M-I SWACO
A Schlumberger Company

Repsol Maintains Well Integrity Using Managed Pressure Cementing Technique to Cement Casing

Efficient cement placement in 9⅝-in casing involves using annular BOP to seal against casing and deviate well returns toward MPD choke system, Peru

CHALLENGE

Overcome a reduced annular flow area between 9⅝-in casing and 11¾-in casing, together with a narrow pressure window, which significantly increased the risk of losses during cement placement.

SOLUTION

- Apply managed pressure cementing (MPC) to pump statically underbalanced drilling fluid without jeopardizing well integrity.
- Use the annular BOP to seal against the 9⅝-in casing and apply surface backpressure when needed in static or dynamic conditions.

RESULTS

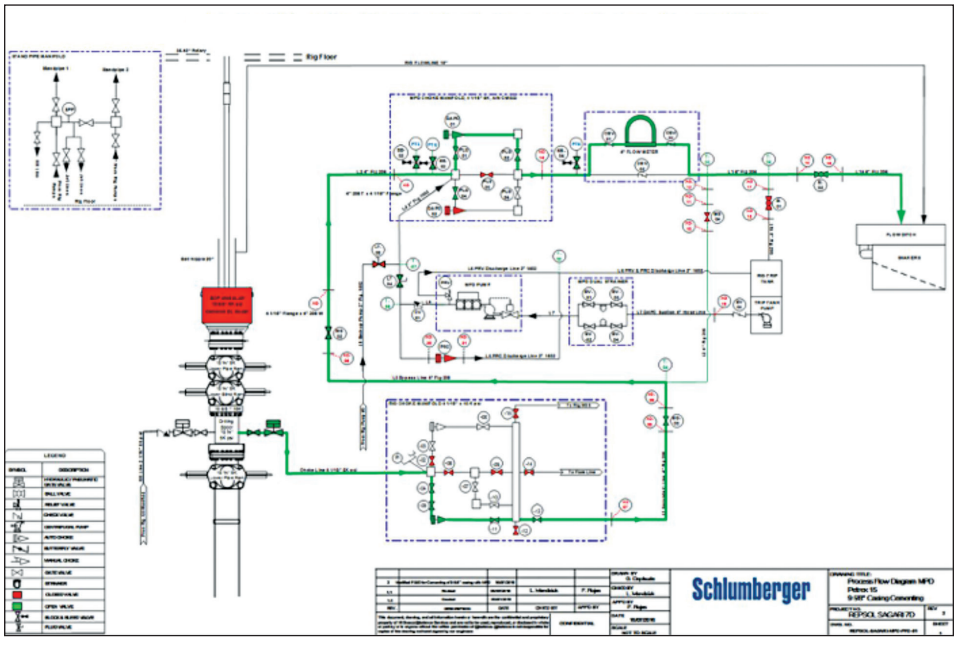
- Maintained well integrity at all times during cement placement and WOC time with no losses or influx.
- Placed the cement at optimal pumping rates and maintained the original cement slurry density to achieve maximum cement strength.
- Successfully provided zonal isolation of the 9⅝-in production casing, as confirmed by casing bond log and casing integrity and formation integrity tests.
- Responded quickly with a fit-for-purpose solution by integrating cementing and managed pressure drilling (MPD) engineering.

Overcome high ECDs caused by to reduced annular flow area

The intermediate 12¼-in section of a deviated well in Peru was drilled conventionally with a final mud weight of 10.6 lbm/galUS. This density was necessary to maintain the integrity and stability of the wellbore. Cementing hydraulic simulations performed with CEMENTICS* zonal isolation software showed that conventional cementing jobs would exceed the minimum fracture gradient. Circulating the 10.6-lbm/galUS drilling fluid and 15.6-lbm/galUS cement slurry in the reduced annular space between the 11¾-in and 9⅝-in casings generated high friction losses and high equivalent circulating densities (ECDs).

Use MPC and statically underbalanced drilling fluid to avoid fracturing the formation

To maintain ECDs below the minimum fracture gradient of 13.23 lbm/galUS during cement placement, M-I SWACO recommended displacing the actual 10.6-lbm/galUS drilling fluid with a 9.5-lbm/galUS fluid. This is less than the maximum pore pressure of 10.14 lbm/galUS, so surface backpressure would need to be applied when necessary with the MPD system to maintain the bottomhole pressure within the operating window (between the pore pressure and the fracture gradient) during the entire cementing operation. The pumping rate and surface backpressure schedule was prepared prior to the cementing job based on up-to-date hydraulics simulations from CEMENTICS software. As an additional safeguard, an MPD flowmeter located at the well returns would be installed to measure the flow out against the flow in, providing early detection of any kick or loss event.

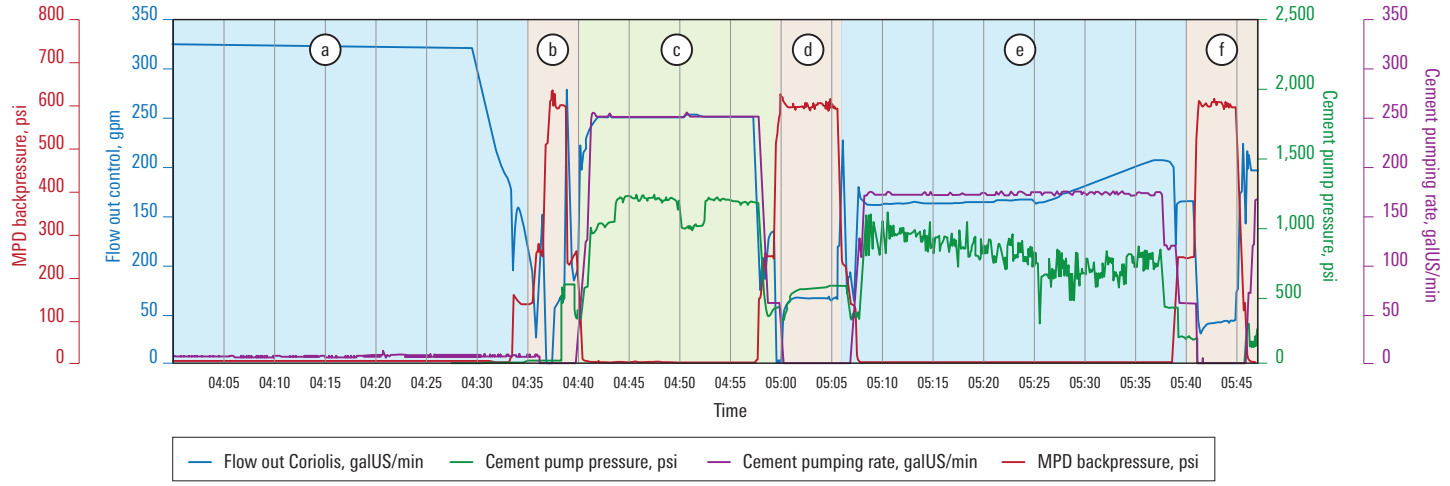


The flow path during the managed pressure cementing of the 9⅝-in section included using the annular BOP to seal the annulus.

Efficiently performed MPC using annular BOP

As the 9⅝-in casing was run to the bottom conventionally, the use of a rotating control device was not necessary to perform MPC. Instead, M-I SWACO sealed the annulus with the annular BOP and applied surface backpressure using the MPC control system via the rig's choke line.

A complete risk analysis ensured that the operation could be performed as safely as possible. Repsol and M-I SWACO also discussed contingency plans prior to the operation.



(a) Circulating 9.5-ppg mud at 7.0 bbl/min.

(b) 1st pump stop to align cement unit pump. MPD applies 600 psi of surface backpressure.

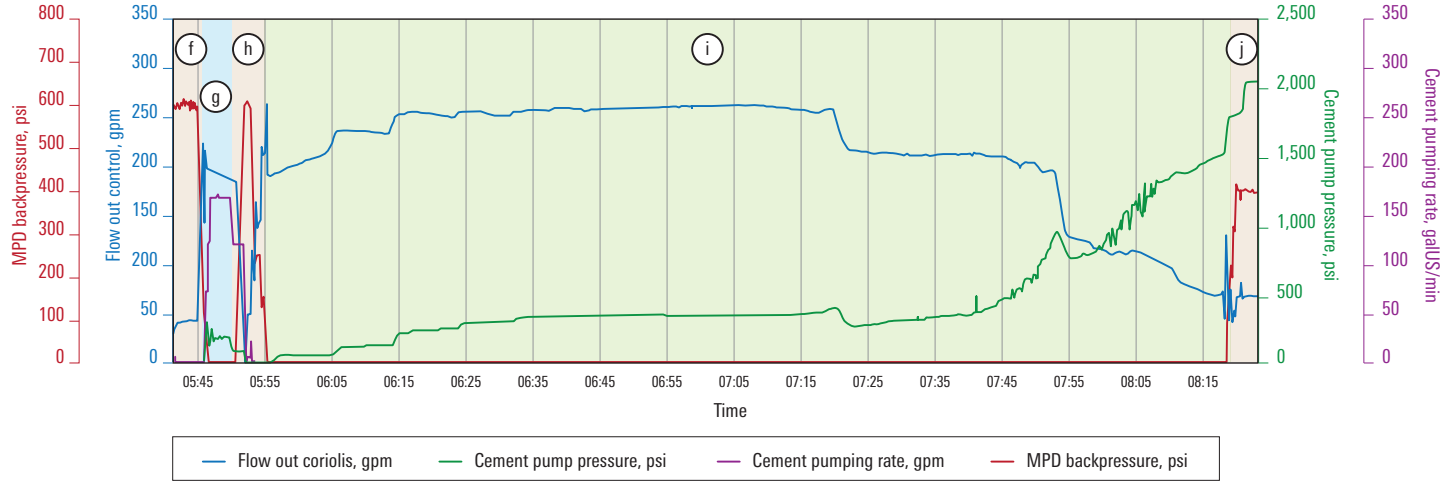
(c) Pumping 110 bbl wash + spacers at 6.0 bbl/min.

(d) 2nd pump stop to drop Bottom Plug and align valves. MPD applies 600 psi of surface backpressure.

(e) Pumping 132 bbl cement slurry at 4.0 bpm.

(f) 3rd pump stop to drop Top Plug. MPD applies 600 psi of surface backpressure.

Because of to high friction losses, it was not necessary to apply surface backpressure while circulating. To maintain an overbalanced condition during pump stops, 600 psi of surface backpressure was applied



(f) 3rd pump stop to drop Top Plug. MPD applies 600 psi of surface backpressure.

(g) Pumping 20 bbl fresh water at 4.0 bbl/min.

(h) 4th pump stop to align rig's mud pump. MPD allies 600 psi of surface backpressure.

(i) Displacing cement slurry by pumping 9.5 ppg mus (500 bbl at 6.0 bpm, 170 bbl at 5.0 bbl/min, 50 bbl at 3.0 bbl/min, and 23 bbl at 2.0 bpm).

(j) Top plug sets on bottom plug (peak in pump pressure could be observed). End of pumping. MPD applies 400 psi of surface backpressure.

Coupling of the top plug on the bottom plug indicates proper cement placement. MPD applied 400-psi surface backpressure until the cement was set.

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