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Improving the understanding, application & reliability of the Perforate, Wash and Cement technique through the use of cement bond logs, tool enhancements and barrier verification via annular pressure monitoring

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Perforate, Wash & Cement value proposition

Value is eroded if limits not understood and method not correctly applied
Comparison of two methods

Closed-system Cup Type
1. Has double swab cups above and below nozzles.
2. Washing fluid is ‘forced’ out of 6 x 0.001in nozzles between swab cups and into annulus via perforations.
3. Fluid has only 1 way to go and has to be forced into the annulus, i.e. a ‘closed system’.
5. Cement is forced between cups and into annulus behind perforations.
6. Fluid bioass minimises surge/swab.

Open-system Jetting Type
1. Does not require swab cups.
2. Washing fluid is jetted out of e.g. 30 x 1/8in nozzles in a ca. 2.5 ft long sub at high velocity & impact force.
3. Fluid can flow both through perforations to annulus behind also DP/casing annulus, i.e. is an ‘open system’.
4. Can rotate entire BHA at 6 rpm (when over perfs) & 120 rpm (when outside perfs).
5. Cement is sprayed out of nozzles from a ca. 3 ft long cementing valve with 4 x 1/8in nozzles.
6. Cement is pushed in to perforations after spraying using an ‘Archimedes’ tool.
7. 18 spl with 1.1in EIs or greater preferred

“Cup Type” tool provides standpipe pressure and flow rate signals which can be correlated to annular conditions
Difficulties circulating 230 gal/min max with high pressures (1400 psi). Loss of returns, annulus packed-off.

Circulation rate 400 – 500 gal/min

Circulating (standpipe) pressure 1,100 – 1,400 psi

CBL never above 12mV (free pipe 57mV)

Dark patches on Al from 5,705 – 5,746 ft suggesting formation contact with casing corresponded with circulation difficulties.

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Initial Field Observations II (workover upper zone)

Consistent circulation at 400 – 500 gal/min

Lower circulating pressures 800 – 1100 psi

CBL never lower than 12.5mV and generally above 15mV
Verification by bond log and SCP monitoring

CBL dropped, bond index, impedance, attenuation min & max all increased indicating improved bond

B-annulus bled off every ~24 hrs following curing of cement: static at 2.9 psi and monitored for ~4 weeks prior to drill-out, tieback casing and upper completion installation
Tool enhancements
CFD analysis & yard tests for method verification
Yard test concept verification
Application to campaigns I (abandonment lower & upper zone)

Establishing circulation difficult initially (red), pressure high (750 – 1750 psi) & erratic (blue)

Circulation stable (orange), pressures lower (650 – 1250 psi) and less erratic (purple)

CBL low (10 – 15 mV)

CBL high (40 – 60mV)

CBL high (>60mV)

Circulation consistent at >450 gal/min (red) and pressures lower (650 -1250 psi) and more stable (blue)

B-annulus static (>6 months of data shown)
Application to campaigns II (workover)

Circulation at 400 gal/min (red), pressure 1000 – 1400 psi (blue)

Circulation harder to establish, reduced to 50 – 350 gal/min (red), persistent high pressure spikes (blue)

CBL low (10 – 15 mV)

CBL high (20 – 38 mV)

CBL dropped, bond index increased.

Note gas build-up below remediated annulus (red)

Well on production, B-annulus static
Conclusions

1. Closed-system "Cup-type" tool ensures direct communication with the annulus & standpipe pressure gives a clear indication of degree of bond and washing effectiveness.
2. Washing parameters can be used to correlate against logging responses and is of great utility in planning & selecting the best zones for remediation.
3. CFD & Yard Testing and 120 field runs confirms "Cup-type" tool as effective.
4. Field observations show that when the method is correctly applied according to the operational limits defined here, job can be de-risked allowing:
   a. Correct identification of the ability to circulate in 94% of cases
   b. Effective remediation of annuli: SCP remediated in every case at point of well handover
5. Track-record of successful remediation vs. logging & washing parameters across >10 fields across in the North Sea qualifies the method as robust.
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Learn more at the Archer Booth #1112

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