The Elgin Wellhead Platform blowout 25 March 2012

Events surrounding the blowout and actions taken in response to this and similar incidents

Contents

Introduction

This report was produced by the Health and Safety Executive's (HSE's) Energy Division. It provides an overview of the events leading to the blowout from well 22/30c-G4 on the Elgin Wellhead Platform on 25 March 2012.

It also looks at how the worldwide industry has responded to loss of well control events before this incident – the Montara incident in the Timor Sea, Australia, in 2009 and the Macondo incident in the Gulf of Mexico in 2010.

The report describes the actions taken by HSE and industry to learn from these incidents and to improve management of major accident hazard risks by the offshore oil and gas industry.

A diagram of a typical well construction, and a glossary at the end of the report, will help people understand how and why the incident occurred.

Overview of the Elgin blowout

Background

The Elgin G4 well was drilled in 1997 and started producing in 2001. It was one of 11 high-pressure, high-temperature (HPHT) wells on Total E&P UK Ltd's Elgin Wellhead Platform.

From 2004 onwards, sustained casing pressure was evident in the A annulus, which is an indicator of potential problems with well integrity. If sustained casing pressure (SCP) is not managed correctly it has the potential to result in the casings being over-pressurised, which can result in loss of containment and ultimately a surface or sub-sea blowout.

In the HPHT areas of the North Sea, including Elgin's location, the hydrocarbon-bearing Hod Formation (between the depths of 11,000 and 13,000 ft) presents additional well engineering challenges. There is the potential for hydrocarbons to flow from the Hod Formation into the well annuli through damaged casings and/or a poor cement bond, such as a micro-annulus between the casing and the formation (see Figure 1 on the next page).

In 2005, eight years after the G4 well was drilled, all three annuli were exhibiting SCP. In line with standard industry practice, Total instituted a programme of bleeding-off pressure from the annuli to maintain them within defined safe operating windows. Total referred to this as an annulus management system. This was permanently implemented as a result of annuli pressures but was not originally part of the installation design.

Total's actions

In March 2010 Total attempted to reduce the influx of Hod hydrocarbons into the A annulus by using a volumetric kill process. This process stabilised the annulus pressure until July 2010 when pressure in the A annulus again began to build and continued to increase.

From October 2010 to October 2011, Total continued to bleed-off the A annulus with increasing frequency, in excess of Total's recommended frequency of one test per month. This increased frequency was increasing the risk to the integrity of G4, as the process increases the pressures seen in the annulus and so can rapidly escalate the seriousness of the problem.

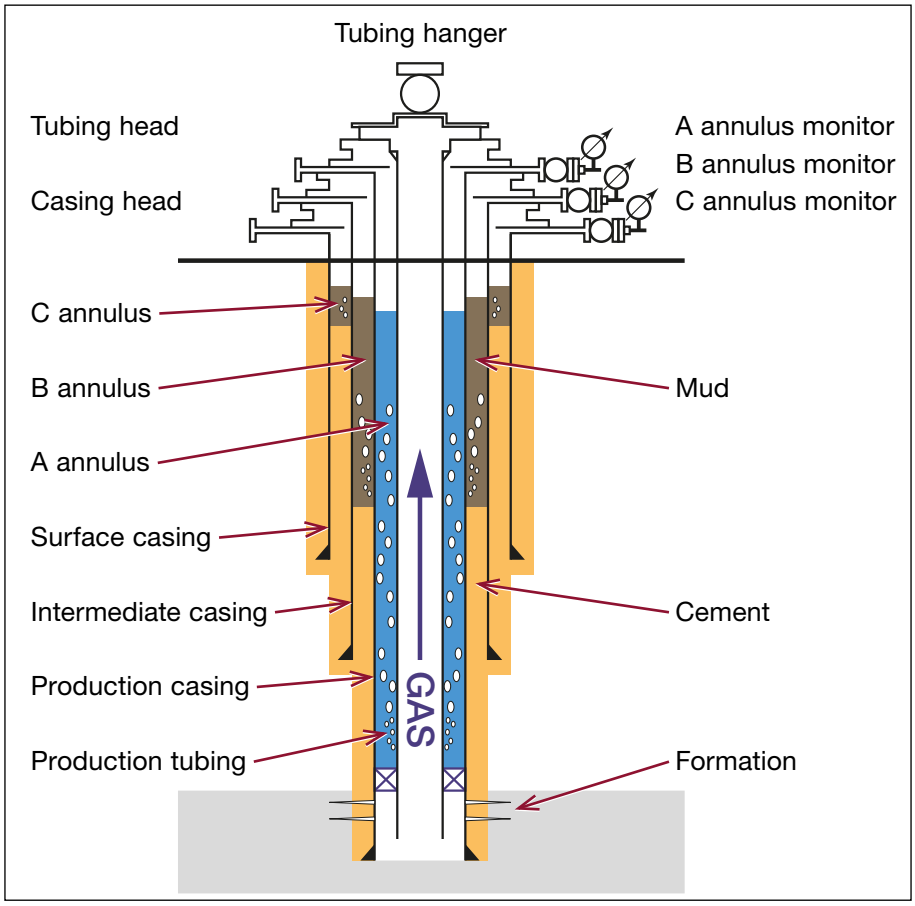

Figure 1 Typical well construction

In addition, the annulus cement sealing integrity may be damaged by pressure cycling if an excessive number of pressure bleed-down/build-up tests are conducted. These tests may cause tensile stress cracking in the cement. These stress induced cracks may substantially increase the flow rate and volume of formation fluids feeding sustained casing pressure in the annulus. By the start of 2012 the pressure in well G4's A annulus had increased to the point that any failure of the A annulus would immediately threaten to over-pressurise the B and C annuli. On 25 February 2012 the production and intermediate casings in well G4 failed, allowing pressure and hydrocarbons to flow across the three annuli.

The situation was being monitored by Total's management team onshore, who were concerned that the rate of pressure increase in the C annulus gave them approximately 100 minutes before a blowout could occur. At this point, Total were considering down-manning both the Elgin platform and Rowan Viking drilling rig. Meanwhile, Total had managed to bleed down the C annulus and stabilise the pressure. Consequently, Total then decided not to down-man, or halt production from the remaining wells.

Total convened a G4 well taskforce to plan and manage the well kill process. The well kill began on 15 March 2012, 19 days after the failure of the production and intermediate casings. However, the operation did not go according to plan and control of well G4 was progressively lost.

On 25 March 2012, pressure rises caused failure of the surface casing, leading to blowout of well G4.

Following the well G4 blowout, Total called in specialist contractors, Wild Well Control Operations, to work with themselves to plan, manage and execute the well kill of G4.

The operation of the flare during the release

The operation of the flare during the release has been the subject of discussion. Total's G4 well taskforce, which convened to plan and execute the original well kill, considered that:

- the Hod Formation remained a tight (ie impermeable) formation and would not flow large volumes of hydrocarbons;
- a surface blowout could not occur.

This meant that the worst-case scenario, a blowout, was not identified. There is no evidence recording the reasons for these decisions and Total did not halt production from the remaining wells.

Once Total made the decision not to halt production of other wells, the flare had to remain lit, as this was part of the mitigation system for the producing wells.

Relevant other incidents and the responses to them

During the time Total was operating well G4 there were two significant blowout incidents – the Montara incident in the Timor Sea, Australia, in 2009 and the Macondo incident in the Gulf of Mexico in 2010. In both cases there was an unexpected influx of well fluids (kick) and loss of hydrocarbons (blowout).

International regulators, including HSE, and the industry world-wide were already working to identify lessons learned from these incidents at the time of the Elgin blowout.

In the UK, an independent review (the Maitland Review), was established to consider the findings from official reports into the Montara and Macondo incidents, and to determine whether they might inform any modification or improvement to the UK regulatory regime.

The Maitland Review published a report, in December 2011, which found that the UK regime already incorporated several positive key features which were not present in the US at the time of the Macondo incident. However, the Review identified areas where improvement could be made.

Some of the initial actions arising from the lessons learned were:

- an increased level of peer review of well design assessment for deepwater wells and auditing of safety case acceptance decisions for mobile offshore drilling units;
- creation of the Oil Spill Prevention and Response Advisory Group (OSPRAG), made up of representatives from the oil and gas industry, its regulators and the trade unions to address, on a proactive basis, the issues raised by the Macondo incident.

One of OSPRAG's recommendations was the establishment of a new industry-wide forum to provide expertise in this specialist area – the Well Life Cycle Practices Forum (WLCPF). Not only is this forum a vehicle for implementing OSPRAG's recommendations, but as a permanent group under Oil & Gas UK, its aim is to ensure the industry continues on the path of improvement long after OSPRAG has been disbanded.

In June 2013, the EU published a Directive on the safety of offshore oil and gas operations with the aim of reducing, as far as possible, the occurrence of major accidents related to offshore oil and gas operations, and to limit their consequences. The UK implemented

the requirements of the Directive, including setting up a Competent Authority, in 2015.

The role of the Competent Authority is to regulate industry compliance with the Directive and to carry out related functions such as accepting, assessing, approving and/or inspecting relevant safety cases, oil pollution emergency plans, well notifications and other notifications. The reporting of incidents is included, as are intervention planning and investigation work.

To deliver the Competent Authority functions, HSE works in partnership with the Offshore Petroleum Regulator for Environment and Decommissioning, part of the Department for Business, Energy and Industrial Strategy, as the Offshore Safety Directive Regulator.

Actions taken after the incident

HSE and Total E&P UK Limited

In September 2012, using its power under Regulation 15(1) of the Offshore Installations (Safety Cases) Regulations 2005, HSE directed Total to prepare a revision to their accepted safety case.

HSE required the revised case to include sufficient particulars to comply with Regulation 12 of the Offshore Installations (Safety Case) Regulations 2005, and that the information provided should describe:

- the plant and systems in place on the HPHT wells that, so far as is reasonably practicable, prevent an unplanned release from those wells;
- the operating procedures, standards and company rules that, so far as is reasonably practicable, prevent an unplanned release from those wells;
- how Total consulted safety representatives on the Elgin installation under Regulation 23(2)(c)(i) of the Offshore Installations (Safety Representatives and Safety Committees) Regulations 1989 in making their revision.

In particular, the revision should demonstrate compliance with Regulation 13, 'General duty', of the Offshore Installations and Wells (Design and Construction etc) Regulations 1996. Regulation 13 requires that: *'The well-operator* [ie Total] *shall ensure that a well is so designed, modified, commissioned, constructed, equipped, operated, maintained, suspended and abandoned that –*

(a) so far as is reasonably practicable, there can be no unplanned escape of fluids from the well; and
(b) risks to the health and safety of persons from it or anything in it, or in strata to which it is connected, are as low as is reasonably practicable.'

A revised safety case addressing the matters above was submitted to HSE and, following assessment by relevant specialists, was accepted.

In March 2014 HSE submitted a report to the Crown Office and Procurator Fiscal Service, recommending prosecution of Total E&P UK Limited under Regulation 13(1) of the Offshore Installations and Wells (Design and Construction etc) Regulations 1996.

In December 2015 Total pleaded guilty and were fined £1.125 million.

Actions by HSE and industry

HSE works with a range of different stakeholders to improve health and safety in the offshore energy sector. One initiative was the formation, with Oil and Gas UK (OGUK), of the OGUK HPHT work group in September 2012 following HSE's letter to industry regarding HPHT wells earlier in the year.

The working group recognised that there had been so much technical development and so many lessons learned in the North Sea that the existing guidance required updating. In June 2013 the working group committed to producing specific guidance for HPHT wells. This guidance captures the key well engineering lessons learned which have been detailed and targeted for well engineers designing HPHT wells.

Throughout 2014, the working group conducted a gap analysis between existing guidance, the Energy Institute Model Code of Safe Practice Part 17 (EI Part 17) and OGUK Well integrity Guidelines. Revised guidelines were issued in April 2016 for industry to review and the finalised version was published in October 2016. EI Part 17 is currently in the process of being updated to reflect current technical knowledge.

The revised OGUK HPHT guidelines contain specific sections relating to lessons from previous incidents where there have been issues with well integrity and well control. The guidelines aim to provide recommendations and good practice for HPHT well engineering, well operations and maintenance. They are based on recent North Sea experience for areas where current practice and experience have moved beyond the published guidance to a significant degree, or are not covered in that guidance.

Some key areas of the guidelines include a section on well design, with specific reference to:

- compaction-induced wellbore damage;
- internal corrosion by unexpected contaminants;
- completion design best practice;
- secondary reservoirs above main reservoirs;
- cement design, testing and placement;
- materials selection.

There are further sections on:

- HPHT well construction operations;
- well testing;
- operation and maintenance;
- well monitoring strategy;
- HPHT well annulus acceptance criteria, including annulus management systems;
- HPHT well abandonment.

The guidelines also have appendices with checklists to help the additional reporting and logging required when drilling HPHT sections of wells.

The Energy Institute publications are produced by working groups made up of specialist well engineers working in the offshore oil and gas industry and HSE specialists from the well engineering and operations team. These publications are available to members free of charge, allowing wide circulation of current standards and practices (see 'Further information' at the end of this publication).

In addition to the work with OGUK, HSE is working with the Step Change in Safety 'Major Accident Hazard Understanding' working group to improve the understanding of managing the risks of major accident hazards. The working group has developed a range of resources to help the whole workforce to understand:

- what a major accident hazard is;
- how they are identified;
- how they are prevented, or the consequences mitigated against.

These resources include a series of packs provided to all installations operating in the UK Continental Shelf (UKCS) to improve understanding of:

- major accident hazards;
- risk analysis;
- bowties and safety and environmental critical elements;
- barrier maintenance and barrier assurance and verification.

Actions by Total

To bring the issues to a wider, international audience, personnel from Total E&P UK prepared and presented a paper to the Society of Petroleum Engineers International Conference in March 2014: *Elgin G4 Release: What Happened and the Lessons to Prevent Recurrence*.

The paper covers:

- incident details;
- G4 leak path and emergency response;
- killing of G4 with heavy mud;
- incident investigation and associated causes;
- action taken to ensure lessons have been learnt to prevent reoccurrence;
- re-evaluation of well integrity and development of well integrity criteria;
- the issues around returning offshore facilities to a fit-for-purpose condition to restart production;
- the role of the installation's safety case and how, by making the revisions directed by HSE, it demonstrated to both HSE and the workforce that production could be safely restarted.

Actions by HSE

To promote consistency in inspection of offshore activities carried out by dutyholders in the UKCS, HSE's Energy Division has published a suite of inspection guides for use by its inspectors during planned inspections to secure regulatory compliance, and also to inform incident investigation.

Four of the inspection guides relate to well control, well integrity and related issues. The publication of these guides on HSE's website means that they are freely available for the information of industry and any other interested party: www.hse.gov.uk/offshore/inspection.

Well Control Inspection Guide

This inspection guide is for use by Energy Division non-wells specialist inspectors. It helps them carry out basic inspection of arrangements for well control during well construction and maintenance. This includes drilling, testing, completion and other well intervention or maintenance/repair (work over) operations, including final decommissioning where the drilling blowout preventers are in use.

It does not cover all aspects of these operations for which industry good practice guidance is available (see *Well Life Cycle Integrity Guidelines* by Oil and Gas UK). Instead, it provides questions to ask key personnel so they can sample crucial components that provide for effective well control.

For clarity, the large topic of well control has been broken down into sub-topics, with sample questions for each:

- well control procedures;
- well control equipment;
- well control training;
- well control drills;
- communications.

Model answers are provided for each question so that the extent of compliance can be gauged by inspectors.

This inspection guide is also used by wells specialist inspectors as part of their more in-depth inspections on this topic.

Since the inspection guide has been published there have been 52 inspections using it, 41 of which rated the dutyholder as broadly compliant.

Wells Competency Inspection Guide

This guide helps offshore inspectors support the delivery of consistent and effective wells competence assessments of offshore wells

personnel. It highlights key areas essential to an effective competence assessment process, providing a framework for inspectors to judge compliance, assign performance ratings, and decide what enforcement action to take when they find legislative breaches.

Major hazard organisations require competent staff, who have the necessary skills, knowledge and experience to carry out critical tasks in such a way as to prevent a major accident or minimise the consequences to people and the environment, should one occur.

The question set that is used has been developed from a background of HSE and the OGUK wells competency guides.

Well Examination Inspection Guide

This inspection guide highlights key areas required in a well examination scheme, providing a framework for inspectors to:

- judge compliance;
- assign performance ratings;
- decide what enforcement action to take when they find legislative breaches.

The inspection requires a review of relevant documentation, followed by a set of role-specific questionnaires. The whole package is captured in a system review overview.

The questions were developed from previous well examination scheme inspections. They have been revised to reflect the maturity of well examination schemes offshore in the UK and changes imposed by the Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015.

Well Integrity Inspection Guide

The most important role of the well-operator is to ensure the integrity of its wells, barriers and the pressure containment boundary throughout the well life cycle from design to final abandonment.

The well-operator should consider the benefits of having a policy defining its commitments and obligations to safeguard health, the environment, assets and reputation by establishing and preserving well integrity. This well integrity policy should be endorsed at a senior level within the well-operator's organisation.

The well-operator is responsible for assessing the well risks and reducing them to 'as low as is reasonably practicable' (ALARP) – see the Glossary. This should be demonstrated to the offshore installation dutyholder who has primary responsibility for the safety of the installation and the personnel on board. It should be noted that the most common situation is for these functions to be performed by the same company.

Well-operators should have a system for ensuring well integrity throughout a well's life cycle, from drilling to plugging and abandonment. Management of operations may be devolved to a third-party contractor, but the responsibility for the integrity of the well remains with the well-operator.

Well-operators should use their auditing arrangements to make sure that their procedures and processes for complying with all relevant legislation are effective.

The inspection guide provides questions sets to be used as a basis for inspection of the well integrity arrangements. This has been developed from a background of HSE and industry guidance on well integrity.

Workforce Engagement Inspection Guide

In addition to the inspection guides addressing the safe operation of wells, HSE's Energy Division has published a guide on workforce engagement to support the delivery of consistent and effective inspection of dutyholder arrangements for complying with the Offshore Installations (Safety Representative and Safety Committees) Regulations 1989.

These Regulations allow the workforce on an offshore installation to elect safety representatives from among themselves, and give them rights, functions and powers in relation to the health and safety of the workforce. They also provide for time off with pay for safety representatives so they can perform these functions and receive relevant training.

Dutyholders must establish safety committees in accordance with the Regulations. The role of the safety committee includes reviewing health and safety on the installation and, as appropriate, making representations and recommendations to the installation manager.

Since 2015, HSE's Energy Division's focus on effective workforce engagement by dutyholders has been demonstrated by it being the only offshore health and safety regulator to employ a workforce engagement specialist inspector. This inspector has extensive offshore experience working in a trade role, both as an elected safety representative (ESR) and a worker represented by ESRs.

Resulting improvements to the regulatory regime

The response to the findings of the Maitland Review and the implementation of the EU Directive has improved the regulatory regime in the UKCS in the following areas:

- The Competent Authority has been introduced to assess:
  - dutyholder safety cases;
  - the requirement for oil spill response arrangements;
  - combining safety and environmental elements in an integrated management system.
- This, coupled with the development of strategic intervention planning arrangements for proactive inspection of offshore installation by the Competent Authority, allows dutyholder management arrangements to be scrutinised from both safety and environmental perspectives.
- The introduction of a suite of inspection guides, including those specifically addressing safe operation of wells and workforce engagement, allows the Competent Authority to target those dutyholders with poor performance to make sure they have the regulatory attention they require to ensure safe operation.

Glossary

As low as is reasonably practicable (ALARP)	Determining that risks have been reduced ALARP involves an assessment of the risk to be avoided, of the sacrifice (in money, time and trouble) involved in taking measures to avoid that risk, and a comparison of the two.
Dutyholder	This means the operator of a production installation (such as Elgin) and the owner of a non-production installation. The dutyholder is the 'person' on whom duties are placed by virtue of the Safety Case Regulations.
High-pressure high-temperature (HPHT) wells	In the UK, HPHT is formally defined as a well having an undisturbed bottomhole temperature greater than 300°F (149°C) and a pore pressure of at least 0.8 psi/ft (~15.3 lb/gal) (ie approximately 10,000 lbs per square inch).
Hod Formation	The central North Sea contains several HPHT gas fields, including the Total operated Elgin and Franklin fields. The reservoirs are typically Jurassic overlain by a thick Cretaceous chalk sequence including the Hod Formation. The unique signature of the Hod Geohazard consists of three clean, thin limestone strata over an interval of around 50m. It is the middle of this limestone which is over-pressured and contains hydrocarbons. While drilling through the Hod Formation of the Upper Cretaceous Chalk, UK Central North Sea, fields such as Elgin and Franklin have encountered problems of over-pressured gas.
Micro-annulus	During the life cycle of an HPHT well, as the reservoir is depleted of oil and gas, its pressure drops. The change in pressure may result in the occurrence of a micro-annulus (ie a gap of just a few microns) at the interface between the cement and the casing, or at the interface between the cement and the formation due to deformation of the cement.
Sustained casing pressure (SCP)	This is defined as measurable casing pressure that rebuilds after being bled down, arising from continuing gas migration. SCP is caused by gas migration from a high-pressured subsurface formation and may occur through a poor cement bond between the casing and the formation, packer and/or the casing itself.

Volumetric kill	This is a means of allowing gas to migrate to the surface under control. In this method the choke is opened and closed in steps to bleed off the inflow gas. As gas moves up and pressure in the well increases, the choke is opened to bleed off and reduce the well pressure and it is then closed when the pressure drops to a certain level. This procedure is maintained until the gas is completely out of the well.
Well-operator	In relation to a well or a proposed well, this has the meaning given in Regulation 2(1) of the Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015. The Regulations state that the well-operator is a person appointed in accordance with Regulation 5 or 6 of those Regulations to conduct the planning or execution of well operations.

Further information

HSE's offshore oil and gas website: www.hse.gov.uk/offshore

HSE's Offshore Safety Directive Regulator site: www.hse.gov.uk/osdr

HSE's inspection guides: www.hse.gov.uk/offshore/inspection.htm

The Energy Institute: https://www.energyinst.org/

Oil and Gas UK publications: https://oilandgasuk.co.uk/publications/

Step Change in Safety 'Major Accident Hazard Understanding' working group has produced a range of products to assist in the understanding of the management of major accident risks: www.stepchangeinsafety.net/MAH

This publication can be found at www.hse.gov.uk/offshore