GasFields Commission Queensland

Onshore Gas Well Integrity

in Queensland, Australia

Technical Communication 4

July 2015

About GasFields Commission Queensland

The GasFields Commission is the independent statutory body formed to manage and improve sustainable coexistence between rural landholders, regional communities and the onshore gas industry in Queensland, Australia.

The Commission's formal powers and functions are enshrined in the GasFields Commission Act 2013 which took effect from 1 July 2013. These include: review and provide advice on the effectiveness of legislative frameworks for the onshore gas industry; encourage factual information and scientific research to help address concerns about the potential impacts of the onshore gas industry on water and other resources; and level the playing field in land access and compensation negotiations between landholders and gas companies through more and better information.

For more information visit the GasFields Commission website at www.gasfieldscommissionqld.org.au

About this Technical Communication

One of the Commission's key functions is to obtain and publish information that can assist in improving knowledge and understanding about the onshore gas industry including its interactions with, and impacts on, rural landholders and regional communities.

The Commission's technical communications aim to fill a gap in information between the simple fact sheet and the full technical reports or scientific papers. They provide an easy to read collation of the science and draw on technical material from a range of sources including CSIRO, universities, Australian and Queensland Government departments, independent technical specialists and scientific experts, and Queensland's onshore gas industry.

Disclaimer

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Introduction

Well integrity ensures that fluids produced by onshore gas wells (i.e. gas and/or water from underground geological formations) are contained in such a way as to protect the environment and assure the safe flow of gas to the surface. For many years, well integrity has been a major focus for continuous improvement in the gas industry, both nationally and internationally; it is "*... a product of local regulation, technology and prevailing operational culture*" (Thorogood and Younger, 2014: p671).

In Queensland, 'conventional gas' comes from gas reservoirs in geological formations that don't initially need stimulation technologies to unlock their potential. Gas reservoirs found in other types of geological formations including coal seams, shale and tight gas formations are commonly referred to as 'unconventional gas' (IEA, 2015).

To access the target gas reservoirs, gas wells are drilled through layers of geological formations which are categorised either as a relatively permeable groundwater aquifer or an impermeable aquitard. Therefore, ensuring well integrity and the isolation of shallow groundwater aquifers from deeper gas bearing geological formations is of prime importance to rural landholders, regional communities, regulators and the onshore gas industry.

Onshore Gas Wells in Queensland

History of the Conventional Gas Industry

There is a long history of conventional onshore gas production in Australia. Gas production in Queensland dates back to the early part of the 20th century when several wells in the Surat Basin produced gas that was utilised in Roma (Roma Gas Supply, 1906). During the 1960s, gas wells drilled in the Surat Basin supplied both retail and industrial customers in Brisbane via a pipeline from Roma. In the 1970s, gas production began in the Cooper Basin to supply gas customers in Sydney and Adelaide.

At the end of 2014, there were over 400 wells producing conventional gas in Queensland, some dating back decades (DNRM, 2015a) and more than 1,800 conventional wells have now been drilled in the Cooper Basin which straddles the South Australia, Queensland boundary (DMITRE, 2015a). Over 700 wells have been safely hydraulically stimulated in the Cooper Basin since 1969 (DMITRE, 2012).

No reports have been found of a failure of subsurface well integrity in conventional gas wells, leading to groundwater contamination in Queensland. Furthermore, in general the early gas wells were drilled and completed to comply with the standards of the day. These standards have been progressively improved both nationally and internationally and current approaches are outlined below.

Growth of the CSG Industry

Exploration for coal seam gas (CSG) in Queensland commenced in the late 1970s and by 1990 around 30 CSG-specific wells had been drilled in the Bowen Basin. By 1995, approximately 160 wells had been drilled, again mostly in the Bowen Basin, with commercial production commencing in 1996 for the domestic market. Gas production from coal seams in Queensland has therefore been occurring for around 19 years with a significant experience base established. The industry was also well established in the US by 2000 with over 14,000 producing CSG wells (also known as coal bed methane wells).

In Queensland, by 2010/11, approximately 1,000 CSG wells were producing gas, at which time the three major CSG-LNG projects received approval. By 2014, the cumulative total was around 3,522 producing CSG wells (DNRM, 2015). The vast majority of these wells were drilled under the *Petroleum Act (1923)* and the *Petroleum and Gas (Production and Safety) Act (2004)*, consistent with the regulations and codes pursuant to those Acts.

Gas Well Design

Conventional, Shale and Tight Gas Well Design

Operating Environment

While operating pressures and fluid types and some operations may be different, from a well integrity perspective shale and tight gas well design and construction is inherently the same as for conventional gas wells. Conventional, shale and tight gas wells tend to be significantly deeper than CSG wells, ranging from 2,000 to 4,000 m underground (DNRM, 2015a & 2015b). This means they are significantly deeper than most groundwater resources. As gas wells may pass through shallow aquifers, this highlights the importance of well design, maintenance and monitoring to ensure well integrity.

Design & Process

Drilling begins from the surface and as each section is drilled deeper underground, layers of casing and cement are installed to ensure groundwater aquifers are isolated from the deeper gas reservoirs (Figure 1).

Once the gas well is completed, the gas typically flows through the *casing perforations*, into the *production tubing* and up to the surface. If any water is produced from the gas reservoir, it usually happens later in the lifecycle of the well and the water will flow to the surface through the same *production tubing* as the gas. The space between the *production tubing* and the *cemented production* casing is the *main annulus*. The *main annulus* is isolated from the gas and water flowing up the *production tubing* by a *sealing packer,* a device that is designed to completely seal-off the *main annulus*.

Conventional, shale and tight gas wells operate at greater depths and therefore higher operating pressures and with more casing layers than CSG wells. Though the main design difference in conventional, shale and tight gas wells is that the flow of gas and water is restricted to the *production tubing* (only), which is isolated from the *annulus* by installing *sealing packers* (see below for flow within CSG wells).

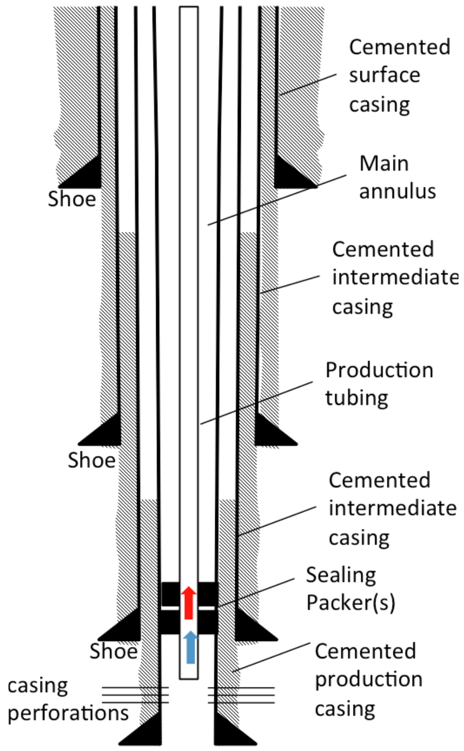

Figure 1: Simplified Well Design
Source: UQ, 2015

CSG Well Design

Operating Environment

Compared with conventional, shale and tight gas wells, CSG wells are relatively shallow (typically 350 to 1,000 m) and are subject to significantly lower pressures and temperatures. Furthermore, unlike conventional gas wells, gas in coal seams is not immediately free to flow towards the well. Rather gas is found adsorbed onto the surface of the coal, held there by the natural pressure of the water in the pores of the coal (GA, 2012). This means that the coal seam has to be depressured before the gas can flow into the gas well.

Design & Process

Water is extracted from the coal seam to reduce the pressure in the coal seam. The pressure reduction causes the gas to be released from the surface of the coal and flow towards the well.

This means that early in the lifecycle of a CSG well, it produces a mixture of gas and water. The gas and water separate downhole and the water is pumped up the *production tubing*, while most of the gas flows naturally up the *main annulus* which is the space between the *production tubing* and the *cemented production casing* (Figure 2). So the separate phases (gas and water) take separate paths up the CSG well to the surface.

Note that in agricultural water bores, the water may also be pumped up a central tubing, like in coal seam gas wells. In agricultural water bores, if there is any gas naturally occurring in the groundwater aquifer, either because there are coals within the aquifers or because it is naturally dissolved in the groundwater, then these wells can also produce some gas in response to pumping (depressurisation) (Walker and Mallants, 2014).

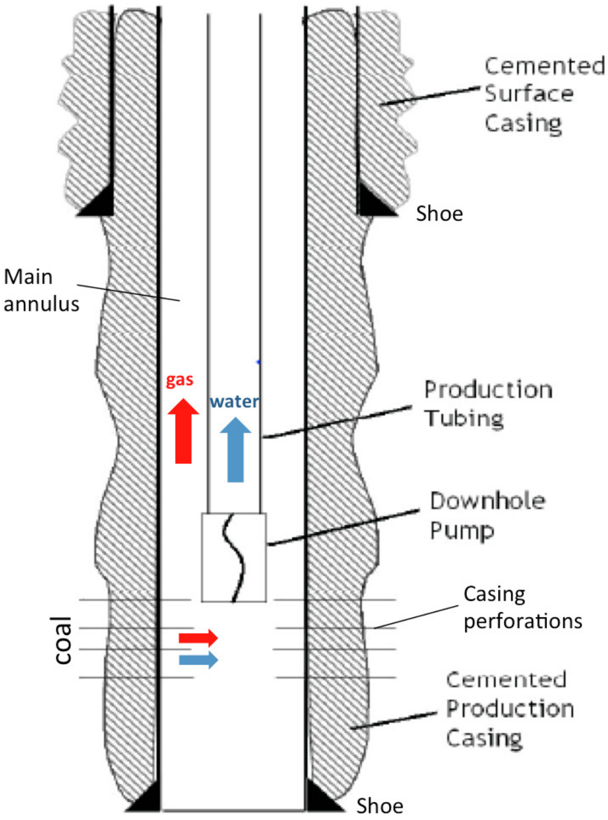

Figure 2: CSG Well Design
Source: adapted from APLNG, 2015

Gas Well Integrity

What is well integrity and why is it important?

The basic function of any gas well is to transport gas from the underground geological formation in which the gas naturally resides (the gas reservoir) up to surface. The objective is to do this without fluids leaking into the surrounding environment and while isolating geological formations, including groundwater aquifers.

Well integrity can be described in terms of both (a) the physical condition of the well (i.e. does it meet the design standards for the various components) and (b) the function of the well (i.e. is it containing and preventing the escape of groundwater and/or gas to the subsurface or surface environments).

The Norwegian NORSOK standard D-010 is widely accepted and defines 'Well Integrity' with respect to fluids from geological formations as the:

"Application of technical, operational and organisational solutions to reduce risk of uncontrolled release of formation fluids throughout the life cycle of a well".

This definition has four main important features, which are all reflected to varying degrees in the relevant Queensland legislation and regulation which are backed up by national and international industry standards (e.g. DNRM, 2013: Appendix 2):

1. The goal of managing well integrity is risk reduction (in most cases to "as low as reasonably practicable" or ALARP).
2. The risk which is to be reduced is of 'uncontrolled release' of formation fluids. It is important to note that the term 'uncontrolled release' does not indicate the fluid type (water or gas), the rate of loss nor the total volume released. It should also be noted that an incident recorded as a 'loss' of well integrity, based on the NORSOK definition, does not necessarily indicate that there has been any environmental harm.
3. Risk reduction is to be achieved across three domains:
   a. Technical (design); and
   b. Operational (construct, maintain, monitoring, decommissioning), and
   c. Organisational (including skills & training, roles, responsibilities & accountabilities)
4. Assessment and management are to be considered across the full life cycle – from site selection and drilling to operations, and, final decommissioning and site remediation.

In practice, therefore, managing well integrity well, through a full life cycle from design to decommissioning includes a number of specification and verification steps at each stage. It also includes monitoring plans, routine inspections and scheduled maintenance, underpinned by international engineering standards, internal management control systems and a focus on staff training. All of this is governed by detailed State regulations (Figure 3).

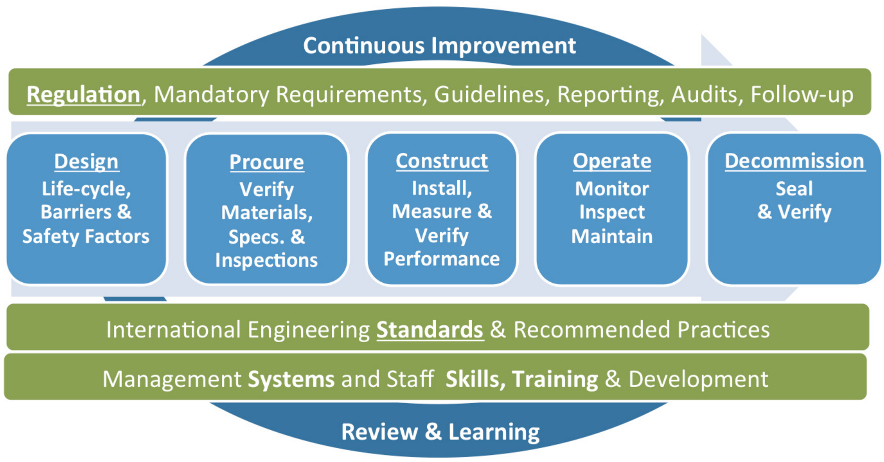

Figure 3: Key Elements of the Full Life Cycle of Well Integrity Management
Source: UQ, 2015

CSG Well Integrity in the Queensland Code

In Queensland, CSG wells are built according to the *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (DNRM, 2013) which is based on a number of international standards and best practice guidelines.

Specifically, the purpose of the Code is "*to ensure that all CSG wells and CSG water bores are constructed and abandoned to a minimum acceptable standard resulting in long term well integrity, containment of gas and the protection of groundwater resources*" (DNRM, 2013: p1).

The Code specifically focuses on two stages of well life: (i) construction, and (ii) decommissioning (commonly called 'abandonment' in the gas industry), though it also includes Principles and Mandatory Requirements for Well Monitoring and Maintenance for the productive life of the well. The Code also includes additional requirements for wells which are to be hydraulically stimulated and references API Guidance Document HF-1. (DNRM, 2013).

Within those stages, the Code describes, recommends and mandates minimum acceptable standards relating to equipment and material selection, risk assessment (both safety and environment), industry practices, management, monitoring and reporting – these are Mandatory Requirements "*... that are enforceable by the regulator and must be complied with*" (DNRM, 2013: p3).

Mandatory Requirements (MRs) cover both design and testing requirements in Queensland. In addition to many good industry practices, the Code includes 60 MRs in 10 areas:

1. Well Design (7)
2. Casing (7)
3. Cementing (14)
4. Wellheads (2)
5. Well control equipment (10)
6. Drilling fluids (2)
7. Evaluation, logging, testing and coring (4)
8. Well monitoring/maintenance (2)
9. Well abandonment (10)
10. Recording and reporting data (2)

What happens if gas well barriers fail?

Wells are designed with a view to the operating environment in which they are located and to have a design life longer than the expected duration of gas production (Miskimins, 2008 and DNRM, 2013: Appendix 2). In rare cases, some well components including barriers (casing and cement) may become degraded (e.g. through natural corrosion or damage) (King and King, 2013).

Most single barrier breaches do not lead to uncontrolled releases to the environment, but act as a warning sign that corrective or further preventative action is required (King and King, 2013).

For well integrity to be lost, full barrier failure and uncontrolled flow must occur. Barrier failure does not automatically lead to outward flow from the well to the surrounding geological formation. In some cases, pressure in the well may be lower than in the surrounding geological formation and an in-flow of water may occur. While this does not cause a release from the gas well to the surrounding environment, it is undesirable as it may cause additional corrosion later on (King and King, 2013).

In cases where an integrity breach does lead to fluid (gas or water) leaking from the well, the amount of the leak, the fluid type and the sensitivity of the receiving environment will govern the amount of environmental harm caused.

Under the *Queensland Petroleum and Gas (Production and Safety) Act 2004* an Operator is ultimately responsible for repairing or decommissioning a well (as directed by the State regulator). Under conditions imposed under the *Queensland Environmental Protection Act 1994* which includes a *'general environmental duty'*, the Operator is responsible for remediating any local environmental damage (as defined by the State regulator) caused by a failure of well integrity.

CSG Well Integrity Testing and Monitoring

Well Testing During Construction

As outlined previously, there are many Mandated Requirements (DNMR, 2013) and good industry practices used to ensure well integrity and the protection of groundwater aquifers in the design phase. However, several tests are run during and after well construction to verify the integrity of gas wells. Key examples of these tests are summarised below.

Casing Pressure Testing

The casing must be selected and defined with appropriate safety margins. Additionally, to verify casing integrity during the well construction process, it must be pressure tested prior to drilling out the next section to install surface or intermediate casings, and, prior to completing the well with production casing. The test pressure must be greater than the maximum anticipated pressure (but not exceed the casing burst pressure rating). Waiting on cement setting prior to drilling out the next section is mandated to achieve the specified minimum compressive strength.

Cement Evaluation Tool

'Cement bond logging' consists of a tool that moves up the gas well, inside the casing sending out sound waves to the casing and cement, and measuring how much sound is reflected back. If the cement is properly bonded to the casing and to the geological formation, the cement absorbs the sound waves and less sound comes back to be measured. If cement bonding is poor, more sound waves are reflected back to the receiver. So if the receiver hears high sound being reflected back, the cement job may be poor and may not be properly isolating the geological formations from each other. In this case, the cement bond must be remediated by squeezing additional cement into the gap between the casing and the geological formation. The cement bond log evaluation is run when necessary on each well until repeated testing demonstrates that the cement is properly bonded to the casing (Schlumberger, 2007).

If cementing operations do not verify the isolation of geological formations, a statutory notification must be sent to the Queensland, Department of Natural Resources and Mines (DNRM) Petroleum and Gas (P&G) Inspectorate (DNRM, 2013).

Well Monitoring During Operations

In addition to engineering standards and testing during construction, regular checks are carried out during the operational life of a well to ensure that integrity is maintained. This includes internal and external inspections for corrosion, inflow tests of well head valves and gas detection under the gas company's Well Operating Plan.

In the case of CSG, any underground leaks would most likely be either methane gas (which may also be found naturally in shallow aquifers) or coal seam water (which will likely be of a higher salinity than water found in shallow aquifers). Typically wells are monitored and regularly checked, therefore significant leakage rates would be detected as a pressure or flow-rate loss at the surface. In such cases wells can be quickly shut down (often remotely) and/or repairs undertaken (e.g. Arrow, 2011 & QGC, 2012).

By the end of 2015, the Queensland P&G Inspectorate will also undertake audits of gas company Well Operating Plans to assure their suitability for managing the integrity of a company's well-stock.

The *Queensland Petroleum and Gas (Production and Safety) Regulation 2004* also includes a mandatory standard, known as the *Code of Practice for coal seam gas well head emissions detection and reporting* (DNRM, 2011). This code, which is based on the stringent standards applicable in an urban environment (AS/NZS: 4645.1:2008), adopts a very conservative approach to reporting as well as a standardised measurement method. Therefore higher levels of reporting may not be indicative of greater risk, rather, they may be a result of the more stringent reporting standards applied to CSG wells compared to conventional wells historically drilled in Queensland.

Well head leaks are inherently limited in size and duration, and, are relatively easy to detect and repair. The *Code of Practice for well head emissions detection and reporting* stipulates that well head leaks resulting in gas concentrations above a specified level (10% of the lower flammable limit) are 'reportable' leaks and must be reported immediately to the P&G Inspectorate. All other 'minor' leaks are required to be reported annually (DNRM, 2011).

Good industry practice requires that well head seal tests (positive pressure tests) are undertaken not just at installation but also during later well interventions, work-overs and repairs. Well control equipment for drilling is also function and pressure tested (API Standard 53) (DNRM, 2013).

Well Testing During Decommissioning

When decommissioning a CSG production well, a cement plug must be set inside the casing as close as practical above the uppermost producing coal seam. This plug must be pressure tested to a mandated value which ensures that the cement seal is tight enough to prevent gas and/or water from leaking into the decommissioned well. The physical strength of the cement plug must also be tested, verifying it can hold 1,000 kg of weight (DNRM, 2013).

CSG Well Integrity Compliance and Auditing

In July 2015, the P&G Inspectorate, in response to queries from the GasFields Commission Queensland, advised that from 2010 to March 2015, 6,734 CSG exploration, appraisal and production wells had been drilled in Queensland. Well integrity related statistics collected by the P&G Inspectorate during that period are discussed below.

Subsurface Gas Well Compliance

According to the P&G Inspectorate, no leaks have been reported to date for subsurface equipment. This is consistent with recent scientific field measurements which found, in a sample of 43 wells "*...no evidence of leakage of methane around the outside of well casings...*" (Day et al, 2014: p2).

There have been 21 statutory notifications (a rate of 0.3%) under the well construction code concerning suspect downhole cement quality during construction. For all of these 21 notifications, the gas companies followed up with subsequent testing to assess well integrity and determine any remedial work. The P&G Inspectorate followed-up on all 21 notifications to ensure that the tests, and any required remediation work, conducted on the well was successful before gas production commenced, with the company also having appropriate monitoring programs in place to ensure ongoing integrity of the well.

The ultimate cementing 'failure' rate *after* testing, remediation, and follow-up according to the Code has thus been 0%. The likelihood and therefore risk of a subsurface breach of well integrity is thus assessed to be very low to near zero.

By comparison, a recent review by King and King (2013) of the data from 253,090 wells in Texas found that only 4 in every 100,000 (0.004%) wells constructed to modern standards experienced a loss of well integrity, compared to 0.2% for older wells.

Surface Well Head Compliance

Wells which have been drilled but have not been put into production, do not have gas flow at the well head and in these cases, well head emissions cannot generally occur. Of the total number of CSG wells drilled, approximately 3,500 wells were actively producing by the end of 2014 (DNRM, 2015).

Since 2010, 199 'reportable' surface well head leaks have been reported to the P&G Inspectorate under the Code. All of these well head leaks were subsequently fixed according to the P&G Inspectorate.

This reporting is consistent with recent research which found that small 'equipment leaks' were relatively common (and often easy to repair) (Day et al, 2014: p35-36).

The P&G Inspectorate is currently developing a new annual reporting online form to improve the quality and consistency of data received from the onshore gas industry.

Inspections and Audits

In addition to the statutory notifications, the DNRM P&G Inspectorate conduct both planned and random inspections of gas wells on a regular basis.

In the 2014 calendar year, the P&G Inspectorate conducted 283 planned and unplanned inspections of gas wells which included testing for leaks from well heads at the surface. As a result, issues were identified on 84 well heads. The P&G Inspectorate subsequently followed up on the identified issues with the gas companies and ensured all issues were rectified.

The P&G Inspectorate is initiating audits of the gas companies' Well Operating Plans as part of their 2015-16 Compliance Program. Any issues identified during the audits will be actioned by the P&G Inspectorate and followed up in due course.

Conclusion

Gas wells are designed to ensure that gas and water from one geological formation is not allowed to escape to the atmosphere or to any other geological formation below the surface.

Well integrity is achieved by creating a barrier (or barriers) using cement and casing to isolate geological formations in the subsurface, and, a series of seals and valves at the well head.

Various national and international codes and standards have been developed to ensure that wells are constructed to minimise the risk of well integrity failure. Each barrier is tested using pressure tests and cement evaluation tools to verify that integrity is achieved and maintained.

No subsurface leaks have been reported for CSG wells in Queensland. Cementing operations which do not verify the isolation of geological formations have only been reported for 0.3% of wells drilled. All wells were successfully remediated during construction with additional monitoring put in place. The likelihood and therefore risk of well integrity failure resulting in underground leakage is assessed to be very low to near zero. Even so, ongoing monitoring during gas operations is designed to detect fluid leakage and trigger the shut down or repair of a well.

Well head leaks have been more common, though stringent standards have been implemented to detect and ensure the reporting and repair of these leaks which tend to be of limited duration.

Both industry and government have comprehensive monitoring, reporting and auditing programs to regularly check that wells are being maintained according to the required standards.

The system of standards and procedures, and, the type and degree of regulatory oversight is undergoing continuous improvement.

Summary

1. Well integrity refers to the design, construction, operation and monitoring of onshore gas wells to ensure that the gas and/or water produced from underground geological formations are contained in such a way as to protect the environment and assure the safe flow of gas to the surface.
2. Conventional, shale and tight gas wells operate at greater depths and therefore higher operating pressures and with more casing layers than coal seam gas (CSG) wells. They are significantly deeper than most groundwater resources, though in some cases they must pass through shallow aquifers. This highlights the importance of well design, maintenance and monitoring to ensure well integrity and protect groundwater aquifers.
3. CSG wells are relatively shallow (typically 350 to 1,000 m) and are subject to significantly lower pressures and temperatures. Unlike conventional gas wells, gas in coal seams is not immediately free to flow towards the well. This means that the coal seam has to be depressurised before gas can flow into the gas well.
4. Natural gas production from coal seams in Queensland has been occurring for almost 20 years. By 2014, there were around 3,522 producing CSG wells drilled under the Petroleum Act (1923) and the Petroleum and Gas (Production and Safety) Act (2004), consistent with the regulations and codes pursuant to those Acts.
5. CSG wells are built according to the Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland. The Code includes 60 Mandatory Requirements across 10 areas from gas well design, construction, operations, testing and decommissioning.
6. Several tests are run during and after well construction to verify the integrity of gas wells such as case pressure testing and cement evaluation testing. In addition, regular checks are carried out during the operational life of a well to ensure that well integrity is maintained.
7. In practice, managing well integrity well, through a full life cycle from design to decommissioning includes a number of specification and verification steps at each stage such as monitoring plans, routine inspections and scheduled maintenance, underpinned by international engineering standards, internal management control systems and staff training.
8. In Queensland, auditing and inspection activities for onshore gas wells are carried out by the State Government regulator.

Glossary

Term	Definition
Aquifer	A saturated underground geological formation or group of formations, that can store water and yield it to a bore or spring. A saturated formation that will not yield water in usable quantities is not considered an aquifer.
Aquitard	A geological formation that prevents significant flow of water, e.g., clay layers or tight deposits of shale; geological material of a lower permeability.
Coal Seam Gas	Coal seam gas (CSG), also known as coal bed methane, is a form of natural gas typically extracted from coal seams at depths of 300-1000 metres. CSG is a mixture of a number of gases, but is mostly made up of methane (generally 95-97 per cent pure methane). It is typically attached by adsorption to the coal matrix, and is held in the coal by the pressure of formation water in the coal cleats and fractures.
Conventional Gas	Natural gas which is produced from conventional gas reservoirs i.e. gas reservoir which are not “unconventional” (shale, or coal seams or low permeability sandstones). Note that some conventional reservoirs are hydraulically stimulated to improve flow rates.
Gas Reservoir	Any geological formation from which natural gas is produced – a gas reservoir may be either conventional or unconventional.
Geological Formation	A sediment or rock, or group of sediment or rocks. Geologists often group rocks of similar types and ages into named formations.
Risk	The combination of the likelihood of a something occurring and the consequence of it. This can be expressed as percentages or odds. For example, the lifetime odds of having a heart attack are estimated to be around 1 in 5, a car accident leading to serious injury or death is around 1 in 10, while shark attack may be closer to 1 in 60,000 (DMITRE, 2015).
Unconventional Gas	Natural gas which is produced from unconventional reservoirs i.e. from coal seams or from shale, or from tight, low permeability sandstones. Note that in the case of the latter two, hydraulic stimulation is required to produce economic flow rates (it is not always required in coal seam gas reservoirs).

References

API Guidance Document HF1, Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines. www.api.org/

API RP 10B-2. American Petroleum Institute Recommended Practice 10B-2. Recommended Practice for Testing Well. www.api.org/

API Spec 5CT. American Petroleum Institute Specification 5CT - Specification for Casing and Tubing. www.api.org/

API Spec 6A. American Petroleum Institute Specification 6A - Specification for Wellhead and Christmas Tree Equipment. www.api.org/

API Spec 10A. American Petroleum Institute Specification 10A - Specification for Cements and Materials for Well Cementing. www.api.org/

API Standard 53. American Petroleum Institute Standard 6A - Blowout Prevention Equipment Systems for Drilling Wells.

Arrow. (2011). Well Integrity: what you need to know. Retrieved June 2015. https://www.arrowenergy.com.au/__data/assets/pdf_file/0013/1273/Well-Integrity.pdf

AS/NZS: 4645.1:2008. Australia and New Zealand Standards number 465.1-2008 'Gas Distribution Network - Network Management'. www.asnzs.org/

Day, S., Dell'Amico, Fry, R., Javanmard Tousi, H., (2014). Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities. CSIRO, Australia

DNRM. (2011). Code of Practice for coal seam gas well head emissions detection and reporting. Version 2 – June, 2011. Department of Natural Resources and Mines, Queensland Government.

DNRM. (2013). Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland. Edition 2.0. October, 2013. Department of Natural Resources and Mines, Queensland Government.

DNRM. (2015a). Queensland Government data. Web site accessed June, 2015; https://data.qld.gov.au/dataset?q=oil&sort=score+desc%2C+metadata_modified+desc

DNRM. (2015b). Queensland Government, Department of Natural Resources and Mines. Web site accessed June, 2015; https://www.dnrm.qld.gov.au/mining/deep-gas-oil-qld

DMITRE. (2015a). Government of South Australia, Department of State Development. Web http://petroleum.statedevelopment.sa.gov.au/prospectivity/basin_and_province_information/prospectivity_cooper. Site accessed June, 2015.

DMITRE. (2015b). Government of South Australia, Department of State Development. http://www.petroleum.dmitre.sa.gov.au/prospectivity/basin_and_province_information/unconventional_gas/frequently_asked_questions/south_east_unconventional_gas_faq, Web Site accessed June, 2015.

DMITRE. (2012). Roadmap for Unconventional Gas Projects in South Australia (Chapter 11). Government of South Australia publication. Web site accessed, June 2015. http://minerals.statedevelopment.sa.gov.au/__data/assets/pdf_file/0008/238175/Roadmap_Chapter_11.pdf

GA. (2012). Geoscience Australia. Coal Seam Gas Fact Sheet. Web site accessed June, 2015. http://www.australianminesatlas.gov.au/education/fact_sheets/coal_seam_gas.html

King GE and King DE. (2013). Environmental risk arising from well construction failure: Difference between barrier and well failure, and estimates of failure frequency across common well types, locations and well age. SPE 166142 Production and Operations 28:323–324.

IEA. (2015). International Energy Agency. FAQa: Natural Gas. www.iea.org/aboutus/faqs/naturalgas/. Site accessed June, 2015.

Miskimins, J. L. (2008). Design and Life Cycle Considerations for Unconventional Reservoir Wells. Society of Petroleum Engineers (SPE-114170-MS). doi:10.2118/114170-MS

NORSOK. (2013). Norwegian petroleum industry standard. D-010 Well integrity in drilling and well operations (Rev. 4, June 2013). www.standard.no/en/sectors/energi-og-klima/petroleum/norsok-standards/

PSAC. (2013). Petroleum Services Association of Canada public outreach program. 'How the Oil Patch Works'. November 2013. www.oilandgasinfo.ca/wp-content/uploads/Nov_2013_conv_vs_unconv.pdf. Site accessed, June 2015

Queensland Petroleum Act, 1923. Current as at January 2015. https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/P/PetrolmA23.pdf

Queensland Petroleum and Gas (Production and Safety) Act 2004. Current as at January 2015. https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/P/PetrolmGasA04.pdf

Queensland Environmental Protection Act 1994. Current as at July 2015. https://www.legislation.qld.gov.au/legisltn/current/e/envprota94.pdf

QGC. (2012). Monitoring & Rehabilitation. Retrieved, June 2015.

http://www.qgc.com.au/qclng-project/in-the-surat-basin/drilling-gas-wells/monitoring-rehabilitation.aspx

Rigzone. (2015). Training: How Does Cementing Work. Retrieved June, 2015. http://www.rigzone.com/training/insight.asp?insight_id=317&c_id=1

Roma Gas Supply. (1906, May 24). The Brisbane Courier (Qld. : 1864 - 1933), p. 4. Retrieved July 19, 2015, from http://nla.gov.au/nla.news-article19451270

Schlumberger. (2007). Cement Bond Logging Tools Product Sheet. Retrieved June 2015. http://www.slb.com/~/media/Files/production/product_sheets/well_integrity/cement_bond_logging_tools.pdf

Thorogood, J. L., & Younger, P. L. (2015). Discussion of "Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation" by RJ Davies, S. Almond, RS, Ward, RB Jackson, C. Adams, F. Worrall, LG Herringshaw, JG Gluyas and MA Whitehead.(Marine and Petroleum Geology 2014). Marine and Petroleum Geology, 59, 671-673.

Walker, Glen R., and Mallants, Dirk (2014). Methodologies for Investigating Gas in Water Bores and Links to Coal Seam Gas Development. CSIRO, Australia