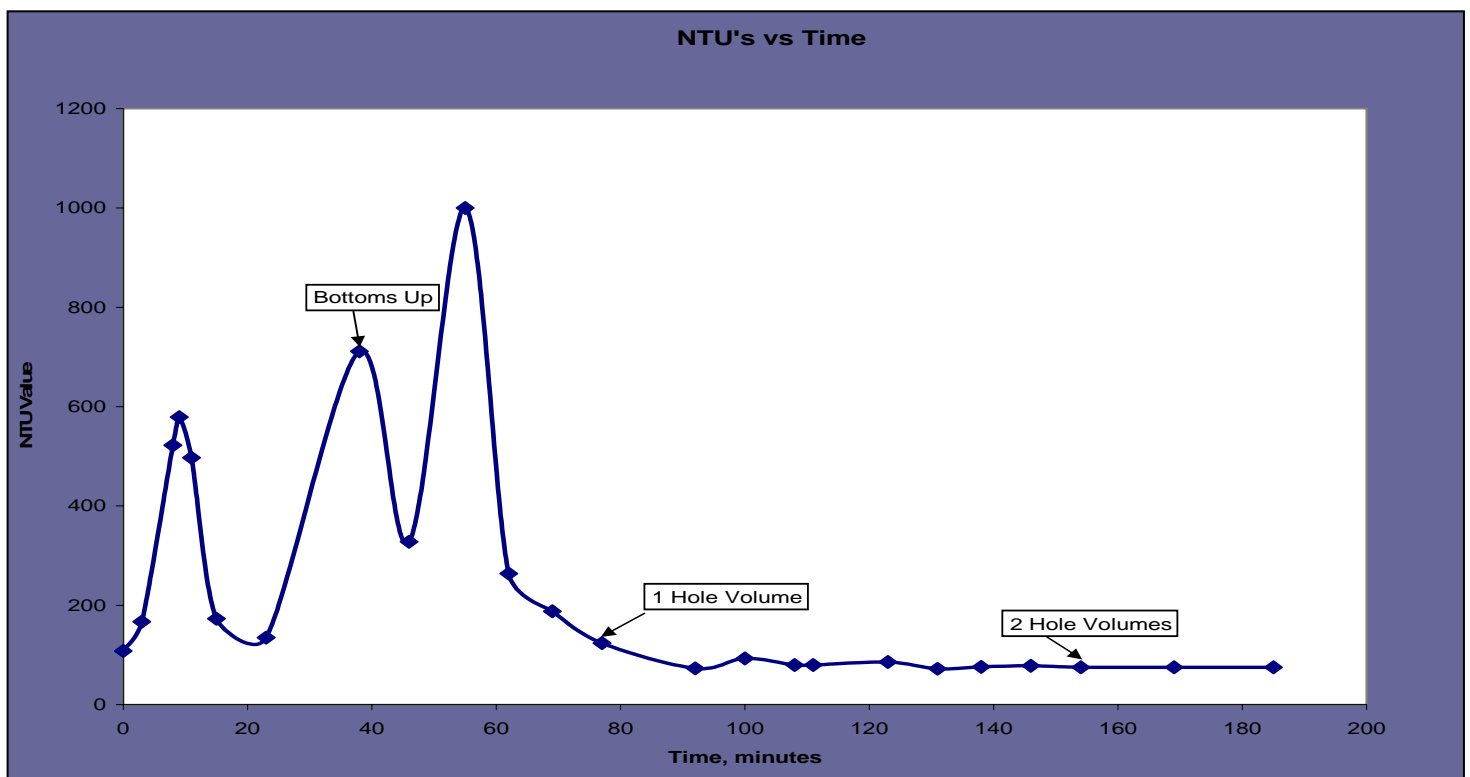
Well "D" plot of NTU versus volume in barrels summarizes the fluid cleanliness as the wellbore is reverse circulated:

- A) with seawater with the bit, brushes and scrapers at desired depth
- B) with seawater and sweeps
- C) with seawater after acid job to pickle the work string
- D) with seawater with the WCT's at desired depth

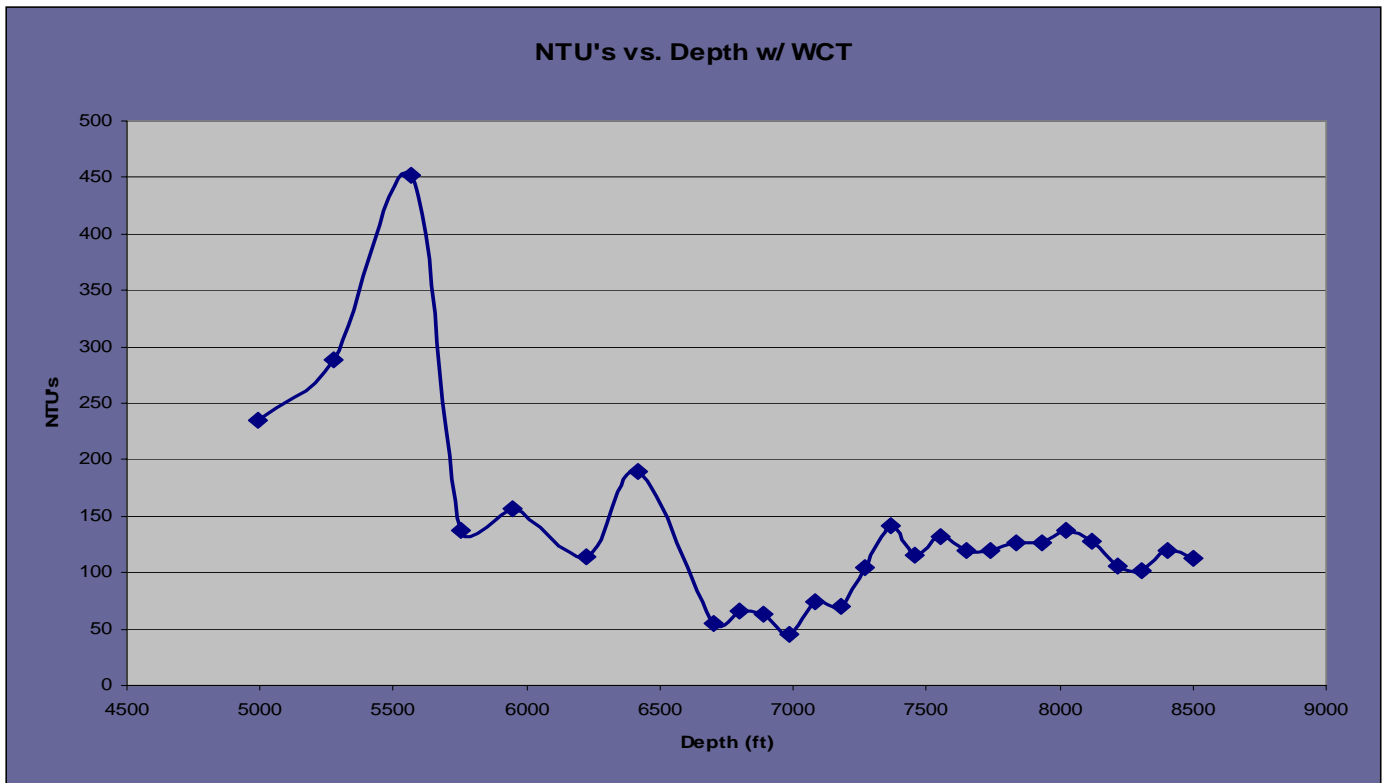
Plot #1 Well "A" Plot of NTU versus Strokes



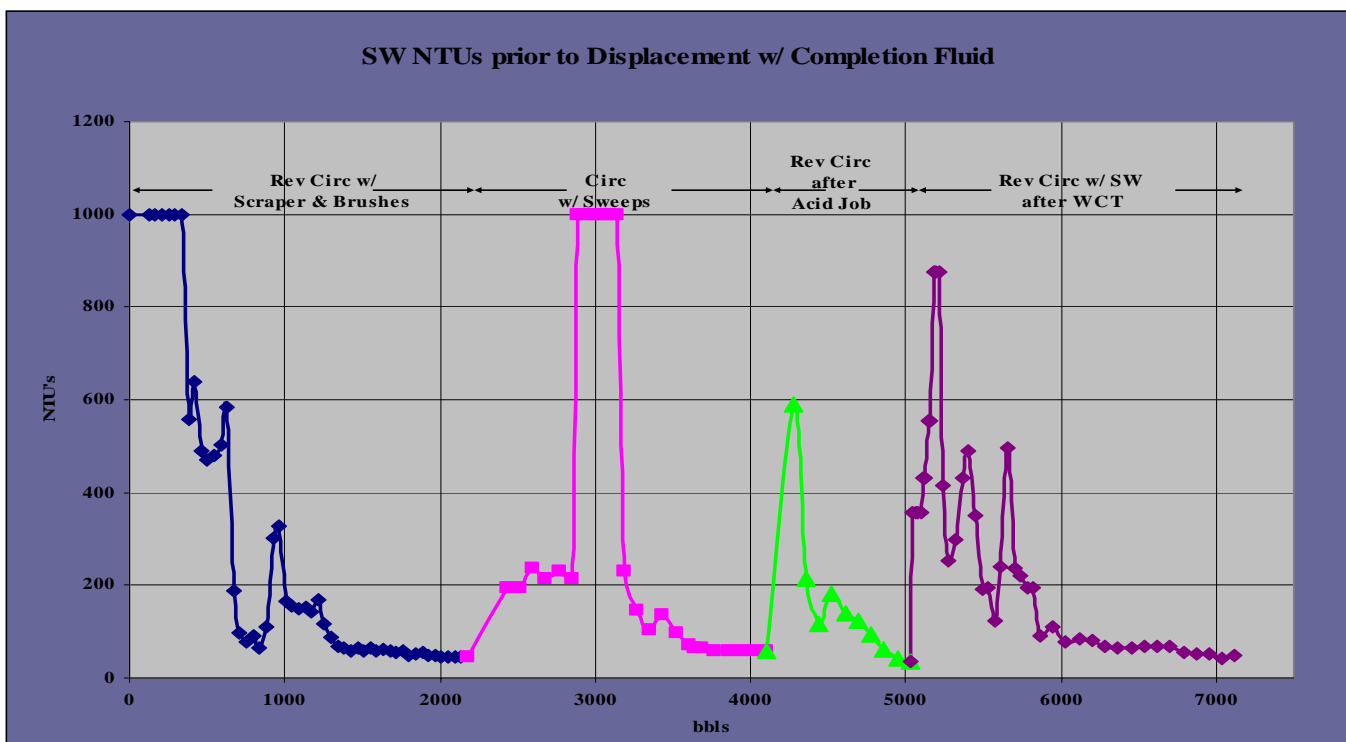
Plot #2 Well "B" Plot NTU's versus Time



**Plot #3 Well "C" Plot of NTU's versus Depth as
WCT's tripped in the hole**



Plot #4 Well "D" Plot of NTU versus Volume

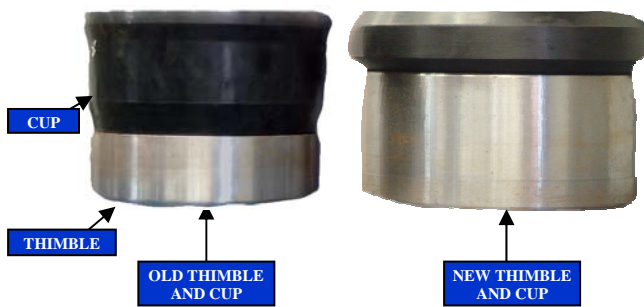


Lessons Learned:

In running the WCT, it was noticed while tripping in the hole that fill up on the annulus was less than expected indicating that cup leakage was occurring. Cup durability was also an issue as the cup was failing at the thimble cup interface resulting in the cup wire support protruding.

The cup leakage was addressed by re-designing the cup for better sealing and the thimble to increase the structural support to the cup wire support as well as centralize the tool with the guide ring. The guide ring was also redesigned to provide better tool centralization.

Conventional brushes and scrapers were also utilized in tandem with the WCT to assist in tool centralization.

**Operational Issues:**

There are pluses and delta issues in using the WCT. First the delta issues: Spacing of the larger WCT is important to insure that it will no-go at the liner top before the mule shoe lands on bottom.

- The WCT can not forward circulate. The pumping of solvent and acid pickle is performed prior to circulating and filtering the completion fluid which can be performed on the bit and scraper run or after the WCT run.
- The WCT is not designed to rotate while circulating and displacing. See Table 2 WCT Torque Limits. The WCT is not a "fit for all" application tool when cleaning wellbores. However, there is no need to rotate and reciprocate as the cups effectively clean through wiping (squeegee effect) the ID of the casing.
- Trip time may be slowed to 30 ft/min contingent on the WCT size.

The pluses:

- The WCT cups make full contact with the casing ID effectively cleaning the wellbore.

- Clean annular fluid is isolated from the contaminated fluid in the work string ultimately minimizing filtering time of the completion fluid.
- Traditional mechanical tools such as brushes and scrapers can be run below the WCT. The ultimate vision of the WCT is to perform displacement and clean up with one trip.

Conclusions:

- Highly deviated wells can be effectively cleaned with the WCT.
- After the well was deemed "clean" through the use of the conventional methods (mechanical, chemical and hydraulic), the WCT removed a significant amount of additional mud debris.
- The WCT successfully isolated the clean annular fluid from the contaminated fluid in the workstring- a smaller volume which minimizes hydraulic by pass.
- The WCT is another tool in the completion tool box for cleaning wellbores especially in highly deviated wells. It offers a unique solution to improve completion time and cost in high angle wellbores.

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