



APPLICATION OF MANAGED PRESSURE DRILLING (MPD) TECHNOLOGY IN WELLS A AND B IN FIELD X

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ABSTRACT

Drilling oil and gas wells in deep formations and depleted reservoirs is often constrained by a narrow drilling margin. Under conditions where the difference between pore pressure and fracture gradient is very small, conventional methods based on static mud hydrostatic pressure carry a high risk of triggering a kick or loss of circulation. This study evaluated the use of the Constant Bottom Hole Pressure (CBHP) variant of Managed Pressure Drilling (MPD) technology to maintain bottom hole pressure (BHP) stability. Through a descriptive and comparative qualitative methodology based on a literature review, the evaluation was conducted on two scenarios: Well A with natural overpressure, and a deepwater well (Well B) with extreme depletion (crossed margin). Hydraulic analysis results demonstrated that the dynamic application of Surface Back Pressure (SBP) in MPD was capable of precisely controlling fluctuations in Equivalent Circulating Density (ECD). In Well A, SBP successfully compensated for the lack of hydrostatic pressure in the bottom mud without damaging the formation. Meanwhile, in Well B, the combination of MPD-CBHP and Wellbore Strengthening proved effective in widening the mud weight window, maintaining borehole stability, and eliminating the need for a contingency liner.

Keywords: *Managed Pressure Drilling; Narrow Drilling Margin; Constant Bottom Hole Pressure; Equivalent Circulating Density; Surface Back Pressure*

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INTRODUCTION

Oil and gas exploration and exploitation are currently faced with increasingly complex subsurface operational challenges. This is because recent drilling operations are mostly conducted in mature fields with deeper target depths. These challenging geological conditions directly cause a narrow drilling window, where the safety margin between formation pore pressure and fracture gradient becomes extremely thin. In narrow drilling window conditions, maintaining wellbore stability is a major challenge that frequently triggers operational hurdles, cost overruns, and environmental safety risks. Problems such as wellbore collapse, pipe sticking, and sudden formation fluid influx (kicks) are highly prone to occur. Conventional



drilling methods, which primarily rely on static mud weight adjustments, often fail and lack the flexibility required to compensate for subsurface pressure dynamics in such complex well conditions.

As a solution to these conventional method limitations, Managed Pressure Drilling (MPD) technology is applied. MPD offers precise and adaptive real-time pressure control by adjusting the annular pressure profile. This technology utilizes special auxiliary equipment such as a choke manifold and Rotating Control Devices (RCD) integrated with advanced monitoring systems to respond rapidly to any changes within the well. Philosophically, MPD shifts the drilling paradigm from static-reactive to dynamic-proactive pressure control. While conventional drilling requires a significant amount of time to adjust annular pressure (since the density of the entire mud volume in the pits must be altered), MPD enables pressure adjustments within seconds through the manipulation of surface back-pressure.

This study aims to analyze the mechanism of the Constant Bottom Hole Pressure (CBHP) variant of MPD technology in stabilizing bottom hole pressure in formations with narrow pressure windows. The evaluation focuses on the role of applying Surface Back Pressure (SBP) through a closed-loop circulating system in keeping the Equivalent Circulating Density (ECD) value between the pore pressure and fracture gradient limits. The novelty of this research lies in presenting a comparative synthesis of applying MPD (Times New Roman 11, before 0 pt, after 0 pt).

RESEARCH METHODS

his study is an applied research utilizing a literature review design. The data used are entirely secondary data collected from reputable scientific literature, technical reports, and Society of Petroleum Engineers (SPE) proceedings published within the last five years (2021-2026). The main object of this research is drilling hydraulic parameters and the performance of MPD auxiliary equipment, specifically the control of Equivalent Circulating Density (ECD) through the application of Surface Back Pressure (SBP) to minimize Non-Productive Time (NPT).

The analysis focuses on two offshore operational scenarios with extremely different geological characteristics: Well A (Offshore Field X, East Kalimantan), which experiences natural overpressure conditions, and Well B (Deepwater Mediterranean) with an average water depth of approximately 930 meters, which suffers from severe depleted reservoir pressure. The technical parameters extracted from the data bank include Pore Pressure (PP), Fracture



Gradient (FG), base Mud Weight (MW), annular friction pressure loss (AFP), SBP magnitude, and the mechanical sealing performance of the RCD. The data were processed using a descriptive-comparative-sintesis method to validate the hydraulic efficiency of the MPD system compared to conventional drilling methods.

RESULTS AND DISCUSSION

The characterization of the hydraulic system and pressure modeling demonstrates a significant variation in the reliability of MPD technology across both case studies. In Well A, directional drilling operations penetrated an abnormal overpressure zone in Formation M, with a target depth reaching 12,749 ft MD (7,585 ft TVD). At a depth of 11,998 ft MD (8-1/2 inch hole section), the equivalent pore pressure reached 11.6 ppg. Conventionally, fulfilling the safety overbalance criterion requires a minimum mud density of 12.2 ppg, which risks generating an ECD value that exceeds the formation fracture pressure. Through the application of MPD-CBHP, the static mud density was maintained lower at 11.4 ppg, while the hydrostatic pressure deficit was precisely compensated by applying SBP up to 328 psi at the section's total depth. This increased the Equivalent Static Density (ESD) value to 12.3 ppg without triggering loss circulation during normal circulation.

In the subsequent 6-1/8 inch hole section of Well A down to a depth of 12,750 ft MD, the pore pressure increased drastically to an equivalent of 13.16 ppg. Optimization was achieved by implementing a base mud weight of 12.4 ppg combined with a gradual increase in SBP up to 555 psi at Total Depth (TD). This surface pressure engineering is mathematically proven to dynamically control annular fluctuations and maintain wellbore stability without altering the overall mud density system at the surface.

Conversely, the analysis of Well B in the Deepwater Mediterranean reveals much higher complexity due to a crossed window phenomenon. Due to massive historical production exploitation of the Serravallian sand reservoir, the pore pressure dropped to 14.95 ppg, but the fracture gradient weakened so severely that mud circulation at an ECD of 14.79 ppg immediately triggered a total loss. This negative operational margin boundary cannot be resolved by MPD technology alone because MPD cannot create new formation fracture strength. Therefore, rock mechanics engineering in the form of Wellbore Strengthening (WS) was applied first using a Stress Caging pill with a massive Loss Prevention Material (LPM) concentration of calcium carbonate and fiber ranging from 39 ppb to 46 ppb to seal micro-fractures (fracture mouths).



Once the upper limit of the fracture gradient was mechanically widened by WS, the MPD system in Annular Pressure Control mode was deployed as a hydraulic navigator. When circulation was stopped for pipe connections (connection mode), the automated choke manifold system automatically adjusted based on a ramp table to apply a constant SBP of 620 psi to maintain pressure stability at a target equivalent ESD of 14.5 ppg. This integrative approach successfully eliminated the need for a 11-3/4 inch contingency liner and mitigated the simultaneous kick-loss hazard cycle

Tabel

Table 1. Comparative Synthesis of MPD Implementation under Narrow Margin Conditions

Evaluation Parameter	Case I (Well A)	Case II (Well B Deepwater)
Geological Base Condition	Natural Overpressure	Depleted Reservoir (Severe Depletion)
Pressure Window Characteristics	Narrow Margin	Crossed Margin (Overlapping / Negative)
Technology Integration	MPD-CBHP Standalone	MPD-CBHP + Wellbore Strengthening
Maximum SBP Applied	~555 psi	~620 psi (During connection mode)
Equivalent Density Strategy	SBP manipulation to elevate static base mud weight.	Lowering ECD during circulation; constant SBP when static.
Operational Outcome	Well successfully reached TD with wellbore stability fully maintained.	Eliminated contingency liner requirement; well stabilized from kick/loss.

Lowering ECD during circulation; constant SBP when static.

Eliminated contingency liner requirement; well stabilized from kick/lo



Table 2 MPD Trayek 8-1/2

ft TVF	ft MD	PP	FP	MW Schedule		Min	Static	
				Density	Overbalance	ESD	SBP	ESD w
						Target		SBP
ft	ft	ppg	ppg	ppg	psi	ppg	psi	ppg
6620	11500	10.82	15.63	11.4	200.7	11.42	8	11.42
6640	11526	10.87	15.65	11.4	183.7	11.47	25	11.47
6660	11552	10.92	15.66	11.4	166.9	11.52	42	11.52
6680	11578	10.97	15.68	11.4	149.7	11.57	60	11.57
6700	11604	11.02	15.70	11.4	133.4	11.62	78	11.62
6715	11623	11.05	15.70	11.4	123.6	11.65	88	11.65
6735	11649	11.08	15.72	11.4	111.7	11.68	100	11.69
6755	11675	11.12	15.73	11.4	98.7	11.72	114	11.72
6775	11701	11.16	15.74	11.4	84.9	11.76	128	11.76
6795	11727	11.20	15.75	11.4	71.4	11.80	142	11.80
6815	11752	11.24	15.77	11.4	57.8	11.84	156	11.84
6835	11778	11.28	15.78	11.4	43.7	11.88	172	11.88
6850	11798	11.31	15.79	11.4	33.5	11.91	182	11.91
6870	11824	11.35	15.81	11.4	19.6	11.95	200	11.96
6890	11850	11.39	15.83	11.4	5.4	11.99	215	12.00
6910	11875	11.42	15.84	11.4	-8.6	12.02	230	12.04
6930	11901	11.46	15.86	11.4	-22.7	12.06	245	12.08
6950	11927	11.50	15.88	11.4	-37.2	12.10	265	12.13
6970	11953	11.54	15.89	11.4	-51.5	12.14	280	12.17
6985	11973	11.57	15.91	11.4	-61.8	12.17	300	12.23
7005	11999	11.61	15.92	11.4	-75.8	12.21	328	12.30

Well SUMUR A is a directional well drilled in the Offshore Field X, East Kalimantan, with a target depth of 12,749 ft MD, equivalent to 7,585 ft TVD. This well penetrated the Y and M formations; in the M formation, an overpressure zone was identified, which caused a narrow pressure window. At a depth of 11,998 ft MD (8-1/2-inch casing), the equivalent pore pressure reached 11.4 ppg. To meet the minimum overbalance standard, the conventionally required mud density is 12.3 ppg. However, using mud with that density resulted in an Equivalent Circulating Density (ECD) value that exceeded the formation fracture pressure, thereby triggering a risk of catastrophic loss of circulation. A similar situation occurred at the 6-1/8-inch borehole at a depth of 12,749 ft MD, where pore pressure reached 13.16 ppg and required a mud density of 13.8 ppg, which also resulted in an ECD outside the safety margin required a mud density of 13.8 ppg, which also resulted in an ECD outside the safety margin.

**Table 2. PPFG Mud weight schedule**

Section		MD (ft)	MW (ppg)
17 1/2"	Start	0	9
	End	576	9
12 1/4"	Start	576	9.5
	End	4197	9.5
8 1/2"	Start	4197	9.5
		10450	10
		10782	10.5
		10988	11
	End	11998	11.4
6 1/8"	Start	11998	12.4
	End	12749	12.4

To address the narrow pressure window, the MPD method was applied to manipulate the Equivalent Static Density (ESD) so that it remained above the pore pressure without allowing the ECD to fracture the formation during circulation.

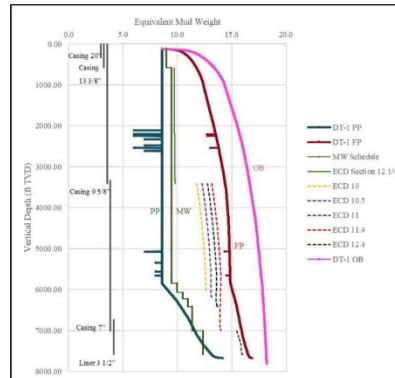
Table 3. MPD Trayek 6-1/8

ft TVF	ft MD	PP	FP	MW Schedule		Min ESD Target	Static	
				Density	Overbalance		SBP	ESD w SBP
				ppg	psi		psi	ppg
7110	12134	11.81	16.00	12.4	217.0	12.41	5	12.41
7115	12141	11.83	16.01	12.4	212.7	12.43	10	12.43
7125	12154	11.85	16.02	12.4	203.8	12.45	25	12.47
7155	12193	11.92	16.05	12.4	177.5	12.52	45	12.52
7185	12232	12.00	16.07	12.4	150.6	12.60	75	12.60
7215	12270	12.07	16.10	12.4	123.4	12.67	100	12.67
7245	12309	12.15	16.13	12.4	96.1	12.75	135	12.76
7275	12348	12.22	16.16	12.4	68.5	12.82	160	12.82
7305	12387	12.29	16.19	12.4	40.6	12.89	190	12.90
7335	12426	12.37	16.22	12.4	12.6	12.97	218	12.97
7365	12465	12.44	16.25	12.4	-15.7	13.04	246	13.04
7395	12504	12.55	16.29	12.4	-56.5	13.15	287	13.15
7425	12542	12.65	16.33	12.4	-95.4	13.25	330	13.25
7455	12581	12.74	16.36	12.4	-133.0	13.34	368	13.35
7485	12620	12.84	16.40	12.4	-170.5	13.44	405	13.44
7515	12659	12.93	16.43	12.4	-208.7	13.53	445	13.54
7545	12698	13.03	16.47	12.4	-248.4	13.63	485	13.64
7575	12737	13.13	16.51	12.4	-287.6	13.73	530	13.75
7585	12750	13.16	16.52	12.4	-300.2	13.76	555	13.81

Gambar

During this mud weight schedule phase, the mud weight will be set to achieve a minimum overbalance of 0.6 ppg above pore pressure. This minimum overbalance is standard for oil and gas drilling, where the standard overbalance is 200 to 300 psi above pore pressure. For drilling the 17 1/2-inch and 12 1/4-inch runs, the mud weights used are 9 ppg and 9.5 ppg, respectively. In the 8 1/2-inch borehole, a mud weight of 9.5 ppg was used from a depth of 4,197 ft MD to

10,449 ft MD. At a depth of 10,450 ft MD (5,845.31 ft TVD), pore pressure increased; therefore, to maintain the BHP above the minimum overbalance pressure, the mud weight was gradually increased. At a depth of 10,450 ft MD, the mud weight was changed to 10 ppg; at a depth of 10,782 ft MD, it was changed to 10.5 ppg; and at a depth of 10,988 ft MD, the mud weight was set to 11 ppg.

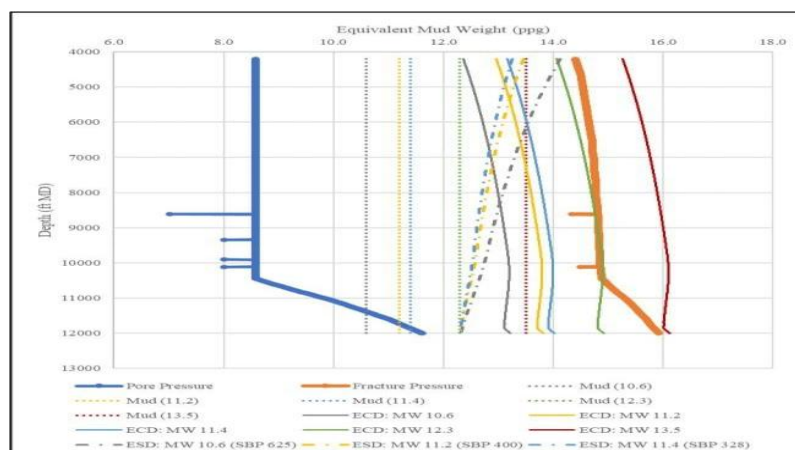


Picture 1 PPFG Dengan Mud Weight Schedule Dan ECD

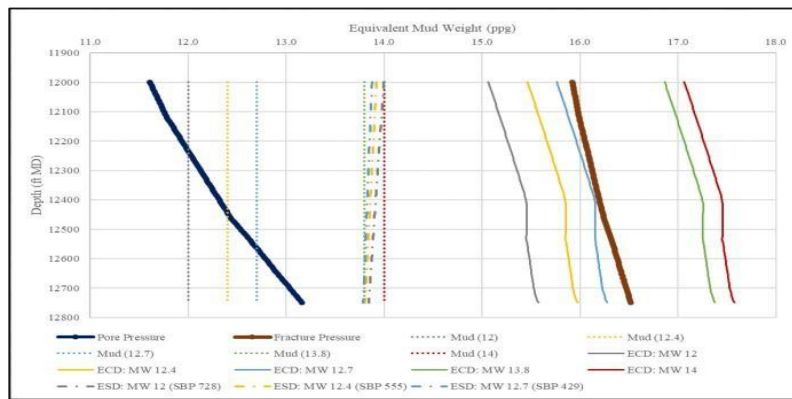
8-1/2-inch section: Drilling was conducted using a static mud density of 11.4 ppg starting at a depth of 11,234 ft MD. To compensate for the shortfall in hydrostatic pressure relative to pore pressure (11.61 ppg at the bottom of the section), Surface Back Pressure (SBP) was gradually applied. At the final depth of 11,998 ft MD, SBP was increased to 328 psi, resulting in an ESD of 12.3 ppg, ensuring that overbalance was safely achieved

6-1/8-inch casing: A bottom mud density of 12.4 ppg was used. SBP was applied starting at a depth of 12,134 ft MD at 5 psi and was gradually increased proportionally until it reached 555 psi at a Total Depth (TD) of 12,750 ft MD (7,585 ft TVD).

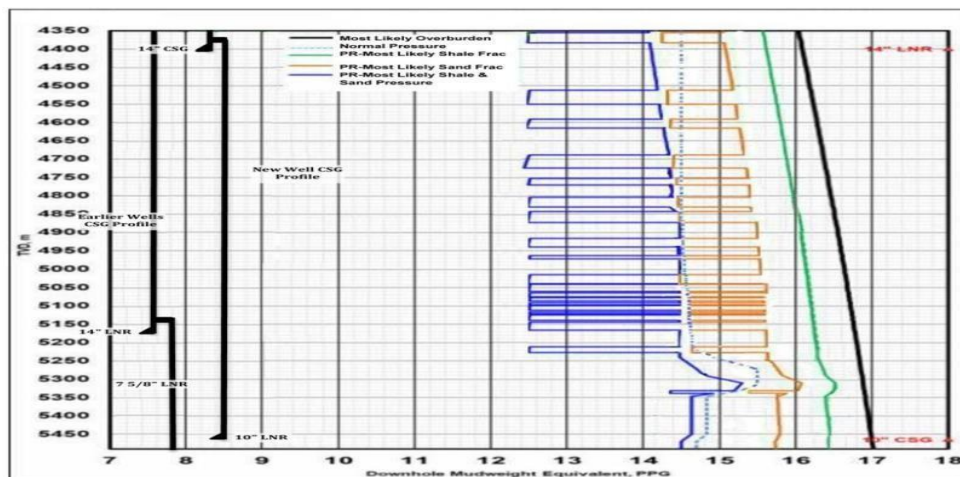
With a static base mud weight of 12.4 ppg, the total ESD value becomes $12.4 + 1.41 = 13.8$. This methodology demonstrates that precise control of surface annular pressure (SBP) provides hydraulic flexibility that cannot be achieved through conventional drilling.



Picture 2. Mud Weight Sensitivity Trayek 8-1/2

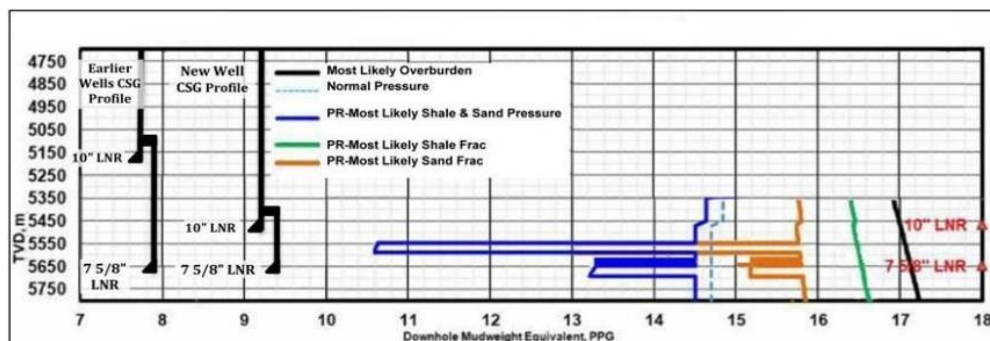


Picture 3. *Mud Weight Sensitivity Trayek 6-1/8*



Picture 4. *12.25\"/>*

Static Wellbore Strengthening: In the 12.25\"/>



Picture 5. *8.5\"/>*

Dynamic Wellbore Strengthening: Pada trayek reservoir 8,5" x 9,5", material WS langsung dicampurkan ke dalam sistem lumpur aktif dengan konsentrasi masif sebesar 39 ppb selama proses pemboran berlangsung

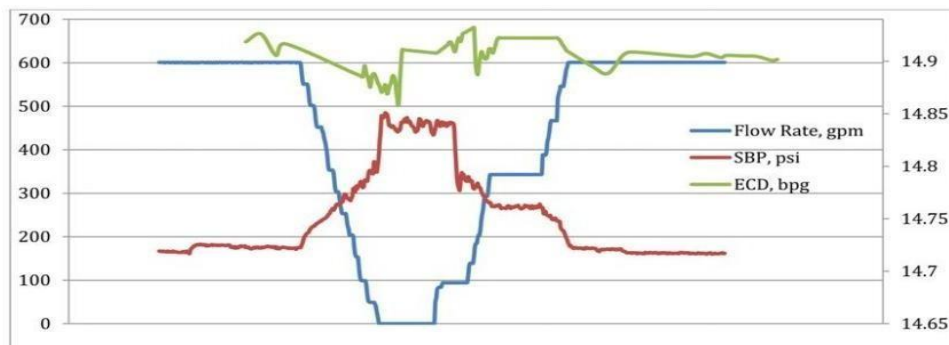
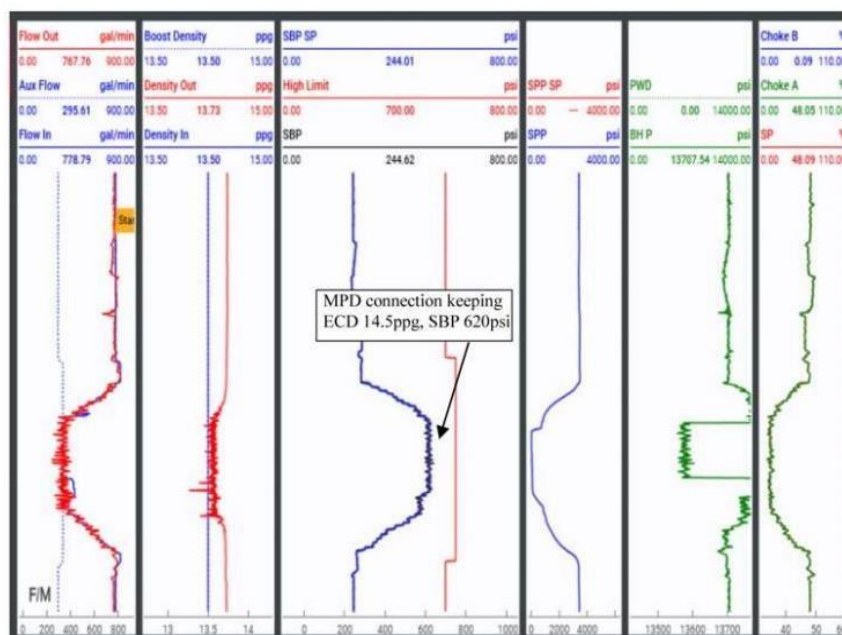


Figure 6. MPD Connection in “C” mode targeting ECD of 14.94bpg

Connection Mode: During pipe connection, the MPD automatically adjusts the choke manifold using a ramp table to maintain Bottom Hole Pressure (BHP) equivalent to the dynamic conditions during drilling. In a depleted reservoir, equivalence is strictly maintained at an ESD of 14.5 ppg through the application of a constant SBP, which successfully prevents pressure spikes and minimizes losses.

Cement Liner Transition: Circulation and cementing operations for the 7-5/8" liner were performed using MPD by precisely reducing the pump rate to accommodate the increased cement viscosity in the annulus, reduce the friction fraction, and maintain the integrity of the brittle zone.



Picture 7. Performing MPD Connection in SBP mode by ramp table keeping ECD of 14,5ppg, SBP 620psi



CONCLUSION

The application of Managed Pressure Drilling (MPD) technology, specifically the Constant Bottom Hole Pressure (CBHP) variant, is highly effective in overcoming the limitations of conventional drilling methods in critical formations with narrow pressure windows. Under natural overpressure conditions (Well A), real-time manipulation of Surface Back Pressure (SBP) up to 555 psi is capable of compensating for low static mud weight and precisely controlling Equivalent Circulating Density (ECD) fluctuations. Meanwhile, in severely depleted deepwater reservoir conditions (Well B), MPD must be integrated with Wellbore Strengthening (WS) methods to provide a safe operational window across a crossed window. The combination of a Rotating Control Device (RCD) as an annular circulating seal and an automated choke manifold successfully dampens pressure spikes, eliminates the need for contingency liners, and significantly reduces Non-Productive Time (NPT) in complex drilling environments.

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