



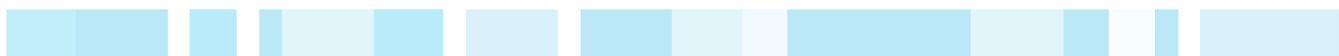
Trade &
Investment
Resources & Energy

Code of Practice for Coal Seam Gas

Well Integrity

DEPARTMENT OF TRADE & INVESTMENT, REGIONAL INFRASTRUCTURE & SERVICES
RESOURCES & ENERGY

SEPTEMBER 2012, WWW.RESOURCES.NSW.GOV.AU



Title: NSW Code of Practice for Coal Seam Gas Well Integrity

ISBN: 978 1 74256 328 2

© State of New South Wales through Department of Trade and Investment, Regional Infrastructure and Services (NSW Trade & Investment) 2012

This publication is copyright. You may download, display, print and reproduce this material in an unaltered form only (retaining this notice) for your personal use or for non-commercial use within your organisation. To copy, adapt, publish, distribute or commercialise any of this publication you will need to seek permission from NSW Trade & Investment.

For updates to this publication, check www.resources.nsw.gov.au

Published by NSW Trade & Investment

First published September 2012

Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (August 2012). However, because of advances in knowledge, users are reminded of the need to ensure that information on which they rely is up to date and to check the currency of the information with the appropriate officer of NSW Trade & Investment, or the user's independent advisor.

TRIM reference: INT12/63683

Preliminary

a. Title

This is the NSW Code of Practice for Coal Seam Gas Well Integrity.

b. Purpose

The NSW Code of Practice for Coal Seam Gas Well Integrity has been developed by the NSW Government in consultation with the CSG industry.

This code provides a practical guide for coal seam gas (CSG) titleholders on how to comply with a condition of title for CSG exploration, extraction or production under the Petroleum (Onshore) Act 1991 (PO Act) and the Petroleum (Onshore) Regulation 2007 to ensure that well operations are carried out safely, without risk to health and without detriment to the environment.

c. Scope and Application

Section 23 of the Petroleum (Onshore) Act 1991 provides for conditions of title which may be imposed by the Minister or prescribed by the regulations. The current version of the legislation is at: www.legislation.nsw.gov.au

This code of practice applies to the design, construction, production, maintenance and ultimate abandonment of CSG wells in NSW.

This code sets out activities, actions, technical requirements, responsibilities or responses to events. This document should also be read alongside the *NSW Code of Practice for Hydraulic Fracture Stimulation Activities*, to form part of a regulatory framework for the CSG industry in NSW.

These guidelines are an essential minimum set of requirements to ensure that:

- The health and safety of workers, landholders and other persons is not put at risk arising from well operations, so far as is reasonably practicable
- Risks to the environment (surface water and groundwater, air, vegetation, fauna) are identified, eliminated where possible or minimised through appropriate management practices
- Water used in well operations is properly sourced (refer to section 4.5 of this document. Also refer to the *NSW Code of Practice for Hydraulic Fracture Stimulation Activities*)
- Waste products are safely and appropriately managed (refer to section 4.5 of this document. Also refer to the *NSW Code of Practice for Hydraulic Fracture Stimulation Activities*)
- Landholders, local councils and relevant authorities (including the department) are notified of specified well operations in a timely manner
- Regulatory requirements are understood and implemented.

This document is designed to be considered in conjunction with the operator's internal risk assessment processes and operating procedures.

Title holders will have met the requirements of the environmental impact assessment process required under Parts 4¹ and 5 of the *Environmental Planning and Assessment Act 1979* including, where required, the Review of Environmental Factors for petroleum prospecting.

This code of practice may also apply to other types of petroleum wells at the discretion of the department.

¹ This includes existing exploration and production approvals under former Part 3A of the EP&A Act

The following types of drilling *do not* fall within the meaning of a coal seam gas well to which this Code applies:

- seismic shot holes
- tiltmeter and monitoring bores
- water monitoring bores²
- Exploration holes demonstrated by risk assessment (eg. likelihood of high pressures, presence of shallow depth hydrocarbons, hole instability) and scientific or technically sound analysis to be 'frontier exploration' holes.

d. Implementation and enforcement

The NSW Code of Practice for Coal Seam Gas Well Integrity has been approved by the Minister for Resources and Energy as the Minister responsible for the administration of the *Petroleum (Onshore) Act 1999 (PO Act)*.

CSG titleholders are required to comply with this code to ensure that any activities relating to coal seam gas well integrity are compliant with conditions of title pursuant to the PO Act.

e. Training

Worker training and certification is central to good practice and the mitigation of safety and environmental risks.

Workers must have the knowledge and skills necessary to perform their work safely and to the highest possible standard.

Titleholders must ensure that workers undertaking any activity that requires a qualification or authorisation or in the case of drilling operating plant, a competency identified for their position under the relevant drilling competency standard, have the relevant qualification or authorisation or competency.

A separate code of practice is being developed in relation to training and the certification for the CSG industry.

f. Review

An approved industry code of practice may be amended from time to time (or may be revoked) by publication in the gazette.

This document will be reviewed 1 year after commencement and then every 2 years or as necessary due to regulatory change or changes in industry standards.

g. Definitions

In this document, references to 'the department' mean the Division of Resources and Energy within the Department of Trade and Investment, Regional Infrastructure and Services.

In this code, the words 'must', 'ensure' and 'mandatory' indicate a legal requirement. It is essential that operators and other persons responsible comply with these requirements.

In this code, the word 'should' indicates a recommended course of action. Words such as 'consider' or 'may' indicate matters which may be chosen from options.

Other definitions and abbreviations are provided in the Glossary at Appendix 1.

h. Current legislative framework for CSG in NSW

Before outlining the requirements for well operations in NSW, it is important to consider legislative requirements for CSG exploration and production in general.

² The well integrity standards referred to in this Code exceed those in the Minimum Construction requirements for Water Bores in Australia

Exploration for and production of CSG is subject to the *Petroleum (Onshore) Act 1991* with grant of petroleum titles by the Minister for Resources and Energy.

The Act provides for the Minister to grant petroleum exploration licences, petroleum assessment leases and petroleum production leases. In accordance with the Regulation to the Act, titleholders are required to comply with the *Schedule of Onshore Petroleum Exploration and Production Safety Requirements* as a condition of their title.

All production projects and most exploration activities require environmental assessment under the *Environmental Planning and Assessment Act 1979* before they can be carried out and many also need development approval, or approval from the Division of Resources and Energy within the department. Refer to Chapter 2 of this document for a summary of the approvals process.

All well activities must be carried out in accordance with the *Work Health and Safety Act 2011* (WHS Act), which places the primary duty of care on the person conducting a business or undertaking, and the *Work Health Safety Regulation 2011*. The Regulator in relation to matters or the exercise of a power or function concerning a place of work at which activities under the *Petroleum (Onshore) Act 1991* applies, is the Head of the Department of Trade and Investment, Regional Infrastructure and Services.

Title holders are responsible to ensure the health and safety of workers and others, as far as is reasonably practicable. In accordance with the WHS Act, contractors and subcontractors must also fulfil their health and safety duties to anyone who may be affected by their operations.

There are additional requirements in relation to water management and environmental protection legislation.

Certain petroleum exploration activities may also require approval under other legislation, for example:

- The Protection of Environment Operations Act 1997
- There is a requirement for a production premises to hold an environment protection licence if it has a capacity to produce over 5PJ of natural gas or methane per year.
- The *State Environmental Planning Policy (State and Regional Development) 2011* specifies types of exploration activities which require approval by the Minister for Planning and Infrastructure.

Other legislation may apply to certain activities, for example the National Parks and Wildlife Act 1974, the Water Act 1912, or the Water Management Act 2000.

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) requires approval by the Commonwealth Environment Minister for certain 'actions'.

Petroleum (CSG) may also be added to a mining lease to mine for coal under the *Mining Act 1992*.

The Government is developing requirements in relation to management of extracted water from CSG wells.

Contents

Preliminary	iii
a. Title.....	iii
b. Purpose	iii
c. Scope and Application.....	iii
d. Implementation and enforcement	iv
e. Training.....	iv
f. Review.....	iv
g. Definitions.....	iv
h. Current legislative framework for CSG in NSW	iv
1 Overview of well operations	1
1.1 Outline of activities.....	1
2 Preliminary activities and requirements	2
2.1 Preliminary approvals	2
2.2 Risk management planning	4
2.3 Additional requirements.....	8
3 Recording and reporting data	9
3.1 Well life cycle records.....	9
3.2 Reporting and notification.....	10
3.3 Incident reporting.....	11
4 Mandatory requirements and recommendations	12
4.1 Well design.....	13
4.2 Casing	14
4.3 Cementing	16
4.4 Wellheads.....	19
4.5 Drilling fluids	20
4.6 Evaluation, logging, testing, coring.....	21
4.7 Well monitoring/maintenance	22
4.8 Well suspension	23
4.9 Well abandonment.....	23
Appendix 1 - Glossary	26
Appendix 2 - Contacts	29
Appendix 3 - Industry Standards	30

1 Overview of well operations

1.1 Outline of activities

Coal seam gas well operations consist of a number of steps:

Preliminary and well design

- Site identification and location
- Completion of environmental controls, monitoring and sampling required to fulfil the REF requirements
- Well construction design
- Identification of water source for drill fluid
- Approval to drill/construct a well or stimulate a well with hydraulic fracturing from NSW Trade and Investment
- Approval to construct production facilities if applicable

Well construction

- Site/lease preparation in accordance with the approved REF and consent conditions
- Well drilling
- Running and cementing of casing
- Logging and/or testing
- Well completion and completion testing

Production

- Workover activities
- Ongoing production testing, sampling and monitoring as required by REF and approval conditions

Hydraulic Fracturing

(refer to Code of Practice for CSG Hydraulic Fracture Stimulation)

Well abandonment/suspension

- Approval to suspend/abandon
- Suspension or abandonment operations
- Rehabilitation activities
- Plug and Abandonment (P&A) Report
- Rehabilitation and Relinquishment Report, may include the P&A Report

2 Preliminary activities and requirements

2.1 Preliminary approvals

2.1.1 Title approvals

Companies or individuals wishing to explore for coal seam gas in NSW must first apply for and be granted a title under the PO Act from the Minister for Resources and Energy.

Exploration titles include the following:

- Petroleum Special Prospecting Authority (PSPA)
- Petroleum Exploration Licence (PEL)
- Petroleum Assessment Lease (PAL)

Refer to the Department's webpage³ for further information about applying for an exploration title.

2.1.2 Land access

Before undertaking any land-based activities, the title holder must enter into a written access arrangement with the landholder. This will normally include compensation.

Title holders must provide information about their activities in accordance with relevant REF requirements and landholder agreements. Refer to the (Draft) Code of Practice for *Coal Seam Gas Exploration and Community Consultation Guidelines*⁴ for further information.

Further information on Access Arrangements is available on the Department's website⁵.

2.1.3 Approval of exploration proposals

There is a specific approvals process for coal seam gas exploration in NSW. The petroleum exploration activity approvals process for petroleum wells requires an environmental impact assessment in accordance with Part 5 of the *Environmental Planning & Assessment Act 1979*. These assessments include consideration of all environmental impacts, as per the department's guidelines⁶. The department is the determining and approval authority for these exploration proposals.

The department uses the information submitted by the proponent to make a determination about whether or not to approve the activity and also to determine the conditions of the approval.

The process also requires the department to consult with the following agencies, and to consider their recommendations prior to making a determination on any coal seam gas exploration activities:

- the NSW EPA
- the Office of Environment & Heritage
- the NSW Office of Water
- the Department of Planning & Infrastructure

Some petroleum exploration activities (see Schedule 1, Clause 6 of the *State Environmental Planning Policy (State and Regional Development) 2011*) are declared State Significant Development and require approval by the Minister for

³ <http://www.resources.nsw.gov.au/titles>

⁴ <http://www.haveyoursay.nsw.gov.au/document/show/194>

⁵ <http://www.resources.nsw.gov.au/titles/landholders-rights>

⁶ <http://www.resources.nsw.gov.au/environment>

Planning and Infrastructure (or delegated representative or authority). These activities may be conducted under petroleum exploration licences or other forms of petroleum title.

Further details, as well as relevant guidelines are located on the department's petroleum exploration⁷ webpage.

The Department has released two draft guidelines for consultation purposes:

- Revised Environmental Impact Assessment Guidelines: intended to apply to activities subject to assessment under Part 5 of the *Environmental Planning and Assessment Act 1979*.
- Additional Part 5 Review of Environmental Factors (REF) requirements for petroleum prospecting: these will assist with informing consideration of CSG projects subject to the new State Significant Development provisions of the *Environmental Planning and Assessment Act 1979*. These requirements apply to 'activities involving drilling, use of chemicals, impacts on groundwater and waste management – including produced formation water...'

2.1.4 Activities requiring approval under other legislation

2.1.4.1 Water sourcing and protection of aquifers

Water sourcing is important to coal seam gas well operations, and activities which affect waters may require Water Licences and Approvals from the NSW Office of Water (NOW).

In addition, NOW regulates water bore drilling, including groundwater monitoring bores drilled by coal seam gas titleholders under the Water (Part 5 - Drillers Licences) Regulation 1995 and the Water (Part 5 – Bore Licences) Regulation 1995. These Regulations along with the *Minimum Construction Standards for Water Bores in Australia* require adherence to certain minimum standards and reporting to NOW⁸.

Title holders should contact the NSW Office of Water to determine licensing and approval requirements if they intend to undertake any CSG operations⁹ that involve drilling, testing and may interfere with aquifers.

2.1.4.2 Other legislation

The requirements of other legislation may also apply to certain activities, for example the National Parks and Wildlife Act 1974 and the *Protection of the Environment Operations Act 1997* (POEO Act).

The Commonwealth has responsibility to approve certain coal seam gas exploration and production plans under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) in order to assess risk relating to protection of matters of national environmental significance. The *Native Title Act 1993* (Cth) requires compliance prior to the granting of a right, and rights to access to land to construct, to the extent that it affects Native Title.

2.1.5 Approval of production proposals

Production of coal seam gas requires development approval by the Minister for Planning and Infrastructure under the *Environmental Planning & Assessment Act 1979* prior to a production lease being granted, which would set out particular conditions for that lease. This process involves considerable community consultation. Many of the abovementioned approvals are also required, either as conditions of consent, should the project be approved, or as licences if consent is given.

⁷ <http://www.resources.nsw.gov.au/environment/petroleum>

⁸ *Minimum Construction Standards for Water Bores in Australia*, ed 2, September 2003 at <http://www.iah.org.au/pdfs/mcrwba.pdf>

⁹ <http://www.water.nsw.gov.au/about-us/contact-us/default.aspx>

2.2 Risk management planning

2.2.1 Nomination of operator

Coal Seam Gas titleholders are required, as a condition of title, to nominate a competent operator prior to the commencement of any well operations and notify the Department (Mine Safety Inspectorate).

The operator has the day to day control of well operations, and must be able to comply with the conditions of the title and the provisions of the PO Act and Regulations. The title holder may be nominated as the operator.

Note that the *Work Health & Safety Act 2011* applies responsibilities to both the titleholder and the operator in ensuring health and safety of workers and others in relation to the well operations.

2.2.2 General risk assessment

CSG Titleholders are required to ensure all significant risk to safety or the environment is managed through an effective risk management process that includes identification of hazards, assessment of risks, implementation of control measures and monitoring integrity and effectiveness of control measures.

A Significant Hazard Risk Register is to be documented for operations, identifying the specific controls put into place for these hazards.

The WHS Act imposes a duty on a person conducting a business or undertaking to manage risks to health and safety, and the WHS regulation, Chapter 3 “General Risk and Workplace Management” applies. A duty holder, in managing risks to health and safety, must identify reasonably foreseeable hazards and eliminate risks to health and safety, as far as reasonably practicable, or minimise those risks so far as is reasonably practicable.

2.2.3 Safety Management Plan

CSG titleholders are required to apply a rigorous, risk based approach to the safety of operations and possess a comprehensive asset integrity regime to minimise risks associated with their operations.

Prior to commencing any operations at a well site, titleholders must ensure that operators and contractors prepare, implement and review as necessary, a safety management plan for the site to address the specific safety risks that might arise from well operations, and to ensure that the design and operation of the site and its equipment are safe.

The safety management plan must provide the basis for the identification of hazards, and of the assessment of risks arising from those hazards, for the development of controls for those risks and for the reliable implementation of those controls through a formal safety assessment process.

The safety management plan must describe the safety standards and safety and maintenance procedures for each stage of well operations, ie:

- (a) commissioning;
- (b) operation;
- (c) maintenance or modification;
- (d) decommissioning.

The operator has the responsibility for the safety of not only workers and visitors on site but also members of the general public who might be affected by the operations. In this regard the titleholder must provide and maintain, so far as reasonably practicable, a site that is both safe and without risks to the health of employees, visitors and members of the public.

The safety management plan must include:

- a short description of the operations and site location
- the management structure of the major contractor for the operations (such as the operator of the drilling company or the company maintaining or repairing a well)
- any systems, policies, programs, plans and procedures in place relating to the work undertaken at the site
- the emergency response plan (see section 2.2.5 below) and communication systems such as emergency communication systems
- a work health and safety policy that includes the work health and safety objectives for the operations
- the arrangements for appropriate instruction, training and provision of information for workers
- the arrangements for the safe use of plant as per the Work Health and Safety Act, including the acquisition of fit-for-purpose plant and its commissioning, operation and maintenance
- Appropriate control systems such as: alarm systems, pressure and flow detection system as part of well control, pressure control systems, emergency shutdown systems, a mud monitoring system, a fire fighting system, a gas monitoring system
- identification and assessment of specific risks from ignition sources, or potential ignition sources
- requirements for well control and related equipment set out in relevant clauses of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements
- a process for managing change including a process for managing any changes to plant, operating procedures, organisational structure, workers and the safety management plan
- the mechanisms for implementing, monitoring and reviewing and auditing safety policies and safety management plans – for example, the plans must be reviewed if a relevant safety code, safety requirement or standard is introduced or amended; or in the event of a reasonably foreseeable incident at the well
- key performance indicators to be used to monitor compliance with the plan
- mechanisms for recording, investigating and reviewing incidents at the well site and implementing recommendations from an investigation or review of an incident
- any site safety rules, with the detail of arrangements for ensuring that all persons at the site, whether workers, contractors, suppliers or visitors, are informed of the rules
- the arrangements for document control and record keeping.

Titleholders are responsible for ensuring that if a contractor is commissioned to undertake well operations, the contractor has a safety management plan encompassing the scope of their work , which includes the following matters to ensure safety management plans are consistent:

- a description of the proposed or likely interactions between safety management systems, and how they will be managed
- an identification of the specific risks that may arise as a result of the proposed or likely interactions between safety management systems, and how the risks will be controlled
- identification of the safety responsibilities of each party.

2.2.3.1 Reporting

The titleholder must submit an annual safety report to the Department on the approved form, which contains the required information above for the well operation during the preceding year, the nature and extent of the activities carried out at the well site, identifying significant safety risks at the plant; and whether the activities and plant complied with the safety management plan, including details of non-compliance and remediation of the non-compliance.

The annual safety report should also address the well operation's performance in relation to any hazards for future coal mining, as per section 2.3.1 below, and identifying measures taken to prevent or reduce these hazards.

2.2.3.2 Records

The titleholder must keep a copy of the safety management plan, available for inspection, and ensure such records are kept for a period of 7 years.

2.2.4 Environmental management plan

An environmental management plan must be in place. It must address the protection and management of environmental values, monitoring and complaints.

This may be in the form of a REF. Refer to 2.1.3 above.

2.2.5 Incident and emergency response

Incidents and emergencies must be prepared for and managed appropriately to ensure that risks to health, safety and the environment are minimised.

2.2.5.1 Pollution Incident Response Management Plans

Part 5.7A of the *Protection of the Environment Operations Act 1997 (POEO Act)* requires environment protection licensees to prepare Pollution Incident Response Management Plans (PIRMP) for each licensed activity. This is mandatory for existing licensees. New licensees are required to develop their PIRMP before they commence the activities covered by their licence.

2.2.5.2 Pollution incident notification requirements

As of 6 February 2012 anyone causing a pollution incident which meets the definition of "material harm" as defined in the *Protection of the Environment Operations Act 1997 (POEO Act)* is required to report pollution incidents immediately, and to comply with the requirements of Part 5.7 of that Act. Other persons also have obligations under the Act in relation to reporting pollution incidents.

There is a protocol for industry notification of pollution incidents¹⁰ including the order in which the 'relevant authorities' should be notified.

Anyone required to meet these obligations must notify all relevant authorities, not just the appropriate regulatory authority (ARA) under the POEO Act. All "relevant authorities" (as defined in the Act) comprise the ARA, the Environment Protection Authority (EPA), the Ministry of Health, the WorkCover Authority, the local authority (such as the local council) and Fire and Rescue NSW. As "immediate" is not defined in the legislation, it has its ordinary meaning: licensees must report pollution incidents promptly and without delay to ensure that the appropriate agencies have the information they need to respond within an appropriate time.

Where a pollution incident relates to a CSG operation, the EPA should be notified. This should be done about the same time as notification to Fire and Rescue NSW to allow the EPA to assist with the coordination of response actions as necessary and appropriate.

For further information, go to <http://www.environment.nsw.gov.au/legislation/poelegisamend2011.htm>

¹⁰ Refer to <http://www.environment.nsw.gov.au/pollution/notificationprotocol.htm>

2.2.5.3 Emergency Response

The WHS Regulation (clause 43) requires that a person conducting a business or undertaking at a workplace must ensure that an emergency plan is prepared, addressing emergency procedures, including:

- Evacuation procedures
- Medical treatment and assistance
- Notifying emergency service organisations at the earliest opportunity
- Effective communication to coordinate the emergency response and all persons at the workplace
- Testing of the emergency procedures, including the frequency of testing
- Regular mandatory Information, training and instruction to workers

The titleholder must ensure that such emergency procedures are in place that are adequately resourced and equipped, specifying actions to be taken and identifying persons responsible, in the event of an emergency arising as a result of:

- i) serious injury or fatality to a person at the site
- ii) well blow-out or loss of well integrity causing an uncontrolled release of gas
- iii) unplanned ignition of methane
- iv) chemical spill or other pollution incident
- v) any other serious event associated with the operations

Serious workplace incidents including injuries and fatalities must be immediately reported to the department (Mine Safety), as per 3.3 of this Code.

The plan must include the name of the project, title, GPS coordinates and location on a roadmap indicating directions to nearest hospital or emergency air evacuation site, contact details for the operating company and contractors at the site. Workers must be trained in emergency response procedures.

Titleholders must ensure that the emergency plan is reviewed and tested as soon as practicable after any emergency has occurred at the site and whenever the safety management plan is reviewed.

Pollution incidents that cause or threaten material harm to the environment must be immediately notified to each of the following authorities:

- (i) the department (Environmental Sustainability Unit and Mine Safety Operations)
- (ii) the Environment Protection Authority (EPA)
- (iii) the Ministry of Health
- (iv) the local council
- (v) Fire and Rescue NSW

The titleholder must also immediately notify the NSW Office of Water (NOW) if a water source is harmed.¹¹

¹¹ NOW may order remediation works or the plugging and abandonment of a well if the beneficial use category of a water source is compromised.

2.3 Additional requirements

2.3.1 Impact on coal mining

In undertaking their operations, coal seam gas operators must consider any potential impacts for coal mining, such as physical disturbances which might affect the structural integrity of coal seam and strata immediately above and below the coal seam (roof and floor) or air paths over pillars; or conduits for the uncontrolled release of gas or water into mine workings.

2.3.2 Shift change communication

The operator must take reasonable steps to ensure that supervisors of a worksite, or a portion of a worksite, inform the next supervisor, orally or in writing, of the state of the operation, plant and equipment, including safety information, at the change of a shift.

2.3.3 Fencing

Titleholders should construct fencing for well sites for safety and to exclude livestock and wildlife. Titleholders must also abide by any additional measures regarding fences set out in the Access Agreement.

The titleholder must ensure that if fencing around the well head is removed during an operation, the fencing is replaced immediately after the operation is completed.

2.3.4 Electrical engineering safety

To prevent explosions from electrical ignition sources and prevent electrical shock at workplaces subject to this Code the following principles need to be applied:

- Hazardous areas must be identified and classified to a set standard
- The equipment installed in hazardous areas must be suitable, that is, certified to a set standard and under the auspices of a credible certification scheme
- The electrical installations must comply with a set standard and be installed by competent people.

Reference should be made to the department's Electrical Engineering Decision Sheet 14.1 :

<http://www.dpi.nsw.gov.au/minerals/safety/resources/electrical-engineering/management-systems-and-work-process/electrical-engineering-safety-decision-sheets>

3 Recording and reporting data

Accurate information on drilling, completion, workover and well abandonment must be recorded. Titleholders must ensure that these records are maintained in an accessible way for the periods specified in legislation or, if no such retention periods are specified, for 5 years following the abandonment of a well.

Titleholders must keep geological plans, maps and records for work relating to the title; and submit plans and reports on the progress of operations, in accordance with the PO Act (s131) and Regulations (Parts 2 & 3).

3.1 Well life cycle records

Accurate information on the design, drilling, construction, reconditioning, and abandonment of wells must be recorded for future reference.

A record of all work undertaken on a well must be maintained for each well's entire life through to abandonment.

3.1.1 Good industry practice

Records to be maintained may include, but are not limited to, the following:

- Engineering design basis
- Kick tolerance/well control design assumptions
- BOP pressure testing requirements, and actual test records
- Laboratory test results for cement slurries
- Casing tallies for all casing strings run (including lengths, weights, grades, inside diameter, outside diameter, setting depth)
- Cementing records for each casing string in each well
- casing pressure test reports
- Leak off test and/or formation integrity test reports
- Wireline logs
- Core description reports
- Downhole installation records/schematic
- records of chemicals used downhole, including any chemicals used in drilling fluid, treatment and workover or other well procedures (name, type CAS number and volume of each chemical used should be recorded)
- Records of drilling and cementing, including any problems encountered during the drilling
- Risk assessments
- Well drilling and completion programs including casing running and cementing procedures
- Daily rig reports
- Daily geological reports, if relevant
- Service company reports

3.2 Reporting and notification

The following well operation reports and notifications to the department are required to be submitted by titleholders.

3.2.1 Location surveys

As soon as is practicable after the location of a well is established and after spudding the titleholder must survey the location of the well using MGA coordinates. These coordinates will be provided to the department as part of all reporting for the well.

Bottom hole location/total depth and the pathway for deviated and horizontal wells must be surveyed and survey data must be included in a report to the department.

3.2.2 Annual reporting

Section 131 of the PO Act requires titleholders to submit an annual report to the department which contains a summary of operations conducted during that year; details of expenditure relating to those operations; and a plan showing the situation of all wells on that land; all development and other work and improvements undertaken by the titleholder in connection with their CSG operations, and full details of ancillary rights acquired in relation to the title.

The plan must be to scale ie 1:25 000; 1:100 000 or 1:250 000.

In addition, an annual safety report must be submitted to the department (as per section 2.2.3 of this document).

3.2.3 Operational reporting

Titleholders must submit a report to the department within 6 months after the completion of:

- A seismic program
- Drilling an exploration well
- Drilling a production well
- A 'significant' component of a work program in the conditions of title.

3.2.4 Notification to drill

Titleholders must lodge a notification on the department's approved Notice of Intention to Drill form, with the required information, including :

- a) Name and contact details of operator
- b) proposed well name and number
- c) location, elevation and co-ordinates of the well site
- d) geological prognosis of the area which includes well objectives accompanied by a time or depth map of near target horizon(s) and seismic sections where possible
- e) programmed depth
- f) estimated spud date
- g) estimated drilling time
- h) name and address of drilling contractor
- i) names and addresses of other contractors involved in the operations and the nature of the services they will perform

- j) type of rig and blow-out prevention equipment, including description of equipment and method of operations
- k) name and contact details of person responsible for communications with the department
- l) proposed well paths (if the well is to be other than vertical)
- m) maps of a suitable scale to enable clear identification of:
 - (i) the existing land tenure including reserves and private property
 - (ii) the location of any other wells and public utilities
 - (iii) any other structure within 150 metres of the proposed well location/well path.

A separate intention to drill notification should also be submitted to the NSW Office of Water.

3.2.5 Well completion reports

Well completion reports, inclusive of the Plug & Abandonment Report, are mandated in Part 3: Reports of the *Petroleum (Onshore) Regulation 2007*. Refer to the guidelines for the submission of these reports within the *Guidelines for Digital Data Submission and Reporting of Onshore Petroleum Exploration Reports*.¹²

3.2.6 Cementing reports

In addition, cementing reports, including all materials and compression strength vs time graphs, cement pump charts and pressure records, logging reports including well deviation details and details of centraliser placing must be completed and submitted to the department with well completion reports.

3.3 Incident reporting

In accordance with Part 3 of the WHS Act, a person who conducts a business or undertaking must ensure that the department's Mine Safety Inspectorate is notified immediately after becoming aware that a notifiable incident arising out of the conduct of the business or undertaking has occurred.

Reporting of Environmental incidents for all coal seam gas well activities must be reported immediately¹³ to the department (Environment Branch).

There is a duty to report pollution incidents to the Office of Environment and Heritage. See <http://www.environment.nsw.gov.au/licensing/Dutytonotify.htm>

If well operations have caused inter-aquifer connectivity, the title holder must immediately contact the NSW Office of Water <http://www.water.nsw.gov.au/About-us/Contact-Us/default.aspx>

In addition, gas leaks ('wellhead reportable leaks' – refer to Glossary) must be reported to the department.

¹² http://www.resources.nsw.gov.au/__data/assets/pdf_file/0005/373514/Guidelines-for-Data-Submission-and-Report-Structure-for-NSW-Petroleum-Onshore-Exploration.pdf

¹³ Refer to departmental Guideline ESB28 – Environmental Incident Reporting Requirements, at http://www.resources.nsw.gov.au/__data/assets/pdf_file/0007/422953/ESB28-Environmental-Incident-Reporting-Requirements.pdf

4 Mandatory requirements and recommendations

NOTE that A section would normally be set below GL. Shown above GL for illustration purposes only.

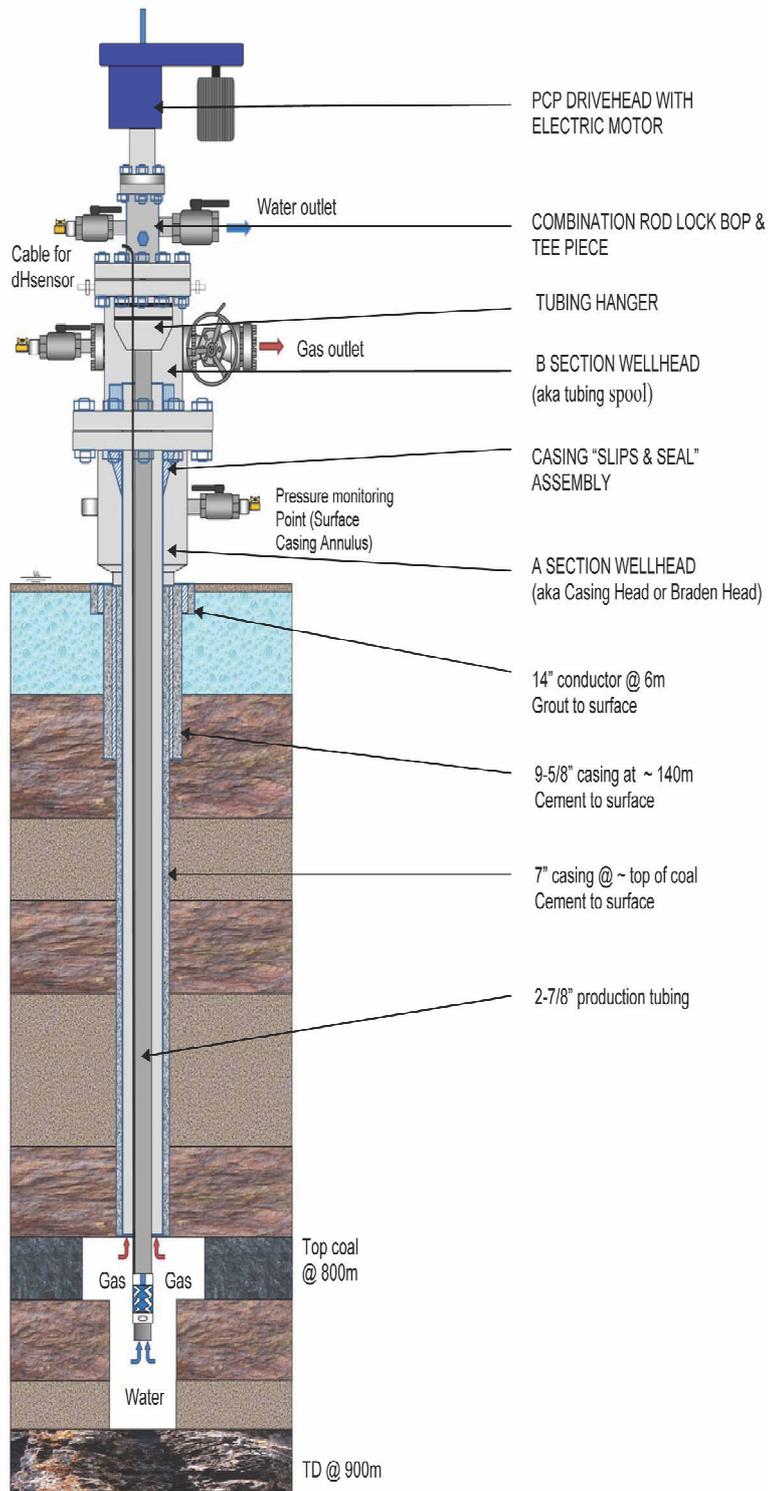


Figure 1: Typical vertical under-reamed completion

4.1 Well design

4.1.1 Principles

CSG wells are designed to ensure the environmentally sound, safe production of gas (predominantly methane) and other wellbore fluids by containing them inside the well, protecting groundwater resources, isolating the productive formations, and by proper execution of treatment/stimulation and/or completion operations.

Well design and construction must ensure that no leaks occur through or between any casing strings. The fluids produced from the well must travel directly from the producing zone to the surface inside the well conduit, without contamination of groundwater or other aquifer resources, and avoiding leakage.

All CSG wells therefore must be designed to ensure the safe and environmentally sound production of gas by:

- preventing any interconnection between hydrocarbon-bearing formations and aquifers;
- ensuring that gas is contained within the well and associated pipework and equipment without leakage;
- ensuring zonal isolation between different aquifers and water bearing zones is achieved; and
- not introducing substances that may cause environmental harm.

4.1.2 Mandatory requirements

The Design Basis for CSG wells must incorporate the following –

- consideration of casing setting depths taking into account aquifer and production zone locations, and the requirements for Well Control
- provision for Blow Out Preventor (BOP)
- use of appropriate casing weight and grade, and casing running procedures
- use of appropriate well design and construction materials
- use of appropriate casing centralisation
- use of engineered cement slurry and effective cement placement techniques
- design to ensure all fluids produced from the well travel directly from the production zone to the surface without contaminating groundwater.

4.1.3 Good industry practice

- a) Offset well information should be reviewed to assist in the design process for new wells.
- b) Nearby water bores should also be included in the record keeping and data-set as part of the offset review.
- c) Consideration should be given to offset data detailing any evidence of tubular corrosion. If corrosion has been observed, petroleum titleholders will need to conduct a risk assessment and take action to ensure maintenance of well integrity.
- d) Identify beneficial aquifers and ensure that these zones are cased off to ensure their long term protection. Formation horizons or zones from which water bores produce should be noted during the offset well review and used to assist the placement of surface and/or production casing.
- e) Sustainable construction practices and operating procedures should be used, for example, to conserve water usage and minimise waste.
- f) All CSG well designs and construction procedures should include contingency planning to mitigate the effects of failures in the event of unplanned process upsets or events during construction.

- g) Casing hardware including float equipment, centralisers, cement baskets, wiper plugs (top and bottom), stage tools and external casing packers should be selected as appropriate as part of the well design to ensure integrity of the required zonal isolation.

4.1.4 Standards and specifications

CSG Titleholders should review at least the following when determining casing design for any CSG well:

- Competency Standard for the Petroleum and Gas Drilling Industry (2007) – Version 2, January 2010
- API Recommended Practice 65-2, Isolating Potential Flow Zones during Well Construction
- API Guidance Document HF1, Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines

4.2 Casing

4.2.1 Principles

Casing should be designed to withstand the various compressive, tensile and bending forces that are exerted while running-in the hole, as well as the collapse and burst pressures that it may experience during different phases of the well's life e.g. cementing, pressure testing, stimulation and production cycles.

Casing strings should be designed to facilitate installation of Blow Out Preventor equipment.

As well as providing a mechanism of extracting gas from the production zones, casing also acts to protect other resources such as groundwater.

The casing design should take into account several factors. In general terms:

Conductor casing:

Should be set deep enough that it is within a competent formation and able to circulate drilling fluids to the shale shakers without eroding the surface sediments below the rig and rig foundations. It may also be used to support structurally some of the subsequent casing or wellhead loads.

Surface casing:

Prevents cave-in of unconsolidated, weaker near surface sediments and can be used to protect shallow, water bearing sands from contamination. The surface casing should also be set deep enough that in the event of a kick, while drilling the next hole section, the casing should be able to contain the flow without fracturing the shoe.

Intermediate casing:

Should be run according to the casing design which will take into account geological considerations, abnormal pressured zones, lost circulation zones, unstable formations and casing mechanical properties and limitations.

Production casing:

Should be designed as per the intermediate casing design requirements and with consideration of exposure to produced fluids and potential corrosion. The production casing will be either set through the producing formation with a connection conduit (perforation) to the inside of the casing or as in barefoot CSG wells set above the target formation. The production casing will be either the primary or secondary barrier which prevents flow from a source.

In addition, liners may be run.

4.2.2 Mandatory requirements

- a) Casing, casing connections, wellheads, and valves used in a CSG well must be designed to withstand the loads and pressures that may act on them throughout the entire well life cycle. This includes casing running

and cementing, any treatment pressures, production pressures, any potential corrosive conditions, and other factors pertinent to local experience and operational conditions.

- b) For CSG wells all surface and production casing in pressure containing applications¹⁴ must meet requirements of relevant API or other standards accepted by the department.
- c) Conductor pipe does not need to meet the requirements in (b).
- d) When designing casing strings and casing connections for CSG wells, CSG operators and their drilling engineers must design each well's casing string using appropriate Design Safety Factors. Commonly used Design Factors are:

Collapse: 1.0 – 1.125

Burst: 1.1 – 1.25

Tension: 1.6 – 2.0

The Design Safety Factors used need to be appropriate for the anticipated well life, service conditions and local experience.

- e) To verify casing integrity during the well construction process, casing must be pressure tested prior to drilling out for the next hole section (in the case of surface or intermediate casing), and prior to completion operations commencing (in the case of production casing). The test pressure must be greater than the anticipated formation pressure possible at the surface, but must not exceed 60% of the burst pressure rating of the casing with the safety factor applied.
- f) Minimum surface casing setting depth should be sufficient to meet isolation requirements of beneficial aquifers and provide an acceptable kick tolerance for the next hole section to be drilled. The kick tolerance criteria shall be selected by the operator and will be dependent upon knowledge of the local pore pressure and fracture gradient profiles, and of the likely kick conditions in the well.
- g) For Exploration or Appraisal wells the minimum setting depth of the surface casing string shall be the greater of 10% of the planned total depth of the well when no intermediate casing string is planned or 100m. If an intermediate casing string is planned then the surface casing string need only be 10% of the planned depth of setting of the intermediate casing shoe.
- h) Production wells must be constructed with at least two strings of casing including the surface control casing and the production casing.
- i) Where the casing design is not part of a barefoot well design, a production casing string should be set at the base of the proposed production interval and extend to the surface; or run as a liner string and in that case the top of the liner must be a minimum of 25m above the intermediate casing string shoe depth.
- j) Horizontal wells that are drilled within a coal seam should have the production casing just inside the coal seam. The coal seam may be left open or lined with suitable (not steel) slotted casing to ensure open hole well stability.
- k) Steel casing connections must be made up to ensure an aligned, round, secure, and leakproof joint
- l) Welded joints are permitted at surface provided a certified pressure welder is used.

4.2.3 Good industry practice

- a) For casing run in CSG wells, pipe body and connections should have verifiable properties (i.e. in terms of burst, collapse and tensile strengths). Note that casing manufactured to API specifications by definition must meet strict requirements for compression, tension, collapse and burst resistance, as well as quality and consistency.

¹⁴ Pressure containing applications include all applications where the integrity of the casing is required to maintain well control.

- b) When making up a casing connection it is important to apply the recommended torque. Too much torque may over-stress the connection and result in failure of the connection. Too little torque may result in leaks at the connection.
- c) Make-up torque specifications for tubulars being run should be incorporated within the Drilling Program.
- d) The correct use of casing dope, and its impact on torque make-up should be incorporated into casing running procedures.
- e) Operators should consider the potential impact of high casing pressure on cement bond quality when determining pressures for any casing tests.
- f) Titleholders, their drilling contractors and their well-site supervisors should review and ensure compliance with the Work Program to run, install and test all casing strings during well construction.
- g) Long term monitoring and recording of the casing condition should be undertaken.

4.2.4 Standards and specifications

CSG Titleholders should review at least the following when determining casing design for any CSG well:

- API Specification 5CT/ISO 11960, Specification for Casing and Tubing
- API Recommended Practice 10D-2/ISO 10427-2, Recommended Practice for Centralizer Placement and Stop Collar Testing
- API Technical Report 10TR4, Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations
- API Specification 5B, Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads

4.3 Cementing

4.3.1 Principles

CSG wells need to be cemented to:

- prevent migration paths and isolate the targeted zone from other formations.
- protect beneficial aquifers from contamination.
- maintain aquifer pressures and quality.
- obtain and maintain well integrity.
- protect the casing from corrosion.

4.3.2 Mandatory requirements

- a) To prevent interconnection between zones of differing pressure and water quality:
 - All surface casing must be cemented from shoe to surface.
 - For cementing production and intermediate casing, operators must design to ensure cement is either brought to surface or designed to an appropriate safety overlap distance of at least 50m back inside the previous casing shoe. Where cement is not returned to surface, pressure testing, or an alternative method accepted by the department, must be performed and recorded to verify zonal isolation has occurred after all the cement has reached a compressive strength of 500 psi. Testing pressures must be no less than 500 psi (3.5 MPa) over the previous casing Leak Off Test at the shoe.

- If cement is not brought back to surface a minimum 50m lap of the previous casing string is required and a secondary barrier must be installed in the annular space. The secondary barrier could constitute a cementing collar, external casing packing or casing hanger with seals.
 - Horizontal wells that are drilled into the target coal seam are to have a production casing enter or tag the coal and casing cemented from casing total depth back to surface. If a horizontal well incorporates a whipstock, the casing and cement must be no less than 30m (MD) below the target coal seam (30m rathole sump).
 - Production casing cement on vertical wells excluding barefoot casing designs must be no less than 30m below the deepest target coal seam (30m rathole sump).
 - If the cementing operations do not verify zonal isolation then written notification must be sent to the department. Remediation work must be undertaken 72 hours before commencing production, and a report must be submitted to the department regarding this work. Subsequently, the integrity of the well must be reviewed and measures put in place prior to bringing the well on production to ensure well integrity for the lifetime of the well.
- b) Cement constituents and properties must be suitable for the intended conditions of use and used in compliance with the relevant MSDS requirements¹⁵.
- c) Appropriate cement laboratory testing procedures must be carried out (see API RP 10B-2) in advance of the well being drilled to ensure the resulting slurry meets the requirements of the well design. The testing, as a minimum, must include Compressive Strength development with time. In the case where a number of similar wells are drilled in an area with constant cement materials and mix water properties, then a representative lab test may suffice.
- d) Wait on cement setting time:
- Wait on cement time prior to slacking off or removing BOPs must be based on the cement achieving a minimum of 100 psi (0.7 MPa) compressive strength at the temperature of any potential flow zone in the annulus just cemented. API RP 65 – Part 2 addresses this issue.
 - Cement top-up after cement recedes after coming to the surface must occur as soon as possible and before any downhole activity commences.
 - Wait on cement time prior to drill out must equate to the laboratory testing time for cement surrounding the casing shoe to have achieved a minimum compressive strength of 500 psi (3.5 MPa).
- e) Titleholders must ensure all zones (both hydrocarbon and beneficial aquifers) are isolated with cement with a minimum ultimate compressive strength of 500 psi (3.5 MPa).
- f) Titleholders must determine and document in their well procedures a minimum required ultimate compressive strength for cement slurries to be used across zones which may be hydraulically fracture stimulated. For example, requirements for ultimate compressive strength of 1,400 psi (10 MPa) to 2,000 psi (14 MPa) are often used in the hydrocarbon industry for cement across zones requiring fracture stimulation treatment.
- g) Titleholders must ensure that the required compressive strength slurry for fracture stimulation also be placed at least 150m above any zone to be hydraulically fractured. API Guidance Document HF-1 addresses this issue.
- h) During all cement jobs, returns to surface must be continuously monitored and recorded to confirm the effectiveness of the cement placement. Pressures during the cement job and in particular immediately prior

¹⁵ Note: API RPs 10A, 10B, 10D and 65-2, Guidance Document HF-1 and Technical Report 10TR are the recommended benchmarks for cementing wells.

to plug bump must be similarly recorded as a potential indicator of height of cement column and downhole problems.

- i) Calcium chloride or other chloride-based accelerants must not be added to the cement mix unless the free water content of the cement is specified as <2%.
- j) A minimum of 19mm cement sheath surrounding the nominal OD of the surface casing over the total cementing depth must be demonstrated. Calculations for a vertical well must include a deviation of 3 degrees from vertical at casing depth unless otherwise proven.
- k) A minimum of 13mm cement sheath surrounding the nominal OD of the production casing over the total cementing depth must be demonstrated. Calculations for a vertical well must include a deviation of 3 degrees from vertical at casing depth unless otherwise proven.
- l) Casing centraliser spacings are to be such that the requirements of (j) and (k) above are achieved.
- m) Centralisers and their connections to the casing must meet API Recommended Practice 10TR4 or its equivalent.
- n) It is mandatory that wiper plugs be used for displacing production casing cement. Top wiper plugs are recommended for surface casing to enable plug bump and pressure test of the casing before cement cures.

4.3.3 Standards and specifications

Appropriate API and Australian standards must be adhered in the selection and use of cementing products, including AS 3972-2010.

4.3.4 Good industry practice

Titleholders should ensure:

- a) Proper wellbore preparation, hole cleaning and conditioning prior to the cement job. Once casing has been run to landing depth, CSG operators should circulate a minimum of one hole volume immediately prior to commencing cementing procedures.
- b) Movement of the casing (rotation and reciprocation) should be considered where appropriate to improve drilling mud removal and promote cement placement.
- c) Cement design should avoid cement shrinkage giving rise to the propagation of fractures and leakage paths
- d) Cement slurry design should include testing to measure the following parameters depending on site-specific geologic conditions (this list is not exhaustive):
 - Slurry density;
 - Thickening time (compared to proposed pumping time);
 - Fluid loss control;
 - Free water;
 - Compressive strength development versus time (at representative bottomhole conditions);
 - Fluid compatibility (cement, source / mix water, drilling mud, spacers used);
 - Mechanical properties.
- e) Cement job design should include proper cement spacer design and volume to ensure the appropriate contact time during pumping.
- f) Caliper logs in production hole sections, where available, should be used to confirm cement volume requirements. The level of excess cement requirements should be based on local experience.

- g) Water and cement slurry samples should be taken (periodically during each cement job) by the petroleum tenure holder's well site supervisors as an aid to monitoring cement job quality and visual confirmation of speed of cement set up. Cement samples should be maintained on site for the duration of the well.
- h) Baseline cement bond log evaluation should be considered in each new field area where confirmation of cement placement has not been demonstrated. Cement bond log evaluation should continue until repetitive success of slurry design and cement jobs, and confirmation of adequacy of cement bond for zonal isolation is confirmed (e.g. five wells in each new field or area of different geological conditions).
- i) Leak-off tests or formation integrity tests should be used on drill out of surface casing shoes as a potential guide to shoe integrity (i.e. good cement around the casing shoe) as well as assisting with well design for well control risk.
- j) Titleholders should ensure all cementing operations are carried out with proper mixing, blending and pumping of the cement job at the wellsite. These activities should be properly supervised and recorded. This includes recording any cementing problems encountered.

4.4 Wellheads

4.4.1 Principles

The primary purpose of a wellhead is to provide the suspension point and pressure seals for the casing strings that run from the bottom of the hole sections to the surface pressure control equipment.

The wellhead ensures well integrity at the surface and enables the installation of Blow Out Preventers.

Wellheads are threaded or welded onto the first string of casing, which has been cemented in place during drilling operations, to form an integral structure of the well.

Wellhead design needs to facilitate installation of Blow Out Preventor Equipment

4.4.2 Mandatory requirements

- a) Operators are required to use wellheads compliant to API Specification 6A/ISO 10432..
- b) Operators must monitor wellheads for leaks or emissions in accordance with the separate code of practice for this purpose.

4.4.3 Good industry practice

- a) CSG titleholders should ensure that during initial wellhead installation and subsequent well intervention workovers, wellhead seal tests are conducted to test the mechanical integrity of the wellhead sealing components (including valve gates and seals) and confirm they are capable of holding against well pressure.
- b) It may be advisable in some circumstances and CSG well types to ensure A and B wellhead sections are used to ensure surface integrity of the surface casing annulus (between production casing and surface casing), as an additional barrier to potential leak paths.

4.4.4 Standards and specifications

CSG Titleholders should review at least the following when selecting wellhead, Blowout Prevention and Production tree equipment:

- API Specification 6A/ISO 10432, Specification for Wellhead and Christmas Tree Equipment
- API Specification 16A, Specification for Drill Through Equipment
- API Recommended Practice 53, Blowout Prevention Equipment Systems for Drilling Operations
- API 11IW Recommended Practice for Independent Wellhead Equipment

4.5 Drilling fluids

4.5.1 Principles

While drilling, fluid is usually circulated down the drill string and up the annulus between the drill string and hole wall. This drilling fluid serves to lubricate the drilling assembly, remove the formation cuttings drilled, maintain pressure control of the well, and stabilise the hole being drilled. Drilling fluid is generally a mixture of water, clays, fluid loss control additives, density control additives, and viscosifiers.

The standard drilling fluid currently used in the CSG industry is water-based. It may be either fresh water or may be based on salt brine. Potassium chloride, the principal salt component, is often used as a weighting agent and to help control swelling clays. Organic polymers or clay may be added to the base fluid to raise the viscosity and aid in removal of drill cuttings.

After use, drilling fluid is returned to the drilling sumps where the solids settle to the bottom of the sump. The liquid may then be recirculated.

Losing drilling fluids down hole is undesirable as they are the primary means of controlling pressure within the well, and maintaining removal of formation cuttings drilled. When a loss is detected, loss circulation material (LCM) may be incorporated in the drilling fluid. LCM prevents fluid loss by blocking the pores in the host rock.

Underbalanced drilling techniques may be used for drilling where air, nitrogen or other underbalance “aerated” fluids are used as a drilling medium.

Titleholders and drilling contractors undertaking underbalanced drilling should ensure that all risk assessment, well design, operational and crew training are addressed prior to and during execution of the project.

In accordance with the Part 5 REF requirements for Petroleum Prospecting, titleholders will have identified and described any substances to be introduced into a drill hole. Title holders should be aware of any chemicals that may be formed following mixing or down-hole reactions.

Disposal of fluids must be done in accordance with the relevant activity approval and all regulatory requirements.

4.5.2 Mandatory requirements

- a) Drilling fluids must be selected and managed to ensure all products used during well procedures on CSG wells are used in accordance with the manufacturer’s recommendations and relevant Material Safety Data Sheets (MSDS).
- b) The name, type, CAS number and quantity of each chemical used on each well throughout the life of the well must be recorded
- c) Oil-based muds must not be used for CSG drilling in NSW
- d) The source of water used for all well procedures (drilling, workover and stimulation) must be recorded for future well monitoring purposes.
- e) Personnel, including contractors, must be aware of the environmental impact and spill emergency procedure of the products and substances in use on site.

4.5.3 Good industry practice

- a) Drilling fluid should be a carefully monitored and controlled mixture designed to –
 - achieve best drilling results and ensure efficient removal of formation cuttings;
 - control formation pressures; and
 - minimise damage to formations.

- b) Petroleum titleholders holders should ensure that the drilling fluid selected is appropriate for the well design, any locally experienced drilling problems and anticipated geological conditions likely to be encountered.
- c) The use of biodegradable substances in the drilling fluid is preferred.
- d) Products should be chosen, stored, and used at concentrations that minimise the risk of causing environmental harm.
- e) Titleholders should use established, effective drilling practices to achieve a stable, uniform, and, as far as possible, in-gauge hole.
- f) Titleholders should consider water quality used in cement mixes.

4.5.4 Standards and specifications

CSG Titleholders should review at least the following when determining suitability of drilling fluids for any CSG well.

- API Specification 13A /ISO 13500, Specification for Drilling Fluid Materials
- API Recommended Practice 13B-1/ISO 10414-1, Recommended Practice for Field Testing Water-Based Drilling Fluids
- API Recommended Practice 13D, Recommended Practice on the Rheology and Hydraulics of Oil-well Drilling Fluids

4.6 Evaluation, logging, testing, coring

4.6.1 Principles

The types of logs that are run in a CSG well are selected by geologists and engineers at the time the well is designed. Common logging tools used for evaluation of CSG wells include natural gamma ray, density, caliper, resistivity and image logs.

Logging produces valuable information on all formations logged to accurately determine the nature and type of all strata encountered.

This information is used in optimising future well design and drilling operations as well as determination of the actual depth and thickness of all subsurface formations in the drilled hole.

Review of well logs assists in setting casing strings in the correct place to achieve well design objectives and to properly achieve the isolation requirements of the casing and cement.

Formation testing may be carried out on some wells. The formation is sampled by either drill pipe conveyed Drill Stem Test tools or by wireline deployed test tools.

In some exploration wells, the well design may be modified to cut 'cores' of the strata encountered. This involves drilling a core of solid rock and recovering it to surface. The core is examined for geological information and any coals are tested for gas content.

Cuttings samples, core samples fluid samples and other samples from the CSG well drilling process should be collected, stored and/or distributed according to legislative and regulatory requirements.

4.6.2 Mandatory requirements

Titleholders must ensure that an accurate downhole survey of each CSG well is carried out,. Such surveys may be carried out using the appropriate logging tools in vertical wells and/or measurement while drilling (MWD) techniques in deviated wells.

4.6.3 Good industry practice

Where appropriate (e.g. when hole conditions and pressure regimes dictate), Operators should ensure secondary well Pressure Control Equipment (PCE) is in place during logging operations. This may include such equipment as wireline lubricators or pack-offs.

4.7 Well monitoring/maintenance

4.7.1 Principles

Wells, like any constructed asset, can deteriorate with age, operational and site specific conditions. This can lead to the well no longer being suitable for the intended use. Well monitoring and maintenance is required to preserve the well and its component parts in good repair for the life of the well.

The titleholder must carry out sufficient monitoring to establish that significant risks have been:

- (i) identified
- (ii) quantified
- (iii) avoided, or appropriately managed so that residual risks are within acceptable limits before, during and after the fracture stimulation activity.

4.7.2 Mandatory requirements

- a) Titleholders must ensure that there is a documented maintenance and monitoring plan for equipment, facilities and pipelines in place. Appropriate records must be maintained.
- b) Monitoring
 - Throughout the life of a producing well, well conditions must be monitored on an ongoing basis to ensure integrity of the well and well equipment.
 - Mechanical integrity/pressure monitoring and evidence of corrosion shall be used to determine the mechanical integrity of casing and other well equipment when the well is producing and during well treatments or well intervention/ workover operations.
 - Monitoring mechanisms and frequencies are to be determined by a comprehensive risk assessment.
- c) Maintenance
 - All products must be used in accordance with the manufacturers' recommendations and relevant material safety data sheets.
 - Maintenance mechanisms and frequencies are to be determined by a comprehensive risk assessment.

4.7.3 Good industry practice

- a) Monitoring
 - Routine operational visits by well operators/well pumpers should monitor, identify and report any abnormal well conditions including wellhead leaks to operating company management. These visits should also be used to monitor regular well pressures in addition to SCADA where used.
 - Regular inspection of the casing and wellhead equipment and annulus pressures should readily indicate any leaks between any of the casing strings.
 - Wellhead pressures, gas and water production rates of all CSG wells should be continuously monitored. This production data can then be analysed by production engineers to identify any abnormal behaviour or problems.

b) Maintenance

- A Preventative Maintenance program should be in place to service all surface equipment at the wellsite.
- During well intervention, or workovers when equipment is removed from a well or depressurized for maintenance, a breakdown or visual inspection should take place and records taken of then condition of the equipment after being in service. Records should be kept of all intervention procedures and chemicals used.
- Operators should carry out regular wellhead maintenance and monitoring for any early signs of potential leaks, including monitoring of the surface casing annulus. If an annulus is being abnormally charged with gas, an analysis of gas content may assist determination of the source and nature of a potential leak.

4.8 Well suspension

4.8.1 Principles

On suspension of a well, the operator must ensure it is sealed in a manner that prevents leakage and facilitates safe recommencement of operations. The site is to be made secure to exclude persons and stock.

4.8.2 Mandatory requirements

- a) A well must not be left in an unsafe condition – even temporarily
- b) In the event of an emergency, or adverse weather conditions, a well must be made safe in accordance with relevant standards
- c) A well must not be suspended without the approval of the department. The following must be included in an application for well suspension:
 - Name and location of the well
 - Reason for suspension
 - Proposed suspension program, including suspension period
 - suspended well schematic
- d) Display appropriate safety signs
- e) Site to be secure with a locked fence around the well
- f) Vegetation cleared around the well
- g) Valves securely chained and locked or removed
- h) A program should be in place for regular inspections to check for gas leaks and other health and safety matters
- i) A record should be kept of all inspections.

4.9 Well abandonment

4.9.1 Principles

CSG well abandonment must ensure the environmentally sound and safe isolation of the well, protection of groundwater resources, isolation of the productive formations from other formations, and the proper removal of surface equipment.

Titleholders are responsible for the well until the department is satisfied that the titleholder can demonstrate that the well is safe and non-polluting.

The outcomes of well abandonment are to:

- maintain isolation of beneficial aquifers within the well from each other and hydrocarbon zones;
- maintain isolation of hydrocarbon zones within the well from each other, from aquifers, water bearing zones or from zones of different pressure;
- minimize risk to possible future coal mining
- isolate the surface casing or production casing from open hole;
- place a surface cement plug in the top of the casing; and recover/remove the wellhead.

The following matters should be considered when abandoning a well:

- The construction characteristics of the well
- integrity of the cement column
- geological formations encountered
- potential loss zones
- hydrogeological conditions i.e. location of beneficial aquifers and water bearing zones
- environmental risk
- regulatory requirements, title conditions and industry standards
- perforated and fraced zones.

4.9.2 Mandatory requirements

- a) A well must not be abandoned or suspended without prior departmental approval.
- b) All CSG exploration wells must be plugged and abandoned and the department notified on the approved form within 3 months of the last drilling or testing activity, unless the well is converted to another approved purpose.
- c) The titleholder must ensure that an abandoned well is sealed by filling the near-vertical section from total depth to top with cement or other sealing program as approved by the department. There is to be no open annulus to the surface.
- d) Any well or drill hole that is to be abandoned shall be sealed and filled in such a manner to prevent leak of gas and/or water.
- e) Cement shall be used as the primary sealing material. Cement testing should be carried out as per requirements set out in Section 4.3 - "Cementing" of this Code.
- f) The titleholder must ensure that an abandoned well is sealed by filling from total depth to top with cement of at least 24 hour laboratory strength of at least 500 psi (3.5 MPa). In near-vertical open hole sections of the well, cement is to be placed in plugs of not more than 200 m lengths with a WOC period of 6 hours between placement. The first plug across the surface casing is to be tested to 500 psi (3.5 MPa) above the estimated or previously recorded LOP. Squeeze-cementing or other method is to be used to effectively seal off abandoned frac zones from the wellbore.
- g) BOPs and/or wellhead must not be removed until the cement plug across the surface casing shoe or plug across the uppermost perforations has been physically tagged for correct location and pressure tested.

- h) Wellheads must be removed, and casing must be cut greater than 1.5m below surface. A wellhead marker plate must be installed and must be placed and marked with details as per the department's requirements.
- i) Complete and accurate records of the entire abandonment procedure must be kept, with these records submitted as part of the titleholder's legislative reporting requirements for the abandonment of CSG wells.
- j) If a CSG well intended for abandonment is proposed for conversion to a water well, necessary approvals and licences must be obtained.

4.9.3 Good industry practice

Use integrated openhole volume calculated from caliper on wireline logs to calculate cement volumes where possible (this applies mostly to exploration wells which are to be plugged and abandoned). If no caliper data is available, 20-30% above theoretical volume or local knowledge should be used.

Appendix 1 - Glossary

Abandonment	A process which involves decommissioning a well and rehabilitating the site.
Annular space (annulus)	The space between two concentric objects, such as between the wellbore and casing or between casing and tubing, where fluid can flow.
Aquifer	Has the same meaning as in the Water Management Act 2000, ie. “a geological structure or formation, or an artificial landfill, that is permeated with water or capable of being permeated with water”.
Barrier	Any means of preventing an uncontrolled release or flow of wellbore fluids from one formation to another or to the surface.
Beneficial aquifer	An aquifer with a water resource of sufficient quality and quantity to provide either ecosystem protection, raw water for drinking water supply, and agricultural or industrial water.
BOP	Blowout Preventer. One of several valves installed in a wellhead to prevent the escape of pressure either in the annular space between the casing and the drill pipe or in the open hole during drilling, completion and work over operations.
CAS number	A unique identifier for chemical substances. A CAS Registry Number provides an unambiguous way to identify a chemical substance or molecular structure when these are many possible systematic, generic, proprietary or trivial names.
Casing	Large-diameter pipe lowered into an open hole and cemented in place. The well designer must design casing to withstand a variety of forces, such as collapse, burst, and tensile failure, as well as chemically aggressive brines. Casing is run to protect fresh water formations, isolate a zone of lost returns or isolate formations with significantly different pressure gradients.
Casing shoe	The bottom of the casing string, including the cement around it, or the equipment run at the bottom of the casing string
Cement	Powder consisting of alumina, silica, lime and other substances that hardens when mixed with water. Different specifications of cement are used for different purposes. Extensively used to bond casing to the walls of the wellbore.
Cementing	The application of liquid slurry of cement and water to various points inside and outside the casing.
Cement plug	A balanced plug of cement slurry placed in the wellbore.
Centraliser	A device fitted with a hinged collar and bowsprings to keep the casing or liner in the center of the wellbore to help ensure efficient placement of a cement sheath around the casing string.
Circulation	The process of pumping a fluid down the well and back up to the surface in a drilling or workover operation.
Company Representative	An employee of the operator who supervises the operations at a drilling site or well site and coordinates the hiring of logging, testing, service and workover organisations. Also called the company man.
Completion	A generic term used to describe the assembly of downhole tubulars and equipment required to enable safe and efficient production from an oil or gas well. The point at which the completion process begins may depend on the type and design of well.
Completion (or Workover) Program	A document that describes the detailed well procedures and risk mitigation for activities including Completions, Testing, Intervention, Well Repair and/or Abandonment.
Contractors	Third parties contracted by the lease tenure holder to provide well engineering equipment including drilling rigs, materials, equipment and services.
Coring	Process of cutting a vertical, cylindrical sample of the formations.

Corrosion	Any of a variety of complex chemical or electrochemical processes (except rust) by which metal is destroyed through reaction with its environment.
Drilling fluid	Any of a number of liquid and gaseous fluids and mixtures of fluids and solids (as solid suspensions, mixtures and emulsions of liquids, gases and solids) used in operations to drill boreholes into the earth.
Drilling Mud	Water-based drilling fluid
Evaluation	Includes mud logging, wireline logging, and formation evaluation while drilling, coring and well testing.
Exploration well	A well-constructed to explore for CSG, In this Guideline, the definition of exploration wells also applies to appraisal wells and gas monitoring wells.
Formation pressure	Force exerted by fluids in a formation
Frontier hole	An exploratory core hole, stratigraphic drill hole or exploration/wildcat drill hole in a frontier sedimentary basin with no nearby well, drilling, geologic or geophysical data to quantify the risks of a gas blowout
Groundwater	Water that occurs beneath the ground surface in the saturated zone
Horizontal well	Deviation of a borehole from vertical so that the borehole penetrates a productive formation in a manner parallel to the formation.
Hydraulic Fracturing ('fracking')	The process by which gas wells are 'stimulated' when water and chemicals are forced at great pressure into hydrocarbon-bearing formations to create a conductive flow path into the target formation resulting in enhanced flow of hydrocarbons to the wellhead.
Injection well	A well in which fluids are injected into an underground stratum rather than produced, the primary objective typically being to maintain or increase reservoir pressure; or to increase reservoir pressure or it may be to dispose of fluid such as salt water.
Kick	An entry of water, gas, oil or other formation fluid into the wellbore during drilling. It occurs because the pressure exerted by the column of drilling fluid is not great enough to overcome the pressure exerted by the fluids in the formation, thus causing flow.
Leak-off	The magnitude of pressure exerted on a formation that causes fluid to be forced into the formation. The fluid may be flowing into the pore spaces of the rock or into cracks opened and propagated into the formation by the fluid pressure.
Leak-off test	Progressive wellbore formation pressure test until leak-off to provide well integrity information. During the test, a real-time plot of injected fluid versus fluid pressure is plotted. The well designer must then either adjust plans for the well to this leakoff pressure, or if the design is sufficiently conservative, proceed as planned.
Liner	A casing string that does not extend to the top of the wellbore, but instead is anchored or suspended from inside the bottom of the previous casing string.
MSDS	Material Safety Data Sheet
Must	Is used when a standard is mandatory.
Offset well information	Near well information available from previous drilling in the immediate vicinity of the proposed well.
Operations	Any work conducted including rig moves, drilling, running and cementing casing, evaluation, completion, workover and abandonment.

Openhole	The uncased portion of a well. All wells, at least when first drilled, have openhole sections. While most completions are cased, some are open, especially in horizontal or extended-reach wells where it may not be possible to cement casing efficiently.
Packer	Piece of down hole equipment that consists of a sealing device. Used to block the flow of fluids through the annular space between pipe and the wall of the wellbore.
Production Casing	A casing string that is set across the reservoir interval and within which the primary completion components are installed.
Production zone	Hydrocarbon producing zone of the formation.
Pumping Time	Calculated time to mix, pump and fully displace cement slurry.
Seal	Cement grout mixture pumped into the bore.
Should	Is used when a standard is recommended as part of good industry practice.
Stratigraphic drill hole	Core or other slim holes primarily drilled for the purpose of recovering information about lithology, stratigraphy and geological structure
Surface	A natural ground surface or the top of the BOP flange when installed.
Surface Casing	Casing run from surface to suitably competent strata, fully cemented in position, and the connection point for blow out preventers used to seal off water/hydrocarbon sands to prevent loss of circulation. Also used to seal off water sands, weak formations and/or lost circulation zones. In some cases surface and intermediate casing requirements are provided by the same string.
Titleholder	The company or person with tenure over a petroleum lease.
Water bearing zone	Geological strata that are saturated with groundwater but not of sufficient permeability to be called an aquifer.
Well	A hole made by drilling in connection with exploration for coal seam gas or operations for the recovery of coal seam gas under the Petroleum (Onshore) Act 1991, but excludes holes used for the following purposes: (a) stratigraphic definition (b) seismic (shot holes) (c) water monitoring (d) environmental assessment where that use does not involve hydraulic fracturing or the recovery of coal seam gas. Includes appraisal wells, pilot wells, test wells and gas injection wells.
Wellhead	Means casing head, and includes any casing hanger or spool, or tubing hanger, and any flow control equipment up to and including the wing valves
Wellhead Reportable Leaks	An emission due to an unplanned release from a well site facility that, at a measurement distance of 150mm immediately above (and downwind) and surrounding the leak source in an open air environment above ground position; gives a sustained LFL reading greater than 10% of LFL for a 15 second duration. The following incidents/circumstances also fall under the definition: a) unplanned hydrocarbon gas release reported by the emergency services, a public authority or member of the general public; b) an unplanned hydrocarbon gas release resulting in an incident involving fire or injury c) an unplanned hydrocarbon gas release which receives media attention d) an unplanned release with the potential for significant escalation close enough to a building or other confined space and large enough that gas is likely to enter any building or confined space
Well Intervention	An operation carried out by re-entering an existing well.
Workover	Well procedure to perform one or more of a variety of remedial operations on a producing well to attempt production increase. Examples of workover operations are pump repairs, well deepening, plugging back, pulling and resetting liners, squeeze cementing and re perforating.

Appendix 2 - Contacts

The 'department':

The Division of Resources and Energy within the Department of Trade and Investment, Regional Infrastructure and Services. Go to the 'Contacts' link on the department's Coal Seam Gas web page:

<http://www.resources.nsw.gov.au/community-information/coal-seam-gas>

The Environment Protection Authority

<http://www.environment.nsw.gov.au/contact/>

NSW Office of Water (NOW):

<http://www.water.nsw.gov.au/About-us/Contact-Us/default.aspx>

The Department of Planning & Infrastructure:

<http://www.planning.nsw.gov.au/SettingtheDirection/Contactus/tabid/66/language/en-US/Default.aspx>

Appendix 3 - Industry Standards

Titleholders should also consider the following industry standards that may be appropriate for the application of this code of practice so as to manage well construction issues associated with the whole of life cycle requirements for CSM wells:

- API Recommended Practice 5A5/ISO 15463, Field Inspection of New Casing, Tubing, and Plain-end Drill Pipe
- API Recommended Practice 5B1, Gauging and Inspection of Casing, tubing and Line Pipe Threads
- API Recommended Practice 5C1, Recommended Practice for Care and Use of Casing and Tubing
- API Technical Report 5C3, Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing
- API Recommended Practice 5C5/ISO 13679, Recommended Practice on Procedures for Testing Casing and Tubing Connections
- API Recommended Practice 5C6, Welding Connections to Pipe
- API Recommended Practice 10B-5/ISO 10426-5, Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure
- API Specification 10D/ISO 10427-1, Specification for Bow-Spring Casing Centralizers
- API Recommended Practice 10F/ISO 10427-3, Recommended Practice for Performance Testing of Cementing Float Equipment
- API Technical Report 10TR2, Shrinkage and Expansion in Oilwell Cements
- API Technical Report 10TR3, Temperatures for API Cement Operating Thickening Time Tests
- API Technical Report 10TR5, Technical Report on Methods for Testing of Solid and Rigid Centralizers
- API Specification 13A /ISO 13500, Specification for Drilling Fluid Materials
- API Recommended Practice 13B-1/ISO 10414-1, Recommended Practice for Field Testing Water-Based Drilling Fluids
- API Recommended Practice 13D, Recommended Practice on the Rheology and Hydraulics of Oil-well Drilling Fluids
- API Recommended Practice 53, Blowout Prevention Equipment Systems for Drilling Operations
- API Recommended Practice 54, Occupational Safety for Oil and Gas Well Drilling and Servicing Operations
- API Recommended Practice 59, Recommended Practice for Well Control Operations API Specification 16C, Choke and Kill Systems
- API Specification 16D, Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment
- API Specification 16RCD, Drill Through Equipment (Rotating Control Devices)
- API Specification 16ST, Coil Tubing Well Control Equipment Systems
- ANSI/API Specification 15LR, Low Pressure Fibreglass Line Pipe and Fittings

- ANSI/API Specification 15R, High Pressure Fibreglass Line Pipe
- ASTM D2996-01 (2007)e1 Standard Specification for Filament-Wound “Fibreglass” (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe
- ASTM D2310 - 06 Standard Classification for Machine-Made “Fibreglass” (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe
- ASTM D2517 – 06 Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
- AS/NZS 1477-1999 PVC Pipes and Fittings for Pressure Applications
- AS 2634 – 1983 Chemical Plant Equipment – Made from Glass-Fibre Reinforced Plastics (GRP) Based on Thermosetting Resins

These standards and specifications are listed as a reference and should be used as and where appropriate to the overall management of integrity of CSM wells.

