# **UK Onshore Shale Gas Well Guidelines**

# Exploration and appraisal phase

Issue 1 February 2013





#### Guidelines for UK Well Operators on Onshore Shale Gas Wells.

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## Foreword

These guidelines are produced by the UK Onshore Operators Group (UKOOG), a body representing the UK onshore oil and gas industry. They were written by a workgroup which included operating and service companies with input from DECC, HSE and the EA/SEPA.

The guidelines are relevant to UK onshore shale gas wells designed and constructed for the extraction of naturally occurring hydrocarbons which includes stimulation by techniques involving high volume hydraulic fracturing. Issue 1 of the guidelines is restricted to the exploration and appraisal phases of shale gas developments. The initial operations will be treated as a pilot to ensure that high standards of safety and environmental management are achieved and to enable the guidelines to be fully evaluated. Further revisions will be required and will be based on experience gained during the pilot phase. A further revision will also be necessary for the eventual operations (production) phase anticipated for shale gas developments.

The guidelines contain what is considered to be good industry practice and they reference the relevant legislation, standards and practices.

The guidelines are not intended as a complete guide to all the regulations that apply to well sites or to equipment or to human factors. Guidance on these matters is available elsewhere through the relevant regulations, Approved Codes of Practice, regulations' guidance etc. Operators should be aware of all the regulations, Approved Codes of Practice and guidance that apply to well sites and to all associated operations.

The guidelines refer extensively to Oil and Gas UK Guidelines, particularly to the Well Integrity Guidelines (issued in July 2012). These apply to every onshore well and concentrate on 'typical' wells and 'standard' operations. Therefore shale gas well operators should use these guidelines in conjunction with the referenced Oil and Gas UK Guidelines.

By adopting the practices presented in these guidelines and the various, referenced, Oil and Gas UK, guidelines, Operators should be able to assure themselves and demonstrate to other stakeholders, on matters of well integrity and fracturing operations, including matters concerning fracturing fluids and flow-back fluids and that they have complied with all relevant regulations that apply to shale gas well designs and operations, including fracturing operations.

The guidelines are not intended to prevent any organisation from adopting an alternative approach to managing well integrity, fracturing operations or environmental management. However, the implications of adopting an alternative approach need to be considered in relation to the overall intent of well integrity and fracturing operational management to ensure, so far as reasonably practicable, there can be no unplanned escape of fluids from the well or equipment involved in fracturing operations, and that the risk to the environment and risks associated with health and safety are as low as reasonably practicable.

#### Note on Titles

In this document 'Well Operator' is used in the context of the DCR definition. 'Operator' may be the Well Operator, the Licence Operator or the Borehole Site Operator who is appointed by the 'Owner'. The 'Owner' in relation to a borehole site means the person who has the right to undertake borehole operations.

Often the same company would fulfil all three of the above operator roles and therefore the term 'operator' is used throughout the document except where there are specific references to duties placed on Well Operators.



#### Summary 1.

The Guidelines are relevant to all shale gas wells, onshore in Great Britain, designed and constructed for the extraction of naturally occurring hydrocarbons which include stimulation by techniques involving high volume hydraulic fracturing. The Guidelines contain what is considered to be good industry practice and reference the relevant legislation, industry standards and practices.

The first issue of the Guidelines relates to the exploration and appraisal phase of shale gas well developments. The shale gas industry in Great Britain is at an early stage and the early wells drilled will be regarded as the pilot phase of development and as such the guidelines are to enable operators to follow good practice while gathering information and gaining experience from operations.

All duty holders should comply with their duties under all relevant regulations and be aware of the associated regulatory guidance. These guidelines will assist with regulatory compliance but they are not a substitute for a full understanding of the regulations. Also planning conditions and permits may be applied to well operations and well sites and operators will need to comply with any such conditions/permit requirements.

Oil and Gas UK have established guidelines related to wells and well operations in Great Britain, including shale gas wells. They contain what is believed to be good industry practice and reference relevant legislation, standards and practices.

These guidelines are intended to supplement the Oil and Gas UK guidelines not to replace any of them. They have been developed to cover the areas that are unique to shale gas wells and high volume fracturing operations and which are not presently covered in detail by Oil and Gas UK guidelines.

Therefore operators involved in shale gas well operations should refer to the following Oil and Gas UK guidelines:

- 1. Well Integrity Guidelines.
- 2. Guidelines for the Suspension and Abandonment of Wells.
- 3. Guidelines on Qualification of Materials for the Suspension and Abandonment of Wells.
- 4. Guidelines for Well Operators on Well Examination.
- 5. Guidelines for Well Operators on Competency of Well Examiners.
- 6. Guidelines on Competency for Wells Personnel.

A full listing of the relevant regulations and guidance references is contained in Appendix 4.

#### 2. Safety and Environmental Management

#### 2.1. Management Systems

To assist in discharging their responsibilities operators and other duty holders should operate in accordance with effective management systems and ensure that personnel are competent in the tasks they are required to do.

Effective risk-based, systematic, management of well integrity, the integrity of the surface equipment used in fracturing/flow-back operations and of other associated operations is critical to ensuring the safety of the well operations and environmental protection.

Operators' management systems should be developed and applied to all operations including any pre-drilling operations such as seismic acquisition work.

In respect of the development of (health and safety) management systems operators should refer to the HSE document "Successful Health and Safety Management". This is the overarching guide on the essential philosophy of good health and safety: what it means; how to achieve it; and how to maintain it.

http://www.hse.gov.uk/pubns/books/hsg65.htm

Operators should also operate in accordance with a suitable environmental management system that conforms to the principles in ISO 14001.

Operators should consider the advantages of adopting a systematic environmental risk assessment and management framework drawing on the "Green Leaves III" guidelines (Cranfield University/Defra, November 2011).

As described in the Oil and Gas UK Well Integrity Guidelines Summary, operators should have developed a system for ensuring well integrity throughout the well life cycle. For well integrity during fracturing/flow-back/testing operations the system should take into account the additional elements described in these guidelines.

Management of operations can be devolved but the responsibility for the integrity of the well and protecting the environment remains with the operator.

Operators should have a management of change (MOC) procedure covering wells and well operations through the full life cycle from initial design to final abandonment. The Oil and Gas UK Well Integrity Guidelines (Section 3.7) contains guidelines on MOC for well operations. A similar MOC procedure should cover changes to fracturing/flow-back/testing and water/fluid transport operations.

## 2.2. Public Available Specification

Operators should adopt and adhere to a "best practice", continuous improvement, approach and work within the Publicly Available Specification (PAS) that will be independently developed by the British Standards Institute (BSI) based on these guidelines.

This will result in accredited independent auditors being able to audit operations against the approved PAS.

The PAS approach will be evaluated by UKOOG with a view to developing a National Standard for shale gas operations as experience is gained.

The PAS approach fulfils two key objectives:

- 1. Promotes "best practice" across the onshore shale gas industry
- 2. Provides public reassurance to help facilitate shale gas development.

**Note**: The referenced Publicly Available Specification has not been developed at the date of the first issue of the Guidelines. This section will be updated after development.

## 3. Disclosure and Transparency

Operators should engage with local communities, residents and other stakeholders at each stage of a development, beginning in advance of any operations and where possible in advance of any application for planning permission. They should provide sufficient opportunity for comment on plans, operations and performance, listen to concerns and respond appropriately and promptly. The emphasis should be on recognising relations with the host community as a key management priority, and having a strategy or plan for engagement which is developed early and which links to any statutory processes. The planning system may provide specific opportunities for open consultation, but operators should also engage more broadly with stakeholders.



Operators need to explain openly and honestly their drilling, fracturing design and operational practices including environmental, safety, and health risks and how they are addressed. The public needs to gain a clear understanding of the challenges, risks and benefits associated with the development.

Referring specifically to hydraulic fracturing, operators should measure and disclose operational data on, for example:

- Water use.
- The volumes and characteristics of waste water.
- Produced water disposal methods.
- Fracturing fluid additives (constituents) concentrations and volumes.
- Shale gas volumes including any emissions.
- Fracture design and containment.
- Any induced seismicity.

Good data, measurement and transparency are vital to public confidence.

For example, effective tracking and documentation of waste water is necessary to demonstrate to stakeholders that good practice is being adopted as well as to record the proper treatment and disposal. Also, public disclosure of the chemicals used in the hydraulic fracturing process and the volumes/constituents/concentrations involved will, in addition to providing sufficient information to regulators, assist the public in understanding the processes involved.

Operators should demonstrate how they intend to minimise disruption to the community during operations, for example any vehicle management and noise reduction measures.

Operators should work towards maximising the economic benefits to local communities from their operations, for example considering local employment and utilising locally-based contractors, where possible.

## 4. **Regulatory Compliance**

The following sections summarise the main regulations that concern shale gas well integrity and hydraulic fracturing for each phase of operations. The summary does not cover all the safety-related regulations that apply to operations at well sites (for example the Electricity at Work Regulations or the Working at Height Regulations). Operators should always refer to the regulations themselves for full details and for any relevant Approved Codes of Practice and associated guidance.

Although the well-related regulations, below, are made under the Health and Safety at Work Act, maintaining adequate well integrity is also critical to environmental protection (e.g. groundwater protection) and therefore operators should ensure that well design standards also achieve best environmental practice.

For guidance concerning Petroleum Exploration and Development Licensing (PEDL), including the well consent system, refer to the DECC website at:

http://og.decc.gov.uk/en/olgs/cms/explorationpro/onshore/onshore.aspx.

Shale gas well operators should open an early dialogue with DECC concerning any requirements for submissions in connection with drilling and fracturing operations. It is likely that the 30 day consent Well Operations Notification System (WONS) will need to be preceded by other submissions of information referred to in these guidelines (for example information on Hydraulic Fracturing Programmes – see Section 5.5).



#### 4.1. Well Design and Construction

The Offshore Installations and Wells (Design and Construction Etc) Regulations 1996 (DCR) apply to wells. The main regulations concerning well design and construction (including fracturing operations) are summarised as follows:

**DCR Regulation 13** (General duties of Well Operators in connection with wells).

The Well Operator 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 health and safety of persons from it or anything in it, or in strata to which it is connected, are as low as reasonable practicable.

Section 5 of these guidelines deals with guidance on well design and construction.

#### DCR Regulation 14 - Assessment of Conditions Below Ground:

- 1) Before the design of a well is commenced the Well Operator shall cause
  - a) the geological strata and formations, and fluids within them, through which it may pass; and
  - b) any hazards which such strata and formations may contain, to be assessed.
- 2) The Well Operator shall ensure that account is taken of the assessment required by paragraph (1) when the well is being designed and constructed.
- 3) The Well Operator shall ensure that while an operation (including the drilling of a well) is carried out in relation to the well, those matters described in sub-paragraphs (a) and (b) of paragraph (1) shall, so far as is reasonably practicable, be kept under review and that, if any change is observed in those matters, such modification is made where appropriate, to
  - a) The design and construction of the well; or
  - b) Any procedures,

as are necessary to ensure that the purposes described in regulation 13(1) will continue to be fulfilled.

Section 5 of these guidelines deals with the assessment of conditions below ground.

#### DCR Regulation 16 – Materials.

The Well Operator must ensure that every part of a well is composed of material which is suitable for achieving the purposes described in Regulation 13(1). (General Duties).

Section 5 of these guidelines deals with well materials.

#### Regulation 20 – Co-operation

This regulation requires any person involved with a well operation to co-operate with the Well Operator in discharging his duties under Regulation 13(1).

All companies involved in the well design and operations processes (e.g. contractors) need to be aware of this duty to cooperate so that the Well Operator can fulfil his general duties under Regulation 13(1) to prevent unplanned escapes of fluids from a well and ensure the risks from the well are as low as reasonably practicable.



#### Borehole Sites & Operations Regulations 1995 (BSOR)

The **BSOR** apply to onshore well sites and to wells. The main regulations concerning well design and construction (including fracturing operations) are summarised as follows:

#### Regulation 9 and Schedule 2(7)

The Borehole Site Operator and other employers must ensure that suitable well control equipment is provided for use during both drilling and fracturing/flow-back operations.

Detailed guidance on well control equipment is provided in the BSOR, Schedule 2(7) guidance.

Section 7.2 of these guidelines deals with surface well control equipment during fracturing and flow-back operations.

#### BSOR Regulation 9 and Schedule 2(3)

When borehole operations are carried on, there shall be provided a sufficient number of competent persons with a view to enabling those operations to be carried on safely.

Section 5.1 of these guidelines deals with management supervision and competence at the well design and construction phase.

Section 7.3 of these guidelines deals with planning, management supervision and competence during fracturing/flow-back.

## 4.2. Operations Phase (Production Phase)

The **DCR and BSOR** regulations, described above, apply to all phases of a well including the operations (production) phase.

Issue 1 of these guidelines relates only to the exploration and appraisal phase of shale gas wells. This will be updated prior to industry moving into the well operations (production) phase.

## 4.3. Suspension/Abandonment Operations

#### DCR Regulation 15 – Suspension & Abandonment

The Well Operator shall ensure that a well is so designed and constructed that, so far as is reasonably practicable –

- a) it can be suspended and abandoned in a safe manner, and
- b) after its suspension and abandonment there can be no unplanned escape of fluids from it or from the reservoir to which it led.

Section 5.8 of these guidelines deals with well suspension and abandonment (well decommissioning).

#### 4.4. Independent Well Examination

**DCR Regulation 18** concerns the provision and implementation of arrangements for independent well examination.

The Well Operator must prepare and put into place arrangements in writing for such examinations, by independent and competent persons, of any part of the well, or similar well, information, or work in progress. The written arrangements are known as the well examination scheme. The scheme describes the independent well examination process.



The Oil and Gas UK Guidelines for Well Operators on Well Examination and the Guidelines for Well Operators on Competency of Well Examiners provide more detailed guidance on the subject of well examination.

Section 5.10 of these guidelines deals with independent well examination in the well design and construction phase. Section 5.11 deals with independent well examination of well abandonment (and well suspension) designs and operations.

Examination of wells during the operations (production) phase will be added at a later issue.

## 4.5. Borehole Site Safety

The **Borehole Sites & Operations Regulations 1995 (BSOR)** place duties on operators in connection with general site safety including:

- 1. The provision of health and safety documents.
- 2. Risk assessments.
- 3. Coordination of safety measures.
- 4. Plans for:
  - Provision of escape and rescue.
  - Prevention of fires and explosions with particular reference to blowouts and escapes of flammable gas.
  - General fire protection.
  - Detection and control of toxic gases.
- 5. Site planning and design.
- 6. Arrangements for attendance of emergency services and site access.
- 7. Stability, strength and suitability of workplaces

These guidelines concern shale gas well integrity and fracturing/flow-back operations. They are not intended to cover the above, general, site safety aspects in any detail. Operators should refer to the BSOR Regulations and detailed guidance.

## 4.6. Fracturing Flow-Back and Well Testing Equipment and Operations

The **DCR** apply to any fracturing equipment that also forms part of a well.

The **BSOR** apply to fracturing equipment and operations at the well site.

The **Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)** (apart from 3 specified exceptions which are covered by the BSOR) apply to any operations involving dangerous substances (including flammable gases).

- Regulation 5 concerns the requirement to carry out and record suitable and sufficient risk assessments.
- Regulation 6 concerns the elimination or reduction of risks from dangerous substances.
- Regulation 8 concerns arrangements to deal with accidents incidents and emergencies.
- Regulation 9 concerns the provision of information, instruction and training to employees and other people who may be present at the workplace.

Therefore the DSEAR regulations are closely linked to the BSOR in respect of managing the risks associated with flammable gases.

Regulation 4 of the Provision and Use of Work Equipment Regulations 1998 (PUWER) concerns the suitability of fracturing equipment:

- 1) Every employer shall ensure that work equipment is so constructed or adapted as to be suitable for the purpose for which it is used or provided.
- 2) In selecting work equipment, every employer shall have regard to the working conditions and to the risks to the health and safety of persons which exist in the premises or undertaking in which that work equipment is to be used and any additional risk posed by the use of that work equipment.
- 3) Every employer shall ensure that work equipment is used only for operations for which, and under conditions for which, it is suitable.

Regulation 5 of PUWER concerns the maintenance of equipment:

- 1) Every employer shall ensure that work equipment is maintained in an efficient state, in efficient working order and in good repair.
- 2) Every employer shall ensure that where any machinery has a maintenance log, the log is kept up to date.

The two parts of regulation 5 outline the general requirements for keeping work equipment and machinery in a condition which does not pose a risk to employees' safety. It highlights the employer's duty to ensure that maintenance logs are kept up to date.

Regulation 6 of PUWER concerns the inspection of equipment:

- Every employer shall ensure that, where the safety of work equipment depends on the (1)installation conditions, it is inspected
  - after installation and before being put into service for the first time; or (a)
  - (b) after assembly at a new site or in a new location,

to ensure that it has been installed correctly and is safe to operate.

- (2) Every employer shall ensure that work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations is inspected –
  - (a) at suitable intervals; and
  - (b) each time that exceptional circumstances which are liable to jeopardise the safety of work equipment have occurred,

to ensure that health and safety conditions are maintained and that any deterioration can be detected and remedied in good time.

- (3) Every employer shall ensure that the result of an inspection made under this regulation is recorded and kept until the next inspection under this regulation is recorded.
- (4) Every employer shall ensure that no work equipment
  - a) leaves his undertaking; or
  - b) if obtained from the undertaking of another person, is used in his undertaking unless it is accompanied by physical evidence that the last inspection required to be carried out under this regulation has been carried out.

DCR, BSOR, PUWER and DSEAR compliance issues in relation to fracturing equipment and operations are covered in Section 7.

General regulatory compliance concerning other types of equipment at a well site is not covered by these guidelines.

Although all the regulations referenced in this section are made under the Health and Safety at Work Act, they relate to the prevention and mitigation of environmental releases of fluids and gases from wells and associated surface equipment.

## 4.7. Planning Legislation

Note: The following makes reference to legislation as applied in England, Wales and Scotland. Whilst the principles discussed below are similar throughout the United Kingdom, there may be some differences in Northern Ireland and to a lesser extent, Wales.

## 4.7.1. The Town and Country Planning Act 1990 (England)

Section 57(1) of the Town and Country Planning Act provides that 'planning permission is required for the carrying out of any development of land'. Such planning permission may be granted following the determination of an express application for permission made to a local planning authority for the area in which the land is situated. In other cases, however, planning permission for the development in question may have been granted by a development order known as 'permitted' development.

The drilling of onshore boreholes and hydraulic fracturing of strata is such a 'development'.

Such operations are defined as 'mineral permissions' and are subject to special provisions considered necessary to control their environmental effects. These include, amongst other matters, 'restoration' and 'after care' of all sites and the imposition of a time limit to govern the duration of the consents.

The Act provided for the establishment of Mineral Planning Authorities (MPA's) more often at County Council level which are responsible for all planning control over mineral workings and the provisions for the review the planning permission from time to time.

## 4.7.2. The Town and Country Planning (Scotland) Act 1997

The Town and Country Planning (Scotland) Act 1997 (as amended by the Planning etc. (Scotland) Act 2006) makes no provisions that specifically apply to minerals applications

Operators in Scotland should contact their local planning authority as MPAs do not apply in Scotland.

## 4.7.3. The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 and The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011

These regulations apply to England and Scotland respectively. There are differences which apply to Wales and Northern Ireland, although the regulations are substantially the same.

In Scotland these Regulations are supported by the "Planning Circular 3 2011":

http://www.scotland.gov.uk/Resource/Doc/350238/0117228.pdf

The regulations set out the types of development which must be accompanied by an Environmental Impact Assessment (EIA) and the manner in which such a statement should be constructed and matters to be included. The EIA can be seen as a technique for the systematic compilation of expert quantitative analysis and assessment of a project's environmental effects, and the presentation of results in a way which enables the importance of the predicted results, and the scope for modifying and mitigating them, to be properly



evaluated by the relevant decision-making body before a planning application decision is taken. The regulations apply to two separate lists of development projects.

- 1. 'Schedule 1 development', for which EIA is compulsory.
- 2. 'Schedule 2 development', for which EIA is required if the particular project is considered likely to give rise to significant effects on the environment by virtue of factors such as its nature, size, or location or to development located wholly or partly in a 'sensitive area'.

The majority of exploration and appraisal boreholes fall under Schedule 2, 'Deep drilling' with thresholds and criteria set at one hectare for the surface installations, including screen bunds and the like, unless the development would likely have significant effect on the environment as described above. 'Sensitive areas' are defined to include SSSIs, National Parks, Areas of Outstanding Natural Beauty, Scheduled Monuments, World Heritage Sites and European Sites. In addition, in Scotland, 'sensitive areas' include Land subject to Nature Conservation Orders, International Conservation Sites, and National Scenic Areas.

In order to identify whether or not a proposal is a 'Schedule 2 development', an applicant may apply to the MPA (planning authority in Scotland) for a screening opinion as to whether the development is to be subject to an EIA. If the applicant fails to apply for such an opinion and the MPA (planning authority in Scotland) fail to screen the proposal, a subsequent grant of planning permission could be challenged within the time allowed and squashed if found to be successful. For this reason it is strongly advised that all such developments are screened before a planning application is made. If an applicant decides that a proposal is a 'Schedule 2 Development' or if a screening opinion is issued to the effect that a proposal is an EIA development, the authority may, or in the case of a request to do so under paragraph 10 of the Regulations, shall give an opinion as to the information to be provided in the environmental statement. The opinion is called a 'Scoping Opinion'.

## 4.7.4. The Environmental Protection Act 1995 (England and Wales)

Schedule 14 of the Act requires Mineral Planning Authorities to review all mineral permissions every 15 years, and to give owners and operators 12 months notice of the date by which an application for approval of new conditions must be submitted to them. If no such application is made by that date the permission will cease to have effect.

An amendment to The Town and Country Planning (Environmental Impact Assessment) Regulations 1992 required that such applications should be treated the same as an application for planning permission and be subject to the regulations. A new acronym 'ROMP' was introduced by the regulations and is now used throughout to describe such applications and permissions.

## 4.8. Waste and Water

Matters concerned with transport, treatment and disposal of waste and protection of water resources are regulated by the Environment Agency (EA) in England and Wales and the Scottish Environment Protection Agency (SEPA) in Scotland. The following makes reference to legislation as applied in England and Wales and in Scotland.

#### 4.8.1. The Water Resources Act 1991

This act makes various provisions in respect of the protection of groundwater in England and Wales. Section 199 requires notice to be given to the EA of an intention to construct or extend a borehole for the purposes of searching for, or the extraction of, minerals.

The EA also requires notification of an intention to extract groundwater and where the operation is likely to extract in excess of 20m<sup>3</sup> per day, the operator will require an abstraction licence.



#### The Environmental Permitting Regulations 2010 (England and Wales) 4.8.2.

These Regulations were introduced in 2010, replacing the 2007 Regulations. They were amended by the Environmental Permitting Amendment Regulations 2012.

In 2007 the Regulations combined the Pollution Prevention and Control (PPC) and Waste Management Licensing (WML) regulations. Their scope has since been widened to cover controls relevant to shale gas operations, including water discharge and groundwater activities, managing radioactive substances and mining wastes.

Guidance on their application is provided by the Environmental Agency at:

http://www.environment-agency.gov.uk/business/topics/permitting/default.aspx

#### 4.8.3. The Water Environment (Controlled Activities) (Scotland) Regulations 2011.

The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) regulates activities associated with the water environment.

The regulations cover the construction of boreholes, the abstraction of water and the discharge of pollutants into the water environment.

Guidance on their application is provided by the Scottish Environment Protection Agency at:

http://www.sepa.org.uk/customer\_information/energy\_industry.aspx

## 4.8.4. The Hazardous Waste Regulations (England and Wales) 2005 and Special Waste Regulations (1996)

These regulations govern the classification, carrying and disposal of hazardous waste.

#### 4.9. Mining Law

Although all petroleum is owned by the Crown and the right to exploit it is governed by DECC through the system of Licensing Rounds, other rights are required to be considered before such exploitation rights can be exercised.

#### The Ownership of Land 4.9.1.

Land ownership is governed by statute and common law and, prima facie, the owner of the surface also owns the substrata to the centre of the earth or more recently, in opinion, the mantle or core of the earth. Before the drilling of wells can take place therefore, it is necessary to acquire access rights to land with the legal owner of such land and any adjacent land under which deviated wells are to be drilled. This will also include other potential mineral bearing strata beneath land so acquired, where the surface and minerals have previously been severed for the purposes of ownership. The law relating to the severance of the surface and minerals is complex and will require specialised legal advice.

#### 4.9.2. **Coal Industry Act 1994**

This act established the Coal Authority for the purposes of the restructuring and privatisation of the coal industry. The key functions of the Authority are to regulate the industry, take custody of the coal vested in the Crown in 1938 and provide information on past and present mining activity. Any well likely to enter or pass through a coal seam, for any purpose, will require the agreement of the Coal Authority. Such agreements lay down stringent requirements for the entering of coal seams and of the subsequent provision for the supply of information. This includes accurate plans and sections of all wells drilled relative to Ordnance Survey datum and full well logs including the method of drilling and method of treatment and sealing of wells and a record of equipment left in the well.



Operators drilling through Coal Measures should be aware of the Guidance on Managing the Risk of Hazardous Gases when Drilling or Piling Near Coal, issued by the Coal Authority.

#### 4.9.3. The Mining Industry Act 1926

This act makes provision for the 'notification of intent to sink boreholes and shafts and subsequent provision of information'. Such powers have now been transferred to the National Environment and Research Council by the Science and Technology Act 1965. The British Geological Survey requires information on any borehole that is intended to penetrate to a depth greater than 100 feet or the deepening of an existing well. Operators carrying out such operations are required to keep a record of the operations in the form of logs and cores or fragments for a period of six months and to allow authorised officers of the BGS access at all reasonable times.

## 5. Well Design and Construction

Relevant Regulations and Guidelines are:

- 1. DCR Regulations and Guidance.
- 2. BSOR Regulation 9(1) and Schedule 7. (Well Control Equipment).
- 3. HSE Semi Permanent Circular (SPC 43) on Well Construction Standards (Section 4).
- 4. HSE "ALARP at a Glance" Document.
- 5. Oil and Gas UK Well Integrity Guidelines (Section 4).
- 6. Oil and Gas UK Guidelines on Competency for Wells Personnel.
- 7. Relevant industry codes of practice (e.g. ISO and API Codes listed at Appendix 4).

## 5.1. Management Supervision and Competence - Wells

Operators should refer to the Oil and Gas UK Guidelines on Competency for Wells Personnel. This guidance is relevant to all employers of personnel working on wells in Great Britain. The guidelines describe the regulations applicable to competency in respect of wells. In addition to these regulations, at onshore well sites, Regulation 9(1) and Schedule 2 of the BSOR require that:

- 1. A competent person appointed by the operator shall be in charge of every borehole site where employees are present and there shall be sufficient competent persons appointed by the operator to exercise immediate supervision of operations with a view to ensuring the health and safety of persons at work at the site.
- 2. There shall be provided a sufficient number of competent persons with a view to enabling operations to be carried on safely.

The Oil and Gas UK Guidelines on Competency for Wells Personnel describe the design, development and implementation of suitable Competency Management Systems. Table 1 contains the following listing of the roles that require formal competencies and assessment for onshore wells' personnel positions:

- 1. Drilling Manager.
- 2. Drilling Superintendent.
- 3. Senior Drilling Engineer.
- 4. Drilling Engineer.
- 5. Senior Completions Engineer.
- 6. Completions Engineer.



- 7. Petroleum Engineer.
- 8. Rig Manager (including well site manager).

#### **Risk Identification and Assessment** 5.2.

In addition to the guidance contained in the relevant regulations (BSOR DCR and DSEAR), well-related risk assessment guidelines are provided in the Oil and Gas UK Well Integrity Guidelines.

The primary responsibility for identifying, assessing and mitigating well hazards rests with the Well Operator.

In respect of shale gas wells, operators should ensure that the following, specific, design and operational risks are considered as part of the well-related risk assessment process:

- 1) Groundwater isolation (see Section 5.4.3).
- 2) Fracturing Containment (see Section 5.5).
- 3) Seismicity induced by hydraulic fracturing (see Section 5.6).

These are not specifically addressed in the Oil and Gas UK Well Integrity Guidelines.

#### 5.3. Well Design and Barrier Planning

Detailed guidance on well design and operations planning, including barrier design and planning is described in Section 4 of the Oil and Gas UK Well Integrity Guidelines.

Section 5.6 of the Oil and Gas UK Well Integrity Guidelines concerns the installation and testing of barriers.

#### Casing and Cementation Design Including Groundwater Isolation 5.4.

All control measures should be based on well design risk assessments and the environmental risk assessments and these should be documented in the well's basis of design documentation and well operations programme(s) (or equivalent document names).

Section 8 deals with environmental management.

#### **Casing Design** 5.4.1.

Section 4.4 of the Oil and Gas UK Well Integrity Guidelines concerns casing design. Section 4.6 refers to designing a well for the eventual suspension and abandonment including references to permeable horizons outside the casing. Section 5.6 concerns the installation and testing of barriers (including casing and cement).

Section 6.2 of the Oil and Gas UK Suspension and Abandonment Guidelines contains guidance on casing annular cement.

The Oil and Gas UK Well Integrity Guidelines make reference to hydrocarbon zones and reservoirs. For shale gas formations operators should consider these as hydrocarbon zones (or horizons) for the purposes of casing (and cement) design.

In addition to the guidance in the Oil and Gas UK Well Integrity Guidelines, operators should also consider the following environmental aspects during the well planning risk assessment and casing design processes:

- 1. The areal extent, including the base, of all local aquifers should be delineated when assessing groundwater, using appropriate techniques dependent on the area (see Section 5.4.3 for guidelines on groundwater isolation).
- 2. All permeable zones (including groundwater and any local aquifers) should be assessed to achieve adequate isolation by casing with verified cement (see Section 5.4.2 for cement design and evaluation guidelines).
- 3. Surface casing should be deep enough, along with sufficient cement, to protect groundwater including local aquifers. The final well abandonment (decommissioning) design should be considered at the well design phase. (See Section 5.8. for well suspension and abandonment (decommissioning) guidelines).

Prior to perforating and hydraulic fracturing operations, the production casing should be pressure tested to a pressure that is adequate to meet the well's operational objectives (which should include potential pressures during fracturing operations). Casing testing is covered in Section 5.6 of the Oil and Gas UK Well Integrity Guidelines (Installation and Testing of Barriers).

Casing test pressures should be documented in the well's basis of design documentation and in the operations programme(s).

Casing deformation has been experienced during some fracturing operations and this has been reported as being caused by bedding parallel slip movement. Operators should ensure the risk of casing deformation is considered as part of the well design risk assessment process and they should document any resultant control measures in the well basis of design documentation and in the operations programme(s).

## 5.4.2. Cement Design and Evaluation

Section 4.5 of the Oil and Gas UK Well Integrity Guidelines concerns cement design and evaluation. Section 4.6 refers to designing a well for the eventual suspension and abandonment including reference to permeable horizons outside the casing. Section 5.6 concerns the installation and testing of barriers including cement.

Section 6.2 of the Oil and Gas UK Suspension and Abandonment Guidelines contains guidance on the adequacy of annular cement heights as barriers.

See Section 5.4.3 for groundwater isolation guidelines.

The Oil and Gas UK Well Integrity Guidelines refer to the isolation of "the shallowest hydrocarbon interval". Operators should ensure that there is adequate isolation of hydraulic fracturing operations from groundwater and other permeable horizons by ensuring adequate cement isolation in each casing annulus. Cementing into the previous casing, as per the Oil and Gas UK Well Integrity Guidelines, should be the preferred design. If this is not practicable the cement design should be documented to demonstrate that adequate annular isolation of the hydraulic fracturing will be achieved.

In cooperation with the specialist contractor, operators should prepare suitable programmes for cement placement operations, including monitoring of the effectiveness of placement, as part of the operations planning.

Programmes should include contingency plans and procedures to cover the possibility of a failure to meet the cementation design objectives, as per Oil and Gas UK Well Integrity Guidelines.

Any proposed changes to the cementation programme (design) should be covered by the operator's Management of Change (MOC) procedure and subject to well examination.



The final well abandonment (decommissioning) design should be considered at the well planning stage to ensure good practice abandonment at the end of well life. (See Section 5.8).

The Well Operator's well examination arrangements should include the examination of cementation design and programmes as well as cementation operations. (See section 5.10).

#### 5.4.3. Groundwater Isolation

#### Note on terminology:

"Groundwater" is used in the context of environment law. Groundwater is defined as "all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil".

Aquifers are underground layers of water-bearing permeable rock or drift deposits from which groundwater can be extracted.

http://www.environment-agency.gov.uk/homeandleisure/117020.aspx

The phrase "permeable zone" is used in the context of well integrity and is based on oil industry practice including the Oil and Gas UK Well Integrity Guidelines and the Suspension and Abandonment Guidelines which use the phrases "permeable horizons" and "permeable zones" when describing well integrity in the casing annulus and for well abandonment purposes when describing barriers.

Operators should ensure that groundwater is adequately isolated by cemented casing. (See Section 5.4.2 for cement design and evaluation guidelines).

Groundwater should be thoroughly researched by the operator as part of the well design risk assessment process using:

- 1. Offset well data.
- 2. Geophysical delineation.
- 3. Research with local landowners.
- 4. Research with Local Authorities.
- 5. Research with utility companies.

Groundwater, including any local aquifers, should be carefully delineated at the well planning stage and operators should include the design of groundwater isolation (and the isolation of other permeable zones) in the well's basis of design documentation and in the operations programme(s) (or equivalent document names). (See Section 5.5 for fracturing containment guidelines).

See Section 8.1 for more detailed guidance on groundwater and aquifer surveys.

The surface casing should be set at a sufficient depth below the bottom of any aquifer/nonsaline groundwater in order to provide adequate isolation. Operators should refer to the Oil and Gas UK Guidelines for the Suspension and Abandonment of Wells for information on the adequacy of annular cement heights as barriers.

Operators should ensure that drilling operations through shallow soils and local aquifers are always undertaken using water or water-based mud systems. Details of the mud systems in use should be declared during the planning application and, where required, in accordance with the environmental permitting process.



#### 5.5. Fracturing Containment

As part of the detailed well integrity planning and risk assessment process, operators should ensure that wellbore integrity during fracturing operations is maintained.

Operators should develop a Hydraulic Fracturing Programme (HFP), based on the risk assessment, that describes the control and mitigation measures for fracture containment and for any potential induced seismicity (see Section 5.6).

The proposed design of the fracture geometry should be included in the HFP including (fracturing) target zones, sealing mechanism(s) and aquifers, both those containing fresh and saline groundwater, so as not to allow fracturing fluids to migrate from the designed fracture zone(s). Performance standards should be documented to characterise the basis for the sealing mechanism and to demonstrate that adequate control measures will be implemented. These will be well-dependent but might include microseismic and tiltmeter monitoring of hydraulic fracture growth. Sealing mechanisms include natural geological seals as well as adequate casing and annular cement.

Faults that might impact the hydraulic fracturing seal mechanism should be thoroughly researched and the assessment documented and referenced in the Hydraulic Fracturing Programme to demonstrate that fracturing fluids cannot migrate, via faults, beyond the designated fracturing zones(s).

A detailed HFP will not be available at the planning consent stage since it can only be developed after drilling and well evaluation. In the meantime an outline HFP will be prepared and this will be updated following drilling and well evaluation and prior to consent for Extended Well Testing being sought. The HFP should be made available to the appropriate regulators in accordance with the applicable regulations.

Fracturing operations should be monitored and recorded against the HFP design performance standards. The HFP and fracturing operations should be examined as part of the well examination arrangements (See Section 5.10).

#### Seismicity Induced by Hydraulic Fracturing 5.6.

#### **General Risk Assessment Principles** 5.6.1.

Very low level microseismic events occur routinely during hydraulic fracturing and are due to the propagation of the engineered fractures. They can be used to evaluate fracture designs.

Other minor seismic events are generally rare but can be induced by hydraulic fracturing in the presence of a pre-stressed fault. These induced events may be perceptible to local communities.

Operators should consider the risks of these induced seismic events as part of their general duty to assess the risks arising from well operations. Using the risk-based approach will enable operators to demonstrate that adequate controls are in place to eliminate the event or to minimise any potential impact.

Operators should include the induced seismicity risk assessment control and mitigation measures in the Hydraulic Fracturing Programme (see Section 5.5).

An evolutionary approach to risk assessment and mitigation should be adopted by operators whereby more conservative assessments and controls are adopted at the exploration/appraisal phase of a development (see below). As experience is gained in the area and where induced seismic events have not occurred, operators may use this as evidence to propose different monitoring and mitigation measures which are sufficient to address the risk. If any induced seismic events do occur during fracturing operations, then the defined control measures can be adopted. The events can then be fully evaluated so that the risk mechanisms are able to be fully understood.



The magnitude of seismicity induced by hydraulic fracturing is affected by pressure changes in the shale formation near to the well. The hydraulic fracturing process fundamentally constrains these pressure changes:

- Pressurisation takes place across a limited volume of rock, typically only a few hundred metres in any direction.
- Pressurisation only takes place over a limited timescale, typically only a few hours.
- Pressure dissipates into the surrounding geology as more fractures are created, limiting the pressure that can build up.

The pressure in the well is also a key determinant of induced seismicity and is affected by:

- The volume of injected fluid. Larger volumes generate higher pressures.
- The volume of flow-back fluid. Larger flow-back volumes reduce the pressure. •
- The injection rate. More rapid injection generates higher pressures.
- The flow-back rate. More rapid flow-back reduces the pressure.

#### Mitigating Induced Seismicity – Fault Characterisation and Identification 5.6.2.

The risks of fault movement can be mitigated by the identification of stressed faults and where practicable, by the avoidance of fracturing fluids entering stressed faults.

Risk assessments will depend on such things as:

- a) Geological knowledge of the play area.
- b) Actual field experience in the area.
- c) The depth of fracturing operations.

Therefore risk management will be related to the amount of information available. During the initial planning stages operators should gather sufficient information to evaluate the area.

Operators should carry out site-specific surveys prior to hydraulic fracturing to characterise local stresses and identify nearby faults. Site characterisations could include desk-based studies of existing geological maps, seismic reflection data, and background seismicity data from the BGS. Stress data from nearby boreholes should be integrated (e.g. core data, borehole imaging, calliper logs and evidence of borehole losses). An understanding of the insitu stress is a key element of well design and fracturing strategy.

Operators should not overlook the potential presence of faults that cannot be detected given the limits of seismic reflection surveys.

Once faults have been identified and geological stresses characterised, operators can assess the orientation and slip tendency of faults and bedding planes.

## 5.6.3. Pre-fracturing Injection Tests

The fracture behaviour of a particular formation is commonly characterised using small prefracturing injection tests with microseismic monitoring. Subsequent operations can then be modified accordingly. A reasonable period of time should be allowed to elapse following a prefracturing injection test to ensure no seismic activity occurs as the injected fluid diffuses away from the well and pressure changes in surrounding rock formations are redistributed.

#### **Traffic Light Monitoring Systems** 5.6.4.

Traffic light monitoring systems are implemented as best practice in Enhanced Geothermal Systems (EGS). Data are fed back to operations so that action can be taken to mitigate induced seismicity:



- **Green.** Injection proceeds as planned.
- **Amber.** Injection could proceed after analysis, but with more caution, possibly at reduced rates and with a longer monitoring period and analysis between injections.
- **Red.** Injection is suspended immediately.

Traffic light monitoring systems are affected by natural delays within geological systems, such as the slow movement of fluids through faults so it is important that the trigger levels are low enough to detect the smaller induced seismic events which may be an indication of, or precursor to, a larger induced seismic event later. By using sophisticated seismic monitoring algorithms, it is possible to discriminate these very small events from background surfaceinduced vibrations.

The thresholds of traffic light monitoring systems need not be magnitude-based. The thresholds used in Enhanced Geothermal Systems are based on ground motions, focusing on peak ground acceleration and velocity in conjunction with frequency. As part of the traffic light monitoring system, the ability to locate the hypocentre of an event is critical to understanding the mechanism for induced seismicity.

Other industries that give rise to ground motion, such as construction, quarrying and mining, are regulated by maximum vibration levels rather than maximum magnitude levels. Ground motion systems have been developed to mitigate induced seismicity.

## 5.7. Workover and Interventions

These operations take place during the well operations (production) phase. Guidelines will be added at a later revision.

## 5.8. Well Suspension and Abandonment (Decommissioning)

Relevant Regulations and Guidelines:

- 1. DCR Regulation 15 and Guidance.
- 2. Oil and Gas UK Well Suspension and Abandonment Guidelines.
- 3. Oil and Gas UK Guidelines on Qualification of Materials for the Suspension and Abandonment of Wells

Operators should conform to the Oil and Gas UK Suspension and Abandonment Guidelines.

The final well abandonment design should be considered at the well planning stage to ensure good practice abandonment at the end of well life.

The main factors to be considered are:

- Height of cement in annulus outside casing.
- Any permeable formations (zones) outside the casing that should be covered by cement.
- Cementing casing overlaps.
- Abandonment plugs need to cover the full diameter of the hole, with only casing (no cables) within the cement.
- Type of fluid in annuli above cement.
- Injecting cement into the annulus is more difficult than primary cementing.

Responsibility for the restoration and aftercare of drilling sites lies with the Licence Operator. Operators should make arrangements to ensure they are able to discharge their responsibilities.



## 5.9. Suspended Well Integrity Management

Operators should ensure that, for all wells that are in the suspension phase following drilling and fracturing (prior to the development phase), management standards and procedures are in place for monitoring wells including the status of the equipment and any annulus pressures.

The procedures should take account of the specific circumstances of the well and must include the reporting criteria for any anomaly. Where there is an anomaly, the situation should be fully risk assessed and the conclusion reached and documented on how to proceed with the suspended well. Notification of any anomalies to the appropriate regulators should be included in the management arrangements and subject to independent well examination.

## 5.10. Well Examination (Design and Construction)

Relevant Regulations and Guidelines:

- 1. DCR Regulation 18 and Guidance.
- 2. Oil and Gas UK Guidelines for Well Operators on Well Examination.
- 3. Oil and Gas UK Guidelines for Well Operators on Competency of Well Examiners.

In addition to following the above-referenced guidance, shale gas Well Operators should include in their well examination scheme the arrangements for the examination of the following aspects of well design:

- 1. Groundwater and aquifer isolation.
- 2. Fracture containment.
- 3. Induced seismicity risks.
- 4. Fracturing and flow-back/testing programmes and operations.

Well examiners of shale gas wells should be provided with these UKOOG Guidelines as well as the referenced Oil and Gas UK Guidelines by the Well Operator.

Well examiners use documentary evidence of well integrity as the primary means of examination to provide assurance to the Well Operator that wells are designed and constructed properly (as per the published DCR Regulation 18 Guidance). It is not the practise that examination schemes need to rely on physical examination of wells, unless reliance cannot be placed on the veracity of the documentary evidence.

However, for the purpose of increasing public confidence in the UK shale gas industry whilst it is in its infancy, UKOOG consider it appropriate for shale gas Well Operators to ask their well examiners to examine certain well integrity and fracturing operations on site, in real time, especially during the early stages of a development to provide a further level of independent oversight. Such, periodic, site visits are to be made at the discretion of the examiner to observe and verify that such operations have been executed satisfactorily in accordance with the approved programme, in addition to assessing documentary evidence of well integrity. The frequency and need for such visits, with experience, would reasonably be expected to reduce with time.

## 5.11. Well Examination (Well Abandonment)

Relevant Regulations and Guidelines:

- 1. DCR Regulation 18 and Guidance.
- 2. Oil and Gas UK Guidelines for Well Operators on Well Examination.
- 3. Oil and Gas UK Guidelines for Well Operators on Competency of Well Examiners.

The Well Operators' well examination arrangements should include arrangements for the examinations of well abandonment designs and operations.



## 6. Well Integrity – Operations (Production) Phase

Guidelines on the operations phase (well production) to be added at a later revision, including independent examination during the operations phase.

## 7. Fracturing/Flow-Back Operations

See Section 5.5 for guidelines on fracturing containment.

#### 7.1. Overview

When conducting fracturing and flow-back/testing operations operators should ensure they adhere to and support the following overarching policies:

- 1. To safeguard the quality of surface water and groundwater resources, through sound wellbore construction practices, sourcing fresh water alternatives where appropriate, and to recycle water for re-use, if practicable.
- 2. To measure and disclose water usage with the aim of minimising environmental impacts.
- 3. To support the development of fracturing fluids and additives with the least environmental risks.
- 4. To continue to advance, collaborate on and communicate technologies and best practices that minimise the potential environmental risks of hydraulic fracturing.
- 5. To eliminate or, if not practicable, to minimise any fugitive emissions (See Section 10).
- 6. To make public the substances used in hydraulic fracturing fluids (see Sections 7.4 and 9.2)

The hydraulic fracturing programme should emphasise and commit the operator to environmental protection.

Since fracturing flow-back/testing may involve dangerous substances (in the form of flammable gas) then both BSOR and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) apply to these operations. Therefore there are requirements for operators to carry out and record suitable and sufficient risk assessments, to eliminate or reduce of risks from dangerous substances and to provide arrangements to deal with accidents incidents and emergencies during operations. The outputs (control and mitigation measures) from these requirements, including the various, required, Borehole Site Health and Safety Document Plans, will contribute to the overall environmental plan (e.g. the reduction of fugitive emissions).

## 7.2. Fracturing/Flow-Back Surface Equipment - Design and Verification

Operators should ensure that:

- 1. Equipment used in fracturing/flow-back/testing operations complies with the Provision and Use of Work Equipment Regulations, Schedule 2(6) ("Maintenance") of the BSOR and Regulation 6 of DSEAR ("Control and Mitigation Measures") and is, therefore, fit for purpose and meets relevant industry standards.
- 2. Well control equipment used in fracturing/flow-back/testing operations complies with Schedule 2(7) ("Well Control") of the BSOR and is, therefore, fit for purpose and meets industry standards. (Well control equipment both as part of the well pressure envelope and equipment used downstream of the well).
- 3. Pressure-containing equipment (that may contain hydrocarbons) is subject to a quality control/certification process operated by the equipment owner and that the results from the process are checked by the operator.
- 4. Pressure vessels used in association with fracturing operations comply with the Pressure Systems Safety Regulations and associated guidance.

- 5. Prior to commencing fracturing/flow-back/testing operations a thorough site inspection of the total system is carried out in accordance with a written procedure and this inspection is witnessed by the operator's site supervisor.
- 6. Water transfer systems are designed to site-specific conditions and these systems are routinely tested and monitored during operations.
- 7. Audits of any third party equipment are reviewed and made available for disclosure.

Any fracturing equipment that forms part of the well pressure envelope is subject to the DCR regulations, including independent well examination.

## 7.3. Fracturing/Flow-Back/Testing Operations

#### 7.3.1. Planning and Supervision

Operators should ensure that:

- 1. Fracturing/flow-back/testing operations are planned and fully risk assessed as part of the well design and operations programming process.
- 2. Suitable and sufficient risk assessments, to eliminate or reduce the risks from dangerous substances (well fluids) being released and their impact on the water environment are carried out, recorded and the findings (control and mitigation measures) implemented.
- 3. Adequate arrangements are in place to deal with emergencies during fracturing and flow-back/testing operations.
- 4. The Borehole Site Health and Safety Document includes relevant details about the fracturing flow-back/testing operations and (where appropriate) contains plans to deal with:
  - Provision of escape and rescue.
  - Prevention of fire and explosion with particular reference to blowouts and escapes of flammable gas.
  - General fire prevention.
  - Detection and control of toxic gases.
- 5. Continuing on from the drilling operations phase, a competent person is appointed to be in charge of the well site ("borehole site") and sufficient competent persons are appointed to exercise immediate supervision of operations in accordance with BSOR Schedule 2. (See Section 5.1 for further detail).
- 6. Sufficient personnel are available who are adequately trained and experienced to operate fracturing/flow-back/testing equipment, emergency shutdown systems and any spill containment equipment.

## 7.3.2. Fracture/Flow-Back/Testing Programming

Operators should ensure that:

- 1. Sufficient and suitable fracturing/flow-back/testing programmes and procedures are developed, authorised and disseminated to include:
  - Equipment rig up and testing, including testing the integrity of all high pressure equipment (fracturing wellhead, flowlines, manifolds, piping and pump equipment).
  - Monitoring pressure on the production string and all well annuli during rig up and testing.
  - Monitoring any adjacent or offset wells for pressure on the production string and other well annuli, as required.



- Monitoring wells on neighbouring well pads, if appropriate. •
- 2. Any changes to programmes follow a Management of Change procedure.
- 3. Records are maintained for all tests of high pressure equipment.
- 4. Sufficient testing of the emergency shutdown/pressure safety valve system(s) is undertaken in accordance with a programme or written procedures prior to the start of the first fracturing stage.
- 5. Procedures are developed to continuously monitor and record the annulus pressures at the wellhead and records are maintained.
- 6. Procedures are developed to continuously monitor and record the pressures in the annulus between the intermediate casing and the production casing and records are maintained. The procedures should include the actions required if any pressure abnormalities are observed.
- 7. Fracturing/flow-back/testing programmes and any changes to them are submitted to the well examiner in accordance with the Well Operator's well examination arrangements.

#### 7.3.3. Flow-back/Testing Operations

Operators should ensure that:

- 1. Programmes and procedures are followed and any necessary changes are authorised in accordance with a management of change procedure.
- 2. Sufficient and suitable records of operations are completed and disseminated.
- 3. Operations' records are submitted to the well examiner as part of the Well Operator's well examination arrangements to ensure that operations in progress are examined.

#### 7.4. **Fracturing Operations Disclosure**

See Section 9.2 for guidelines on fracturing fluid disclosure. The following guidelines relate to the disclosure of operational information by the operator.

The operator will disclose pre-operational information during the planning application process since most documentation provided by the operator will be made available by the Local Planning Authority via their normal "open access" policies, including web-site access.

The following guidelines concern the recommended disclosure of fracturing information only.

In addition to statutory reporting, Operators should have available the following for potential disclosure:

- 1. Geological information including the proposed depth(s) of the top and the bottom of the formation into which well fracturing fluids are to be injected.
- 2. Information concerning water supply, usage, recycle and re-use.
- 3. A detailed description of the well fracturing design, including:
  - Estimated total volume of fluid to be used.
  - Fracturing fluid compositions and concentrations. •
  - ٠ Anticipated surface and downhole treating pressure range.
  - Maximum injection treating pressure. •
  - Estimated or calculated fracture length and fracture height. •
  - Annuli and offset well pressure monitoring programme to be performed.
  - Testing and flow-back plans.



- 4. A detailed post-fracture job report, including:
  - Actual total volume of fluids used.
  - Actual surface and downhole treating pressure range. •
  - Maximum injection treating pressure. •
  - The actual or calculated fracture length and fracture height. ٠
  - Annuli and offset well pressure monitoring results.
  - Confirmation that wellbore integrity was maintained throughout the operation. •
  - Testing and flow-back results.
  - Any operational variations to the pre-job design. •
  - Any induced seismic events that have been recorded including any steps taken as a result of recording such events (for example in accordance with the traffic light system).

#### **Environmental Management (Construction and Operations)** 8.

#### **Groundwater Surveys** 8.1.

Section 5.4.3 contains guidelines on the well design aspects of groundwater and aguifer isolation.

Groundwater, aquifers and where applicable, mine workings, should be thoroughly researched by the operator as part of the well design and fracturing risk assessment process.

Operators should be aware of any specific planning or environmental permits that may set out requirements in respect of groundwater surveys.

During the well planning phase the following baseline surveys of groundwater and any shallow aquifer(s) should be undertaken by operators. This will allow for subsequent pre- and postfracturing sampling of the groundwater that can then be compared with the "baseline" value.

- 1. Surface water sampling at the well site prior to the start of site construction.
- 2. Groundwater sampling prior to the start of site construction.
- 3. Surface sampling following site construction, drilling and fracturing operations.
- 4. Groundwater sampling following site construction, drilling and fracturing operations.

Operators should ensure that all water sampling and analysis is carried out by qualified third party organisations using recognised sampling and analytical methods.

Operators should disclose all ongoing water testing results in accordance with any specific planning requirements or environmental permits. Any anomalies detected that are connected with operations should be risk assessed and reported as required by the regulator (EA/SEPA).

The above survey data should also be reported to the British Geological Survey (BGS) who are collating similar data across the UK.

#### 8.2. Site Containment

Site pollution control is a part of the local planning process and operators should be able to demonstrate best practice in this area, including the prevention of contamination of soils, by the provision of suitably designed impermeable site underlay systems and site drainage arrangements etc.

## 9. Fracturing Fluids and Water Management

## 9.1. Fluid Composition

Operators should be committed to minimising and, if possible, the elimination of environmental and health risks associated with fracture fluids and additives.

Operators should assess the potential risks from the use of fracturing fluids and additives and create risk management plans (fracturing programmes) to effectively manage the additives and make the process used to develop specific plans available for public disclosure. This assessment should include:

- Identifying chemical ingredients and characteristics of each additive.
- Identifying the volume and concentration of the substances in the fracture fluids.
- Assessing potential environmental and health risks of fracture fluid additives.
- Defining operational practices and controls for the identified risks. E.g. the amount of fluids that is likely to be recovered.
- Incorporating risk management plans for each well fractured.

Operators should lead and support the advancement of new, more environmentally sound, products.

Guidance on the UK methodology for determining the hazardous/non-hazardous status of substances in relation to groundwater can be found at:

http://www.wfduk.org/sites/default/files/Media/120628\_JAGDAG\_det\_meth\_final.pdf

## 9.2. Public Disclosure of Fracture Fluid Composition

Operators will disclose on the UKOOG website, <u>www.ukoog.org.uk</u>, the chemical additives of fracturing fluids on a well-by-well basis.

Information for fluid disclosure should include:

- Any EA/SEPA authorisations for fluids and their status as hazardous/non-hazardous substances.
- Material Safety Data Sheets information.
- Volumes of fracturing fluid, including proppant, base carrier fluid and chemical additives.
- The trade name of each additive and its general purpose in the fracturing process.
- Maximum concentrations in percent by mass of each chemical additive.

The Public Disclosure of Fracture Fluid Form is shown in appendix 2 and will be downloadable from <u>www.ukoog.org.uk</u>.

## 9.3. Disclosure of Flow-back Fluids

The following information should be available for disclosure by the operator concerning flowback and handling of recovered/produced fluids:

- The estimated and actual volume of fluid to be recovered during flow-back.
- The expected rates, pressures and temperatures of fluid recovery and production.
- Water compositional analysis.
- Water mineralogical analysis.
- Any identified contamination issues.



- Any radioactive contaminated fluids.
- The proposed method of handling the recovered fluids, including but not limited to, tank • requirements, pipeline requirements, flaring, flow-back and storage periods, recycle and re-use for other activities.
- Proposed disposal method of the recovered fluids up to the end location. •
- Proposed volume of flow-back fluids to be recycled and re-used.
- Regulatory approval and compliance records. •

#### Fluid transport 9.4.

The operator should ensure:

- 1. Sufficient planning to ensure the minimisation of fluid transport movements and distances.
- 2. Detailed planning and robust estimation of transport movement is undertaken during the local planning process stage.
- 3. Regulatory approved transportation, service providers and 3<sup>rd</sup> party contractors (if outsourced from the operator) are used for the transport of fluids.
- 4. Implementation management procedures to address the risks associated with fluid transport.
- 5. Natural gas is removed from fluids prior to transport and a system for checking and recording is implemented.

#### 9.5. Fluid Storage

Fracture fluid storage and site conditions should be covered in detail during the planning application stage.

Best practice should be adopted to ensure that there is no risk of fluid leaks or spillages, this should include:

- Fluids stored and mixed in appropriate above-ground tanks that are fit for purpose and • meet industry standards.
- Natural gas removal from fluids prior to storage and a system for checking and • recording implemented.
- Storage site locations should be secure and safe.

Operators should make the following available for disclosure:

- Tank maintenance records.
- Tank cleaning records and off-take waste disposal records. •
- The volume and chemical composition of all fluids stored on a location. •

#### 9.6. Fracture Fluid Disposal

Operators should always dispose of fracture fluid that is no longer required (or unable to be reused) at an approved waste management facility in accordance with EA/SEPA regulations.

Guidance on the environmental permitting requirements can be found at the following **Environment Agency website:** 

http://www.environment-agency.gov.uk/business/topics/134508.aspx

In Scotland SEPA guidance is available at:



#### http://www.sepa.org.uk/customer\_information/energy\_industry.aspx

#### 9.7. Water Sourcing and Use/Re-Use

Water sourcing is dependent on the area of operations. Operators should ensure:

- 1. Transparency concerning water sourcing and any recycling process
- 2. Consideration is given to the re-use of fracturing fluid to reduce freshwater resource impacts and potential disposal issues.

Operators should make available for disclosure specific information about the water to be used in any fracturing operation, including:

- 1. Location and supply source of the water to be used for the base fluid.
- 2. Water usage volumes.
- 3. Baseline water compositional analysis.

The following Environmental Agency website refers to abstraction licensing and the potential availability of water:

http://www.environment-agency.gov.uk/business/topics/water/32032.aspx

In Scotland SEPA guidance is available at:

http://www.sepa.org.uk/water/water\_regulation/regimes.aspx

#### Minimising Fugitive Emissions 10.

Operators should plan and then implement controls in order to minimise all emissions.

Operators should be committed to eliminating all unnecessary flaring and venting of gas and to implementing best practices from the early design stages of the development and by endeavouring to improve on these during the subsequent operational phases.

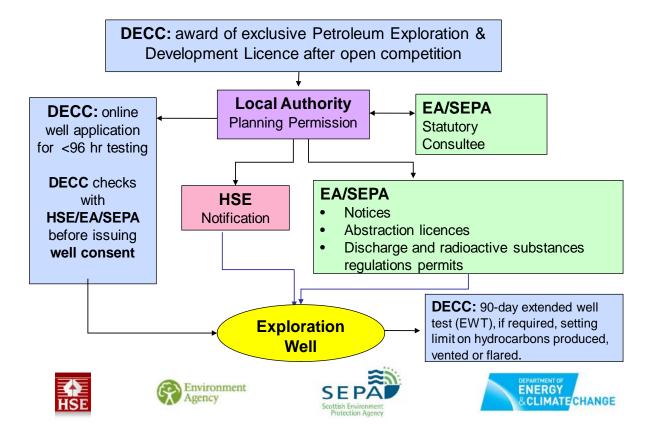
Emphasis should be placed on "green completions" whereby best practice during the flow-back period is to use a "reduced emissions completion" in which hydrocarbons are separated from the fracturing fluid (and then sold) and the residual flow-back fluid is collected for processing recvclina. However this approach will not always be practicable and at the exploration/appraisal stage of a development where separation and flaring of natural gas should be the preferred option, minimising venting of hydrocarbons wherever practicable.

Operators should make available and disclose emissions data in line with best practice and any regulatory reporting requirements (e.g., flaring would be in accordance with DECC approvals etc.).



# Steps through the regulatory process Exploration and Appraisal Wells

**CACKOOG** United Kingdom Onshore Operators Group





## Appendix 2 Public Disclosure of Fracture Fluid Form

# United Kingdom Onshore Operators Group

#### Shale Gas Well - Hydraulic Fracturing Fluid and Additive Component Transparency Service (HF FACTS)

Well Location	<u>Well De</u>	scription	Hydraulic Fracturing Fluid Data
Country	Operator of Well		Water Volume (1) (Cubic Metres)
Latitude	Name of Well		Max mass % of Total HF Fluid
Longitude	DECC Well Registration No		Proppant (kilograms)
Long/Lat projection	HF Completion Date		Max mass % of Total HF Fluid
			% of Water Volume -
County	Well Depth (TVD Meters)		recycled/produced water
Regulator Consents	Avge frac perf depth (TVDm)		% of Water Volume - fresh water
EA EPR Permit No			Max (mass %) Water+Proppant=
Town & Country Planning cons	ent		
DECC Hydraulic Fracture Progra approval	mme		

#### HF Fluid Products

Product Trade Names in Fracturing Fluid	Product Purpose	
(if applicable)	in Well	Supplier(s)

#### HF Fluid Constituents

Chemical Substance in Fracturing Fluid (2)	Chemical Abstract Service Number (CAS Number) (3)	Maximum Chemical substance Mass % in HF Fluid (4)	Comments

Notes:

(1) Water utilized may be any combination of recycled water, produced water or fresh water.

(2) All chemical additive substance data is provided by suppliers and is consistent with Safety Data Sheets.

(3) See www.echa.europa.eu to find ECHA numbers; blank if confidential business information but regulator fully appraised.

(4) Because maximum percentages are shown, total of water, proppant and HF chemical substance components may be greater than 100%.



# Appendix 3 Glossary

ALARP	As Low as Reasonably Practicable
API	American Petroleum Institute
BGS	British Geological Survey
BSI	British Standards Institute
BSOR	Borehole Sites and Operations Regulations
DECC	Department of Energy and Climate Change
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
EA	Environment Agency
EIA	Environmental Impact Assessment
EGS	Enhanced Geothermal Systems
HFP	Hydraulic Fracturing Programme
HSE	Health and Safety Executive
ISO	International Organization for Standardization
MOC	Management of Change
MPA	Mineral Planning Authorities
PEDL	Petroleum Exploration and Development Licensing
PUWER	Provision and Use of Work Equipment Regulations
PAS	Publicly Available Specification (BSI)
PPC	Pollution Prevention and Control
SEPA	Scottish Environment Protection Agency
SPC	HSE Semi Permanent Circular
SSSI	Site of Special scientific Interest
WONS	DECC Well Operations Notification System
WML	Waste Management Licensing



## Appendix 4 References

#### 1. Oil and Gas UK Well-Related Guidelines

Oil & Gas UK quidelines can be the publications accessed at website http://www.oilandgasuk.co.uk/publications/publications.cfm. Members of Oil & Gas UK can access the guidelines via the extranet.

- 1. Oil and Gas UK Well Integrity Guidelines.
- 2. Oil and Gas UK Guidelines for the Suspension and Abandonment of Wells.
- 3. Oil and Gas UK Guidelines on Qualification of Materials for the Suspension and Abandonment of Wells.
- 4. Oil and Gas UK Guidelines for Well Operators on Well Examination.
- 5. Oil and Gas UK Guidelines for Well Operators on Competency of Well Examiners.
- 6. Oil and Gas UK Well Guidelines on Competency for Wells Personnel.

#### 2. API Relevant Recommended Practices

API documents are available from http://api.org/publications-standards-and-statistics.aspx

- 1. API S65 part 2 Isolating Potential Flow Zones During Well Construction, 2nd Edition: Dec 2010
- 2. API 10 Recommended practices for testing well cements: series, various dates.
- 3. API RP 14B Design, installation, repair and operation of subsurface safety valve systems (ISO 10417) 5th edition: July 2005.
- 4. API RP 14B Design, installation, repair and operation of subsurface safety valve systems (ISO 10417) 5th edition: July 2005.
- 5. API HF1 Hydraulic Fracturing Operations Well Construction and Integrity Guidelines.
- 6. API HF2 Water Management Associated with Hydraulic Fracturing
- 7. API HF3 Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing
- 8. API RP 53: Recommended practices for blowout prevention equipment systems for drilling wells: 3rd edition: 1 March 1997

#### 3. International Organization for Standardization (ISO) documents

A list of standards is available from the OGP website (in addition to the ISO website) http://www.ogp.org.uk/pubs/4210.pdf

- 1. BS EN ISO 11960 Petroleum and natural gas industries steel pipes for use as casing and tubing (API Spec 5CT), 2011.
- 2. BS EN ISO 15156 Materials for use in H<sub>2</sub>S-containing environments in oil and gas production (NACE MR 0175), 2009.
- 3. BS EN ISO 10423 Petroleum and natural gas industries drilling and production equipment – wellhead and christmas tree equipment (API Spec 6A), 2009.
- 4. BS EN ISO 14310 Petroleum and natural gas industries downhole equipment packers and bridge plugs, 2008.
- 5. BS EN ISO 10417 Petroleum and natural gas industries subsurface safety valve systems - design, installation, operation and redress, 2004.



6. BS EN ISO 13680] Specification for corrosion resistant alloy (CRA) seamless tube for casing and tubing (API Spec 5CRA).

## 4. HSE Information

- 1. HSE Semi-Permanent Circular (SPC 43) on Well Construction Standards. http://www.hse.gov.uk/foi/internalops/hid\_circs/technical\_general/spc\_tech\_gen\_42.htm
- 2. ALARP HSE internet guidance (accessed October 2011), http://www.hse.gov.uk/risk/theory/alarpglance.htm
- 3. Successful Health and Safety Management. http://www.hse.gov.uk/pubns/books/hsg65.htm

## 5. Environment Agency Information

- 1. Guidance on Environment Agency permits for unconventional gas http://www.environment-agency.gov.uk/business/topics/126689.aspx
- 2. Guidance Note: "Regulation of exploratory shale gas operations" Link on the page above.

## 6. Scottish Environment Protection Agency Information

- 1. Guidance on Water Environment (Controlled Activities) (Scotland) Regulations (CAR) http://www.sepa.org.uk/water/water\_regulation/regimes.aspx
- 2. Regulatory Guidance on Coal Bed Methane and Shale Gas http://www.sepa.org.uk/customer\_information/energy\_industry.aspx

## 7. Coal Authority

Guidance on Managing the Risk of Hazardous Gases when Drilling or Piling Near Coal.

http://coal.decc.gov.uk/assets/coal/whatwedo/4860-guidance-on-managing-the-risk-ofhazardous-gases-w.pdf

## 8. Relevant Regulations

1. The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996, (SI 1996/913).

DCR guidance - A guide to the well aspects of the Offshore Installation and Wells (Design and Construction, etc) Regulations 1996. www.hse.gov.uk/pubns/books/l84.htm.

2. BSOR - Borehole Sites and Operations Regulations 1995 (SI 1995/2038).

BSOR guidance - A guide to the Borehole Sites and Operations Regulations www.hse.gov.uk/pubns/books/I72.htm

3. PUWER – The Provision and Use of Work Equipment Regulations.

PUWER Approved Code of Practice and guidance. http://www.hse.gov.uk/pubns/books/l22.htm.

4. DSEAR – The Dangerous Substances and Explosive Atmospheres Regulations 2002.

DSEAR Approved Code of Practice and guidance. http://www.hse.gov.uk/pubns/books/I138.htm.

5. MHSWR - Management of Health and Safety at Work Regulations 1999.

MHSWR Approved Code of Practice and guidance http://www.hse.gov.uk/pubns/books/l21.htm



6. Pressure Systems Safety Regulations 2000.

Pressure Systems Safety Regulations – Approved Code of Practice and guidance. http://www.hse.gov.uk/pubns/books/l122.htm.

- 7. The Environmental Permitting Regulations. http://www.environment-agency.gov.uk/business/topics/permitting/default.aspx.
- 8. Water Environment (Controlled Activities) (Scotland) Regulations http://www.sepa.org.uk/water/water\_regulation.aspx
- 9. The Town and Country Planning (Environmental Impact Assessment) Regulations 2011. http://www.legislation.gov.uk/uksi/2011/1824/contents/made.