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Maximum Efficient Rate Analysis of a Treated High Water Cut-Shutoff Wells

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***Abstract-** Increased water and gas production in oil recovery operations affects well performance and cause a reduction in oil production, making it necessary to determine the Maximum Efficient Rate (MER) for proper production control. This study estimates MER and appropriate choke size for selected wells for efficient production. The Study was achieved by estimating choke sizes, carrying out MER tests, determining MER using technical plots, and analyzing the data using statistical methods. Well test data in a field in Niger Delta was collected and used after approval from the regulatory authority. MER tests were carried out on selected wells using five different choke sizes, with proper stabilization and test periods. The well parameters such as flowing tubing head pressure (FTHP), oil rate, gas rate, and water cut were measured. Technical plots were used to determine MER, while regression and ANOVA were used to check relationships and differences in the data. The results show that MER values obtained include 423 bopd for Case 1A, 1069 bopd for Case 2A, 798 bopd for Case 3A, and 1115 bopd for Case 4B. An increase in choke size led to increase in oil, gas, and total liquid rates, while FTHP reduced. The regression model shows an inverse relationship between choke size and FTHP. ANOVA results show significant differences among wells and choke sizes. The study shows that MER can be effectively determined using technical plots and statistical methods, and that choke size and pressure are important for controlling well performance.*

***Index Terms-** Maximum Efficient Rate (MER), Technical Allowable Rate (TAR), Choke Size, Flowing Tubing Head Pressure (FTHP), Oil Production Rate, Water Cut, Technical Plot Analysis*

I. INTRODUCTION

Oil production operations are often constrained by the presence of excessive water and gas production, which leads to environmental degradation, reduction of the net oil production and increase in the rate of corrosion. These challenges necessitate the application of Maximum Efficient Rate (MER) testing for monitoring the reservoir and well performance and subsequently proffering solutions to excessive water and gas production by putting up control mechanisms to mitigate them and further increase oil production. Maximum Efficient Rate (MER) means the maximum sustainable daily oil or gas withdrawal rate from a reservoir which will permit depletion of that reservoir without detriment to ultimate recovery. The MER is the maximum rate at which oil or gas can be produced without damaging the reservoir natural energy, and any rate above this limit results in pressure decline and reduced ultimate recovery. Maximum Efficient Rate (MER) is therefore regarded as the highest daily rate of production which can be sustained without loss of recoverable reserves from a given pool (Ibianga & Peter, 2018; Chowdhury et al., 2019; Davarpanah et al., 2018).

The occurrence of excessive water production in oil wells, especially in mature fields, has been widely reported as a major production challenge requiring effective diagnosis and control strategies(Nmegbu et al.,2020).Water production may arise due to mechanisms such as water coning, channeling, or aquifer encroachment, and its presence significantly affects well productivity and reservoir performance (Mahgoup & Khairb, 2015; Rabiei, 2011; Taha & Amani, 2019; Khiary, 2016; Kim & Crespo, 2013). It is also known that gas and water coning occur when oil is produced from relatively thin formations located below a gas cap or above a water zone, where low bottom-hole pressure draws unwanted fluids into the wellbore. To mitigate this, it is essential to control the rate of fluids flowing through the wellhead using surface choke or bean adjustments to regulate pressure differential and reduce the incursion of sand, water, and gas (Ahmad et al., 2012; Permana et al., 2015; Sydansk & Romero-Zeron, 2011). The application of water shut-off treatments has been identified as a viable approach to reduce unwanted water production and improve oil recovery in such wells (Joseph & Ajienka, 2010; Taha & Amani, 2019; Permana et al., 2015).

MER testing plays an important role in evaluating well productivity after interventions such as water shut-off treatments and re-perforation. Maximum efficient rate test (MER) and bottom-hole flowing/build-up surveys are done after well completion and when required in order to investigate changes to reservoir conditions and well productivity (Chowdhury et al., 2019; Davarpanah et al., 2018; Friehauf, 2013). The acquisition of MER is sensitive to reservoir drive mechanisms such as solution gas drive, water drive, and gas cap expansion, which influence the correctness of test results and interpretation (Ibianga & Peter, 2018; Onwukwe & Izuwa, 2018). These factors make it necessary to carefully evaluate production parameters during MER testing to ensure reliable results.

Recent studies have highlighted the significance of integrating diagnostic tools and production data analysis in understanding excessive water production and improving MER estimation. Techniques such as production logging and reservoir performance evaluation have been put into practical use to identify sources of water production and optimize well performance (Chowdhury et al., 2019; Davarpanah et al., 2018; Mukerji, 2013). Advances in water shut-off technologies and diagnostic methods have enhanced the success rate of intervention strategies in mature oil fields (Taha & Amani, 2019; Nmegbu et al., 2020; Mahgoup & Khairb, 2015). However, there is still a need to evaluate the performance of treated wells to ensure that production rates remain within efficient limits.

This study therefore focuses on the Maximum Efficient Rate analysis of treated water shut-off wells, with emphasis on evaluating well performance after intervention and ensuring optimal production rates. By examining the relationship between choke size, production rate, and reservoir response, the study seeks to provide a better understanding of MER behavior in wells affected by excessive water production and subsequent treatment.

II. METHODOLOGY

The field materials and equipment used for the Maximum Efficient Rate (MER) exercise in the field include buckets, foam, distilled bottles, polyethylene materials, demulsifier chemicals, personal protective equipment (PPEs), jerry cans, and detergents. The equipment utilized for the MER test consists of test trees, surface safety valves, data headers, choke manifold, pressure gauges, steam heat exchangers, oil transfer pumps, oil diverter manifolds, burners, emergency shutdown (ESD) systems, test separators, vertical surge tanks, atmospheric gauge tanks, centrifuge and laboratory facilities, and spanners. Glassware such as beakers, conical flasks, and measuring cylinders were used for laboratory analysis. Other supporting tools include crew boats, correct choke/bean sizes, and portable radios for communication.

MER Well Testing Procedure

The MER well testing process was carried out using standard field procedures after receipt of notification from the regulatory agency. Well test production data of producing strings or wells were obtained from an indigenous producing firm. The procedure provides a step-by-step guide to safely perform the Maximum Efficient Rate (MER) test. Pre-work activities included carrying out Job Safety Analysis (JSA), establishing communication with control room operators, and conducting toolbox meetings. Appropriate staffing was ensured, and all required materials, including choke sizes and communication tools, were made available. The MER test was conducted in the presence of regulatory representatives. The test commenced by selecting the candidate well and confirming that the test separator was properly lined to receive process fluids. Choke inspection was carried out to ascertain correct size and check for erosion or sand cut. The well was then flowed and allowed to stabilize for an average of 3 hours for low-pressure wells and 4 hours for high-pressure wells.

After stabilization, flowing parameters were measured and recorded, including shut-in tubing pressure (SITP), flowing tubing pressure (FTP), flowline pressure (FLP), casing pressure (CSP), and sand count. Process fluid samples were collected for determination of Bottom Sediment and Water (BS&W) and API gravity. The well was then diverted to the test separator, and time-in and time-out readings were recorded over a 6-hour test period using the turbine meter. Gas measurements were obtained using an orifice plate and chart recorder. The test procedure was repeated for selected choke sizes in ascending order until all test conditions were completed. The collected data were recorded and processed using standard well test reporting formats.

Selection of MER Choke Sizes

Selection of choke sizes was carried out using well surveillance data and well test history plots. Monthly routine production test data obtained after notification from the regulatory agency were used as a guide. Three choke sizes were selected for flowing wells, while five choke sizes were selected for newly perforated or reperforated wells. The selected choke sizes were tested in ascending order to evaluate well performance.

Well test historical data were plotted using Microsoft Excel to evaluate production trends. Parameters considered include date of test, duration of test, choke size, oil rate, gas rate, producing gas-oil ratio (GOR), water cut (BS&W), sand production, water rate, and total liquid produced. These plots served as a guide for choke selection and MER determination.

MER Parameters and Calculations

The evaluation of MER involved calculation of key production parameters using field data.

Total Liquid Rate (TLR)

Total Liquid Rate is the total volume of oil and water produced daily and is expressed in Equation 1:

"TLR=Oil Rate+Water Rate" (1)

Water Cut (BS&W)

Water cut is the ratio of water produced to total liquid produced and is expressed in Equation 2:

$$Water\ Cut\ (\%) = \frac{Water\ Rate}{Total\ Liquid\ Rate} \times 100 \qquad (2)$$

Oil Rate

Oil rate is determined from total liquid rate and water cut and is expressed in Equation 3:

$$Oil\ Rate = Total\ Liquid\ Rate \times (1 - Water\ Cut) \qquad (3)$$

Water Rate

Water rate is calculated as expressed in Equation 4:

$$Water\ Rate = Total\ Liquid\ Rate - Oil\ Rate \qquad (4)$$

Producing Gas-Oil Ratio (GOR)

The producing GOR is defined as Equation 5:

$$GOR = \frac{Gas\ Rate}{Oil\ Rate} \times 1000 \qquad (5)$$

API Gravity

API gravity is determined from the specific gravity of crude oil and is expressed in Equation 6:

$$API = \frac{141.5}{SG} - 131.5 \qquad (6)$$

Determination of Maximum Efficient Rate (MER)

The Maximum Efficient Rate was determined using technical plot analysis. A cross-plot of tubing head pressure (THP) versus production rate and choke size versus production rate was generated using Microsoft Excel. The point of intersection of these plots represents the stable operating condition and corresponds to the Maximum Efficient Rate. Least square regression analysis was applied to obtain the slope and intercept of the tubing head pressure trend. The intersection point of the two trend lines defines the MER, which represents the optimum production rate without causing reservoir damage.

Choke Performance Analysis

Choke analysis was conducted using the MER test results to determine the most suitable choke size for optimal performance. The selected choke size corresponds to the rate closest to the determined MER, ensuring controlled production and minimizing excessive water or gas production. The analysis provides a basis for regulating flow conditions and maintaining reservoir stability.

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Statistical Analysis
A statistical approach using Randomized Completely Block Design (RCBD) and regression models was applied to evaluate the accuracy of field measurements and the performance of production parameters. The analysis considered the effects of choke size on oil rate, liquid rate, water rate, and gas rate to determine the significance of variations and interactions between variables.

III. RESULTS

3.1 Well Test History Plots
Routine well test data for the different case wells are presented in Tables 1, 2, 3 and 4. This was done to ascertain the correctness in the selection of chokes sizes and well test rates to the well and to check if there is high or low produced water(watercut), Gas oil ratio , sand count, total liquid produced , Tubing head pressure level, casing head pressure , oil rates before selecting the appropriate choke size to be tested.

Well Case 1 Field A Well Test History
The well test result for Case 1/DB-01 A is presented in Table 1, while the historical production trends are shown in Figure 1 and Figure 2. From Table 1, the well produced 474 BOPD at a choke size of 16/64" with a gas rate of 1123 MCFD and a GOR of 2369 scf/bbl. The water cut was 25%, indicating increasing water production in the well. Sand production was negligible.

Table 1: Case 1/DB-01 A Well Test Result

Well	Date of Test	Choke	FTHP	BOPD	MCFD	GOR	BS&W	Cs.P	Sand
Case 1	01/11/2020	16	1120	474	1123	2369	25	0	0

Figure 1 shows the well test history for oil rate, gas-oil ratio (GOR), and water cut. Oil production increased gradually from the early production period and reached a peak after about six years. During this period, the GOR showed fluctuations, indicating unstable flow conditions. As production progressed, water cut increased significantly. The increase in water cut corresponds with a decline in oil rate, showing the effect of water production on well performance. The GOR also reduced as water production became dominant in the later years.

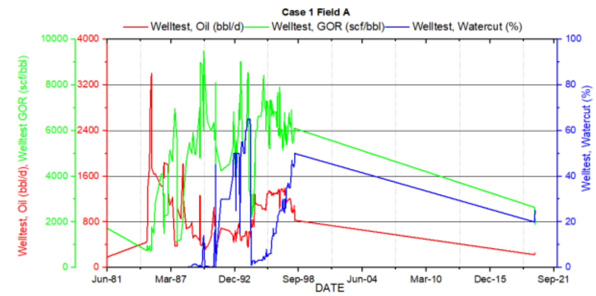

Figure 1. Case 1/ DB-O1 A Well Test History Plot for Oil produced and GOR

Figure 2 presents the relationship between flowing tubing head pressure (FTHP) and choke size. The FTHP increased with increasing production up to a maximum level and later declined. The choke sizes were adjusted in stages, reflecting operational control of the well. Larger choke sizes correspond to higher production periods, while smaller choke sizes were used as production declined.

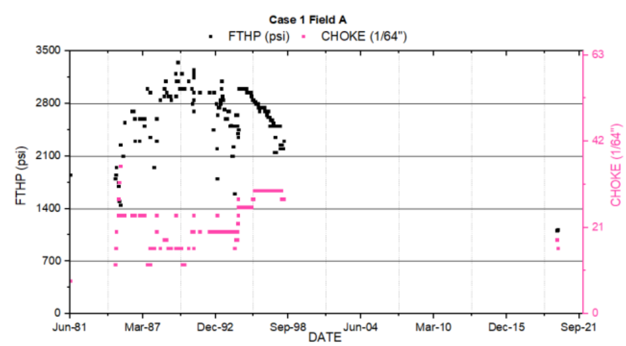

Figure 2. Case 1/ DB-O1 A Well Test History Plot for FTHP

The results show that the well performance was affected by increasing water production, which led to a reduction in oil output. The variation in FTHP and choke size indicates changing reservoir conditions. These trends are important for MER analysis, as they show the production limits and the need to control flow rate to avoid excessive water production and maintain stable well performance.

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Well, Case2/ CB-08 Field A Well Test History

The well test result for Case 2/CB-08 A is presented in Table 2**,** while the historical production trends are shown in Figure 3 and Figure 4. From Table 2**,** the well produced 892 BOPD at a choke size of 18/64" with a gas rate of 1324 MCFD and a GOR of 1484 scf/bbl. The water cut was 3%, indicating low water production at the time of test. Sand production was negligible.

Table 2: Case 2/CB-08 A Well Test Result

Well	Date of Test	Choke	FTHP	BOPD	MCFD	GOR	BS&W	Cs.P	Sand
Case 2	11/24/2019	18	1700	892	1324	1484	3	0	0

Figure 3 shows the well test history for oil rate, gas-oil ratio (GOR), and water cut. Oil production was highest during the early years of production, particularly within the first and second year. During this period, GOR was also high, indicating strong reservoir energy. As production continued, oil rate declined steadily, while water cut increased. The increase in water cut corresponds with the decline in oil production, indicating the onset of water production effects in the well. The GOR also decreased with time as production declined.

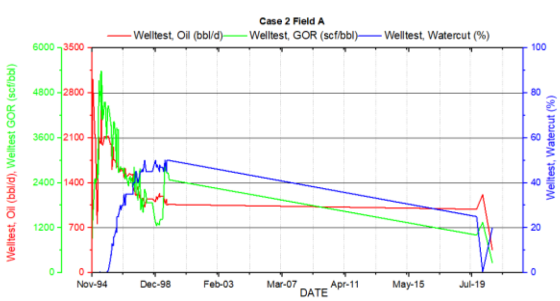

Figure 3.Case 2/ CB-O8 A Well Test History Plot for Oil produced and GOR

Figure 4 presents the variation of flowing tubing head pressure (FTHP) with choke size. The FTHP was higher during the early production period and decreased as production declined. The choke sizes were adjusted during the production period, reflecting operational control of the well. Larger choke sizes correspond to higher production periods, while smaller choke sizes were used as production declined.

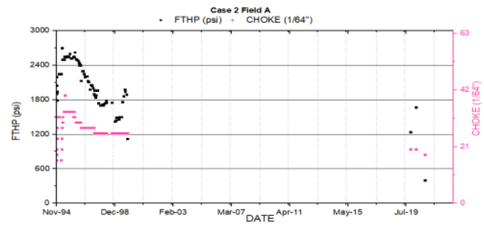

Figure 4.Case 2/ CB-O8 A Well Test History Plot for FTHP

The results show that the well initially produced at high oil rate with low water cut, but performance declined with time due to increasing water production. The reduction in FTHP and changes in choke size indicate declining reservoir pressure and flow capacity. These trends are important for MER analysis, as they define the production behavior of the well and the need to control flow conditions to maintain efficient production.

Well Case 3 EA -10 Field A Well Test History

The well test result for Case 3/EA-10 A is presented in Table 3, while the historical production trends are shown in Figure 5 and Figure 6**.** From Table 3**,** the well produced 830 BOPD at a choke size of 24/64" with a gas rate of 2905 MCFD and a GOR of 3500 scf/bbl. The water cut was 20%, indicating moderate water production at the time of test. Sand production was negligible.

Table 3: Case 3/EA-10 A Well Test Result

Well	Date of Test	Choke	FTHP	BOPD	MCFD	GOR	BS&W	Cs.P	Sand
Case 3	01/09/2020	24	750	830	2905	3500	20	0	0

Figure 5 shows the well test history for oil rate, gas-oil ratio (GOR), and water cut. Oil production increased during the early stage of production and

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reached optimum levels within the first and second year. During this period, GOR was also high, indicating strong reservoir drive. As production progressed, oil rate declined steadily with a corresponding increase in water cut. The increase in water cut shows the gradual dominance of water production in the well. The GOR declined uniformly after the peak period, reflecting reduced gas contribution as the reservoir depleted.

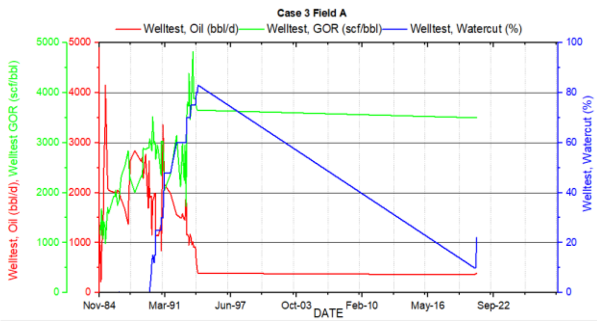

Figure 5.Case 3/ EA-10 A Well Test History Plot for Oil produced and GOR

Figure 6 presents the variation of flowing tubing head pressure (FTHP) with choke size. The FTHP shows fluctuations during the production period, indicating unstable flow conditions. The choke sizes were adjusted across the production life of the well, reflecting operational control. Higher choke sizes correspond to earlier production stages, while adjustments were made as production declined.

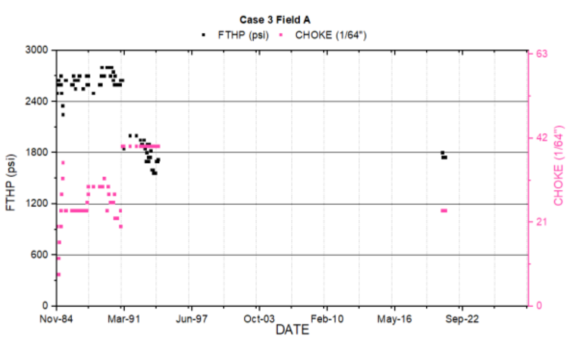

Figure 6.Case 3/ EA-10 A Well Test History Plot for FTHP

The results indicate that the well experienced optimum production at early stages, followed by a steady decline due to increasing water production. The fluctuating FTHP and changes in choke size reflect variations in reservoir pressure and flow behavior. These trends are relevant for MER analysis, as they define the production limits and the need to regulate flow rate to maintain stable well performance.

Well Case 4 /CD -05 Field B Well Test History

The well test result for Case 4/CD-05 B is presented in Table 4**,** while the historical production trends are shown in Figure 7 and Figure 8**.** From **Table 4**, the well produced 1102 BOPD at a choke size of 18/64" with a gas rate of 998 MCFD and a GOR of 906 scf/bbl. The water cut was 32%, indicating significant water production at the time of test. Sand production was negligible.

Table 4: Case 3/CD-05 B Well Test Result

Well	Date of Test	Choke	FTHP	BOPD	MCFD	GOR	BS&W	Cs.P	Sand
Case 4	02/20/2022	18	600	1102	998	906	32	0	0

Figure 7 shows the well test history for oil rate, gas-oil ratio (GOR), and water cut. Oil production was highest within the first and second year of production. During this period, GOR was relatively high, indicating active reservoir drive. As production continued, oil rate declined while water cut increased. The increase in water cut corresponds with the reduction in oil production, showing the impact of water production on the well. The GOR fluctuated during the production period but generally decreased as the well matured.

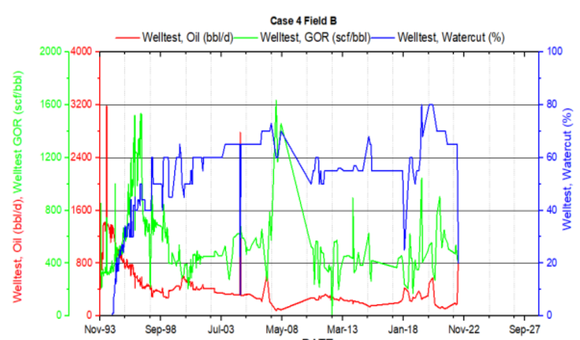

Figure 7.Case 4/ CD-O5 B Well Test History Plot for Oil produced and GOR

Figure 8 presents the variation of flowing tubing head pressure (FTHP) with choke size. The FTHP decreased with time as production declined. The choke sizes were adjusted during the production period, indicating operational control of the well. Higher choke sizes were associated with early production stages, while lower choke sizes correspond to later stages of declining production.

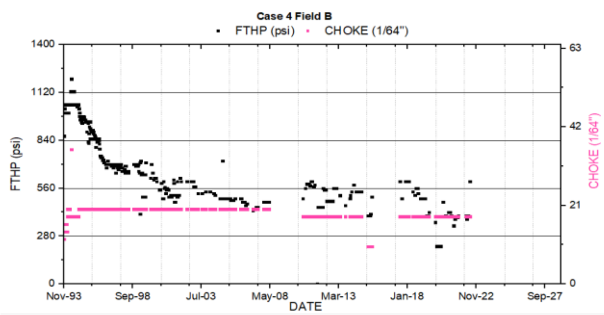

Figure 8. Case 4/ CD-O5 B Well Test History Plot for FTHP

The results show that the well experienced high production at early stages, followed by a decline due to increasing water cut. The decrease in FTHP and changes in choke size reflect declining reservoir pressure and flow capacity. These trends are relevant for MER analysis, as they indicate the need to control production rate to minimize water production and maintain stable well performance.

3.2 Selection of MER Well Test Choke Sizes

A pre-MER well performance analysis in form of data QA/QC was carried out on the observed well test data as presented in appendixes A, B, C, D (Tables 1, 2, 3 , 4) . In this field cases, because there is a laid down rule by the regulators that all wells that undergo new perforation should be tested on five chokes sizes while producing strings be tested on three choke sizes the selection was based on the stated above test result parameters . The five (5) bean or choke sizes selected as presented in table 5 and the programme of activities of well test as presented in table 6. The selection was based on the well test history plot as presented in Fig. 1 to 8 and it was produced with aid of an origin software and rule of thumb while evaluating the current water rate, oil rate, GOR and THP which are essential parameters in considering MER well test exercise.

Field MER Well Test

The MER well test results for the selected candidate wells (Case 1A, 2A, 3A, 4B, 5, 6, 7, 8, and 9) are presented in Table 5 to Table 13**.** The tests were conducted using five (5) different choke sizes for each well, with a stabilization period of four (4) hours and a test duration of six (6) hours.

From Table 5 (Case 1A), as choke size increased from 12/64" to 20/64", oil rate increased from 270 BOPD to 691 BOPD, while liquid rate increased from 360 BPD to 1,152 BPD. Gas rate also increased from 820 MSCF to 1,781 MSCF. Water rate increased from 90 BWPD to 461 BWPD, and BS&W increased from 25% to 40%. GOR decreased from 3,037 scf/stb to 2,577 scf/stb at higher choke sizes.

Table 5: Case 1A MER Well Test

TEST DATE	TEST DURATION	FTHP, Psi	Liquid Rate, bpd	Gas Rate, Mscf	BS&W, %	Sand lbs/bbl	Choke Size, /64"	Oil Rate, bopd	Water, bwpd	GOR, scf/stb	GLR, scf/stb	PS - PWF	PI, Stb/d/psi
22/Mar/20	6HRS	1,330	360	820	25	0	12	270	90	3,037	2278	N/A	N/A
23/Mar/20	6HRS	1,260	512	996	30	0	14	358	154	2,782	1945	N/A	N/A
24/Mar/20	6HRS	1,200	640	1,106	30	0	16	448	192	2,469	1728	N/A	N/A
25/Mar/20	6HRS	1,180	864	1,203	34	0	18	570	294	2,111	1392	N/A	N/A
26/Mar/20	6HRS	1,160	1,152	1,781	40	0	20	691	461	2,577	1546	N/A	N/A

From Table 6 (Case 2A)**,** oil rate increased from 945 BOPD at 18/64" choke to 1,728 BOPD at 26/64". Liquid rate increased from 984 BPD to 2,304 BPD, while gas rate increased from 1,400 MSCF to 2,333 MSCF. Water rate increased from 39 BWPD to 576 BWPD, and BS&W increased from 4% to 25%. GOR decreased slightly from 1,482 scf/stb to 1,350 scf/stb.

Table 6: Case 2A MER Well Test

TEST DATE	TEST DURATION	FTHP, Psi	Liquid Rate, bpd	Gas Rate, Mscf	BS&W, %	Sand lbs/bbl	Choke Size, /64"	Oil Rate, bopd	Water, bwpd	GOR, scf/stb	GLR, scf/stb	PS - PWF	PI, Stb/d/psi
26/Mar/20	6HRS	1,750	984	1,400	4	0	18	945	39	1,482	1423	N/A	N/A
27/Mar/20	6HRS	1,650	1,188	1,539	10	0	20	1,080	119	1,425	1295	N/A	N/A
28/Mar/20	6HRS	1,600	1,434	1,244	15	0	22	1,219	215	1,021	868	N/A	N/A
29/Mar/20	6HRS	1,500	1,830	1,851	20.0	0	24	1,464	366	1,264	1011	N/A	N/A
30/Mar/20	6HRS	1,400	2,304	2,333	25	0	26	1,728	576	1,350	1013	N/A	N/A

From Table 7 (Case 3A), oil rate increased from 630 BOPD at 20/64" choke to 1,150 BOPD at 28/64". Liquid rate increased from 788 BPD to 1,643 BPD, while gas rate increased from 2,185 MSCF to 3,620 MSCF. Water rate increased from 158 BWPD to 493 BWPD, and BS&W increased from 20% to 30%. GOR varied between 3,468 scf/stb and 3,148 scf/stb.

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Table 7: Case 3A MER Well Test

TEST DATE	TEST DURATION	FTHP, Psi	Liquid Rate, bpd	Gas Rate, Mscf	BS&W, %	Sand lbs/bbl	Choke Size, /64"	Oil Rate, bopd	Water, bwpd	GOR, scf/stb	GLR, scf/stb	PS - PWF	PI, Stb/d/psi
3/22/21 10:00	6HRS	750	788	2,185	20	0	20	630	158	3,468	2773	N/A	N/A
3/23/21 10:00	6HRS	750	945	2,647	20	0	22	756	189	3,501	2801	N/A	N/A
3/23/21 18:00	6HRS	750	1,092	3,150	24	0	24	830	262	3,795	2885	N/A	N/A
3/24/21 18:00	6HRS	700	1,243	3,590	26	0	26	920	323	3,902	2888	N/A	N/A
3/25/21 18:00	6HRS	750	1,643	3,620	30	0	28	1,150	493	3,148	2203	N/A	N/A

From Table 8 (Case 4B), oil rate increased from 810 BOPD at 14/64” choke to 1,200 BOPD at 22/64”. Liquid rate increased from 1,013 BPD to 2,182 BPD. Water rate increased significantly from 203 BWPD to 982 BWPD, and BS&W increased from 20% to 45%. GOR increased from 600 scf/stb to 1,150 scf/stb.

Table 8: Case 4B MER Well Test

TEST DATE	TEST DURATION	Choke Size, /64"	FTHP, Psi	Oil Rate, bopd	Gas Rate, Mscf	GOR, scf/stb	BS&W, %	Sand lbs/bbl	Water, bwpd	Liquid Rate, bpd	GLR, scf/stb	PI, Stb/d/psi	PS - PWF
3/12/22 0:00	6HRS	14	650	810	486	600	20	0	203	1,013	480	N/A	N/A
3/13/22 0:00	6HRS	16	650	900	657	730	20	0	225	1,125	584	N/A	N/A
3/14/22 0:00	6HRS	18	620	1,098	966	880	32	0	517	1,615	598	N/A	N/A
3/15/22 0:00	6HRS	20	600	1,120	1,198	1,070	39	0	716	1,836	653	N/A	N/A
3/16/22 0:00	6HRS	22	600	1200	1380	1150	45	0	982	2182	632	N/A	N/A

From Table 9 (Case 5), oil rate increased from 345 BOPD at 20/64” choke to 610 BOPD at 28/64”. Gas rate increased from 1,241 MSCF to 2,198 MSCF. Water produced increased from 421 BWPD to 746 BWPD, while total liquid increased from 766 BLPD to 1,357 BLPD. GOR remained relatively constant around 3,600 scf/stb.

Table 9: Case 5 MER Well Test

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	Cs.P (psi)	BS&W (%)	API	Sand lbs/1000 bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Remarks
CASE 5	30/Oct/18	4	6	20	345	1,241	3,600	1,227	210	0	55	45	0	421	766	TESTED
CASE 5	31/Oct/18	4	6	22	409	1,474	3,604	1,207	210	0	55	45	0	501	910	TESTED
CASE 5	1/Nov/18	4	6	24	478	1,722	3,603	1,190	210	0	55	45	0	585	1,063	TESTED
CASE 5	2/Nov/18	4	6	26	546	1,967	3,603	1,161	200	0	55	45	0	668	1,214	TESTED
CASE 5	3/Nov/18	4	6	28	610	2,198	3,603	1,127	190	0	55	45	0	746	1,357	TESTED

From Table 10 (Case 6), oil rate increased from 259 BOPD at 16/64” choke to 588 BOPD at 24/64”. Gas rate increased from 35 MSCF to 178 MSCF. Water rate increased from 113 BWPD to 276 BWPD, while total liquid increased from 372 BLPD to 864 BLPD. GOR increased slightly from 350 scf/stb to 303 scf/stb.

Table 10: Case 6 MER Well Test

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	Cs.P (psi)	BS&W (%)	API	Sand lbs/1000 bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Remarks
CASE 6	28/Mar/22	4	6	16	259	35	135	350	170	0	30	18.2	0	113	372	TESTED
CASE 6	29/Mar/22	4	6	18	421	109	259	340	170	0	30	18.2	0	180	601	TESTED
CASE 6	30/Mar/22	4	6	20	498	135	271	300	170	0	30	18.2	0	213	711	TESTED
CASE 6	31/Mar/22	4	6	22	544	162	298	300	170	0	32	18.2	0	256	800	TESTED
CASE 6	1/Apr/22	4	6	24	588	178	303	300	170	0	32	18.2	0	276	864	TESTED

From Table 11 (Case 7), oil rate increased from 2,433 BOPD at 38/64” choke to 2,986 BOPD at 46/64”. Gas rate increased from 4,939 MSCF to 6,062 MSCF. Water production increased from 183 BWPD to 225 BWPD, and total liquid increased from 2,616 BLPD to 3,211 BLPD. GOR remained relatively constant around 2,030 scf/stb.

Table 11: Case 7 MER Well Test

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	Cs.P (psi)	BS&W (%)	API	Sand lbs/1000 bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Remarks
CASE 7	6/Aug/00	4	6	38	2,433	4,939	2,030	1,280	300	0	7	18	0	183	2,616	TESTED
CASE 7	7/Aug/00	4	6	40	2,588	5,253	2,030	1,252	310	0	7	18	0	195	2,783	TESTED
CASE 7	8/Aug/00	4	6	42	2,730	5,543	2,030	1,224	310	0	7	18	0	206	2,936	TESTED
CASE 7	9/Aug/00	4	6	44	2,860	5,806	2,030	1,195	310	0	7	18	0	215	3,076	TESTED
CASE 7	10/Aug/00	4	6	46	2,986	6,062	2,030	1,170	320	0	7	18	0	225	3,211	TESTED

From Table 12 (Case 8), oil rate increased from 591 BOPD at 18/64” choke to 1,056 BOPD at 26/64”. Gas rate increased from 325 MSCF to 564 MSCF. Water rate increased from 130 BWPD to 225 BWPD, while total liquid increased from 721 BLPD to 1,251 BLPD. GOR remained approximately constant at 550 scf/stb.

Table 12: Case 8 MER Well Test

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	Cs.P (psi)	BS&W (%)	API	Sand lbs/1000bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Remarks
CASE 8	20/Apr/21	4	6	18	591	325	550	848	160	0	18	18	0	130	721	TESTED
CASE 8	21/Apr/21	4	6	20	706	388	550	825	160	0	18	18	0	155	861	TESTED
CASE 8	22/Apr/21	4	6	22	813	447	550	791	160	0	18	18	0	179	992	TESTED
CASE 8	23/Apr/21	4	6	24	922	507	550	759	170	0	18	18	0	202	1,124	TESTED
CASE 8	24/Apr/21	4	6	26	1,026	564	550	726	170	0	18	18	0	225	1,251	TESTED

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From Table 13 (Case 9), oil rate increased from 786 BOPD at 28/64" choke to 1,197 BOPD at 36/64". Gas rate increased from 3,912 MSCF to 4,364 MSCF. Water production increased from 454 BWPD to 804 BWPD, while total liquid increased from 1,240 BLPD to 2,001 BLPD. GOR decreased from 4,977 scf/stb to 3,646 scf/stb.

Table 13: Case 9 MER Well Test

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	CsP (psi)	BS&W (%)	API	Sand lbs/1000bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Remarks
CASE 9	6/Aug/00	4	6	28	786	3,912	4,977	1,840	220	0	37	43	0	454	1,240	TESTED
CASE 9	7/Aug/00	4	6	30	783	3,935	5,026	1,840	220	0	37	43	0	469	1,252	TESTED
CASE 9	8/Aug/00	4	6	32	896	3,959	4,419	1,810	220	0	38	43	0	545	1,441	TESTED
CASE 9	9/Aug/00	4	6	34	920	3,972	4,317	1,800	220	0	38	43	0	626	1,642	TESTED
CASE 9	10/Aug/00	4	6	36	1,197	4,364	3,646	1,800	220	0	40	43	0	804	2,001	TESTED

The results also show that water production increased with increase in choke size. This is evident in several wells where water rate and BS&W values increased as the choke size increased. This behavior reflects the effect of higher drawdown, which promotes water influx into the wellbore. Gas-oil ratio (GOR) and gas-liquid ratio (GLR) show varying trends across the wells. In some cases, GOR decreased with increase in choke size, while in other cases, it increased. This variation is due to differences in reservoir drive mechanisms and fluid distribution within the reservoirs. Flowing tubing head pressure (FTHP) generally decreased with increase in choke size. This indicates that larger choke openings reduce flow restriction, resulting in lower surface pressure and higher production rates.

The results across all cases show a consistent relationship between choke size and production parameters. Increase in choke size improves production rates but also leads to increased water production and changes in gas behavior. These results form the basis for MER determination, where the optimum production rate is selected to balance oil production and control excessive water and gas production.

3.3 Technical / Potential Plots Analysis

The technical plot analysis for Case 1A to Case 8B wells are presented in Figure 9 to Figure 16.

Figure 9 is Case 1 A well producing on natural depletion. The MER Test was conducted on five choke sizes of 12, 14, 16, 18 & 20 with a corresponding THP of 1330psi, 1260psi & 1200psi, 1180psi & 1160psi. The flow rates obtained from the choke sizes and the corresponding THP are 270bopd, 358bopd, & 448bopd, 570bopd & 691bopd respectively as shown in table 4.5. The results of excel model graphical/ technical plots yield MER value of 423bopd which is regarded as the approved Technical Allowable Rate (TAR).

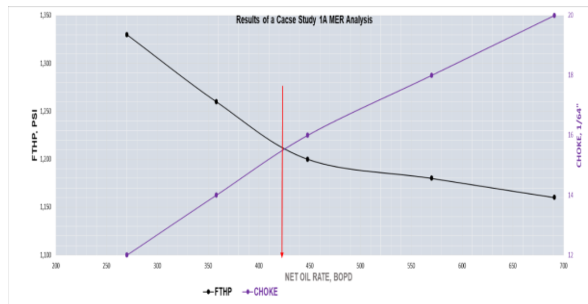

Figure 9.DB-01/ A-01 Case 1A Well Technical model Plot

Figure 10 is Case 2 A well also producing on natural depletion. The MER Test was conducted on five choke sizes of 18, 20, 22, 26 & 28 with a corresponding THP of 1750psi, 1650psi & 1600psi, 1500psi & 1400psi. The flow rates obtained from the choke sizes and the corresponding THP are 945bopd, 1080bopd, & 1219bopd, 1464bopd & 1728bopd respectively as shown in Table 6. The results of excel model graphical/ technical plots yields MER value of 1069bopd which is regarded as the approved Technical Allowable Rate (TAR).

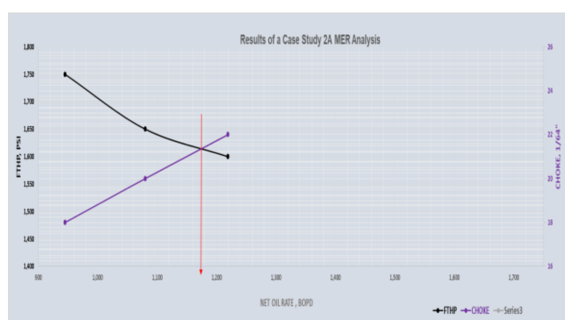

Figure 10. CB-08/A-01/Case 2A Well Technical model Plot

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Figure 11 is Case 3 A well also producing natural depletion. The MER Test was conducted on five choke sizes of 20, 20, 24, 26 & 30 with a corresponding THP of 750psi, 750psi & 750psi, 700psi & 750psi. The flow rates obtained from the choke sizes and the corresponding THP are 630bopd, 756bopd, & 830bopd, 920bopd & 1150bopd respectively as shown in Table 9. The results of excel model graphical/ technical plots yields MER value of 798 bopd which is regarded as the approved Technical Allowable Rate (TAR).

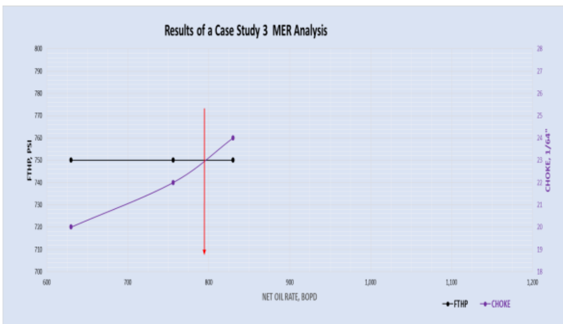

Figure 11.EA-10/A-01/Case 3A Well Technical Model Plot

Case 4 B well producing on natural depletion is presented in figure 12. The MER Test was conducted on five choke sizes of 14, 16, 18, 20& 22 with a corresponding THP of 650psi, 650psi & 620psi, 600psi & 600psi. The flow rates obtained from the choke sizes and the corresponding THP are 810bopd, 900bopd, & 1098bopd, 1120bopd & 1200bopd respectively as shown in Table 10. The results of excel model graphical/ technical plots yields MER value of 1115bopd which is regarded as the approved Technical Allowable Rate (TAR).

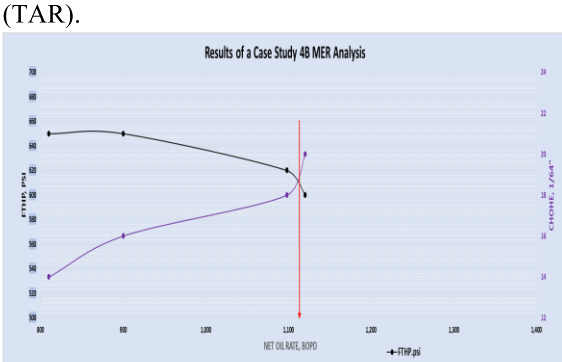

Figure 12.CD-05/B-01/Case 4B Well Technical model Plot

Figure 13 is Case 5 C well also producing natural depletion. The MER Test was conducted on five choke sizes of 20, 20, 24, 26 & 28 with a corresponding THP of 1227psi, 1207psi ,1190psi, 1161psi & 1127psi. The flow rates obtained from the choke sizes and the corresponding THP are 345bopd, 409bopd, 478bopd, 546bopd & 610bopd respectively as shown in Table 9. The results of excel model graphical/ technical plots yields MER value of 583 bopd which is regarded as the approved Technical Allowable Rate (TAR).

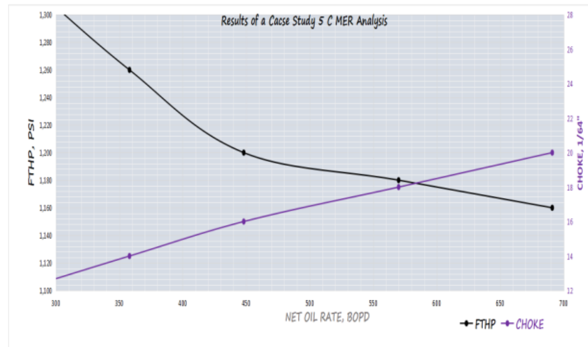

Figure 13.Case 5C Well Technical model Plot

Case 6 well producing on natural depletion is presented in figure 14. The MER Test was conducted on five choke sizes of 16, 18, 20, 22 and 24 with a corresponding THP of 350psi, 340psi, 300psi, 300psi & 300psi. The flow rates obtained from the choke sizes and the corresponding THP are 259bopd, 421bopd, 498bopd, 544bopd & 588 bopd respectively as shown in Table 10. The results of excel model graphical/ technical plots yields MER value of 205bopd which is regarded as the approved Technical Allowable Rate (TAR).

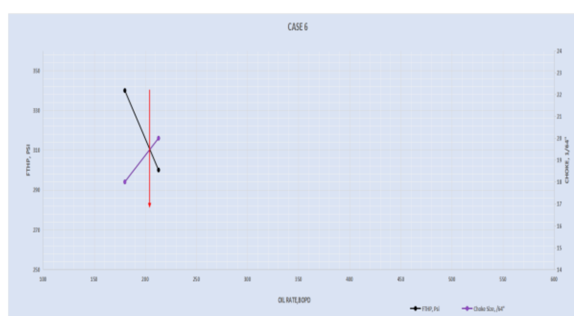

Figure 14. Case 6 Well Technical model Plot

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Figure 15 is Case 7D well also producing natural depletion. The MER Test was conducted on five choke sizes of 38, 40, 42, 44 & 46 with a corresponding THP of 1280psi, 1252psi ,1224psi, 1195psi & 1170psi. The flow rates obtained from the choke sizes and the corresponding THP are 2433bopd, 2588bopd, 2730bopd, 2860bopd & 2986bopd respectively as shown in Table 11. The results of excel model graphical/ technical plots yields MER value of 2705 bopd which is regarded as the approved Technical Allowable Rate (TAR).

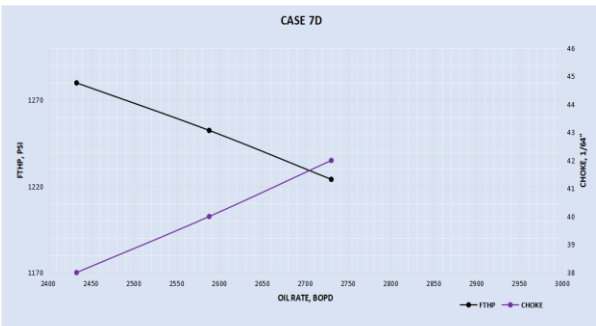

Figure 15. Case 7D Well Technical model Plot

Case 8B well producing on natural depletion is presented in figure 16. The MER Test was conducted on five choke sizes of 18, 20, 22, 24 and 26 with a corresponding THP of 848psi, 825psi, 791psi, 759psi & 726psi. The flow rates obtained from the choke sizes and the corresponding THP are 591bopd, 706bopd, 813bopd, 922bopd & 1026 bopd respectively as shown in Table 12. The results of excel model graphical/ technical plots yields MER value of 890bopd which is regarded as the approved Technical Allowable Rate (TAR).

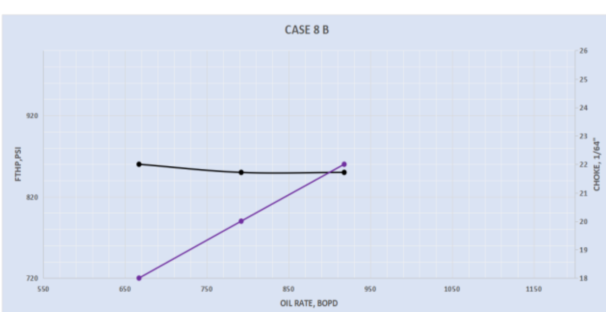

Figure 16.Case 8B Well Technical model Plot

The technical plots show that increase in choke size leads to increase in oil rate and decrease in FTHP. The point of intersection between the THP and choke trends defines the optimum production rate. The MER values obtained represent the maximum rates at which the wells can be produced without causing instability in flow conditions. These values serve as the basis for regulating production to ensure efficient reservoir performance.

3.4 Post MER Rate/TAR Choke Analysis

Table 14 presents results of the approved TAR from the regulatory agencies of the various Case Wells of 1A, 2A, 3A ,4B , 5C,6C,7D,8B and 9D are 423 Bopd, 1069 Bopd, 798 Bopd, 1115 Bopd, 583Bopd, 205Bopd, 2705Bopd,890Bopd , and 860Bopd respectively

.

The approved rate, the wells are expected to produce within the half which is a period of Six (6) months. The approval was based on a carefully evaluated performance of the wells or string with the available information and computed MER or Technical potential plot rate .

Table 14: Approved Technical Allowable Rates

FIELD	RESERVOIR	WELL	STRING	MER (BOPD)	APPROVED TAR (BOPD)
A	DB-01/A-01	1A	SS	423	423
	CB-08/A-01	2A	LS	1069	1069
	EA-10/A-01	3A	SS	798	798
FIELD A TOTAL				2,290	2,290
B	CD-05/B-01	4B	SS	1115	1115
	JD-07/B-01	8B	T	890	890
FIELD B TOTAL				1,706	2,005
C	RB-12/C-03	5C	LS	583	583
	RB-5/C-03	6C	SS	205	205
FIELD C TOTAL				976	788
D	DA-04/A-01	7D	LS	2,705	2,705
	DC-03/C-01	9D	LS	860	860
FIELD D TOTAL				2,433	3,565
TOTAL					8,648

The foregoing analysis in Tables 15 and 16 shows results of Post TAR and Choke/Bean analysis that the wells will flow for a period of six months or the next round of the Maximum Efficient Rate (MER) test that will be conducted in accordance with the regulators instruction. The green color in Table 15 represents the Choke/Bean Size and rate the Wells will flow and produce after the analysis while Table 16 presented shows the Field, Case Wells, Previous choke/Bean Sizes, Approved TAR, Current Choke/Bean Sizes and Expected Oil rate.

Since the Technical Allowable Rate is not transferable and that the individual well rate represents the maximum daily production from each well. The analysis was done with the different well test results presented in summary sheet and approved TAR.

In Case Well 1A, the current choke size is 16/64 with corresponding test rate of 448 Bopd above the approved of TAR 423 Bopd which is against regulation and approval was made to flow by one (1) choke down 14/64 with a corresponding oil rate of 358 Bopd on the MER test result of 23rd March 2020.

Table 15: Post TAR Choke/Bean Analysis (1)

FIELDS CASES TAR CHOKE SIZE ANALYSIS

Well Name	Date Tested	Stabilization Period (Hrs)	Test Duration (Hrs)	Bean Size (1/64")	Oil Rate (BOPD)	Gas Rate (MCF/D)	GOR (SCF/STB)	THP (psi)	FLP (psi)	Cs.P (psi)	BS&W (%)	API	Sand lbs/1000bbls	Water Produced (BWPD)	Total Liquid (BLPD)	Approved TAR &Choke Size
CASE 1	22/Mar/20	4	6	12	270	820	3,037	1,330	200	0	25	26.9	0	90	360	
CASE 1	23/Mar/20	4	6	14	358	996	2,782	1,260	200	0	30	26.9	0	154	512	
CASE 1	24/Mar/20	4	6	16	448	1,106	2,469	1,200	190	0	30	26.9	0	192	640	423 Bopd, 14/64
CASE 1	25/Mar/20	4	6	18	570	1,203	2,111	1,180	200	0	34	26.9	0	294	864	
CASE 1	26/Mar/20	4	6	20	691	1,781	2,577	1,160	200	0	40	26.9	18/64	461	1,152	
CASE 2	26/Mar/20	4	6	18	945	1,400	1,482	1,750	115	2,200	4	37.5	0	39	984	
CASE 2	27/Mar/20	4	6	20	1,080	1,539	1,425	1,650	120	2,200	10	37.5	0	119	1,188	
CASE 2	28/Mar/20	4	6	22	1,219	1,244	1,021	1,600	150	2,200	15	37.5	0	215	1,434	1069 Bopd, 18/64
CASE 2	29/Mar/20	4	6	24	1,464	1,851	1,264	1,500	170	2,200	20.0	37.5	0	366	1,830	
CASE 2	30/Mar/20	4	6	26	1,728	2,333	1,350	1,400	208	2,200	25	37.5	0	576	2,304	
CASE 3	30/Mar/20	4	6	20	630	2,185	3,468	750	140	0	20	24	0	158	788	
CASE 3	31/Mar/20	4	6	22	756	2,647	3,501	750	140	0	20	24	0	189	945	
CASE 3	1/Apr/20	4	6	24	830	3,150	3,795	750	170	0	24	24	0	262	1,092	798 Bopd, 22/64
CASE 3	2/Apr/20	4	6	26	920	3,590	3,902	700	170	0	26	24	0	323	1,243	
CASE 3	3/Apr/20	4	6	28	1,150	3,620	3,148	750	172	0	30	24	0	493	1,643	
FIELD B CASE 4 TAR CHOKE SIZE ANALYSIS																
CASE 4	12/Mar/22	4	6	14	810	486	600	620	140	0	20	24	0	203	1,013	
CASE 4	13/Mar/22	4	6	16	900	657	730	610	140	0	20	24	0	225	1,125	
CASE 4	14/Mar/22	4	6	18	1,098	966	880	600	170	0	32	24	0	517	1,615	1115 Bopd, 18/64
CASE 4	15/Mar/22	4	6	20	1,120	1,198	1,070	600	170	0	39	24	0	716	1,836	
CASE 4	16/Mar/22	4	6	22	1,200	1,380	1,150	600	172	0	45	24	0	982	2,182	
FIELD C CASE 5 TAR CHOKE SIZE ANALYSIS																
CASE 5	30/Oct/18	4	6	20	345	1,241	3,600	1,227	210	0	55	45	0	421	766	
CASE 5	31/Oct/18	4	6	22	409	1,474	3,604	1,207	210	0	55	45	0	501	910	
CASE 5	1/Nov/18	4	6	24	478	1,722	3,603	1,190	210	0	55	45	0	585	1,063	583 Bopd , 26/64
CASE 5	2/Nov/18	4	6	26	546	1,967	3,603	1,161	200	0	55	45	0	668	1,214	
CASE 5	3/Nov/18	4	6	28	610	2,198	3,603	1,127	190	0	55	45	0	746	1,357	
FIELD C CASE 6 TAR CHOKE SIZE ANALYSIS																
CASE 6	28/Mar/22	4	6	16	259	35	135	350	170	0	30	18	0	113	372	
CASE 6	29/Mar/22	4	6	18	421	109	259	340	170	0	30	18	0	180	601	
CASE 6	30/Mar/22	4	6	20	498	135	271	300	170	0	30	18	0	213	711	205 Bopd , 16/64
CASE 6	31/Mar/22	4	6	22	544	162	298	300	170	0	32	18	0	256	800	
CASE 6	1/Apr/22	4	6	24	588	178	303	300	170	0	32	18	0	276	864	
FIELD D CASE 7 TAR CHOKE SIZE ANALYSIS																
CASE 7	6/Aug/00	4	6	38	2,433	4,939	2,030	1,280	300	0	7	18	0	183	2,616	
CASE 7	7/Aug/00	4	6	40	2,588	5,253	2,030	1,252	310	0	7	18	0	195	2,783	
CASE 7	8/Aug/00	4	6	42	2,730	5,543	2,030	1,224	310	0	7	18	0	206	2,936	2705 Bopd , 4064
CASE 7	9/Aug/00	4	6	44	2,860	5,806	2,030	1,195	310	0	7	18	0	215	3,076	
CASE 7	10/Aug/00	4	6	46	2,986	6,062	2,030	1,170	320	0	7	18	0	225	3,211	
FIELD B CASE 8 TAR CHOKE SIZE ANALYSIS																
CASE 8	20/Apr/21	4	6	18	591	325	550	848	160	0	18	18	0	130	721	
CASE 8	21/Apr/21	4	6	20	706	388	550	825	160	0	18	18	0	155	861	
CASE 8	22/Apr/21	4	6	22	813	447	550	791	160	0	18	18	0	179	992	890 Bopd , 22/64
CASE 8	23/Apr/21	4	6	24	922	507	550	759	170	0	18	18	0	202	1,124	
CASE 8	24/Apr/21	4	6	26	1,026	564	550	726	170	0	18	18	0	225	1,251	
FIELD D CASE 9 TAR CHOKE SIZE ANALYSIS																
CASE 9	6/Aug/00	4	6	28	786	3,912	4,977	1,840	220	0	37	43	0	454	1,240	
CASE 9	7/Aug/00	4	6	30	783	3,935	5,026	1,840	220	0	37	43	0	469	1,252	
CASE 9	8/Aug/00	4	6	32	896	3,959	4,419	1,810	220	0	38	43	0	545	1,441	860 Bopd , 30/64
CASE 9	9/Aug/00	4	6	34	920	3,972	4,317	1,800	220	0	38	43	0	626	1,642	
CASE 9	10/Aug/00	4	6	36	1,197	4,364	3,646	1,800	220	0	40	43	0	804	2,001	

Table 16: Post TAR Choke/Bean Analysis (2)

FIELD	CASE WELLS	PREVIOUS CHOKE SIZE (0/64")	EXPECTED OIL RATE (Bopd) MER TEST	CURRENT TAR Bopd	CURRENT CHOKE SIZE (0/64")	RECOMMENDATION
A	1	16	358	423	14	CHANGE CHOKE
A	2	18	945	1069	18	MAINTAIN CHOKE
A	3	24	756	798	22	CHANGE CHOKE
B	4	18	1098	1115	18	MAINTAIN CHOKE
C	5	24	546	583	26	CHANGE CHOKE
C	6	16	205	205	14	CHANGE CHOKE
D	7	40	2588	2705	40	MAINTAIN CHOKE
B	8	18	813	890	22	CHANGE CHOKE
D	9	28	783	860	30	CHANGE CHOKE

In Case Well 2A, the current choke size is 18/64 with corresponding test rate of 945 Bopd below the approved TAR of 1069Bopd and choke up to 20/64 with a corresponding oil rate of 1080 Bopd of the MER test result of 27th March 2020 is against the regulation. Therefore, it’s approved to maintain the current choke of 18/64 of MER test results of 26th March 2020.

In Case Well 3A, the current choke size is 24//64 with corresponding test rate of 830 Bopd above the approved TAR of 798 Bopd which is against

regulation and approval was made to flow by one (1) choke down 22//64 with a corresponding oil rate of 756 Bopd on the MER test result of 31st March 2020.
In Case Well 4B, the current choke size is 18/64 with corresponding test rate of 1098 Bopd below the approved TAR of 1115Bopd and choke up to 20/64 with a corresponding oil rate of 1120 Bopd of the MER test result of 15th March 2022 is against the regulation. Therefore, its approved to maintain the current choke of 18/64 of MER test results of 14th March 2022.

In Case Well 5C, the current choke size is 24/64 with corresponding test rate of 478 Bopd below the approved TAR of 583Bopd and choke up to 26/64 with a corresponding oil rate of 546 Bopd of the MER test result of 2nd November 2018 is against the regulation. Therefore, it's approved to maintain the current choke of 14/64 of MER test results of 2nd November 2018.

In Case Well 6C, the current choke size is 20//64 with corresponding test rate of 498 Bopd above the approved TAR 205 Bopd which is against regulation and approval was made to flow by one (1) choke down 16//64 with a corresponding oil rate of 205 Bopd on the MER test result of 28th March 2022.
In Case Well 7D, the current choke size is 42/64 with corresponding test rate of 2730 Bopd above the approved TAR 2705 Bopd which is against regulation and approval was made to flow by one (1) choke down 40/64 with a corresponding oil rate of 2588 Bopd on the MER test result of 7th August 2000.

In Case Well 8B, the current choke size is 18/64 with corresponding test rate of 591 Bopd below the approved TAR 890Bopd and choke up to 22/64 with a corresponding oil rate of 813 Bopd of the MER test result of 22nd April 2021 is against the regulation. Therefore, it's approved to maintain the current choke of 18/64.

In Case Well 9D, the current choke size is 28/64 with corresponding test rate of 786 Bopd below the approved TAR 860Bopd and choke up to 30/64 with a corresponding oil rate of 783 Bopd of the MER test result of 7th August 2000 is against the regulation. Therefore, it's approved to maintain the current choke of 28/64.

This analysis is in accordance with the industry standard of operation; violators were severely dealt with or penalty for the period of the MER quarterly year.

3.5 Accuracy of Field Measurements
The analysis of variance (ANOVA) result for the Randomized Completely Block Design (RCBD) is presented in Table 17, and the following observations were made. There is a high significant difference among the results of the experiments conducted at different wells. This is evident as the calculated F-value for replication (Fcal = 19.25) is greater than the tabulated F-values (Ftab = 2.73 at 5% and 4.07 at 1% significance level). This indicates that the results obtained from the wells at different conditions are significantly different. There is also a high significant difference among the wells (Factor A). The calculated F-value for Factor A (Fcal = 69.21) is much greater than the tabulated F-values (Ftab = 2.50 at 5% and 3.59 at 1% level). This shows that the wells behave differently in terms of production performance and measured parameters.

Table 17: ANOVA Result for the RCBD Table Constructed

Source of variation	Degree of fraction	Sum of Square	Mean of Square	F_{cal}	F_{cab}	
					5%	1%
Replication	3	4552775.23	1517591.74	19.25	2.73	4.07
Treatment	24	24810076.5	1033753.19	-		
-Factor A	4	19619044.8	4904761.2	69.21	2.50	3.59
-Factor B	4	2310093.55	577523.39	7.33	2.50	3.59
-Interaction	16	2880938.15	180058.63	2.28		

Error Source	72	5676293.02	78837.40	-
Total	99	-	-	-

For Factor B (choke size), the calculated F-value **(**Fcal = 7.33**)** is greater than the tabulated F-values **(**Ftab = 2.50 at 5% and 3.59 at 1% level)**.** This indicates that choke size has a significant effect on the flow rates and production parameters such as oil rate, total liquid, and water production. The interaction between Factor A and Factor B shows no significant difference. The calculated F-value for interaction (Fcal = 2.28) is less than the tabulated F-value at 5% significance level. This indicates that the combined effect of wells and choke size does not significantly influence the results beyond their individual effects.

3.6 Test for the Linearity Relationship

The test for linearity between flowing tubing head pressure (THP) and the corresponding variables is presented in Table 18**.**

Table 18: Test for the Linearity Relationship

Y	THP (X)	Y-$\bar{Y}$	X-$\bar{X}$	y^2	x^2 -	Xy
12	1330	-81	2895	65.61	8381025	-234495
14	1260	-61	219.5	37.21	43180.25	-131895
16	1260	-4.1	1595	16.81	25700.25	-653.95
18	1180	-2.1	1395	4.41	1948025	-292.95
20	1160	-0.1	119.5	6.01	14250.25	-11.95
18	1750	-2.1	709.5	4.41	50339025	-1489.75
20	1650	-0.1	609.5	6.01	371490.25	-60.95
22	1600	1.9	5875	4.41	313048.25	1063.05
24	1500	3.9	4595	0.01	211140.25	1792.05
26	1400	5.9	359.5	3.61	129.24021	2121.05
20	700	-0.1	-290.5	15.21	84390.25	29.05
22	750	1.9	-290.5	34.81	84390.25	-551.95
24	750	3.9	-290.5	15.21	84390.25	-1132.95
26	750	5.9	-290.5	34.81	84390.25	-171395
30	750	9.9	-290.5	98.01	84390.25	-2875.95
14	620	-6.1	-420.5	37.21	17682015	256505
16	610	-4.1	-430.5	16.81	18533025	1765.05
18	600	-2.1	-440.5	4.41	19404025	925.05
20	600	-0.1	-440.5	0.01	19404025	44.05
22	600	-1.9	-440.5	3.61	19404025	-836.95
348402	20810			3958	3085695	-3001

Regression Analysis

Regression analysis was used to establish the relationship between choke (bean) size and flowing tubing head pressure (FTHP). The computed deviations, squares, and cross-products $(x^2, y^2, and xy)$ formed the basis for the linear regression model. From these calculations, The linking model for the bean size and THP called the regression model is stated as Equation 7.

$$Y = 21.112 – 0.001X \quad (7)$$

where, Y= bean size

X = THP.

The result shows a negative linear relationship between the two variables. This indicates that as the FTHP increases, the corresponding choke size decreases slightly. The relatively small coefficient (0.001) suggests that the change in choke size with respect to FTHP is gradual, indicating controlled and steady well performance rather than abrupt variations.

The regression model is reliable and is linear due to the regression coefficient is within their True values and that the possible interval for the regression coefficient are –0.007 to 0.005 flows rate units. From the test of simple linear correlation analysis, the correlation coefficients are not significant since $|R_{Cal}| = 0.086 \leq R_{\alpha}$. This indicates that the relationship of the bean size and THP should not be linear as the experimental values obtained are far from the linear.

IV. CONCLUSION

The Study aimed on evaluating Maximum Efficient Rate (MER) using well test data and technical plot methods. The results obtained from the wells were used to evaluate the relationship between choke size, pressure, and production performance. statistical tools helped to prove that observed relationships are consistent and reliable. The following conclusions are drawn from the Study:

i. The Maximum Efficient Rate (MER) for each selected well was estimated through technical/potential plot analysis, showing that optimal production can be achieved without without compromising the integrity reservoir.

ii. Choke size has a direct influence on production performance, as an increase in choke size leads to increase in oil, gas, water, and total liquid rates, and also with change in pressure conditions.

iii. The ANOVA results show that there are variations in wells as well as in choke sizes, while their interaction has no significant effect, confirming that individual factors govern well performance during MER testing.

iv. The regression and statistical analysis confirmed a positive linear relationship between flowing tubing head pressure and choke size, hence showing that well performance can be effectively predicted and controlled.

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