Directive 008

Release date: February 8, 2024

Effective date: February 8, 2024

Replaces previous edition issued August 22, 2022

Surface Casing Depth Requirements

Contents

Appendices

1 Introduction

1.1 Purpose of This Directive

The primary purpose of *Directive 008: Surface Casing Depth Requirements* is to design appropriate depths of surface casing to assist with well control and groundwater protection.

Surface casing is an integral part of the well control system. It provides sufficient pressure integrity to facilitate the drilling of a well to total depth or to an intermediate casing point, as well as primary support for the wellhead and the landing loads of subsequent casing and tubing strings. It may also be used to cover zones of caving, sloughing, and lost circulation, as well as other weak zones. Surface casing is a permanent structure of the wellbore that effectively protects in-use aquifers that supply domestic water wells.

This directive

- details the minimum surface casing depth requirements under section 6.080 of the *Oil and Gas Conservation Rules* (*OGCR*) and section 24 of the *Geothermal Resource Development Rules* (*GRDR*),
- defines conditions required for setting deep surface casing,
- provides additional requirements for specified areas in the province, and
- sets out the conditions for exemption from the surface casing requirements and defines standards for conductor pipe.

Surface casing must be cemented in accordance with the requirements in *Directive 009: Casing Cementing Minimum Requirements*.

Potentially toxic substances in the drilling fluids must not be used while drilling the surface hole, in accordance with *Directive 036: Drilling Blowout Prevention Requirements and Procedures*.

1.2 What's New in This Edition

References to *Directive 023*: *Oil Sands Project Applications* have been updated now that the directive has been finalized.

1.3 AER Requirements

Following AER requirements is mandatory for the responsible duty holder as specified in legislation (e.g., licensee, operator, company, applicant, approval holder, or permit holder). The term "must" indicates a requirement, while terms such as "should," "recommends," and "expects" indicate a recommended practice.

Each AER requirement is numbered. Information on compliance and enforcement can be found on the AER website.

2 Surface Casing Depth

1) Surface casing must be designed in accordance with this section, and the surface casing depth must be used in the well licence application (see *Directive 056: Energy Development Applications and Schedules*).

There are some assumptions that are typically used when determining surface casing depths. These assumptions are the basis of the surface casing depth calculation set out in this directive.

The assumptions are that

- a 3 cubic metre (m^3) kick can be circulated out of the hole without fracturing the casing shoe,

- the required pressure at the surface casing shoe is a linear relationship between 50 per cent of the maximum bottomhole pressure for a well depth of 0 metres true vertical depth (m TVD) and 27.5 per cent of the maximum bottomhole pressure for a well depth of 3600 m TVD (see figure 1), and
- the formation leak-off test (FLOT) is used to determine the fracture pressure at the shoe at 450 m using a 10 kPa/m formation pressure gradient. The maximum pressure integrity gradient is 22 kilopascals per metre (kPa/m). (Refer to appendix C.)

2.1 Surface Casing Depth Calculation Form

2) The Surface Casing Depth Calculation form must be used to determine the minimum amount of surface casing required and any reductions that are applicable. The form and detailed instructions on how to complete it can be found in appendix B.

2.2 Surface Casing Set <650 m

3) Surface casing must be set in accordance with the Surface Casing Depth Calculation form.

If the licensee is setting surface casing at a depth less than 650 m TVD, an application does not need to be submitted to the AER.

4) If a known hydrocarbon zone (see appendix A) may be encountered above the surface casing setting depth,

   a) conductor pipe must be set in accordance with section 5, and

   b) a Class I BOP system (as defined in *Directive 036*) must be installed.

If no known hydrocarbon zones are present, the licensee is not required to set conductor pipe or install a Class I BOP system.

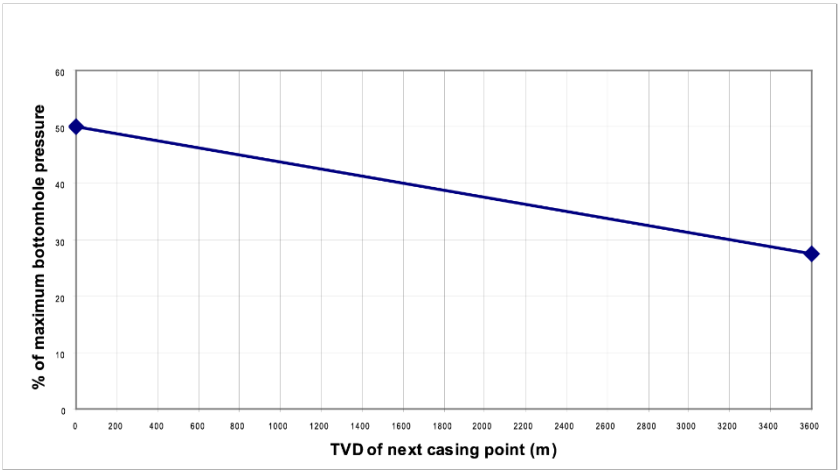

Figure 1. Percentage of maximum bottomhole pressure at the surface casing shoe

2.3 Deep Surface Casing (>650 m)

5) If the licensee is setting surface casing deeper than 650 m TVD, although an application does not need to be submitted to the AER, the following requirements must be met, and all supporting documentation must be available for auditing purposes:

   a) Conductor pipe must be set in accordance with section 5.

   b) A gas detection device must be installed during the drilling of the surface hole.

   c) A Class I BOP system (as defined in *Directive 036*) must be installed.

   d) Surface casing must be set a minimum of 50 m above the shallowest known hydrocarbon zone (see appendix A).

   e) The field kick rate must be 0 per cent to surface casing depth.

   f) Requirements associated with the Surface Casing Depth Calculation form must be met

   g) There must be at least 5 offset wells within a 5 km radius from the surface location of the proposed well. The offset wells, from surface down to the surface casing depth (from the Surface Casing Depth Calculation), must meet the following requirements:

      i) There are no blowouts (including water flows) in the proposed surface hole interval.

      ii) There are no severe lost circulation incidents.

      iii) There are no enhanced recovery schemes (conventional or thermal) in the area.

   h) There must be no water wells within a 200 m radius from the surface location of the proposed well.

   i) Checklist 1 in appendix F must be completed and available at the well site. Multiple wells can be included on an attached list. All requirements must be met for each well.

2.3.1 Reporting Requirements

6) If a well control incident (kick) occurs while drilling the surface hole, the licensee must report the following information to the appropriate AER field centre immediately:

   a) well location

   b) time and date of occurrence

   c) depth, kick volume, and final drilling fluid weight to control occurrence

   d) duration

   e) licensee contact (name and phone number)

Upon consultation with AER Well Operations, surface casing may need to be set at a shallower depth than planned.

The licensee must also meet the reporting requirements in *Directive 059: Well Drilling and Completion Data Filing Requirements*.

2.4 Specified Areas

7) If a proposed well is in one of the areas specified in this section, the surface casing must be set in accordance with the minimum requirements.

2.4.1 Senex, Kidney, Trout, and Associated Areas

Senex, Kidney, Trout, and associated areas are within

- Townships 86 to 90, Ranges 1 to 6, West of the 5th Meridian, and
- the north half of Township 90 to Township 99, Range 1 to the east half of Range 14, West of the 5th Meridian (see figure 2).

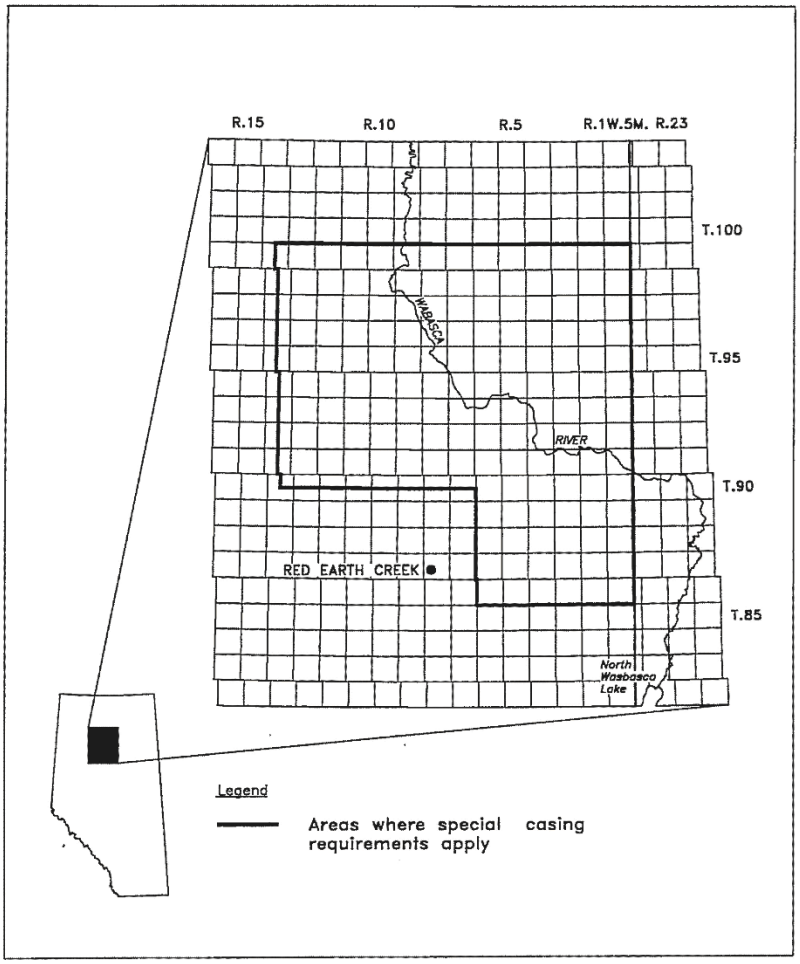

Figure 2. Senex, Kidney, Trout, and associated areas

8) The licensee must meet the following requirements:

   a) Conductor pipe must be set in accordance with section 5.

   b) A Class 1 BOP must be used while drilling the surface hole.

   c) Qualified personnel must be on site to evaluate drill cutting samples to determine the appropriate surface casing depth.

   d) The surface casing must be set below the oil sands formation and above the Upper Devonian (Wabamun) lost circulation zone.

Refer to the following for additional requirements:

- *Directive 009: Casing Cementing Minimum Requirements* presents the minimum requirements for casing cementing.
- *Directive 020: Well Abandonment* provides the minimum abandonment requirements.

2.4.2 High-Hazard Area of Southeastern Alberta

Directive 036 defines the area within Townships 19 to 24, Ranges 5 to 10, West of the 4th Meridian, as a high-hazard area (see figure 3) and sets out the requirements for wells drilled in this area.

9) A minimum of 180 m of surface casing must be set if the well penetrates the Mannville Group.

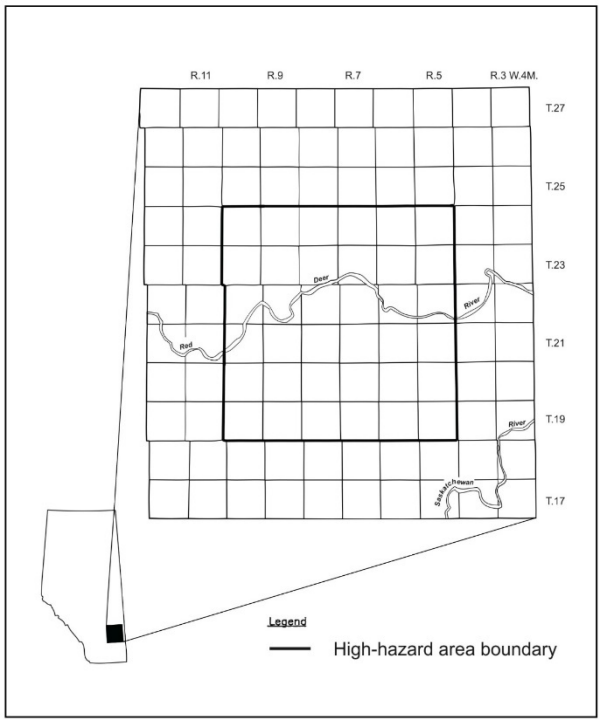

Figure 3. High-hazard area of southeastern Alberta

2.4.3 Surface Mineable Area (Oil Sands Core Holes and Oil Sands Evaluation Wells)

The following applies to oil sands core holes and oil sands evaluation wells only.

For wells not deeper than 200 m TVD and inside the surface mineable area (see figure 4), surface casing is not required if conductor pipe is set into a competent formation. *Directive 036* sets out the minimum requirements with respect to blowout prevention practices and equipment needed for drilling oil sands core holes and oil sands evaluation wells.

Wells not exceeding 200 m TVD and within 10 km of the surface mineable area may conform to the same blowout prevention and drilling practices as inside the surface mineable area.

10) Wells deeper than 200 m TVD or 10 km outside of the surface mineable area must follow the requirements of this directive for minimum surface casing.

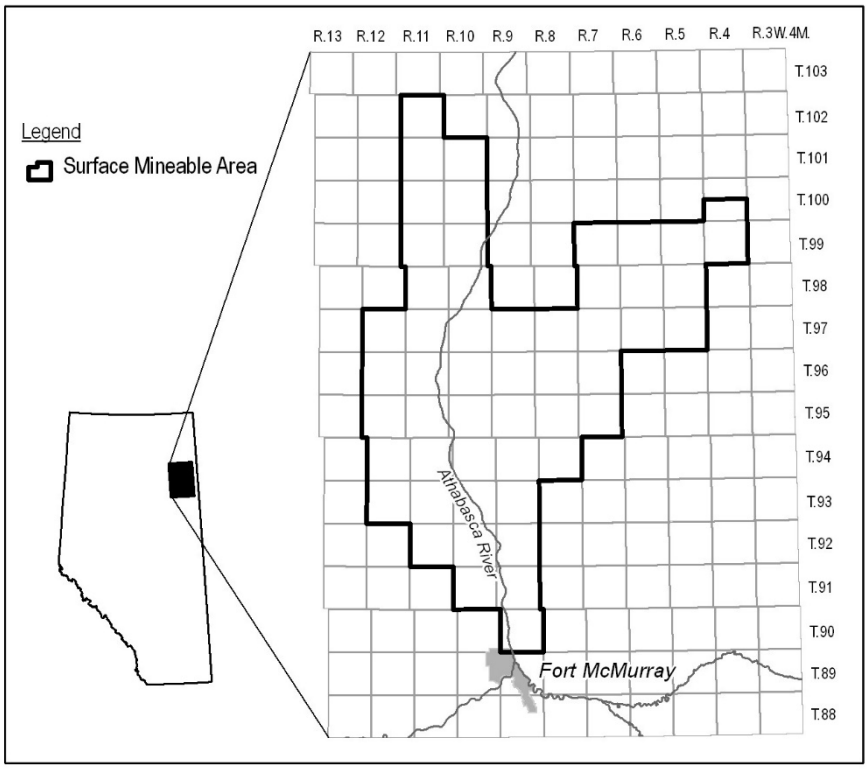

Figure 4. Surface mineable oil sands area

2.5 Non-Thermal Injection and Disposal Wells

Surface casing depths for non-thermal injection and disposal wells must meet the requirements set out in the Surface Casing Depth Calculation form and *Directive 051: Injection and Disposal Wells*.

11) Injection wells associated with caverns for solution mining or hydrocarbon storage and disposal must have surface casing set to the base of groundwater protection.

2.6 Thermal Wells

12) Thermal injection and production wells must have surface casing set. The surface casing depth must meet the requirements of *Directive 051*, the scheme approval conditions (*Directive 023*: *Oil Sands Project Applications*), and any additional requirements set by the AER. These conditions and requirements are designed to protect groundwater, and the depth for surface casing should be based on the geological setting.

3 Surface Casing Exemptions

This section details the requirements that must be met when surface casing is not set. Surface casing exemptions do not apply to thermal wells (see section 2.6).

13) The following criteria must be met for surface casing exemption without AER approval. Supporting documentation must be available for auditing purposes:

a) The well must terminate at 1000 m TVD or less.

b) Conductor pipe must be set in accordance with section 5.

c) A Class I BOP system (as defined in *Directive 036*) must be installed.

d) The diverter line must terminate in a flare tank. (Flare tanks must meet the requirements in *Directive 036*.)

e) The well must be drilled in an established area (see appendix A).

f) The bottomhole of the well must be located a minimum of

i) 300 m away from the closest bottomhole location of an existing steam-assisted gravity drainage (SAGD) well,

ii) 1000 m away from the closest bottomhole location of an existing cyclic steam stimulation (CSS) well, and

iii) 1000 m away from a non-thermal enhanced recovery scheme well.

g) The offset wells within a 3 km radius from the bottomhole location of the proposed well must meet the following requirements:

i) The kick rate is 0 per cent.

ii) There are no blowouts (water flows included).

iii) There are no severe lost circulation incidents.

iv) The maximum pressure gradient of any formation does not exceed 10 kPa/m.

v) The estimated unstimulated absolute open flow potential (AOFP) does not exceed 113 10^3 m^3/day.

vi) There is no hydrogen sulphide (H_2S) present (0.0000 moles per kilomole [mol/kmol] H_2S) while drilling the well.

h) There must be no water wells within a 200 m radius from the surface location of the proposed well.

i) Checklist 2 in appendix F must be completed and available at the well site. Multiple wells can be included on an attached list. All requirements must be met for each well.

If the above requirements are met, the well licence application should be submitted as routine.

14) An application for a surface casing exemption must address all the items listed in *Directive 056* and must provide the reason why the criteria above are not met. The licensee must also indicate on Schedule 4 of *Directive 056* that the requirements of *Directive 008* are not met and submit the well licence application as nonroutine.

3.1 Reporting Requirements

15) If a well control incident (kick) occurs while drilling the well, the licensee must report the following information to the appropriate AER field centre immediately:

a) well location

b) time and date of occurrence

c) depth, kick volume, and final drilling fluid weight to control occurrence

d) duration

e) licensee contact (name and phone number)

Upon consultation with AER Well Operations, surface casing may need to be set on future wells.

The licensee must also meet the reporting requirements in *Directive 059: Well Drilling and Completion Data Filing Requirements*.

4 Surface Casing Set, Class I BOP Installed

16) The following criteria must be met if a Class I BOP system is to be used after surface casing is set. No AER approval is required, but supporting documentation must be available for auditing purposes.

a) The well must terminate at 1000 m TVD or less.

b) Surface casing must

i) be set in accordance with the well licence, and

ii) meet *Directive 010: Minimum Casing Design Requirements*.

c) The diverter line must terminate in a flare tank. (Flare tanks must meet the requirements of *Directive 036*, section 2.4.)

d) The well must be drilled in an established area (see appendix A).

e) The bottomhole of the well must be located a minimum of

   i) 300 m away from the closest bottomhole location of an existing SAGD well,

   ii) 1000 m away from the closest bottomhole location of an existing CSS well, and

   iii) 1000 m away from a non-thermal enhanced recovery scheme well.

f) The offset wells within a 3 km radius from the surface location of the proposed well must meet the following requirements:

   i) The kick rate is 0 per cent.

   ii) There are no blowouts (water flows included).

   iii) There are no severe lost circulation incidents.

   iv) The estimated unstimulated AOFP does not exceed 113 10^3 m^3/day.

   v) The maximum pressure gradient of any formation does not exceed 10 kPa/m.

   vi) There is no hydrogen sulphide (H_2S) present (0.0000 moles per kilomole [mol/kmol] H_2S) while drilling the well.

g) The surface casing must be set 25 m deeper than any water wells within a 200 m radius from the surface location of the proposed well.

h) Checklist 3 in appendix F must be completed and available at the well site. Multiple wells can be included on an attached list. All requirements must be met for each well

Surface casing depth calculation (see section 2) is not required.

4.1 Reporting Requirements

17) If a well control incident (kick) occurs while drilling a well with a Class I BOP system, the licensee must report the following information to the appropriate AER field centre immediately:

a) well location

b) time and date of occurrence

c) depth, kick volume, and final mud weight to control occurrence

d) duration

e) licensee contact (name and phone number)

Upon consultation with AER Well Operations, the appropriate class of BOP may need to be installed on the next well.

The licensee must also meet the reporting requirements in *Directive 059*.

5 Conductor Pipe

18) If required for well control, the depth of the conductor pipe must be between 20 to 30 m, set into a competent zone, cemented full length by the forward circulation method, and meet the requirements of *Directive 009*. (See appendix D in this directive for suggested conductor and diverter line configurations.) Setting conductor pipe does not replace the need for surface casing unless the requirements for surface casing exemption have been met (see section 3).

19) The licensee must search a 1 km radius from the surface location of the proposed well and use a conductor pipe and a Class I BOP system if there are:

    a) offset wells that indicate water flows, or

    b) springs or flowing seismic shot holes (see Environment and Sustainable Resource Development water well database).

For wells located within 100 m of a water body, using conductor pipe and a Class I BOP system should be evaluated as a mitigative measure in conjunction with assessing and addressing site sensitivities, as required by *Directive 056*.

20) Wells with conductor pipe set beyond 30 m (to find a competent zone) will be considered surface casing and must meet all regulatory requirements associated with surface casing.

6 Water Flows

21) If an uncontrolled water flow is encountered (a blowout, as defined in *Directive 036*)

    a) the blowout must be reported to the appropriate AER field centre,

    b) a risk assessment must be conducted to determine if an additional string of casing is required, and

    c) approval must be obtained from the appropriate AER field centre before the licensee proceeds with drilling operations.

Note: Reporting requirements for blowouts are set out in *Directives 036* and *059*.

The AER expects licensees to take precautions to ensure that the water flow is controlled and the aquifer is protected during the drilling operation.

Appendix A Definitions for the Purposes of *Directive 008*

absolute open flow potential (AOFP)	The maximum unstimulated, stabilized flow rate a well could theoretically deliver with zero pressure at sandface.
conductor pipe	Pipe used to keep the wellbore open and to provide a means of conveying the drilling fluid flowing up from the wellbore to the rig tanks and, if required for well control purposes, to accommodate a diverter system. (See appendix D for recommended conductor pipe and diverter line sizes.)
established area (formerly development-type setting)	An area that has a minimum of three offset wells, each in a different direction, and within a 1.5 km radius from the bottomhole location of the proposed well. The offset wells must be drilled to the same formation, or deeper, than the proposed wells.
known hydrocarbon zone	Any zone in a well within a 5 km radius of the proposed well that has produced or is producing hydrocarbons and has been reported to the AER.
pit volume totalizer (PVT) system	A drilling fluid volume monitoring device installed at a drilling rig.
severe lost circulation	The loss of more than 75 m^3 of drilling fluid from the wellbore into a permeable formation or a loss that takes more than 48 hours to control.
surface casing	The first string of casing that is set in a well (unless conductor pipe is set). It provides structural integrity to support the BOP system and subsequent tubulars run in the well and has sufficient pressure integrity to facilitate well control. Surface casing is an integral part of the well control system.
thermal well	A well that penetrates a reservoir that is, was, or has the potential to be artificially heated.
water body	Refer to *Directive 056* for a definition.
water flow	Any flow of water from an aquifer that is encountered while drilling a well.

Appendix B Surface Casing Depth Calculation Form and Instructions

Part I: Water Well Search

A.	**Depth of deepest water well within 200 m**	Determine the depth of the deepest water well within a 200 m radius from the surface location of the proposed well.
B.	**Minimum surface casing depth required**	Calculate the minimum surface casing depth using the depth from (A) and adding 25 m. The minimum surface casing depth must be 25 m below the deepest water well within 200 m radius from the surface location of the proposed well.

Part II: Surface Casing Required

1.	**Representative pressure measurement in area**	Determine the representative pressure measurement (kPa) from the wells within a 5 km radius from the surface location of the proposed well. Note: A search must also be conducted within a 1 km radius from the surface location of the proposed well for water flows, springs, and flowing seismic shot holes, in accordance with section 6. Option 1: Use the maximum pressure that may be encountered while drilling the proposed well (include pressure data from enhanced recovery schemes). • For a description of representative pressure measurements, see appendix B. • If the well is in an area where there is insufficient pressure data, see (5) below. Option 2: Provide the representative pressure measurement (kPa) used to calculate the maximum gradient.
2.	**Depth of pressure measurement**	Provide the true vertical depth of the pressure measurement (m TVD).
3.	**Reference well(s)**	Provide the location of the reference well(s).
4.	**Higher pressures were found but were discounted**	YES means higher pressures were found in the area but were discounted. If YES, state why. Supporting technical information (including data on the use of pressure gradients and leak-off gradients used in the calculations) must be kept on file in case of an audit.

5. Maximum gradient

Provide the maximum gradient (kPa/m).

- Calculate the maximum gradient using the maximum pressure measurement in the area divided by the true vertical depth of the pressure measurement.

  Note: The maximum gradient may not occur using the maximum pressure, and a thorough review of pressures in the area may need to be completed to determine the maximum gradient.

- If a well is in an area where there is insufficient pressure data, use 11 kPa/m in the equation.

6. Surface casing depth required

Enter the SC depth required. Use Option 1 or 2 to calculate.

Option 1: Using the maximum gradient from (5), calculate the surface casing depth:

$$SC\ depth = \frac{Maximum\ gradient \times TVD \times (0.5 - 0.0000625\,TVD))}{22\ kPa/m}$$

where TVD is the TVD of the first intermediate casing or the total depth of the well.

Option 2: In some instances the maximum gradient might occur above the planned TVD of the next casing string and may result in a deeper than necessary surface casing. In this case, to correctly calculate the required surface casing depth, the pressure gradient and depth of each zone must be used. Use the maximum gradient (5) and depth at each zone to calculate the surface casing depth:

$$\boldsymbol{SC\ depth = \frac{Maximum\ gradient\ (at\ zone) \times TVD(at\ zone) \times (0.5 - 0.0000625\ TVD\ [at\ zone])}{22\ kPa/m}}$$

The maximum surface casing depth calculated must be used.

If the leak-off gradient of an offset well is known and is less than 22 kPa/m, licensees should use the gradient from the leak-off test in the calculation. (Refer to appendix C for formation leak-off test information.)

7. 10% of TVD

Calculate 10% of TVD.

8. Surface casing depth required

Use (B), (6), or (7), whichever is greater. This is the surface casing depth.

The surface casing depth must be a minimum 25 m below the deepest water well within a 200 m radius from the surface location of the proposed well. If (6) and (7) are greater than this, the surface casing must be set to a minimum of 10% TVD regardless of the pressure expected (unless surface casing is waived or reduced).

If a well is being drilled near a valley, the AER recommends the well design include locating the well at a sufficient distance from the valley wall or setting surface casing at a sufficient depth below the base of the valley to prevent breakthrough to the valley during drilling operations.

If the planned surface casing setting depth terminates in an unconsolidated zone, the AER recommends that drilling continue at least 5 m into a competent zone.

The amount of surface casing required does not allow a well to be shut in indefinitely. The intent of a minimum shut-in period is to obtain stabilized shut-in pressures that will allow implementation of acceptable methods of well control, provided the surface casing is set in a competent zone (see well control methods set out by Energy Safety Canada, the International Well Control Forum, or the International Association of Drilling Contractors).

Part III: Surface Casing Depth Reduction

Four types of surface casing depth reductions are permitted, as outlined below, unless the wells are to be drilled in the areas specified in section 2.4, in which case these reductions do not apply. Refer to appendix B for background information about these reductions.

The reduced surface casing depth, regardless of the type of reduction, must be equal to or greater than the minimum surface casing depth calculated in Part I(B).

Type 1 – Reduction for Wells Drilled with Well Control Enhancements

Surface casing depth required	Enter the depth (m) from no. 8 in part II.
Reduced surface casing depth	Multiply the normal surface casing depth required by a factor of 0.913.

One of the following two options must be used to reduce the surface casing depth. Indicate which one will be used:

1) A pit volume totalizer (PVT) system will be installed, accurate to ±0.5 m^3 and sounding an alarm at ±2.0 m^3, with a probe in every active drilling fluid compartment (see appendix B).
2) A formation leak-off test or a formation integrity test will be performed, in accordance with appendix C, to determine the maximum allowable casing pressure and the maximum allowable TVD.

Type 2 – Reduction for Low-Risk Wells

Surface casing depth required

Enter the depth (m) from (8) in part II.

Reduced surface casing depth

Multiply the normal surface casing depth required by a factor of 0.707.

At least three of the following criteria must be met to use the reduced surface casing depth. Indicate which criteria will be met:

1) The well is in an established area.

   Data and depths for offset wells must confirm the proposed well is within an established area and be available for audit upon request.

2) The well is low risk.

   The field kick rate (see appendix B) is less than 3% of the wells drilled to a formation not exceeding the terminating formation of the proposed well.

3) A PVT system will be used, accurate to ±0.5 m^3 and sounding an alarm at ±1.0 m^3, with a probe in every active drilling fluid compartment (see appendix B).
4) A formation leak-off test or a formation integrity test will be performed, in accordance with appendix C, to determine the maximum allowable casing pressure and the maximum allowable TVD.
5) Supporting documentation verifying the above must be available for audit upon request.

Type 3 – Reduction to Historical Setting Depth

Surface casing depth required

Enter the depth (m) from no. 8 in part II.

Historical surface casing depth required

For wells drilled in established areas, normal surface casing may be decreased to the average setting depth in the area. For background information on historical setting depths, see appendix B.

All of the following must be met to reduce the surface casing to the historical depth. Indicate if each one will be met:

1) The well is in an established area (see appendix A).

   Data and depths for offset wells must confirm that the proposed well is within an established area, and this information must be available for auditing upon request.

2) The well is low risk.

   The field kick rate is less than 3% of wells drilled to a formation not exceeding the terminating formation of the proposed well (see appendix B).

3) A PVT system will be used, accurate to ±0.5 m^3 and sounding an alarm at ±0.5 m^3, with a probe in every active drilling fluid compartment (see appendix B).

4) A formation leak-off test or a formation integrity test will be performed, in accordance with appendix C, to determine the maximum allowable casing pressure and the maximum allowable TVD.

5) An emergency flare line will be installed in accordance with *Directive 036*.

Supporting documentation verifying the above must be available for audit upon request.

Historic depth data

List the wells where surface casing was set to the depth applied for in this application. This list must be available for audit upon request.

Type 4 – Reduction to a Depth Above a Problem Zone

A Type-4 reduction is suitable for wells drilled in areas where it is necessary to set surface casing immediately above a problem zone (such as in the Milk River area in southeastern Alberta) for the purposes of obtaining a high-quality cement job on the surface casing.

Surface casing depth required	Enter the depth (m) from no. 8 in part II.
Estimated top of problem zone	Enter the estimated top of the problem zone (m).
Name of problem zone	Enter the name of the problem zone.
Reason zone is a problem	Provide the nature of the problem (e.g., lost circulation).
Surface casing depth proposed	Enter the proposed surface casing depth (m). This depth should be no more than 15 m above the estimated top of a zone known to be a problem in the area and above any known hydrocarbon zones. A deeper problem zone will result in deeper surface casing being set. All of the following must be met to use proposed surface casing depth. Indicate if each one will be met: 1) A PVT system will be installed, accurate to ±0.5 m^3 and sounding an alarm at ±1.0 m^3, with a probe in every active drilling fluid compartment (see appendix B). 2) A formation leak-off test or a formation integrity test will be performed, in accordance with appendix C, to determine the maximum allowable casing pressure and the maximum allowable TVD. 3) An emergency flare line will be installed, in accordance with *Directive 036*.

Part IV: Surface Casing Exemption

Part IV is only filled out if the licensee is not setting surface casing. The licensee must then meet the requirements set out in section 3 in order to submit a routine well application. If the licensee is not setting surface casing and the requirements in section 3 are not met, the licensee must apply for an exemption and submit a nonroutine well application.

Appendix C Background Information for the Surface Casing Depth Calculation Form

Representative Pressure Measurements

To obtain representative pressure measurements when drilling outside known pools, use the maximum test pressures in the area; when drilling inside of a known pool, use current bottomhole pressure measurements, especially for pools subject to enhanced recovery or pools depleted through extensive production. Wherever the licensee chooses to use depleted pressures to calculate surface casing setting depth, the licensee must have supporting geological information down to and including the terminating formation. This information must be available in case of audit to confirm that the subject well will be within the known pool in question.

Methods of Determining Maximum Pressures

- Drillstem test or other acceptable open-hole methods
- AOFP test pressures
- Pressure buildup
- Static pressure gradient
- Acoustic well sounder survey

PVT System for Type-1 Reduction

For wells drilled with a PVT system accurate to within ±0.5 m^3 and sounding an alarm at ±2.0 m^3, the licensee may apply a general reduction factor to the surface casing required by the Surface Casing Depth Calculation form, part II, no. 8. The PVT system must be installed with a probe in every active drilling fluid compartment.

Kick tolerance theory shows that the surface casing required is proportional to the square root of the initial kick volume. The surface casing required by the Surface Casing Depth Calculation form, part II, no. 8, has been found sufficient for circulation of a 3.0 m^3 kick (assumed to be a maximum volume before well control action is initiated). Where the licensee uses PVT systems during drilling operations, it is reasonable to assume that initial kick volumes can be limited to 2.5 m^3 if the system is preset to sound an alarm at ±2.0 m^3. The licensee may apply the following factor to the surface casing required by the Surface Casing Depth Calculation form, part II, no. 8:

$$(1.5\ m^3 \div 3.0\ m^3)^{\frac{1}{2}} = 0.913$$

PVT System for Type-2 Reduction

For low-risk wells in an established area drilled with a PVT system accurate to ±0.5 m^3 and sounding an alarm at ±1.0 m^3, the licensee may apply the following factor to the surface casing required by the Surface Casing Depth Calculation form, part II, no. 8:

$$(1.5\ m^3 \div 3.0\ m^3)^{\frac{1}{2}} = 0.707$$

This assumes that the initial kick volume can be limited to 1.5 m^3 if the alarm is preset to sound at 1.0 m^3.

Historical Setting Depth

If a reduction in surface casing depth that is greater than a Type-2 reduction results in insufficient casing to control the well, a well control method set out by Energy Safety Canada, the International Well Control Forum, or the International Association of Drilling must be used. Since using any of the methods set out by these organization will put added pressure on the bleed-off system, an emergency flare line is required.

Field Kick Rate

A 3 per cent field kick rate is based on previous versions of *Directive 008*, which stated a field kick rate of 3 per 100 wells. Field counts of less than 100 wells are acceptable to calculate the field kick rate if the requirement for an established area is met.

Appendix D Formation Integrity Test and Formation Leak-off Test

The formation leak-off test results from the nearest offsetting wells, if known and less than 22 kPa/m, should be used in the equation to calculate the surface casing depth required (section 2).

Figures 5 and 6 show the effects of the formation pressure gradient and a formation leak-off test result lower than 22 kPa/m on surface casing setting depth.

Figure 5 shows the effect of the formation pressure gradient on surface casing depth assuming that the pressure integrity test gradient is 16 kPa/m.

Figure 6 shows the effect of the formation pressure gradient on surface casing depth assuming that the pressure integrity test gradient is 22 kPa/m.

Procedure

The integrity of the formation at a casing seat or in the open hole is a key factor during well control operations. The integrity of the formation can be determined by conducting a pressure integrity test (PIT). A formation leak-off test (FLOT) is a form of PIT conducted to the point of fracture initiation in the wellbore. A formation integrity test is a form of PIT conducted to a predetermined pressure set at some point below the fracture initiation pressure. The maximum allowable casing pressure can be determined by testing the integrity at the surface casing seat. The AER supports the concept of conducting a test on all wells due to the variability of PIT results.

The recommended test procedure and reporting requirement for FLOTs are as follows:

1) Use a low-volume, high-pressure pump capable of pumping steadily and consistently at rates as low as 4 litres per minute (L/minutes).
2) Drill at least 5 m, but not more than 10 m, below the surface casing shoe.
3) Pull up off bottom and fill hole.
4) Close blowout preventers. Ensure that the system is free of leaks.
5) Start pumping slowly at a consistent rate of about 4 to 8 L/minute, depending on the setting depth of the casing. (Pumping down both the annulus and drill pipe is preferable.)
6) Record pressure after every 4 L pumped, if possible.
7) Plot pressure against volume injected during the pumping, not afterwards (see figure 7).
8) Do not use a rig drilling fluid pump for performing a PIT at the shoe of the surface casing. The pump must be low-volume, high-pressure, and instrumented to accurately record and display the volume pumped and surface pressure as the test is being performed to determine the proper point at which to terminate the test. A linear pressure volume chart is preferable.

9) Record results on a calculation sheet and retain the information. Do not submit this information to the AER unless requested to do so.

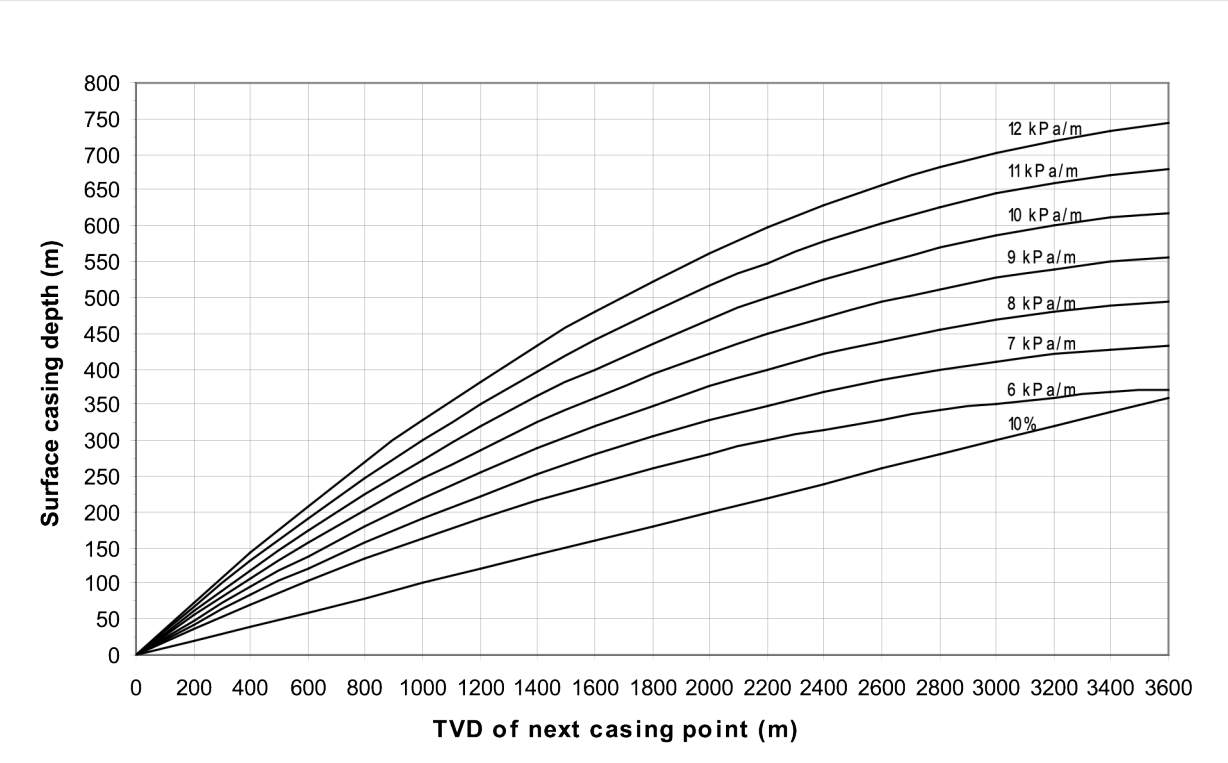

Figure 5. Effects of maximum surface casing depth for 16 kPa/m pressure integrity test (PIT) using different formation pressure gradients.

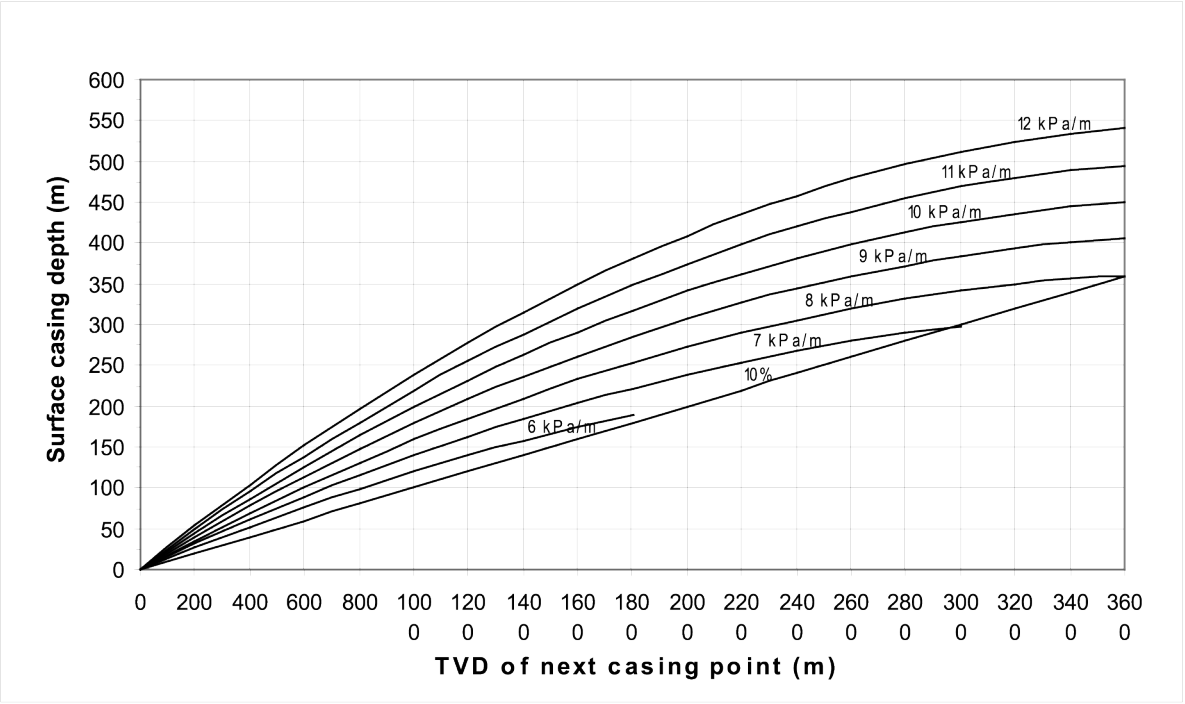

Figure 6. Effects of maximum surface casing depth for 22 kPa/m PIT using different formation pressure gradients.

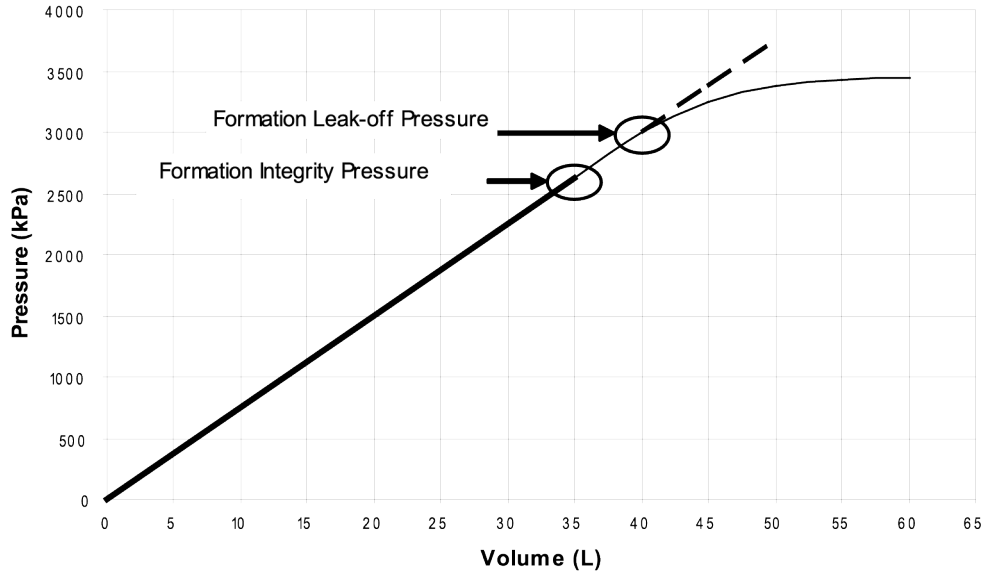

Figure 7. PIT pressure versus volume plot.

Appendix E Conductor Pipe and Diverter Line Sizes

When drilling with only a conductor pipe set and a Class I BOP system, the table below can be used as a guide to determine the required conductor pipe size and diverter line size to reduce the risk of flow to surface on the outside of the casing during an unanticipated flow from the wellbore.

Table 1. Recommended conductor pipe and diverter line sizes.

Conductor pipe size (Nominal) mm (in)	Diverter line size (Nominal) mm (in)	Kill pump rate m^3/min	Drill collar size mm	Hole size mm
177.8 (7)*	152.0 (6)	1.0	120	152
203.0 (8)	152.0 (6)	1.0	120	152
273.0 (10)	152.0 (6)	1.7	177	215
406.4 (16)	177.8 (7)*	3.3	229	311
508.0 (20)	203.0 (8)	5.5	229	444

Source: *API RP 64: Recommended Practice for Diverter Systems Equipment and Operations*

* 177.8 mm (7 in) casing not recommended; pressure drop too great in conductor pipe/drill collar annulus and diverter line unless the assumptions below are revised; use 193.7 mm (7-5/8 in) casing or 203.0 mm (8 in) nominal pipe.

Assumptions

10) Gas flow rate approximately 90 10^3 m^3.

11) Kill pump rate approximately 35 per cent above normal pump rate (annular velocity approximately 40 m/min).

12) Gas specific gravity 0.65.

13) Drilling fluid weight 1100 kg/m^3.

14) Two-phase flow program (Beggs & Brill) used to calculate pressure drop.

15) Drill collars through entire length of conductor pipe.

16) Conductor pipe set at 20 m below ground level, diverter close to ground level.

Appendix F References

AER Documents

Directive 009: Casing Cementing Minimum Requirements
Directive 020: Well Abandonment
Directive 023: Oil Sands Project Applications
Directive 034: Gas Well Testing, Theory and Practice
Directive 036: Drilling Blowout Prevention Requirements and Procedures
Directive 043: Well Logging Requirements—Surface Casing Interval
Directive 051: Injection and Disposal Wells
Directive 056: Energy Development Applications and Schedules
Directive 059: Well Drilling and Completion Filing Requirements
Directive 089: Geothermal Resource Development
Interim Directive (ID) 91-03: Heavy Oil/Oil Sands Operations

Oil and Gas Conservation Act
Oil and Gas Conservation Rules
Geothermal Resource Development Act
Geothermal Resource Development Rules
Base of Groundwater Protection Query Tool (AER website, www.aer.ca)

~~API Documents~~

~~API RP 64: Recommended Practices for Diverter Systems~~ Equipment and Operations

Miscellaneous

Findings of the Committee on Surface Casing Requirements in the Lindbergh/Elk Point Area
Shallow Gas Well Completion Flare Line Length and Flare Height Review (commissioned by Pan Canadian) (available in the AER library)

Appendix G Checklists