Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.
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ANNEX A SAFE JOB ANALYSIS (SJA) 36
FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead times and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in future petroleum industry developments and operations, subject to the individual company's review and application.

The NORSOK standards make references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

Annex A, SJA Form is informative.
1 SCOPE

This NORSOK standard defines functional and performance oriented requirements for well design and planning and execution of safe and efficient drilling and well operations in Norwegian waters.

2 NORMATIVE REFERENCES

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

API Bulletin 5C3 Formulas and calculations for casing, tubing, drill pipe and line pipe properties


NORSOK D-005 Coiled tubing (presently D-SR-005)
NORSOK D-006 Snubbing equipment (presently D-SR-006)
NORSOK D-008 Wireline equipment (presently D-SR-008)
NORSOK M-702 Drill string components (presently M-CR-702)
NORSOK N-001 Structural design
NORSOK N-005 Condition Monitoring
NORSOK S-002 Working Environment
NORSOK S-003 Environmental Care (presently S-DP-003)

NPD Regulations for Emergency Preparedness
NPD Regulations for Loadbearing Structures, etc.
NPD Regulations for drilling and well activities, etc.
NPD Regulations relating to safety zones, etc.
NPD Regulations relating to prohibition on anchorage and fishing
NPD Regulations for Drilling and Well Activities and Geological Data Collection
NPD Regulations relating to systematic follow-up of the working environment
NPD Publication: The arrangement of regulatory supervision relating to safety and working environment, etc.

OLF Guidelines for Safety Requirements to Temporary Equipment
OLF/NR Standard Agreement concerning Principal Enterprise responsibilities
OLF/NR Recommended Guidelines for systematic follow-up of the working environment on Mobile Units, etc.
OLF/NR Recommendations for Training of Drilling Personnel
OLF/NR Guidelines for documentation of Mobile Offshore Units taking part in the petroleum activity

US-MMS Well control training and certification standards
3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

**Appraisal well**: A well drilled to establish the extent and the size of a petroleum deposit that has already been discovered by a wildcat well.

**Barrier**: One or several interdependent barrier elements which are designed to prevent unintentional flow of formation fluid.

**Can**: Can-statements are conditional and indicates a possibility open to the user of the standard.

**Development well**: A well used for production of petroleum or injection water, or injection of gas, water or other medium, or mapping or monitoring well parameters. Development well is a generic term for production wells, injection wells and observation wells.

**Exploration well**: A well drilled in order to explore a petroleum deposit and to map the extent and size of the deposit. Exploration well is a generic term for wildcat and appraisal wells.

**HPHT Well**: A well in which wellhead pressure would exceed 690 bar or where bottom hole static temperature could exceed 150°C.

**May**: May indicates a course of action that is permissible within the limits of the standard (a permission)

**Normative references**: Shall mean normative (a requirement) in the application of NORSOK Standards.

**NORSOK**: Norsk Sokkels Konkurranseposisjon, the Competitive standing of the Norwegian Offshore Sector, the Norwegian initiative to reduce cost on offshore projects.

**Primary cementing**: Entails casing and liner cementing operations.

**Shall**: Shall is an requirement to be followed in order to conform to the standard. Shall requirements shall preferably be used in all NORSOK standards. Non-compliance to shall-requirements shall be subject to acceptance by the client.

**Should**: Should is a recommendation. Alternative solutions having the same functionality, quality and level of safety are acceptable to the client.

**Secondary cementing**: Entails squeeze-, remedial-, and plug cementing operations.

**Shallow borehole**: A hole drilled to a depth between 25 and 200 m below the sea bed.

**Simultaneous operations**: Two or more activities being in process parallel in time.
Test development well: A well used for test development with a view to evaluate the petroleum deposit for commercially or production properties.

Tested barrier: It shall be possible to test the barriers. Testing methods and intervals shall be determined. To the extent possible the barriers shall be tested in the direction of flow.

Underbalanced Drilling: A well drilled under following circumstances:
Effective pore pressure in the formation is greater than the effective circulating downhole pressure of a drilling fluid (flow drilling)

Wildcat well: A well drilled to explore a new, clearly defined geological unit, delimited by rock types by way of structural or stratigraphic boundaries.

3.2 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>ASV</td>
<td>Annulus Safety Valve</td>
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<tr>
<td>BHA</td>
<td>Bottom Hole Assembly</td>
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<tr>
<td>BOP</td>
<td>Blow out Preventer</td>
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<td>CT</td>
<td>Coiled Tubing</td>
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<td>DC</td>
<td>Drill Collar</td>
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<tr>
<td>DDRS</td>
<td>Daily Drilling Reporting System (NPD`s computerised reporting system)</td>
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<td>DP</td>
<td>Dynamic Positioning</td>
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<td>ECD</td>
<td>Equivalent Circulating Density</td>
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<td>ERD</td>
<td>Extended Reach Drilling</td>
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<td>FIT</td>
<td>Formation Integrity Test</td>
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<td>HC</td>
<td>Hydro Carbons</td>
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<td>HAZAN</td>
<td>Hazard Analyses</td>
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<td>HAZID</td>
<td>Hazard Identification</td>
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<td>HAZOP</td>
<td>Hazard and Operability Analyses</td>
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<td>HPHT</td>
<td>High Pressure High Temperature</td>
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<tr>
<td>HWDP</td>
<td>Heavy Weight Drill Pipe</td>
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<tr>
<td>HSE</td>
<td>Health, Safety and Environment</td>
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<tr>
<td>IADC</td>
<td>International Association of Drilling Contractors</td>
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<td>IWCF</td>
<td>International Well Control Forum</td>
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<td>LCM</td>
<td>Lost Circulation Materials</td>
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<td>LMRP</td>
<td>Lower Marine Riser Package</td>
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<td>LWD</td>
<td>Logging while Drilling</td>
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<td>IEC</td>
<td>International Electrotechnical Commission</td>
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<tr>
<td>ISO</td>
<td>International Organisation for Standardisation</td>
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<tr>
<td>IWCF</td>
<td>International Well Control Forum</td>
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<td>MD</td>
<td>Measured Depth</td>
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<tr>
<td>MUT</td>
<td>Make up Torque</td>
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<td>MWD</td>
<td>Measurement while Drilling</td>
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<tr>
<td>NPD</td>
<td>Norwegian Petroleum Directorate</td>
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<tr>
<td>NR</td>
<td>Norges Rederiforbund (Norwegian Ship Owners Association)</td>
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<td>NTS</td>
<td>Norwegian Technology Standards Institution</td>
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<td>OLF</td>
<td>Oljeindustriens Landsforening</td>
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<tr>
<td>P&amp;A</td>
<td>Plug &amp; Abandon</td>
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<tr>
<td>PGB</td>
<td>Permanent Guide Base</td>
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<tr>
<td>POOH</td>
<td>Pull out of Hole</td>
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4 GOALS FOR WELL DESIGN, DRILLING AND WELL OPERATIONS

All drilling and well operations shall be properly planned and executed to achieve the objectives of the activity, with strong focus on areas relating to (1) safety, (2) environment, and (3) cost effectiveness. The goals should be defined accordingly. The goals should be challenging.

The main goals should be set for individual drilling campaigns/wells, and in a manner that enables measurement by clear/recognised performance indicators, and with due consideration to possible benchmarking purposes. The goals should address the objectives of the activity and targets for performance. Detailed goals may also be defined for each operations sequence.

The Operator’s goals shall be properly conveyed to the contractors for the purpose of alignment, buy-in and commitment.

5 WELL DESIGN

5.1 Classification
Registration number, well identification and classification/reclassification to be obtained from the NPD for each well. Rules for well identifications and classifications are drawn up by the NPD.

5.2 Geological conditions/Premises

5.2.1 Geological Prognosis and Well Path
The well design shall be based on a geological prognosis comprising the following aspects:
• Expected stratigraphy and lithology
• At least two interpreted deep seismic cross-section through the field/planned well
• Particulars for exploration wells:
  Geological description of primary and secondary prospects
• Particulars for deviated wells:
5.2.2 Pore Pressure Prognosis & Formation Strength
- Expected pore pressure development, expected well bore stability (wellbore collapse), mud weight prognoses and expected formation strength.
- Evaluation of possible overpressured formation and related uncertainties, based on seismic data and/or experience from offset well data.

5.2.3 Data Acquisition
- Data acquisition containing details on data demands and log types to be used at the various intervals.
- An evaluation of the data acquisition program in relation to anticipated problems related to drilling and borehole conditions.

5.2.4 Examination of the Drilling Location
An evaluation of the possibilities of encountering drilling hazards/problems like shallow gas, hydrates, and boulder beds during the top hole drilling based on seismic data shall be performed. The seismic data shall have a penetration covering the geological sequence to the setting depth for casings for the blow-out preventer. Connecting lines to neighbouring wells shall be established if practically possible.

Where there are possibilities of being exposed to shallow gas hazards prior to installation of the BOP, a pilot hole shall be considered to be drilled through the anomalies and well data evaluated prior to a further opening of the well to necessary diameter is commenced. Necessary weighted mud volumes shall be available for contingencies and for displacement prior to tripping out of hole.

The site survey shall also include an assessment of sea bed conditions, water depths, possible obstructions, cables, pipelines, etc. of concern. The survey shall also cover possible surface locations for relief wells.

5.3 Well Design Characteristics

5.3.1 Well Design Process
Prior to the commencement of the well design process, the following considerations shall be established:
- Type of well (exploration, appraisal, production)
- Location and installation (integrated platforms, wellhead platforms, subsea)
- Main and secondary targets
- Data collection demands
- Well evaluation methods to be applied (coring, logging, sampling, testing, stimulation)
- Application of the well (exploration, appraisal, production, injection, monitoring, relief/killing)
- Characteristic inclinations and depths (vertical, deviated, horizontal, side-track, HPHT, deepwater)
- Type of drilling-, production-, and workover system (fixed-, floating-, subsea installation, jack-up)
• Life time prognosis (permanent-, temporary abandonment, production-, injection completion, partial completion and later tie-back, expected time between workovers, downhole pressure and temperature profile)
• Environmental and safety constraints

All well design activities shall include the following minimum of activities:
• Definition of objectives
• Fall back objective if unable to meet main objective
• Definition of design basis
• Definition of well's lifecycle
• Collection of background information
• Identification of governing regulations and standards
• Collection and evaluation of information from reference wells, experience transfer report system or databases and other relevant sources
• Collection and evaluation of information from vendors of equipment and services
• Well design with special emphasis on relevant procedures
• Review and verification of design
• Well design upgrade if deemed necessary
• Design review
• Design approval

5.3.2 Underbalanced Drilling Design
To succeed in proper well design, the issues below shall be considered:
• Wellbore stability and consolidation
• Safety and well control
• Inability to use conventional MWD technology for through-string injection techniques
• Gravity drainage effects in high permeability zones
• Condensate drop-out or gas liberation effects
• Near wellbore damage
• Probability for corrosion problems
• Discontinuity of the underbalanced situation

For the underbalanced drilling design and for evaluation if beneficial, it is important to gather complete information from pre-existing data sources. Review the data with reservoir engineering, geology and underbalanced drilling experts for determining whether the well meets the base criteria for optimal underbalanced drilling implementation. In addition the platforms facilities and ability for performing underbalanced drilling must be evaluated as part of the design.

5.4 Barrier philosophy

5.4.1 Primary Requirements
During drilling and well intervention activities at least two independent and tested barriers should be in place after setting the surface casing, to prevent an unintentional flow to surface from the well. A barrier shall be present in the event of possible cross flow between different pressure regimes in the formation.

The individual Operator shall establish a barrier philosophy.
The barriers shall be defined and failure criteria established. The availability of barriers should be considered with regard to risk associated with the operation. Methods and intervals for pressure testing shall be established. To the extent possible the barriers shall be tested in the direction of flow. The position/status of the well barriers should be known at all times.

It should be possible to activate the two barriers independently. Systems shall prevent failure or individual accidents to simultaneously eliminate both barriers.

The barriers should be independent of each other without any barrier element in common. The defined well barriers should allow for immediate re-establishment when lost.

In the event of a barrier failure, immediate compensating measures shall be taken in order to keep adequate safety level, until two independent and tested barriers have been restored. No activities for any other purpose than re-establishing two barriers shall be carried out in the well.

If two tested barriers cannot be achieved, efforts shall be made to ensure that the total level of risk is not increased.

If the ordinary 2 - barrier concept is being compromised (e.g.: for deep water, under-balanced drilling), a non-conformance handling for validation of the integrity for well control must be provided/documented. Under the condition that the total safety level is maintained compatible with a 2-barrier solution, there may be a trade-off between the actual availability of the barriers in question, and operational precautions.

5.4.2 Barrier Elements

Examples of recognised barrier elements are:

- BOP arrangements
- Christmas tree arrangement
- Properly cemented casing
- Production tubing
- Cement plugs
- Production packer elements
- Mechanically/hydraulically operated plugs/packers
- Well safety valve (SCSSV)
- Lubricators
- BOP system of coil tubing/snubbing unit
- Seal assembly of casing/production tubing
- Wellhead systems
- ASV (Annulus Safety Valve)

The various valves of a BOP or X-mas tree valve are considered to be barrier elements and will together with the well anchorage form one barrier.

The shear ram is regarded as a barrier element which increases the accessibility of the secondary barrier, e.g. in those cases where a pipe ram is leaking or where the drill string is out of the hole.

Certain individual parts of a barrier element, e.g. circulation valves in production tubing, represent a part of the production tubing integrity and are consequently required to comply with the requirements applicable to production tubing as barrier elements.
Furthermore it follows from the barrier requirements that if the annulus is to be used for gas lifting, an annular barrier element is to be installed, unless the gas lift valves can be qualified as a tested barrier element.

It should also be evaluated if an annulus barrier element is needed.

5.4.3 Barriers during Overbalanced Drilling Operations

During the ordinary drilling process, the following barrier status shall remain:

- A barrier consisting of a homogenous column of drilling fluid in hydrostatic overbalance in relation to the pore pressure
- A barrier consisting of a cemented casing, wellhead, ram/annular preventer and drillstring with kelly valve/check valve

It shall be aimed for continuously monitoring of a fluid which constitute a barrier or which forms part of a barrier element.

Prior to drilling out of the surface casing, all operations shall be performed with a minimum of one barrier, normally drilling fluid.

While drilling it is a regulatory deviation to underbalance the well in order to release a stuck drillstring, if the drilling fluid constitutes one of two barriers.

Single operational or equipment failure shall not endanger the well barriers. Hence the fluid column used as a barrier in connection with drilling and subsea BOP must typically include a marine riser margin.

At sea depths of a certain magnitude, the riser margin may constitute a considerable hydrostatic pressure contribution above other hydrostatic safety margins (e.g. trip margin). Requirement with regard to riser margin should be seen in conjunction with the barriers:

- Availability of other barriers (E.g. inspection status and performance records for BOP, extra shear ram, packers etc.)
- The consequence of barrier failure
- Availability of mud materials onboard
- Drilling in well known area
- Monitoring and control of well conditions
- Enhanced following up of weather forecasts
- Well control procedures, effectiveness
- Special operational precautions
- Reliability of DP system while drilling operations in DP mode

Kick margins must be considered with regard to the well design and control systems in place.

5.4.4 Barriers during Underbalanced Drilling Operations

During the underbalanced drilling process, special equipment is needed:

- Minimum 2 float valves shall be installed in the drill string downhole to eliminate backflow up the pipe
- An annular diverter system which seals against the kelly or drill pipe is needed for jointed pipe. This could be a conventional rotating control head or a more advanced rotating BOP
• A choke manifold for controlling live well at surface
• Pressurised sample catchers to be used if cuttings is to be saved and analysed
• Chemical injection pump for minimising emulsions or corrosions (option)
• A surface separation system is required to handle gas, liquid hydrocarbons, drill fluid and cuttings returning to surface

The one barrier will consist of a cemented casing, wellhead, rotating head/rotating BOP and drill string with kelly valve/check valve.

The conventional BOP stack improves the availability for the one barrier system. Deviations from the 2-barrier concept require concurrence from the NPD.

5.4.5 Barriers in connection with Wireline Operations
The normal barrier status for wireline run while in permeable zone/reservoir shall be:
• A barrier consisting of a homogenous column of drilling fluid in hydrostatic overbalance in relation to the pore pressure.
• A barrier consisting of cemented and pressure tested casing, wellhead seal assembly and BOP.

5.4.6 Barriers of production well
Long term planning for possible future stimulation and/or injection should be considered with special emphasis on temperature and pressure. The normal barrier status for a production well shall be:
• One barrier consisting of a cemented casing, packer, production tubing and down hole safety valve
• One barrier consisting of a cemented casing, wellhead and X-mas tree with associated valves

5.4.7 Barriers in connection with pressurised well intervention

5.4.7.1 General
Well intervention shall be planned and carried out in such way that it meets the requirement to barriers and simultaneous operations.

Two fully independent barriers do not exist when wireline, coiled tubing or snubbing has passed the SCSSV. Proper job simulations, is an important part of the planning prior to any well intervention job.

5.4.7.2 Wireline Operations
The normal barrier status for such operation shall be:
• A barrier consisting of tested cemented casing/liner, packer, production casing, completion string, wellhead, X-mas tree housing and wireline well control equipment as outlined in NORSOK Standard D-008.

All effort possible should be made to avoid accidental closure of any X-mas tree valves while the wireline is passing through. Shearing capabilities shall be documented.
5.4.7.3 Coil Tubing Operations

The normal barrier status for such operation shall be:
- A barrier consisting of tested cemented casing/liner, packer, production casing, completion string, wellhead, X-mas tree housing, coiled tubing check valve and coil tubing well control equipment as outlined in NORSOK D-005
- On floaters with CT intervention on a Subsea tree, the LMRP shall include two CT shear/seal functions, to facilitate a controlled and safe emergency abandonment from the well.

All effort possible should be made to avoid accidental closure of any X-mas tree valves while the coil tubing is passing through. Shearing capabilities shall be documented.

5.4.7.4 Snubbing Operations

During snubbing the well is controlled by a combination of surface pressure and hydrostatic pressure. The BOPs are integral to the primary method of well control. The normal barrier considerations for such operation shall be:
- A barrier consisting of tested cemented casing/liner, packer, production casing, casing hanger, wellhead, completion string, snubbing pipe check valve and snubbing well control equipment as outlined in NORSOK Standard D-006.

All effort possible should be made to avoid accidental closure of any X-mas tree valves when the snubbing pipe passing through. Tapered string requires additional BOP equipment and the snubbing stack arrangements must be prepared for the particular job in question. The snubbing BOP shall sequentially operate if an emergency shut down have occurred. Shearing capabilities shall be documented.

5.4.8 Cemented Casing as a Barrier

When cementing a casing string the cement column shall isolate permeable intervals with abnormal pressures and zones containing hydrocarbons typically extended at least 200 m MD above such zones/intervals. The cement shall be planned to extend at least 200 m MD above casing shoe.

Conductor strings and surface casing shall have sufficient lateral support to be able to withstand all forces that can be expected during the lifetime of the well.

The liner lap shall be covered by cement or a liner top packer.

If not a liner top packer is set, pressure testing of the liner lap should not commence before the cement is verified to retain necessary compressive strength.

5.4.9 Cement Plug as a barrier

A cement plug being part of an abandonment program shall extend a sufficient length above the highest leak passage (i.e. casing shoe, liner hanger, perforation etc.):
- Open hole; 50 m (min. total 100 m cement plug)
- Cased hole; 100 m alternatively mechanical bridge plug with 20 m top cement if run as a retainer
- A top plug of 200 m is to be placed at the top of the well, so that the top of the plug is not more than 50 m below the sea bed.
Isolation is verified by pressure test to 70 bar above measured formation. Also 10 tons weight test to be performed for plugs against open hole/leak passage.

5.5 Casing Design

5.5.1 General Requirement
When performing the casing design, the casing strings shall be set at such depth that full control of the well can be maintained at all times.

This further means that casing shall be installed in such a way as to take account of geological and pressure related conditions in the well in order to maintain full control of the well at all times.

Casings shall be of such diameter, weight and strength, and shall otherwise be made, installed and anchored in such a way that they can withstand the pressures and loads from fluids and gases that can be expected in the well at all times. Casings shall also be of such quality that they can withstand particularly corrosive media in the well (H₂S, CO₂ etc.), if they can be expected to be exposed to such environment.

Casings shall be designed and installed in such a way as to enable cutting without the use of explosives.

If an exploration or appraisal well is planned to be a future production well, the casing design must also take into account temperature expansion causing an increased collapse force on the production casing.

5.5.2 Well Design Criteria
The casing shall be designed with respect to realistic load conditions during the lifetime of the well.
The load shall be corrected for additional loads and effects:
- Biaxial stress - collapse
- Casing wear
- Bending in deviated hole sections
- Temperature effects
- Corrosion
- Plastic Formations and reservoir compaction
- Pressure during completion, workover and kill operations

5.5.3 Safety Factors
The following minimum design safety factors are in general recommended:
- Burst: 1.1
- Collapse: 1.1
- A minimum design factor of 1.3 for tension loads is normally sufficient (ref. API rated values for body yield load or joint parting load whichever is the smaller.) A design factor of 1.3 can be justified when it is known that the tension load includes static casing load, bending forces, and the greater of pressure testing forces or shock loads. If there are considerable uncertainties about loads in addition to those mentioned above, a higher factor may be required.
- Triaxial: 1.25
Detailed analyses may be used to justify for reduced safety factors.

5.6 Cement Design

5.6.1 Design parameters and objectives

Based on the objectives and the design criteria, necessary design parameters are established for the final cementing programme. It is important that the drilling programme indicates design parameters that are specific to the individual cementing operation.

The minimum requirement for cementing of the various casings will be that the well shall be cased in such a way that full control can be maintained in further operations. The design criteria set out below for cementing of various casing strings are based on current industry practice.

5.6.2 Primary Cementing Operations

5.6.2.1 Conductor casing

Conductor casing shall be cemented back to the sea bed if a hole for the casing has been made by water-jetting or drilling (exceptions may apply for conductor driving). When cementing the conductor casing, the requirement that it shall be capable of providing the necessary support for the surface casing and also be capable of absorbing the forces that occur when well control equipment is placed on the sea bed, shall be taken into consideration. Also mechanical cutting during P&A shall be possible.

5.6.2.2 Surface casing

The primary function of the surface casing is to ensure adequate anchorage of the BOP stack. Therefore the surface casing shall be planned cemented so that sufficient vertical and lateral support is achieved. If the casing is planned to be cemented back to the sea bed, secondary cementing shall be considered to ensure sufficient anchorage. If the cement mixture is not brought up to the sea bed during the primary cementing work, secondary cementing shall be carried out to ensure cement is brought sufficiently high for anchorage. The set cement mixture shall have such properties and such quality as to be able to withstand the forces that may occur due to pressure under the blow-out preventer and the weight of same. Furthermore, the set mixture shall be able to resist expected pressures in the next section and provide hydraulic seal preventing migration of formation fluid and gas at the shoe. Possible shallow gas problems shall be taken into account for design.

5.6.2.3 Intermediate/Production casing

Objectives for cementing of the casings will be:

- All permeable intervals with abnormal pressure and zones containing hydrocarbons are to be isolated; the level of the cement shall be at least 200 meters above the most shallow zone/interval, or, if applicable, 200 meters above the casing shoe if there are no zones containing hydrocarbons or permeable intervals with abnormal pressure above the shoe;
- The cement shall be of such quality and shall have sufficient compression strength so as to be able to resist expected pressure in the next section, and provide a reliable and permanent seal against permeable formations in the cemented area
- Casings that are not planned to be drilled out of should have at least 25 meters of cement at the bottom, or the cement plug shall be inflow tested in the case of a shorter cement column. In addition a check valve in float collar and shoe, or a double float collar/shoe with check valves to be in place.
5.6.2.4 Liners
Objectives for cementing of liners coincide with those applicable to intermediate/innermost casing.

In addition, the annulus between the liner and casing string shall be secured with a cement plug of at least 100 meters or a packer.

In the case of liners set through horizontal reservoir sections where permeable zones are interconnected and have same pressure requirements to cementing may be waived. The requirement relating to sealing of the annulus between the liner/previous casing string and previous casing shoe shall be complied with.

5.6.3 Secondary Cementing Operations
Objectives, design criteria and design parameters are determined in the same way as for primary cementing operations.

Cement plugs intended to have a permanent sealing function against downhole influx or isolation, shall be designed so that strength reduction and/or altered permeability over a period of time will not entail operational or safety problems

This is applicable in particular if the plug is expected to be subjected to a temperature that exceeds 115 degrees C.

5.6.4 Isolation Requirements
Squeezing of cement can be used to cure lost circulation zones. The cement is intended to penetrate into the week formation and fill the pores and/or fractures that cause the loss. Zones which are suspected to be a source for migration and which have not been isolated during the primary cementing shall be isolated by pumping cement into the annulus via perforations. When carrying out squeeze cementing in cased wells, the perforation intervals should be chosen with a view to ensuring as successful an operation as possible, and maximum pump pressure is assessed with reference to fracturing pressure, circulation velocity, friction etc.

5.7 Drilling Fluid Design

5.7.1 General Requirements
Special requirements for the actual well must be identified per interval to be drilled. Each interval may require a special drilling fluid system. The number of systems per well will, however, be limited and reuse of mud should be emphasised in order to maintain total efficiency and reduced costs.

5.7.2 Contingencies
Enough drilling fluid materials or reserve drilling fluid to be able to replace at least 100% of each well section volume, including riser volume, is to be stored onboard the platform or available onboard a boat close to the platform. Possible LCM and additives for H₂S precautions should be considered.

5.8 Drill String/Work String Design
Drillpipe in general shall be in accordance with NORSOK standard M-702. In addition, dimensions, drilling torque and tension, hydraulics, make-up torque (MUT) of pin and box and
fatigue, factors must be accounted for when selecting the drill string for the well(s) in question. ID and OD on tool joints, should be selected with due considerations to giving a balanced tool joint with respect to make-up torque. Inspection routines to be defined in the maintenance program as agreed upon between Operator and Drilling Contractor.

Drill pipe for a standard well should be selected with respect to capacity of:
- Make-up torque necessary related to avoid down hole make-up
- Tension and torque capacity when both factors are working simultaneously. A curve showing these factors should be established with due consideration to the effect of fatigue

When selecting drillpipe for ERD, horizontal and HPHT Wells, the additional factors should be evaluated, friction, pressure, temperature, abrasive formation, buckling and hardbanding effect of casing wear.

5.9 Test String Design

5.9.1 General
The test string will be composed of individual equipment components depending on the well in question and special objectives to be achieved.

5.9.2 Design factors and criteria
All equipment shall be able to withstand the maximum loads arising during testing. The following design criteria will apply for all downhole testing equipment. The test string should be designed to meet the relevant loads during the test. Special considerations shall be made for biaxial stress, bending, temperature effects, and well control.

The following minimum factors are in general recommended:
- Burst: 1.1
- Collapse: 1.125
- Tension: 1.3

Strength reduction on account of high temperatures are normally in the region of 5 to 15% for temperatures up to 180 degree C. Should design factors in case of extreme temperatures be less than minimum design factor + 15%, a separate evaluation shall be made.

The testing tubes' tensile, burst and collapse strengths are calculated in accordance with API Bulletin 5C3.

5.10 Well Completion Design

5.10.1 General
The below factors must be evaluated to determine their impact on the design:
- Environmental data
- Reservoir data
- Well data
- Production data
- Fluid data
- Well control contingencies
- Interfaces / compatibility
• Well intervention and treatment

5.10.2 Completion String design

The strength requirements of the tubing must be evaluated to determine the appropriate grade and weight. The material selected should be resistant to corrosion in the actual well environment. Tubing size to allow for the required production/injection rates preventing the flow rate to exceed the erosional velocity of the tubing.

Acceptable thread connection should be determined based on the application and the tubing material.

The design factors listed below are required as a minimum:

- Burst: 1.1
- Collapse: 1.1
- Tension (Pipe body and thread connections): 1.3
- Triaxial: 1.25

The completion string shall be designed with respect to realistic load conditions during the life time of the well.

5.10.3 Completion Equipment

During the completion design one must select the appropriate pieces of equipment to meet the particular application and future options. Design compromises for individual items may be required to meet the over all design objectives.

Following objectives for a completion design shall be complied with:

- Well control
- Optimised to satisfy the completion design factors
- Compatible with the tubing design and materials
- Contingencies/back-up tools and methods

5.10.4 Completion Fluids

Following design criteria shall as a minimum be considered:

- Fluid volumes
- Fluid density
- Crystallisation temperature
- Fluid loss control
- Particle content
- Formation compatibility
- Compatibility with other fluids
- Effects on elastomers
- Corrosion
- Contingencies
- Long term plans for the well

The completion fluids shall be evaluated on their compatibility with the elastomers of the completion equipment. Especially the fluids that remain in contact with the equipment over an extended period of time shall be carefully analysed. The corrosion inhibitor used in the packer fluid shall be compatible with the elastomers in the equipment which prevent annulus communication.
5.11  Protective Structure for Subsea Completed Wells/Suspended Exploration Wells

Exploration wells that have been temporarily plugged and abandoned and sub sea completed wells (applies for areas where no prohibition against anchoring and fishing has been granted by the Authorities) shall be protected such that subsequent activities will not cause damage to the well or any damage to fishing gear.

The integrity of the wellhead shall be maintained concerning capability of equipment to be over-trawled. The requirement with regard to securing the wellhead may be met as follows:

- The wellhead is covered by a corrosion cover
- A protective structure is installed above the wellhead system. The structure must be capable of being over-trawled, i.e. the shape, height above the sea bed etc. of the structure shall be such as to prevent fishing gear which is pulled over it from becoming entangled and damaged or from causing damage to the wellhead system
- The design is to withstand the anticipated overtrawl load and shock treatment from fishing gear (ref. NPD’s Regulations for Loadbearing Structures, etc. and NORSOK standard N-001) Furthermore the structure must have openings enabling a visual inspection of the wellhead
- The well is equipped for localisation and identification
- Inspection of wellhead and protective structure is carried out at least once a year. A planned inspection programme is to be drawn up, cf. guidelines to the NPD’s Regulations for drilling and well activities, etc., and NORSOK standard N-005 Condition Monitoring, etc.
- Dropped object protection on pipeline/template for drilling, completion and workover situations, including anchor handling

5.12  Blow-out Contingencies/Relief Well Design

5.12.1  General

The blow-out contingency plan is developed to meet the Governing legislation as well as Operator internal requirements. The main objective of the plan is to cover mobilisation of necessary emergency equipment, personnel, services as well as kill methods in the case of a blow-out occurrence.

5.12.2  Relief Well

The objective of a relief well is to dynamically kill and stabilise a blowing well. If a surface intervention cannot be performed on the blowing well immediately after a dynamic kill, then the blowing is to be killed/plugged via the relief well.

The following items shall as a minimum be covered for a coarse relief well design:

- Mapping of suitable drilling locations (including shallow seismic interpretation of the top section)
- Evaluation of blow-out scenarios and kill methods
- Requirements to facilities for relief drilling and well killing
- Evaluation of relevant well profiles and casing programme
- Estimation of necessary pumping capacity
- List of available equipment and time critical activities, including possible rigs/facilities for well intervention options as appropriate.
6 OPERATIONS PLANNING

6.1 Organising Work, Exploring Possibilities & Limitations
Well engineering and operations planning are typically project oriented, and the demands for personnel resources and necessary lead times varies a lot. The quality of the planning, ability to make necessary decisions and commitments, clear definition of interfaces and distribution tasks are critical aspects for the success of the project. Organisation of work should typically comprise:

- Establish a Drilling/Well Team early to work critical tasks.
- Identify obligations or restrictions imposed by licence, data acquisition, operations, climate, other simultaneous activities or facilities in the area, and by environmental protection.
- Identify relevant sources of experience to be used as support for preparations.
- Establish project plan/schedule, milestone dates and budgeterial premises.
- Ensure responsibilities for planning, execution and follow-up is being clearly defined. Ensure goals are properly outlined/communicated.
- Select suitable drilling rig/facilities, and get the dedicated contractor personnel involved early to assist in the preparations work. Determine status with regard to regulatory compliance and specific demands for rig analyses and qualifications/training of personnel. Explore the potential for co-operation with other Operator(s)/Companies.
- Secure service contracts early to ensure sufficient up-front support from service company personnel in the preparations work.
- As appropriate, define preliminary well location and geological prognosis, obtain relevant experience data, obtain Site Survey, prepare well specific pore pressure study and perform preliminary well design(s) and/or completion designs. Evaluate the conditions for lateral support of the conductor casing and wellhead.
- Do early simulations on well path drilling torque and drilling hydraulics to identify possible need for rig equipment upgrading. Identify shortcomings of other existing equipment.
- Determine specifics for securing/procuring of tubulars, contingency strings, wellhead systems and other critical items with long lead time.
- Explore possibilities for doing simultaneous/parallel work onboard outside critical path, (through rotary), and possibilities for doing preparations work onshore.
- Determine the need and capabilities for emergency response.
- Perform detailed well design and initiate special technical and regulatory assessments in due time to support operations planning and applications for consents/permits.
- Identify special regulatory provisions regarding environmental protection, including studies requiring excessive public hearings and handling time by the state pollution authorities.
- Review possibilities for the use of existing assessments and documentation.
- Ensure preparations are done with due regard to effective implementation throughout operations. Involve operations personnel early.

6.2 Personnel Skills
It is important that a highly skilled and motivated team is secured and actively involved as early as possible. Besides specific technical/operational skills, it is important that key members can work effectively within a multi-disciplined team, consisting of personnel with varying experience.

In accordance with the Regulations, requirements to qualifications/training shall have been set out for all job categories with great impact on safety through the various phases of drilling and well operations. Special training should be provided in the case that new equipment/technology is being used.
6.2.1 Qualifications and Training for Offshore Operations

The following specific qualifications requirements for drilling and well operations personnel are supplemental to the common requirements for offshore personnel regarding such as health certification, basic safety and contingency training w/refreshers.

Supervisory personnel shall have training or experience in Norwegian Acts, Regulations and Provisions. Training with respect to work environment factors shall be in accordance with the NPD Regulations relating to systematic follow-up of the working environment.

Personnel involved shall have the education and experience required in compliance with Norwegian Regulations, and shall be able to show proven track records for the same. The OLF/NR’s Recommendations for Training of Drilling Personnel is considered to represent the industry norm. Documented experiences for the specific offshore positions can be provided through an on-the-job-training system compatible with that system recommended/issued by the NR. Requirements to personnel qualifications should also comprise theoretical and practical training when new equipment is introduced. As supplementary standard for personnel qualifications in the area of well service, reference is made to the Education Plan approved by the Norwegian Ministry of Church, Education and Research in respect of Well Service Techniques, detailed within the areas of Wireline Operations and Cementing.

Well Control Training and Refreshers are required for the following offshore positions:

  Drilling Supervisor, Toolpusher, Tourpusher, Driller, Assistant Driller, Leader for Well Operations/Intervention.

Basic well control training and subsequent refresher courses shall be completed in accordance with US-MMS, UK-HSE or International Well Control Forum (IWCF) certification standards.

The Operator can carry out mandatory control by requesting the Contractors to confirm there is consistence in personnel qualifications requirements by detailed references to existing regulations and standards, and to present any discrepancies and the existing training schedule for personnel involved.

6.2.2 Planning for Safety Drills

Generally safety drills are planned and executed according to relevant operations, and shall be performed with due regard to the NPD's Regulations and Guidelines.

For each drilling crew, pit level drills should be carried out at least twice per week regarding measures to be taken in the event of pit level variations.

Drills involving use of blow-out preventers to handle inadvertent influx of fluid or gas into the well during drilling, should be carried out weekly for each crew.

A kick drill should be carried out prior to drilling out of a new casing string, from setting the surface casing and onwards.

Determine and implement well operations safety drills.
Special wells/operations or analyses may result in specific input to type and scope of training and drills. (E.g. for deep water drilling and HPHT wells).

6.3 Site Specific Considerations for Fixed and Mobile Installations
The operations shall be considered with due regard to potential drilling problems/hazards and other activities in the area. Such issues could be potential shallow gas, boulders, subsidence, seabed features, anchor holding/demands, accessibility for relief well locations, ship traffic, interference with pipelines, subsea installations and cables which may cause operational constraints.

Orientation and protection of the facilities should be optimised with regard to prevailing meteorological and oceanographic conditions and with due regard to emergency preparedness.

Any deployment of anchor or anchorline closer than 500 m from other installations requires special safety considerations and early clarifications to be undertaken. Efforts should be made to eliminate the need to place anchors closer than 500 m off other platforms/subsea installations, and 200 m off pipelines and cables, assuming direction of pull is away from these facilities and the other Owner/Operator has concurred to the precautions being taken. Increased distances/clearances and additional safety precautions are required where direction of pull is towards other installations/pipelines/cables.

The distance to adjacent acreage should be set in order to avoid the well path to compromise the lease-line as a cause of positioning uncertainty. In this context, a surface distance of minimum 15 m off the lease-line is considered to represent the state-of-the-art for the surface hole. This distance may be increased according to international agreements when drilling adjacent to boarder lines to neighbouring countries.

General provisions of the NPD’s «Regulations relating to safety zones, etc.» and relevant «Regulations relating to prohibition on anchorage and fishing» for specific areas must be observed/followed.

For floating drilling units the station keeping capabilities must be verified to be within set criteria (with due consideration to possible anchoring/positioning failure), and it is a mandatory requirement to be able to move off location in an emergency. For anchored installations this may be accomplished by chain/wire rope stoppers or if applicable, pal mechanism, that shall individually be capable of being released from a protected location near the winch and from a manned control room or bridge. The release must be possible to carry out without particular preparations and by means of stored energy, emergency power or similar within 15 seconds and up to a tension corresponding to the breaking strength of the anchor chain/wire rope. During this operation the nominal stress of the structure shall not exceed the lowest specified yield point, however at a maximum 80% of the breaking strength of the material.

6.4 Main Units and other Services
Evaluation and selection of drilling unit/facilities and required services should be subject to a systematic process, employing existing documentation and recognised industry specifications/standards as far as reasonable possible.
6.4.1 Selection/Chartering Units and Drilling Facilities
For the purpose of chartering mobile drilling units, the OLF/NR «Guidelines for documentation of Mobile Offshore Units taking part in the petroleum activity» should be used to the extent practically possible, supplemented with premises derived from the pre-planning of the well/operations. The formal evaluation and selection process is a regulatory mandated requirement, and shall be traceable. There is a commercial part and a technical/operational part to be addressed. Certain formal assessments to ensure compliance must be conducted by the Operator as the accountable party towards the coastal state authorities.

The assessments of technical/operational aspects should comprise technical/operational capabilities, status on quality assurance, personnel competence and work arrangements, working environment, risk assessments of facilities and operations, emergency preparedness, environmental protection, health and hygiene, and regulatory compliance/exemptions.

According to Norwegian legislation, all contractors shall have implemented systems to ensure quality and to accommodate for their duty to exercise Internal Control for their scope of work. The Operator should make use of existing documents from other party and make use of Contractor’s established quality system as part of own internal control.

Coiled Tubing, Snubbing and Wirelines shall be in accordance with NORSOK standards D-005, D-006 and D-008.

Particular emphasis should be made on the assessment of the operations limits and the well control procedures. This is to validate suitability for the operations in question and to ensure the limits and procedures are properly understood and concurred to.

6.4.2 Rig Services & Supply
A Rig Service and Supply Plan should be prepared when details of the well design and operations program is about to be completed. The plan will typically identify equipment, services and consumables needed for the various hole sections, in order to support the operations without delay.

Special operational considerations must be made for vessels which may accommodate for VSP, storage purposes at location, disposal of well testing fluids, contingencies, etc.

6.5 Simultaneous/Parallel Operations
Simultaneous and parallel (independent) operations shall be thoroughly planned, analysed and performed with the objective of limiting excessive risk imposed by multiple operations at the same time, as opposed to the risk associated with the execution of these operations individually. Relevant procedures for the control of simultaneous/parallel operations shall have been developed and validated/assessed prior to commencement of operations.

6.5.1 Definition of Operations and Basic Safety Criteria
The following operations are defined as simultaneous operations if two or more operations are executed at the same time within the defined area for such activity:
- Production/Injection
- Drilling
- Well completion work
- Pumping/stimulation operations
• Work on X-mas tree/workover operations
• Wireline Operations
• Coiled tubing operations
• Snubbing operations
• Heavy construction
• Heavy lift
• Pigging operations exposing well area
• Running/pulling riser
• Skidding rig
• Hot Work

A prerequisite for simultaneous activities to be carried out in a safe and prudent manner, is that particular emphasis is placed on drawing up administrative and operational procedures ensuring that the activities are carried out in a systematic and controlled manner.

Governing safety criteria can be defined by barrier status and/or specific risk-rating of operations within a defined well area, and possibly supplemented with criteria for operational conditions in multiple areas where applicable.

6.5.2 Preparations of Simultaneous Operations
Following measures shall be taken in connection with simultaneous operations:
• Establishment of procedures on the basis of assessments of all simultaneous operations in order to identify possible factors of physical, administrative and of an emergency preparedness related nature that may lead to an increase of risk in excess of the defined acceptance criteria.
• Training of involved personnel.
• Ensuring that the day-to-day follow-up of simultaneous activities during the operational phase takes place in a coordinated and systematic way, and that possible deviations are identified and corrected.

6.5.3 Operational Considerations
Operational measures to ensure that simultaneous activities are carried out in a safe and prudent manner should include the following considerations:
• Producing wells should be protected against damage from neighbouring wells during drilling. If during drilling a well deviates within defined minimum distances to completed and perforated wells, correlated for the uncertainty of the position indication, barriers (plugs) shall be introduced below a possible point of contact in the said production or injection wells. If a possible point of contact is located above the SCSSV, closing and testing the SCSSV will be sufficient.
• The annular space of wells that may be exposed to collision with a well where drilling is in progress, should be brought into an overpressure condition in relation to the well being drilled, and the annular pressure of the wells should be closely monitored
• Restriction in simultaneous operations during heavy lifts if a sudden loss of suspended loads endanger the safety of other concurrently ongoing operations like:
  * Handling, running and pulling of BOP, X-mas tree etc. above wellhead areas
  * Running and pulling of risers, drill strings, casings and wellhead components in open water
  * Transfer of heavy equipment between supply boats and rig, etc.
• Activities shall be halted if the gas level in the drilling area exceeds a certain limit.
• Special precautions are taken for welding, grinding, cutting and other high energy in the 
wellhead, BOP or drillfloor area in parallel with simultaneous activities.

During simultaneous drilling and production, special restrictions shall be implemented for 
activities that could lead to a reduction of the safety level during drilling through layers containing 
hydrocarbons.

6.6 Preparation of Program
Operations premises and a detailed description of the planned tasks to be executed shall be 
included in specific operations programs for the well/operation in question. The program shall 
have been subject to an inter-discipline check involving the Operator and the main Contractor(s) 
prior to implementation. The program may be supplemented by more detailed offshore guidelines 
and SJAs if appropriate. Administrative requirements and guidelines regarding the minimum 
content and times for delivery of such programs to the authorities is outlined in the NPD’s 
«Regulations for Drilling and Well Activities and Geological Data Collection, etc».

As operations proceeds, significant deviations from the program shall be formally recorded, with 
proper information to the NPD.

Typical programs to be developed are:
• Drilling program
• Completion program
• Testing programme
• Plugging program
• Work-over program
• Well intervention program

Emphasise should be made on the use of simple formats/schematics and existing support 
documents. The use of flowcharts should be promoted.

6.7 HSE, Emergency Preparedness and Risk Assessments

6.7.1 Management System
Health, safety and environmental protection should receive particular attention through operations 
planning. A HSE Management system shall be implemented to meet regulatory requirements to 
Internal Control, and should be compatible with the E&P Forum’s «Guidelines for the 
Development and Application of Health, Safety and Environmental Management Systems». 
Evidence on shortcomings in HSE performance should result in special 
measures/support/mentoring as agreed between the Operator and Contractor concerned.

6.7.2 Working Environment & Occupational Health
Work areas should be subject to regular evaluation/charting against the NPD’s «Regulations 
relating to systematic follow-up of the working environment, etc.»), NORSOK standard S-002 
Working Environment and/or against OLF/NR’s «Recommended Guidelines for systematic 
follow-up of the working environment on Mobile Units, etc.». For operations with mobile units 
designated for drilling and well operations, the Drilling Contractor can be assigned the role as 
Principal Enterprise according to the OLF/NR’s «Standard Agreement concerning Principal 
Enterprise responsibilities» for coordination and follow-up of the working environment onboard. 
On fixed installations, this role will typically rests with the Operator/Owner. Working
environment and occupational health factors with high potential for changes between various wells should receive extra focus, like the changes imposed by the use of chemicals, drilling and completion fluids/additives.

Before start of the operations the workforce shall receive relevant information concerning health hazards related to their work and measures to prevent harmful exposure, including possible training in correct use of personnel protective equipment and with emphasis on risk and preventative measures associated with non-routine operations, tasks, methods, materials and chemicals.

All chemicals used during the course of the work shall have Material Safety Data Sheets conforming to quality requirements issued by the OLF.

Systems should be properly implemented for the reporting of accidents, work related diseases, unsafe acts and conditions. A safety delegate system shall be implemented for the drilling and well operations area, and the system shall also include representatives to serve the interests of the Well Service Contractors.

6.7.3 Environmental Protection

Appropriate systems for protection of the environment should be in accordance with the operative parts of the NORSOK S-003 standard for «Environmental Care».

Suppliers of chemicals in drilling, cementing and completion operations shall have implemented an effective quality system to support continuously improvements and by contributing to reduce the environmental risk.

Chemicals which are discharged to the water or emitted to the air shall cause as little harm as possible to the environment. Selection of chemicals should be based on an overall evaluation of efficiency, environmental data, safety data and economic criteria. The total evaluation of the product should also address the quantity and concentration of emissions.

All chemicals (also for emergencies, detergent and thread dope) which may end up in the environment shall have been tested in accordance with SFT’s guidelines. Chemicals on SFT’s list A and B should be as clean as possible. Chemicals which are included in the Paris Convention’s Annex A part I or contain alkylfenol or alkylfenol-connections shall not be discharged.

An assessment of measures for reduced fuel/energy demands and steps to reduce the consumption of chemicals and use of chemicals with better environmental characteristics shall be part of the continuous improvement process. The technology available for reducing discharges to the sea and emissions to the air shall be continuously evaluated.

There shall be systems in place for handling waste and keeping track of chemicals/substances onboard. Discharges shall be within the SFT’s regulatory requirements or in the actual discharge permit for the operation.

Discharge of drilling fluids and completion well stimulation fluids etc. - should be minimised, by reuse of other effort to reduce discharges. All discharges to sea as a results of cementing operations should be minimised for both environmental and economical reasons.
Data sheets with details about composition, personnel safety data, toxicity, bio-accumulation and biodegradability shall be available for all products.

The use of thread dope with heavy metal content should be avoided for tubulars. The use of heavy metal containing dope should only be used if demanded by technical/safety reasons.

Concerning well testing, other methods than burning shall be considered, including collecting oil. Use of special vessels for collecting oil should be considered, and this evaluation shall be documented.

Effective burning must be provided for, both technically and operationally. Wellbore fluid in the transition between the water/diesel column and the perforations shall not be routed directly over the burners, but may be routed to production or be produced to a storage tank system onboard for subsequent handling.

All discharges shall be recorded and reported via the Operator to the SFT according to mandatory provisions.

The need for documenting an environmental risk assessment is much dependent of the area/activity in question, and to what extent previous/existing environmental risk analyses can be used. SFT should be consulted early, if uncertainties exist.

6.7.4 Operations Control & Safety

6.7.4.1 Preventive Maintenance

Equipment and facilities shall be subject to systematic preventive maintenance. Experiences from operations/maintenance shall be recorded and treated systematically to obtain improvements in reliability, safety and operations efficiency.

6.7.4.2 Risk Assessment

The drilling and well operations should be subject to risk assessments according to the regulatory provisions. The process typically include a review of existing risk analysis for the facilities, followed by a HAZOP (HAZID/HAZAN) type analysis of the operations program.

The review of the analysis for the facilities is done to ensure the premises and risk acceptance criteria are consistent with those defined by the Operator for the activity, and to ensure that no outstanding action items represent unacceptable conditions for the campaign.

Premises from the analysis of facilities should be considered as basis for the operations specific assessment.

The operations specific risk assessment (HAZOP) is to identify operational safety concerns (“what can go wrong”) regarding people, rig and environment, and to decide on corrections to ensure an improved and acceptable safety level throughout the sequence of operations. These reviews also include evaluations of technical/operational quality of the equipment, program and measures for enhanced performance/effectiveness.
Results of the risk assessments and emergency preparedness assessments, must be properly communicated to personnel involved in offshore operations, and workforce involvement is assumed. The assessments and follow-up must be traceable.

6.7.4.3 Emergency Preparedness
Emergency preparedness measures for well control purposes shall be documented/implemented for the potential situations of hazards and accidents. Where an enhanced risk for H₂S can be foreseen, additional preparedness shall be introduced by information, special plans, equipment and training. Oil spill contingencies according to the NPD’s «Regulations for Emergency Preparedness» shall be checked, or validated if an Environmental Risk Analysis is performed. A coarse relief well contingency plan shall be developed according to the NPD’s «Regulations for Drilling and Well Activities and Geological Data Collection, etc.».

6.8 Application for Consents, Permits & Approvals
According to the «Regulations relating to safety, etc.», Consents from the NPD are required at certain milestones, prior to commencement of drilling and well operations. The Consents must be obtained by the Operator, they are activity specific, and are typically related to the use of a particular installation at a certain area over a defined period. The provisions for content and timing for the authorities’ handling of the Application for Consent are outlined in the NPD’s publication «The arrangement of regulatory supervision relating to safety and working environment, etc.». The assessments required to support and document the application for Consent need to be a well organized approach, with multi-discipline involvement from the Operator and Contractors.

The Operator is accountable towards the authorities, but the process assumes commitments from all parties involved. The regulatory exemptions, for which the authorities concurrence is requested, are typically detailed in the Application for Consent.

Details regarding the subsequent Permits, Approvals and submittal of programs for specific drilling and well operations are outlined in the NPD’s «Regulations for Drilling and Well Activities and Geological Data Collection, etc.». Activity plans, possible regulatory discrepancies and extraordinary HSE aspects should be highlighted by submission of these documents.

A Discharge Permit must also be obtained from the SFT for field development operations.

In the case of regulatory uncertainties, requests for clarifications shall be directed to the Operator for possible consultations with the Authorities in questions.

6.9 Back-up Equipment
Critical spare parts or back-up equipment with long lead-time should be identified and possibly planned to be located offshore or at the shore base.

7 MOBILIZATION
7.1 Team mobilisation
The mobilization of operations team for start up of activities will depend on the size and complexity of the activity, from light intervention subsea, heavy intervention from a platform to
the more demanding drilling campaigns. Time needed for preparations onshore and offshore shall be considered.

7.2 General Preparations & Demand for Resources
Special arrangements for storage, transportation, and installation of equipment must be made. Possibilities to do preparations work during rig-move should be clarified. Provisions of personnel and services must be organised. Reporting demands must be clarified. Pre-job meetings must be accomplished. Back-up arrangements must be secured. Mandatory Consents, Permits and confirmation on well classification/identification must be obtained.

7.3 Equipment Rig-up & Testing
It is important that required documentation and certification of new/temporary equipment have been achieved prior to shipment, in order to demonstrate suitability, regulatory compliance and compatibility with existing facilities. Modifications and installation of new/temporary equipment will assume prior consultation and concurrence by the operator/owner of the existing facilities.

Specifications for acceptance testing and integrity testing shall have been subject to inter-discipline check and concurrence by responsible parties by commencement of such testing. Considerations for simultaneous activities shall have been made.

Rigging up equipment and testing which are not considered as ordinary operations, shall be subject to a formal Pre-job Meeting or a Safe Job Analysis (SJA) with involved personnel by commencement of these jobs. (Annex A, contains more information on how SJA can be done). Further, the existing safety requirements onboard must be observed and followed, including any directions given by the offshore installation management.

Proper, formal interface with the maintenance system for the offshore facilities must be established.

OLF’s "Guidelines for Safety Requirements to Temporary Equipment" is considered as recognised standard in this context.

Requirements to drill string and BHA inspection should be determined. Make up of non-standard connections should be considered done prior to shipment to the rig to limit the use of rig tongs offshore and to save rig time.

8 OPERATIONS EXECUTION

8.1 Organising the Work on Site

8.1.1 General Requirements
A pre-operation meeting shall be conducted at a convenient time prior to commencing a new well work-program in order to familiarise key staff and suppliers in the operation of the planned
Similar meeting shall take place offshore the necessary number of times to ensure that all relevant staff and individuals have attended.

Before positioning the drilling vessel on location, verify that consent to the location has been granted by the NPD. The drilling contractor must also have NMD approval for the anchor model and respective calculations.

On location, Operator shall be represented with the right number of qualified personnel in charge for 24 hours coverage. Drilling operations call for close co-operation between the Operator and the Contractor staff, to ensure that operations are performed in a safe and efficient manner. Roles and responsibilities shall be clearly defined. A communication system shall be maintained between personnel in charge of operation and installation.

There shall be a system for communication/dialogue with service contractors representatives offshore and onshore for ensuring that scope of work of planned operations and progress are well understood and that timing for relevant actions are prepared for.

During programmed well construction and drilling operations, the offshore operations shall be supported by a base office organisation. An “on duty” system and clear reporting lines shall be defined for ensuring continuous operations without interruptions caused by insufficient technical and/or logistical assistance.

The activities for the next 24 hours shall be identified and included in daily plans. A time plan (e.g. 7 days plan) shall be implemented ensuring overview of personnel, equipment and material required for the upcoming work and that callouts can be made in due time.

The Drilling/Well Operations Programme shall be supported by operations manuals issued by the Operator/Contractor/Manufacturers. Alternatively, the IADC Drilling Manual can be used as support document where applicable.

Operation manuals shall be available covering all aspects of significance to safety, including procedures, organisational matters, areas of responsibility etc. The performance of the tasks is typically governed by:

- Project execution plan and/or project handbook
- Drilling and well operations manual
- Installation-specific administrative, contingency and operating procedures
- Statutory Authorities requirements
- General Operator and Contractors procedures
- Discharge permits
- Inventory and progress reports
- Experience data
- Specific procedures and criteria relating to equipment and operations in significance to safety:
  - Risk analysis
  - Emergency preparedness analysis
  - Blow-out contingency plans

8.1.2 HSE Requirements

It should be an overall HSE objective that no single failure shall entail life threatening situations for involved personnel, or significant damage to material and the environment. The Operator shall
ensure that Contractors are made familiar with the HSE goals, objectives and requirements for drilling and well activities.

The Operator shall draw up risk acceptance for the activities in question, with reference to the regulatory requirements and regulations, the operator’s safety objectives, and perform risk assessments as indicated in chapter 6.7.4.

8.1.2.1 HSE Meetings
Monthly HSE Review Meetings should take place (onshore) between the Operator and the Drilling Contractor reviewing any operational safety incidents and accidents, HSE statistics, health and working environment, emergency preparedness, action plans etc. Other active Service Companies may be represented in such meetings.

Weekly Safety Meetings offshore, as governed by regulatory requirements to be held offshore by Contractor or Principal Enterprise. Contractors are responsible for ensuring that all their offshore personnel involved in the operations also attend these meetings.

A safety meeting should be held to ensure all personnel are aware of the operational limitations applicable in connection with the operation in question. Further requirements to barriers, pollution control, precautions to be taken against fire, explosion and exposure of people and the environment to toxic and other noxious substances.

Specific meetings to be held as often as required for reviewing risk in the activities (safe job analysis).

8.1.2.2 Task Analysis/Inspections
Regular task analysis (SJA) shall be carried out to review hazards and consequences of operations and failures that may occur so that risk reducing measures may be taken. Prior to every operation, introduction of new equipment and when evaluating change in premises, a separate analysis should be considered carried out. HSE inspections shall take place on a regular basis verifying that HSE requirements are implemented. (Annex A, contains more information on how SJA can be done).

8.2 Reporting during Operations

8.2.1 Reporting to NPD
The Operator shall inform the NPD when the activities are based on other solutions than those indicated in the regulations with supplementary guidelines. In the event of significant alterations of the activity program, operational interruptions, dangerous incidents and accidents, the operator shall immediately notify the NPD. The Operator shall outline and communicate criteria for such reporting to personnel with dedicated responsibilities for such operation.

During the time that drilling and well activities are in progress, the operator shall on a daily basis keep the NPD informed with regard to the progress of the operations. The extent of the reporting and reporting routines is defined by the NPD.

8.2.2 Contractors Communication/Documentation
In order to ensure proper communication and documentation of planned work performed/to be performed, a structured system for ensuring continuity shall be in place. The system shall include:
• Hand-over reports/meetings at all work levels at crew change and between shifts
• Daily (morning) meetings with offshore and base onshore organisation covering the last 24 hours of operation, accidents/incidents, progress, material requirements and the next actions both at the office and the well site.
• Filing system established onshore and offshore comprising records of:
  * Information on how the operation was carried out, drilling reports, mud reports etc.
  * Documentation of the actual condition of the operation
  * HSE and cost, time, resources, accident/incident reports
  * Non-Conformance Reports/Overview

### 8.2.3 Reporting

A reporting system covering how and what events and plans of the execution, shall be established. The reporting system should typically include when applicable:

- **Company reports:**
  * Daily/weekly (progress) reports
  * Wellhead reports
  * Inventory reports
  * Shipping manifests

- **Contractors or Company reports:**
  * IADC, or other format as agreed
  * Daily Geological Reports
  * Environmental reports (balance)
  * Manifests
  * Maintenance reports
  * Mud/shaker room reports
  * Bit reports/records
  * Anchor patterns
  * Daily mud reports incl. volumes in well and pits
  * Daily mud logging reports
  * Logging reports
  * Coiled tubing reports
  * Snubbing reports
  * Wireline operations reports
  * Well Position and Survey Reports
  * Directional Survey Data Reports

- **Deviation reports**
  * Accident reports
  * Incident reports
  * Non-conformance reports
  * Acute pollution
  * Material damage
  * Lost Time

- **Other reports or records:**
  * Kick sheet for BOP (subsea or surface)
8.3 Operational Aspects

Drilling and well operations shall at all times be carried out in a safe and prudent manner in accordance with formal plans and requirements. Relevant equipment specifications for operation and maintenance with associated limitations shall to the extent necessary be reflected in applicable operations and maintenance procedures. Measures shall be taken to ensure high regularity throughout operations.

Exact position of the well and the distance to other wells in the vicinity shall be known at all times.

Drilling and Well operation shall be performed with the barriers in place according to the Drilling/Well Operations Program. Operational measures shall be taken to prevent blow-out, fire, explosion, pollution or other damage. Well Control Procedures shall have been defined and agreed to in advance, and followed accordingly. All drills carried out shall be documented.

This applies for:
• Drilling
  • Directional Drilling
  • Casing Running
  • Drilling Fluid handling
  • Cementing
  • Logging
• Well Evaluation & Testing
• Completion
• Start-up & Production
  • Preparations prior to Perforation and Production
  • Perforation and Production
• Well Intervention
  • Testing and Maintenance
  • Wireline, Coiled Tubing, Snubbing Operations Through Tubing
  • Fluid Operations
• Plugging/Abandonment
9 DEMOBILIZATION

9.1 Removal of Equipment/Facilities
Similarly as for the mobilisation, it is important that required documentation and certification of the facilities remain valid when demobilisation commences, in order to demonstrate suitability, regulatory compliance and compatibility with committed standards. Plans for demobilisation will assume prior consultation and concurrence by the operator/owner of the equipment and existing facilities. Any impact for safety & emergency systems must be addressed.

Specifications for removal and shipment shall have been subject to concurrence by responsible parties by commencement demobilisation. Considerations for simultaneous activities shall have been made.

Rigging down equipment and handling for shipment to shore which are not considered as ordinary operations, shall be subject to a formal pre-job meeting or a Safe Job Analysis (SJA) with involved personnel by commencement of these jobs (ref. Annex A). Further, the existing safety requirements onboard must be observed and followed, including any directions given by the offshore installation management.

10 DOCUMENTATION AND EXPERIENCE TRANSFER

10.1 Post Analyses
Post-activity analyses shall comprise economical, technical, safety and environmental related aspects.

10.2 Performance Review & Experience Transfer
Performance shall be evaluated against the goals set up in-front the operations.

Besides the Operators own assessment of performance, and for the purpose of the continuous improvement and transfer of experience, the Contractor is encouraged to advise the Operator of such matters as:

a) Challenges in performance versus set goals for the activity.
b) Contractor's suggestions for improvements/simplifications in work processes and methods that might contribute to more efficient/cost effective performance by the Operator and his other contractors for future work.
c) Information and feedback from incidents, events, conditions and other matters arising during operations or affecting performance of the services and which have reinforced or changed Contractor's knowledge of or attitude towards specific subjects; or which have resulted in or might lead to changes in Contractor's relevant documentation, methods or work processes.
d) Contractor's assessment of deviations from this standard and mandatory requirements, including recommendations for the future.

10.3 Operational Reports
Regular operations reports shall be obtained in IADC format, or as agreed with the Operator. Special reports from services executed must be compiled for individual services involved (E.g.: Directional, logs, cementing, drilling fluids)
A Final Well Report shall be produced after each well in accordance with the provisions outlined in the NPD’s «Regulations for Drilling and Well Activities and Geological Data Collection, etc.».
ANNEX A   SAFE JOB ANALYSIS (SJA)

**Objective:** Systematic approach to identify and assess hazards associated with a specific job, for the purpose of deciding on precautional measures to be used to eliminate or control risk to people, the environment and the integrity of the facilities.

**Scope:** To be performed for jobs where enhanced risk can be assumed, the employees’ experiences are limited, procedures are incomplete, work permit system or other instructions demand so.

**Responsibilities & Participants:** Participating in a SJA should normally be those who are responsible for:
- job performance (Foreman and personnel who perform the job)
- the area where work is to take place (Area Supervisor)
- the system (System Supervisor), if work is performed on a system where the system responsibility is not the same as the area responsibility.

**Records:** The SJA should be documented by:
- a brief description of the planned work, with reference to work orders and other relevant documentation
- listing of sub-activities in the correct sequence
- identification of potential hazards, including possible effect on or from other simultaneous activity
- description of measures to reduce the probability and the consequences of an incident. This includes a description of personal protective equipment which must be used during the job, including type and designations safety equipment.

**Guide-words:** A guide-word technique may be used to initiate discussions for the identification of hazards and associated precautions.

**Risk Rating:** Option, only. Could be defined (from a matrix) when hazards are being assessed, but may not be overly focused/emphasised.

### SJA-form, Part I - Premises & Background Information:

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<tr>
<th>Job to be assessed:</th>
<th>Reference document:</th>
<th>Reason for SJA (tick off category):</th>
<th>Date, performed:</th>
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<td>◊ New operation / Enhanced risk</td>
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<td>◊ Simultaneous Operations</td>
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<th>System Responsible:</th>
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<thead>
<tr>
<th>Experience data:</th>
<th>Attachment(s):</th>
<th>Participants in SJA:</th>
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### SJA-form, Part II - Job Sequence & Assessment:

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### SJA-form, Part III - Guide-words (examples):

**Hazards:**
- Incidents - similar jobs
- Tool failure/suitability
- Insufficient instructions
- Insufficient communication
- Lack of light / ventilation
- Loss of barrier(s)
- Interruption of job
- Timing / Phasing problems
- External influence (weather)
- Work over sea
- Work at height / elevations
- Movement, dynamic energy
- Pressure / Loads / Radiation
- Position of people
- Hot work / Ignition sources
- Access / Clearances
- Falls, slips & trips
- Combustible / Toxic substances
- Simultaneous / Parallel Ops.
- Testing

**Precautions / Risk reducing measures:**
- Probability reducing measures
- Consequence reducing measures
- Training / Drills / Supervision / Co-ordination
- Announcement / Information
- Safety Guards / Entry restriction
- Isolation / barriers
- «Permit to Work» system
- Personnel Protective Equipment
- Fire protection
- Materials Safety Data Sheet
- Monitoring / Gas measurements
- Tie-down / Equipment support
- Escape - Evacuation - Rescue
- Spill containment
- Back-up equipment / tools