# Determination and Submission of Gas Oil Ratio

Guideline PNG034

April 2024

Revision 2.0

Governing Legislation:

| | |
|---|---|
| Act: | *The Oil and Gas Conservation Act* |
| Regulation: | *The Oil and Gas Conservation Regulations, 2012* |
| Directive: | *Directive PNG017: Measurement Requirements for Oil and Gas Operations* |
| | *Directive PNG032: Volumetric, Valuation and Infrastructure Reporting in Petrinex* |

**Record of Change**

| Revision | Date | Description |
|---|---|---|
| 1.0 | July 20, 2018 | Approved first version |
| 2.0 | April 2024 | • Well -level GOR determination:<br>  ○ Qualifying criteria, formula for GOR test, methods for determining GOR including GIS.<br>  ○ Examples of step-by-step calculation for determining GOR, GIS, and Petrinex volumetric reporting.<br>• Battery Level GOR determination<br>  ○ Qualifying criteria, formula for GOR test, methods for determining GOR including GIS<br>  ○ Example of step-by-step calculation for determining battery level GOR, GIS, and Petrinex volumetric reporting.<br>• Miscellaneous updates in line with Directive PNG017 revision 5.0. |

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## 1. Introduction

*Directive PNG017: Measurement Requirements for Oil and Gas Operations* (Directive PNG017) consolidates, clarifies, and updates the regulatory requirements with respect to measurement points used for accounting and reporting purposes, as well as those required for upstream petroleum facilities and some downstream pipeline operations.

This guideline is intended to provide guidance on conducting gas oil ratio (GOR) tests for non-heavy crude oil and heavy crude oil operations, determining the GOR including the gas in solution and how to submit the GOR to the Saskatchewan Ministry of Energy and Resources (ER) if necessary.

GORs are submitted to ER to suppress certain Petrinex volumetric warnings and errors and Enhanced Production Audit Program Compliance Assessment Indicators (CAI). A battery-level GOR cannot be submitted to Petrinex for an annual period as the battery-level GOR is calculated monthly based on the monthly battery gas and oil production volumes. However, a battery-level GOR could be provided to ER on a monthly basis before the volumetric deadline to prove and ensure the volumetric warning, errors and CAIs are not triggered.

GORs can also be provided for historical production months to turn off historical volumetrics warnings and errors in Petrinex. The GOR must be valid for the production period and meet all the applicable requirements. If GOR submission is approved, the operator may need to resubmit all applicable production months and reporting facility volumetrics to clear the warnings and errors.

## 2. Well-level Gas Oil Ratio determination

*Directive PNG017: Measurement Requirements for Oil and Gas Operations* (Directive PNG017), allows for the estimation of reported monthly gas production volumes in certain situations by using a well-level Gas Oil Ratio (GOR) that is applied to the reported monthly oil production volume. A well's GOR is typically determined by conducting a well test and measuring the well's gas and oil production volumes. The test gas volume is then divided by the test oil volume to determine the GOR. The determination of a well's GOR may include gas volumes originating from the following sources as applicable:

- Measured well test separator (or dry flow meter) gas.
- Measured casing gas.
- Flare (including incineration), fuel and vent gas volumes.
- Gas in solution (GIS) determined from a GIS factor obtained from a separator or wellhead oil sample under pressure and then sent to a lab to undergo a Pressure Volume Temperature (PVT) analysis or a flash liberation analysis.
- Stock tank vapors from produced oil/emulsion tanks and produced water tanks.

It is important to understand that all applicable well gas production sources must be included in the determination of the well-level GOR, in accordance with Section 6.5 of PNG017. The number and location of production sources is dependent on the specific operational configuration of the well.

A common oversight in the determination of a well's GOR is excluding the well's gas production attributed to the gas that evolves from the oil/emulsion when the oil is depressurized from separator or wellhead pressure to stock tank conditions, known as a gas in solution (GIS). The GIS is typically one of the gas production sources that must be included in the determination of a well's GOR.

Acceptable methods for determining the GOR and GIS factor can be found in Sections 6.5.3, 12.2.2 and 12.2.3 of Directive PNG017.

### 2.1 Well-level GOR qualifying criteria

For non-heavy crude oil wells (oil density < 920.0 kg/$m^3$):

- A GOR may be used to determine a well's monthly reported gas production volume if the annual daily average gas production rate is ≤ 500.0 $m^3$/day.
    - Gas production rates > 500.0 $m^3$/day must be continuously metered.
- Directive PNG017 Section 6.5.3 describes the procedure and requirements for conducting GOR tests or methods for determining GORs on non-heavy crude oil wells.
- The GOR tests must be, at minimum, 24-hours duration.

For heavy crude oil wells (oil density ≥ 920.0 kg/$m^3$):

- a GOR may be used to determine a well's monthly reported gas production volume if the annual average gas production is ≤ 2,000.0 $m^3$/day.
    - Gas production rates > 2,000.0 $m^3$/day must be continuously metered.
- Directive PNG017 Sections 12.2.2 and 12.2.3 describes the procedure and requirements for conducting GOR tests and methods for determining GORs on heavy crude oil wells.
- GOR tests must be, at minimum, 72-hours duration, however, if after the first 24-hours of the test the test records show steady state production then the test duration may be reduced to 24-hours as per Section 12.2.3 of Directive PNG017.
    - No measurement exemption application is required to stop the GOR test after the first 24-hours however, the licensee must have proof that they have reached steady state as per Section 12.2.3.
    - If the licensee cannot prove they reached steady state after the first 24-hours and therefore stopped the test, then the GOR test must be reconducted.

### 2.2 Formula for Well-level GOR

To provide clarity in determining a well's GOR, which includes the GIS, the following defines the gas sources that must be considered and the formula to be used in the determination of the GOR.

1. Metered well gas test production, which is the well gas production that is separated from the oil and metered in a single phase during a well test. This may be gas metered off the top of a test separator and or casing gas metered with a dry flow meter. More details on how to conduct an accurate GOR test can be found in Section 2.2.1 of this guideline;
2. GIS, which is the gas that is entrained in the pressurized oil and will evolve from the oil as the oil is depressurized to stock tank conditions. The GIS volume is determined by

applying a GIS factor ($m^3$ gas/$m^3$ test oil production) to the oil volume produced during the well test. Furthermore, the volume of solution gas that evolves from one $m^3$ of test oil production is determined by multiplying the GIS rate ($m^3/m^3/kPa$) by the pressure drop (kPa). The GIS rate is obtained from a PVT / flash liberation analysis, degassing a sample of the pressurized oil, rule of thumb estimate, or other methods listed in Section 6.5.3 of Directive PNG017; and,

3. The GOR = (metered well gas volume during the test + the GIS volume during the test) / measured oil volume during the test.

### 2.2.1 Well-level GOR Test

Metering the gas streams during a GOR test can be challenging and incur greater uncertainty in accuracy due to potentially low gas rates encountered during the test. As a result, there are some operational practices and data collection requirements that should be adhered to ensure the most accurate test results. For at least 48 hours prior to a GOR test being conducted, there should be no adjustment to the well operating conditions that could result in a change to the oil or gas production rates. The test should be conducted with conditions such as operating pressure and temperature being as close to normal as possible.

If a differential pressure gas meter is used when conducting a GOR test, then a gas analysis is required for the gas stream that is being metered and it must be used for the volume determination of the gas. As per Section 4.3.6.1 of Directive PNG017, a compressibility factor of 1.0 can be applied for non-delivery point measurement points for volumetric determination if the operating pressures are ≤ 700 kPa(g). An initial gas analysis for the pool may be satisfactory for the GOR test gas volume determination, see Directive PNG017 Table 8.3 for the various types of wells and facilities sampling frequency requirements.

In accordance with Directive PNG017, the following GOR test information must be documented and made available to ER upon ER's request. Failure to provide this information will result in ER requiring the licensees to reconduct the GOR test and submit the following:

- The meter readings associated data (e.g. temperature and pressure), flow rate and cumulative test volume for each time period (e.g. 20 minutes) that the measurements were taken for each determination of the value of gas and oil.
- The date, time, and duration of each of those periods. The maximum period duration must be no longer than 1 hour.
- The production parameters (e.g., pressure, pump rate) during each of those periods and in the 48 hours before each of those periods; and
- A description of the meter(s) and other equipment used during the test. At a minimum, the meter type, make, and model should be included.
- Any factors used (e.g., GIS) to determine estimated volumes and the associated documentation of the estimation methods.
- If a separator cannot be used, then a liquid turbine meter may be used to measure the test emulsion/oil provided there is no solution gas breakout in the meter, or the monthly oil disposition volume and inventory must be provided that were used in the determination of the test oil production volume.

To determine the sediments and water (S&W) contained in the test oil volume the operator must follow the procedures laid out in Section 14.8.2 and Appendix 3 of Directive PNG017. If the S&W is less than 10%, manual sampling can be used to determine the S&W and will require a minimum of 3 samples to be taken throughout the test (beginning, middle and end). If the S&W is greater than 10% an online product analyzer, proportional sampler, or other approved methods in Appendix 3 of Directive PNG017 must be used.

Meters used for GOR testing must be calibrated, proved, and inspected in accordance with the requirements in Section 2 of Directive PNG017.

If an orifice meter with chart recorder is used to measure the gas flow rate during the GOR test, the differential pen should record at ≥ 33% within the chart range and the static pressure pen should record at ≥ 20% within the chart range as per Section 4.3.2 of Directive PNG017.

#### 2.2.1.2 Well-GOR test frequency and duration

GOR test frequencies and durations for non-heavy crude oil wells and heavy crude oil wells can be found in Section 6.5 and Section 12.2.2, respectively, of Directive PNG017. The table below is a reproduction of those requirements.

Table 1: Summary of GOR Testing for Non-Heavy and Heavy Oil Wells

<table>
<tr><th>Well Type</th><th colspan="2">GOR Test Frequency</th><th>Duration of GOR Test</th></tr>
<tr><td rowspan="3">Non-Heavy Oil Wells (oil density < 920 kg/m$^3$)</td><td colspan="2">Initial, within the first 90 days of a new well being put on production</td><td rowspan="3">24 hours</td></tr>
<tr><td colspan="2">Annually, after the initial test or</td></tr>
<tr><td colspan="2">Triennially, if qualifying criteria in Section 6.5.1.1 of Directive PNG017 is met.</td></tr>
<tr><td rowspan="3">Heavy Oil Wells (oil density ≥ 920 kg/m$^3$)</td><td colspan="2">Initial, within the first six months for a new well being put on production</td><td rowspan="3">72 hours unless in the first 24 hours stabilized flow is observed (see Section 12.2.3 of Directive PNG017 for definition of stabilized flow).</td></tr>
<tr><td>If gas rate is ≤ 1,000 m$^3$/d</td><td>Annually, after the initial test</td></tr>
<tr><td>If gas rate is > 1,000 m$^3$/d and < 2,000 m$^3$/d</td><td>Semi-Annually, after the initial test</td></tr>
</table>

### 2.2.2 Gas in Solution for well-level GOR

In some scenarios a gas volume must be determined, such as the GIS, where the gas is dissolved in an oil volume under pressure, and there is no opportunity to meter the gas volume prior to it being commingled with other gas volumes. In that scenario, the gas volume may be determined by methods other than direct metering. An example of such a gas volume is the gas held in solution with oil volumes leaving a test separator at an oil proration battery, where the test oil volumes are combined with production from other wells downstream of the test separator. The purpose of accounting for the gas in solution is to determine the total gas produced by a well during a production or GOR test, since the gas volume measured by the test gas meter will not include the gas that is still in solution with the test oil volume.

As per Section 6.5, 12.2.2, and 12.2.3 of Directive PNG017, a single GIS factor may be determined and used to estimate the GIS volume where the wells are producing from the same pool and test separator operating conditions are similar. Additional GIS factors are required for wells in a battery that produce from different pools or where other test separators operate at different pressure and/or temperature conditions. Licensees should also consider determining seasonal GIS factors where ambient temperature differences may affect the factors or when operating conditions change.

If a licensee utilizes a common pool GIS rate to determine the GIS factors at multiple facilities, then each facility's individual pressure drop must be used to determine the GIS factor.

As per Directive PNG017, the GIS factor must be reviewed on an annual basis to ensure accuracy. If no changes are made to the reservoir or operating conditions, then the GIS factor requires no update subsequent to the initial determination. If operating conditions change that result in the pressure drop changing, then the GIS factor must be updated.

Determining the gas in solution for a single well battery where a flash liberation analysis, PVT analysis or the rule of thumb is used, requires the determination of the pressure drop. The pressure drop for a single well battery, where the emulsion is flowlined from the wellhead to a storage tank, will be the operating pressure of the wellhead in kPa(g) minus the pressure of the storage tank in kPa(g). If the storage tank is an atmospheric tank the pressure at the tank will be 0.0 kPa(g). If the wellhead pressure is not constant due to hydrostatic head pressure from the tank and tank level changes, ERD recommends that the wellhead pressure resulting from the maximum hydrostatic head pressure from the tank be used as the initial pressure for the pressure drop calculation.

#### 2.2.2.1 Example GIS for single well battery

Example: Determine the GIS factor for a single well GOR test

- Operating pressure at the wellhead 35.0 kPa(g)
- Storage tank pressure 0.0 kPa(g) as it is an atmospheric tank (i.e. tank is venting to atmosphere)
- Pool level GIS rate was determined by a lab flash liberation analysis and the result was 0.15236 $m^3$ of gas / $m^3$ of oil / kPa of pressure drop.

Calculate the GIS factor:

- GIS Factor ($m^3$ gas/$m^3$ test oil production) = GIS rate ($m^3/m^3$/kPa) × pressure drop (kPa)
- GIS Factor = 0.15236 ($m^3/m^3$/kPa) × (35.0 – 0.0 (kPa))
- GIS Factor = 5.3326 $m^3$ of gas/$m^3$ of oil

The GIS factor is then multiplied by the test oil volume ($m^3$) to determine the volume of GIS that evolved from the oil during the test. The GIS volume ($m^3$) is then added to metered test gas volume ($m^3$) and this combined test gas volume is then divided by the test oil volume to determine the well GOR.

### 2.3 Methods for determining GOR including GIS

As described in Section 6.5.3 of Directive PNG017, if well gas production volumes are calculated through the use of a GOR:

1. A 24-hour test must be conducted such that all the produced test gas and oil volumes are measured, including vented gas. The test gas volume is then divided by the test oil volume to determine the well GOR.
2. A sample of oil taken under pressure containing the gas in solution that will be released when the oil pressure is reduced may be submitted to a laboratory where a PVT analysis can be conducted. The analysis must be based on the original and final pressure and temperature conditions the oil sample would be subjected to e.g. test separator and storage tank. This procedure is used to determine a well's GIS factor. The GIS factor will be calculated based on the volume of gas released from the sample and the volume of oil remaining at the end of the analysis procedure. The volume of GIS (determined by multiplying the GIS factor by the test oil volume) is then added to the metered test gas volume, and other gas volumes as applicable, to determine the well's total test gas production. The total test gas production is then divided by the test oil production to determine the test GOR.
3. A sample of oil taken under pressure containing the gas in solution that will be released when the oil pressure is reduced may be submitted to a laboratory where a compositional analysis can be conducted. A computer simulation program may then be used to determine the GIS factor based on the compositional analysis and the original and final pressure and temperature conditions the oil sample would be subjected to e.g., test separator and storage tank. This is commonly called a flash liberation (FLIB) analysis. The results of the FLIB are reported as $m^3$ of gas/$m^3$ of oil/kPa pressure drop and this is called the GIS rate. The GIS Rate is then multiplied by the pressure drop from the oil sample point to the storage tank to determine the GIS factor. The volume of test GIS is then determined by multiplying the GIS factor by the test oil volume and that is then added to the measured test gas volume, and other gas volumes as applicable, to determine the well's total test gas production. The total test gas production is then divided by the test oil production to determine the test GOR.

In addition to the methods described above to determine the GIS factor, other acceptable methods include:

1. Methods listed under *Guideline PNG035: Estimating Venting and Fugitive Emissions.*
2. A rule of thumb estimate (0.0257 $m^3$ of gas/$m^3$ of oil/kPa of pressure drop) may be used as the GIS rate for non-heavy and heavy crude oil until a more accurate, specific GIS rate is determined. It may be used on a continuous basis, without the need for determining a GIS rate from a PVT or FLIB analysis if the well oil production rate is ≤ 2.0 $m^3$/day.

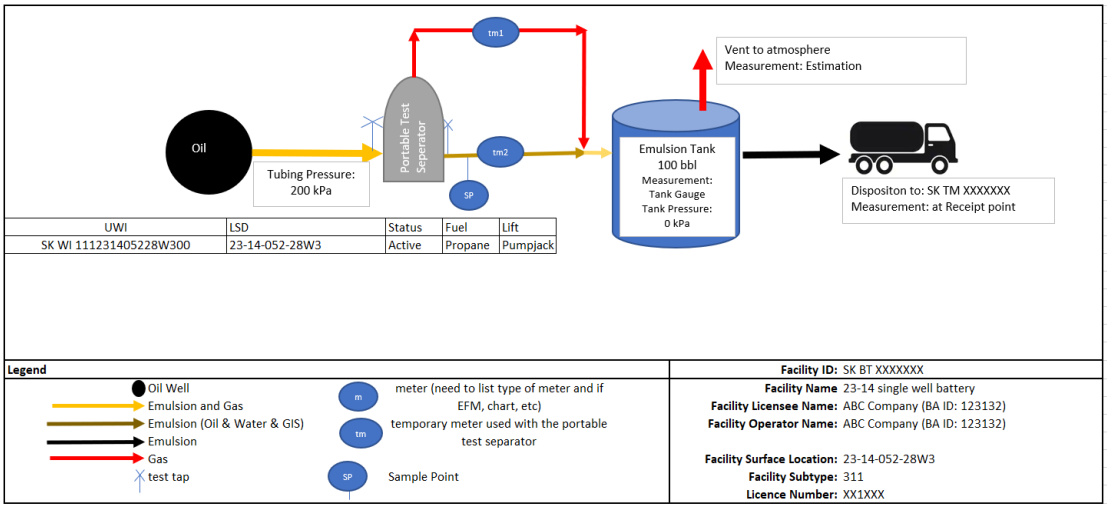
## 3. Examples of Well-level GOR applications

### 3.1 Example 1: Determining the GIS, GOR, and Petrinex monthly reported volumes for a crude oil single well battery

The procedure described in this example also applies to heavy crude oil facilities, the only difference is the GOR test period duration.

A crude oil single well battery produces effluent (oil, water, and gas) directly from the well to a production tank. In this case, a portable test separator is connected between the well and the emulsion tank to conduct the GOR test. The well emulsion and gas are separated and metered throughout the duration of the test. Figure 1 shows the GOR testing set up utilizing a test separator with the separator gas commingled with the emulsion prior to the emulsion entering the production tank.

**Figure 1:** GOR testing set up using a test separator for a crude oil single well battery that produces well effluent directly to a production tank.




In this case, the gas sources used to determine the well-level GOR include the measured separator gas plus the GIS contained in the emulsion leaving the separator.

**Sample data and information about the battery for one specific production month. Volumes have already been corrected to 101.325 kPa and 15.0°C.**

- Test duration = 24.0 hours
- Metered well gas test volume for the 24-hour period = 35.0 $m^3$
- Metered well oil test volume for the 24-hour period = 3.0 $m^3$
- Test oil S&W % from three grab samples = 9.8%
- GIS rate is 0.25 $m^3$ of gas/$m^3$ of oil/kPa of pressure drop (from FLIB analysis)
- Wellhead tubing pressure = 200.0 kPa
- Production tank pressure = 0.0 kPa
- Monthly oil dispositions = 81.1 $m^3$
- Emulsion tank opening month inventory = 35.1 $m^3$
- Emulsion tank closing month inventory = 35.5 $m^3$
- Monthly water dispositions = 9.4 $m^3$ of water
- No oil or water volumes were received into the facility
- No gas volumes were received into the facility
- All gas produced from well is vented to atmosphere

- No gas volumes are sent from this facility
- Fuel for pumpjack is propane

**Determine the GOR and Petrinex reported volumes for a crude oil single well battery:**

**Step 1:** Determine the metered well gas production volume during the GOR test.

- *Metered well gas test volume= 35.0 $m^3$*

**Step 2:** Determine the volume of well oil production during the GOR test.

- *Metered well oil test volume = 24-hour test emulsion volume × (100% - S&W%)*
- *Metered well oil test volume = 3.0 $m^3$ × (100%-9.8%)*
- *Metered well oil test volume = 2.7 $m^3$*

**Step 3:** Determine test oil GIS volume.

The GIS rate was determined through a flash liberation test (FLIB analysis) based on an emulsion sample obtained from the sample point (SP) shown on Figure 1 however, it must be converted to a GIS factor based on the actual pressure drop of this well.

Calculate the GIS factor:

- *GIS factor ($m^3$ gas/$m^3$ test oil production) = GIS rate × wellhead to emulsion tank pressure drop*
- *GIS factor ($m^3$ gas/$m^3$ test oil production) = 0.25 $m^3$/$m^3$/kPa × (200.0 kPa – 0.0 kPa)*
- *GIS factor = 50.0 $m^3$ gas/$m^3$ test oil production*

Now that the GIS factor has been determined the GIS volume for the entire test period can be calculated:

- *GIS volume during test ($m^3$) = GIS factor ($m^3$ gas/$m^3$ test oil production) x test oil production volume ($m^3$)*
- *GIS volume during test ($m^3$) = 50.0 $m^3$ gas/$m^3$ test oil x 2.7 $m^3$ test oil*
- *GIS volume during test = 135.0 $m^3$*

Calculate the GOR:

- *GOR ($m^3$ gas/$m^3$ oil) = (Metered well gas test production volume ($m^3$) + GIS volume during test ($m^3$)) / Metered well oil test production volume ($m^3$)*
- *GOR ($m^3$ gas/$m^3$ oil) = (35.0 $m^3$ + 135.0 $m^3$) / 2.7 $m^3$*
- *GOR = 62.96296 $m^3$ gas/$m^3$ oil*

**Step 4:** Determine the Petrinex monthly reported volumes for this single well battery.

Calculate battery monthly oil production:

- *Monthly oil production = monthly oil dispositions + oil inventory close – oil inventory open - monthly oil receipts*
- *Monthly oil production = 81.1 $m^3$ + ((35.5 $m^3$ – 35.1 $m^3$) x (100.0% - 9.8%)) – 0.0*
- *Monthly reported oil production = 81.5 $m^3$*

Note: Since this is a single well battery, the monthly reported oil production is reported as the well's monthly oil production.
Calculate battery monthly gas production:

- *Monthly gas production = GOR × monthly reported oil production*
- *Monthly gas production = 62.96296 $m^3/m^3$ × 81.5 $m^3$*
- *Monthly gas production =5,131.5 $m^3$ / 1000*
- *Monthly reported gas production=5.1 $10^3$ $m^3$*

Note: Since this is a single well battery the monthly reported gas production is reported as the well's monthly gas production.

Calculate battery monthly vent gas:

- *Monthly vent gas = sum of all vent points at the battery*
- *Monthly vent gas = monthly reported gas production*
- *Monthly reported vent gas = 5.1 $10^3$ $m^3$*

Note: since all the produced gas is vented to the atmosphere the monthly reported vent gas is equal to the monthly reported gas production volume. Since this is a single well battery the vent volume must be reported at the well level in Petrinex.

Calculate battery monthly water production:

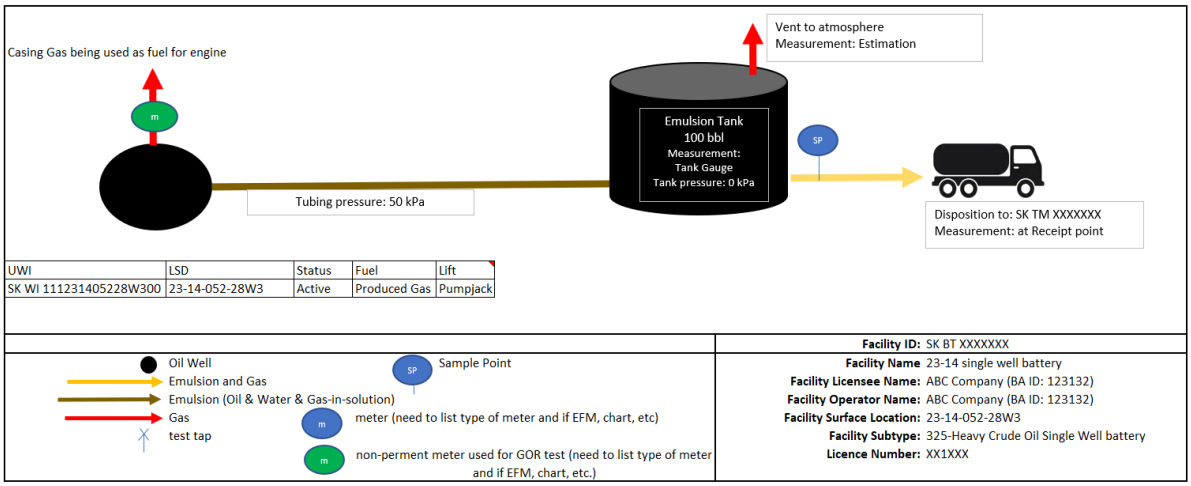
- *Monthly water production = monthly water dispositions + water inventory closing – water inventory opening – monthly water receipts*
- *Monthly water production = 9.4 $m^3$ + (35.5 $m^3$ – 35.1 $m^3$) x 9.8%*
- *Monthly reported water production = 9.4 $m^3$*

Note: since this is a single well battery the monthly reported water production is reported as the well's monthly water production.

### 3.2 Example 2: Determining the GIS, GOR, and Petrinex monthly reported volumes for a heavy crude oil single well battery that produces gas through casing and uses it as fuel

In this case, the emulsion is produced directly from the well to a production tank and a dry flow gas meter is connected to the casing gas stream to meter the casing gas volume for the duration of the GOR test. Figure 2 shows the GOR testing set up utilizing a dry flow gas meter to meter the casing gas.

**Figure 2:** GOR testing set up using a dry flow meter at a heavy crude oil single well battery that produces gas through the casing/tubing annulus while emulsion is produced directly to a production tank.




In accordance with Directive PNG017 Section 12.2.3, if a separator cannot be used to conduct the GOR test and the well effluent is flowlined directly from the wellhead to a production tank then the GOR test oil production volume may be determined by using the monthly well oil production volume for the same month the GOR test is conducted. In this case, the following formula is used to calculate the test period oil production volume:

*GOR test oil production volume = ((oil disposition +emulsion tank oil closing inventory – emulsion tank oil opening inventory oil – oil receipts) ÷ number of hours the well was on production for the month) x GOR test duration in hours.*

The S&W would be determined from the Petrinex reported monthly battery oil and water production volumes for the month.

**Sample data and information about the facility for one specific production month. These volumes have already been corrected to 101.325 kPa and 15°C.**

- Duration of GOR test = 72 hours
- Metered test gas volume for 72-hours = 350.06 $m^3$ (from measurement point m on measurement schematic in Figure 2)
- GIS rate = 0.0257 $m^3$ gas/$m^3$ oil/kPa of pressure drop (Directive PNG017 rule of thumb)
- Wellhead tubing pressure = 50.0 kPa
- Emulsion storage tank pressure = 0.0 kPa
- Total monthly oil dispositions = 150.5 $m^3$
- Emulsion tank closing month inventory = 80.1 $m^3$
- Emulsion tank opening month inventory = 25.5 $m^3$
- S&W of emulsion in tank = 25.0% based on the oil and water production volumes for the month
- No oil or water receipts into the facility
- No gas receipts into the facility

- GIS produced from the well and entrained in the oil volume is vented at the tank.
- Casing gas produced from the well is used as fuel in a 30 HP 5.7L GM Engine at a rate of 13.8 $m^3$/hr. Engine start is not pneumatic. Propane is added to the engine if not enough gas is produced.
- No gas volumes are delivered from this facility to another facility
- Monthly water dispositions = 37.5 $m^3$ of water
- Days in the month = 31
- Number of hours the well produced in the month = 744

**Step 1:** Determine the metered well gas production volume during the GOR test.

- *72-hour test metered gas volume= 350.06 $m^3$*

**Step 2:** Determine the volume of well oil production during the GOR test.

Calculate monthly oil production:

- *Monthly oil production = monthly oil dispositions + oil inventory change - monthly oil receipts*
- *Monthly oil production = monthly oil dispositions +((closing inventory - opening inventory) × (100% - S&W%)) – oil receipts*
- *Monthly oil production = 150.5 $m^3$ + ((80.1 $m^3$ - 25.5 $m^3$) × (100% - 25.0%) -0.0*
- *Monthly oil production = 191.45 $m^3$*

Calculate 72-hour test oil production:

- *Test oil production volume = (monthly oil production / monthly hours on production) x 72 hours*
- *Test oil production volume = (191.45 $m^3$ / 744 hrs) x 72 hours*
- *Test oil production volume = 18.53 $m^3$*

**Step 3:** Determine the GOR

Calculate the GIS factor:

- *GIS factor ($m^3$ gas/$m^3$ test oil production) = GIS rate ($m^3$/$m^3$/kPa) × wellhead to emulsion tank pressure drop (kPa)*
- *GIS factor = 0.0257 m3 gas/m3 oil/kPa × (50.0 – 0.0 kPa)*
- *GIS factor = 1.2850 $m^3$ gas/$m^3$ test oil production.*

Now that the GIS factor has been determined the GIS volume for the entire test period can be calculated.

- *GIS volume during test ($m^3$) = GIS factor ($m^3$ gas/$m^3$ test oil production) x test oil production volume ($m^3$)*
- *GIS volume during test = 1.2850 $m^3$ gas/$m^3$ test oil production x 18.53 $m^3$ test oil*
- *GIS volume during test = 23.8 $m^3$*

Calculate the GOR m3 gas / m3 oil:

- *GOR ($m^3$ gas/$m^3$ oil) = (Metered well gas production volume ($m^3$) + GIS volume during test ($m^3$)) / Test Oil production volume ($m^3$)*
- *GOR = (350.06 $m^3$ + 23.8 $m^3$) / 18.53 $m^3$*
- *GOR = 20.18 $m^3$ gas/$m^3$ oil*

**Step 4:** Determine the Petrinex monthly reported volumes for this single well battery

Calculate battery monthly oil production:

- *Monthly oil production = monthly oil dispositions + oil inventory change - monthly oil receipts*
- *Monthly oil production = 150.5 $m^3$ + ((80.1 $m^3$ - 25.5 $m^3$) × (100% - 25.0%))-0.0 $m^3$*
- *Monthly reported oil production = 191.5 $m^3$*

Note: Since this is a single well battery, the monthly reported oil production is reported as the well's monthly oil production.

Calculate monthly gas production:

- *Monthly gas production = GOR × monthly battery oil production*
- *Monthly gas production = 20.18 $m^3$ gas/m3 oil × 191.5 $m^3$*
- *Monthly gas production = 3,864.5 $m^3$ / 1000*
- *Monthly reported gas production = 3.9 $10^3$ $m^3$*

Note: Since this is a single well battery the monthly reported gas production is reported as the well's monthly gas production.

Calculate battery monthly vent gas:

- *Monthly vent gas = sum of all vent points at the battery*
- *Monthly vent gas = gas in solution*
- *Monthly vent gas = GIS factor × monthly oil production*
- *Monthly vent gas = (1.285 $m^3$/$m^3$ × 191.5 $m^3$)*
- *Monthly vent gas = 246.08 $m^3$ / 1000*
- *Monthly reported vent gas = 0.3 $10^3$ $m^3$*

Note: Since the only gas that is vented is the GIS, the GIS is reported as the vented gas volume. If the engine had a pneumatic start, then the gas volume vented from the pneumatic start would also have to be included in the vent gas volume. Since this is a single well battery the monthly reported vent gas volume must be reported at the well level in Petrinex.

Calculate battery monthly fuel gas:

- *Monthly battery fuel gas = sum of all fuel points at facility*
- *Gas needed for engine = manufacturers fuel gas consumption rate*
- *Gas needed for engine = 13.8 $m^3$ × 744 hours*
- *Gas needed for engine = 10,267.2 $m^3$ / 1000 = 10.2 $10^3$ $m^3$*

Note: Since more gas is needed for the engine than is produced, propane is kept onsite. The monthly reported fuel gas is the total gas volume produced from the casing. The propane portion of the fuel gas volume is not reported as fuel gas. Below provides the calculation to determine the monthly reported fuel gas volumes which in this case will not be the same as the gas needed for engine volume since there is not enough gas produced to continuously run the engine.

- *Monthly fuel gas = 72-hour test metered gas volume / 72 hours x 744 hours*
- *Monthly fuel gas = 350.06 $m^3$ / 72 hours x 744 hours*
- *Monthly fuel gas = 3,617.3 $m^3$ / 1000*
- *Monthly reported fuel gas = 3.6 $10^3$ $m^3$*

Note: Since this is a single well battery the fuel volume must be reported at the well level in Petrinex.

Calculate battery monthly water production:

- *Monthly battery water production = monthly water dispositions + water inventory closing - water inventory opening - water monthly receipts*
- *Monthly battery water production = 37.5 $m^3$ + (80.1 $m^3$- 25.5 $m^3$) x 25%) – 0.0 $m^3$*
- *Monthly reported battery water production = 51.2 $m^3$*

Note: since this is a single well battery the monthly reported water production is reported as the monthly well water production.

## 4. Battery-level Gas Oil Ratio determination

### 4.1 Battery-level GOR qualifying criteria

Section 6.5.2 of Directive PNG017 outlines the qualifying criteria for the use of a battery-level GOR at facility subtype 322 (crude oil multi-well proration battery). Section 12.2.2.2 outlines the qualifying criteria for the use of a battery-level GOR at facility subtype 327 (heavy crude oil multi-well proration battery).

A battery-level GOR (battery gas production ÷ battery oil production) must be determined monthly. To calculate individual well gas production volumes using the battery-level GOR the following conditions must be met:

a. All wells using the battery-level GOR must produce ≤ 0.5 $10^3m^3$/day (facility subtype 322) or ≤ 2.0 $10^3m^3$/day (facility subtype 327) of gas;

b. Any well producing > 0.5 $10^3m^3$/day (facility subtype 322) or > 2.0 $10^3m^3$/day (facility subtype 327) of gas is not eligible to use the battery-level GOR, and well gas production must be determined using test rates obtained during proration testing;

c. Monthly gas and oil volumes from wells not eligible to use the battery-level GOR must be subtracted from the total battery gas and oil production volumes before calculating the battery-level GOR. For gas, the volume to be subtracted would be the total

estimated gas determined from proration testing for all the ineligible wells; for oil, the volume would be the total prorated oil production for all the ineligible wells;

d. New wells added must produce ≤ 0.5 $10^3m^3$/day (facility subtype 322) or ≤ 2.0 $10^3m^3$/day (facility subtype 327) of gas for a minimum of six months before being eligible to use the battery-level GOR;

e. If there is no common ownership of all the wells in the battery, written notification must have been given to all working interest participants, with no resulting objections; and,

f. If there is no common Crown or common Freehold royalty and only Freehold royalties are involved in all wells in the battery, written notification must have been given to all Freehold royalty owners, with no resulting objection received. If there is a mix of Freehold and Crown royalties involved, the licensee must apply to ER for approval if any Freehold royalty owner objects.

### 4.2 Formula for Battery-level GOR

To provide clarity in determining a battery's GOR, which includes the GIS, the following defines the gas sources that must be considered and the formula to be used in the determination of the battery-level GOR:

- Battery monthly gas production ($10^3m^3$) = battery monthly gas dispositions ($10^3m^3$) + battery monthly fuel ($10^3m^3$) + battery monthly flare ($10^3m^3$) + battery monthly vent ($10^3m^3$) - battery monthly gas receipts ($10^3m^3$). These are the monthly volumes whether they are estimated or metered for each of these activities.
- Battery monthly oil production ($m^3$) = battery monthly oil dispositions ($m^3$) + battery oil inventory closing ($m^3$) – battery oil inventory opening ($m^3$) - battery monthly oil receipts ($m^3$)
- Battery-level GOR = battery monthly gas production ÷ battery monthly oil production

The battery-level GOR is then multiplied by the reported prorated oil production for each well or reported oil production for each well (if a group battery) to determine the reported gas production in $10^3m^3$ in each month.

### 4.3 Gas in Solution for battery-level GOR

If a battery-level GOR is used to determine reported well gas production, then the GOR is calculated by adding the monthly GIS volume determined at the group separator/treater to the monthly battery metered gas production volume.

Determining the gas in solution for a battery-level GOR where a flash liberation analysis, PVT analysis or the rule of thumb is used, requires the determination of the pressure drop between the group separator/treater and the oil storage tank. The pressure drop that must be considered for a multi-well battery, where the emulsion is flowlined from the wellheads to a test separator and then to a group separator or treater and then to a tank, will be the operating pressure of the group separator/treater in kPa(g) minus the vapour pressure of the storage tank in kPa(g). If the storage tank is an atmospheric tank, the vapour pressure at the tank will be 0.0 kPa(g).

If the group separator/treater pressure is not constant due to the hydrostatic head pressure in the tank changing with tank level changes, ERD recommends using the group separator/treater vapour pressure from when the maximum hydrostatic head pressure from the tank occurs as the initial pressure for the pressure drop calculation.

#### 4.3.1 Example of Gas in Solution for battery-level GOR

Example: Determine the GIS factor for a battery level GOR

- Operating pressure at the group separator 100.0 kPa(g)
- Storage tank vapour pressure 0.0 kPa(g) as it is an atmospheric tank (i.e., tank is venting to atmosphere)
- Pool level GIS rate was determined by a lab flash liberation analysis and the result was 0.15236 $m^3$ of gas / $m^3$ of oil / kPa of pressure drop.

Calculate the GIS factor:

- GIS Factor ($m^3$ gas/$m^3$ battery oil production) = GIS rate ($m^3/m^3/kPa$) × pressure drop (kPa)
- GIS Factor = 0.15236 ($m^3/m^3/kPa$) × (100.0 – 0.0 (kPa))
- GIS Factor = 15.236 $m^3$ of gas/$m^3$ of oil

The GIS factor is then multiplied by the battery oil production for the month. This gas volume is then added to the battery gas production for the month.

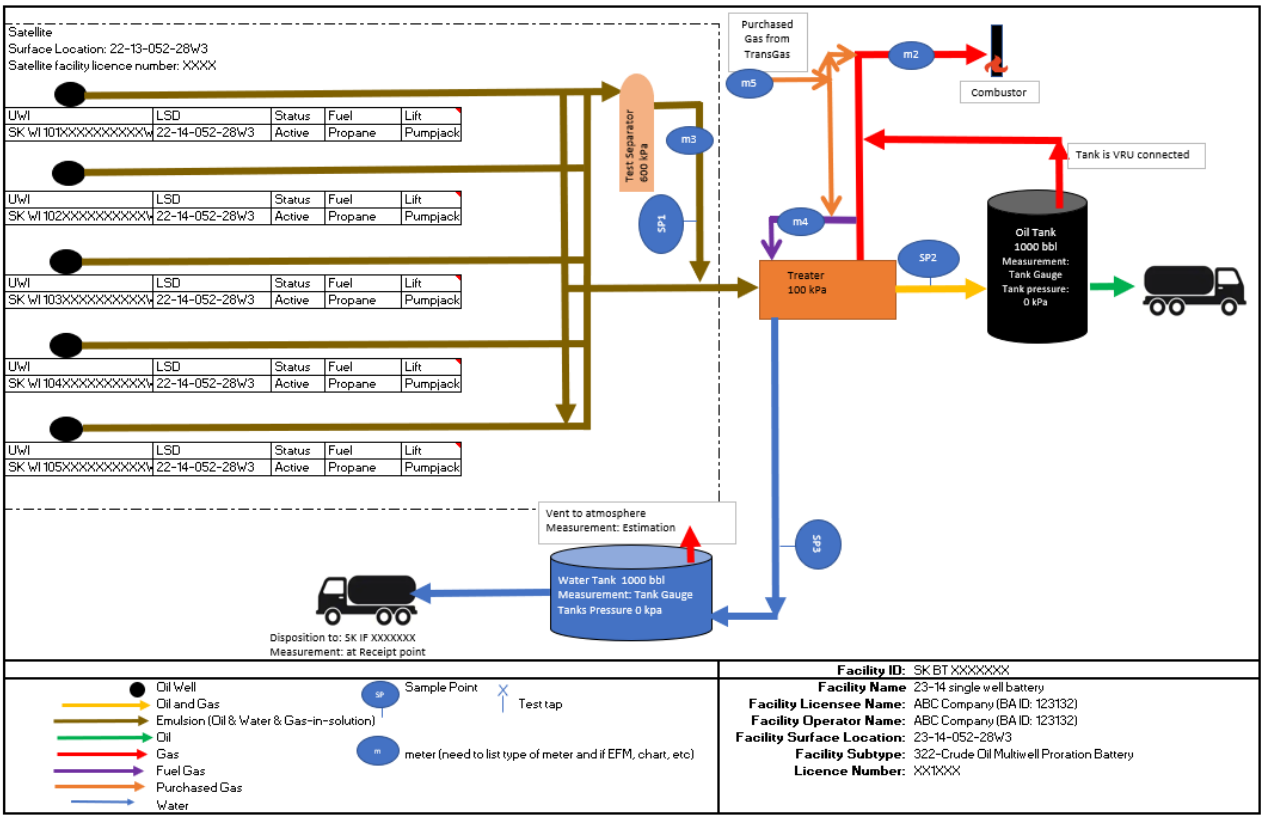
## 5. Examples of Battery-level GOR applications

### 5.1 Example 1: Determining battery-level GIS, GOR, and Petrinex reporting volumes for a crude oil multi-well proration battery

In this example, the non-heavy crude oil multi-well proration battery produces effluent (oil, water, and gas) at wells in a satellite and sends the volumes to the main battery. The water, emulsion and gas are separated, and emulsion is treated. Water and oil are sent to separate tanks and the gas is sent to a flare stack. See Figure 3 for example of facility setup.

All the wells within the battery produce less than 0.5 $10^3m^3$ per day.

**Figure 3:** Facility set up of a crude oil multi-well proration battery utilizing a battery level GOR.




**Sample data and information about the facility for one specific production month. These volumes have already been corrected to 101.325 kPa and 15°C.**

- Production Month = June = 720 hours
- Monthly oil dispositions = 352.6 $m^3$
- Oil tank closing month inventory = 535.1 $m^3$
- Oil tank opening month inventory = 435.5 $m^3$
- S&W from oil sample taken from the oil storage tank during the month = 0.5%
- No oil or water volumes were received into the facility
- Monthly flare gas volume for meter point 2 (m2) = 50.9 $10^3m^3$
- GIS Rate from sample point 2 (SP2) = 0.12530 $m^3$ of gas/$m^3$ of oil/kPa of pressure drop
- GIS Rate from sample point 3 (SP3) = 0.00001 $m^3$ of gas/$m^3$ of water/kPa of pressure drop
- Treater operating pressure = 100.0 kPa (g)
- Test separator operating pressure = 600.0 kPa (g)
- No gas volumes are sent from this facility
- Fuel for pumpjack is propane
- Fuel for the treater is produced gas and received in gas from TransGas, which is a metered (m4 on measurement schematic). Total monthly fuel gas usage is 15.8 $10^3m^3$.
- Received in gas from TransGas (m5 on measurement schematic) = 34.8 $10^3m^3$
- Total monthly water dispositions = 1,631.9 $m^3$ of water
- Water tank opening month inventory = 555.0 $m^3$

- Water tank closing month inventory = 452.1 $m^3$
- Water tank is 100% water

Table 2: Estimated oil and gas production volumes from 24 hour well tests completed for the month

| **UWI** | SK WI 101XXXXXXXXXXW00 | | | **Test duration** | **Hourly test rate** | | **Total Estimated Volume** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test date** | | **Test oil** | **Test water** | | **Oil** | **Water** | **Prod** | **Oil** | **Water** |
| dd | mm | $m^3$ | $m^3$ | Hours | $m^3/hr$ | $m^3/hr$ | hours | $m^3$ | $m^3$ |
| 01 | 6 | 5.12 | 11.63 | 24 | 0.2133 | 0.4846 | **720** | **153.58** | **348.91** |
| | | | | | | **Totals** | **720** | **153.58** | **348.91** |

| **UWI** | SK WI 102XXXXXXXXXXW00 | | | **Test duration** | **Hourly test rate** | | **Total Estimated Volume** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test date** | | **Test oil** | **Test water** | | **Oil** | **Water** | **Prod** | **Oil** | **Water** |
| dd | mm | $m^3$ | $m^3$ | Hours | $m^3/hr$ | $m^3/hr$ | hours | $m^3$ | $m^3$ |
| 02 | 5 | 2.43 | 10.99 | 24 | 0.1013 | 0.4579 | 24 | 2.43 | 10.99 |
| 02 | 6 | 2.24 | 11.99 | 24 | 0.0933 | 0.4996 | 696 | 64.94 | 347.72 |
| | | | | | | **Totals** | **720** | **67.37** | **358.71** |

| **UWI** | SK WI 103XXXXXXXXXXW00 | | | **Test duration** | **Hourly test rate** | | **Total Estimated Volume** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test date** | | **Test oil** | **Test water** | | **Oil** | **Water** | **Prod** | **Oil** | **Water** |
| dd | mm | $m^3$ | $m^3$ | Hours | $m^3/hr$ | $m^3/hr$ | hours | $m^3$ | $m^3$ |
| 03 | 5 | 3.63 | 11.45 | 24 | 0.1513 | 0.4771 | 48 | 7.26 | 22.90 |
| 03 | 6 | 3.28 | 11.78 | 24 | 0.1367 | 0.4908 | 672 | 91.86 | 329.82 |
| | | | | | | **Totals** | **720** | **99.12** | **352.72** |

| **UWI** | SK WI 104XXXXXXXXXXW00 | | | **Test duration** | **Hourly test rate** | | **Total Estimated Volume** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test date** | | **Test oil** | **Test water** | | **Oil** | **Water** | **Prod** | **Oil** | **Water** |
| dd | mm | $m^3$ | $m^3$ | Hours | $m^3/hr$ | $m^3/hr$ | hours | $m^3$ | $m^3$ |
| 04 | 5 | 2.98 | 11.45 | 24 | 0.1242 | 0.4771 | 72 | 8.94 | 34.35 |
| 04 | 6 | 2.77 | 12.98 | 24 | 0.1154 | 0.5408 | 648 | 74.78 | 350.44 |
| | | | | | | **Total** | **720** | **83.72** | **384.79** |

| **UWI** | SK WI 105XXXXXXXXXXW00 | | | **Test duration** | **Hourly test rate** | | **Total Estimated Volume** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test date** | | **Test oil** | **Test water** | | **Oil** | **Water** | **Prod** | **Oil** | **Water** |
| dd | mm | $m^3$ | $m^3$ | Hours | $m^3/hr$ | $m^3/hr$ | hours | $m^3$ | $m^3$ |
| 05 | 5 | 1.43 | 2.25 | 24 | 0.0596 | 0.0938 | 96 | 5.72 | 9.00 |
| 05 | 6 | 1.34 | 2.55 | 24 | 0.0558 | 0.1063 | 624 | 34.82 | 66.33 |
| | | | | | | **Total** | **720** | **40.54** | **75.33** |

**Determine the monthly reported volumes for this crude oil multi-well battery using a battery level GOR**

**Step 1:** Determine the well's monthly oil production volumes.

Calculate battery monthly oil production volume:

- *Battery monthly oil production ($m^3$) = battery monthly oil dispositions ($m^3$) + battery oil inventory closing ($m^3$) – battery oil inventory opening ($m^3$) - battery monthly oil receipts ($m^3$)*
- *Battery monthly oil production = 352.6 $m^3$ + 535.1 $m^3$ - 435.5 $m^3$ – 0.0 $m^3$*
- *Battery monthly oil production = 452.20 $m^3$*

Calculate the battery estimated monthly oil production volume:

- *Battery estimated monthly oil production ($m^3$) = the sum of each well's estimated monthly oil production ($m^3$)*
- *Battery estimated monthly oil production = 153.58 $m^3$ + 67.37 $m^3$ + 99.12 $m^3$ + 83.72 $m^3$+ 40.54 $m^3$*
- *Battery estimated monthly oil production = 444.33 $m^3$*

Calculate the battery monthly oil proration factor:

- *Battery monthly oil proration factor = monthly battery oil production ($m^3$) ÷ battery estimated monthly battery oil production ($m^3$)*
- *Battery monthly oil proration factor = 452.20 $m^3$ ÷ 444.33 $m^3$ = 1.01771*

Calculate the monthly prorated oil production volume for each well:

- *Monthly prorated oil production for each well ($m^3$) = well estimated monthly oil production ($m^3$) × battery monthly oil production factor*
- *Monthly prorated oil production for SK WI 101XXXXXXXXXXW00 =153.58 $m^3$ × 1.01771*
- *Monthly prorated oil production for SK WI 101XXXXXXXXXXW00 = 156.3 $m^3$*
- *Monthly prorated oil production for SK WI 102XXXXXXXXXXW00 = 67.37 $m^3$ × 1.01771*
- *Monthly prorated oil production for SK WI 102XXXXXXXXXXW00 = 68.6 $m^3$*
- *Monthly prorated oil production for SK WI 103XXXXXXXXXXW00 = 99.12$m^3$ × 1.01771*
- *Monthly prorated oil production for SK WI 103XXXXXXXXXXW00 = 100.9 $m^3$*
- *Monthly prorated oil production for SK WI 104XXXXXXXXXXW00 = 83.72 $m^3$ × 1.01771*
- *Monthly prorated oil production for SK WI 104XXXXXXXXXXW00 = 85.2 $m^3$*
- *Monthly prorated oil production for SK WI 105XXXXXXXXXXW00 = 40.54 $m^3$ × 1.01771*
- *Monthly prorated oil production for SK WI 105XXXXXXXXXXW00 = 41.3 $m^3$*

**Step 2:** Determine the well's monthly gas production volumes.

Calculate battery monthly gas production volume:

- *Battery monthly gas production ($10^3m^3$) = battery monthly gas dispositions ($10^3m^3$) + battery monthly fuel ($10^3m^3$) + battery monthly flare ($10^3m^3$) + battery monthly vent ($10^3m^3$)* - battery monthly gas receipts ($10^3m^3$)*

* From vent volume calculation below:

- *Battery monthly gas production ($10^3m^3$) = 0.0 $10^3m^3$ + 15.8 $10^3m^3$ + 50.9 $10^3m^3$ + 0.0 $10^3m^3$ – 34.8 $10^3m^3$*
- *Battery monthly gas production = 31.9 $10^3m^3$*

Calculate battery level monthly GOR:

- *Battery level monthly GOR = battery monthly gas production ($10^3m^3$) ÷ battery monthly oil production ($m^3$)*
- *Battery level monthly GOR = 31.9 $10^3m^3$ ÷ 452.20 $m^3$*
- *Battery level monthly GOR = 0.07054 $10^3$ $m^3/m^3$*

Calculate the monthly gas production volume for each well:

- *Monthly gas production for each well ($10^3m^3$) = monthly prorated oil production volume for each well ($m^3$) × battery level monthly GOR $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 101XXXXXXXXXXW00 = 156.3 $m^3$ × 0.07054 $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 101XXXXXXXXXXW00 = 11.02 $10^3m^3$*
- *Monthly gas production for SK WI 102XXXXXXXXXXW00 = 68.6 $m^3$ × 0.07054 $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 102XXXXXXXXXXW00 = 4.83 $10^3m^3$*
- *Monthly gas production for SK WI 103XXXXXXXXXXW00 = 100.09 $m^3$ × 0.07054 $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 103XXXXXXXXXXW00=7.11 $10^3m^3$*
- *Monthly gas production for SK WI 104XXXXXXXXXXW00 = 85.2 $m^3$ × 0.07054 $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 104XXXXXXXXXXW00= 6.01 $10^3m^3$*
- *Monthly gas production for SK WI 105XXXXXXXXXXW00 = 41.3 $m^3$ × 0.07054 $10^3$ $m^3/m^3$*
- *Monthly gas production for SK WI 105XXXXXXXXXXW00=2.91 $10^3m^3$*

Note: A proration factor of 1.00000 is required to be submitted into Petrinex as per Directive PNG017.

**Step 3:** Determine the well's monthly water production volumes.

Calculate battery monthly water production volume:

- *Battery monthly water production ($m^3$) = battery monthly water dispositions ($m^3$) + battery water inventory closing ($m^3$) – battery water inventory opening ($m^3$) - battery monthly water receipts ($m^3$)*
- *Battery monthly water production = 1,631.9 $m^3$ + 452.1 $m^3$ – 555.0 $m^3$ – 0.0 0 $m^3$*

- *Battery monthly water production = 1,529.0 $m^3$*

Calculate the battery estimated monthly water production volume:

- *Battery estimated monthly water production ($m^3$) = the sum of each well's estimated monthly water production ($m^3$)*
- *Battery estimated monthly water production = 348.91 $m^3$ + 358.71 $m^3$ + 352.72 $m^3$ + 384.79 $m^3$ + 75.33 $m^3$*
- *Battery estimated monthly water production = 1,520.5 $m^3$*

Calculate the battery monthly water proration factor:

- *Battery monthly water proration factor = monthly battery water production ($m^3$) ÷ battery estimated monthly battery water production ($m^3$)*
- *Battery monthly water proration factor = 1,529.0 $m^3$ ÷ 1,520.5 $m^3$ = 1.00559*

Calculate the prorated monthly water production volume for each well:

- *Monthly prorated water production for each well ($m^3$) = well estimated monthly water production ($m^3$) × battery monthly water production factor*
- *Monthly prorated water production for SK WI 101XXXXXXXXXXW00 =348.91 $m^3$ × 1.00559*
- *Monthly prorated water production for SK WI 101XXXXXXXXXXW00 = 350.9 $m^3$*
- *Monthly prorated water production for SK WI 102XXXXXXXXXXW00 = 358.71 $m^3$ × 1.00559*
- *Monthly prorated water production for SK WI 102XXXXXXXXXXW00 = 360.7 $m^3$*
- *Monthly prorated water production for SK WI 103XXXXXXXXXXW00 = 352.72 $m^3$ × 1.00559*
- *Monthly prorated water production for SK WI 103XXXXXXXXXXW00 = 354.7 $m^3$*
- *Monthly water production for SK WI 104XXXXXXXXXXW00 = 384.79 $m^3$ × 1.00559 $10^3$ $m^3/m^3$*
- *Monthly water production for SK WI 104XXXXXXXXXXW00=386.9 $10^3 m^3$*
- *Monthly water production for SK WI 105XXXXXXXXXXW00 = 75.33 $m^3$ × 1.00559 $10^3$ $m^3/m^3$*
- *Monthly water production for SK WI 105XXXXXXXXXXW00 = 75.8 $10^3 m^3$*

**Step 4:** Determine the battery monthly flare volume:

The flared volume is a metered volume determined from an orifice meter with electronic flow measurement (EFM) and the meter location is m2 on measurement schematic Figure 3.

- *Battery monthly flared gas volume = metered volume = 50.9 $10^3 m^3$*

**Step 5:** Determine the battery monthly vent volume.

There is no venting occurring at the satellite. There is venting occurring at the battery water tank. Liquid samples were obtained at sample point 2 (SP2) and sample point 3 (SP3) and FLIB analyses were conducted to determine the GIS rates. The vent gas at the oil tank is collected and sent to the combustor therefore the FLIB analysis at SP2 is not required for determining gas production.

Calculate the monthly gas vent volume at the water storage tank:

- *SP3 GIS Factor ($m^3$ gas/$m^3$ water production) = GIS rate ($m^3/m^3/kPa$) × pressure drop (kPa)*
- *SP3 GIS Factor = 0.00001 ($m^3/m^3/kPa$) × (100.0 – 0.0 (kPa))*
- *SP3 GIS Factor = 0.00100 $m^3$ of gas/$m^3$ of water production*
- *SP3 GIS volume ($m^3$) = SP3 GIS factor ($m^3$ gas/$m^3$ water production) x battery monthly water production volume ($m^3$)*
- *SP3 GIS volume = 0.00100 $m^3$ gas/$m^3$ water x 1,529.0 $m^3$ battery monthly water production*
- *SP3 GIS volume = 1.529 $m^3$ /1000 = 0.0 $10^3m^3$*

Calculate the monthly battery vent gas volume:

- *Monthly battery vent gas volume ($m^3$) = SP3 GIS volume ($m^3$)*
- *Monthly battery vent gas volume = 0.0 $10^3m^3$*

**Step 6:** Determine the battery monthly fuel volume:

Fuel for the pumpjack is propane and propane is not reported in Petrinex when it relates to fuel usage.

The fuel gas volume is a metered volume determined from an orifice meter with electronic flow measurement (EFM) and the meter location is m4 on measurement schematic Figure 3.

- *Battery monthly fuel gas volume = metered volume = 20.8 $10^3m^3$*

**Step 7:** Determine the battery monthly gas received in volume:

Gas is received from Trans Gas.

The receipt gas volume is a metered volume determined from an orifice meter with electronic flow measurement (EFM) and the meter location is m5 on measurement schematic Figure 3.

- *Battery monthly received gas volume = metered volume = 34.8 $10^3m^3$*

## 6. Petrinex Volumetric Errors and Compliance Assessment Indicators

In some cases, the reason gas production is not reported is that there is not enough gas produced to be reported in accordance with Petrinex reporting requirements. For situations listed below, operators may request to suppress volumetric errors (VME) and the Enhanced Production Audit Program (EPAP) compliance assessment indicators (CAI) from being triggered by submitting the current and/or historical GOR for the well to ER. Upon review and approval by ER, the GOR will be entered into Petrinex. Petrinex will then use the GOR to calculate the monthly gas production for the well (based on reported monthly oil production for the well) and determine whether the gas volume is reportable. A reportable gas volume is any volume ≥ 0.05 $10^3m^3$ / month. If the gas production volume is too low to be reported, Petrinex will automatically suppress the VMEs, and the CAIs as outlined below.

Petrinex generates VME0041, VME0010, or VME0042 errors in cases where monthly reported oil production volumes have been reported at a well or facility and no accompanying gas production has been reported (a list of applicable facilities is provided below). These Volumetric Errors (VMEs) can result in penalties being applied for each month the VMEs are triggered.

The following are the definitions and associated applicable facilities for the Petrinex VMEs triggered when gas production is not reported.

**VME0041** – Production or recovery of the GAS or SOLVENT product group must be reported when oil production > 15.0 $m^3$ has been reported at an oil well in a production month. This error warning applies to the following facility subtypes:

- 311-Crude Oil Single Well Battery
- 321-Crude Oil Multi-well Group Battery
- 322-Crude Oil Multi-well Proration Battery
- 325-Heavy Crude Oil Single Well Battery
- 326-Heavy Crude Oil Multi-well Group Battery
- 327-Heavy Crude Oil Multi-well Proration Battery
- 344-Thermal In-Situ Battery.

**VME0010** – Production or recovery of the GAS or SOLVENT product group must be reported when total oil production ≥ 50.0 $m^3$ has been reported at a crude oil or heavy crude oil facility in a production month. This error applies to the following facility subtypes:

- 321-Crude Oil Multi-well Group Battery
- 322-Crude Oil Multi-well Proration Battery
- 326-Heavy Crude Oil Multi-well Group Battery
- 327-Heavy Crude Oil Multi-well Proration Battery
- 344-Thermal In-Situ Battery.

**VME0042** – Production or recovery of the GAS or SOLVENT product group must be reported when oil production ≥ 50.0 m3 has been reported at an oil well in a production month. This error applies to the following facility subtypes:

- 311-Crude Oil Single Well Battery
- 313-Heavy Crude Oil Paper Battery
- 316-Crude Oil Multi-well Swab Paper Battery.

Petrinex generates monthly CAI 171 in cases where monthly reported oil production volumes have been reported at a well and no accompanying gas production has been reported (a list of applicable facilities is provided below), and CAI 143 and CAI 144 if the calculated gas oil ratio is lower than the expected threshold.

The following are the definitions and associated applicable facilities for the Petrinex EPAP CAIs triggered when gas production is not reported.

**CAI 171** – Missing Gas Volume for a crude oil/heavy oil well - Well-Level (VME0041). Oil/Heavy Oil production at a well is greater than 15 $m^3$, without a corresponding gas volume for a crude oil well.
This CAI applies to the following facility subtypes:

- 311-Crude Oil Single Well Battery
- 313-Heavy Crude Oil Paper Battery
- 314-Crude Oil Multi-well Swab Group Battery
- 316-Crude Oil Multi-well Swab Paper Battery
- 321-Crude Oil Multi-well Group Battery
- 322-Crude Oil Multi-well Proration Battery
- 325-Heavy Crude Oil Single Well Battery
- 326-Heavy Crude Oil Multi-well Group Battery
- 327-Heavy Crude Oil Multi-well Proration Battery
- 344-Thermal In-Situ Battery

**CAI 143** – Low Gas/Oil Ratio – Heavy Oil Battery - The calculated Gas/Oil Ratio (GOR) is less than or equal to 2 $m^3$ gas/$m^3$ oil for a Heavy Oil battery. This CAI applies to the following facility subtypes:

- 325-Heavy Crude Oil Single Well Battery
- 326-Heavy Crude Oil Multi-well Group Battery
- 327-Heavy Crude Oil Multi-well Proration Battery
- 344-Thermal In-Situ Battery
- 313-Heavy Crude Oil Paper Battery

**CAI 144** – Low Gas/Oil Ratio – Oil Battery - The calculated Gas/Oil Ratio (GOR) is less than or equal to 5 $m^3$ gas/$m^3$ oil for an Oil battery. This CAI applies to the following facility subtypes:

- 311-Crude Oil Single Well Battery
- 321-Crude Oil Multi-well Group Battery
- 322-Crude Oil Multi-well Proration Battery

## 6.1 Submitting a GOR Test Result to ER

Operators must submit their current or historical GOR upon request by ER, as required in Section 6.5.3 and 12.2.3 of PNG017, or in the case where Petrinex VME0041, VME0042, VME0010, CAI 171, CAI 143, or CAI 144 are being triggered and the operator would like the VME and CAI to be suppressed because there is not enough gas production to be reported.

A battery-level GOR cannot be submitted to Petrinex as it is calculated on a monthly basis using the monthly battery gas and oil production volumes.

The submission of a well-level GOR should be in the form of a measurement exemption application. On the webpage https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/oil-and-gas/oil-and-gas-licensing-operations-and-requirements/oil-and-gas-drilling-and-operations/measurement-requirements/apply-for-a-measurement-exemption

an application form can be used when submitting this application. Guidance on what is required in the submission of the measurement exemption is found within the form.

For more information on how to submit a measurement exemption application on IRIS see the document "Example of Measurement Exemption Supporting Documentation and ApplicationProcessinIRIS" on the webpage https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/oil-and-gas/oil-and-gas-licensing-operations-and-requirements/oil-and-gas-drilling-and-operations/measurement-requirements/apply-for-a-measurement-exemption

### 6.2 ER Assessment of GOR

Upon receipt of a measurement exemption application, ER will review the application and supporting information and, if approved, the GOR will be entered into Petrinex by ER. On a monthly basis, Petrinex will determine the volume of reported monthly well oil production that is required to arrive at the minimum reportable monthly gas production volume. If the reported monthly oil production volume is less than the calculated oil volume that requires gas production to be reported, then no VME will be triggered. If the reported monthly oil production volume is greater than the calculated oil volume, then Petrinex will trigger a VME.

### 6.3 Expiration of GOR

For a well to continue to qualify for the VME and CAI suppression, Operators must submit updated GORs for the well based on the frequency required in Section 6 and 12 of Directive PNG017. If an updated GOR is determined as the result of a change in operations, the updated GOR must be submitted to ER as soon as is reasonably possible. Once an updated GOR is submitted to ER and the review of the supporting documentation is completed by ER, ER will enter the GOR into Petrinex.

Depending on the frequency of GOR testing required by Directive PNG017, ER will enter the appropriate expiring date of the current GOR. The updated GOR must be submitted to ER via application prior to the expiration of the current GOR period to ensure the ongoing suppression of the VMEs. A Petrinex notification advising the operator of the requirement to submit an updated GOR will be sent to the operator in each of the five months leading up to the expiration of the current GOR.

## 7. GOR Information and Functionality Available in Petrinex

ER, in conjunction with Petrinex, has developed functionality within Petrinex that provides industry operators current GOR information, notifications regarding the submission of updated GORs and reports to assist operators in the management of GOR data. The following discussion is a description of the information and functionality that is available to industry operators within Petrinex.

### 7.1 Query Gas Oil Ratio Factor Screen

In Petrinex, under Well Infrastructure there is a "Query Gas Oil Ratio Option". This option allows the operator to review submitted GORs for a well completion.

## 7.2 Notifications

Three notifications have been implemented in Petrinex. They are designed to notify operators of the addition of a GOR for a well completion ID (i.e., well event ID) and when new GOR must be resubmitted.

### 7.2.1 GOR has Changed

Industry will receive a notification, GOR001, when a GOR has been entered into Petrinex by ER for a particular well completion. The GOR001 notification is as follows:

> *Well [well event id] has changed its GOR [GOR] for the period starting on [Start Prod Month] and ending on [End Prod Month].*

### 7.2.2 GOR has Been Backdated

Industry will receive a notification GOR002 when a GOR has been entered into Petrinex by ER for a particular well completion and the volumetric data for the dates that the GOR applies to has already been submitted to Petrinex. The GOR002 notification is as follows:

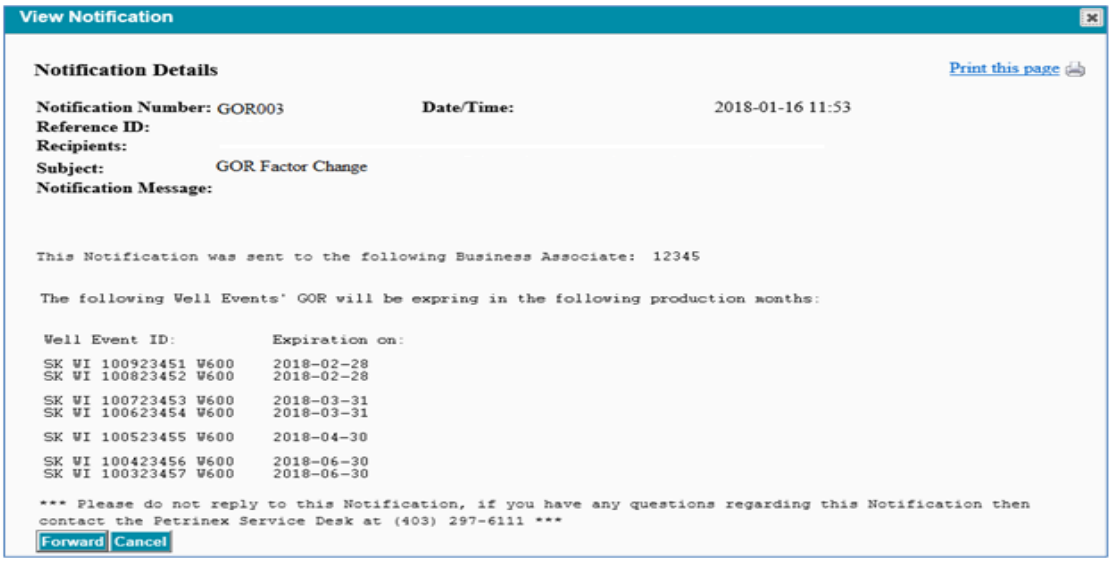
> *Well [well event id] has changed its GOR [GOR] for the Month starting on [Start Prod Month] and ending on [End Prod Month].*

Volumetric data must be resubmitted to Petrinex in order to remove existing VMEs.

### 7.2.3 Expiring GORs

For each of the five months leading up to the expiry of a well event GOR, Petrinex will send a notification to the industry operator of the expiry date. The notification will identify all the wells in which the GOR will be expiring in the next five months. Figure 5 below is an example of the notification screen.

**Figure 5:** GOR003 Monthly Notification on expiring GORs



## 7.3 Reports

Petrinex has created a Gas Oil Ratio report that can be run by industry. This report provides information on all the submitted GORs and which GORs are about to expire. The report is available under Submit Report Request. Figures 6 and 7 below are examples of the selection screen and resultant report details, respectively.

**Figure 6:** Gas Oil Ratio Report Selection Screen

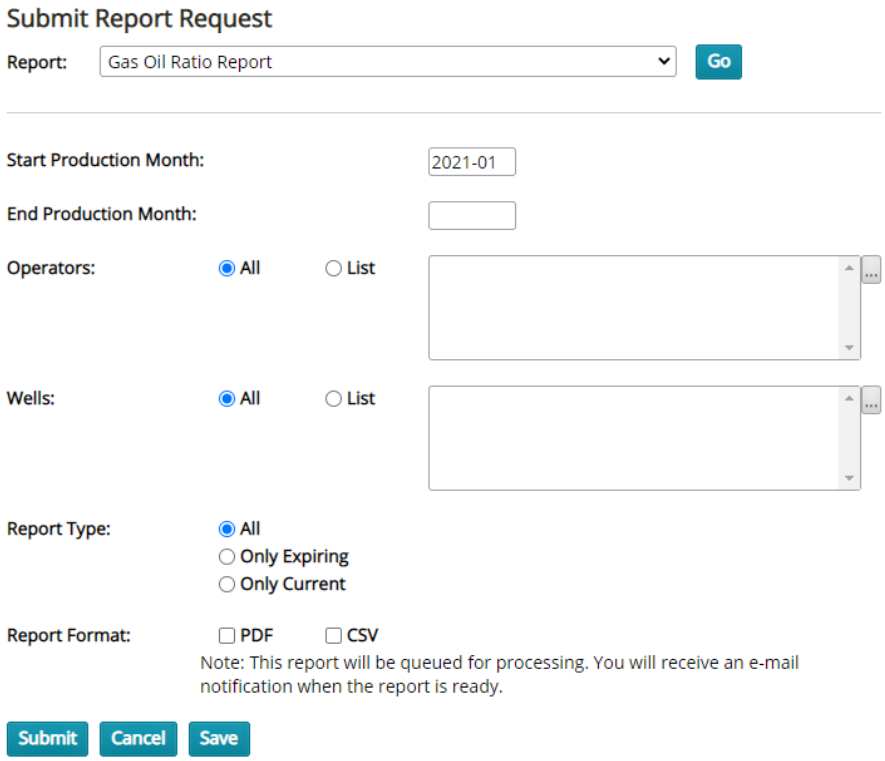


**Figure 7:** Gas Oil Ratio Factor Report Details

**PETRINEX**
**Gas Oil Ratio Report**

**00000 MINISTRY OF ENERGY AND RESOURCES**

**Operator** 01235 ABC Oil
**Current Well Status:** OIL ACTIVE PROD BOSS
**Status Effective Date:** 1995-10-11
**Licencee ID:** 01235 ABC Oil
**Current Link** SK BT 0123456

| GOR Factor | Start Prod Month | End Prod Month | Comments | Submission Date |
|---|---|---|---|---|
| 14.31844 | 2020-07 | 2021-09 | GOR Application | 2021-08-03 14:35 |
| 14.31844 | 2021-10 | 2022-01 | Granted GOR extension | 2021-10-25 14:50 |
| 17.51334 | 2023-06 | 2023-06 | BT-Level GOR for June 2023 | 2023-07-19 12:08 |
| 17.29527 | 2023-07 | 2023-07 | BT-Level GOR for July 2023 | 2023-08-18 17:16 |
| 16.99568 | 2023-08 | 2023-08 | BT-Level GOR for August 2023 | 2023-09-13 13:51 |

**Well Even** SK WI 0123456789W2
**Operator** 01235 ABC Oil
**Current Well Status:** OIL ACTIVE PROD N/A
**Status Effective Date:** 2005-08-22
**Licencee ID:** 01235 ABC Oil
**Current Linke** SK BT 0123456

| GOR Factor | Start Prod Month | End Prod Month | Comments | Submission Date |
|---|---|---|---|---|
| 828.79585 | 2022-09 | 2023-11 | This GOR was conducted for the month of September 2022. | 2022-09-06 11:35 |

**Well Even** SK WI 0123456798W2
**Operator** 01235 ABC Oil
**Current Well Status:** OIL ACTIVE PROD N/A
**Status Effective Date:** 1988-02-05
**Licencee ID:** 01235 ABC Oil
**Current Linke** SK BT 0123456

| GOR Factor | Start Prod Month | End Prod Month | Comments | Submission Date |
|---|---|---|---|---|
| 25.97453 | 2023-07 | 2024-06 | Initial upload | 2023-09-06 14:52 |