Allowable Rate of Production: Oil Wells

Directive PNG012

March 2020

Revision 1.1

Governing Legislation:

Act:	*The Oil and Gas Conservation Act*
Regulation:	*The Oil and Gas Conservation Regulations, 2012*
Order:	61/20

Record of Change

Revision	Date	Description
0.0	September, 2015	Draft
1.0	November, 2015	Live Version, Added Directive Number
1.1	March, 2020	Update of EA Table in Appendix 4

Contents

1. Introduction

The Saskatchewan Ministry of Energy and Resources (ER) regulates the production of oil wells in the province in order to ensure equitable distribution of the resources, particularly in relation to off-target wells, and to minimize the impacts of resource depletion on oil pools. ER achieves these objectives by assigning and monitoring production limits for oil wells in the province.

This Directive outlines how ER assigns production limits for different types of oil wells, how various penalties on production are calculated, and how an operator is to deal with underproduction and overproduction. Other requirements that are pertinent to this topic can be found in:

- *Directive PNG006: Horizontal Oil Well Requirements* (Directive PNG006)
- *Directive PNG007: Off-Target Well Requirements* (Directive PNG007)

Questions concerning the requirements outlined in this document may be directed to the ER Service Desk at 1-855-219-9373 or email at ER.servicedesk@gov.sk.ca.

1.1 Governing Legislation

The requirements set out in this Directive are based on *The Oil and Gas Conservation Act* (OGCA) and *The Oil and Gas Conservation Regulations, 2012* (OGCR).

Sections 17(1)(d), (e) and (f) of the OGCA provide ER with the authority to regulate, limit and allocate production from one or more oil wells. Section 33(1) of the OGCR contain the regulations specific to allowable rates of oil production. Licensees should consult these documents in conjunction with this Directive.

It is the responsibility of all operators, as specified in the legislation, to be aware of ER requirements and to ensure compliance with these requirements prior to and during the productive life of an oil well.

1.2 Definitions

Allowable rate of production (ARP): means the assigned daily limit on oil production, which could be one of the following: minimum allowable; maximum permissible rate (MPR); maximum permissible rate–off-target penalty (MPR–OTW Penalty); good production practice (GPP); or economic allowance (EA).

Block: a block is equal to the drainage area of a horizontal well, as defined within Directive PNG006.

Block MPR: is the sum of all maximum permissible rates for all vertical well drainage units within a block.

Economic allowance (EA): is the daily production rate calculated based on well type (vertical or horizontal) and wellbore or well completion depth.

Gas-to-oil ratio (GOR): is the ratio of the number of cubic metres (m^3) of gas to the number of m^3 of oil produced in a well.

Gas-to-oil ratio penalty factor (GORPF): this is a multiplier that is applied to any maximum permissible rate or economic allowance value. The GOR penalty factor is based on the gas-to-oil ratio from the previous producing month (see section 4 in this Directive for more details on GOR penalty factors).

Good production practice (GPP): means production of oil from a well at a rate not governed by a defined allowable rate of production, but limited to what can be produced on the basis of technical parameters without adversely and significantly affecting the ultimate recovery of oil or the opportunity of other owners to obtain their share of production from the pool.

Maximum permissible rate of production (MPR): this is the maximum amount of oil an operator is authorized to produce in a day from a well or wells.

Month: means a calendar month.

Monthly ARP: is the product of the assigned daily allowable rate of production multiplied by the number of days a well is on production within a month.

Off-Target means a well not completed within the prescribed target area of the drainage unit (see *Guideline PNG021: Determining Drainage Units and Target Areas* for more information on target areas and drainage units).

On-Target means a well completed within the prescribed target area of the drainage unit.

Overproduction: means the production of an oil well in excess of the monthly allowable in a given month.

Pay: means the thickness of rock that can deliver hydrocarbons to the wellbore via the completion.

Recovery multiplier (RM): this is a factor that applies to horizontal wells.

Underproduction: means the production of an oil well less than the monthly ARP in a given month.

2. Well Completions Governed by Good Production Practice

2.1 Non-Horizontal Well Completions

A non-horizontal well completion that is located within the area and stratigraphic units outlined as being within Spacing Area E (see https://publications.saskatchewan.ca/#/categories/1224 for locations of Spacing Areas in Saskatchewan), and not subject to an off-target penalty (see Directive PNG007 for an explanation of off-target) will have an ARP of GPP assigned.

A non-horizontal well completion that has been granted approval for GPP via a Pool Order, or other prior approval, and which is not subject to an off-target penalty, will have an ARP of GPP assigned.

2.2 Horizontal Well Completions

A horizontal well completion that is located within the area and stratigraphic units outlined as being within Spacing Area E (see https://publications.saskatchewan.ca/#/categories/1224 for locations of Spacing Areas in Saskatchewan) or that has been granted approval for GPP rates of production by a Pool Order or other prior approval, will have an ARP of GPP assigned.

3. Well Completions Not Governed by Good Production Practice

Any proposed well completion that does not have approval for GPP will be assigned one of the ARPs set out in subsections 3.1, 3.2 or 3.3.

3.1 Economic Allowance

A **non-horizontal well completion** not approved for GPP, and not subject to an off-target penalty, will be assigned an 'Economic Allowance' (EA). The economic allowance production rate is based on the well's depth, measured as the vertical depth from the kelly bushing to the top of the producing pool.

A **horizontal well completion** not assigned GPP will default to an EA.

For a horizontal well with a single wellbore, the EA is the total measured depth from the kelly bushing to the end of the productive wellbore.

For a horizontal well with multiple wellbores, the EA is the total measured depth from the kelly bushing to the end of the longest productive wellbore.

The gas-to-oil ratio penalty factor applies to the economic allowance of a well.

Appendix 4 contains a table of economic allowance values relative to depth for horizontal and non-horizontal wells.

3.2 Maximum Permissible Rate

For a **non-horizontal well completion** that is not under off-target penalty, a company may–at any point after drilling–apply for a maximum permissible rate of production by submitting the *MPR Application Form (Non-Horizontal)* through the Integrated Resource Information System (IRIS). A completed example of this form is shown in Appendix 1.

The maximum permissible rate of production for non-horizontal wells is calculated using the following equation:

$$MPR = 0.5 \times F_A \times F_H \times F_\phi \times F_{Sw} \times F_{1/Boi}$$

where
F_A is the area factor, which is equal to the drainage unit expressed in legal subdivisions (LSDs) multiplied by 1.0188;

F_H is the thickness factor, and it is equal to the thickness of the pay expressed in metres to the nearest one tenth of a metre;

F_ϕ is the porosity factor, which is equal to the average porosity of the pay used to calculate F_H, above, expressed in per cent (%) and divided by 10;

F_{Sw} is the interstitial water factor, which is equal to 1 minus the average interstitial water content of the pay used in F_H, above, expressed as a decimal, divided by (1-0.25); and

$F_{1/Boi}$ is the shrinkage factor, which is equal to the change in volume of oil from reservoir conditions to stock tank conditions, expressed as a decimal, divided by 0.75.

For a **horizontal well completion**, a company may–at any point after drilling–apply through IRIS for a maximum permissible rate of production (MPR) by submitting the *MPR Application (Oil) - Horizontal Well* form. A completed example of this form is shown in Appendix 2.

The maximum rate of production for a horizontal oil well is calculated as the combined rate at which vertical oil well MPRs within a block are allowed to produce ('block MPR'), and it is equal to the block MPR multiplied by the recovery multiplier (RM). The RM factor–which cannot exceed 2.0–is derived from the equation below.

$$RM = 1 + (L-100)/500$$

where L is the length in metres of the productive portion of the horizontal wellbore of a horizontal well, or the sum of the productive horizontal wellbores of the horizontal well.

So, a maximum rate of production for horizontal oil wells within a block is:

block MPR (sum of MPR of each vertical drainage unit within the block) x RM

A maximum permissible rate of production is subject to a gas-to-oil ratio penalty factor.

3.3 Off-Target Wells- Non-Horizontal Wells Only

3.3.1 Default to Minimum Allowable

Any off-target well completion subject to an off-target penalty will default to a minimum allowable production rate of 3.0 m^3 per day (m^3/day).

A gas-to-oil ratio penalty factor does not apply to an ARP that has been set at the Minimum Allowable.

3.3.2 Maximum Permissible Rate – Off-Target Penalty

If a well completion is off-target, a licensee may apply for a maximum permissible rate-off-target well penalty (MPR-OTW penalty).

The MPR–OTW penalty is set based on the distance the off-target completion is from the centre of the target area. The equation used to calculate the MPR shown in section 3.2, above, is also used to calculate the MPR–OTW penalty, but the F_A factor in these cases is reduced in proportion to the distance the well completion is from the centre of the assigned target area.

So, for example, for a well with a single LSD drainage unit, a well completion that is on-target or has no off-target penalty will have F_A = (1) x 1.0188.

If there is an off-target penalty where the well completion's distance from the centre of the target area reduces the LSD area by 25 per cent, then the F_A = 0.75(1) x 1.0188.

Appendix 3 illustrates some examples of how to calculate the net productive area for centred and off-centred target areas within several sizes of drainage unit.

The MPR–OTW penalty application is submitted using the standard *MPR Application Form (Non-Horizontal)*, but a licensee reduces the FA used in the form by the amount calculated using the formula above.

4. Gas-to-Oil Ratio Penalty

For both horizontal and non-horizontal oil wells, the gas-to-oil ratio penalty is determined the same way.

For any month, the gas-to-oil ratio penalty factor (GOR_{PF}) will be determined by ER using the gas-to-oil ratio (GOR) from the previous producing month. The gas production used to calculate the GOR will include those gas volumes measured and/or estimated during testing plus all gas liberated when the pressure of the crude oil is decreased from treater or separator conditions to stock tank conditions.

The following penalty factors apply:

- if the produced GOR is less than the base GOR, the penalty factor = 1.0;
- if the produced GOR is greater than the base GOR, the penalty factor = base GOR divided by produced GOR (rounded to the nearest 0.01).

where 'base' GOR = 177 (unless otherwise outlined by the minister), and 'produced' GOR is the GOR calculated for the well in the previous producing month, to the nearest 0.1 m^3/m^3.

Note: IRIS displays the daily allowable rate of production (ARP) for a well, but does not factor in the GOR_{PF}. A licensee is expected to monitor the monthly ARP for their wells and factor in the GOR_{PF}, if applicable, in the course of their production monitoring.

All production monitoring by ER <u>does</u> factor in the GOR_{PF}, where applicable.

5. Testing

For testing purposes, an oil well may produce up to 160 m^3 more than its daily allowable rate of production during the first 60 days of production - from any producing pool - without penalty.

6. Overproduction

All overproduction is cumulative.

An oil well operator is responsible for keeping a record of current and cumulative overproduction, and for correcting any overproduction as soon as possible without notification from ER.

If the overproduction is not being addressed, or if production in any day exceeds the allowable rate of production by more than 25 per cent, ER may require the operator to submit additional information, shut-in the well for a specified period of time, or take some other action as deemed advisable by the Minister.

If a well is required to be shut-in, in accordance with the regulations, the Minister may seal or cause to be sealed any or all valves at the well.

7. Underproduction

Correcting overproduction is done by underproducing a well.

The amount of underproduction in any month is applied against the amount of cumulative overproduction.

Underproduction will only be considered cumulative when attempting to mitigate overproduction.

8. Assignment or Revocation of ARP and GPP by Ministerial Authority

Notwithstanding any of the requirements in this Directive, ER may:

- assign GPP to a single well or a group of wells;
- assign an ARP to a single well or group of wells;
- assign concurrent production to a well or group of wells; or
- assign an ARP to a single horizontal well within a block containing more than one horizontal well.

The provisions of this Directive are subject to, and may be superseded by any order made by the Minister relating to a specific well, block, pool or area.

The Minister, at any point, may revoke GPP and assign an MPR or Minimum Allowable to a well completion if, in the opinion of the Minister, the well is not being produced in accordance with GPP.

Appendix 1: Example of Completed Application for MPR (Oil) – Non-Horizontal Wells

Government of Saskatchewan

MPR Application (Oil)

Non-Horizontal Well

Petroleum and Natural Gas Division

General Information

BOTTOM HOLE LAND LOCATION

LSD	SEC	TWP	RGE	M	Re-entry
2	3	0 4	5	W 2	/

CWI: SK0123456

Licence Number: 11A001

Subject to an Off-Target Penalty? [X] No [ ] Yes

Pool Name: Wascana Park Sand Pool

Pool Code: 123456

Pay Interval: 1001.0 - 1031.0

Contact Intervals: 1001.5 - 1002.5, 1004.0 - 1010.0

(For Ministry use only)
Ministry's Pay Interval

Reservoir Data		Values	Source of Values	Ministry's Reservoir Data
A	Drainage Unit (LSD's)	2	As drilled survey	
H	Net Pay Thickness (metres)	30.0	Logs	
O	Porosity (%)	15.0	Logs	
S_w	Interstitial Water (frac.)	0.35	Logs	
1/Boi	Shrinkage (frac.)	0.81	Fluid analysis	

MPR Factors

				Ministry's MPR Factors
F_A	=	A x (1.0188)	= 2.0376	
F_H	=	H	= 30.0	
F_O	=	O / 10	= 1.5	
F_{Sw}	=	$(1 - S_w) / 0.75$	= 0.8667	
$F_{1/Boi}$	=	(1/Boi) /0 .75	= 1.0800	

MPR Calculation

MPR = $(0.5)(F_A)(F_H)(F_O)(F_{Sw})(F_{1/Boi})$ = 42.9 m^3/day

Ministry's MPR Calculation

_____ m^3/day

Economic Allowance

_____ m^3/day

Required Attachments

[X] Applicable well logs, with producing horizon perforations and net pay clearly marked.
[X] Core test data (if available)
[X] Map of the subject and off-setting wells with last available oil production.
[X] Gas production and GOR values for subject and surrounding producing wells.

Applicant Information

Company/Agent Contact [ ] Mr. [X] Ms. Jane Doe

Telephone # 306-234-5678 ext _____ Email Address Janedoe@ABCenergy.ca

By signing below, I hereby certify that the application form and the attached supporting documentation is complete and accurate. If the application is found to be incomplete or inaccurate, I acknowledge that the Ministry of the Economy will reject the application after notifying me of the deficiencies and that I will be required to submit a new application.

Signed by: _____ Date: November 19, 2015

Application Submission

Submission is to be made within the IRIS system. This form and required attachments must be included as part of the submission.

Applications - Start an Application - Production and Measurement Applications - Maximum Permissible Rate (MPR) Oil

Decision (Ministry's use only)

The application is [ ] Denied [ ] Approved

[ ] Authorized MPR _____ m^3/day

[ ] Issue Date: YY MM DD Effective Date: YY MM DD

Reviewed by: _____ on _____

Authorized by: _____ on _____

Non-Horizontal Oil Well Maximum Permissible Rate (MPR) Application Form November 2015

Appendix 2: Example of Completed Application for MPR (Oil) - Horizontal Wells

Government of Saskatchewan

MPR Application (Oil)

Horizontal Well

Petroleum and Natural Gas Division

General Information

BOSS LEG BOTTOM HOLE LAND LOCATION

LSD	SEC	TWP	RGE	M	Re-entry
2	3	4	5	W 2	/

CWI: SK0123456

Licence Number: 11A001

Pool Name: Wascana Park Sand Pool

Pool Code: 123456

Pay Interval: 1001.0 - 1031.0

Contact Intervals: 1250.0 - 1750.0

Land Description Of Vertical DU within Block	MPR of Vertical DU m^3/day
1 & 2 of Section 3-4-5-W2M	42.9
3 & 4 of Section 3-4-5-W2M	42.9

(For Ministry use only)

Ministry's Pay Evaluation

Ministry's MPR Evaluation

MPR Calculation

L	= bore length (m)	=	500	Sum of all productive bore lengths
RM*	= 1 + (L-100)/500	=	1.8	* if the RM > 2, then is set at 2
Block MPR	= MPR sum	=	85.8	Sum of all MPR Vertical DUs within the Block
Adjusted Block MPR		=	154.5	Block MPR x RM
Economic Allowance		=	24.8	Based on measured depth of longest bore

if the EA>Adjusted Block MPR, an application is not required.

Ministry's MPR Calculation

_____ m^3/day

Economic Allowance

_____ m^3/day

Required Attachments

- [X] Applicable well logs, with producing horizon perforations and net pay clearly marked.
- [X] Vertical Well DU MPR Values and Calcuation Information.
- [X] Map of the subject and off-setting wells with last available oil production.
- [X] Gas production and GOR values for subject and surrounding producing wells.

Applicant Information

Company/Agent Contact [X] Mr. [ ] Ms. John Doe

Telephone # 306-234-5678 ext _____ Email Address johndoe@ABCenergy.ca

By signing below, I hereby certify that the application form and the attached supporting documentation is complete and accurate. If the application is found to be incomplete or inaccurate, I acknowledge that the Ministry of the Economy will reject the application after notifying me of the deficiencies and that I will be required to submit a new application.

Signed by: _____ Date: November 19, 2015

Application Submission

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Applications - Start an Application - Production and Measurement Applications - Maximum Permissible Rate (MPR) Oil

Decision (Ministry's use only)

The application is [ ] Denied [ ] Approved

[ ] Authorized MPR _____ m^3/day

[ ] Issue Date: YY MM DD Effective Date: YY MM DD

Reviewed by: _____ on _____

Authorized by: _____ on _____

Non-Horizontal Oil Well Maximum Permissible Rate (MPR) Application Form November 2015

Appendix 2: Example of Completed Application for MPR (Oil) – Horizontal Wells (cont.)

Government of Saskatchewan

HORIZONTAL WELL BLOCK CALCULATION

Petroleum and Natural Gas Division

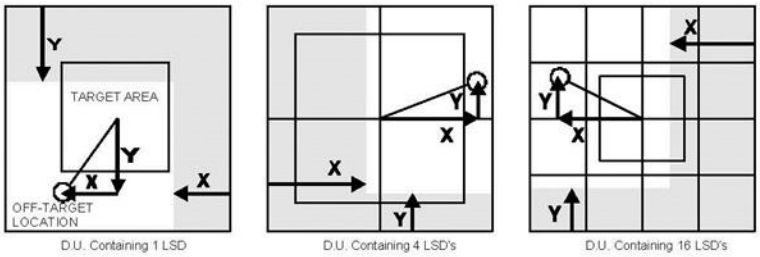
LAND DESCRIPTION					RESERVOIR DATA					MAXIMUM ALLOWABLE RATE OF PRODUCTION FACTORS					MPR
Blocks					Drainage Unit	Net Pay	Porosity	Connate Water Saturation	Shrinkage Factor	F_A	F_H	F_O	F_{Sw}	$F_{1/Boi}$	m^3/day
					Lsds	m	%	(fraction)	STB/bbl						
DU	SE	TW	RG	M											
1 & 2	3	4	5	2	2	30.0	15	0.35	0.810	2.0376	30	1.5	0.86667	1.08	42.91
DU	SE	TW	RG	M											
3 & 4	3	4	5	2	2	30.0	15	0.35	0.810	2.0376	30	1.5	0.86667	1.08	42.91
DU	SE	TW	RG	M											
DU	SE	TW	RG	M											
DU	SE	TW	RG	M											

Appendix 3: Calculating Net Productive Area

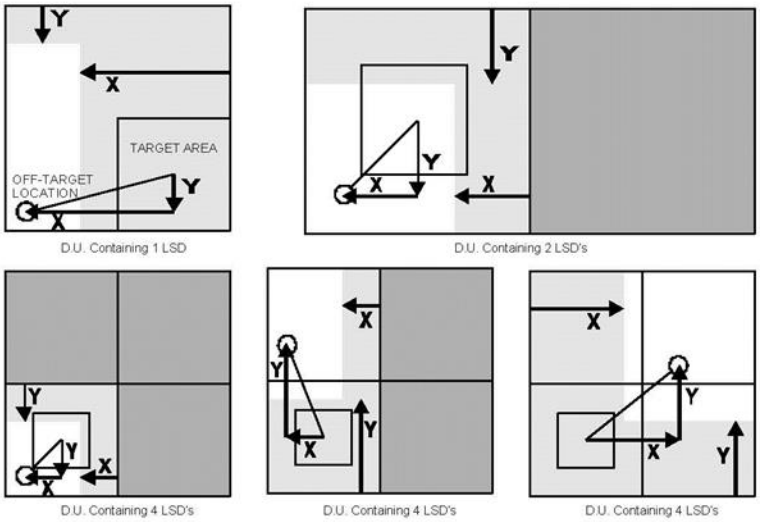
OIL AND GAS CONSERVATION

Illustration of Principle for Establishing Net Productive Area for Off-target Wells

(Section 30 of THE OIL AND GAS CONSERVATION REGULATIONS, 1985)



1. Drainage Units with Target Areas centered on the Drainage Unit



2. Drainage Units with Target Areas not centered on the Drainage Unit

Note: The Net Productive Area equals the unshaded area in each case

Any legal subdivisions that do not form a part of the target area and are located in a position that is in the opposite direction of a vector of displacement are removed from the drainage unit

Area removed from drainage unit by virtue of N-S/E-W vectors of displacement

Appendix 4: Table of Economic Allowance Values for Vertical and Horizontal Oil Wells

Well Depth (m)	Economic Allowance Vertical Wells (m^3/d)	Economic Allowance Horizontal Wells (m^3/d)	Well Depth (m)	Economic Allowance Vertical Wells (m^3/d)	Economic Allowance Horizontal Wells (m^3/d)
0 - 180	4.8	19.2	2591 - 2650	8.2	32.8
181 - 270	4.9	19.6	2651 - 2710	8.3	33.2
271 - 360	5	20	2711 - 2770	8.4	33.6
361 - 450	5.1	20.4	2771 - 2825	8.5	34
451 - 540	5.2	20.8	2826 - 2880	8.6	34.4
541 - 625	5.3	21.2	2881 - 2940	8.7	34.8
626 - 700	5.4	21.6	2941 - 2995	8.8	35.2
701 - 780	5.5	22	2996 - 3050	8.9	35.6
781 - 860	5.6	22.4	3051 - 3105	9	36
861 - 930	5.7	22.8	3106 - 3160	9.1	36.4
931 - 1005	5.8	23.2	3161 - 3210	9.2	36.8
1006 - 1085	5.9	23.6	3211 - 3260	9.3	37.2
1086 - 1165	6	24	3261 - 3305	9.4	37.6
1166 - 1240	6.1	24.4	3306 - 3350	9.5	38
1241 - 1310	6.2	24.8	3351 - 3400	9.6	38.4
1311 - 1395	6.3	25.2	3401 - 3600	9.7	38.5
1396 - 1470	6.4	25.6	3601 - 3700	9.9	39
1471 - 1545	6.5	26	3701 - 3800	10	39.4
1546 - 1620	6.6	26.4	3801 - 3900	10.1	40.2
1621 - 1690	6.7	26.8	3901 - 4000	10.3	40.8
1691 - 1765	6.8	27.2	4001 - 4200	10.6	42
1766 - 1830	6.9	27.6	4201 - 4400	10.9	43.2
1831 - 1900	7	28	4401 - 4600	11.2	44.4
1901 - 1970	7.1	28.4	4601 - 4800	11.5	45.5
1971 - 2035	7.2	28.8	4801 - 5000	11.8	46.7
2036 - 2100	7.3	29.2	5001 - 5200	12.1	47.8
2101 - 2165	7.4	29.6	5201 - 5400	12.4	49.1
2166 - 2230	7.5	30	5401 - 5600	12.7	50.3
2231 - 2290	7.6	30.4	5601 - 5800	13	51.4
2291 - 2355	7.7	30.8	5801 - 6000	13.3	52.6
2356 - 2415	7.8	31.2	6001 - 6200	13.6	53.8
2416 - 2475	7.9	31.6	6201 - 6400	13.9	55
2476 - 2535	8	32	6401 and deeper	14	55.6
2536 - 2590	8.1	32.4			