Energistyrelsen

Vejledning for boring og brønd operationer på land i Danmark 2024

Guidelines for drilling and well operations onshore Denmark 2024

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Preface

These guidelines are inspired by the offshore well operations guidelines of the Danish Working Environment Authority (DWEA): https://offshore.at.dk/en/regulations/wea-guidelines/well-operations/

The guidelines are issued in order to facilitate processing by the Danish Energy Agency (DEA) of applications concerning “works” (Danish: arbejder) pursuant to Section 28 of the Danish Subsoil Act[1]. To facilitate this, the guidelines address areas to be considered and described to ensure, that the DEA receives necessary, complete and full project information.

Issues concerning well operations in general (maintenance, well integrity etc.) are addressed in context of the purpose of the Subsoil Act, cf. Section 1(1), as well as the overarching responsibility of the DEA to ensure, that the use of the subsoil is carried out in a safe and appropriate manner, cf. Sections 10(1) and 23(d)(1).

The guidelines will be updated as the need arises. Please contact the DEA if you have feedback or would like to suggest changes: ddr@ens.dk.

Latest version is available here: https://ens.dk/en/our-responsibilities/oil-gas/legislation-and-guidelines.

[1] Consolidated Act no. 1461 of 29 November 2023 on the Use of the Danish Subsoil.

Contents

Background & Scope

These guidelines provide guidance on how to set up onshore drilling projects, specifically with the aim of facilitating the processing of applications for approval pursuant to Section 28(1) of the Subsoil Act. Furthermore, it also provides guidelines on important aspects to be covered by applications for approval of "works" (Danish: "arbejder") related to the operations, reentry, work overs, wireline operations and abandonment phases of a well life cycle.

The document also covers certain life cycle and maintenance issues which is relevant to ensure that the subsoil is used in a safe and appropriate manner, cf. Sections 10(1) and 23(d)(1) of the Subsoil Act.

Apart from approval in accordance with the Danish Subsoil Act, onshore drilling operations are subject to a variety of different legislative regimes under the purview of different authorities. The guidelines therefore include certain other issues outside the scope of the Subsoil Act that are relevant to onshore drilling operations.

The issues to be considered, include, but are not necessarily limited to:

- Obtaining a drilling permit (DEA)
- Drinking water aquifer protection – well design related (DEA)
- Drinking water aquifer protection (Local municipality, possibly the – Danish Environmental Protection Agency - DEPA)
- Notification of construction site (DWEA & Local Municipality)
- Environmental permits, screening etc. (Local municipality, possibly the environmental agency DEPA)
- Plan for safety and health – "Plan for sikkerhed og sundhed" (DWEA)
- Registry of foreign workers – Registret for udenlandske Tjenesteydere (RUT) (DWEA)
- Certification of load bearing equipment and pressure vessels (DWEA)
- Chemical management (DWEA, possibly the environmental agency DEPA)
- Special certificates, such as for fork lift & crane drivers (DWEA)
- Access control to the drilling site
- Notification to and coordination with the local emergency services
- Transport and storage of explosives and radioactive sources
- Etc.

In order to obtain an approval in accordance with Section 28, you must have a permit pursuant to Sections 3, 5, 23, or rules issued in accordance with Section 23 x of the Subsoil Act. If you have a permit, you will also need an approved field development plan in accordance with Sections 10(1) (raw materials) or 23(d)(1) (storage and other uses of the subsoil).

The guidelines are applicable to all types of deep onshore wells requiring a permit under the Subsoil Act: Exploration, development, appraisal, oil, gas, salt, geothermal, CO_2 storage, Hydrogen, Compressed air, brine storage wells, etc.

The document covers a wide range of well types/projects with vastly different risk profiles. **Risk assessment** of specific projects/works etc. is therefore crucial, and operators should aim to **demonstrate,** that a risk is As Low As Reasonably Practicable **(ALARP).** Since the document covers a wide range of well types/projects, not every issue mentioned in the document will be relevant in all cases.

Introduction

These guidelines address the design and planning, construction, maintenance and performance of onshore well operations from conception to permanent plug and abandonment. The guidelines are inspired by the Danish Working Environment Authority guidelines for offshore well activities [https://offshore.at.dk/en/regulations/wea-guidelines/well-operations] and incorporates the experience of the DEA regarding onshore well operations.

If the issues outlined in these guidelines are considered and addressed, it is expected that the processing time for applications for approval of onshore well operations will be shortened.

These guidelines are intended for operators and rig owners involved in onshore well operations in Denmark and focus on issues related to the Subsoil Act.

The guidelines are also relevant for safety representatives and employees, as they must contribute to reducing the risks in accordance with the ALARP principle. Furthermore, the guidelines are intended for drilling and well personnel, well verifiers, and inspection and testing bodies carrying out activities on behalf of operators and rig owners.

1. Legal basis

Pursuant to Section 28(1) of the Danish Subsoil Act, any works to be carried out in connection with activities covered by the Subsoil Act, including drilling wells, sinking shafts, and driving adits and drifts, may not be initiated until the approval of the Minister for Climate, Energy and Utilities has been obtained for equipment, working programme and working methods in each individual case, (…).

Approval in accordance with Section 28(1) aims at ensuring an appropriate completion of activities and prevent damage to persons and property, the environment and materiel. The approval includes equipment, working programme and working methods. According to Section 28(4), the Minister for Climate, Energy and Utilities may lay down terms and conditions for approvals pursuant to Subsection 28(1).

According to Section 10(1) and 23(d)(1), use of the subsoil shall be carried out in a safe and appropriate manner. This applies in relation to activities associated with the exploration and production of raw materials, cf. Section 10(1), as well as exploration and other uses of the subsoil, cf. Section 23(d)(1). The obligation encompass a.o. life cycle issues, f.ex. maintenance and well integrity.

Pursuant to Section 25(1), the Minister for Climate, Energy and Utilities shall supervise compliance with the provisions of the Subsoil Act and with the rules and regulations, terms and conditions drawn up in pursuance of the Subsoil Act. The Minister for Climate, Energy and Utilities may issue enforcement notices ordering compliance with the Subsoil Act and with regulations issued in pursuance hereof (…).

Pursuant to Section 34(1), the Geological Survey of Denmark and Greenland (GEUS) and the DEA shall collect all information available about the Danish subsoil. With a view hereto, samples and other information about the subsoil obtained in connection with the performance of activities covered by this Act shall be submitted to GEUS and the DEA them in accordance with rules and regulations laid down by the Minister for Climate, Energy and Utilities. Rules regarding Section 34(1) has been laid down in the Executive Order on Submission of Samples and Other Information about the Danish Subsoil[2].

The DEA exercise the powers of the Minister for Climate, Energy and Utilities in relation to approval of works encompassed by Section 28[3].

[2] Executive Order No. 56 of 4. February 2002 on Submission of Samples and Other Information about the Danish Subsoil.
[3] Cf. Executive Order No. 910 of 26 June 2024 on the tasks and competence of the Danish Energy Agency, Section 3(1)(1).

2. Risk management

To ensure a safe and efficient operation with due regard to the environment, a risk management system that covers all phases of the well project from design and planning to final permanent abandonment as well as all types of well operations that will be carried out by the project should be implemented.

The risk management system will make it possible to identify elements that warrants attention as well as elements that, from a risk perspective, are irrelevant. For example, if there is 100% certainty that shallow gas and/or H_2S is **not** present, then this does not have to be covered in detail. Another example is a geothermal injector well, which is on vacuum (sub-hydrostatic). In this case, the blow out risk could be considered non-existent and a fully-fledged BOP system + procedures and training are not necessary.

The risk management system should include, but is not necessarily limited to, the following main topics

- identification of main hazards
- risk reduction through the ALARP (As Low As Reasonably Practicable) principles
- qualification of personnel.

The risk management system should be based on qualitative methods and may include quantitative methods. Furthermore, the risk management system should be based on preventative measures.

The operator's risk management system should cover all well phases from design and planning to final permanent abandonment.

The operator should for each planned well operation carry out an assessment of health and safety risks and risks of major accidents and reduce these risks to a level as low as reasonably practicable (the ALARP principle). See the DWEA site on ALARP: https://offshore.at.dk/en/regulations/wea-guidelines/alarp-principle/

The rig owner's risk management system should cover all the types of well operations that will be carried out on the rig.

The operator or rig owner should continuously seek to improve the health and safety level through reduction of the relevant health and safety risks. The risk assessment should always include the potential risk for accidental release of substances and materials that may lead to a major accident.

3. Management system

3.1. Operator's and rig owner's management system

A management system for health, safety and environment to prevent harm to people and the environment in connection with drilling operations covered by the Subsoil Act should be established, implemented and maintained. The management system should ensure and document compliance with Danish regulation. The management system should be established according to norms and standards for management systems, or other similar systems and should be established and implemented before commencing well operations.

The management system should also include management of changes (MOC) in the organisation, its activities or materials, modification to the management system including temporary changes, and their impact on operations, processes and activities.

Prior to introduction of changes, the organisation should identify and address hazards and risks associated herewith.

3.2. Bridging document

The bridging document should align and co-ordinate the requirements and responsibilities of various parties in relation to the operation. It is also used to align and coordinate the emergency response procedures between operator and rig owner.

The purpose of the bridging document between the operator and the rig owner is to ensure:

- description of responsibilities for the operator and rig owner
- acknowledgement that management of change and risk assessment processes should be used in the well operations
- involvement of the drilling contractor when operational changes and/or conditions are identified that could require a well operation risk assessment
- an alignment of all parties regarding drilling as well as health, safety and environment (HSE) standards and applicable regulatory requirements
- to communicate safety activity such as "stop work authority" to enhance safe operations and a basis for discussion of well construction, equipment, barriers, risks, and the mitigations for these risks.

The bridging document should at all times be updated and reflect the actual situation and responsibilities on the installations.

3.3. Contingency planning

As part of each operation, contingency plans should be established, implemented and maintained as necessary. Where there is a risk of a.o. H_2S, blowout etc. a contingency plan would be considered relevant for the safe and appropriate killing of the well. A blowout contingency plan should be considered for all wells that are not permanently abandoned with a flow potential from any formation. The need for relief wells should be based on a risk assessment of each well, which could entail the option of one or two relief wells to be drilled in order to kill the well. In all cases, the operator should plan for two locations for relief wells, an assessment of equipment requirements for capacities and demonstrate that drilling a relief well at the planned location is feasible in a timely manner.

Blowouts while drilling have happened onshore in Denmark in the past, mainly while drilling in Zechstein salt diapirs present in central and northern Jutland. These blowouts tend to be of high intensity but short duration and can contain toxic gasses, such as H_2S. Preparatory work should evaluate how to handle this rare, but not impossible, event, up to and including consideration for a diverter system and degasser equipment for wells penetrating the Zechstein salt.

Furthermore, an evaluation of the shallow gas potential and a plan for how to handle this eventuality should be prepared as part of the drilling program.

Additionally, the potential for shallow water kicks (such as artesian flows) should also be included in these evaluations.

In the event of an incident requiring a relief well, the operator must apply for an approval of the operation according to Section 28 of the Subsoil Act.

In relation to minimum requirements for onshore wells in relation to blowout contingency planning and relief well planning, inspiration can be found in NORSOK D-010 or Offshore Energies UK guidelines.

The contingency plan should also include management of H_2S in the well. If it is expected, that H_2S will be present in levels that could be harmful to the health and safety of personnel, a H_2S contingency plan should be implemented and should be part of the bridging documentation between the operator and the rig owner.

3.4. Norms and standards

Recognized norms and standards should be followed when designing, constructing and maintaining wells.

The recognized norms and standards used should be listed in the operator and/or rig owner management system.

The International Association of Oil & Gas Producers (IOGP) publishes a reference list of the primary standards and guidelines for well construction and well operations, which includes:

- ISO (International Standard Organisation) standards
- API (American Petroleum Institute) standards
- NORSOK standards
- Offshore Energies UK Guidelines
- Norwegian Oil and Gas Association Guidelines

The use of recognized norms and standards does not exclude the use of the ALARP principle.

When deciding if a specific standard is appropriate and applicable in relation to, for example, underground gas storage facilities, the level of detail and relevancy, e.g. in relation to well design and integrity, of the standard should be taken into account.

The planned and potential uses of the facilities in question should also be taken into consideration.

Requirements for facilities meant for storage/handling of flammable and/or volatile substances in a geological structure naturally differ from requirements related to storage of other, more inert substances.

Regardless of the planned use, it is expected that facilities will be designed and operated in accordance with the most current relevant norms and standards. In the case of underground storage facilities for hydrocarbons, existing norms and standards for the oil and gas/hydrocarbon industry should be considered as relevant.

Besides using recognized norms and standards, the operator and rig owner should consider good practice onshore in the EU and in the North Sea region. This is a prerequisite for adhering to the ALARP principle.

3.5. Competence and training

3.5.1 Formal competences

The operator and rig owner should ensure that the drilling and well personnel have sufficient qualifications and training to perform their assigned tasks professionally, safely and in accordance with procedures and instructions.

Examples of competency profiles for drilling supervisor and for senior well operations supervisors are available in ISO standard 17969 Annex B and C respectively.

3.5.2 Well control expertise and certificates

The operator and rig owner respectively should ensure that the personnel responsible for the well operations have completed a recognized well control course, which should be renewed or refreshed every two years, when applicable.

An IWCF / IADC well control certificate level 3 or 4 or equivalent, are considered sufficient for the following positions:

Level 3 for:

- driller and assistant driller
- equivalent position in well servicing, well intervention and operations.

Level 4 for:

- well-site drilling and well personnel with a supervisory role such as drilling supervisor, assistant drilling supervisor, drilling manager (company man and drilling contractor employee), assistant tool pusher (night) and day tool pusher
- office based personnel that are involved with well design and planning and operation decision making process such as supervisor (operating companies and drilling contractors / well services company), head of the 1st line duty (country / office).

Information about IWCF / IADC levels 3 and 4 is available on the following webpages:

iwcf.org

and

iadc.org

3.5.3 Activity Specific Training

Drilling and well personnel must be informed about and given the necessary training on activity-specific factors in advance of an operation. These include conditions and operations such as the risk of shallow gas, special pressure and temperature regimes e.g. high pressure, high temperature, H_2S, managed pressure drilling (MPD), well interventions, use of new technologies, etc.

4. Approval and notification of well operations

4.1. Prior to the start of any well operation

Prior to commencement of a well operation, the operator should conclude a risk assessment of the operation.

The risk assessment should identify the following topics:

- the particular hazards associated with the well operation, including any environmental, weather and local conditions that will prevent the operations from being performed safely
- appropriate risk mitigation measures.

The risk assessment should always include an assessment of the potential risk for accidental release of substances and materials that may lead to a major accident.

4.2. Application for approval of well operations (Section 28 of the Subsoil Act)

The application for approval including well operation programmes and manuals should be submitted to the DEA at least six (6) weeks before scheduled commencement of the well operation. The DEA cannot guarantee that 6 weeks is sufficient for processing the application, due to frequent resource constraints, but will endeavor to process the application within this time frame. If clarifications and further information is required, then that could easily delay the permit.

The process steps typically looks like this:

- Early notification to the DEA of the plans, scope and timing of the project.
    - This enables the DEA to allocate resources, which in turn increases the possibility of a smooth approval process.

- Consider conducting a meeting with the project team, the DEA and the environmental authority (typically the local municipality) to present the project.
- Consider conducting a meeting with the project team, DEA and GEUS to present the data acquisition plans and/or objectives
- Submit the application to the DEA
    - include the risk assessment documentation
- DEA processing the application with the opportunity to contact the application for questions and/or clarifications
- A draft version will be sent to the applicant for comments on the stated facts.
    - Up to 10 days available for the applicant to comment.
- DEA finalizes and issues the final approval

The well operation programme should (e.g. together with the operator's manuals) state unambiguously how the well operations are expected to be carried out.

Some of the required documentation concerning the approval of the well operation programme may be forwarded as separate appendices and, where relevant, reference may be made to other documentation material such as the operator's general operation manual, general safety regulations, general regulations for test production, etc.

NB: Please note that the well name and number needs approval by the DEA and it is important that the well numbering is chronological and sequential, which can be an issue if more than one well is planned. It is therefore recommended to work with target names and then allocate the well number when the well is firm to prevent confusion if late changes to the drilling sequence are required.

Documentation referred to in the programmes must be made available to the DEA upon request.

Applications for approval of well operations to be prepared in accordance with Section 28 of the Subsoil Act should contain at least the following information:

- the name and address of the operator of the well
- the name of the well to be used and the name and address of the owner and the name & address of the main contractor planning and performing the work
- details that identify the well and any association with existing installations and connected infrastructure

- information on the well work programme, including the period of its operation, details and independent verification of barriers against loss of well control (equipment, drilling fluids and cement etc.), directional control of the well path (incl. a well trajectory in side view + plan view), and limitations on safe operations in keeping with the risk management.
- Anti-collision screening and risk management
- in the case of an existing well: information regarding its history and condition, incl. information on the barriers, condition of the barriers and barrier diagrams
- any details concerning safety equipment to be deployed which are not described in the current safety and health document for the installation and connected infrastructure
- a risk assessment with a description of

    a. the particular hazards associated with the well operation including any environmental, -meteorological and local limitations on safe operations
    b. protection of ground water aquifers
    c. particular environmental sensitivities, such as Natura 2000 areas etc.
    d. any other well operations which entail a simultaneous risk of a major accident
    e. suitable risk mitigation measures.

- a description of the well's condition at the end of operations, i.e. permanently or temporarily abandoned; and whether equipment has been placed in the well for future use
    - incl. associated barrier diagrams
- in the case of altering a previously submitted application for approval of well operations: sufficient information to fully update the application
- in the case of a well needing to be constructed, modified or maintained, additional information as follows:

    a. a description of any environmental, meteorological and local limitations on safe operations and the arrangements for identifying risks from hazards which present a risk, such as pipelines or risks posed by the presence of adjacent installations
    b. a description of conditions and events that have been taken into account within the emergency response plan of the project
    c. a description of the emergency response arrangements including arrangements for responding in the event of

environmental incidents that are not described in the safety and health document

d. a description of how the well operator's and the owner's management systems are to be coordinated in such a way that health and safety risks and risks of major environmental incidents are reduced at all times to a level as low as reasonably practicable.

- If 3rd party verification has been done: a report with the findings of the independent verification, and a statement by the well operator, that, after considering the report and findings of the independent verification, the risk management relating to the well design and the barriers to prevent the loss of well control are suitable for all anticipated conditions and circumstances.

4.3. Deviations from the approved work programme – amendments

If things do not go according to plan, or if the plans change for whatever reason, then changes to the approved work programme might be required. These changes could be changes to the well operation such as changes in the well path, well design and plan, barrier management, the originally planned safety and environmental critical elements, procedures or management arrangements that would affect the hazards, unforeseen interruptions that would affect the hazards, etc.

Changes to an approved work programme must be approved by the DEA in accordance with Section 28(1) of the Subsoil Act, before the well operation can continue.

The amendment application should include:

- a description of the reasons/purposes for the changes
- a description of the current well status
- a detailed description of the changes
- a well schematic presenting the changes, and stating the primary and secondary barriers
- a risk assessment of the proposed changes, incl. mitigations and possible contingencies
- consequences safety-wise which the amendment activities cause or may cause to the well (i.e. affecting overall well integrity negatively)

In emergencies, where immediate action is required to prevent a major accident, the well operation may be altered without prior consent from the DEA. In such cases, the DEA must be notified as soon as possible after the alterations with the

reason for such alterations. The DEA will subsequently have to approve the steps taken after the event.

4.4. Notification of well operations

The DEA should be involved in the operations planning from an early point. It is important to note, that the approval process of the DEA can take quite some time, especially during periods of high activity. It is therefore important to think through and describe the risks and contingency plans in the original program to minimize the risk of project delays due to the required authority approvals.

4.5. Verification scheme for wells

For complex, non-standard drilling and well operations in Denmark, the DEA may request a third party review of the plans, program or design. This could take the form of a well examination, and the operator of a well could consider establishing, implementing and maintaining a verification scheme for well operations in connection with the approval of the well operations.

The types of wells in this category include, but are not limited to: H_2S risks, Environmentally sensitive areas, HP &/or HT, Extreme geological uncertainties (such as Zechstein salt drilling etc.), long horizontal sections having Oil based mud in the plans (or contingency), relief well drilling etc.'

It is imperative that such verification scheme activities are performed by a qualified and independent (from the operator/operations) entity.

5. Well design and well planning

Achieving a high level of health and safety for personnel and environment must be a high priority during the phases of well design and well planning. The health and safety level must be sufficient to eliminate, minimize, control and contain any hazard associated with all planned well operations. All known or potential hazards which can lead to an accidental release of substances and materials that can lead to a major accident affecting human or environment, are subject to a risk assessment, see section 2 – "Risk Management".

The detailed drilling programme should be submitted to the DEA well in advance of the requested time for a drilling permit. This can be in a draft format at first and later adding the rig specifics, 3rd party service providers and associated equipment in the final issue. All equipment (load bearing, hoisting & pressure vessels) should be certified to industry recognized and relevant standards.

All relevant parties involved in the drilling operations, should be included in the preparation of the drilling programme. Furthermore, relevant parties should be given the opportunity to comment and object to any expected or known hazard or HSE related issue resulting from drilling programme implementation.

If applicable, the independent competent 3rd party well verifier should be involved in the verification process during the well design and planning phase as early as possible, thus enabling the well verifier to conduct the verification in full compliance with Danish legislation.

Furthermore, in the well design and planning phase, the whole life cycle of the well should be taken into account allowing for safe well performance and management during the entire well life and in the end a safe and sufficient permanent abandonment.

Sufficient data in the well design and planning phase must be available, interpreted and analyzed by skilled and experienced personnel in order to identify all hazards (ref. section 2), and devise sufficient contingency procedures and plans based on the risk profile. These data can be collected from offset wells or any other source.

Special attention and emphasis should be placed on the following:

- formation pressure prediction (normal, abnormal or subnormal)
    - shallow gas issues
    - aquifer protection
    - H_2S risks
    - particular Zechstein salt drilling risks, incl. blow-out, potential H_2S, High Pressure brine etc.
- drilling mud specifications
- casing design and casing setting depths
- cement programme and proper verification of good cement and bonding qualities
- barriers: placement, testing and verification of these
- completion programme
- define requirements for drilling rig, equipment and crew competencies or any contractor or service company.
- In cases where the tophole is drilled by water well drillers the directional control of the well(s) must be risk assessed and consideration given to running a gyro or similar surveying where deemed necessary to reduce the collision potential of subsequent wells

If the risk assessment identifies hazardous conditions such as the presence of shallow gas, abnormal pressure or that the well is classified as a high pressure, high temperature well, these conditions should be reflected in the resulting mitigating actions where additional safety measures and safety equipment should be implemented or special drilling techniques such as managed pressure drilling applied.

5.1 Casing and tubing design

Casing and tubing should be designed with an adequate safety factor to be able to withstand all planned and possible load cases (burst, collapse and tension/compression, including tri-axial loads), during the entire well life cycle and under all circumstances. Both known operations and possible well control situations should be taken into account.

Wear, erosion and corrosion should also be taken into consideration in the design phase, and load calculations documenting the abovementioned should be performed.

Casing/liner and tubing should be able to withstand adverse effects from compressed air, hydrogen, CO_2, H_2S, various chemicals and other such factors present in the well under all circumstances and during the entire well life cycle. The corrosion & erosion resistance of the casing should thus be considered in the design phase.

Furthermore, in the design phase of the casing, tubing or liner, factors such as changing of internal and external pressures, thermal effects and effects of possible subsidence should also be taken into consideration.

5.2 Well completion

The completion design should ensure that the completion equipment is suitable for the future production and injection of gas, liquids and particles and suitable for collecting well data of significance for safety. Furthermore, the equipment should be suitable for well intervention, workover and future abandonment of the well.

In considering the use of artificial lift, all applicable methods should be assessed. The risk to health and safety from the selected means of artificial lift must be reduced to ALARP.

The well design should include as a minimum two (2) qualified barriers as well as monitoring and safeguards protecting drinking water aquifer(s) in case of leakage.

6. Well operations

6.1. Daily Operations Reports

The daily drilling report (DDR) for the well operations should be submitted to the DEA daily as long as operations are ongoing as well as during periods of rig mobilization and de-mobilization.

6.2. Drilling & completion

The main operations in the drilling phase are outlined in the following, based on the recommendations in these guidelines.

Casing operations

The casing and liner installation should be compliant with recognised norms and standards, and should fulfil the abovementioned design requirements and recommendations in section 5.

Casing testing

After installation and cementing of the casing strings and liners, a pressure test taking maximum estimated casing exposure pressure into account should be performed. The production casing should be retested (against the production packer) in the completion phase. Test details and results are to be recorded and stored.

Conductor casing

The conductor casing should be set at a depth where sufficient support is ensured to unconsolidated formations below ground level. Conductors should be cemented to surface and a seal made around the conductor to prevent seepage into the drinking water aquifer.

Surface casing

The installation of the surface casing should take into consideration, all the load conditions arising from installed equipment. The surface casing should be cemented to surface, which is especially important in the protection of the drinking water aquifer(s).

Intermediate casing

The intermediate casing should be cemented in such a way that all hydrocarbon bearing zones and ground water zones are isolated. Furthermore, isolation from abnormally pressured zones and normally pressured zoned should be ensured. The intermediate casing should be cemented into the previous casing according to good industry practice. If there are well specific safety considerations for not cementing into the previous casing, the operator should demonstrate equivalent or higher safety level. However, if the abovementioned can only be achieved by cementing to the surface, then this should be done.

Production casing
Same cementing requirements as outlined for the intermediate casing.

Liner placed in the reservoir section
Good industry practice should be followed for the installation of liner depending on the type of liner used.

Production tubing
Design requirements and recommendations outlined in section 5 also apply to production tubing. Furthermore, it should be documented, that the design of the production tubing has taken the production (or injection) profile of the well and well specific properties into account.

In case a pressure test of casing or production tubing fails, which requires an amendment to the approved and verified programme, the operator should handle the situation according to section 3.3.

Appropriate monitoring (e.g. monitoring of pressure and/or temperature) and a shutdown system must be included in the design in order to verify that all critical barriers are intact throughout the lifetime of the well and shutdown operations if irregularities are observed.

Cement setting time
Following every successful cementing operation, the cement should be given sufficient time to set, based on cement samples and tests, in order to obtain its minimum compressive strength and bonding qualities before operations proceed. The cement setting time should be in accordance with recognised norms, standards and good industry practices.

Cement testing
After cementing of casing and liners, cement tests should be performed in order to confirm the quality of the cement job, sealing ability and cement length, especially if the cement job was not carried out according to the cement programme (i.e. significant deviations), or if any irregularities occurred during the cementing operation. Verification of good cement bonds should be carried out according to recognised norms, standards, and good industry practice.

Tests may include:

- pressure testing
- volume calculations
- logging (e.g. cement bond log, temperature survey, ultrasonic imaging tool).

The cement job execution in all its processes should be documented in detail and form the basis for a job performance evaluation. Records hereof should be kept by the operator.

Onshore in Denmark, protection of the aquifer(s) is very important. It will often be a requirement to log the annular cement in all sections penetrating these layers in order to document these barriers against drinking water aquifers.

Cementing operations

The cement operations should be executed so it fulfils its purpose of:

- isolating water and hydrocarbon bearing zones
- preventing movement of formation fluid in casing-formation annuli and casing-casing annuli
- proving proper structural casing support and protecting against casing corrosion.

Drilling fluids

Drilling fluids, intended as a well barrier, should be designed, operated and maintained in such a way, that can hydrostatically balance the pressure in the well at all times. Therefore, its properties must be continuously monitored, and a sufficient amount of reserve weighting material must always be present during well operations and be ready for immediate use. Frequent measurements of drilling fluid properties, level, cutting analysis and gas content should be carried out, and immediate action taken in case of serious irregularities. Borehole stability must be maintained at all times. If geomechanical forces are causing borehole stability problems then a risks and mitigations assessment must be evaluated and clarified.

Borehole stability should also be maintained during tripping operations, and the well must be monitored carefully for any drilling fluid gain or loss. In case hereof, appropriate measures must be taken.

During well testing or underbalanced drilling (UBD) operations, the hydrostatic pressure can, as an exception, be reduced to a level allowing flow of formation fluids to the borehole.

Drilling fluids that are harmful to health should be handled in such a way that its harmful effects are reduced according to the ALARP principle.

Separation of cuttings and gas from the drilling fluid should be done in a safe way protecting health and environment.

The type of drilling fluids should be chosen based on drilling conditions as well as health and safety aspects.

In case H_2S is present or can be expected in the well, a sufficient stock of H_2S scavengers must be available.

Data acquisition

The DEA will ensure that GEUS has approved the data acquisition programme and that data and file transmissions are subsequently cleared with GEUS. Cuttings sampling is deemed part of the data acquisition programme.

It is expected that the DEA is kept in the loop of these data transmissions to GEUS. This could be by copying ddr@ens.dk and the relevant DEA contact person on the data transmission notification(s).

The following are examples of data that may be acquired and all issues surrounding the acquisition, transmission, storage, analysis, reporting etc. should be coordinated with GEUS:

- seismic
- electric logs
- logs while drilling
- fluid & pressure samples
- cores
- well test data
- cuttings samples
- PLTs
- Etc.

See Executive Order on Submission of Samples and other Information about the Danish Subsoil.

https://www.retsinformation.dk/eli/lta/2002/56

Well Completion

Well completion is part of well construction and must also be approved by the authorities as described in section 3.2.

Well completion should be carried out in a safe manner and the completion design should ensure that the risks that can lead to safety hazards are minimized.

6.3. Well intervention/Workover

Well intervention or workover is an operation that is usually required for maintaining and/or repairing a well. From a DEA perspective, this could include a side-track to a new location. This type of operation is more common with ageing wells.

This type of operation usually requires change to or deactivation of the existing barriers and may result in a new well setup that fulfils barrier requirements. The work programme should ensure that the changes made to the well during a well workover or intervention, still enables the well to be maintained and performed

safely throughout the life of the well and be safely permanently plugged and abandoned.

For all well interventions and workovers, a risk assessment should be conducted in accordance with section 2.

6.4. Suspension and abandonment of wells

This section covers guidelines for maintaining well integrity during suspension and abandonment of all wells such as production- and injection wells, wells under construction and exploration wells.

Definitions

Suspension – Relates to suspension of an activity or operation on a well. It is the construction or operational activity that is suspended, not the well. No permanent isolation of reservoir or intermediate zones with flow potential are performed. The well is monitored continuously, and a plan for actions presented in case of irregular pressures appear.
Abandonment - Reservoirs and all intermediate zones with flow potential have been permanently isolated with permanent barriers. Tubing may be left in place, partially or fully retrieved. The well is monitored.

Permanent abandonment – Reservoirs and all intermediate zones with flow potential have been permanently isolated with permanent barriers. The wellhead is removed, and the conductor is cut under the cellar (ground level) and installed with an environmental plug. The surface location is restored as per the requirements of the environmental authorities. The well will not be re-entered, is not monitored, and is considered decommissioned. All permanent barriers are installed and verified according to a recognized standard (see section 2.4). However, a monitoring period should be considered, if relevant, to ensure no leakage from flow zones to the environment prior to cutting the well head and conductor.

Suspension and abandonment of wells with potential flow zones should consist of a minimum of two independent and verified well barriers, placed between the zone and the surface. The well operator should perform risk assessment for every single well to demonstrate that the risks are ALARP. The barriers must be designed to retain the fluid (gas or liquid) that it is meant to contain.

Regardless of whether the purpose of a barrier is to isolate formations, fluids and pressures for suspension, abandonment and permanent abandonment, the requirements outlined above are the same. However, the choice of well barrier elements can differ depending on the suspension or abandonment period, and ability for later re-entering the well.

Well barriers and well barrier element materials should have sufficient integrity to meet the suspension and abandonment period, including a safety margin. The suspended or abandoned wellbore should be monitored throughout the whole period. It should be possible to monitor the pressure in the tubing and in the annuli. In case of sustained casing pressure (SCP), the bleed pressure, bled off fluid type and frequency should be registered. In such cases, the operator should calculate the maximum allowable pressures to ensure that formation and well barrier elements are not compromised by the SCP.

The application for approval to carry out the operations of suspension, abandonment and permanent abandonment of a well should include a detailed programme describing the facility and verification of the integrity of well barriers and a proposed final well schematic with all well construction features labelled, including the proposed position of installed well barriers, stating the primary and secondary barriers.

For wells already suspended, abandoned or permanently abandoned the operator should address potential re-pressurisation of all formations to virgin pressure, changes in fluid composition in the wellbore and deterioration of the well over time.

If a well is suspended and typically before the suspension period reaches two years, the future plans for the well and the reasons for not starting with an abandonment or permanent abandonment should be documented. The planned duration of the prolonged suspension period should be included in the documentation.

6.5. Plug and abandonment

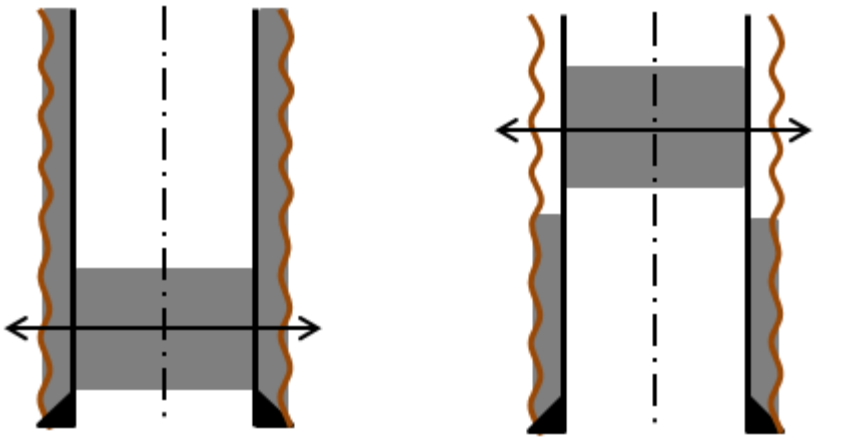
This section covers plug and abandonment of wells. When a well is plugged and abandoned, whether it is abandoned or permanently abandoned, the permeable formations should be isolated with permanent barriers.

Wells to be abandoned or permanently abandoned should be plugged in order to prevent releases of fluids or crossflow between formations with an eternal perspective taking into account the effects of any foreseeable chemical and geological processes, and the natural recharge of formation pressure.

Cap rock and intermediate formations that were sealing prior to drilling should be restored to similar pressure integrity as originally found.

Permanent well barriers should extend across the full cross section of the well, include all annuli and seal both vertically and horizontally. Hence, the plug or well

barrier element set inside a casing, as part of a permanent well barrier, should be located in a depth interval where there is a validated quality of the current cement / well barrier element in all annuli. An example of a valid and an invalid permanent well barrier is illustrated in the figure below.



Permanent barrier: Cement across the full cross section

Not valid permanent barrier

It must be emphasized that the operator should demonstrate, that the cement and formation behind casing is qualified as a barrier at the time of abandonment. This means that the evaluation should be based on the state of the cement at the time the abandonment operation is taking place.

Furthermore, the well barriers should be placed adjacent to an impermeable formation with sufficient formation integrity for the maximum anticipated pressure. It is expected, that the design of the barrier depths, heights and verification pressure is tied in with the formation strength – a.k.a. the geomechanical model.

The DEA recommends that plugs should be set with the objective to:

- isolate any abnormally pressured formations
- isolate any hydrocarbon zones or water zones, including isolating for potential crossflow from one formation to another.
- For leached (solution mined) salt caverns, the well must not be plugged until thermal equilibrium has been reached after a resting period (typically years). Provisions for bleeding down the pressure must be installed, ensuring no spills to the environment. Running regular temperature logs in

the cavern should be considered in order to fine-tune the models predicting resting time.

For quality assurance, plugs in place should be tested and verified. All cement plugs placed against formation should be dressed off, load tested and pressure tested. Pressure tests in open hole(s), where plug(s) is set between two formations is not required. For internal cement plugs, the first plug should be verified by dressing off, load testing and pressure testing. The secondary plug should be load tested or tagged. If there are doubts about the integrity of cement quality of the secondary plug, the plug must be dressed off.

Fluids in abandoned wells should be suitable to minimize corrosion.

For exploration wells, that are not planned to be test produced or suspended, the drilling work programme should include a detailed plan for plug and abandonment of the wells. These wells should be permanently abandoned when drilling operations as well as relevant logging and test programmes have been carried out and accepted by the DEA and other relevant authorities.

In order to ensure a safe operation, the following standard and guidelines regarding plug and abandonment can serve as an inspiration:

- NORSOK-D010, Well Integrity Standard
- Offshore Energies UK, Guidelines for the suspension and abandonment of wells (Well Decommisioning).
- Dutch NOGEPA industry standard no. 45: “Decommissioning of wells”.

Other material than cement can be used as plugs in plug and abandonment operations. However, the suitability of the selected plugging materials should be verified and documented. Degradation of the casing and cement over time should be considered.

The use of other material than cement for permanent well barriers should be of equal or better quality and should, amongst other properties, have the following characteristics:

- provide long term integrity (eternal perspective)
- impermeable
- non-shrinking
- able to withstand mechanical loads/impact

- resistant to chemicals/ substances (e.g. H_2S, CO_2, H_2 and hydrocarbons)
- resistant to temperature degradation
- ensure bonding to steel
- not harmful to the steel tubulars integrity.

Wells will not be regarded as permanently plugged and abandoned until the surface location is cleared and the well site is back to the original state, or in compliance with the local municipality's requirements. This includes the installation of an environmental plug, if required. Obtained documentation from location clearance and restoration should be submitted to the DEA, and can be sent as part of the end of well documentation.

6.6. Well commissioning and well handover

This section covers tie-in of the well to the production and/or injection system on the facility, and handover of the operational responsibility of the well to the operator's production department.

The main goal of commissioning is to verify that the well can fulfil the overall requirements specified in the well design.

Commissioning should be a quality-focused process that, besides the general verification of design specifications e.g., also includes accept criteria and/or performance indicators of safety critical elements as a way to measure the success of the commissioning and thereby positively contribute to a better and safer operation and performance of the well.

Well commissioning can be handled separately or incorporated during well construction.

Commissioning should be carried out in similar or as close as possible to the wells operational conditions when connected to the installation for production or injection. All barriers should be installed and tested before commissioning takes place.

Identified operational well conditions and risks should be described and assessed according to the ALARP principle.

Well barriers and well barrier elements and their integrity should be described and be a part of the well barrier schematic.

Well commissioning plan and results for all wells connected to the installation should be available offshore for the production team on the installation.

The commissioning should include well handover documentation with specifications that clearly describes:

- well construction data and details
  - x-mas tree schematic
  - wellhead schematic
  - casing and tubing schematic
  - cement data
  - perforated zones details
  - barrier schematic illustrating all barriers and well integrity controls.
- pressure tests of
  - wellhead
  - x-mas tree
  - fluid status for annuli and tubing
  - well pressure status
  - valve status.

Commissioning should also include:

- maximum allowable annulus surface pressures (MAASP) for each annulus including fluid type and weight in each annulus
- maximum allowable operating pressures (MAOP) for each annulus
- information on electrical and hydraulic well control systems. Systems should be tested and found fully operational
- other construction data, such as component details: manufacturer, component description, material, working pressures and temperatures, TAG-numbers and serial numbers
- anomalies for every component and any deviation that are identified should be addressed and explicitly highlighted
- all relevant limitations for operating the well.

6.7. Handover from production to well operations

This section covers hand-over from production to well operations prior to a well operation.

Handover documentation should as a minimum include:

- the well schematic with status on all valves

- the latest SCSSV test and results
- annuli pressures
- flowing and shut-in tubing head pressures and temperatures
- any relevant production issues of the well such as scale, wax, asphaltene, hydrates, etc.

Well handover from production to well operations should take place prior to any start of well operations.

7. Wells in the operational phase

7.1. Well operation

During the operational phase, all wells must be controlled in such a manner that the following are adhered to at all times:

- safely operate the well within the well design operating envelope and according to any operating instructions.
- monitor wellbore integrity (see well integrity in section 9)
- monitor and maintain wellbore barriers
- monitor operating conditions for deviations from the well basis of design and potential risks to well integrity.
- identify and confirm wellbore problems affecting wellbore integrity.
- recommend the wellbore for repair as required.

7.2. Well operating envelope

The operator should define the well operating envelope and operate within those criteria. If a well barrier element is degraded, the maximum allowable annulus surface pressure, maximum allowable operating pressure, and the well operating envelope should be adjusted accordingly.

For salt cavern wells the minimum operating pressure is an additional parameter to be considered.

7.3. Well maintenance

The operator is responsible for well maintenance during the entire life of the well. Well maintenance should be part of the operator management system, which includes:

- a method for identifying the maintenance routines for safety and environmentally critical elements; leading to a documented maintenance schedule and procedure

- a means of ensuring that the impairment of any safety and environmentally critical elements is identified
- a process for capturing any deferred maintenance
- provision for a register of overdue maintenance tasks and a process of analysis and control
- a process for remedying maintenance backlog items
- a mechanism to inform management about maintenance backlogs in general and specifically about safety and environmentally critical elements
- a documented maintenance history.

Operators are expected to identify any safety and environmentally critical elements that has degraded to the point where it does not meet its performance standard. In instances where safety and environmentally critical elements are found to be degraded, operators are expected to ensure that they are restored to its established performance standard and to notify the DEA.

The maintenance schedule and procedure should include, but not be limited to:

- visual inspection and leak detection
- valves greased and function tested according to recognised norms and standards.

These critical elements include but are not limited to:

- X-mas tree valves (closing function, closing times, and leakage rates)
- SCSSV (Surface Controlled Subsurface Safety Valve) (closing function and leakage rates)
- tubing (pressure test to a maximum containment pressure (shut in pressure))
- the well annuli (pressure build-up).

Well maintenance activities carried out should be fully documented on an ongoing basis. Function tests, test frequency and acceptance criteria should at least follow recognised norms and standards.

When the well is handed over to production operations, the well's safety and environmentally critical elements are part of the verification scheme for safety and environmentally critical elements and not the well verification scheme.

8. Well testing

For well test planning and operations for exploration wells, inspiration can be found in the NORSOK D-007 Well testing systems or equivalent.

Before test production, the test programme has to be submitted for approval as part of the well operation according to Section 28(1) of the Subsoil Act.

Test production, perforating, hydraulic fracturing, acidizing or other chemical treatment of the well may only take place when special safety precautions, relevant for the operation, are observed. Test production using a flare stack should be started in daylight. Test production is not to take place when safety is adversely affected by weather and wind conditions. Caution should be exercised to prevent accidental releases of chemicals and hydrocarbons to the environment.

Before start-up of test production, the drilling site and neighbouring facilities and houses/accommodation should be specially prepared for the operation. All necessary fire precautions should be taken. Valves, lines, temporary well test equipment and where relevant Blowout Preventer (BOP) should be pressure and function tested. The whole operation should be coordinated with the local emergency services.

9. Well integrity

The following section describes the guidelines to maintain well integrity at all times during the life cycle of the well.

9.1. Well control

The BOP and all pressure and well control equipment should be designed, constructed, inspected, installed, maintained, monitored and tested in such a way, that it fulfils its intended purpose at all times and under all circumstances, and conform to recognised norms, standards and good industry practices. Furthermore, the BOP system and other pressure and well control equipment should allow for remote operation to the extent possible.

Well control manuals, standards, procedures, measures and equipment must be established, implemented and maintained during the entire duration of all well operations related hereto in order to minimize the risk of loss of well control. In the event of any unintentional and unwanted influx of formation fluids into the wellbore, or any other uncontrolled event, implemented procedures and equipment must be sufficient to control and contain it, and prevent a blow-out.

If shallow gas needs to be handled safely, a diverter system should be installed and tested according to recognized norms and standards after the installation of the conductor casing. It is recommended that the diverter lines be dug in below ground level.

Furthermore, a diverter system and handling of the associated pressurized toxic fluids (gas and/or liquids) must be considered for drilling in the Zechstein salt structures as violent blow-outs have happened in the past.

In drilling operations, the BOP should be installed as soon as practicable possible, and no later than after the installation of the surface casing and before drilling ahead. This requirement can be waived in exceptional circumstances, for example, when the risk of encountering hydrocarbons can be verified as zero. The BOP system should consist of at least one annular preventer, one set of pipe rams of fixed or variable type, blind rams or blind shear rams, and choke and kill lines connected to the manifold. After the BOP installation and before drilling out from any casing string, all abovementioned BOP components and other pressure and well control equipment should be function and pressure tested according to recognised norms and standards, such as API standard 53.

For well intervention operations, a BOP should also be installed and configured for the well operation to be executed.

Function tests, pressure tests and test frequencies should be conducted in accordance with recognised standards and norms such as the above-mentioned API standard 53.

9.2. Well barriers

Generally; during the entire life cycle of the well, two or more independent, verified and tested barriers should be in place. Unless it can be documented as ALARP to have less barriers in place. Examples of this situation could be in wells with no flow potential; such as geothermal wells, salt production wells, certain observation wells, seismic monitoring wells.

Standards and procedures covering testing, testing intervals, acceptance criteria, repair and restoration, replacement, determining position and status of the well barriers or any other well control measures, should be in place and implemented. Barrier tests should, if practicable, be in the direction of flow.

If the primary and secondary barriers fail, the DEA must be notified immediately. This requirement applies for the entire life cycle of the well, i.e. during well operations, the operational phase and well suspension.

In the event that one of the minimum two required barriers fails, the only allowed well operations would be those aiming at repairing and restoring or replacing it. There are a few exceptions, as outlined below:

When one of the minimum two barriers fails during the operational phase (production or injection) and if the well has no ability to flow naturally, the well can be operated with only one well barrier provided the following has been considered:

- a risk assessment has been performed and the residual risks are ALARP. The risk assessment has to include the potential risk of accidental releases from all zones of the well with a flow potential. Furthermore, an assessment of the potential failure of the remaining barrier has to be included
- a dispensation has been approved and granted according to the operator's own management system
- the independent verification concludes that the potential risk of accidental releases of substances and materials are ALARP
- the well is monitored closely, and the abovementioned dispensation is controlled and regularly reviewed
- a plan to re-instate the minimum two barriers should be in place. If the well is scheduled to undergo a workover, the plan should be a part of the workover activities
- the DEA should be notified about the abovementioned

A well barrier can consist of one or several well barrier elements and it should be designed to withstand the fluid at hand. As an example, a casing connection meant to function as a barrier against gas should be a premium connection with a metal-to-metal sealing face and made up with full QA including torque-turn monitoring.

Well barrier elements contributing to maintaining well integrity includes, but are not limited to:

- formation with adequate strength ref. the pertinent geomechanical model
- x-mas tree
- wellhead
- tubing hanger
- annulus safety valve
- surface controlled subsurface safety valve

- casing
- cement
- production tubing
- production packer
- completion string components (gas lift valves, chemical injection valves)
- mechanical plugs
- cement plugs.

NORSOK D-010 and Offshore Energies UK guidelines are considered as reference for well barriers and well barrier elements; those include well barrier design, construction, selection, maintenance, testing, verification and monitoring methods. Their recommendations are, at the time of writing (2024), considered as good practice.

A well barrier schematic with all relevant data and test results should be devised for each well phase and well operation and should be updated to reflect the current state of the well.

9.3. Well integrity

Well integrity must be maintained at all times and under all circumstances during the entire life cycle of the well. All well components, barriers and elements contributing to maintaining well integrity should be designed, constructed, inspected, installed, maintained, monitored and tested in such a way, that they fulfil their intended purpose at all times and under all circumstances, and conform to recognised norms, standards and good industry practices.

Well components, barriers and elements critical for maintaining well integrity should be identified, and their position and complete status should at all times and under all circumstances throughout the life cycle of the well be known. Procedures for monitoring, maintaining, testing, repair and restoration or replacement should be in place and implemented. Criteria for failure and acceptance should be specified, and immediate remedial action must be taken in case of failure or malfunction. Company standards and procedures should conform to recognised norms and standards such as NORSOK D-010 and Offshore Energies UK Well Life Cycle integrity guidelines and good industry practices in the North Sea & European region.

A well integrity categorization system should be devised, and each well should be categorized based on its complete integrity status, where all well integrity components, barriers and elements are taken into account, and evaluated based on predefined criteria. All types of wells in operation, suspended or abandoned

should be included in the well categorization system. A procedure should be in place and implemented dealing with wells placed in the category representing wells with reduced well integrity.

A method of categorizing well integrity is described in the Norwegian guideline “117 – Norwegian Oil and Gas Recommended guidelines for well integrity”.

The operator should have a well integrity management system in place that should cover the entire life cycle of the well and include all the wells. The operator should extract the integrity status of all their wells from the well integrity management system and send it to the DEA. Guidelines on the content of such a well integrity status are given in Appendix 6.

10. Other hazardous materials

The following section will highlight guidelines on the handling of other hazardous materials, such as; chemicals, explosives, radioactive and waste materials

All these items and substances must be handled according to the present regulation and it is recommended to utilize specialized consultants to ensure compliance is maintained at all times.

10.1. Radioactive materials

All uses, including handling and storage of radioactive materials, require permission from the Danish Health Authority, Radiation Protection (Sundhedsstyrelsen, Strålebeskyttelse, SIS) and should comply with their legislation.

SIS administer regulations for the safe handling of radioactive materials including Normally Occurring Radioactive Materials (NORM) that can be present in case scale has formed in the well.

On the website of the Danish Health Authority, Radiation Protection, https://www.sst.dk/en/english/Expertise-and-guidance/Radiation-and-radon/Guides/Radioactivity there are contact details and links to relevant legislation, guidelines, and forms for use when applying for permission for use of radioactive materials.

Regarding measuring instruments or other devices containing radioactive sources that constitute or over time can pose a safety, health or environmental risk, which are left in a well - after deciding that the source(s) cannot possibly be brought to the

surface, since all practical possibilities have been explored, the operator should notify the DEA, if possible, before making an amendment to the work programme.

The source should be located, protected and isolated, to the extent practicable achievable, so that it does not in any way come into contact with reservoir fluids. Source fixation and isolation can be performed using verified cement plugs of an appropriate length in accordance with good industry practices. The location of the source(s) must be, as precisely as possible, included in the final well report, well schematics and the handover documentation.

If further drilling activities are planned in the immediate vicinity of an isolated source, standards and procedures for anti-collision should be implemented and identified risks should be reduced as low as is reasonably practicable.

Approval by the DEA in connection with the above-mentioned amendment will typically be conditional upon approval by SIS and the DWEA.

11. Safety incidents and near misses

Safety incidents and near misses should be reported to DEA.

12. Documentation to be provided to the DEA

Prior to approval in accordance with Section 28(1) of the Subsoil Act, documentation regarding the planned operation must be provided to the DEA. The required documentation includes, as applicable:

- drilling programme
- completion programme
- workover programme
- intervention programme
    - slick line
    - e-line
    - braided wire
    - coiled tubing in all its forms
- plug and abandonment programme
- report from the well verifier and the operator measures based on this report (if applicable)
- amendments to programme.

Notification documentation (Section 28):

- In case of a longer drilling campaign:
    - a monthly update of planned well operations for the next quarter with a short and sufficient description of the operations to be carried out including
- a list of well operations carried out during last period
- work programme or
- a description with objectives of the well operations to be performed.

Daily well operations documentation are to be sent electronically in a readable format, such as .pdf:

- daily drilling reports (DDR)
- daily mud report (DMR)
- daily geology reports (DGR) icl. The mud log when applicable

Other documents may include:

- drilling schedule (frequency to be agreed upon with DEA)
- well integrity status (frequency to be agreed upon with DEA)
    - end of operations report, as applicable, not later than 6 months after end of operations
    - incidents and near misses related to wells

    - Final well report, or
    - Final completion report, or
    - Final work over report, or
    - Final intervention report, or
    - Final test report

Daily Drilling Reports (DDR)

A daily report of the latest 24 hours of operation should be sent to the authorities before 11.00 am by email (ddr@ens.dk). Reporting commences when a drilling rig or the well operation equipment is mobilized for the operation, and finishes when the equipment is demobilized and the site is cleared. The reports should cover an operational 6 o'clock morning update on the reporting day.

The report should include the information as per appendix 5.

Appendices

1 - Drilling and completion work programme
2 – Workover/well intervention programme
3 – Plug and abandonment work programme
4 – Notifications to the DEA
5 - Daily Drilling Report
6 – Well Integrity Status
7 – List of Abbreviations

Appendix 1 - Drilling and completion work programme

These can be split into separate documents reflecting the project plan. However, it is important that the DEA receive adequate and timely information on the overall objectives to avoid inappropriate “slicing” of the project.

Information about the well and drilling

To the extent possible, the international system of units (SI) should be applied, and the drilling programme should as a minimum contain information about the following:

1. The ID number of the well as given in the Danish Energy Agency numbering system.
2. The name of the well. Wells not named by the operator will be named by the Danish Energy Agency.
3. Well objective(s).
4. Name of operator and information about the operator's organisation in connection with the drilling operation and the rig owner’s organisation and other companies involved.
5. Well surface position and maximum tolerance on this position. The position should be given in geographical and Universal Transverse Mercator ETRS89 coordinates.
6. Name of the rig or unit and owner/operator.
7. Time schedule or planned duration of the operation.
8. Water depth/ground level elevation.
9. Expected rotary table elevation above reference level when drilling unit/equipment is ready to start drilling.
10. Estimated total well depth, positions for targets and planned well trajectory. In case a well safety zone (anti-collision) is unintentionally crossed, an amendment along with a risk assessment should be submitted to the DEA for approval.
11. Information about directional drilling and a description of method for and maximum vertical interval between measuring the well inclination and direction.
12. Depth to and description of the anticipated geological horizons and eras:

    a. Stratigraphic column showing and describing anticipated lithology, pore pressure and fracture pressure gradients, planned casing points, estimated reservoir pressure and temperature. Method used for pore pressure and fracture pressure prediction should be stated. If a geomechanical model has been made then the collapse pressure gradient should be included.

b. Representative interpreted seismic sections near the planned well (normally 2 intersecting lines). Location map and location map including offset wells.
c. Depth and time structure maps showing primary and secondary prospects as well as time and possibly depth structure maps for other key horizons with a scale of not less than 1:25,000.
d. The velocity functions used in the area.
e. A prospect description of primary and secondary objectives.

13. Abnormal pressures:

    a. An evaluation of the possibilities of encountering over-pressured zones with the well in question. This should be based on seismic data and/or experience from neighbouring wells.
    b. A description of methods and procedures to be used for detecting any overpressure in the well.

14. An evaluation of the possibilities of encountering zones with H_2S and other poisonous gases within the well, including description of the methods for detecting and handling.
15. An evaluation of the possibilities of encountering gas pockets in the well in question based on seismic data and experience from neighbouring wells, including the possibility of encountering shallow as well as deep gas pockets.
16. A list of any other possible significant deviations from the geological/drilling prognosis which may be encountered during the drilling of the well, (e.g. salt zones, swelling clay, high pressured zones) and information on precautions planned in this connection.
17. A summary sequence of all operations including an estimate of the time required for the different main operations (typical as a time versus depth curve i.e. drilling curve).
    The summary should give a general description of the operations, including information on any special safety related requirements (caused by e.g. possible gas pocket or abnormal pressure).
18. Tentative well schematic for plug and abandonment of the well and for re-establishing the well site. Final plug and abandonment programme must be submitted to the DEA for approval.
19. Information of preparedness and contingency plan for handling H_2S and other dangerous gases.

20. Contingency plan related to well operations for use in the event of major accidents or emergency situations regarding health, safety and environment.
21. Information about planned underbalanced drilling operations and its safe performance.
22. Barrier diagrams for relevant stages of the operations.

Information about risk assessments – the ALARP principle

The programme should include a risk assessment, cf. section 2. For additional guidance, see: https://offshore.at.dk/en/regulations/wea-guidelines/alarp-principle/

- Assessment of subsurface conditions and identified potential hazards should be stated.
- Identified risks should be recorded and stated and mitigation measures should be specified and implemented.
- Residual risks should be as low as reasonable practicable (ALARP).

Information about casing

The programme should contain the following:

- Diameter of drilled hole.
- Casing dimension.
- Grade, and type.
- Thread name and type
- Planned setting depth for the casing.
- Strategy for centralisation of casing, including type of exterior packers and centralisers, where applicable.
- programme for cementing of casing, including type of cement, estimated height of cement behind the casing, and strategy for calculations of necessary volumes of cement.
- Demonstration of the sufficiency of the casing string strength with regard to burst, collapse, and tension and added safety factor including justification. Reference may be made to company procedure for casing design calculation. In this case the parameters used in the design (pressure, cementing height, mud density etc.) must be stated.
- Procedure and minimum requirements for testing the formation strength after drilling out the individual casings, including calculations demonstrating that the required formation strength is sufficient for drilling to the next casing setting depth.
- Precautions to be taken if the required formation strength is not obtained.

Information about the cement programme

The programme should contain the following:

- Detailed information about the type of cement planned to be used and how the drinking water aquifer will be isolated from the well and site fluids at all times.
- information about the previous casing, dimensions, leak off test (LOT) or formation integrity test (FIT) and the actual casing to be installed and cemented
- information about hole size and drilling mud in the borehole
- information about estimated pressure profile identifying any possible anomalies and top overpressures
- planned height of good cement behind the casing, how this objective is achieved and verified (e.g. CBL, VDL or USIT). Calculations of cement volumes should also be outlined
- information about thickening time, main and tail slurry and pumping time, and all cement additives, and in case of hazardous additives or substances, plans for safe handling
- complete cement testing programme including testing time after cement job, test values, duration, acceptance criteria etc.

Information about well control equipment and blow-out preventer system

- list of all well control equipment required for the operation, specifying manufacturer, size, working pressure, maximum pressure, arrangement, specific purpose, function and categorisation (primary or secondary)
- information regarding the control system operating the blow-out preventer stack. A list of the blow-out prevention equipment available on the drill floor ready for mounting on the drill pipe
- procedure for kick control, stating i.e., the data and calculations which by routine are updated to ensure the necessary background for handling emergency situations
- information on how blow-out preventers, measuring equipment, drilling fluid circulation and mixing equipment are expected to be used under such conditions
- programme for function testing of the blow-out preventer and pressure testing of blowout preventer and casing at different stages during the drilling operation. The programme should also include test intervals, acceptance criteria, maintenance and monitoring
- procedures and plans for well control incidents, including the elimination, minimising, containing, controlling and preventing of a full blow-out. Reference to a well control manual would suffice.

Information about drilling fluid

The programme should contain the following:

- a detailed description of the types of drilling fluids to be used specifying density and rheological properties etc.
- a detailed description of the components of the drilling fluids. Reference may be made to relevant chemical data sheets
- a detailed description of check equipment and procedures for the drilling fluid or reference to relevant standard
- procedure for monitoring the drilling fluid volume
- a list of the quantities of safety related material (e.g. barite and cement) to be stored on the drilling site during normal operations and an argumentation for these quantities (see section 6.1)
- information about potential borehole instability caused by drilling fluid and formation interaction, and established mitigation plans
- information about environmentally harmful drilling mud discharge while drilling, type, content and quantity.

Information about independent verification

In the case of complex well operations: the programme should include independent well verification, see section 4.

Information about logging and measurements

The programme should contain the following:

- information on types of measurements and logs to be run at various intervals and zones
- programme for taking geological samples, including a coring programme
- tentative programme for planned drill stem testing or test production. Final test production programme should be submitted and approved separately.

Information about dispensations

The programme should include the dispensations from the operator's own management system/standards and justifications.

If the above information requirements are for some reason not stated in the drilling programme, references should be made to relevant documents.

Completion programme

In the following, the minimum required documentation to be submitted with regard to completion operations is outlined.

The documentation to be submitted will depend on the type of the chosen lower and upper completion to be installed.

The equipment information should include type, data specifications, installation, tests and acceptance criteria.

The completion programme should as a minimum, contain the following:

Information about scope of work

The completion programme should include the main objectives of the completion.

Information about the well

The completion programme should include:

- well description and its current state
- well and reservoir data which could be a potential hazard (CO_2, H_2S, etc.)
- well schematic prior well operations
- well barriers schematic stating primary and secondary barriers prior well operations
- pore pressure and fracture gradient profile along the wellbore and its stratigraphy
- well geology if not provided with the above profile.

Information about the well operation

The programme should include:

- detailed well schematic of the proposed solution(s)
- well barriers schematic stating primary and secondary barriers of the proposed solution(s)
- lessons learned from previous completion if available
- detailed programme of the operation including planned tests and their acceptance criteria for all safety and environmental critical elements
- detailed programme of the relevant contingencies if any including planned tests and their acceptance criteria for all safety and environmental critical elements.

Information about the risk assessment – ALARP principle

The programme should include the risk assessment, see section 2.

- assessment of actions planned to safeguard the drinking water aquifer(s)

- assessment of subsurface conditions and identified potential hazards should be stated, i.e. all potential leak paths to surface or intra formations (crossflows)
- identified risks should be recorded and stated and mitigation measures should be specified and implemented
- residual risks should be as low as reasonable practicable (ALARP).

Information about independent verification

In the case of complex well operations: the programme should include independent well verification, see section 4.

Information about completion

If the required information listed below for some reason are not stated or included in the completion programme, references should be made to relevant documents. These documents should be made available to the DEA.

The programme should a.o. include information on:

- Operational steps
- Completion fluids
- Wellhead system
- X-mas tree design
- Completion and barrier schematics

Information about upper completion

The programme should include information on:

- tubing and hanger
- surface controlled subsurface safety valve and annular safety valve as applicable
- downhole pressure and temperature gauges, chemical injection valves
- Electrical Submersible Pump (ESP), Hydraulic Submersible Pump (HSP) or gas lift valves.

Information about lower completion

The programme should include information on:

- liner type
- production packer
- flow control components (sliding sleeves, nipples, etc.).

Information about perforation and perforation guns if applicable

The programme should include information on:

- type and data
- safety procedures covering as a minimum safe handling of all devices and equipment planned used, running in and pulling out of hole and firing
- description of the planned explosives, safe handling and shot density
- target intervals and depths.

Information about stimulation, fracturing and acidizing if applicable

The programme should include information on:

- type and data regarding fracturing fluid, proppant and acids, including expected quantities
- safety procedures covering as a minimum safe handling of all equipment intended used, vessel hook-up activities and coordination, running in and pulling out of hole
- pressure, function or inflow tests of valves, fracturing lines and other equipment as applicable, specifying test frequency and acceptance criteria.

Information about dispensations

The programme should include the dispensations from the operator's own management system/standards and justifications.

Appendix 2 - Workover/well intervention work programme

Appendix 2 outlines the minimum required documentation to be submitted with regard to workover/well intervention operations.

The documentation depend on the type of the workover / well intervention operations to be carried out. Relevant information from Appendix 1 should be included.

Information about scope of work

The programme should include the main objectives of the planned workover / well intervention.

Information about the well

The programme should include:

- summary of the last interpreted calliper/logging survey if available
- well history and previous intervention(s)
- well and reservoir data which could be a potential hazard (scale, wax, CO_2, H_2S, etc.)
- information about casing and tubing restrictions
- equipment status
- well integrity status
- well schematic prior well operations
- well barriers schematic stating primary and secondary barriers prior well operations
- pore pressure and fracture gradient profile along the wellbore and its stratigraphy
- well geology if not provided with the above profile.

Information about the well operation

The programme should include:

- well schematic of the proposed solution(s)
- well barriers schematic stating primary and secondary barriers of the proposed solution(s)
- detailed programme of the operation including planned tests and their acceptance criteria for all safety and environmental critical elements
- detailed programme of the contingencies if any including planned tests and their acceptance criteria for all safety and environmental critical elements
- tentative well schematic for plug and abandonment of the well and for re-establishing the well site.

Information about the risk assessment – ALARP principle

The programme should include the risk assessment, see section 2.

- assessment of subsurface conditions and identified potential hazards should be stated, i.e. all potential leak paths to surface or intra formations (crossflows)
- identified risks should be recorded and stated and mitigation measures should be specified and implemented
- residual risks should be as low as reasonable practicable (ALARP).

Information about independent verification

In the case of complex well operations: the programme should include independent well verification, see section 4.

Information about dispensations

The programme should include the dispensations from the operator's own management system/standards and justifications.

Appendix 3 - Plug and abandonment work programme

Appendix 3 outlines the minimum required documentation to be submitted with regard to plug and abandonment operations.

In the following, only the relevant information for the chosen solution is required.

Information about scope of work

The programme should include the abandonment objectives of the planned plug and abandonment operations. This should include the objectives for each layer to be abandoned.

Information about the well

The programme should include:

- summary of the last interpreted calliper/logging survey if available
- well history and previous intervention(s)
- well and reservoir data which could be a potential hazard (scale, wax, CO_2, H_2S, etc.)
- information about casing and tubing restrictions
- equipment status
- well integrity status
- well schematic prior well operations
- well barriers schematic stating primary and secondary barriers prior well operations
- pore pressure and fracture gradient profile along the wellbore and its stratigraphy
- well geology if not provided with the above profile.

Information about the well operations

The programme should include:

- well geology with identification and assessment of flow potential from hydrocarbons and water sources/reservoir
- well schematic of the proposed solution(s)
- well barriers schematic stating primary and secondary barriers of the proposed solutions
- verification of the barriers to be used as permanent barriers
- detailed programme of the operation including planned tests and their acceptance criteria to be achieved for all safety and environmental critical elements

- detailed programme of the contingencies if any including planned tests and their acceptance criteria to be achieved for all safety and environmental critical elements.

Information about the risk assessment – ALARP principle

The programme should include the risk assessment, see section 2.

- assessment of subsurface conditions and identified potential hazards should be stated, i.e. all potential leak paths to surface or intra formations (crossflows)
- identified risks should be recorded and stated and mitigation measures should be specified and implemented
- residual risks should be as low as reasonable practicable (ALARP).

See the DWEA description of the ALARP principle:
https://offshore.at.dk/en/regulations/wea-guidelines/alarp-principle/

Information about independent verification

In the case of complex well operations: the programme should include independent well verification, see section 4.

Information about dispensations

The programme should include the dispensations from the operator's own management system/standards and justifications.

Appendix 4 – Notifications to the DEA

Appendix 4 outlines the minimum required documentation to be submitted with regard to notification.

The following should be submitted a minimum of six (6) weeks prior to the planned start of a well operation:

- the work programme or
- a description with objectives of the well operation to be performed.

On the basis of the received information, the DEA may request additional information and documentation, e.g. the performed risk assessment and the work programme. It may be relevant to send the detailed programme in a draft format to the DEA well in advance of the planned start of the operation in order to answer any initial questions and then include the final details in the final version when the rig and 3rd party suppliers have been selected.

For campaigns longer than 3-4 months, a monthly update of planned well operations for the next three months with a short and sufficient description of the operations to be carried out should be submitted.

The work programme should as a minimum include:

Information about scope of work

See appendix 1 – 3 for details

- the programme should include the objectives of the planned operation.

Information about the well

The programme should include

- well history and previous intervention(s)
- well and reservoir data which could be a potential hazard (scale, wax, CO_2, H_2S, etc.)
- information about casing and tubing restrictions
- well integrity status
- well schematic prior well operations
- well barriers schematic stating primary and secondary barriers prior operations.

Information about the well operations

The programme should include:

- well schematic of the proposed solution(s)
- well barriers schematic stating primary and secondary barriers of the proposed solution(s)
- detailed programme of the operation including planned tests and their acceptance criteria to be achieved for all safety and environmental critical elements if applicable
- detailed programme of any contingencies including planned tests and their acceptance criteria to be achieved for all safety and if applicable, environmental critical elements.

Information about the risk assessment – ALARP principle

The programme should include the risk assessment, see section 2. The risk assessment should form the basis for demonstrating the risks are ALARP.

Information about dispensations

The programme should include the dispensations from the operator's own management system/standards and justifications.

Appendix 5 - Daily Drilling Report

The daily drilling report should include the following information:

1. reporting date
2. the name of the well
3. drilling unit name and owner name + well site address
4. name of operator
5. HSE incidents last 24 hours
6. total days on the drilling site
7. daily cost and cumulative cost
8. present operation
9. depth of the well
10. operational summary of the last 24 hours
11. summary of the plan ahead
12. detailed description of the day's operations stating substantial results and descriptions of any operational problems. Among the conditions to be specified in the description, where appropriate are:
    a. significant liquid flow to or from the wellbore
    b. problems with the hole/well stability
    c. problems with management of the bore direction or control of this
    d. significant deviations from geological assumptions
    e. significant deviations from the anticipated formation pressure
    f. performing line operations, including data for the conductors (diameter, weight, quality and embedment depth) data for cementing (density, volume, theoretical top) and cementing process (circulation rate and pressure process, increment/loss of drilling fluid and any other indications of good or bad quality of cementing)
    g. completed pressure and function tests of both equipment and (formation)
    h. completed logs with ranges of potential problems
    i. completed production tests with listing of the main results, the trial process, covering both the flow of liquid and gas production as pressure and temperature pathways and main data
    j. produced liquids and gas (e.g. densities, gas composition, and for the water produced an indication of trace elements, salt and conductivity)
    k. performed plugging operations stating conducted tests
    l. performed perforations with the ranges, shoot density and type

m. performing hydraulic and chemical treatments in the formation

13. main data of the drilling fluid, including the density and temperature in and out of the wellbore, the viscosity, water loss, pH, oil content, trace element concentration as well as the main components in general
14. gas content of drilling fluid from the hole during drilling, pipe joint (connection) and trip indicating the total gas and gas composition comprising at least C1 to C4 and H_2S, and background gas of the circulated drilling fluid
15. drill bit diameter and type
16. description of the drill string composition
17. last casing diameter
18. last casing depth
19. test pressure for formation under the casing (LOT or FIT gradient)
20. maximum allowable surface pressure with the current density of the drilling mud
21. wind speed and direction
22. measurements of the direction of the wellbore
23. deflection of the wellbore both horizontal and vertical position from the last executed direction measurement
24. description of the report period drilled geological strata, indicating the depth, lithology, colour, grain size and porosity, including detailed results from preliminary core descriptions. The description should be accompanied whenever possible with information of suspected geological age
25. quantitative and qualitative indications of hydrocarbons
26. drilling speed in the penetrated layers
27. main results from the completed logs
28. date of last full BOP test
29. position/coordinates of the rig (ETRS 89 zone 32 for most of onshore DK – zone 33 for the eastern-most regions)
30. drills performed.

Appendix 6 - Well intgrity status

The well integrity status should include as a minimum the following:

a. well stock overview with the number of wells in each well integrity severity category
b. well stock overview with the number of wells in each well integrity severity category, prior mitigation (e.g. temporary plug setting)
c. the last 3 months' history of wells exceeding bleed down frequency (break down per well)
d. the last 3 months' history of annuli exceeding bleed down frequency (break down per installation for operator with more than one installation)
e. progress in wellhead maintenance compared to planned (number of wellhead maintenance overdue, and average days overdue per well)
f. progress in SCSSV tests (number of well tests overdue, and average days overdue per well)
g. list of all the wells with a barrier failure with the description of failure(s) and the current plan/status, including the well integrity severity category
h. list of all wells with a dispensation from the operator's own management system
i. number of closed and opened integrity issues per month by well integrity severity category for the last 12 months
j. list of all wells suspended more than six months including date of suspension.

Appendix 7 – List of abbreviations

ALARP: As Low As Reasonably Practicable as used in Risk Assessments
API: American Petroleum Institute

BOP: Blowout Preventer - A large valve arrangement at the top of a well that may be closed if the drilling crew loses control of formation fluids or used for pressure testing downhole items.

C1 – C4: Flammable hydrocarbon gasses with 1-4 carbon atoms in the molecular structure. E.g., C1 is CH_4, a.k.a. Methane
CBL: Cement Bond Log
CO_2: Carbon Di-Oxide

DDR: Daily Drilling Report
DEA: Danish Energy Agency
DEMA: Beredskabsstyrelsen, Danish Emergency Management Agency
DEPA: Danish Environmental Protection Agency
DGR: Daily Geological Report
DMR: Daily Mud Report, sometimes known as FSR: Field Service Report
DWEA: Danish Working Environment Authority

ED50: European Datum - Reference system used in mapping
ESP: Electrical Submersible Pump
ETRS89: European Terrestial Reference System 89
EU: European Union

FIT: Formation Integrity Test
FSR: Field Service Report, sometimes known as DMR: Daily Mud Report

GEUS: The geological survey of Denmark and Greenland

H_2S: Hydrogen Sulfide, toxic gas
H2: Hydrogen, a highly flammable gaseous compound
HSE: Health, Safety & Environment
HSP: Hydraulic Submersible Pump
HPHT: High Pressure High Temperature. In the UK, HPHT is formally defined as a well having an undisturbed bottom-hole temperature of greater than 300 degF [149 degC] and a pore pressure of at least 0.8 psi/ft (~1,83 sg) or requiring a BOP with a rating in excess of 10,000 psi [68.95 MPa]

IADC: International Association of Drilling Contractors
IOGP: International Association of Oil & Gas Producers
ISO: International Standard Organisation
IWCF: International Well Control Forum

LOT: Leak Off Test

MAASP: Maximum Allowable Annulus Surface Pressure
MAOP: Maximum Allowable Operating Pressure
MoC: Management of Change(s)

MPD: Managed Pressure Drilling

NOGEPA: Netherlands Oil and Gas Exploration and Production Association. A dutch association of companies licensed to research and explore for oil and gas in the Netherlands.
NORM: Naturally Occuring Radioactive Materials, aka LSA Scale – Low Specific Activity scale
NOROG: Norwegian Oil and Gas Association

NORSOK: Originally from 1994 “Norwegian Shelf Competitive Position). Commonly understood as a reference to the Norwegian standards for the Oil & Gas industry.

OBM: Oil Based Mud
OEUK: Offshore Energies UK is a trade association for the United Kingdom offshore energies industry which includes the Oil & Gas industry.

QA: Quality Assurance

RUT: Registeret for Udenlandske Tjenesteydelser (Register of Foreign Service Providers)

SCSSV: Surface Controlled Subsurface Safety Valve
SCP: Sustained Casing Pressure
SIS: Statens Institut for Strålebeskyttelse (Danish Radiation Protection Agency)
SST: Sundhedsstyrelsen, Danish Health Authority
TAG Number: An identification number affixed to an asset

UBD: Under Balanced Drilling
USIT: Ultra Sonic Imaging Tool
UTM: Universal Transverse Mercator

VDL: Variable Density Log

WBM: Water Based Mud

X-mas tree: Christmas tree - The set of valves, spools, and fittings connected to the top of a well to direct and control the flow of formation fluids from the well.