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		CRIOP[®]: A scenario method for Crisis Intervention and Operability analysis.	
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ABSTRACT <p>CRIOP[®] is a methodology used to verify and validate the ability of a control centre to safely and efficiently handle all modes of operations including start up, normal operations, maintenance and revision maintenance, process disturbances, safety critical situations and shut down.</p> <p>The methodology can be applied to central control rooms, emergency control-rooms, drillers' cabins, cranes and other types of cabins, both onshore and offshore.</p> <p>The key elements of CRIOP[®] are checklists covering relevant areas in design of a Control Centre (CC), Scenario Analysis of key scenarios and a learning arena where the workforce with operating experience, designers and management can meet and evaluate the optimal CC.</p> <p>A CRIOP[®] analysis is initiated by a preparation and organisation phase, to identify stakeholders, gather necessary documentation, establish analysis group and decide when the CRIOP[®] analysis should be performed.</p> <p>This version of CRIOP[®] was developed in 2003 and 2004, with minor adjustment done in 2008.</p>			
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Preface

The aim of this section is to give a short background of the CRIOP methodology and describe how the new version has been developed. The first version of CRIOP (Crisis Intervention in Offshore Production) was published in 1990. The scope was a scenario and general checklist - method for Evaluation of the Offshore Control Centre. The focus of the methodology was on the human aspects in terms of conditions for successful crisis handling.

The initial methodology was a result of the CRIOP project, “Crisis Intervention in Offshore Production”, taking place in the period 1985-90, with support from Norsk Hydro, Saga and Elf. Some of the key events since the development of CRIOP in the 1990’s have been:

- 1990 and onward: CRIOP used as preferred methodology at Norsk Hydro (On Oseberg C, Troll B, Njord, Visund, Troll C, Oseberg Sør, Oseberg D, Grane).
- 1990: New regulation of Norwegian offshore industry, new standards such as NORSOK.
- 1997: CRIOP is recommended as a preferred methodology in NORSOK S002, Rev 3.
- 2000: NPD (Norwegian Petroleum Directorate) is increasing focus on Man Machine interfaces and Human Factors (HF), ISO 11064 (Ergonomic design of control centres).
- 2001: New NORSOK standard I-002 on SAS systems.
- 2002: NPD published new HSE rules and regulations. These include requirements for analysis, systematic end user involvement, alarm handling, validation and verification, competence, reduction of human errors and Man Machine Interface in Control Rooms.
- 2003: NPD published guidelines for validating and verifying HF in Control Rooms.
- 2004: New version of NORSOK S-002, Revision 4.

Based on the use of the CRIOP methodology in the petroleum industry, Norsk Hydro decided to initiate a revision of the methodology in 2003. A project initiation meeting was arranged at 9/12-2002. This group, with some included members, has been used as a Steering Committee (SC) for the project to update CRIOP, chaired by Norsk Hydro/J. Monsen.

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The Research Council of Norway has financed a part of the CRIOP revision project.

The project team working with the revised method has consisted of Scandpower, SINTEF, Statoil and NTNU. Quality Assurance has been performed by Human Factors Solutions, IFE, NTNU and SINTEF. In addition to the Working Group and Steering Committee members, the project team has received valuable comments and assistance from:

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We gratefully acknowledge the contributions from the steering committee members and others participating in the work.

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Change history of CRIOP

Version	Major changes in relation to initial version published in 1990
CRIOP (version 2003)	Checklists updated in relation to changes in NPD regulations, NPD Guidelines such as YA-711 (Principles for alarm system design) and Human Factors in Control Rooms, ISO-11064 (Ergonomic design of control centres) and NORSOK. The scenario methodology has been substantially revised. Revision and updating of content of methodology has been based on interviews, user discussions, contributions from experts and workshops.
CRIOP (version 2004)	Questions related to Drillers Cabin have been incorporated. The e-Operations checklist has been developed and tested together with the industry. The CRIOP checklists have been simplified and structured. The language has been simplified. Experience from several CRIOP analyses has been incorporated.
CRIOP (version 2008)	A scenario related to SAS/SIS breakdown in combination with communication breakdown has been added. The e-Operations checklist has been integrated in section 4 and relevant references have been added. The language has been simplified.

The new CRIOP methodology has been improved through experience from several CRIOP analyses in 2004, among others at Snøhvit /Statoil, Visund/Statoil /Norsk Hydro and Oseberg Feltcenter /Norsk Hydro. The user experience has been discussed with an expert team. The experience from the pilots has been included in the revised version of CRIOP.

Further revisions are planned to be carried out iteratively, by revising and updating the electronic version that is available on the web at <http://www.criop.sintef.no>.

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1. Introduction – what is CRIOP?

1 Introduction – what is CRIOP?

The aim of this section is to describe the goal and scope of CRIOP, the background for CRIOP and provide description of CRIOP and its context of use.

1.1 Goal and scope

Goal: CRIOP is a methodology that contributes to verification and validation of the ability of a control centre to safely and efficiently handle all modes of operations including start up, normal operations, maintenance and revision maintenance, process disturbances, safety critical situations and shut down.

The methodology can be applied to central control rooms, driller's cabins, crane and other types of cabins, onshore, offshore, emergency control-rooms. It is important to evaluate the interaction between cabins, control-rooms and control panels e.g. on drill floor as illustrated below and between control rooms (e.g. emergency and central control room). The CRIOP methodology can also be used for control centres / cabins such as the driving cabin of a train or the bridge of a boat. The present CRIOP methodology is customised for offshore control centres.

The CRIOP method focuses on the interaction between people, technology and organisations. The CRIOP method consists of three parts:

- Introduction and context of use
- General Analysis checklists
- Scenario Analysis



Figure 1.1: The control centre and its relationship with other cabins or panels.

The “control room” can be a centralised room, or a number of interconnected panels and cabins as illustrated above.

1.2 The CRIOP Method: Key principles and its relation to the design process

One of the most important principles of the CRIOP method is to verify that a focus is kept on important human factors, in relation to operation and handling of abnormal situations in offshore control centres, and to validate solutions and results. Key principles in human factors design are:

- Improve design through iteration (see Fig. 1.2, adapted from ISO 11064)
- Conduct human factors analyses such as function and task analysis
- Ensure systematic end user participation
- Form an interdisciplinary team
- Document the process

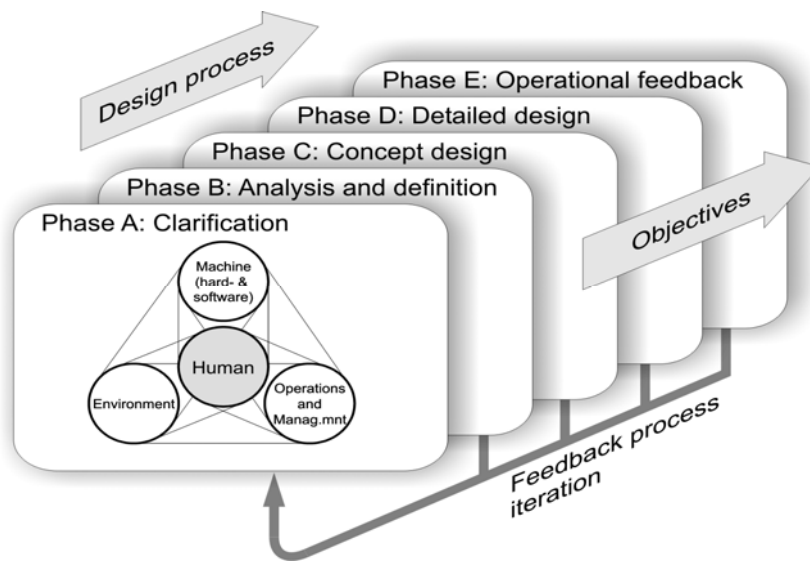


Figure 1.2: Improve design through iteration (adapted from ISO 11064)

Given that the design process is iterative, the CRIOP method should be applied several times during the design process, as indicated by the grey arrows in Figure 1.3. This includes during operation as well as the different design phases of a control room. Note the potential for improvements naturally is largest during the early phases of the design process. The Build phase is not illustrated, but takes place between D) Detailed design and E) Operation.

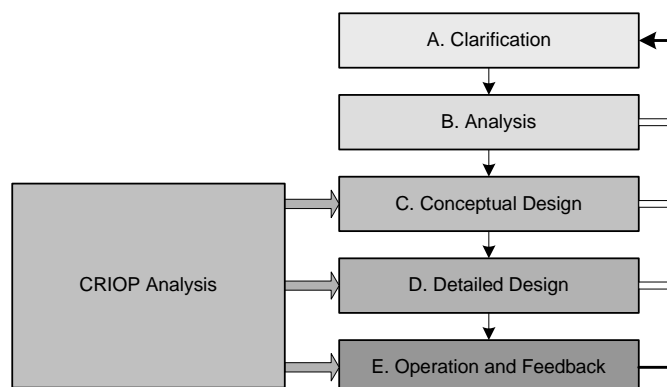


Figure 1.3: Integration of CRIOP in design process

The scope of a CRIOP analysis is between 2 to 5 days of effort.

1.3 Reducing costs with CRIOP

The cost of changes increases significantly between each phase in the design process. Experience shows that the cost of a change increases significantly (exponentially) between each phase. See K. Samset (2001) and B. Boehm (1974).

The cost of the same change could be:

- 1-10 NOK in the analysis phase
- 10-100 NOK in the design phase
- 100-1,000 NOK in the build phase and
- 1,000-10,000 NOK in the operations phase

Increased change costs are illustrated in the attached Figure 1.4.

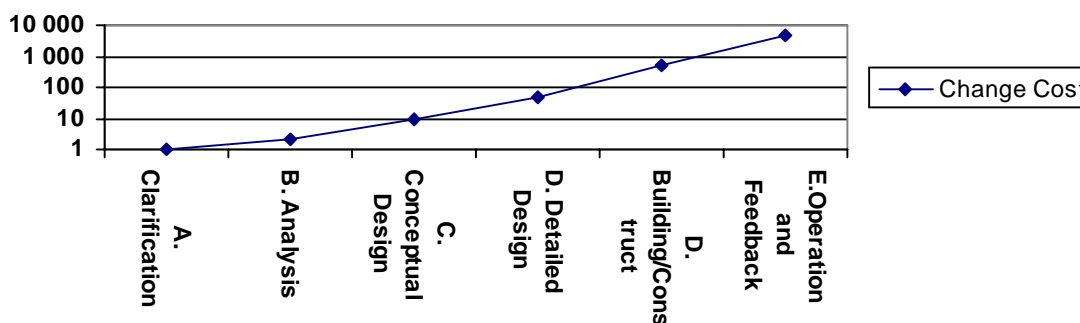


Figure 1.4: The cost of change dependent on phase (clarification through operation)

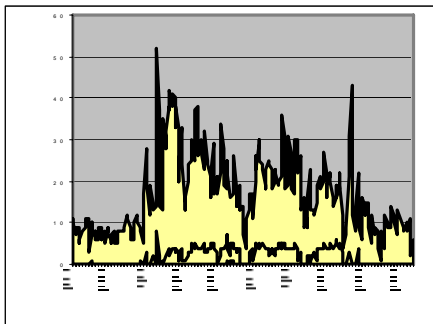
1.4 Background

One of the key functions with control rooms, cabins and panels is to provide safety critical barriers against major hazards. Despite this, and the emphasis placed on safety and the environment by the petroleum industry, a number of problems exist that both individually and collectively reduce the efficiency of these safety barriers. As noted by the NPD (2003), examples include:

“The control room operator having to deal with too many alarms simultaneously, several safety critical tasks that have to be performed simultaneously, operating stations as well as communications and display equipment that should be used simultaneously is located distant to each other, operators work load is uneven and at times relatively high, there is a lack of a total overview of events/incidents. “ (NPD 2003, Human Factors Assessment Method)

These problems are closely interrelated. For example, with regard to alarm systems, the work by Surry (1974) and Rosness (2001) indicates that too many alarms in a critical situation could also add to the overload of the operators and also increase the probability of errors. NPD (2002f) has illustrated the effects of alarm reduction as described in YA-711, “Principles for design of alarm systems”. This example is illustrated in Figure 1.5.

Before: Original alarm rate



After: Nuisance alarms removed

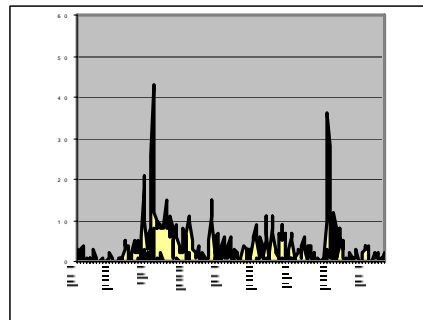


Figure 1.5: Original alarm rate versus alarm rate after removal of nuisance alarms (from NPD, 2002f).

Despite the considerable focus on HSE, and the “safety barrier” philosophy that permeates the petroleum industry, incidents still occur. Experience shows that incidents occur when two or more safety barriers have been broken, as illustrated in Figure 1.6.

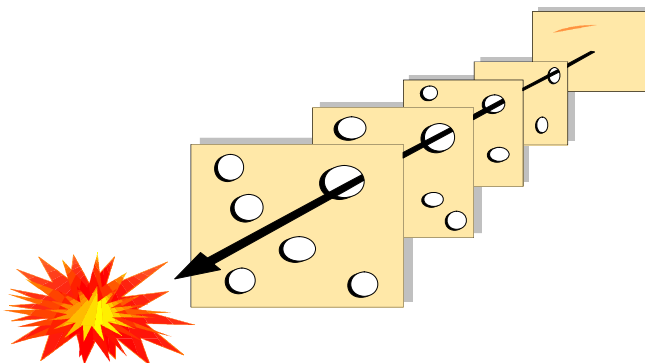


Figure 1.6: Incidents occur as a result of several safety barriers being broken (Adapted from Reason, 1990).

In addition to the typical problems to be found in a control room, and the interrelationships between these problems, there are a number of trends in the petroleum industry that will also impact the safe and efficient operation of the control centre. As noted by the NPD (2003) these include:

- “Increasing technological complexity in control rooms (integration of traditionally separated interfaces – process/safety),
- new functions and tasks allocated to the control room (e.g. helicopter transit, environmental monitoring, telephone exchange) without a corresponding increase in manning,
- process output is being pushed above design limits over long periods of time. “

A systematic method is therefore needed to identify the typical problems that exist in control rooms today, test how multiple safety barriers function, and take account of trends in the petroleum industry.

The CRIOP method attempts to address this need.

1.5 Definitions and abbreviations

The following definitions apply to this document:

- Alarm:** An alarm is a visual and/or audible indication of an abnormal condition which requires attention and/or corrective action. An alarm shall not be used to indicate status information only.
- Best practice:** The processes, practices, or systems identified in public and private organizations that performed exceptionally well and are widely recognized as improving an organization's performance, such as effectiveness, efficiency, safety, ecology, and/or innovativeness. The processes, practices, or systems are usually recognized as "best" by the other peer organizations and could be adapted to improve performance in another situation and/or in other organisations. (The scope of "best practice" that is possible to adapt to other organisations must be assessed. The adaptation of "best practice" to others could be a challenge since organisations have different culture, values and structure. The implementation process and evaluation of "best practice" must take these differences into account.)
- Control centre (CC):** Is a combination of control rooms, control suites and local control stations which are functionally related and all on the same site.
- Control room (CCR):** Is a core functional entity, and its associated physical structure, where operators (CROs – Control Room Operators) are stationed to carry out centralised control, monitoring and administrative responsibilities. The term "control room" in this document includes all types of control rooms, such as central control rooms, emergency control rooms, drillers' cabins, off loaders cabins and crane cabins. Control rooms can be either onshore or offshore.
- Control suite:** A group of functionally related rooms co-located with the control room and including it, which houses the supporting functions to the control room, such as related offices, equipment, rooms, rest-areas, training rooms (ISO 11064-1).
- Emergency control room:** A control room provided to relieve the CC and its staff from personnel traffic in a distress situation, usually located close to the CC.
- Emergency preparedness:** All technical, operational and organisational measures that prevent a dangerous situation that has occurred from developing into an accidental event or that prevent or reduce the harmful effects of accidental events that have occurred.
- Ergonomics:** Ergonomics is a scientific discipline that applies systematic methods and knowledge about people to evaluate and approve the interaction between individuals, technology and organisation. The aim is to create a working environment and the tools in them for maximum work efficiency and maximum worker health and safety. (An ergonomically designed workplace has proper light to reduce eyestrain, chairs that support good posture, lowest possible exposure of workers to undesirable workloads, radiations, etc.) Ergonomics is from Greek "ergon" work and "nomoi" natural laws.
- Human factors:** Human factors is a scientific discipline that applies systematic methods and knowledge about people to evaluate and improve the interaction between individuals, technology and organisations. The aim is to create a

working environment (that to the largest extent possible) contributes to achieving healthy, effective and safe operations.

Key alarms	<i>Key alarms</i> are a selection of high priority alarms such as important safety-related and safety critical alarms. Examples are: Fire and Gas alarms, Emergency Power system status information and failure alarms, Fire Pumps failure alarms and status information, Fire Protection System status information and failure alarms and Flare & relief system. Key alarms should be defined. Key alarms should be presented in a way that makes them available and usable even during alarm overloads. (YA-711).
Verification:	To satisfy stated requirements. Confirmation by examination and provision of objective evidence, that the requirements have been fulfilled. (ISO 8402, IEC 61508). Requirements can be statutory, company defined, in relation to standards and/or contractual.
Validation:	To satisfy implied needs, i.e. that the control room is usable. Confirmation by examination and provision of objective evidence, that the particular requirements for a specific intended use are fulfilled. (ISO 8402, IEC 61508).
Working environment:	The totality of all physical, chemical, biological and psychological factors at work that may affect the employees' health and well being through acute trauma or lasting exposure. The influences from lasting exposure may be positive and negative (NORSOK S-002 rev 4).

The following abbreviations apply to this document:

AAD	Ministry of Labour and Government Administration <i>Norwegian abbreviation (No):</i> Arbeids- og Administrasjonsdepartementet
AR	Activity Regulations from PSA (<i>No:</i> Aktivitetsforskriften) 2002
CC	Control Centre
CCR	Central Control Room
CRIOP	CRisis Intervention and OPerability analysis (Prior: CRisis Intervention in Offshore Production)
CRM	Crew Resource Management
CR	Control Room
CRO	Control Room Operator
DC	Drillers Cabin
ESD	Emergency Shutdown (system)
FA	Facilities Regulation from PSA (<i>No:</i> Innretningsforskriften) 2002
FPSO	Floating Production Storage and Offloading
FR	Frame Regulations from PSA (<i>No:</i> Rammeforskriften) 2002
GA	General Analysis
HF	Human Factors
HFAM	Human Factors Assessment Method
HMI	Human Machine Interface
HRO	High Reliability Organisation
HSE	Health, Safety and Environment
HTA	Hierarchical Task Analysis

HVAC	Heating, Ventilating and Air-Conditioning
ICT	Information and Communication Technology
IEC	International Electro technical Committee standard
ISO	International Standards Organisation
IO	Integrated Operations
MR	Management Regulations from PSA (<i>No: Styringsforskriften</i>) 2002
MMI	Man Machine Interface
NLIA	Norwegian Labour Inspection Authority, (<i>No: Arbeidstilsynet</i>)
No	Norwegian name
NORSOK	<i>No: Norsk Sokkels Konkurransesepisjon</i>
NPD	Norwegian Petroleum Directorate (<i>No: Oljedirektoratet</i>)
NUREG	Document published by the staff of the Nuclear Regulatory Commission
P & IDs	Piping and Instrumentation Diagram
PSA	Petroleum Safety Authority Norway (<i>No: Petroleumstilsynet-Ptil</i>)
SAS	Safety and Automation System (See also SCADA)
SIS	Safety Instrumented Systems
SCADA	Supervisory Control and Data Systems (Often used to denote SAS)
SEPA	Safety and Emergency Preparedness Analysis
STEP	Sequentially Timed Events Plotting
VDU	Visual Display Unit

2. CRIOP in Short

2 CRIOP in short

The aim of this section is to give a short and illustrative description of the necessary steps in CRIOP. This section summarises the information found in Sections 3 through 5.

A CRIOP analysis is initiated by a preparation and organisation phase, in order to identify stakeholders, gather necessary documentation, establish analysis group, decide the scope and size of the analysis and decide when the CRIOP should be performed.

The two main phases in the CRIOP analysis are:

- I. **General Analysis (GA) with checklists** to verify that the control centre satisfies the stated requirements based on best industry practice. This is a standard design review of the CC.
- II. **Scenario Analysis** of key scenarios performed by an experienced team from to validate that the control centre satisfies the implied needs. Scenario analyses helps analyse new accidents that may happen in the future rather than at the summary level of the traditional technical risk analysis. The analyses help us to identify issues to be elaborated and solved later such as remedial actions that will stop a scenario from developing.

CRIOP specifies that workers, management and the design team should meet to discuss key scenarios and the checklists, in an environment supporting open and free exchange of experience. Experience from operations should be discussed with the design team and management. Issues found in co-operation should be resolved with management. The goal is to achieve double loop organisational learning as oppose to single loop organisational learning, by taking action to change the “governing variables” as CC design, procedures or work organisation, as suggested in Figure 2.1 (see Argyris 74). The group process should focus on a good co-opting process and a possibility to change these governing variables.

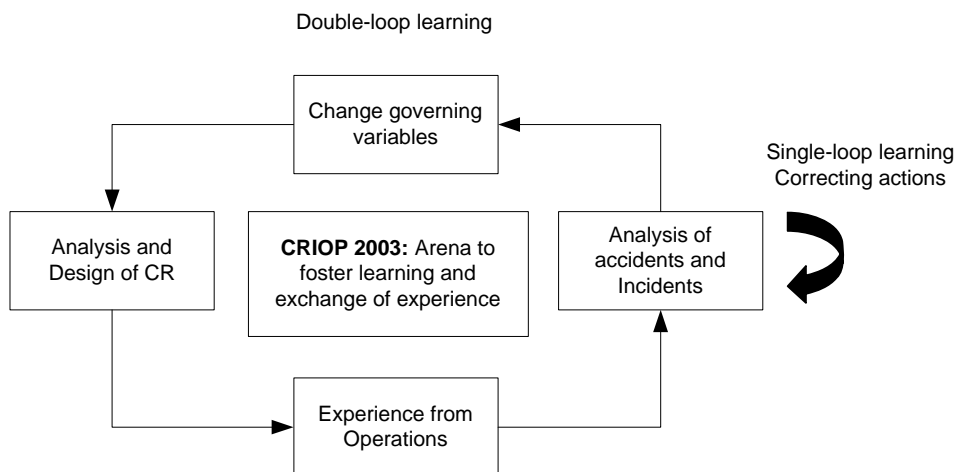


Figure 2.1: CRIOP as an arena for organisational learning

A web site has been established at <http://www.criop.sintef.no>. This web site contains the last version of CRIOP, a short PowerPoint presentation of the methodology and available Network in Industry related to CRIOP analysis. The web site contains references to key CRIOP projects and contact information to key personnel. It is possible to post comments on the CRIOP methodology by sending an e-mail to CRIOP@SINTEF.NO.

A flow-chart illustrating the relationship between the different phases in the CRIOP methodology is given in Figure 2.2.

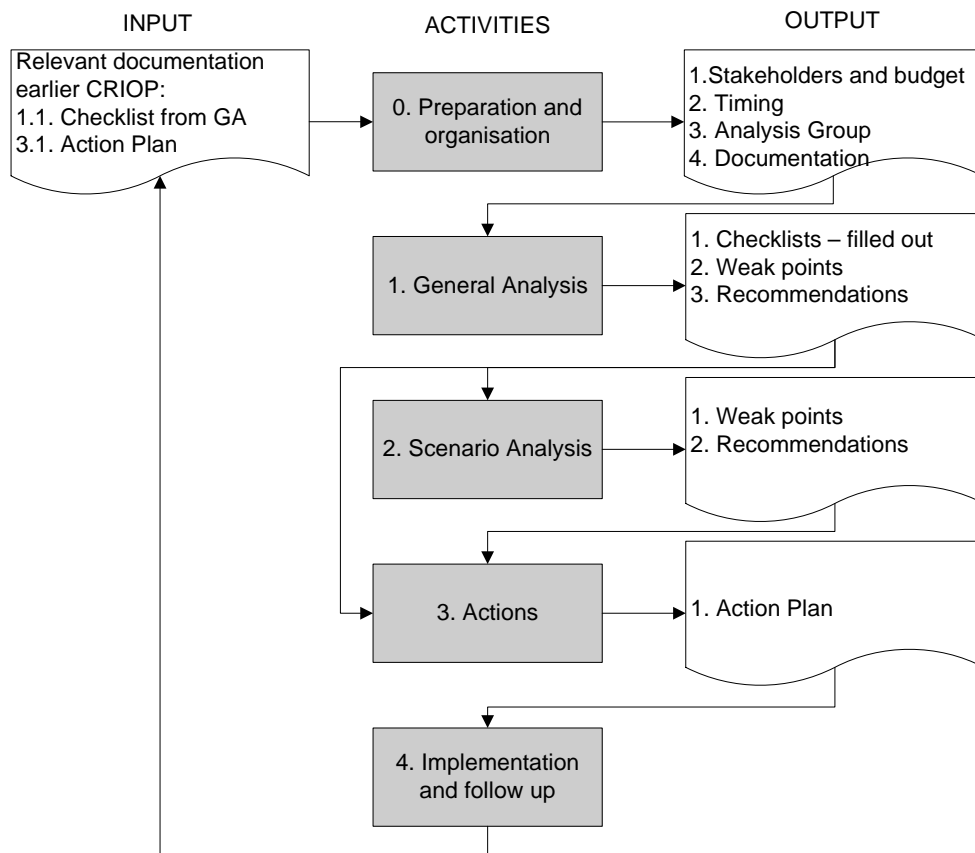


Figure 2.2: The main steps in the CRIOP methodology

2.1 General Analysis checklists

The *General Analysis (GA)* concerns factors affecting the working environment in a control centre and the ability to handle normal operation and abnormal situations that *do not need to be related to a specific sequence of events*.

The General Analysis contains a checklist requiring yes/no answers. The questions are not related to scenarios, and provide only a static assessment of the control centre.

The General Analysis has an important function in making the analyst familiar with the control centre concept in question, and should therefore be carried out prior to the more detailed Scenario Analysis.

The checklist in CRIOP has been structured to cover seven areas:

1. Layout (Abbreviated L)
2. Working environment (Abbreviated W)
3. Control and safety systems (Abbreviated C)
4. Job organisation (Abbreviated J)
5. Procedures and work descriptions (Abbreviated P)
6. Competence and training (Abbreviated T)
7. e-Operations or integrated operations (IO) (Abbreviated E)

An example of a question related to control and safety systems:

C 10.2 Can communication equipment be reached from the operator's workplace?

Control room operators should be able to communicate with other personnel while working at the VDUs. Check radio, VHF, telephones, public address system (PA), and intercom.

Each question must be addressed and comments and recommendations must be documented as suggested in the standard layout of the checklist, Table 2.1.

All questions applicable to Drillers Cabin (DC) are highlighted by “DC: Applicable to the DC” in the Comments column.

Table 2-1: CRIOP Checklists, example

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	N.A			
C 10.2	Can communication equipment be reached from the operator's workplace?					DC: Applicable to the DC	

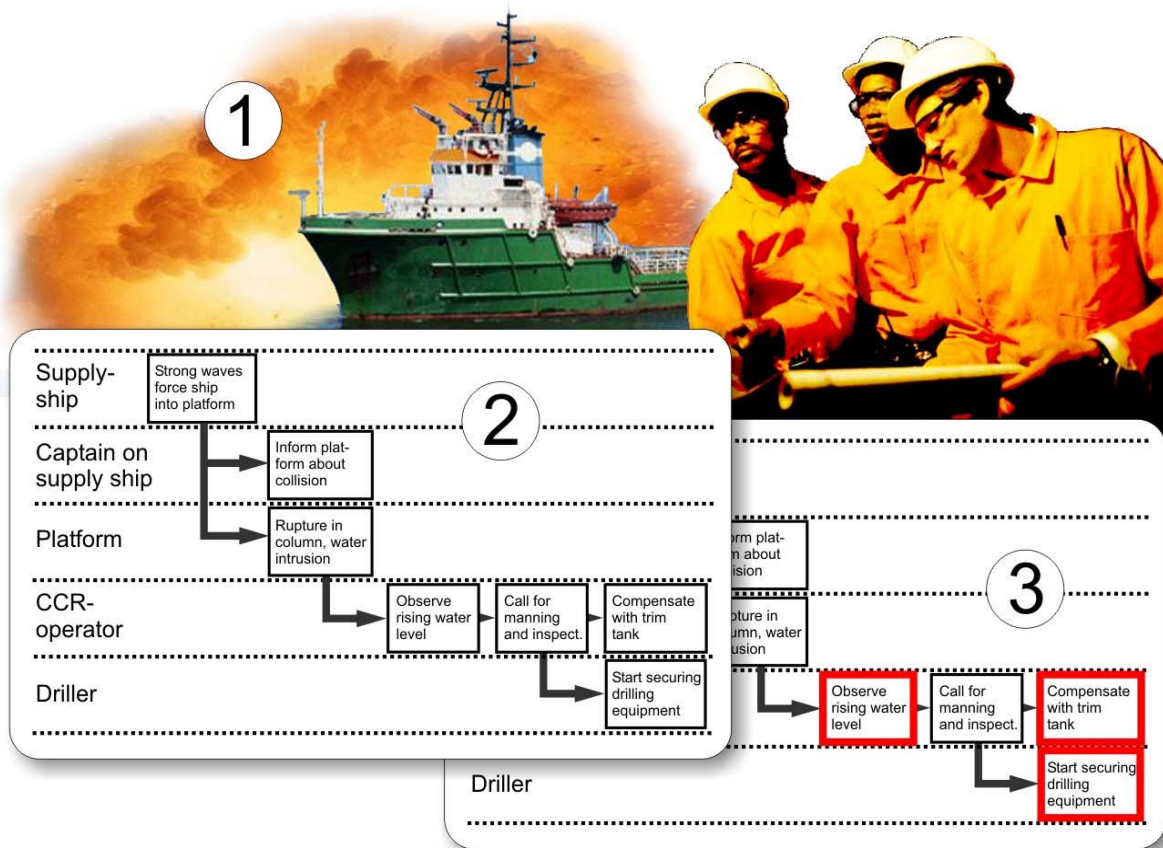
At the end of the General Analysis the findings, recommendations and Weak Points are documented and a responsible person is identified to carry out the actions.

2.2 Scenario Analysis

The Scenario Analysis, on the other hand, represents a different approach, and assesses control room actions in response to possible scenarios. Based on the scenarios, a ‘dynamic’ assessment is made of interaction between important factors in the control room, e.g. presentation of information and time available.

The Scenario Analysis is performed in a group with participants from CR and based on four main activities, see Figure 2.3:

1. Selection of a realistic scenario
2. Description of the scenario by means of a STEP diagram
3. Identification of critical decisions and
4. Analysis of the decisions and possible evaluation of barriers (see Figure 5.5).



1. Selection of a scenario
2. Description of the scenario
3. Identification of critical decisions
4. Analysis of decisions and barriers

Figure 2.3: The main steps in a Scenario Analysis

The scenarios are illustrated by a STEP-diagram; see Hendrick and Benner (1987).

In particular, the Scenario Analysis concerns factors affecting the control room operators' possibility to *observe/identify* deviations, *interpret* the situation, perform *planning/decision making* and *take action/execute* following a given abnormal situation in the process and subsequent sequences of events. Through systematic analysis of scenarios, the analyst identifies possible weak points in handling the situations, which are used as a basis for recommendations.

Even though the Scenario Analysis is based on a selected sequence of events, the method also addresses alternative sequences, i.e. “what could have happened if “. In this way, the analysis may cover a broader selection of events than the scenario indicates. The Scenario Analysis is detailed, and the corresponding findings are on a more detailed level than the General Analysis. The two parts of the analysis supplement each other.

2.3 Actions /implementation and follow up

At the end of the CRIOP analysis the findings, recommendations and weak points are documented in the General Analysis and the Scenario Analysis.

In agreement with the management an action plan is established with budgets, target dates and persons responsible to carry out the actions.

3. Preparations and organisation

3 Preparations and organisation

The aim of this section is to describe how to prepare and organise the CRIOP analysis and to describe when CRIOP should be used related to the design and operation of the control centre (CC). The first activities in the CRIOP analysis are to:

- State preconditions for study
- Plan and decide on the “timing” of the CRIOP analysis
- Establish the analysis group
- Collect relevant documentation
- Work load assessment
- Practical considerations (facilitate the group process.)

In the accompanying table 3-1 we have described the result of these activities.

Table 3-1: Results from preparation activity

Activities	Results/milestones
3.1 State precondition for study.	<ul style="list-style-type: none"> • Document key stakeholders • Identify context, such as appropriate standard (ISO-11064) and method (CRIOP). • Identify elements to be used from CRIOP. • Document scope of work and budget • Establish guidelines for conflict resolution
3.2 Plan and decide on the “timing” of the CRIOP analysis	<ul style="list-style-type: none"> • Document when the CRIOP analysis should be performed related to the design and operation of a control centre. • Allocate and document necessary resources.
3.3 Establish the analysis group	<ul style="list-style-type: none"> • Establish and document participants in the analysis group
3.4 Collect relevant documentation	<p>Document present status (see Table 3-2), as:</p> <ul style="list-style-type: none"> • Control room layout, alarm strategy, screen dump (Prints of screen layout), process characteristics and installation layout. <p>Document possible changes and development plans, as :</p> <ul style="list-style-type: none"> • Document strategies and all major changes that can influence the CC with analysis of consequences.
3.5 Work load assessment	<ul style="list-style-type: none"> • Perform and document workload assessment (should be performed before CRIOP).
3.6 Practical Considerations	<ul style="list-style-type: none"> • Collate and distribute introductory information and the relevant documentation to the attendees before attending the analysis • Arrange satisfactory physical conditions of the meeting room (enough size, useful equipment for graphical presentations, enough workplace for each attendee, good room climate) • Perform briefing and debriefing

3.1 State preconditions for study

Key points to be performed are:

- Identify the important stakeholders, key stakeholders, in the project and document this via an organisational chart of the analysis with the stakeholders and the responsible parties.
- Is an appropriate design methodology being used as ISO-11064? CRIOP is a method for reviewing the design of a control centre as it progresses through the development and operation phase. Use of CRIOP presupposes that there has been or will be used a structured design process as ISO-11064.
- What is the user Need and key requirements? Is CRIOP the appropriate solution? There are several other tools that can be used.
- What should be used from the CRIOP methodology based on the key user requirements? What have been done earlier, what are the relevant checklists and relevant scenarios? Estimate the scope of the analysis and confirm the “budget” of the project describing the necessary effort in man days and resources to perform the analysis. The scope of a CRIOP analysis is usually between two to five days.
 - **In the projected “scope of work”, the relevant parts of CRIOP should be selected before the actual work is started.** This should be done together with personnel having CRIOP experience. It is important to select the relevant parts of CRIOP to be used. This is dependent both on the timing of the CRIOP, and the complexity and size of the equipment being analysed.
 - If possible it should be planned to fill out some of the checklists in advance
 - A minor modification must be planned quite different than the analysis of a large new control centre. (See chapter 3.2).
- Guidelines for conflict resolution should be established. There could be conflicting interests in a CRIOP analysis. One issue is to document how open points are handled and how disagreements are handled between the different stakeholders. There could be some conflict of interest if a CRIOP analysis is performed within a project with fixed budget and strict time frames. Suggestions from the CRIOP analysis could influence the overall budget and time frame. The responsibilities for the CRIOP analysis must be clearly stated. The procedures for change orders influencing the budget and time frames must be clearly defined.

In relation to the organisation of the CRIOP, it is important to establish clear responsibility between the different stakeholders. In general, the key stakeholders are as documented in Figure 3.1.

It is important to select the relevant parts of CRIOP to be used, and focus the analysis on key issues. This is dependent both on the timing of the CRIOP, and the complexity and size of the equipment being analysed.

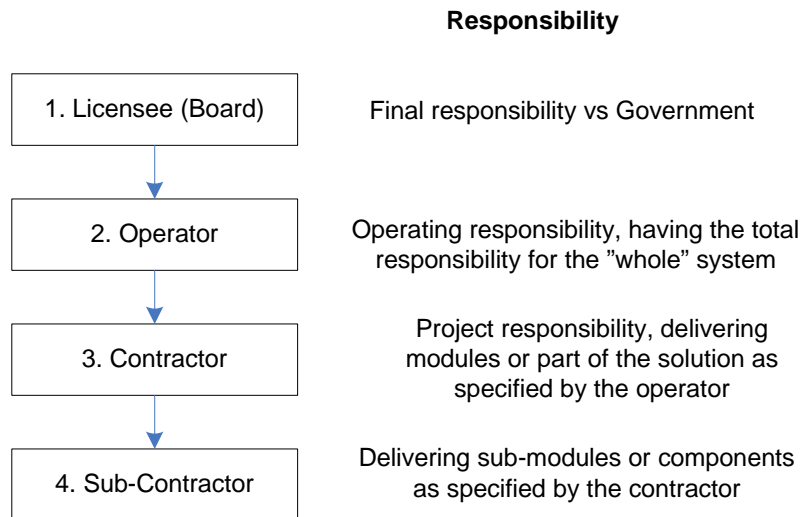


Figure 3.1: The key stakeholders in establishing a new CC or modifying a CC

During a CRIOP it is important to decide who is responsible for the CRIOP analysis.

There are usually two alternatives:

- The operator, having the necessary operating staff as control room operators
- The contractor, who is designing and building the CC based on specifications from the operator within specified time and budget

The participation from experienced control room operators and the CRIOP analysis in itself could influence the design, and budget, of the CC. A CRIOP analysis could be organised as a project, reporting to the steering committee of the project. In the steering committee both the operator and the contractor should be represented – making it possible to adjust the solution within the scope (time and budget) of the project.

In general a project is organised as described in Figure 3.2.

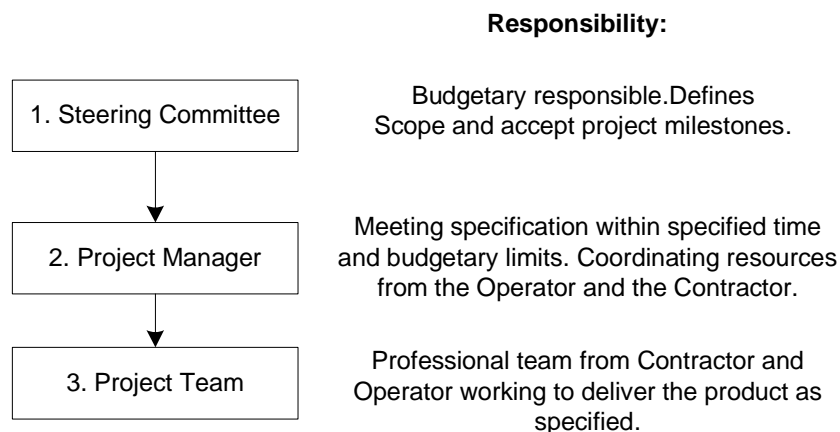


Figure 3.2: The key stakeholders in establishing a new CC or modifying a CC

3.2 Plan and decide on the timing of CRIOP related to the design and operation of the CC

The CRIOP methodology must be used at the right times during design and operation of a control centre. The recommendations are to perform the CRIOP analysis at:

- I. The first time during analysis or conceptual design (I); using checklist 1, 2, 3 (and 7 if appropriate) and perform a Scenario Analysis.
- II. The Second time during detailed design (II); complete checklist 1, 2 and 3 using checklist 4, 5, 6 (and 7 if appropriate) and performing a Scenario Analysis.
- III. The Third time after one year of operating experience (III); completing the checklist 1, 2, 3, 4, 5, 6 (and 7 if appropriate) and perform a Scenario Analysis.

The questions in the checklists have been structured in such a way that high level questions from 4, 5 and 6 also can be explored during phase “C. Conceptual design”.

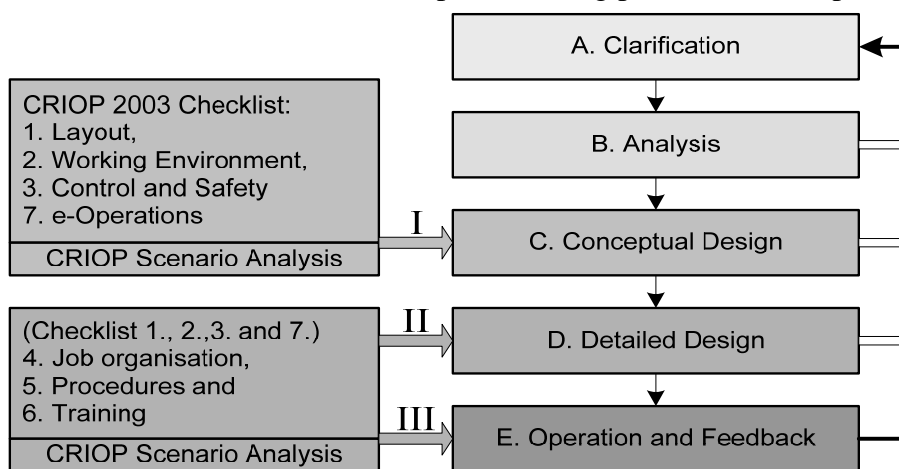


Figure 3.3: Examples of use of CRIOP based on ISO 11064 phases

Recommendations concerning the control room are easier to implement if the analysis is performed early in design. Major changes in control room layout will for instance rarely be made after start-up of the installation, because this has major economic consequences. On the other hand, several questions are not applicable if the analysis is carried out too early, because certain design issues may not be settled. Therefore, the timing of the CRIOP analysis will be crucial and evaluating this should be given high prioritisation.

The phases performed in establishing a new CC or in modification of an existing CC is described in ISO 11064 (2000), HF (2003) and other methodologies. The typical five steps A to E as illustrated in Figure 3.3 consist of:

- | | |
|---|---|
| A. Clarification | Clarify the purpose, context, resources and constraints of the project when starting the design process, taking into account existing situations which could be used as a reference |
| B. Analysis (Analysis and definition in ISO 11064) | Analyse the CC’s functional and performance requirements resulting in a preliminary functions allocation and job design. |
| C. Conceptual design | Develop initial room layout, furnishing designs, displays and controls, and communications interfaces necessary to satisfy the needs identified in step B - analysis and design. |

- D. Detailed design and building/construction** Develop the detailed design specifications necessary for the construction and/or procurement of the control centre, its content, operational interfaces and environmental facilities. Perform the actual building and construction of the CC.
- E. Operation and operational feedback** The day to day operation of the CC. This activity should contain a post commission review to identify successes and shortcomings in the design in order to positively influence subsequent design or maintenance.

Dependent on project scope, other HF activities and other verify and validate activities, it may be considered to perform only one CRIOP during design. However, the recommendation is to use the CRIOP methodology at three main points in the design of a CC as illustrated in Figure 3.3, and described below:

- C. Conceptual design** Develop a comprehensive design of a control centre that satisfies the allocated functional and tasks requirements, job descriptions and organisational plans established in phase-B. This conceptual design shall include the physical attributes of the control centre, the proposed operator interface (displays, controls and communication). Using the **CRIOP checklists**: 1. Layout, 2. Environment, 3. Control and Safety systems (and 7. e-Operations if appropriate) and perform a **Scenario Analysis**. (The ISO 11064 activity is: #C: 8-Review and approve the conceptual design.)

- If possible, it will be beneficial to carry out parts of the analysis already in phase B (Analysis and definition, point 6; Verify and validate the obtained results).

- D. Detailed design** Develop the detailed design specifications necessary for the construction and/or procurement of the control centre, its content, operational interfaces and environmental facilities. Using the **CRIOP checklists**: 4. Job organisation, 5. Procedures and 6 (and 7. e-Operations if appropriate).Competence and training and perform a **Scenario Analysis**. (The ISO 11064 activity is #D.10-Verify and validates the detailed design proposal.). The checklists: 1. Layout, 2. Environment, 3. Control and Safety should be completed.

- E. Operation and Feedback** (Operational feedback in ISO 11064). The day to day operation of the CC. This activity should contain a **post commission review** to identify successes and shortcomings in the design in order to positively influence subsequent design or maintenance. A CRIOP analysis is suggested to be performed after one year of experience is gathered. At this point the **CRIOP checklists**: 4. Job organisation, 5. Procedures and 6.Competence and training should be used. The checklists: 1. Layout, 2. Environment, 3. Control and Safety (and 7. e-Operations if appropriate) should also be checked out. A **Scenario Analysis should be performed**. (The ISO activity is #E.11- Collect operational experiences).

Issues/points that is impossible to address at this point in time, should not be ignored, but noted and left to be resolved at the next verification/validation. It is important that the responsibility for this is delegated and followed up by the responsible person. This decision on when a CRIOP should take place is a trade off between the quality of the design work and the cost of changes identified by means of CRIOP. The later a change is identified, the more costly the change becomes. Our advice is to arrange a CRIOP as early as possible and to utilise the “best practice” from the industry.

3.2.1 Use of CRIOP in a Modification Project

The CRIOP analysis during a modification project should be performed as a normal CRIOP analysis as suggested in Figure 3.3. Assessment of present status should be done in a modification project to identify areas of interest and challenges.

During a modification it is important to focus on the changes in the installation. The relevant CRIOP questions in the General Analysis should be identified in the planning phase. In the Scenario Analysis it is important to analyse scenarios where the changes are explored. The scope of the CRIOP analysis should be from 2 to 4 days, to be able to get knowledge of the modification and explore relevant scenarios.

The project team should be exposed to “Best practice” from new installations to be able to see new possibilities.

3.3 Establish the analysis group

A typical analysis group consists of the following personnel:

- Two (ideally three) control room operators; at least one operator should be senior with long experience
- An instrument engineer
- A process engineer
- A facilitator with good understanding of human factors issues, preferably a human factors specialist
- Meeting reporter – scribe with good understanding of human factors issues, to document issues and points from the analysis

The analysis group should contain or be lead by a person with experience in human factor issues. The leader should be familiar with the CRIOP method and responsible for steering discussions, keeping time schedules, etc. The leader should be an independent trusted third party to insure a good impartial process. To assure the best results the two (three) control room operators should have different experience and background.

In addition, the following personnel may be required for shorter periods during special topics during the analysis:

- Training personnel
- Safety personnel
- Specialised disciplines, e.g. electrical, HVAC, ergonomics, telecom, ICT, SAS experts
- Personnel designing procedures and work instructions

The operator company/the owner must be represented in the CRIOP by key personnel from the engineering or operation organisation.

3.4 Collect necessary documentation

Important documentation should be provided to the analysis group beforehand (See documentation checklist in Table 3-2).

This is an important step in making the evaluation efficient. Note that the documentation checklist presented in the method is extensive, as only some of these information sources may be needed. The checklist must be regarded as an overview of documentation that *may be needed*, rather than documentation requirements. The most important documentation is presented in bold types in Table 3-2. Documentation requested should reflect phases in the design process.

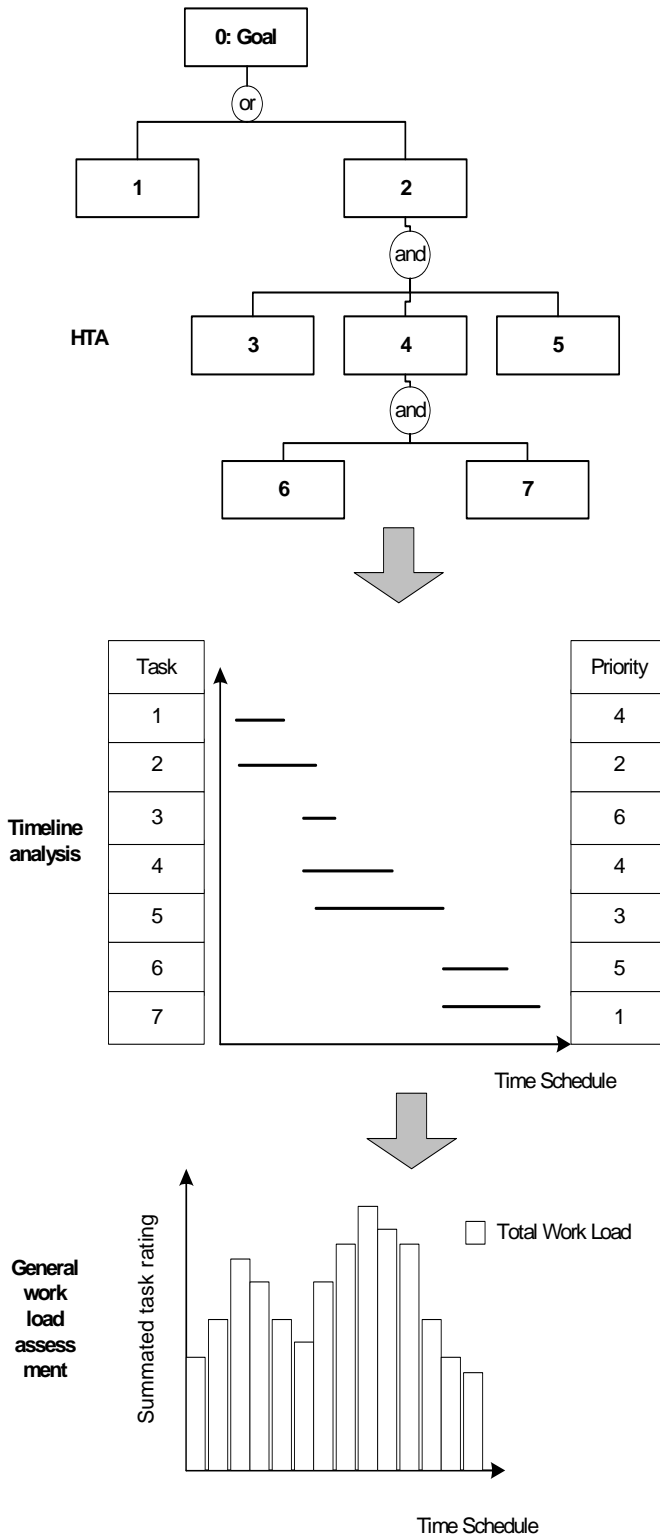
Table 3-2: CRIOP Documentation checklist

Area	Documentation	Yes/No
1. Project description and project plans Installation layout	Project definition and Project plan (description of context and scope) – especially which changes are taking place? Plant or installation plan Plan of modules where scenarios occur	
2. Goals and strategies to improve HSE	The established Goals and strategies to improve HSE (as described in MR § 4)	
3. Process characteristics	Process flow sheet (process overview) Piping and instrumentation diagrams (P & IDs) Shutdown logic matrix (cause & effects) Detailed equipment drawings. ICT architecture and system description Safety, risk and emergency preparedness analysis (QRA, HazOp)	
4. Results from other analysis Results from earlier CRIOP studies	Task analysis (job-, task- and time line analysis) and Work load assessment. Situation analysis HAZOP, working environment analysis and predictions CRIOP analysis reports performed in earlier phases of project	
5. Control room layout	Control room/sections layout plan Control room ceiling plan, lighting, colours, architectural descriptions	
6. Control room equipment	Description of process control system equipment Description of safety shutdown system equipment Printout samples (alarm listings/VDU displays) List of acronyms/abbreviations/coding conventions Description of controls, desks, VDU's, large screens and furniture	
7. Alarm strategy and design	Description of alarm strategy or alarm philosophy and design	
8. Organisation	Description of control room organisation Description of installation (plant or platform) emergency organisation and Operating and emergency procedures Job rotation plan, control room personnel shift schedule Incidents/accident reports (from existing and similar control rooms) Suggested improvements (related to work environment) Training material (concerning abnormal situations)	

3.5 Work load assessment for abnormal situations

It is of great importance to evaluate the operator workload during abnormal situations. Too high work load on the operators can draw attention from handling the situation in a correct manner. The collection of documentation concerning “Organisation” should at least include job-, task- and timeline analysis for normal operation and a work load assessment for normal operations. This

documentation should be used as a basis for evaluating the operator’s workload during crisis or stressful situations. This documentation should be produced by experienced human factor personnel. A short example is given below.



Example

A general work load assessment for normal operation should already have been carried out before performing the CRIOP analysis. This work load assessment may have been done by using the following three steps:

1. Hierarchical Task Analysis (HTA),
2. Timeline analysis, and
3. General work load assessment.

Starting with the HTA, this analysis is performed to map all the operator actions which have to be carried out to complete a specified operation or Goal (see Figure 3.5).

The results from the HTA are the basis for the timeline analysis, where the different tasks are scheduled for execution based on a timeline analysis. The different tasks must be scheduled as parallel or sequential activities and each task is to be given a defined priority. By using the timeline analysis as a basis, the general work load assessment can be calculated per team or person. The general work load assessment for normal operation should then be used for evaluating the operators’ work load during crisis situations. The analysis group should choose operations which are relevant for the specific crisis situation and then adapt this to the stressful environment and constraints that are typical for crisis situations. *A method for work load assessment for abnormal situations should be chosen and the analysis should be carried out during the Scenario Analysis with experienced operations personnel present.*

Figure 3.4: Example of workload assessment approach (from Fartum, 2003)

3.5.1 Timing of the work load assessment for normal operations

A general work load assessment for normal operations should be performed in accordance with ISO 11064, which suggest carrying out the “Design job and work organisation” as a part of phase B. Analysis (see Figure 3.4).

3.6 Practical considerations - facilitating the group process during a CRIOP analysis

An excellent design and operation of a control room is dependent on interaction between personnel with different backgrounds. A CRIOP analysis is focusing on the interaction between man, technology and organisation. The aim of the analysis is to support the operator by enabling her/him to maintain the necessary level of safety during various operational modes and crisis situations. The CRIOP analysis gathers personnel from different fields of expertise. We want to optimise the use of knowledge and experience from each participant during the CRIOP group process. One important issue to support this is to employ a CRIOP leader with good understanding of group processes and knowledge related to human factor issues.

The facilitation of the group process can be divided into four general phases, where each phase presents issues to be observed on by the CRIOP leader:

- A. Preparation
- B. Briefing
- C. The CRIOP analysis
- D. Debriefing

A. Preparation

Introductory information

The participants of the analysis should receive relevant information before the analysis. This could be an introduction to CRIOP, scope and purpose of the specific analysis, background of the participants and a short description of relevant scenarios - when a Scenario Analysis is performed.

The physical layout of the room

The physical layout is important when performing a CRIOP analysis. Key elements are:

- *Size of the room:* The room should accommodate 8-12 persons and sufficient space and equipment for graphical presentation concerning the events during scenarios.
- *Equipment:* The room should have all necessary equipment present and functioning before the analysis starts, such as a flip-over and a projector.
- *Workplace:* The room should accommodate space for participants to bring supporting additional information and documentation (laptop PC's, books, etc)
- *Seating:* All participants should have good visual and audible overview of the graphical presentations from their seats.
- *Room Climate:* The room must have good ventilation and good lighting conditions.

B. Briefing

The initialization of the Analysis introduces the structure and content of the group process. The CRIOP leader is going through important factors essential for a successful outcome, such as:

- Introduction:** CRIOP leader welcomes the participants and outlines the background and main focus for the analysis and WHY the analysis is taking place.
- Presentation:** Each participant and the CRIOP leader should provide a short presentation of themselves including name, background and role during the CRIOP analysis.
- Setting Rules:** The CRIOP leader outlines rules of interaction and dialogue during the analysis, emphasising the need for a structured, open, non-judgemental and explorative approach.
- Setting the Agenda:** The CRIOP leader provides an overview of the time schedule for the analysis and the relevant issues to be focused on, in which the participants agree upon.
- Questions:** Inviting participants to ask questions or to comment on matters concerning the structure or content of the CRIOP analysis.
- Analysis initialisation:** CRIOP leader clearly marks when the briefing ends and the analysis starts.

C. The CRIOP Analysis

The CRIOP analysis aims to facilitate the sharing and combination of the participant's knowledge. Important elements in order to maximise the joint effort of the participants are:

- Dialogue:** CRIOP leader should facilitate a non-judgemental exploration of participant knowledge by 'active questioning' aiming to uncover premises and assumptions underlying the statements made.
- Second stories:** CRIOP leader should push for detailed descriptions of chain of events with focus on how problems actually are solved and interpreted in everyday situations by the operators.
- Involvement:** CRIOP leader should facilitate engagement of all participants, ensuring an even and reasonable amount of participation in the process. No participant should dominate excessively or be exceedingly passive.
- Joint focus:** CRIOP leader should facilitate the combination of knowledge by translating the individual statements and experiences into phrases useful for all participants, and allowing joint group focus.
- Summary:** The CRIOP leader should provide clear and useful summaries of themes and findings during the analysis that all participants can understand and respond to. The project team should agree on the recommended actions.
- Maintain rules:** If necessary, the CRIOP leader should remind the group of the rules of interaction and dialogue stated during the briefing.

Maintain focus: If necessary, CRIOP leader should remind the group of their aim and focus of the CRIOP analysis, limiting efforts to relevant issues.

Conflict resolution: CRIOP leader should facilitate conflict resolution between participants in case of unresolved disagreement inhibiting group performance.

D. Debriefing

Important elements concerning the closure and debriefing of the CRIOP analysis are:

Preparing termination: CRIOP leader should announce the termination of the analysis in advance (30-45 min) in order for the participants to prepare for final conclusions.

Final conclusions: CRIOP leader should present summaries of main conclusions and findings, allowing participants to comment.

Closing the session: CRIOP leader clearly marks when analysis is closed before moving to evaluations and verbal debriefing.

Q&A and evaluation: Participants should be allowed to comment on the analysis in terms of value of the analysis, how the group was functioning, the CRIOP leader, and so forth.

Contact: The participants should be informed on how to contact the CRIOP leader for further comments etc. after the closing of the current CRIOP session.

Orientation: CRIOP leader shortly describes the procedures further in terms of how the information is handled, and how participants may get access to the final report.

The main challenge is to create a productive and effective group process, allowing each participant to contribute with their knowledge to the joint exploration of the system in focus. This is done by establishing joint focus and rules of interaction, and flexibly applying these during the analysis. The ending stages of the CRIOP analysis should provide a smooth closure leaving major issues resolved and summarised, enabling the participants to agree on the statements. The CRIOP analysis ends by all participants knowing the outcome and follow up procedures.

3.7 Suggested Agenda – CRIOP Analysis meeting

If the scope of the CRIOP Analysis is around 4 days, our suggestions are to use the Agenda below. The participants in the meeting should not be changed. The meeting should be planned to last 4 days or two times 2 days, to support the group process. In advance of the meeting it should be made clear why the CRIOP analysis is taking place, and the scope of the analysis. In advance of the meeting the project team should identify and describe 2 to 3 (or 4) important scenarios to be elaborated in the Scenario Analysis.

General Analysis (2 Days)	Scenario Analysis (2 Days)
Day-1: Introduction of Participants	Day-3: Summary of Recommendations so far
Day-1: Description of Scope and challenges	
Day-1: Walk trough of Checklist 1 to 3	Day-3: Walk trough of Scenario 1-2
Day-2: Walk trough of Checklist 4 to 6,7	Day-4: Walk trough of Scenario 3
Day-2: Agreement on Recommendations	Day-4: Agreement on Recommendations

4. General Analysis – Checklists to be used in Design and Operation

4 General Analysis – checklists to be used in design and operation

The aim of this section is to describe the principles behind the checklists in CRIOP, how the checklists should be used and present the checklists.

The checklists used in the General Analysis concern factors affecting the control centre’s ability to handle abnormal situations that are not related to a specific sequence of events.

Several checklists for control centres have been published in regulations, standards and guidelines, but there is a lack of an overall balanced checklist. Thus the objective of CRIOP has been to combine the relevant material in a “best practice” checklist. The checklist in CRIOP has been developed based on:

- Existing international standards and guidelines such as ISO 11064, NUREG0700, EEMUA #191, IEC 61508. (NUREG 0700 alone contains around 700 pages. A Selection of the most important issues from NUREG and other standards has been performed based on empirical studies.)
- All relevant requirements in NPD regulations as Activity Regulations-AR, Facilities Regulation-FA, Management Regulations-MR, Frame Regulations-FR, and YA-711. The goal has been to insure that all relevant NPD regulations have been taken into account when we have performed a CRIOP analysis.
- Best practice in the industry
- Norsok S-002 rev 4, Norsok I-002 (NPD regulations and YA-711 supersedes Norsok.)
- User requirements, wanting to have relevant materials in the CRIOP checklists

The main relations between the checklists and relevant standards are illustrated in Figure 4.1.

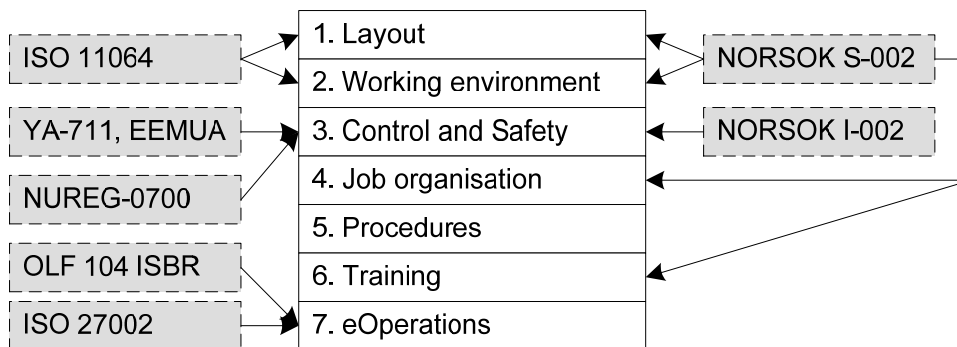


Figure 4.1: The relationships between CRIOP checklists 1 to 7 and standards

The e-operations checklist is based on relevant ICT and SAS standards, ISO/IEC 27002 (former ISO 17799) and ANSI/ISA-99. After the e-operation checklist has been developed, OLF has developed a short list of suggested best practice called OLF Guideline 104 ISBR. A list of best practice guidelines can be found at www.us-cert.gov/control_systems/csstandards.html, among other NIST SP 800-82, “Guide to Industrial Control Systems.”

The general checklist is presented in Section 4.3, following this introduction.

4.1 Planning

The General Analysis has an important function in making the analyst familiar with the control centre concept in question. Suggestions for participants in addition to the analyst and duration of sessions are given in Table 4.1.

Table 4-1: Participants - General Analysis

Topic	Duration	Participants
Layout	1-2 hrs.	Operations, instrument, architect, working environment engineer /HF-engineer.
Working environment	1-2 hrs	HVAC, electrical (lighting), architect, (safety), working environment, noise/vibration control.
Control and safety systems	4 hrs.	Operations, instrument, safety, process, ergonomics, manufacturer, working environment engineer /HF-engineer
Job organisation	1 hr.	Operations, HF-engineer
Procedures	1 hr.	Operations, HF-engineer
Training	1 hr.	Operations, HF-engineer
e-Operations	4 hrs.	ICT project management, ICT security, Operations, instrument, safety, process (SAS) expert, HF-engineer

Note that participation from experienced control room operators and line management (operations) is important throughout the analysis. The duration could vary within a range of -50% up to +200% depending on the complexity of the scope and the participants in the analysis group.

4.2 Checklist

The checklists in the method support in identifying problems and possible *solutions* to human factors questions related to the control room. Explanations to the questions are also given. The questions are phrased so that the “correct” answer is “yes”. (The “comments” field could be used to document HOW an issue is implemented when appropriate.)

Each point in the checklists consists of:

- **A point:** Structured number of question, syntax: is <area >. <level>. (One digit implies a high level question, next level implies a more detailed question, ex: L2 is high level question having detailed questions L2.1 thru L2.4)
- **A description or a question::**
E.g.: C 6.2 Are warnings provided if out-of-range values are entered?
- **A rationale for the question or criteria for evaluating the question, e.g.:**
Entry of out-of-range/extreme values (e.g. out-of-range values can be expressed as % change in relation to a given value) may initiate deviations in the process and damage equipment. Check keyboard entry commands for potentially dangerous similarities. Data being entered should be displayed and the data should be checked and a confirmation requested.
- **Questions in the checklist should be answered:**
 - Yes (Y). Yes is also used when the activity is planned. The planned activity must be written in the “Comment” field. The CRIOP project group must agree that the action is planned and is going to take place.

- No (N) Reason for N must be thoroughly explained and documented.
- Not Applicable (NA). Reason for NA must be thoroughly explained and documented.

- **References to documentation, e.g.:**

NORSOK I-002, point 4.4.1.2, p. 10., NUREG0700, point 2.7.4-1, p. 199.

References to documentation specific to Drillers Cabin have the prefix DC.

Questions applicable to Drillers Cabin (DC) are highlighted by “DC: Applicable to the DC” in the Comments column.

(This column could also be used to prioritise the importance of the issues. It is suggested to use: H - High importance, M - Medium Importance, L - Low importance.)

- **Comments:**

Should be written in the dedicated space in the checklists.

The “comments” field could be used to document HOW an issue is implemented when appropriate.

- **Recommendations:**

Weak points are identified by answering the questions in the general checklist. Based on these weak points, suggestions for recommendations should be made.

- **Responsibility (RESP.):**

At the end of the General Analysis the findings, recommendations and weak points are documented and a responsible person is identified to carry out the actions.

4.3 Documentation of results

The documentation of results from the General Analysis should include:

- Reference to questions in the general checklist
- A description of identified weak points
- Suggestions for remedial measures and recommendations based on the identified weak points
- Responsible person for the weak point/suggested recommendation (Resp.)

An example is shown in Table 4.2.

Table 4-2: Documentation of results - Example (General Analysis)

Ref	Question/ Weak points	Suggestions/Recommendations	Resp.
L 4.7	<p>Can the operator have a natural posture while seated at his workplace?</p> <p><i>The operator's legs touch the lower part of the desk at the VDU work stations.</i></p>	The seating arrangement at the VDUs should be redesigned (desk/chairs).	Statoil/ A.Smith
W 4.2.1	<p>Are glare and reflection from lighting avoided?</p> <p><i>Ceiling lighting causes glare on the VDU screen.</i></p>	Lighting should be redesigned to avoid reflections on the VDUs.	Statoil/ A.Smith
W 5.4	<p>Are vibrations in the control room within acceptable limits?</p> <p><i>The control room is planned to be located below vibrating equipment.</i></p>	Increase distance between vibrating equipment and the control room, or initiate special measures.	Statoil/ A.Smith
C 5.2.1	<p>Are suppression mechanisms used to reduce the number of consequence alarms?</p> <p><i>Unnecessary alarms are not suppressed.</i></p>	Too many unimportant alarms divert the operators' attention from important alarms, and the operators may not have sufficient time to analyze the situation.	Statoil/ A.Smith
C 6.2	<p>Are warnings provided if out-of-range values are entered?</p> <p><i>There is no warning function for out-of-range values, and operators may enter wrong values into the system (e.g. 44000 instead of 4400).</i></p>	Warnings should be provided if out-of-range values are entered by the operators.	Statoil/ A.Smith

Checklist 1: Layout

Central Control Centre (Room/Cabin) Review

Facility	Performed by / date	Approved by /date

1. LAYOUT

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 1	<p>Does the room location, room volume and room layout of the CC take into account relevant design issues?</p> <p><i>The CC should be designed in accordance with analyses and considerations that will ensure proper room location, -volume and -layout such as:</i></p> <ul style="list-style-type: none"> - <i>Function analysis</i> - <i>Task analysis including full range of process conditions and administrative tasks.</i> - <i>Cooperation with remote installations</i> 					FR § 12. DC: NORSOK D-001, S-002 rev 4, EN 292-1.	
L 2	<p>Does the room location and room layout of the CC take into account safety and security considerations?</p> <p><i>When placing and designing the CC, consideration should be given to safety and security issues. In general, the CC should be placed in a safe location that also ensures security. Specific considerations have to be made for each individual CC and its respective environment.</i></p>					FR § 12. DC: NORSOK D-001, S-002 rev 4, EN 292-1.	

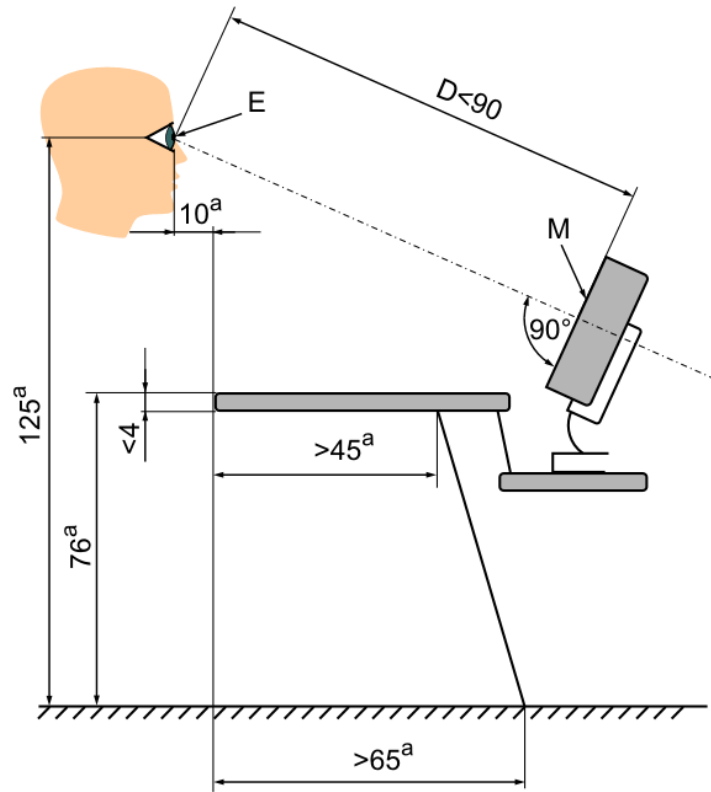
POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 2.1	<p>Are entrance restrictions to the CC implemented during abnormal situations?</p> <p><i>Irrelevant personnel in the control room distract operators during stressing situations.</i></p>					DC: Applicable to the DC	
L 2.2	<p>Are there at least two escape routes from the CC?</p> <p><i>There should be at least two easily accessible escape routes from the CC.</i></p>					FR § 12. DC: NORSOK S-001	
L 2.3	<p>Does location and layout prevent the control room from being used as a natural passage for personnel?</p> <p><i>Personnel should not be tempted to use the control room as a short cut between different areas of the installation as this may disturb the operators.</i></p>					ISO 11064-2, 5.2 DC: Applicable to the DC	
L 2.4	<p>Does the layout and location of the CC and emergency control centre allow for quick and easy information exchange between the two centres and yet avoid unnecessary noise and disturbance?</p> <p><i>Operators should not be distracted by activities in the emergency control centre. Check: In case of major incidents, a separate facility, generally fitted with special communication equipment, might be necessary. Consider whether the control room fulfils this role.</i></p>					ISO 11064-2, annex.4 DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 3	<p>Are internal traffic routes in the CC designed?</p> <p><i>An analysis of internal traffic routes should be performed to show how people move in the CC, and whether functions have been placed in an optimal manner with regard to this.</i></p>					DC: Applicable to the DC	
L 3.1	<p>Can personnel work at and move past the workstations without accidentally altering the controls?</p> <p><i>For main walkways: Vertical - 2700 mm (2300 mm is recommended) Horizontal – 1000 mm.</i></p> <p><i>For access ways: Vertical – 2100 mm (2050 mm in door openings and above each step in a fixed stepladder) Horizontal – 600 mm. Minimum width 900 mm for access to permanently and intermittently manned workplaces.</i></p> <p><i>Distance between panels / cabinets / walls / equipment should be greater than 915 mm for desk to opposing surface, or 1250 mm between a single row panels where one person work at a time, 2500 mm for opposing rows where two or more persons work simultaneously.</i></p>					NORSOK S-002, REV 4, annex b NUREG 0700, rev.2, 12.1.1.3-5, 3-6 DC: Applicable to the DC, however the numbers are not	
L 3.2	<p>Are tripping hazards, protruding objects, and slippery liquids avoided?</p> <p><i>Check: Different floor levels, cables, waste bins, clothes, thresholds and table edges.</i></p>					NORSOK S-002 rev 4 DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 3.3	<p>Are frequently used walkways within the control room unobstructed?</p> <p><i>Check: Walkway between operator's workplace and instrument on panels. All work areas shall have a layout that provides for safe access for operation and maintenance. Protruding objects shall be avoided in walkways, access ways, and transportation ways.</i></p>					NORSOK S-002 rev 4 DC: Applicable to the DC	
L 4	<p>Is the workplace of the operator designed according to ergonomic principles and best practice?</p> <p><i>Consult ISO 11064, relevant NORSOK standards as mentioned in these checklists.</i></p>					DC: ISO 11064, NORSOK S-002 rev 4 and D-001, EN 547-1/2/3, EN 614-1, EN 1005.	
L 4.1	<p>Do the operators have an adequate view of the visual display from their workplace (seated and standing)?</p> <p><i>Viewing distance to the visual display should be between 450 mm and 800 mm. It should not be necessary to turn head more than 35 degrees left or right to see important displays (95 degrees for less important / not frequently used displays). Check: Process control system, safety system, utility system and supervisory system, and possible obstructions from personnel during emergencies.</i></p>					NUREG, 0700, rev.2, 11.1.2-8. ISO 11064-4 5.1.2 User Requirements. DC: NORSOK S-002, REV 4,.	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 4.2	<p>Do the operators have an adequate, unobstructed view of panels from their normal workplace?</p> <p><i>For monitoring, the distance between panels and the operator's workplace should be minimum 2 meters, and operators should not have to turn their heads more than 60 degrees. Console height in front of operators should be no greater than approximately 1150 mm. Check: personnel possibly obstructing view of process mimics, fire and gas panels, equipment status overviews, inhibition overviews and CCTV during emergencies. (The measurement requirements should not be applied when utilising a cockpit design solution. Distances and degrees of view to panels and consoles do not apply to the DC.)</i></p>					<p>ISO 11064-4 FR § 19.</p> <p>DC: Applicable to the DC. <i>The access to BOP and choke panels must be free from obstructions and there should be an adequate and unobstructed view to these.</i></p>	
L 4.3	<p>Is sufficient room provided at the operators' workplaces for use of written documentation without interfering with controls and visual displays?</p> <p><i>The desk at the workplace should be at least 400 mm deep and 610 mm wide. Desks must allow support for elbow in front, keyboard, A3 sheets and books. Check: Provision should be made so that the procedures, manuals, and other reference materials can be consulted easily while task sequences are performed at the consoles.</i></p>					<p>NUREG 0700, rev.2, 11.1.2 NUREG 0700, rev.2, 11.1.3</p> <p>DC: Applicable to the DC <i>Nearby, at hand, close to the driller's chair there should be room for pipe tallies and procedures.</i></p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 4.4	<p>Is other important and frequently used information easily available to the operators?</p> <p><i>The information should be stored and structured to provide easy and quick access.</i></p> <p><i>Check: work permits, printers, procedure manuals, P & IDs.</i></p>					<p>ISO 11064-2, 5.8</p> <p>DC: Applicable to the DC</p>	
L 4.5	<p>If back-up displays are provided, are they located so that the operators can communicate easily when using them?</p>					<p>CRIOP 15/2-1990</p> <p>DC: Applicable to the DC</p>	
L 4.6	<p>Does the seating arrangement allow for easy co-operation, voice communication and reach between operators?</p> <p><i>Operators should not need to turn their heads more than 90 degrees to communicate.</i></p>					<p>ISO 11064-4</p> <p><i>DC: Many DCs have foot pedals or similar in order to communicate whilst operating. It must be ensured that these are easy to use and are protected from inadvertent operation (which may block information flow).</i></p>	
L 4.7	<p>Can the operator have a natural posture while seated or standing at his workplace?</p> <p><i>The desk and chair at the operator's workplace shall be easy adjustable from seated and standing position. Note that a thick desk plate (e.g. with draws) may cause an unwanted working posture. Desk thickness shall be <40 mm. It is important that the desk is adjustable. Figure 4.2 shows important measures for the workplace as suggested from ISO 11064-4.</i></p>					<p>ISO 11064-4 Figure 2</p> <p>FR § 19.</p> <p>DC: NORSOK S-002 rev 4, EN 547-1/2/3, EN 614-1, EN 1005.</p> <p><i>Measures in Figure 4.2 do not apply to the DC.</i></p>	



Legend

^a Examples, the values of the anticipated user population shall be applied

D Viewing distance

M Monitor (20" LCD)

E Design eye point

All figures in cm

Figure 4.2: Example for a seated and standing control console (Measures in cm as given in original figure, for seated posture)

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 4.8	<p>Can the operator get in and out of the chair at the workplace freely?</p> <p><i>Minimum requirements for operator manoeuvring space are approximately 760 mm laterally (“sideways”) and 915 mm from the edge of the desk to any opposing surface (“backwards”).</i></p> <p><i>Ref. Figure 4.3. inspired by NUREG0700</i></p>					<p>NUREG 0700, rev.2, 12.1.1.3-5</p> <p>DC: NORSOK S-002, REV 4, Annex C. <i>The chair should be able to be rotated to allow easy access - at least 180 degrees.</i></p>	

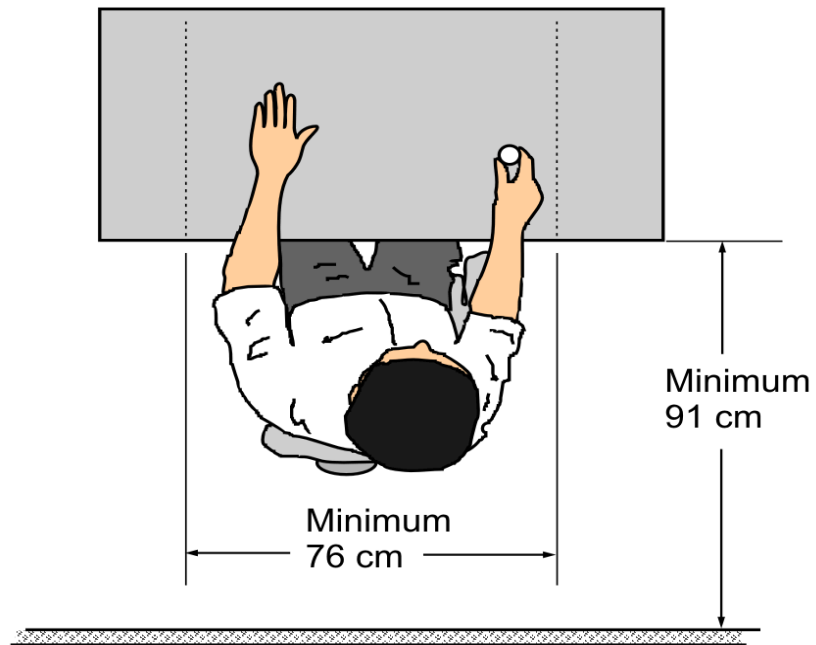


Figure 4.3: Spacing of equipment to accommodate seated users (In cm as suggested in original figure)

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 4.9	<p>Is a separate workplace or uncluttered area provided for paper work?</p> <p><i>A useful approach is to specify a task zone for each work task: These task zones should then be allocated to workstation. Check: documentation tasks, administrative tasks. The area should accommodate A3 folders.</i></p>					ISO 11064-2, 4.5 ISO 11064-2, Annex A.1 DC: Applicable to the DC	
L 4.10	<p>Is the placement and use of the control functions (joysticks, touch pad, buttons etc) of the operator station designed according to ergonomic principles and best practice?</p>					EN 547-/1/2/3, EN 614-1 og EN 1005 DC: Applicable to the DC	
L 5	<p>Is the CC designed for use by other personnel?</p> <p><i>Supervisor, shift leader, maintenance operators, field operators etc.</i></p>					<i>DC: Only relevant personnel should have access to the DC to avoid disturbance. Barriers should be established to avoid disturbances by other personnel. Restricted access to the DC and drill floor should be stated in procedures.</i>	
L 5.1	<p>Can other personnel (maintenance, instrument, etc.) obtain necessary information without disturbing the operators?</p> <p><i>Check: work permits, information for fault diagnosis, information requests, location in safe area, entrance, toilet / wardrobe/ coffee facilities / rest area / dining room, noisy areas, room for printers / faxes / computers</i></p>					ISO 11064-2, 5.6 DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 5.2	<p>Is the supervisor provided with a separate workplace?</p> <p><i>Information and work permit requests are frequently directed to the supervisor. Operators should not be distracted by these activities. The supervisor's workplace should be a natural meeting point when entering the room.</i></p>					<p>ISO 11064-3, 4.4.2, ISO 11064-2, Annex A.1 DC: EN 547-1/2/3, EN 614-1, EN 1005. <i>DC: No permanent workplace – but a separate all purpose workplace can be available.</i></p>	
L 5.2.1	<p>A) Does the supervisor's workplace allow easy visual and voice contact with operators?</p> <p>B) If the supervisor is not located in the control room, are dedicated communication lines provided?</p> <p><i>Communication between operators and supervisors must be possible in spite of heavy communication during abnormal situations.</i></p>					<p>ISO 11064-3, 4.4.2 NUREG0700, point 12.1.1.6-2, p. 464. DC: Applicable to the DC</p>	
L 5.2.2	<p>Does the supervisor's workplace allow him to obtain important information in the control room?</p> <p><i>Check: process mimics, fire and gas panels, equipment status overviews, inhibition panel and work permits.</i></p>					<p>ISO 11064-3, 4.4.2 DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
L 6	<p>Are the social needs of the operator considered?</p> <p><i>Such as a social corner/pantry/meeting table and a lockable space within or nearby the control room for personal effects A social corner provides change and rest for the operators. Note, however, that a social corner may also cause people to gather and may divert the operators' attention. The social area should be sheltered from visitors.</i></p>					ISO 11064-1, 9.2 ISO 11064-3, 4.3.5 DC: There should be coffee and rest facilities in the vicinity of (not within) the driller's cabin to facilitate rest and coffee breaks. Also, drillers should be provided with a locker for personal effects, not necessarily in the DC.	
L 7	<p>Are all necessary questions asked related to Layout?</p> <p><i>Evaluate the need for a summary question – such as “In conclusion – what is your evaluation of the CC layout?”</i></p>					DC: Applicable to the DC	
L 8 Drillers Cabin	<p>Does the driller have an adequate unobstructed view of the drilling area on drill floor, including the derrick, drilling equipment and pipe-handling equipment?</p> <p><i>The driller's cabin should be designed so the view to the drilling area from the DC is free of obstructions to for instance the top drive, racking arms, cat-walk, iron roughneck, personnel etc. It is often seen that the view is obstructed by beams that support the driller's cabin structure.</i></p>					DC: NORSOK S-002 rev 4, Annex C.	

Checklist 2: Working Environment

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

2. WORKING ENVIRONMENT

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 1	<p>Does the design of the CC take into account ergonomic criteria related to a safe and comfortable working environment?</p> <p><i>The CC should be designed in accordance with ergonomic principles and best practice to ensure optimal user interface and a workplace that will protect against physical and mental strain.</i></p>					ISO - 11064 DC: NORSOK S-002 rev 4 and D-001.	
W 2	<p>Are construction material and surfaces considered with respect to work environment and health hazards?</p>					ISO - 11064 DC: Applicable to the DC	
W 2.1	<p>Are indoor building materials and inventories selected with respect to</p> <p>A) emission of pollution and odour</p> <p>B) easy cleaning of surfaces?</p> <p>C) clean building concept?</p> <p>D) ergonomic factors?</p> <p><i>Low emitting materials should be chosen. The manufacturer should give declarations on material emissions and cleaning methods.</i></p>					NLIA (2003) DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 2.2	<p>Are colours and surfaces in the control room chosen to minimise contrast and reflection?</p> <p><i>The following features are recommended: White ceiling, dark floor, reflection factor on walls between 0.5-0.8. Glare in visual display units from reflecting surfaces shall be avoided. Surfaces, which diffuse light such as flat paint, non gloss paper and textured finishes reduce reflected glare.</i></p>					NORSOK S-002 rev 4, sec. 5.6 DC: Applicable to the DC	
W 2.3	<p>Are dust sources avoided?</p> <p><i>Dust content in the air has a considerable effect on personnel well being. Check dust sources such as materials, carpeting and textiles. Carpets should be avoided. Materials containing synthetic mineral fibres shall be fully sealed.</i></p>					NORSOK S-002 rev 4, sec. 5.7 DC: Applicable to the DC	
W 2.4	<p>Are measures taken to prevent static electricity?</p> <p><i>Static electricity can cause failure/loss of visual displays when displays are touched. Materials in chairs, floor and footwear should be chosen to reduce static electricity.</i></p>					DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 2.5	<p>Are measures taken to prevent electromagnetic disturbances of control room equipment?</p> <p><i>Electromagnetic disturbances may cause interference to electrical signals and damage electronic equipment in the control room. Relevant measures include shielding of equipment and appropriate selection of parts. Examples of potential sources: Lightning, radio/radar transmitters, switches, thermostats and mobile phones.</i></p>					NORSOK S-002 rev 4, Section 5.9 DC: Applicable to the DC	
W 3	<p>Are thermal environment, air distribution and air composition designed according to working environment and best practice?</p>					ISO - 11064 DC:NORSOK S-002 rev 4, Annex A,	
W 3.1	<p>Is the operative air temperature between 20° C and 24° C under all weather conditions?</p> <p><i>It is recommended that the air temperature be kept below 22° C at any time and especially in wintertime. Too high or too low temperature may cause inattention and is a risk factor during work requiring mental tasks. Individual temperature adjustments should be possible.</i></p>					NORSOK S-002 rev 4 Annex A; NLIA (2003) DC: For DC, temperature range between 19 - 26° C	
W 3.2	<p>Is the difference in temperature between floor level and head level less than 3 - 4° C?</p> <p><i>A difference in temperature between feet and head of more than 3 - 4° C will be uncomfortable, and likewise daily or periodic temperature variations of more than about 4° C.</i></p>					NLIA (2003) DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 3.3	<p>Is the ventilation need calculated as the sum of the following:</p> <p>A) air flow requirements for personnel,</p> <p>B) emissions from materials and</p> <p>C) emissions from work or process?</p> <p><i>Pollution from personnel calls for an air flow rate of 7 - 10 l/s per person.</i></p> <p><i>Emissions from normal building materials without strong odour calls for an air flow rate of 2 l/s per m².</i></p> <p><i>Extra airflow should be added for e.g. heat generating equipment.</i></p> <p><i>Balanced ventilation is required and displacement ventilation is preferred to dilution ventilation.</i></p>					<p>NORSOK S-002 rev 4 sec. 5.7 and Annex A, and D-001.</p> <p>Climate and air quality at the work place, NLIA(2003) order no. 516 (NLIA-2003)</p> <p>FR § 13</p> <p>DC: Applicable to the DC</p>	
W 3.4	<p>Is the air intake located in open air:</p> <p>A) at a safe distance from exhaust outlets and vent pipes and</p> <p>B) in a shady place so the air is as cool as possible in the summer?</p>					<p>NORSOK S-002, REV 4 sec. 5.7; NLIA (2003)</p> <p>DC: Applicable to the DC</p>	
W 3.5	<p>Is gas detection equipment located at air intake and air outlet?</p>					<p>NORSOK S-002, REV 4 sec. 5.7</p>	
W 3.6	<p>Is easy and safe access provided for operators for</p> <p>A) Internal inspection and cleaning of ducts?</p> <p>B) Change of air filters?</p>					<p>NORSOK S-002, REV 4 sec. 5.1.2 and 5.7</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 3.7	<p>Is the air ventilation velocity less than 0.15 meters per second measured at the operator's work place?</p> <p><i>Low air velocity is necessary to avoid air draught.</i></p>					NLIA (2003) DC: Applicable to the DC	
W 4	<p>Is lighting designed according to ergonomic principles and best practice?</p>					ISO - 11064 EN 12464-1 NORSOK S-002, REV 4, sec 5.6 DC: Applicable to the DC	
W 4.1	<p>Is access to daylight provided?</p> <p><i>Permanently manned workplaces should have access to daylight.</i></p>					NORSOK S-002, REV 4, sec. 5.1 <i>DC: Access to daylight is not required but is considered favourable for the working environment</i>	
W 4.1.1	<p>Are windows exposed to sunlight equipped with effective shades?</p> <p><i>In choosing shading one should evaluate</i></p> <ul style="list-style-type: none"> <i>A) achievable reduction of heat input</i> <i>B) ease of use and regulation</i> <i>C) durability and ease of cleaning</i> <i>D) that the light is not distorted by the reflective coating</i> <i>E) that the view is not permanently blocked to any great extent</i> <i>F) individual adjustments</i> 					NLIA (2003). DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 4.1.2	<p>Are glare and reflections from windows avoided on visual displays?</p> <p><i>Location of windows in relation to displays may cause direct glare or reflections on displays and discomfort to operators. Displays should be perpendicular to windows.</i></p>					NORSOK, S-002, sec. 5.6 DC: Applicable to the DC	
W 4.2	<p>Is the lighting level in the CC at least 500 lux and adjustable in intensity and direction?</p> <p><i>Adjustable lighting offers the following advantages:</i></p> <ul style="list-style-type: none"> A) Gives personal control over the environment B) Gives varying light level according to different tasks to be carried out. C) Caters for different physiological lighting needs between day and night. D) Make sure that adjustable directional lighting does not cause reflections 					NORSOK S-002, REV 4, Annex A DC:400 lux for DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 4.2.1	<p>Are glare and reflection from lighting avoided?</p> <p><i>Direct glare and reflections on displays cause discomfort and problems reading displays. The choice of fittings influences reflections significantly. Indirect lighting should be considered used. Fittings should be to the side rather than behind workstations, perpendicular to displays. Adjustable/flexible fittings are recommended. Displays should be tiltable and antireflection coating or a matt finish should be used. Also check possibilities of glare from emergency lighting.</i></p>					NORSOK S-002, REV 4, sec. 5.6 DC: Applicable to the DC	
W 4.2.2	<p>Is lighting with high colour temperature (e.g. light tubes with white light) used in the control room?</p> <p><i>Different levels of lighting require different light colour if the lighting is to be comfortable. High colour temperature, white light, should be used in areas with high lighting levels like the control room.</i></p>					NORSOK S-002, REV 4, sec. 5.6 EN 12464-1 DC: Applicable to the DC	
W 4.3	<p>Is additional lighting provided in areas where greater intensity is needed?</p> <p><i>Lighting intensity at workplace for paperwork should be min. 500 Lux.</i></p>					CRIOP 15/2-1990 DC: Lighting must not disturb view to the drill floor, derrick etc.	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 4.4	<p>Is emergency illumination between 15 and 50 Lux?</p> <p><i>1 lux is the requirement of EN 1838 for escape routes 0.5 lux for open areas. Areas of high physical risk, or the control rooms of dangerous plant and production lines, need emergency lighting to enable them to be shut down safely. BS5266 Part 1: 1999 defines that emergency lighting should provide 10% of the normal lighting level at the hazard, with a minimum of 15 Lux.</i></p>					<p>NUREG0700 6.1, NORSOK S-001, EN 1838, BS 5266.</p> <p>DC: Applicable to the DC</p>	
W 5	<p>Are acoustic environment and vibrations designed according to working environment and best practice?</p>					<p>ISO - 11064</p> <p>DC: In addition NORSOK S-002, REV 4</p>	
W 5.1	<p>Is the total noise level below 45 dB (A)?</p> <p><i>The noise level limit refers to background noise including HVAC as well as noise sources in continuous use within the room. For mobile offshore units the maximum noise limit is 5 dB higher during operation. Noise contribution from the HVAC system should be max. 40 dB (A). Check: control room equipment, ventilation system/fans, printers, equipment in adjacent rooms and process equipment.</i></p>					<p>NORSOK S-002, REV 4, Annex A.</p> <p>Forskrift om støy på arbeidsplassen §§6 og 7.</p> <p>DC: Total noise level: 65 dB (+ 5 dB for mobile Offshore Units). Noise from the HVAC system should be maximum 60 dB (A).</p>	
W 5.1.1	<p>Is the average octave band sound absorption coefficient not less than 0.2 in the frequency range 250 Hz to 2 kHz?</p>					<p>NORSOK S-002, REV 4, sec. 5.5.3</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 5.1.2	<p>Is the minimum airborne sound insulation index (R'w) 40 dB with respect to the control room?</p> <p><i>Minimum permissible airborne sound insulation index (R'w) for horizontal, vertical and diagonal sound transmission between adjacent rooms should be 40 dB for control rooms.</i></p>					NORSOK S-002, REV 4, sec.5.5.3 DC: Applicable to the DC	
W 5.2	<p>Is it ensured that speech communication is not masked by noise sources especially under the noisiest conditions, e.g. emergency preparedness?</p> <p><i>Has ISO/DIS 9921 "Ergonomics – Assessment of speech communication" been used with regard to the specification and location of communication equipment?</i></p>					ISO/DIS 9921 DC: Applicable to the DC	
W 5.3	<p>Are noisy office machines like printers, copy machines and telefaxes placed in a separate, unmanned area?</p> <p><i>Such machines should not be located in the CC due to noise and dust emission. If location in a separate room close to the CC is not practicable, location in special cabinets in the CC may be considered.</i></p>					NORSOK S-002, REV 4 sec. 5.7. DC: Not applicable to the DC,	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
W 5.4	<p>Are vibrations in the control room within acceptable limits?</p> <p><i>Vibrations cause discomfort and fatigue to personnel, and may damage control room equipment. Limits for vibration are stated as acceleration (m/s^2), as a function of frequency (Hz).</i></p> <p><i>For vibration limits, reference is made to NORSOK S-002, REV 4, Annex A. Control rooms are considered as Category 1 rooms.</i></p>					<p>NORSOK S-002, REV 4, sec. 5.5.2, Category 1 in Annex A.</p> <p><i>DC: DC is considered as Category 2 room (Drilling areas).</i></p> <p><i>ISO 2631-1, ISO 5349, FA § 23.</i></p>	
W 6	<p>Are all necessary questions asked related to Working Environment?</p>					DC: Applicable to the DC	

Checklist 3: Control and Safety Systems

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

3. CONTROL AND SAFETY SYSTEMS

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 1	<p>Are the screens (displays and large screen displays) in the CC designed according to ergonomic principles and best practice to suit the manner in which they are to be used?</p> <p><i>All screens that are present in the CC should be designed according to ergonomic principles and best practice to ensure that the users may interact with the displays in a safe and efficient manner.</i></p>					ISO 9241-3 DC: Applicable to the DC,	
C 1.1	<p>A) Are the displays designed in such a way that they support operators' tasks?</p> <p>B) Is navigation between different displays quick and easy?</p> <p><i>Examples are "one key commands", "pop-up" or direct access. Changing between different types of displays should be easy to carry out and should require little memorisation. Navigation in alarm displays should be quick and easy.</i></p>					NORSOK I-002, point 4.4.1.1, p. 10, YA-711, point 42, p. 21. NUREG0700, point 4.2.1-2, p. 269. DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 1.2	Is information presented in a way that supports rapid detection and comprehension?					NUREG0700, point 1.3.4-5, p. 51. NORSOK I-002 DC: Applicable to the DC	
C 1.2.1	<p>A) Is information presented using graphical coding to easily identify deviations?</p> <p>B) Is information presented in graph format to enhance trends?</p> <p>C) Is graphical coding used to emphasize primary information?</p> <p><i>Utilize graphical coding (instead of or in addition to other coding mechanisms e.g. figures) to support pattern recognition to reduce mental effort required to spot deviations and problems. To be read “at a glance”.</i></p>					DC: NORSOK I-002	
C 1.2.2	<p>Is display information presented using consistent and unambiguous symbols?</p> <p><i>Symbols should require little interpretation and memorization, and should be consistent within the control room.</i></p>					NUREG0700, point 1.3.4-5, p. 51. DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 1.3	<p>Does the visual salience (eye-catching) of screen objects correspond to their importance?</p> <p><i>The visual salience of graphical objects and information should follow this general rule:</i></p> <ul style="list-style-type: none"> • Primary information (alarms and key information): high • Other dynamic information: medium • Static information: low <p><i>Note that the importance might change in different operational contexts (e.g. suppressed, not suppressed alarms).</i></p>					DC: NORSOK I-002	
C 1.5	<p>Do operator interaction principles for screen work follow commonly used interaction principles?</p> <p><i>It is important that the interaction principles used follow general conventions to the highest possible extent. For instance should there be consistency with work performed on PC which is familiar to the personnel. This will minimise effort and time utilised and will reduce guessing.</i></p>					<i>DC: Applicable only to DCs where screen work is much used. "One key commands" may be used as screen interaction tool</i>	
C 1.6	<p>Is the time to complete a visual display with 100 dynamic points less than 2 seconds?</p> <p><i>The time to complete a display should be short, in order to avoid annoyance to operators. Note that response time may increase when system load is high. Check how modifications will affect response time.</i></p>					NORSOK I-002 Annex B; YA-711, point 10, p. 11. DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 2	<p>Are the main objectives for large screen displays properly identified and documented?</p> <p><i>Large screen displays should be used when crew performance may be enhanced by access to a common view of plant information or a means of sharing information between personnel. Check that it provides:</i></p> <p>A) <i>key information and overall plant status information to relevant users</i></p> <p>B) <i>high level information to reduce mental workload or enhance team performance</i></p> <p>C) <i>permanently visible safety related information, as key alarms</i></p>					<p>NUREG0700, point 6.1.1-1, p. 313.</p> <p>DC: Not applicable to the D</p>	
C 2.1	<p>Are the users of the large screen displays identified?</p> <p><i>Different personnel may need different information. Check e.g.: control room operators, technicians, additional personnel needed in a disturbance, system engineers, test personnel, emergency preparedness team members, supervisors/management and maintenance.</i></p>					<p>NUREG0700, point 6.1.5-5, p. 322., YA-711, point 39, p. 20.</p> <p>DC: Not applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 2.2	<p>Are the different operational contexts for which the large screen is providing assistance to operators</p> <p>A) identified and</p> <p>B) primary information related to these situations defined?</p> <p><i>The operational context could be e.g. alarm management or overview of the process condition. These contexts have very different information needs. This is important since primary information related to different operational context will vary. To prevent the displays from being crowded and thereby reducing readability and operator awareness, the operational context should be adhered to.</i></p>					DC: Not applicable to the DC	
C 2.3	<p>Is information presented on large screen displays utilising their benefits?</p> <p><i>Where the information on large screen visual display needs to be regularly used by control room operators, the design of the visual display and the layout of the control room should ensure that all of the information which needs to be used by a control room operator can be seen from the normal working position for both the vertical and horizontal planes.</i></p>					ISO 11064-3, point4.5.1, p. 16. DC: Not applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 3	<p>Is the alarm system clearly defined by means of the physical components and software components which constitute the alarm system?</p> <p><i>It is important to clearly define the scope of the alarm system. The scope of the alarm system could include parts of several systems examples are the marine systems, fire & gas, process control system (PCS), ESD and PSD system, and other relevant field instrumentation.</i></p>					<p>Related to YA-711, point 9, p. 10</p> <p><i>DC: Normal alarms in the DC are drilling parameters (pressure, volumes) drilling equipment (height of top drive), pipe handling equipment (racking arms), anti collision/ zone management/ block control, fire and gas (HC, H₂S), well control(BOP), ESD and PSD alarms.</i></p>	
C 4	<p>Is a critical review of what needs to be alarmed, performed?</p> <p><i>It is important to reduce the amount of alarm information.</i></p>					<p>NORSOK I-002 4.4.6.</p> <p><i>DC: Applicable to the DC</i></p>	
C 5	<p>Is the alarm system designed in accordance with ergonomic principles and best practice?</p> <p><i>The alarm system should be designed based on recognised ergonomic principles in order to ensure usability and safe operation.</i></p>					<p><i>DC: Visual alarms signals should be located in front of the driller</i></p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.1	<p>Is the design of the alarm system based on</p> <p>A) an alarm philosophy and</p> <p>B) an alarm specification?</p> <p><i>The alarm system should be designed based on an alarm philosophy, which states aims of the alarm system including how to approach human factors issues. The alarm system should also be based on an alarm specification, in which the components of the alarm system are specified.</i></p> <p>Check:</p> <p>A) <i>that there exist routines to improve the usefulness and usability of the system such as performance requirements,</i></p> <p>B) <i>the role of the operator, how this changes according to operating state, and what support the operator has,</i></p> <p>C) <i>how the design accounts for human limitations,</i></p> <p>D) <i>use of alarm priorities: The purpose of using priorities, how priorities are defined and the rationale behind the definitions,</i></p> <p>E) <i>the use of alarm acknowledgment, describing its purpose and how operators should be trained in using it and</i></p> <p>F) <i>standards, alarm generation and structuring principles.</i></p>					DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.2	<p>Are human factors, capabilities and limitations explicitly taken account for when designing the alarm system?</p> <p><i>Some of the key factors to be taken account of are:</i></p> <p>A) <i>Number of background alarms should be few (Suggested- EEMUA: fewer than one per 5 minutes)</i></p> <p>B) <i>Standing alarms should be few (Suggested from EEMUA: fewer than 10 in normal operations)</i></p> <p>C) <i>Alarm flooding should be reduced (Suggested from EEMUA: fewer than 10 in ten minutes after upset)</i></p> <p><i>This should be documented. The design should ensure that the alarm system remains usable in all process conditions, by ensuring that unacceptable demands are not placed on operators by exceeding their cognitive capabilities.</i></p>					<p>YA-711, point 1, p. 7</p> <p>EEMUA 191.</p> <p>DC: Applicable to the DC</p>	
C 5.2.1	<p>Are suppression mechanisms used to reduce the number of consequence alarms?</p> <p><i>This is especially important during equipment / process shutdown. Too many unimportant alarms divert the operators' attention from important alarms, and the operators may not have sufficient time to check all alarms and analyse the situation. Operators may thus miss critical alarms.</i></p>					<p>YA-711, point 22, p. 15, NUREG0700, point 4.1.3-3, p. 268</p> <p>DC: <i>May not be applicable to the DC, as there is a limited number of alarms</i></p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.2.2	<p>Are spurious alarms avoided?</p> <p><i>Spurious alarms are following on false alarms because of shutdown actions. A high number of false alarms may cause operators to become insensitive to safety alarms and subsequently fail to respond to abnormal situations. They may try to “beat” the safety system by inhibiting safety functions or interpret false alarms as being “real” alarms. Check the frequency of alarms caused by testing of the sensors. Is there a system for planned testing and correlation on sensors?</i></p>					<p>NUREG0700, point 5.3-1, 2, p. 306.</p> <p>DC: Are spurious alarms logged in order to reduce false alarms?</p>	
C 5.2.3	<p>Are performance requirements to the entire alarm system</p> <p>A) defined and</p> <p>B) used?</p> <p><i>Performance measures include usefulness i.e. how many of the alarms are useful for the operator and implies that the operators has to do an action. This is a key performance indicator (KPI). The entire alarm system could include marine, utility, communications, F&G and process systems.</i></p>					<p>YA-711, point 7, p. 9</p> <p>DC: Applicable to the DC</p>	
C 5.3	<p>Is the alarm system context sensitive?</p> <p><i>Check if alarms are designed so that they are worthy of operator attention in all the plant states and operating conditions in which they are displayed. E.g. when the context is the possibility of a marine collision, these alarms should be highlighted instead of process alarms.</i></p>					<p>YA-711, point 2, p. 7</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.4	<p>A) Does each alarm state have a unique presentation?</p> <p>B) Is there consistency between how the different alarm states are presented in the process displays versus other display formats e.g. lists, large screens, panels and matrices?</p> <p><i>Operators must be able to rapidly distinguish between states as e.g. new, accepted, cleared or suppressed alarms.</i></p>					<p>NORSOK I-002, point 4.4.6, p. 13, NUREG0700, point 4.2.3-1, p. 272.</p> <p>DC: Applicable to the DC</p>	
C 5.5	<p>Are alarms integrated in the process displays?</p> <p><i>Operators cannot know the physical location of all alarm sensors by heart, and should therefore have means of identifying the location of infrequent alarms. Information about geographical arrangements of detectors and fire areas shall be available in the CC.</i></p>					<p>YA-711, point 32, p. 18.; NORSOK I-002, point 4.4.5, p. 13</p> <p>DC: Is the location of an activated sensor (pressure, gas, fire, height etc.) presented visually in the drilling displays?</p>	
C 5.6	<p>A) Are alarms assigned different priorities and</p> <p>B) is this documented?</p> <p><i>The rationale behind this prioritisation should be documented. It is important to be able to identify the different priorities and to easily identify high priority alarms.</i></p>					<p>NUREG0700, point 4.1.3-1, p. 268, YA-711, point 25, p. 16.</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.7	<p>Are key alarms (a selection of high priority alarms) identified and presented in a manner that supports rapid detection under all alarm conditions?</p> <p><i>The alarm processing system should ensure that alarms which require immediate operator action or indicate a threat to safety critical functions are presented in a manner that supports rapid detection and understanding, e.g. in a spatially dedicated continuously visible displays (SDCV) manner.</i></p>					<p>YA-711, point 11, p. 11. DC: This question is applicable only to some DCs where there are multiple alarms</p>	
C 5.7.1	<p>Can all key alarms be read even if many alarms are annunciated simultaneously?</p> <p><i>A full overview over key alarms should be provided, e.g. on a dedicated display for all alarms.</i></p>					<p>YA-711, point 40, p. 21., NUREG0700, point 4.2.3-3, p. 272., 4.2.2.2, p 271 DC: This question is applicable only to some DCs where there are multiple alarms</p>	
C 5.8	<p>Are new alarms presented in a manner that supports rapid detection and comprehension?</p>					<p>YA-711, point 35 and 36, p. 19. DC: Applicable to the DC</p>	
C 5.8.1	<p>Are new alarms presented both audibly and visually?</p> <p><i>Audible alarm annunciation should be used when new alarms arrive. Special visual annunciation should be used for new alarms.</i></p>					<p>YA-711, point 35 and 36, p. 19. DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.8.2	<p>Are auditory and visual alert signals</p> <p>A) unambiguous and</p> <p>B) perceivable from all relevant workplaces in the control room under all operating conditions?</p> <p><i>The purpose of auditory and visual alert signals is to attract the operators' attention to a deviation. The use of flashing (or blinking) should be limited. E.g., in alarm messages, only a small symbol should be flashing. Text should never flash. Instead of flashing, other effects could be used that are less disturbing to the eye (i.e. raised face / 3D-effects that highlight new alarms). Operators should be able to easily distinguish between system alarms, process alarms and events. Note to point B) – in some cases there could be just one operator alone in the CC, can he perceive all alarms?</i></p>					<p>NUREG0700, point 4.2.3-1, p. 272., NUREG0700, point 4.6-1, p. 299</p> <p>YA-711, point 35, 36, 39, p. 19-20.</p> <p>DC: Applicable to the DC</p>	
C 5.8.3	<p>Do auditory and visual alert signals have appropriate intensity?</p> <p><i>Alarm signals should not startle, annoy or distract operators, or interfere with verbal communication. Auditory signals should be 10 dB (A) above the ambient noise, but should not exceed 95 dB (A). Signal levels of 115 dB (A) may be used if indicating extreme danger. Visual signals, such as flash lights or flashing symbols, should have a flash rate of 3-5 flashes per second with approximately equal on and off times.</i></p>					<p>NUREG0700 point 4.2.6.3-9, p. 280, NUREG, point 4.2.6.2-3, p. 278.</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.8.4	<p>Is the presentation of alarm information being done by using consistent and unambiguous colours?</p> <p><i>Colours used to prioritise alarms should not be used for other purposes.</i></p>					NUREG0700, point 1.3.8-1, p. 60, YA-711. DC: Applicable to the DC	
C 5.8.5	<p>Are alarm texts informative and easy to understand?</p> <p><i>Understanding alarm texts should require little interpretation and memorization. Alarm texts should only contain information that is essential to the operators. Acronyms and abbreviations should be standardized and known to the operator. Operators should participate in development of alarm texts.</i></p>					YA-711, point 37, 38, p. 20., NUREG0700, point 4.2.5-1, p. 275 DC: The question is applicable to some DCs, where alarms are presented in alarm lists or similar.	
C 5.9	<p>Can the operator</p> <p>A) silence auditory signals from any workstation</p> <p>B) acknowledge alarms only from locations where the alarm message can be read?</p> <p><i>It should be possible to silence an auditory alert signal from any set of alarm system controls in the main operating area. An alarm acknowledgement function should cause the alarm's visual coding to change from that indicating an unacknowledged alarm to an acknowledged state. Acknowledgement should be possible only from locations where the alarm message can be read.</i></p>					NUREG0700, point 4.3.2-1, p. 287, NUREG0700, point 4.3.3-1, p. 288. NORSOK I-002, point 4.4.6, p. 13 DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.10	<p>Does the operator have access to alarm inputs?</p> <p><i>The operator should have the capability of viewing inputs to the alarm processing system (sensor data). Operators may need to view sensor data that results from alarm system processing under certain circumstances, such as if the pattern of alarm messages appears to be contradicting, or if operators suspect that there is a problem with the processing system. The alarm system should provide functions that enable users to evaluate the meaning or validity of the alarm messages.</i></p>					<p>NUREG0700, point 4.1.2-11, p. 267.</p> <p>DC: Applicable to the DC for some alarms.</p>	
C 5.10.1	<p>Are time indications of alarms sufficiently accurate to represent the correct sequence of events especially during an alarm flood?</p> <p><i>Accurate time indications of alarms assist operators in determining the order of alarms and thereby the cause of deviations. This is especially important in distributed systems.</i></p>					<p>NORSOK I-002, point 4.4.10, p. 15</p> <p>DC: Applicable to the DC</p>	
C 5.10.2	<p>Is the warning alarm related to trip limit, set in such a manner that the operator can react before the trip limit is reached?</p> <p><i>This can be done by monitoring parameter trends. (This question should be resolved before the CRIOP meeting.)</i></p>					<p>Smidt Olsen & Wendel, 1998, App.2</p> <p>DC: For instance height of the top drive. Is mud logging involved in setting the trip limits and the alarm settings?</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 5.12	<p>Are relevant availability requirements defined for the alarm system?</p> <p><i>It is important that the components constituting the alarm system are fault tolerant, so that the system ensures that safety critical information always is available to the operators, both in normal operation and during emergencies. Factors to be considered include: redundant CPU, I/O and bus systems, UPS as back up to electrical/electronic equipment and redundant displays.</i></p>					<p>YA-711, point 9, p. 10</p> <p>DC: Is independent backup of safety critical systems in the drilling module available (H₂S, HC, pressure, flow rates)?</p>	
C 6	<p>Are control actions fault tolerant and simple to execute?</p> <p><i>Errors in manual actions are more likely in stressing situations, e.g. accurately placing light pen on displays or entering words longer than 7 characters.</i></p>					<p>NUREG0700, point 3.1.1-14, p. 219, point 2.2.1-5, p. 115.</p> <p>DC: Applicable to the DC</p>	
C 6.1	<p>Are operational systems, instruments and controls which are used together located next to each other?</p> <p><i>Related controls and displays should be easily identified as being associated such as metering system, marine system, F&G system</i></p>					<p>NUREG0700, point 11.2.1-1, 3, p. 429.</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 6.2	<p>Are warnings provided if out-of-range values are entered?</p> <p><i>Entry of out-of-range/extreme values (e.g. out-of-range values can be expressed as % change in relation to a given value) may initiate deviations in the process and damage equipment. Check keyboard entry commands for potentially dangerous similarities. Data being entered should be displayed and the data should be checked and a confirmation requested.</i></p>					<p>NORSOK I-002, point 4.4.1.2, p. 10., NUREG0700, point 2.7.4-1, p. 199.</p> <p>DC: Applicable to the DC</p>	
C 7	<p>Is the emergency shutdown system status available, clearly readable and unobstructed from the operator's workplace?</p> <p><i>Check: by-pass of emergency shutdown system actions (inhibitions) and fire and gas detections.</i></p>					<p>NORSOK I-002, point 4.2.1, p. 6, NUREG0700, point 5.4-1, p. 307.</p> <p>FA § 32. § 7.</p> <p>DC: Applicable to the DC</p>	
C 7.1	<p>Is the shutdown logic available on displays (cause and effects)?</p>					<p>CRIOP 15/2-1990, See 9.3.2 in S-001</p> <p>FA § 32.</p> <p>DC: Not applicable to the DC</p>	
C 7.2	<p>Does the operator receive the correct chronological order of shutdown activation?</p> <p><i>It is important that the operator is alerted when a shutdown function is released and the cause of the shutdown (first out alarm).</i></p>					<p>FA § 32.</p> <p>DC: Few levels, seldom applicable to the DC</p>	
C 8	<p>In the case of fire or gas detection, are follow on actions performed automatically?</p> <p><i>E.g. PA messages to go out automatically or deluge performed automatically.</i></p>					<p>FA § 31.</p> <p>DC: Not applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 8.1	<p>Is the operator timely informed about deviations when performing the shut down function?</p> <p><i>In order to be able to intervene, operators must be able to detect any failures in shutdown actions. A separate deviation list could be presented to the operator. Check: process control system, process shutdown system, emergency shutdown system, fire and gas detection and depressurizing system.</i></p>					<p>NUREG0700, point 1.1-22, 23 p. 13, point 5.3-1, p. 306.</p> <p>FA § 32.</p> <p>DC: Not applicable to the DC</p>	
C 9	<p>Can safety systems be started manually from the CC?</p> <p><i>Examples: De-pressurisation, fire pumps etc.</i></p>					<p>FA § 34 and 35.</p> <p>DC: Partly applies to the DC. Emergency shutdown in the drilling area may include ESD valves in different levels, stop of all moving items (top drive, racking arms etc.), BOP, fire pumps, deluge etc.</p>	
C 9.1	<p>Are emergency controls on panels easily accessible?</p> <p><i>Emergency controls on panels should be located between 76 cm and 125 cm above the floor when seated (see Figure 4.2) and between 90 cm and 150 cm (shoulder height) when standing for easy operation.</i></p>					<p>ISO-11064-4, Figure-2, NORSOK S-002, REV 4, 5.2.1.1.</p> <p>DC: Are emergency shutdown buttons easily accessible?</p>	
C 9.2	<p>Are critical actions/shutdown actions protected from accidental activation?</p> <p><i>Controls may be recessed, shielded, or otherwise surrounded by physical barriers to protect shutdown actions for accidental activation. Controls should be operable from the location where the user is most likely to need to interact with the system. Check: keyboard, mouse, trackball and light pen.</i></p>					<p>NUREG0700, point, 3.1.1-4, 5, p. 218.</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 9.3	<p>Is any bypass of the emergency shutdown system entered in a log book?</p> <p><i>Information concerning bypass of automatic shutdown actions must be available to all involved personnel, who, when, why is important to document. The log book might be electronic. It is important to easily extract a short list of outstanding bypasses.</i></p>					<p>CRIOP 15/2-1990.</p> <p>DC: Applicable to the DC when safety systems and emergency shutdown systems are bypassed</p>	
C 10	<p>Are the main objectives and specification for the communication equipment properly identified and documented?</p> <p><i>Equipment may be telephones (hot line, emergency, and mobile phone), VHF and UHF radios, videophones and smart boards. Things to consider: prioritisation, localisation, numbers, ringing tones, visual marking, user configuration, caller displays, set over, Bluetooth and hands-free.</i></p>					<p>DC: Applicable to the DC</p>	
C 10.1	<p>Is communication equipment distinguished both visually and audibly?</p> <p><i>Similar communication equipment should be marked to avoid confusion concerning “which is which”. High priority telephones should be distinguished audibly and visually from other telephones. This should be based on a communication specification – which prioritizes communication equipment.</i></p>					<p>NORSOK S-001, point 9.1, p. 18, NUREG0700, point 10.2.2-7, p. 399.</p> <p>DC: Intercom, telephone and radio communication equipment should be easily distinguishable.</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 10.2	<p>Can communication equipment be reached from the operator's workplace?</p> <p><i>Control room operators should be able to communicate with other personnel while working at the displays. Check radio, VHF, telephones, public address system (PA), and intercom.</i></p>					NUREG0700, point 10.1-1, p. 395. DC: Applicable to the DC	
C 10.3	<p>A) Is back-up communication equipment or alternative means of communication provided?</p> <p>B) Is the communication equipment connected to emergency power supply?</p> <p><i>Alternative means of communication should be available in the case of equipment failure or danger or accidents. There must be an emergency power supply.</i></p>					NUREG0700, point 10.2.7-1, p. 404. FR § 17. DC: Applicable to the DC	
C 10.4	<p>Are dedicated communication lines provided between the emergency control centre and the control room?</p> <p><i>Communication between operators and the emergency control centre must be possible in spite of extensive heavy communication during abnormal situations.</i></p>					NUREG0700, point 12.1.1.6-2, p. 464. DC: May be applicable to the DC	
C 11	<p>Are all necessary questions asked related to Control and Safety Systems?</p>					DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
C 12 Drillers Cabin	<p>Has the communication in the driller's cabin been considered with respect to:</p> <p>A) Communication between the driller's cabin and other control cabins in the drilling module?</p> <p>B) Activation of communication equipment whilst operating drilling equipment?</p> <p>C) Communication between driller cabin and drill floor personnel?</p> <p><i>It is important that the communication between the driller's cabin and other control cabins in the drilling module is easy to perform. The communication equipment should be designed based upon an analysis of the communication needs. The communication equipment should be designed to protect against inadvertent operation.</i></p>					Other relevant cabins are mud logging, derrick mans cabin etc.	

Checklist 4: Job Organisation

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

4. JOB ORGANISATION

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 1	<p>Is it documented that the job and work organisation takes into account relevant information such as:</p> <ul style="list-style-type: none"> A) Task analysis covering all modes of system operation and administrative tasks B) Workload analysis C) Workstation design D) Job satisfaction E) Lessons learnt from incidents <p><i>The analyses should consider all modes of system operation including start-up, normal operation, shutdown, anticipated emergency scenarios, periods of partial shutdown for maintenance, the results used in the design process and the development of staffing plans. In addition to the immediate and obvious ergonomic requirements imposed by the installation in focus, more subtle psychological demands may be require attention. These include self-fulfilment, motivation, and cultural considerations. Define factors influencing the job satisfaction. Determine how to measure them.</i></p>					<p>HFAM (NPD 2003), ISO 11064-1 / 4.6</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 1.1	<p>Are tasks adequately allocated between operator and system?</p> <p><i>Check: Are high speed, high accuracy or highly repetitive tasks done automatically? Document the criteria used in this allocation. Function allocation should support cooperation between operator and machine.</i></p>					<p>ISO 11064-1, 7.3 DC: Applicable to the DC</p>	
J 1.1.1	<p>A) Is the operator fully aware of what he or she is expected to do at all times?</p> <p>B) Are operators given reasons for what they are expected to do under all circumstances?</p> <p><i>The operator should be fully notified about targets, priorities and consequences of failure. Criteria for taking over manual control from automatic equipment should be clear and unambiguous. A job assignment criteria checklist should be developed to help assign the tasks to a particular job. In addition, the operator should be given reasons for what s/he is expected to do, as operators are less likely to engage in alternate behaviours if they are well aware of the cause of a required behaviour.</i></p>					<p>ISO 11064-1, 7.4, 7.5; HFAM (NPD 2003) DC: <i>Is there a system for safety job analysis, pre-job meetings and information meetings at departure to drilling location? Are the drillers involved in preparing and checking the procedures?</i></p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 1.1.2	<p>Are there conflicts or incompatibilities in operator requirements?</p> <p><i>The operator should not be expected to resolve conflicts between production regularity and safety. Operators must not be “rewarded” for unsafe acts or for maintaining production when they should have shut down.</i></p>					DC: Applicable to the DC	
J 1.2	<p>Are jobs organized so that all operators have a roughly equal workload?</p> <p><i>A workload analysis should be carried out to ensure that all operators have an optimal and roughly equal workload.</i></p>					HFAM (NPD 2003) DC: Applicable to DCs where there is more than one operator	
J 1.3	<p>Is the allocation of responsibility and authority clear, complete, non-overlapping, known to and accepted by the operators and their collaborators?</p> <p><i>Each operator should be informed about his or her responsibilities, as this will ensure that all tasks are conducted as required. This is also very important related to collaboration related to remote operations or remote support.</i></p>					ISO 11064-1, 7.5 DC: Is the driller's and assistant driller's responsibilities clearly stated and known to supervisors, drillers, deck personnel and relevant operators in the drilling module?	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 1.4	<p>Are periods of high and low mental workload within acceptable limits?</p> <p><i>Good operator performance during high workload periods can only be maintained for short periods of time, not to exceed 45 minutes. Describe periods with high mental or physical workload. Operator ability to detect visual signals is significantly reduced after periods of boredom (half an hour).</i></p>					DC: Applicable to the DC	
J 1.5	<p>Are the shifts designed according to rules, regulations and standards?</p> <p><i>Examples are HSC Rules and regulations (In Norway: Arbeidsmiljøloven and ISO 11064).</i></p>					Ref. Arbeidsmiljøloven. DC: Applicable to the DC	
J 1.5.1	<p>Is job rotation practiced?</p> <p><i>Job rotation implies that operators alternate between the control room and the field. Job rotation reduces boredom and may improve operator motivation and alertness. In addition, operators learn the process systems and installation layout better by having experience from the field. Job rotation reduces boundaries between organisational units, and thereby encourages co-operation and information flow between these units (but only if proper training is provided) .Not applicable (NA) is a possible answer.</i></p>					ISO 11064-1, annex b, b4 DC: May not applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 1.5.2	<p>Are breaks planned / coordinated with control centre tasks?</p> <p><i>The work load must be planned so that operators can take breaks during quiet periods.</i></p>					ISO 11064-1, 7.5 DC: Applicable to the DC	
J 1.6	<p>Is the job and work organisation designed to handle abnormal situations?</p>					ISO 11064-1 DC: Applicable to the DC	
J 1.6.1	<p>Are the changes in responsibilities during an emergency / abnormal operation clearly defined and established through practice?</p> <p><i>Responsibilities and operator task in the control room change from normal situations to abnormal operations. These changes must be known to and accepted by all personnel.</i></p>					ISO 11064-1, 7.2 DC: Are the driller's responsibilities versus the company man's or tool pusher's responsibilities in case of a well control situation clearly defined and known by relevant personnel?	
J 1.6.2	<p>Is relevant and competent assistance to the control room operators from other personnel available during abnormal situations?</p> <p><i>The job organisation shall allow operators to exchange or share information in such cases where teamwork is required to carry out a task. Check: field operators, supervisors, management, instrument, maintenance, electrical. This should be part of emergency operation procedures (EOP) and should describe who does what and when.</i></p>					ISO 11064-1, 7.5, NUREG0700, 070, rev 2, 12.1.1.6 DC: Are other personnel with required certificates and courses available during abnormal situations? Are there dedicated personnel for this on each shift?	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 2	Is the job organisation designed to provide effective information transfer?					DC: Applicable to the DC	
J 2.1	<p>Does the work permit system assure that operators and supervisors are continuously aware of all critical and hazardous work in progress?</p> <p><i>A large number of work permits often make it difficult to have an overview over work in progress. Possible measures are:</i></p> <p>A) <i>Check: transfer of information between shifts, different departments and installations (example flotels).</i></p> <p>B) <i>Ensure that work permits are issued for critical or hazardous operations.</i></p> <p>C) <i>Establish a maximum number of work permits operators are allowed to issue.</i></p> <p>D) <i>Improve control by reducing administration of work permits/ persons involved.</i></p>					FR § 44. DC: Applicable to the DC related to drill floor, drilling cabin, etc.	
J 2.2	<p>Are procedures for communication drawn up and followed?</p> <p><i>Check: restrictions concerning unnecessary use of radio, acknowledgement of important messages, use of different radio frequencies/channels, communication equipment checks, use of standard abbreviations and acronyms familiar to all involved parties to avoid misunderstanding.</i></p>					ISO 11064-1, 7.5 DC: <i>Is there a dedicated drilling channel?</i>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 2.3	<p>Are there clear procedures for the handover of information and responsibility between different control room shifts and between different personnel categories?</p> <p><i>Frequent changes of personnel are a common source of misunderstandings and communication breaches in offshore organisations. Procedures and checklists for handover must be drawn up and practiced in order to ensure that important information is transferred. In addition, the transfer of information between different personnel categories should be considered, as personnel may operate with different mindsets and different verbal expressions.</i></p>					<p>AR § 30. ISO 11064-2, 4.5 <i>DC: Are proper handovers between drillers and assistant drillers performed?</i></p>	
J 3	<p>Is the information from incidents used for modifications and future design?</p> <p><i>Experience from incidents should be used to ensure that problems are not repeated in future design. Experience from process disturbances are a useful source of information when designing a new control centre and upgrading installations. Is there a system to ensure distribution of information regarding incidents, modifications to relevant personnel? Experience also helps operators mentally prepare for similar situations as well as preventing mistakes from being repeated.</i></p>					<p>ISO 11064-1, 10.1 & 10.2 <i>DC: Is there a system to ensure distribution of information to relevant personnel such as drillers, derrick man etc?</i></p>	
J 3.1	<p>Is there a reporting system for near incidents and near misses?</p> <p><i>There should be a focus on the reporting system. The system should be actively used for recording near misses, incidents and accidents. The system should be capable of providing a list of all incidents.</i></p>					<p>ISO 11064-1, 10.2 FR § 13, MR § 18, 19. DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
J 3.1.1	<p>Is the reporting system used actively?</p> <p><i>See above.</i></p>					ISO 11064-1, 10.2 FR § 13, MR § 18, 19. DC: Applicable to the DC	
J 3.1.2	<p>Are the recommended changes following an incident implemented within an acceptable time frame?</p> <p><i>All actions regarding equipment, procedures, training etc. following incidents must be followed up within the organisation. It is important to inform personnel about the resulting changes and their timely execution as this may increase awareness and also motivate for further reporting.</i></p>					ISO 11064-1annex b, b3. FR § 13. DC: Applicable to the DC	
J 4	<p>Are all necessary questions asked related to Job Organisation?</p>					DC: Applicable to the DC	

Checklist 5: Procedures and work descriptions

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

5. PROCEDURES AND WORK DESCRIPTIONS

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1	<p>Is a consistent approach used to develop, use and maintain procedures and work descriptions?</p> <ol style="list-style-type: none"> 1. <i>Has a philosophy and goal/vision for development of procedures and work descriptions been established?</i> 2. <i>Have principles been established to distinguish between mandatory procedures and guidelines (work descriptions)?</i> 3. <i>Is there coherence between philosophy, goals, rules, procedures, work descriptions and working practice?</i> 					Vatn (1997) DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1.1	<p>Are procedures developed in a structured manner, based on functional analysis and task analysis?</p> <p><i>The structured approach should consist of the following steps:</i></p> <ol style="list-style-type: none"> 1. <i>Identify core tasks, identify hazards and working environment issues and identify supporting tasks related to these.</i> 2. <i>Plan the sequence of the core tasks and supporting tasks.</i> 3. <i>Perform a hierarchic breakdown of the tasks.</i> 4. <i>Perform tabular task analysis of critical and difficult task steps. This should include human – machine interaction and possible erroneous actions.</i> 5. <i>Perform structured walk trough of the procedures/ work descriptions.</i> 					Vatn (1997) DC: Applicable to the DC	
P 1.1.1	<p>Are procedures clearly marked with titles/labels?</p> <p><i>Titles and labels should allow the operator to choose the required procedure quickly. Check: typographical, colour and shape coding of procedures. It is important that the use of the latest version is verified and that the version is clearly stated in the procedure.</i></p>					DC: Applicable to the DC.	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1.1.2	<p>Are the criteria and conditions for use of procedures clear and unambiguous?</p> <p><i>The procedures should be used as a measure to prevent errors and accidents. Are all conditions required to perform the operation stated before first step in the procedure is performed.</i></p>					<p>UKAEA p.12 AR § 22.</p> <p><i>DC: Are all conditions stated before first step in the procedure such as all pipes are drifted and measured, pipe tally is supplied to the driller, 5200 m 5 ½" drill pipe in derrick, pressure test prior to drill out cement etc.?</i></p>	
P 1.1.3	<p>Do the procedures include information about why a certain method of working is necessary?</p> <p><i>Operator understanding is complimented if procedures provide knowledge about actions in the process, rather than a set of rules for the operator to follow blindly. . The procedures should also contain information about operating envelopes.</i></p>					<p>UKAEA p.12 Rasmussen (97)</p> <p><i>DC: Do the procedures contain a short start-up list in case of temporary stops in the operation, crew change, breaks, personnel off hazard areas on the drill floor, racking arm removed, all involved personnel ready to proceed etc.?</i></p>	
P 1.1.4	<p>Can the instructions in procedures be easily understood and followed, particularly by a person who is unfamiliar with them?</p> <p><i>The wording in the operation procedures should be kept short and consistent. Procedures in a step-by-step columnar format reduce the number of words necessary to describe actions, as opposed to a narrative format. Drawings, figures, check-off provisions and feedback from control room systems should be provided.</i></p>					<p>UKAEA p.14</p> <p><i>DC: The procedures should keep the selection of methods and conditions separated from the actual action steps in the procedure</i></p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1.1.5	<p>Do the procedures and work descriptions support fault tolerant work practices?</p> <p><i>Fault tolerant work practices allow human errors to be detected and be recovered.</i></p>					<p>Skjerve (2004)</p> <p><i>DC: In case a step can cause a result to turn out differently, the events with their actions steps should be clearly separated. For instance, "if running tool is not released, add additional 5 tons (Total maximum 50 tons) and proceed"</i></p>	
P 1.2	<p>Do operators participate in the development and testing of procedures?</p> <p><i>Operator participation in the development and testing ensure that procedures are practical and in accordance with "real life" on the installation, thus ensuring personnel acceptance.</i></p>					<p>CRIOP 15/2-1990.</p> <p>AR § 23.</p> <p>DC: Applicable to the DC</p>	
P 1.2.1	<p>Are the procedures and operators' skills complementary?</p> <p><i>Where the operators are skilled and experienced, and an absolutely standard sequence is not necessary, the procedures should be in the form of reminder checklists with guidance on priorities, rather than detailed instructions.</i></p>					<p>UKAEA p.13</p> <p>DC: Applicable to the DC</p>	
P 1.3	<p>Is a system for checking and modification of procedures established?</p>					<p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1.3.1	<p>Are procedures checked routinely, compared with operator action and revised as appropriate?</p> <p><i>The updating of procedures is often not carried out systematically in the organisation, causing information to be out of date. Check:</i></p> <p>A) <i>the company's system for updating procedures and</i></p> <p>B) <i>that all the written procedures are used and really necessary.</i></p>					UKAEA p.12, CRIOP 2/15-1990 DC: Applicable to the DC	
P 1.3.2	<p>Is it easy to modify procedures when needed?</p> <p><i>There must be rules and authorisation to cover these areas.</i></p>					DC: Applicable to the DC	
P 1.3.3	<p>Are the procedures available on-line, and in latest version?</p>					DC: May not be applicable to the DC because of missing on-line terminals.	
P 1.4	<p>Do the procedures and work description support handling of abnormal situations?</p> <p>A) <i>Do the procedures and work description describe how to handle the most common abnormal situations?</i></p> <p>B) <i>Do the procedures and work descriptions support improvisations in critical and unforeseen situations?</i></p>					Skjerve (2004) DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 1.4.1	<p>Are emergency procedures distinguished from other procedures?</p> <p><i>The emergency procedures should be available as a hard copy, clearly marked, in the CC.</i></p>					DC: The emergency procedures used during a serious condition must be separate, clearly marked documents. Procedures used in a less serious situation can be part of the normal operation procedure, clearly distinguished such as last chapter. Reference from the normal operation procedure steps to the emergency procedure should be made	
P 1.4.2	<p>Are emergency procedures provided in sufficient number in the control room?</p> <p><i>Each control room operator should have access to a complete set of procedures in the control room, to be used if power supply is failing. It could be easier to access the procedures in a binder while the displays must be used to other purposes.</i></p>					UKAEA p.12 DC: Applicable to the DC	
P 1.4.3	<p>Are written bypass procedures provided for manual actions when automatic actions are unavailable?</p> <p><i>Is there guidance when the automatic action fails? Can the CC be manually operated?</i></p>					DC: Applicable to the DC	
P 1.4.4	<p>Is any bypass of the emergency shutdown system authorized by a responsible person?</p> <p><i>Bypass of automatic shutdown actions are vital to installation safety, and must only be carried out after authorization by personnel who have a full overview over activities on the installation.</i></p>					DC: Applicable to the DC – example collision avoidance systems.	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
P 2	Are all necessary questions asked related to Procedures?					DC: Applicable to the DC	

Checklist 6: Training and Competence

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

6. TRAINING AND COMPETENCE

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 1	<p>Is the requirement for a training program established?</p> <p><i>The requirements should cover what (all operating conditions) and who (who participates in the team?). This can for instance be presented in a competence matrix.</i></p>					<p>Management Regulations section 11.</p> <p>DC: Applicable to the DC.</p>	
T 1.1	<p>A) Is a systematic method used to document all CC tasks across all operating conditions including abnormal conditions and remote support?</p> <p>B) Is a systematic method used to document associated training needs?</p> <p><i>Training needs should be identified through a systematic process covering function- and task analyses. This process must be carried out when the overall design of the CC is ready and the amount of remote support has been decided. Training needs also have implications for manning of the CC.</i></p>					<p>Management regulations chapter 2, section 17 AR § 19.</p> <p>DC: Applicable to the DC</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 1.2	<p>Have all involved team members been identified including personnel involved in remote support?</p> <p><i>All the team members involved must be identified. In an environment with remote support, team members could be involved from both offshore and onshore. The team members could be involved in all operating conditions including abnormal conditions and remote support.</i></p>					DC: Applicable to the DC	
T 1.3	<p>Does the operator have the required qualification and competence to perform the task?</p> <p><i>Competence criteria should be defined for jobs that are of significance to safety. Can be presented in a competence matrix. (This area could be explored by discussing- How is the qualification objectively documented?)</i></p>					Management Regulations chapter 2, section 17 Management Regulations section 11. FR §.10 DC: Applicable to the DC.	
T 1.4	<p>A) Are learning objectives identified? B) Are learning objectives incorporated into the training programme?</p> <p><i>Learning objectives should be based on the task analysis conditions and standards of performance including HSE issues and include these in the training programme.</i></p>					HFAM (NPD 2003) AR § 20. <i>DC: Is there a programme for training of the drillers, and are the learning objectives identified and incorporated in the programme? Are the drillers frequently and systematically trained?</i>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 1.4.1	<p>Are operators trained in all operational conditions including abnormal situations?</p> <p><i>This should include start up, shut down, abnormal situations and normal operations. During start-up, many problems arise that do not occur when the process is in a stable running state. Shutdowns and abnormal situations are frequent in this period and this experience is an important contribution to operator competence.</i></p>					<p>ISO 11064-1, 10.2 Management Regulations section 11.</p> <p><i>DC: Are the driller, tool pusher, company man etc. trained to work as a team in abnormal situations?</i></p>	
T 1.4.2	<p>Is training given in the use of all job aids?</p> <p><i>Check: Procedures, work permits, logs and emergency equipment.</i></p>					DC: Applicable to the DC	
T 1.4.3	<p>Do operators receive instruction and systematic training in all realistic operational usage of the alarm system?</p>					<p>YA-711, point 3, p. 8. DC: Applicable to the DC</p>	
T 1.4.4	<p>Are operators trained in the use and objectives of mimics and large screen displays?</p>					<p>IFE (2003) question 8, p. 33, App. 2 DC: Applicable to the DC – related to mimics</p>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 1.4.5	<p>Are operating teams trained to communicate effectively using the equipment available?</p> <p><i>Check: Team members onshore, offshore, expert teams giving remote support and supporting staff from suppliers and other remote staff.</i></p>					DC: Applicable to the DC	
T 1.4.6	<p>Are operating teams trained together in the allocation/transfer of responsibility?</p> <p><i>Check: Team members onshore, offshore, expert teams giving remote support and supporting staff from suppliers and other remote staff.</i></p>					DC: Is an onshore emergency /support team established? Are the "on location team" and the onshore emergency team trained to work together as a team in abnormal situations?	
T 1.4.7	<p>Are operators trained in diagnostic skills which will help them to cope in unfamiliar situations?</p>					AR § 20. DC: Applicable to the DC	
T 1.4.8	<p>Are operators trained in correcting their own errors?</p>					DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 2	<p>Is there an attitude of non-penalization and organisational learning when an operator makes an error?</p> <p><i>Learning from own and other's errors/experiences is valuable. Is there a system for sharing experiences/errors in the organisation? In order to ensure an optimal workplace, where reporting of deviations result in positive changes, an attitude of non-penalisation must be implemented. This attitude is important, as it not only will lead to improvements during operation, it can also affect the development of new projects in a positive manner. It also affects the reporting culture in the organisation.</i></p>					ISO 11064-1, 4.6 DC: Applicable to the DC	
T 2.1	<p>Are simulators or other training methods used for teaching manual operations and fault handling?</p> <p><i>In order to ensure adequate training covering fault handling and exception handling simulators, scenario workshops or training based on virtual reality should be used.</i></p>					DC: Applicable to the DC	
T 2.1.1	<p>Does the simulator or other training methods allow for training of emergency scenarios that the operator seldom experiences in reality?</p>					DC: Applicable to the DC	
T 2.1.2	<p>Does the simulator or other training methods accurately mimic relevant process characteristics?</p>					<i>DC: Does the simulator or other training methods mimic relevant drilling and well operations, including well control operations?</i>	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 2.2	<p>Is the effectiveness of different training methods evaluated for the different types of tasks to be performed?</p> <p><i>Examples of tasks are day-to-day vs. emergency operations. Different training methods have different outcomes depending on task. To select the most suitable training method, it is necessary to compare outcomes from different methods.</i></p>					HFAM (NPD 2003) DC: Applicable to the DC	
T 2.2.1	<p>Is on-the-job training practiced and followed up?</p> <p><i>The operators' basic training is supplemented with practical experience through on-the-job training.</i></p>					DC: Applicable to the DC	
T 2.3	<p>Is a CRM (Crew Resource Management) training concept:</p> <p>A) evaluated and</p> <p>B) implemented</p> <p><i>CRM training covers areas such as communication, situational awareness, team work, decision making, leadership and personal limitations.</i></p> <p><i>CRM training has been demonstrated to reduce the number of accidents by preventing errors, trapping errors and mitigating errors.</i></p>					Mearns (2001), Flin (1997). DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 2.4	<p>Are the learning outcomes of the training programmes evaluated?</p> <p><i>Transfer of training is critical to operator performance. The only way to assess how well training transfer into task performance is to conduct an evaluation of what the operator has learned.</i></p>					HFAM (NPD 2003) DC: Applicable to the DC	
T 2.5	<p>Is upgrade training provided at regular time intervals?</p> <p><i>Operators take time to adjust from a free period to work in the control room, and to: “get the picture” of the process again. Ultimately, this may imply that the production organisation is more vulnerable to process disturbances when a new shift takes over.</i></p>					DC: Applicable to the DC	
T 2.5.1	<p>Are operators re-trained regularly in knowledge of and handling of emergencies?</p> <p><i>During stable production phases, the operators encounter few process disturbances in their daily work. Experience and skills which have been accumulated through training and participation in the platform start-up will gradually be forgotten if they are not maintained regularly.</i></p>					DC: Applicable to the DC	
T 3	<p>Are experience and the information from incidents used in the re-training of operators?</p> <p><i>Experience and the information from incidents should be spread systematically to all operators on the installation through the company training department.</i></p>					ISO 11064-1, 10.2 DC: Applicable to the DC	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
T 3.1	<p>Do changes in requirements for task performance result in changes in training and training materials?</p> <p><i>Multiskilling, job-rotation, new equipment, new technology and minor alterations to the CC may change the work situation for the operator. These changes should be documented analyse and new associated training needs should be included in existing training programmes.</i></p>					<p>HFAM (NPD 2003) AR § 20. DC: Applicable to the DC</p>	
T 4	<p>Are all necessary questions asked related to competence and training?</p>					<p>DC: Applicable to the DC</p>	

***Checklist 7: e-Operations or Integrated Operations (IO)
(Remote Control, Remote Operations)***

Integrated Operations (IO) or e-Operations are increasingly influencing operations due to organisational and technical changes. Main motivations for implementation of IO has been the potential for increased yield and income from the fields, operational cost reduction and increased safety. IO may enable better utilization of expertise and resources independent of geographical location, leading to more interaction between different actors placed at dispersed sites. Key actors involved in IO are the control room offshore, the operator's onshore operating centre, service companies' onshore operating centre and external experts.

We are moving from teams close to the operational environment i.e. close to people offshore; to remote support or remote operations when IO is implemented. In remote operations more of the team is isolated from the operations i.e. other people offshore, environment such as weather (storm or calm), sound (does the sound of the mechanical equipment indicate need for maintenance) or smell (such as the smell of gas). This may be a challenge when operational knowledge and situational awareness must be shared to improve operations and avoid incidents. Several tasks in operations and maintenance may be outsourced and this trend may increase. The increased connectivity, geographical distances, outsourcing and the increased use of suppliers leads to a network of actors which by accident, misunderstanding or purpose can inflict unforeseen incidents or accidents.

The technical ICT systems used in operations include three main areas; the ICT infrastructure, the process control systems (PCS) and the safety instrumented systems (SIS). The ICT infrastructure consists of network, supporting systems such as SAP, maintenance systems, infrastructure such as telephone support systems, radar and video systems (closed-circuit television – CCTV). Process control systems are used during production and include sensors and process shut down systems (PSD). The safety instrumented systems are used during emergency shutdowns (ESD) and to prevent fire & gas emissions (F&G). The PCS and SIS systems together are usually called safety and automation systems (SAS). The technologies used are changing from proprietary stand-alone systems to standardized PC-based ICT systems integrated in networks, which may be connected to the Internet. The standardization and increased networking between the production systems, SAS systems, and the general ICT infrastructure may lead to tighter couplings and more complexity; and this may increase the possibilities of unwanted incidents.

The e-Operations checklist has been developed together with partners from the industry such as ABB, EKA, Hydro, Scandpower, SENSE Intellifield and Statoil. We have used key resources having long experiences with e-Operations. The rationale behind the e-Operation questions has been published in Johnsen (2005b) at ESREL 2005. The checklist has been designed to be used:

- in a normal CRIOP analysis when e-Operations is involved, together with the other CRIOP checklists. The checklist should then be used as the other checklists.
- individually to **focus on e-Operations**, using the other CRIOP checklists when appropriate. (Such as checking room layout, design of alarms, etc.) The e-Operations checklist can be used in an earlier stage such as during A. Clarification and B. Analysis as described in figure 4-3.

When the e-Operations checklist is used during the phases A. Clarification or B. Analysis, the focus is on common definitions, visions, goals and strategies.

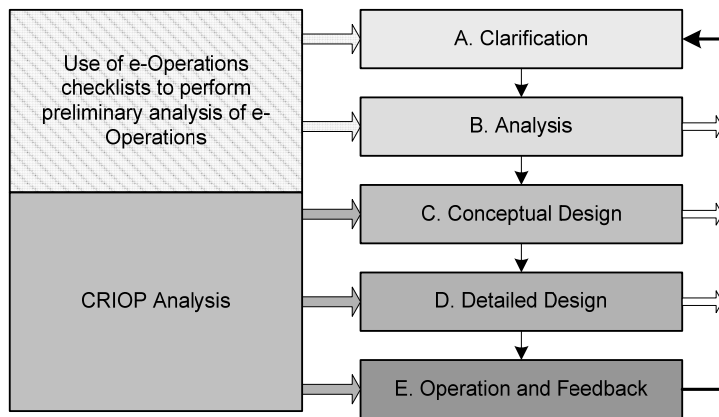


Figure 4.4: Scope of the e-Operation checklist, used stand-alone

Based on experiences, some key issues to explore during a CRIOP analysis of IO could be:

- Has increased safety been a actual goal when IO (remote operations or remote support) has been implemented?
- Has a systematic risk analysis been performed of IO?
 - Has suppliers and contractors been involved in the risk analysis in order to identify the most common risks and establish common risk perceptions?
- Has a scenario analysis been performed involving participants from the different organizations involved in IO?
 - Scenarios could be loss of communication or emergency situation involving collaboration between distributed teams?
- Has incidents related to IO been shared between the different actors involved in IO, such as between control rooms or different organisations?
 - Relevant incidents could be related to security.

Central Control Centre (Room/Cabin) Review

Facility	Performed by/date	Approved by/date

7. e-OPERATIONS

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 1	<p>A) Is e-Operation defined and precisely described?</p> <p>B) Is the degree of remote operations or remote support defined and precisely described?</p> <p><i>To avoid misunderstandings and uncertainty it is important to define the concept and the degree of remote operations precisely, this will ensure a better implementation process and better result. This is an important foundation to create a common situational understanding and awareness among all the different actors and participants. Four examples of different degrees of remote operations are listed.</i></p> <p><i>Which alternative is most appropriate?</i></p> <p><i>1. Remote Support: The operation is managed or operated offshore, but some sort of remote support is being given by onshore experts via teleconferencing, video, phone or radio.</i></p> <p><i>2. Remote Monitoring: The operation is managed or operated offshore, but some sort of remote monitoring is being performed by onshore experts.</i></p> <p><i>3. Remote Control: Parts of the operation is managed and operated remotely.</i></p> <p><i>4. Remote Control of all operations: The operation is managed and operated remotely.</i></p>					Kotter(1996), Johnsen (2005a)	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 2	<p>A) Is a compelling vision and a goal of e-Operations defined in cooperation with the key stakeholders?</p> <p>B) Are the vision and goal of e-Operation in accordance with the underlying values and philosophy of the organisation?</p> <p>C) Is the rationale behind the vision and goal understood by the key stakeholders?</p> <p><i>To avoid complacency and resistance it is important to establish a compelling vision and goal of e-Operations in cooperation with key stakeholders. The goal and vision of e-Operations must be in accordance with the underlying values and philosophy of the organisation or some of the issues must be changed or brought in accordance with each other.</i></p>					Kotter(1996)	
E 2.1	<p>Are e-Operations specified and developed in co-operations with the key stakeholders such as employees?</p> <p><i>To ensure participation from management and employees the development of e-Operations should be done both top-down and bottom-up. This could aid in the change process. Key stakeholders such as top and middle management and the employees should participate in the change process. Both the end result, implementation process and time schedule should be developed in co-operation with the key stakeholders.</i></p>					Pinto(1996)	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 2.2	<p>Is a cost/benefit analysis documented in cooperation with the key stakeholders?</p> <p><i>A compelling cost/benefit analysis should be documented in cooperation with the key stakeholders. Management has the responsibility to develop a cost/benefit analysis. A consequence analysis should be performed, documented, and presented to the key stakeholders.</i></p>					Kotter(1996)	
E 3	<p>Is experience from other relevant projects used?</p> <p><i>Experience from relevant projects within and outside the company should be gathered to avoid pitfalls and ensure good organisational learning.</i></p>					Kotter(1996)	
E 4	<p>A) Is the project prioritised by management? B) Are sufficient competent resources been allocated to the project to meet the deadlines? C) Are senior management accountable?</p> <p><i>Management must allocate key resources from the line to the e-Operations project to ensure the success of the project.</i> <i>Since e-Operation could make fundamental changes – it is important to involve competent resources.</i> <i>To ensure the necessary focus on safety and security- top management must be directly and personal accountable for the changes.</i></p>					Kotter (1996), HSE (2003).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 5	<p>A) Are the important stakeholders identified, analysed and involved in the change project?</p> <p>B) Is a powerful guiding coalition established to support the e-Operations project?</p> <p><i>The different stakeholders should be identified and involved in the project in the right way to support the change project. A guiding coalition consisting of the influential stakeholders and management should be established.</i></p> <p><i>The Steering Group should be selected from the guiding coalition. Participants from all the “virtual organization” involved in remote operations should be involved, third parties such as vendors and suppliers if they are supposed to deliver design solutions e-Operations or operational support after implementation of e-Operations.</i></p>					Kotter(1996), Pinto (1996)	
E 5.1	<p>Is a communication plan established to inform the relevant stakeholders?</p> <p><i>To ensure an optimal change process it is important to ensure common understanding, participation and involvement among the different stakeholders. The communication plan should inform about the benefits of the change among the relevant stakeholders. The communication plan must ensure that relevant information is gathered and distributed.</i></p>					Kotter(1996)	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 6	<p>Are the organisation and the infrastructure continuously adjusted to e-Operations as seen by operations (the end users)?</p> <p><i>The end users (operations) must continuously be involved. Organisational routines and practices must continuously evolve as e-Operation is being implemented. The supporting infrastructure must be able to support e-Operations in a safe and secure manner. It is therefore important to document and fill the gaps between present organisation and infrastructure facilities and future needs by e-Operation.</i></p>					Kotter(1996)	
E 7	<p>Is the functional requirement of e-Operations developed based on good co-opting processes with the relevant stakeholders?</p> <p><i>Requirements should be specified together with the key stakeholders and adjusted based on experience feedback. Relevant stakeholders could be users, management and third party providers.</i></p>					Kotter (1996), Pinto (1996).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 7.1	<p>A) Are the changes in the work processes specified and documented?</p> <p>B) Are the changes in work processes analysed in a Human Factor context taking into account Man, Technology and Organisation?</p> <p>C) Is a preliminary operational risk analysis (“pre HazOp”) performed?</p> <p><i>The changes in the work processes must be analysed with respect to overall organisational implications.</i></p> <p><i>The work process must be analysed from a Human Factor context. Successful realisation of new work processes will have some prerequisites related to technology and human factors: Technology can be new tools, upgrades of existing control systems, improved user interface etc. Human factors can be new tasks, work load, roles, new skills, and new competence. Culture could be explored through using www.sjekkIT.sintef.no</i></p> <p><i>A preliminary operational risk analysis (pre HazOp) should be performed in order to identify relevant risks when e-Operations (IO) are implemented. Integration of ICT and SAS systems can introduce new vulnerabilities. Increased reliance on IO can introduce new vulnerabilities.</i></p>				<p>HSE (2003), Henderson (2002).</p> <p>NIST (2007) SP 800-82.</p> <p>Johnsen (2006).</p>		

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 7.2	<p>Are information needs specified and analysed?</p> <p><i>The information needs to perform the work processes must be specified and analysed with respect to which remote functions are being implemented. Information needs should address needs related to collaboration, remote control or monitoring. The different ways to fulfil the information needs must be documented:</i></p> <ul style="list-style-type: none"> ○ <i>Direct communication - face to face, social corners, by direct perception.</i> ○ <i>Interactive real time communication – telephone, videoconferencing, indirect perception via IT-systems</i> ○ <i>Interactive communication – logs, e-Mail.</i> 					Henderson (2002)	
E 7.3	<p>Are the technology gaps specified?</p> <ul style="list-style-type: none"> ○ <i>The technology gaps must be identified such as tools and systems for operation and control and support systems for maintenance, condition monitoring etc)</i> 						

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 8	<p>A) Are the requirements to establish common situational knowledge between the participants in e-Operation established?</p> <p>B) Does the requirements reflect the following common ground knowledge:</p> <p><i>Common situational knowledge could be a key issue during an emergency situation, but also during regular operation. Key resources are involved from dispersed geographical locations and must acquire common situational knowledge to be able to function as a team to solve an emergency situation and possible operational problems. The requirements should cover:</i></p> <ol style="list-style-type: none"> 1. Knowledge and assumptions about the current situation, termed "situational knowledge" 2. Professional knowledge about each participant's roles and responsibilities? 3. Professional knowledge and understanding about standard operating procedures, termed "procedural knowledge"? 4. Cultural knowledge, e.g. beliefs and norms based on company specific policies and norms? 					Kotter(1996), Orasanu et al 1997	
E 9	<p>Do the technical solutions adhere to recognized Human Factors standards such as ISO-11064, NORSOK, CRIOP (especially recommendations from this checklist)?</p> <p><i>Technical solutions should support user requirements and support new work processes in a way to reduce Human Errors.</i></p>					ISO 11064, NORSOK, HSE(2003).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 10	<p>Are all interfaces clearly defined and are all organizational areas of responsibility clearly defined?</p> <p><i>An example of an interface could be a Network connection. Related to an interface, the following responsibilities should be defined:</i></p> <ul style="list-style-type: none"> ○ <i>Responsible user (The responsible user decides functional requirements, specifies the contract and specifies the SLA – Service Level Agreement)</i> ○ <i>User (asked about user satisfaction, informed about modifications and updates)</i> ○ <i>Who is operating the interface and has responsibilities to follow the Service Level Agreement (SLA)</i> ○ <i>Who does maintenance</i> 					HSE (2003), Henderson (2002)	
E 11	<p>A) Has a risk assessment of the operations been performed both prior to and after implementation of remote operations?</p> <p>B) Is the risk analysis approved by responsible senior management?</p> <p><i>A risk assessment should be performed before and after implementation of e-Operations to identify major hazards in the production process.</i></p> <p><i>Senior management are accountable and responsible.</i></p>					Hopkins (2000), HSE (2003), ISO/IEC 27002, OLF Guideline 104 ISBR (2007).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 11.1	<p>A) Is an assessment of the criticality of the ICT systems in e-Operations performed?</p> <p>B) Is such an assessment performed periodically?</p> <p><i>The use of an ICT system is changing as the users learns and becomes more reliant on the system. The criticality of the ICT system can change based on the reliance from the users.</i></p>					ISO 27002, OLF Guideline 104 ISBR (2007).	
E 11.2	<p>A) Is the security of e-Operations assessed?</p> <p>B) Is a safety and security policy established based on the major risks?</p> <p>C) Is the policy obeyed?</p> <p><i>The safety and security policy should be based on the principles in ISO 27002.</i></p>					ISO 27002, OLF Guideline 104 ISBR (2007).	
E 11.3	<p>Are all remote accesses documented, analysed and protected from unauthorised use?</p>					ISO 27002, OLF Guideline 104 ISBR (2007).	
E 11.4	<p>Are new vulnerabilities caused by e-Operations described in the SRS (Safety Requirement Specification)</p> <p><i>The SRS must cover the new vulnerabilities introduced by e-Operations. As an example - if internet access is allowed – the new vulnerabilities must be included in the SRS.</i></p>					IEC 61508/61511, OLF Guideline 104 ISBR (2007).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 11.5	<p>A) Are new risk based barriers established as e-Operations are implemented?</p> <p>B) Are the barriers sufficient?</p> <p><i>Examples of barriers are:</i></p> <ul style="list-style-type: none"> • <i>Organisational barriers such as personnel redundancy, training or procedures</i> • <i>Technical and physical barriers such as ICT firewall, doors with entrance restrictions</i> • <i>Human barriers such as knowledge.</i> 					ISO 27002, Johnsen (2006).	
E 12	<p>A) Are all safety and security incidents documented, analysed and treated?</p> <p>B) Are the root causes identified?</p> <p><i>All incidents must be reported, documented, and analyzed. The root causes behind the incident should be found. The organisations involved in the incident should share their experiences to improve knowledge, attitudes and mitigation actions among the relevant participants.</i></p>					ISO 27002, OLF Guideline 104 ISBR (2007), Jaatun (2007).	
E 13	<p>Is a thorough scenario analysis performed involving accidents, incidents and the effect of e-Operations?</p> <p><i>Scenario analysis involving personnel from different geographic locations should be performed. Scenarios should address normal operation, operational deviations, complexity and defined emergency situations involving e-Operations. The exploration of unwanted ICT incidents involving actors from suppliers and other organisations should be performed.</i></p>					HSE (2003), Jaatun (2007).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 14	<p>Is necessary training involving e-Operations done?</p> <p><i>Training must be performed based on the new procedures and new roles and responsibilities. Risk related to Information Security should be explored and communicated to increase awareness among the operators in the Central Control Rooms and operators in the Collaboration rooms.</i></p>					HSE (2003), Johnsen (2006).	
E 14.1	<p>A) Is the cooperation between onshore and offshore included in the training?</p> <p>B) Is cooperation between third parties involved in e-Operations included in the training?</p> <p><i>Training should address issues like decision handling collaboration within a support centre and with different actors at different physical locations. In case remote operations are implemented, handling of operational deviations should be covered.</i></p>					HSE (2003)	
E 15	<p>Are the e-Operations solutions tested and approved by the responsible user prior to production?</p> <p><i>The IT system, the relevant procedures and the training must be tested. The recently trained user should perform the testing. The testing should also involve the backup solutions. Simulators could also be used to test the solutions.</i></p>					HSE (2003), Kotter (1996)	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 15.1	<p>Has the video equipment been tested and approved by the end users?</p> <p><i>The video equipment should be tested and approved by the users. Important issues are:</i></p> <ul style="list-style-type: none"> ○ <i>Simplicity of use</i> ○ <i>User guides and user training</i> ○ <i>Stability and quality.</i> 						
E 16	<p>A) Is a SLA (Service Level Agreement) for the ICT systems established?</p> <p>B) Does the SLA define:</p> <ul style="list-style-type: none"> • Responsibilities, service levels , stability requirements, exception handling and reporting requirements <p><i>The SLA usually specifies the operational period such as 24 hours/7 days a week, stability requirements such as 99, 9%, and reporting requirements.</i></p>					ISO 27002.	
E 17	<p>A) Is a user forum related to e-Operations established?</p> <p>B) Can the involved users and stakeholders influence the process and the solution?</p> <p><i>The user forum must ensure that involved users and stakeholders can influence the process and the solution. The user forum must ensure that experience is shared and that the solutions can be continuously improved.</i></p>					Kotter (1996), Pinto (1996).	

POINT	DESCRIPTION				REFERENCE TO DOCUMENTATION	COMMENTS/RECOMMENDATIONS	RESP.
		YES	NO	NA			
E 18	<p>A) Does top management check that the goals of e-Operations are achieved?</p> <p>B) Does top management check why the goals of e-Operations are achieved, or not achieved?</p> <p><i>Top management must check periodically that the goals of e-Operations are achieved. Two key questions are:</i></p> <ul style="list-style-type: none"> <i>Why are the goals reached? or</i> <i>Why are the goals not reached?</i> 					Kotter (1996), HSE (2003).	
E 19	Are all necessary questions asked related to e-Operations?						

5. Scenario Analysis

5 Scenario Analysis

The aim of this section is to describe how to conduct Scenario Analysis, when it might be appropriate to perform it and give a framework of types of scenarios to be developed for analysis.

5.1 Introduction

This section presents the elements of the Scenario Analysis in detail. The Scenario Analysis comprises a detailed assessment of the control room operator's responses to abnormal situations.

Particular emphasis is made on the operator's possibilities of *observing / identifying* deviations, *interpreting* the situation, *planning / making decisions* and *taking action / executing* following given abnormal situations in the process.

5.1.1 Planning

The Scenario Analysis should be carried out after the General Analysis. In this way, the group will be more familiar with the control room in question. The Scenario Analysis is highly detailed, and a good knowledge of the process and information presentation in the control room is required.

5.1.2 Participants

Participants in the Scenario Analysis are described in “3.3 Establish the analysis group”.

The most important participants during the Scenario Analysis are operations and instrument personnel. Process personnel could be required for outlining the main steps of the scenarios.

5.1.3 Duration

The analysis group should aim at completing the analysis of one scenario in approximately one work day, see Table 5-1 below. The first scenario may take longer to complete, depending on the participants' knowledge of the method and the control room, and availability of information and key personnel. Subsequent scenarios will be completed in shorter time, because certain topics will already have been thoroughly discussed.

Table 5-1: Approximate duration of activities in the Scenario Analysis

Activities	Duration
Construction/adaptation of scenarios	2 hrs
Graphic presentation of events	1 hr.
Identification of weak points/Recommendations	4 hrs.

The duration could vary within a range of -50% up to +200% depending on the complexity of the scenarios and the participants in the analysis group.

5.1.4 Group discussions

The Scenario Analysis should be carried out as a discussion of problems related to the events described in the scenarios. It is, however, important that discussions are open and free. One should therefore not limit discussions to the scenarios, but allow discussions to drift around other topics. In this way, the participants trigger each other, and many findings are identified which are not directly related to the tasks in the scenarios.

5.1.5 Documentation

The needs for documentation cover the following areas (see Table 3.2 for more information):

- Control room layout and control room equipment
- Alarm strategy and design
- Process characteristics
- Organisation
- Installation layout

5.1.6 Number of scenarios

Analysis of two or three scenarios will give a good indication of problems in handling abnormal situations from the control room.

5.1.7 Pedagogical effects

Note that the method has important pedagogical effects on the personnel who participate. By participating actively in the design of scenarios and subsequent evaluations, the personnel's awareness to handling abnormal situations seems to be heightened.

5.1.8 Arena for organisational learning

The Scenario Analysis will be an important arena for organisational learning by actively using the findings to not only correct weak points directly, but also change the “governing values/variables” in the organisation. This means that findings in the analysis should activate change in governing procedures, documentation and design material.

5.2 Framework

The Scenario Analysis is designed to verify that the CRO (Control Room Operator) can perform the task at hand taking into account cognitive abilities, human-system interaction and other Performance Shaping factors. The analysis is human-centred, focusing on the CRO's interaction with the system including communication with other personnel. Emphasis is on *how the systems support the operator's situation awareness and decision making in different situations*. To achieve this goal the analysis must have a framework for analysing the cognitive functions. The framework selected is a Simple Model of Cognition (Hollnagel, 1998).

5.2.1 A Simple Model of Cognition (SMoC)

In the SMoC model of information processing four elements are identified. These are:

- Observation / identification
- Interpretation
- Planning / Choice - decision making
- Action / execution

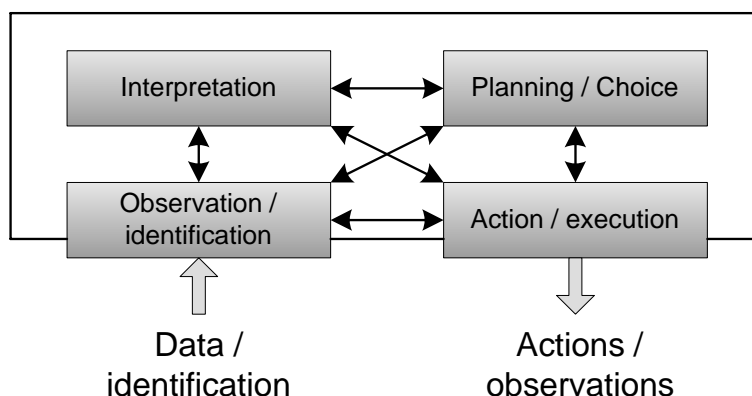


Figure 5.1 : Simple Model of Cognition (Hollnagel, 1998). Figure 5.1 shows the four elements contained in a simplified model of human information processing. A person observes and identifies a signal, interprets the signal, plans and decides what she or he has to do and finally initiates and executes an action.

5.2.2 Observation / identification

The first stage of the SMoC information processing model addresses the observation and identification of signals or signs received by the CRO. The type and quality of information plays an important part.

5.2.3 Interpretation

The second stage describes how the CRO interprets and organises the information into a meaningful whole. The CRO selects relevant cues from a potentially large pool of information and puts these cues together to interpret and develop situation awareness. The potential for misunderstanding the situation is critical at this stage.

5.2.4 Planning / decision making

The third stage addresses the planning and decision making processes involved. This includes evaluations of alternative solutions, the potential for human error and whether a decision must be made. Decision making is assessed from recognition-primed to the search for the optimal solution.

5.2.5 Action / execution

The fourth and final stage refers to execution of the planned actions. Improper execution, execution out of sequence and the consequences if the action does not happen, amongst others, are

critical to this stage. This stage also addresses other aspects such as motivation and the possibility to make short-cuts.

5.2.6 Performance shaping factors

In addition to the cognitive functions described in the Simple Model of Cognition, a number of performance shaping factors (or socio-technical factors) may play an influential role in the CRO's ability to handle emergencies. These factors should be considered when they appear of relevance to the questions at hand. The performance shaping factors have been selected to represent common root causes found in incidents and accidents across various industries. The performance shaping factors to be considered are:

- Competence and training
- Procedures
- Human-system interface
- Team work
- Goal conflicts
- Time of day
- Time available
- Work environment
- Emergency response
- Interventions

5.3 How to conduct a Scenario Analysis

The Scenario Analysis proceeds through two stages:

1. Development of two or three scenarios in STEP (Sequentially Timed Events Plotting) diagrams for the analysis based on the prototypical scenarios provided (see ref).
2. Conduct the analysis by asking questions relating to SMOc for each event involving CRO personnel. Use the checklist of performance shaping factors and ask additional questions to elaborate on answers received.

5.3.1 Scenario development

To identify and develop suitable and relevant scenarios for the CCR, the CRIOP leader depends on the input from the participants in the analysis. The group is asked to select two or three prototypical scenarios of pertinence to the CCR. These are then adapted to the installation being analysed. It is important to ensure that the scenarios include a variety of input and behaviours to cover as broad a spectrum of factors as possible.

5.3.2 Graphic presentation of events – using STEP

The STEP method was originally developed for detailed analysis of incidents and accidents. (What happened and why did it happen.) The STEP method provides a common framework for the analysis group in the form of a graphic presentation of the events during the scenario.

The method is conducted in the following manner:

1. The actors who are involved in the event are identified. The term actor denominates a person or object that affects the event” by his or her own force”. The actors do not only react in a passive manner to outside influence, they are actively involved in the events leading up to the accidents by e.g. their own actions, decisions or omissions. The actors are drawn under each other in a column on the left side of the STEP diagram.
2. Identify the events that influenced the accident. The events are described by ”whom”, ”what” and ”how”, and are placed in the diagram according to the order in which they occurred. There should only be one event in each rectangle. A mental event, that is what the actor perceives, interprets or actions she or he intends to conduct should be included in the diagram.
3. Place events in the correct place on the time-actor sheet. If the exact time of an event is not known, attempts should be made to identify the correct order of events. In some situations it is better to identify the sequence of events first. This is not a problem as long as the investigator remembers to identify all the involved actors afterwards.
4. Identify the relationship between the events, what caused each of them, and show this in the diagram by drawing arrows to illustrate the causal links. For each event the previous events leading to this event are assessed. This is done by the use of a logic test. The logic test consists of a necessary and a sufficient test. The logic tests address whether one event is sufficient to cause the following event. If not, then other events that are necessary in order to cause the following events are identified. Finally the connection between the events is shown using arrows. This will also ensure that the events are in correct order with regard to the time line.

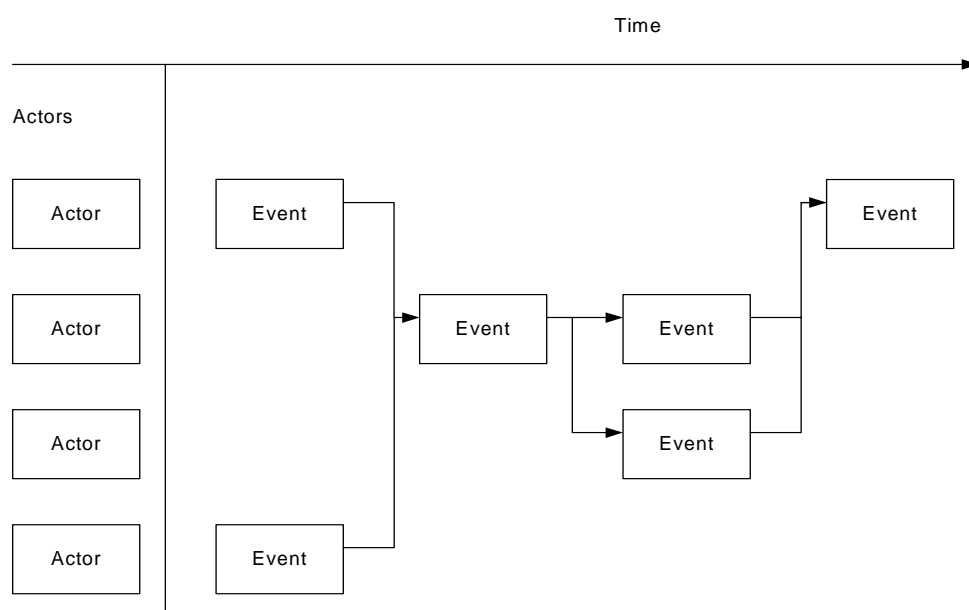


Figure 5.2: Schematic STEP diagram

It is practical to use yellow post-it notes and large pieces of paper when the incident is constructed. The text is written on the post-it notes, which are placed in the presumed correct position and moved when needed. The connecting lines should be drawn with pencil, so that they can be altered easily.

5.4 The main steps of the analysis

The analysis can start when the scenarios are documented. The analysis proceeds as follows:

For each event involving a CRO, questions are asked regarding observation / identification, interpretation, decision making / planning and action / execution (see next section). As some of the categories have little or no implications for some events, irrelevant questions are ignored. The questions are asked to identify how the systems support the situation awareness of the operator and his/her ability to take decisions and execute actions.

The questions from the performance shaping factor checklist are selected for their relevance, e.g.:

If the event relates to the **CRO receiving information**;

questions regarding human-system interface may be appropriate, or

If the event relates to the **CRO making decisions**;

questions regarding training, procedures and time available may be appropriate etc.

The questions in the checklist help identify potential error sources.

The result of the Scenario Analysis consists of an identification of weaknesses in the:

- information systems,
- the ability of the CRO to achieve an adequate level of situation awareness,
- whether sufficient information is available to allow the CRO to make decisions when required, and
- potential error sources.

Identified problems are called “weak points”.

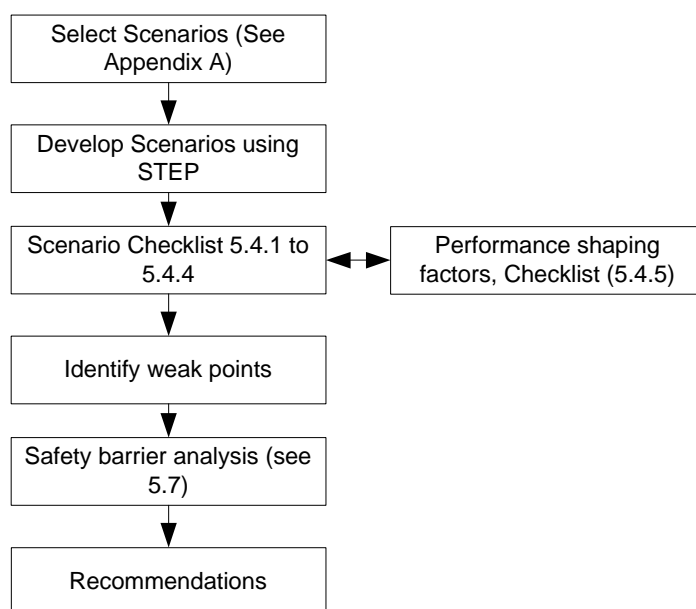


Figure 5.3: Flowchart describing the main steps in the Scenario Analysis

5.4.1 Observation / identification

QUESTION	COMMENTS	CONSIDER THESE FACTORS
1. Who receives the information?		<ul style="list-style-type: none"> ▪ Competence and training ▪ Procedures ▪ Human-system interface ▪ Team work ▪ Number of goals ▪ Time of day ▪ Time available ▪ Work environment ▪ Emergency response ▪ Interventions
2. Is the information easily perceived in all relevant contexts?		
3. Is the content of the information relevant?		
4. Can the information be misunderstood?		
5. Where is the information presented?		
6. Are more sources of information available at the same time?		
7. Can these sources be contradicting the main source of information?		
8. Are there rules/procedures that define which sources to trust?		
9. Is the information timely presented?		
10. What happens if the information is not presented?		
11. Are there problems with attention or perception in relation to information presentation?		
12. Are there other factors that influence observation / identification?		

5.4.2 Interpretation

QUESTION	COMMENTS	CONSIDER THESE FACTORS
13. Can the information be misinterpreted?		<ul style="list-style-type: none"> ▪ Competence and training
14. Does the order in which information is received have any effect on the interpretation?		<ul style="list-style-type: none"> ▪ Procedures ▪ Human-system interface ▪ Team work
15. Are necessary informational elements presented required for a correct interpretation?		<ul style="list-style-type: none"> ▪ Number of goals ▪ Time of day ▪ Time available
16. If two sources contradict one another, which is considered to be most trustworthy?		<ul style="list-style-type: none"> ▪ Work environment
17. How is the reliability of the information assessed?		<ul style="list-style-type: none"> ▪ Emergency response
18. Are there other factors that influence interpretation?		<ul style="list-style-type: none"> ▪ Interventions

5.4.3 Planning/decision making

QUESTION	COMMENTS	CONSIDER THESE FACTORS
19. What planning is required?		<ul style="list-style-type: none"> ▪ Competence and training ▪ Procedures
20. Which decisions must be taken?		<ul style="list-style-type: none"> ▪ Human-system interface ▪ Team work
21. Is there any alternatives?		<ul style="list-style-type: none"> ▪ Number of goals ▪ Time of day
22. If information is missing, how will this impact on the decision?		<ul style="list-style-type: none"> ▪ Time available ▪ Work environment
23. Which erroneous decisions can be made? For example use of wrong rule, use of rule in wrong situation, no use of rule, memory errors?		<ul style="list-style-type: none"> ▪ Emergency response
24. Are there other factors that influence planning / decision making?		<ul style="list-style-type: none"> ▪ Interventions

5.4.4 Action/execution

QUESTION	COMMENTS	CONSIDER THESE FACTORS
25. Is the action necessary?		<ul style="list-style-type: none"> ▪ Competence and training
26. Are there alternative actions?		<ul style="list-style-type: none"> ▪ Procedures
27. What will happen if the action is not conducted?		<ul style="list-style-type: none"> ▪ Human-system interface
28. What will happen if the action is conducted incorrectly or out of sequence?		<ul style="list-style-type: none"> ▪ Team work
29. What is the expected result in relation to the execution of the action?		<ul style="list-style-type: none"> ▪ Number of goals
30. Is sufficient means available for execution of the action?		<ul style="list-style-type: none"> ▪ Time of day
31. Is it possible to take short-cuts?		<ul style="list-style-type: none"> ▪ Time available
32. If the consequences are different than expected, what corrections can be done?		<ul style="list-style-type: none"> ▪ Work environment
33. Are the execution and/or communication verified i.e. can the result of the action be verified?		<ul style="list-style-type: none"> ▪ Emergency response
34. Can personal motivation affect the actions?		<ul style="list-style-type: none"> ▪ Interventions
35. Are there other factors that influence action / execution?		<ul style="list-style-type: none"> ▪

5.4.5 Checklist for Socio-technical factors

SOCIO-TECHNICAL FACTORS	QUESTIONS TO BE CONSIDERED
Competence and training	37) Has the CRO received training on this specific task? 38) Was the training adequate (theory vs. practice)? 39) If training is not provided for this task, why not? 40) Does the CRO understand the risks involved in the task? 41) Does the CRO's understand their role as human barriers?
Procedures	42) Are there procedures written for the task? 43) Are the procedures accessible? 44) Is it possible to follow the procedures? 45) Is the sequence of actions in the procedures correct?
Human-system interface	46) Is the operator interaction means sufficient and easy to use? 47) Is necessary information timely available and understandable? 48) Can the CRO see and use required equipment according to emergency response? 49) Is there a risk of making errors?
Team work	50) Are the persons involved to solve the task, trained for it? 51) Is communication central to task success? 52) Is there sufficient communication equipment available? 53) Is the quality of the communication equipment adequate? 54) If communication does not happen or happens too late, what are the consequences? 55) Can communication be misunderstood? 56) Is reception of information confirmed?
Number of goals	57) Do goal conflicts exist? 58) Does the CRO have guidelines for task prioritisation?
Time of day	59) Will it have any impact if the event happens at another time? 60) Is the shift work pattern designed so that it minimises the risk of human error?
Time available	61) Does the CRO have sufficient time available to carry out the task? 62) Is the CRO workload acceptable?
Work environment	63) Does the physical environment allow the CRO to perform the task in the best possible way? 64) Does the psychosocial environment allow the CRO to perform the task in the best possible way?
Emergency response	65) Are roles and responsibilities clear? 66) Are roles and responsibilities clear if a team member fails to show up? 67) Are decisions dependent on onshore personnel? 68) Are the ER plans adequate? 69) Does the CRO receive sufficient support to perform the task?

SOCIO-TECHNICAL FACTORS	QUESTIONS TO BE CONSIDERED
Interventions	70) Is it difficult to identify and correct errors? 71) What type of information does the CRO receive with regard to own errors? 72) Is there sufficient time available to correct errors?

5.5 Basis for scenarios

5.5.1 Selection of scenarios

The basis for the Scenario Analysis is accident or incident scenarios that the control room must be able to handle. The analysis aims at evaluating how well the control room personnel are able to handle the scenarios with the available/planned control room equipment, organization, layout, etc.

As an introduction to the method for building scenarios, Appendix B presents prototypical *examples* of scenarios that have occurred in the North Sea. These are only scenario examples and should not be used directly in the analysis. To make the prototypical scenarios relevant for the installation in question, these have to be adapted. This is done through a process of extending the prototypical STEP diagrams by incorporating installation specific information and behaviours (actors and events). The prototypical STEP diagram is set-up so that it is visible for the analysis group and input is then given to the CRIOP leader so that she or he can adapt the diagram to the actual installation. When no more installation specific information or behaviour can be identified, the STEP diagram is completed according to the description and the analysis can begin.

5.5.2 Development of scenarios

Scenarios based on incidents on other installations cannot be applied directly to the installation. It is important that the scenarios are made specific for the installation in question. This should be done by only using *ideas* from earlier incidents and then develop the scenarios for the first time during the Scenario Analysis. One can say that the scenarios must be *adapted* to the specific conditions on the installation being analyzed.

5.5.3 Sources of scenarios

Scenarios for the purpose of the analysis may be obtained from different sources:

- Incidents that have occurred on *the installation*
- Incidents that have occurred on *other installations*
- Hypothetical incidents *constructed* by the analysis group, e.g. based on HazOp-analyses.

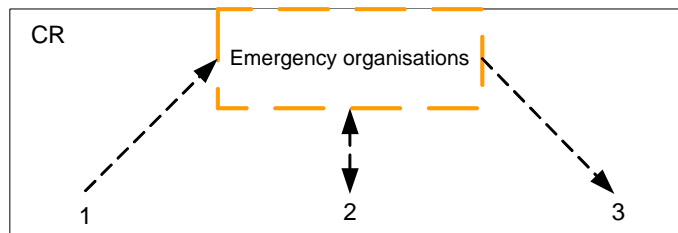
The term scenario is in the following used for all of the above categories.

It is underlined that even if one uses incidents from the installation in question or other installations, the scenario should always be developed during the analysis and the final scenario must be a result of continuing interaction between the participants.

5.5.4 Criteria for selecting scenarios

Scenarios for the purpose of the method should take into consideration the following characteristics:

- **Failure of barriers** I.e. accident scenarios involve failures in several safety barriers.
- **Feasibility** I.e. scenarios must be physically possible in the process in question.
- **Acceptance** I.e. scenarios must be accepted as possible by the participants in the analysis.
- **Hazard potential** I.e. the scenarios should have a potential to cause major accidents or installation damage. Environmental pollution should be evaluated.
- **Operator involvement and stress** I.e. the scenarios must involve control room operators and cause stress. Consider situation when one of the CCR operators is missing, and/or a peak work load.
- **Real situations** It is an advantage if the scenarios are based on situations that have occurred on installations in the North Sea as far as possible. This implies that one cannot argue that the scenarios are “*unrealistic*”, “*impossible*” or “*cannot happen here*”. Also, real scenarios illustrate relevant time constraints in handling the situation.
- **Different scenarios** I.e. the scenarios should not be too similar, so that different aspects of the control room may be addressed.
- **Width and depth** I.e. at least one “width scenario” and one “depth scenario” should be carried out. Width means involvement of several persons, parties and other factors where multiple conditions are analysed over time all the way to an emergency situation. Depth means covering special functions isolated, i.e. not involving emergency team and external groups.
- **Human error** Human error should be vital for the outcome of the scenario. It should be of great importance whether the operators make errors or executes the correct actions. The scenario should “provoke” the participants in such a way that they don’t feel comfortable with the selected solutions. In this way focus is always on making improvements.
- **Specificity** The chosen scenario must be specific for the installation in question. This is to ensure that one exposes weak points on the control room in question.
- **Complexity** To make sure the operators are stressed the chosen scenarios should be sufficiently complex. Simultaneously operations/incidents, extensive communication and fallacy of multiple safety barriers are key words.
- **Emergency preparedness** At least one scenario should be pursued to emergency preparedness, where the crisis team and the emergency organisation take control of the situation, se Figure 5.4 below.



Responsibilities between CR and emergency organisation to be checked and discussed in a CRIOP analysis:

1. Handover from CR to the Emergency organisation
2. Responsibilities and tasks of CR during the Emergency
3. Handover from Emergency Organisation to CR

Figure 5.4: Handover between control room (CR or CC) and emergency organisation during a crisis

5.5.5 Scenarios based on incidents on the installation

If the control room in question has been in operation for a period of time, *incidents that have previously occurred on the installation* may be used as a basis for scenarios. Detailed information concerning the incidents may be obtained from the company reporting system or accident reports.

5.5.6 Scenarios based on incidents on other installations

Another source of scenarios is *incidents that have occurred on other production installations* in the North Sea. In this way, the Piper Alpha accident, for example, may be applied to the installation in question, i.e. “*Could Piper Alpha have happened on our installation/how can we prevent the Piper Alpha accident on our installation?*” Sources of information concerning incidents are company reporting systems or accident reports.

Note that the incidents must adapt to process equipment on the installation in question.

5.5.7 Hypothetical incidents constructed by the analysis group

Finally, scenarios may be constructed based on *hypothetical situations*, i.e. not necessarily on situations that actually have occurred. The approach to constructing hypothetical scenarios is to consider *malfunction or bypass of safety barriers*. This implies that the method does not attempt to identify scenarios that have been overlooked in e.g. a HazOp-analysis, but rather to analyze how well the operators will be able to handle failures in safety barriers.

HazOp-analyses of the installation in question may provide a basis for constructing hypothetical incidents.

Example of adaptation of scenarios

The main equipment involved in the scenario example is:

- Condensate separator
- Condensate pumps downstream from separator
- Blind flanges on pressure safety valves

The installation in question does not have condensate pumps, and this makes an adaptation of the scenario necessary.

A similar accident (a hydrocarbon leak from a pump) preserving the main features of the original scenario can be constructed on the installation in question involving the following equipment:

- *Oil separator* (instead of condensate separator)
- *Oil booster pumps* downstream from separator (instead of condensate pumps)
- *Oil leak from blind flange on manual valve* (instead of condensate leak from blind flanges on pressure safety valves)

The main features of the adapted scenario are shown in Table 5-2.

Table 5-2: Main features of original and adapted scenarios – Example

Original scenario	Adapted Scenario
Equipment trip due to vibrations on condensate pump	Equipment trip due to vibrations on oil pump
Maintenance work on pressure safety valve	Maintenance work on manual valve
Inadequate communication between shifts	Inadequate communication between shifts
Operator reacts to an initially normal situation by switching condensate pumps	Operator reacts to an initially normal situation by switching oil pumps
Hydrocarbon leak from blind flange on PSV	Hydrocarbon leak from blind flange on valve
Operator misses information due to high workload	Operator misses information due to high workload

At first glance, it seems that the original scenario has been changed substantially to be feasible on the installation in question. However, the *main features* of the adapted scenario are similar to the original, see Table 5-2.

5.5.8 Guidelines for adaptation of scenarios

Input Scenario examples or incidents on other installations.

Adaptation of scenarios is a group process with involvement of control room operators.

1. Consider the original scenario and the process equipment on the installation in question. Decide whether the equipment involved in the original scenario is the same as or similar to equipment on the installation in question.
2. If there are *no major differences* in the equipment, use the main features of the original scenario as a basis for constructing a similar scenario on the installation in question (adapted scenario). Use “local” terminology on the installation in question.
3. If there are *major equipment differences*, adaptation of the scenario is necessary. List the main features of the original scenario (e.g. equipment failures, operator actions, leaks, misunderstandings).
4. Construct a similar (adapted) scenario on the installation in question by using the main features of the original scenario. Note that this may involve other equipment (e.g. oil pump instead of condensate pump, leak from manual valve instead of pressure safety valve), but the main features of the original scenario should be preserved (e.g. equipment failures, operator actions, misunderstandings).
5. Draw a simplified equipment diagram of the equipment involved in the adapted scenario.

Output Main features of the scenario, adapted to process equipment on the installation in question

Constructing/adapting scenarios are a very important step of the method, because it provides the basis for the subsequent identification of weak points. Be prepared to spend some time on this step. It is particularly important to emphasize that the objective of constructing scenarios is not to imply that they are probable on the installation, but rather to establish a concrete basis for discussion of operator tasks.

It is vital to the progress of the analysis that all personnel involved *accept* the scenario as *possible* (but not necessarily probable). Remember that personnel who are unfamiliar with the method need time to adapt to the scenario approach. Once convinced, personnel have little problems constructing adequate scenarios for the analysis.

The above emphasizes the benefits of using real scenarios as a basis for the analysis. In this way, one cannot argue that the scenario is impossible.

5.6 Identification of weak points

5.6.1 Objective

The objective of the identification of weak points is:

- To identify weak points in the control centre's ability to handle abnormal situations.

The identification of weak points comprises an identification of possible conditions or safety problems in the achievement of operator tasks, such as high work load or insufficient information.

The identification of weak points is based on the *operator action tasks* that are included in the graphic presentation of events. Although only operator *actions* are included in this description, such tasks also involve *identification, interpretation and planning* of the situation. Answering the questions in the Scenario Checklist covers problems in operator identification, interpretation and planning.

5.6.2 Alternative operator actions

The scenario represented in the graphic presentation of events is only *one of many possible scenarios*. In order to investigate operator actions other than the ones described, for each operator action the analyst should ask:

- How could a harmful outcome be produced by changes in operator actions?

In other words, the analyst should look for *other unwanted operator actions* that are feasible at that point in the scenario, due to insufficient information, time pressure, misunderstandings, etc.

5.6.3 Operator actions

For the purpose of the analysis, operator actions in the following will therefore include:

- Operator action tasks identified in the graphic presentation of events.
- Alternative operator actions that are identified.

5.6.4 Guidelines for Identification of weak points

Input	Graphic presentation of events in the scenario, Scenario Checklist.
1.	Consider each operator action task which is identified in the graphic presentation of events.
2.	Identify weak points in the identification, interpretation, planning and action by answering the questions in the Scenario Checklist. Use the checklist for Performance Shaping factors if more detailed information is needed.
3.	Before you proceed to a new operator action task, consider other unwanted operator actions that are feasible at each point in the scenario (" <i>alternative operator actions</i> ").
Output	Weak points in handling the scenario

5.7 Safety barrier analysis in combination with STEP-scenario

The safety philosophy of offshore installations is generally that *multiple* technical safety devices are installed to prevent escalation of deviations into adverse consequences. This implies that offshore processes are designed to be self-contained in the event of disturbances. If the process control system or the operator fails to keep process parameters within predetermined limits, the process equipment is designed to shut down and prevent adverse development of the situation.

With these redundant safety devices, how can accidents occur? It is evident that in order to reach a critical situation, safety barriers must not function as intended. Barriers can be put out of function intentionally or unintentionally, due to errors or slack in operating procedures on the installation, as well as insufficient component reliability.

5.7.1 Basic hypothesis

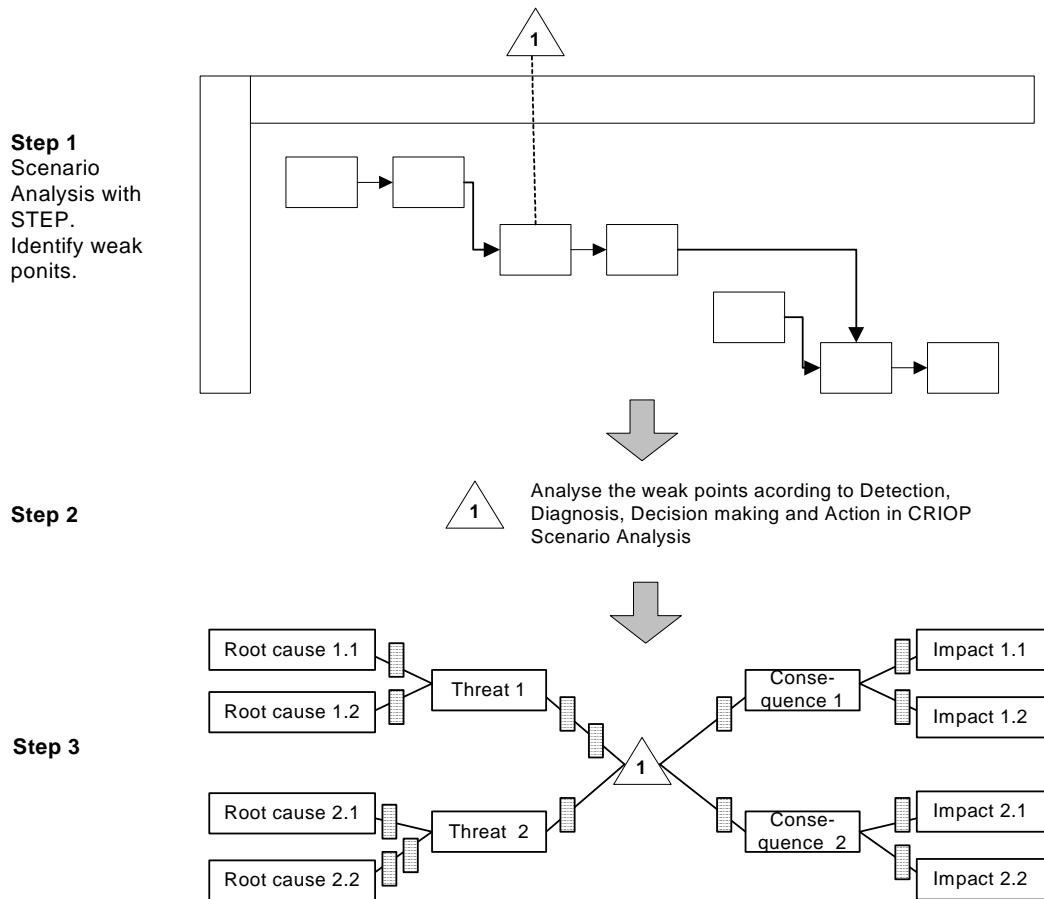
When constructing scenarios for the analysis, the following hypothesis must be kept in mind:

“Accident scenarios involve failures in several safety barriers”

The safety philosophy on the installations implies that if all safety barriers function as intended, the safety systems would handle or contain abnormal situations. Experience shows that major incidents typically are caused by a combination of instrument failures, incorrect operator actions and inadequate organisational communication systems. Therefore, safety barriers can be technological, human or organisational.

5.7.2 Combining the barrier analysis with STEP

To fully understand the root causes and consequences of weak points and safety problems found in the Scenario Analysis, the analysis team should evaluate the existing and missing safety barriers. One way of evaluating the safety barriers and their relation with the weak point is to carry out the three steps shown in Figure 5.5 below. (See also MR § 1. and 2.)



Explanation of STEP 3

- Evaluate the threats which can lead to a weak point
- Identify the root causes leading to the threat
- Identify the Consequences and Impacts of the weak point (use the results from Step 2)
- Identify the existing and missing barriers to hinder root causes and threats
- Identify the existing and missing barriers to reduce negative consequences and impacts
- Summarise weak points, root causes, safety barriers and impacts in a table showing their relations to one another

NB! The triangle represents the weak point. The shaded vertical blocs represents safety barriers.

Figure 5.5: Evaluating the weak points in combination with safety barrier analysis (from Fartum, 2003)

5.8 Recommendations

Using the identified weak points, the final step of the Scenario Analysis is to:

- Identify measures that should be taken to improve the identified weak points.

5.8.1 Documentation of results

The documentation of results from the Scenario Analysis should include:

- A description of operator tasks
- A description of identified weak points
- Reference to questions in the scenario checklists
- Suggestions for remedial measures based on the identified weak points

An example is shown in Table 5-3.

Note that many of the findings represent *possible* safety problems that may be used as a basis for recommendations when preparing operators in the handling of abnormal situations. Typical of many findings is that they highlight negative aspects of the control centre, but in most cases there is a trade-off between the negative and positive effects of measures. The weak points therefore do not necessarily require design changes, but in many cases the purpose is rather to prepare and call the operators' attention to possible safety problems.

The identified recommendations should be assessed with regard to need for implementation and cost of implementation, although the method does not suggest a systematic procedure for this.

Table 5-3: Documentation of results - example

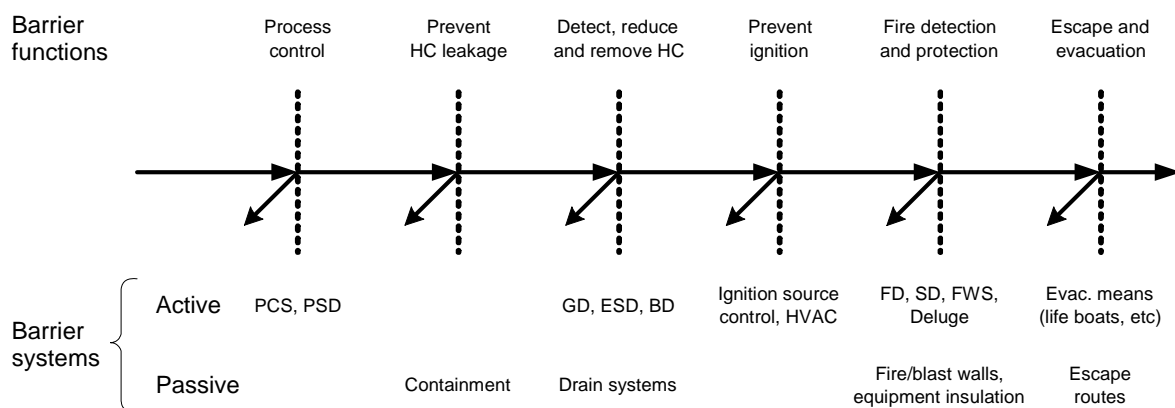
Weak points	Recommendations	Resp.
Alarm texts may be difficult to understand because they are: <ul style="list-style-type: none"> ▪ Too general, not self-explanatory, do not indicate the nature of the problem immediately. ▪ Too short and abbreviated, due to insufficient space provided. 	More space should be reserved for alarm texts.	Statoil/A.Smith
The oil pump cannot be started from the control room. A field operator must assist the control room operator for this action.	Means should be provided for operators to start oil pumps from the control room.	
The changing of pumps causes a large number of alarms to appear in the control room, making it difficult to identify additional alarms.	Alarm suppressing mechanisms should be used.	
The valve that is involved is a manual valve, and is not indicated on the control room VDUs, and the operator must remember the location of the valve.	Reminder/message functions on the VDUs should be provided to remind operators of safety-related actions in the process.	
Information concerning the removed valve may be found in the work permit system, but the operator cannot check this within the time available.	In cases where two related/dependent components are involved, a work permit system should be introduced to prevent start-up before both components have been checked (e.g. using two dependent key locks).	

5.9 Prototypical scenarios

Several prototypical STEP scenarios have been developed to support the analysis. The scenarios are:

1. Gas leak
2. Utility systems start-up after blackout
3. Sub sea start-up
4. Emergency shutdown
5. Blackout
6. Sudden listing

See Appendix B for descriptions of the scenarios. The prototypical scenarios describe different types of emergencies in which the CRO plays an important role. During the Scenario Analysis these scenarios should be combined with failures in barrier functions or systems as showed in Figure 5.6.



HC - Hydro Carbons; PCS - Process Control System; PSD - Process Shutdown; GD - Gas Detector; ESD - Emergency Shutdown; BD - Blowdown; HVAC - Heating, Ventilation and Air Conditioning; FD - Fire Detector; SD - Smoke Detector, FWS - Fire Water System

Figure 5.6: Barrier functions and barrier systems that may fail

The prototypical scenarios and the examples of possible failures in barrier functions and systems are just meant as a helping start for the scenario development. By combining the scenarios mentioned, with different failures and consequences, i.e. personnel injuries, all kinds of operator aids can be tested in all of the prototypical scenarios.

6. Actions, Implementation and Follow Up of a CRIOP Analysis

6 Actions, Implementation and Follow up of a CRIOP Analysis

The aim of this section is to describe the result from a CRIOP analysis and how it should be used and followed up.

The report from the CRIOP analysis should be discussed with all the main stakeholders to ensure understanding and commitment to the proposed actions. The competence related to Human Factors is usually varying, and some stakeholders may be negative to some of the identified weaknesses, thus it may be important to highlight some of the positive aspects to create a more positive context of the report.

The report from the CRIOP analysis should contain a short summary, containing both positive and negative issues from the CRIOP analysis to ensure that the results from the CRIOP analysis is being distributed and read by the stakeholders and participants.

The report should be given to the responsible management that initiated the analysis. The report should contain:

- Summary from the CRIOP analysis
- The checklists from the General Analysis
- Documented weak points and recommendations from the General Analysis
- Documented weak points and recommendations from the Scenario Analysis
- Result from safety barrier analysis and recommendations

The weak points and recommendations from the report should be analysed by relevant personnel with clear lines for responsibility regarding follow-up. An action plan should be established, documenting points that are resolved and not resolved. An action is based on a recommendation but may be adjusted taking into consideration budgetary limits, available resources and target date. Short and long term actions must be described.

The responsible person for each recommendation should as soon as possible make a plan for actions and deadline for following through (see example in Table 6-1).

Table 6-1: Action Plans as a result of a CRIOP Analysis

Ref	Weak point (resolved)	Prioritised actions (recommendation)	Responsible person	Target date
	No clear alarm philosophy	Establish alarm philosophy in accordance with YA-711.	NN	DD.MM.YY.
Ref	Weak point (unresolved)	Comments	Responsible person	Target date
	No access to daylight is provided in the CC	No available budget	NN	NA

The management responsible in the initiating organisations should consider change in the relevant governing variables for each action which is carried out, i.e. changing safety or design procedures. The findings from this CRIOP analysis should be checked out in the next CRIOP analysis. Have all findings from previous CRIOP's been followed up in a responsible manner?

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Appendix

Appendix A – Scenarios

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Scenario 1 – Gas Leak

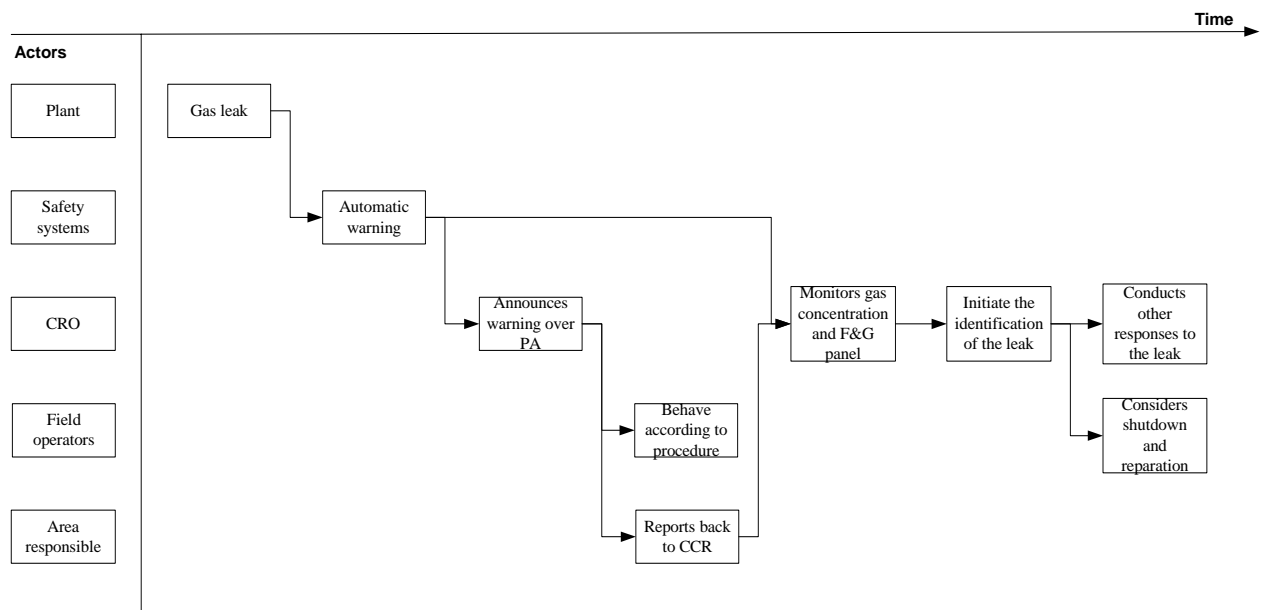
Scenario Description

A gas leak takes place in the process area. The gas leak is large enough to be detected by the gas detectors, but does not lead to automatic shutdown.

Main Steps of the Scenario

1. Automatic warning from F&G panel
2. CRO announces the warning over PA
3. Field operators behave according to procedure
4. Area responsible reports back to CCR
5. CRO monitors gas concentration (shown as % of LEL [Lower Explosion Limit])
6. CRO monitors F&G panel
7. CRO initiate identification of the leak
8. Area responsible considers shutdown and reparation
9. Emergency responsible initiate necessary further actions according to procedure

STEP



Scenario 2 – Utility Systems Start Up

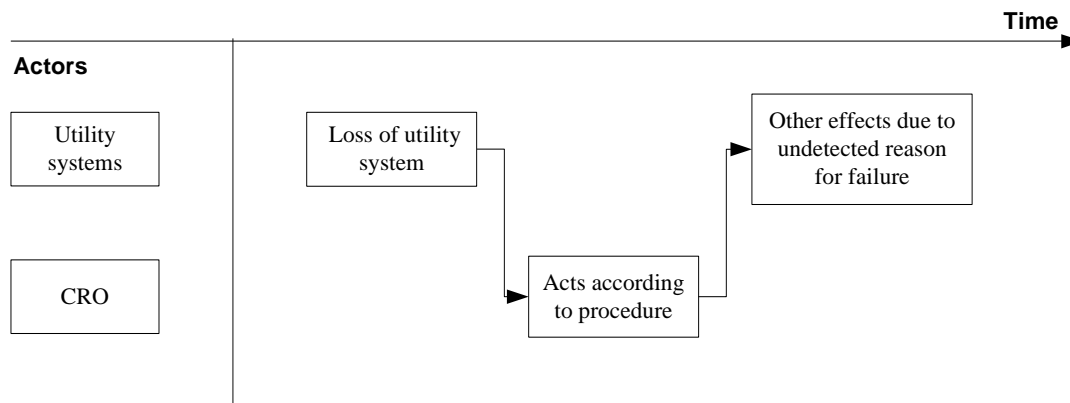
Scenario Description

After loss of utility systems the CRO will act according to procedure for utility systems start up. The CRO may start this procedure without acknowledging the reason for failure. Most likely reason for failure is loss of power, due to e.g. valves failing or contaminated diesel. This problem may cause other effects later in the scenario.

Main Steps of the Scenario

1. Loss of utility systems
2. CRO acts according to procedure
3. Effects due to undetected reason for failure of utility systems

STEP



Scenario 3 – Subsea Start-up

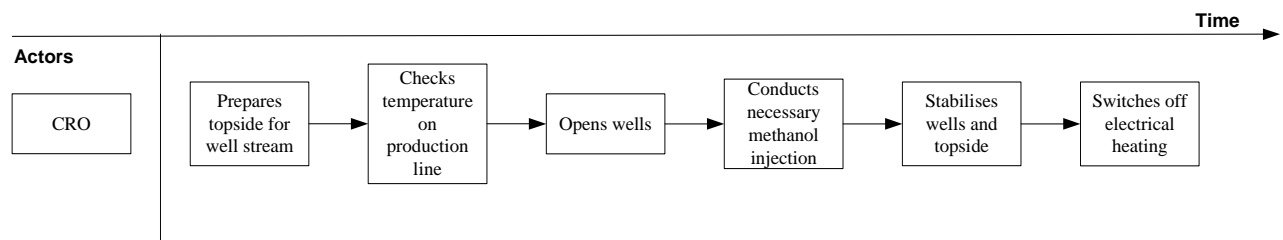
Scenario Description

After a revision due to maintenance the quality assurance has failed and a leak point has been established. This leak point initiates a gas leakage which will be detected during the subsea start-up procedure. Follow procedure for subsea start-up in combination with scenario 1 - gas leak.

Main Steps of the Scenario

1. CRO prepares topside for well stream
2. CRO checks temperature on production line
3. CRO opens wells
4. CRO conducts necessary methanol injection
5. CRO stabilises wells and topside
6. CRO switches off electrical heating
7. CRO starts subsea

STEP



Scenario 4 – Emergency Shutdown

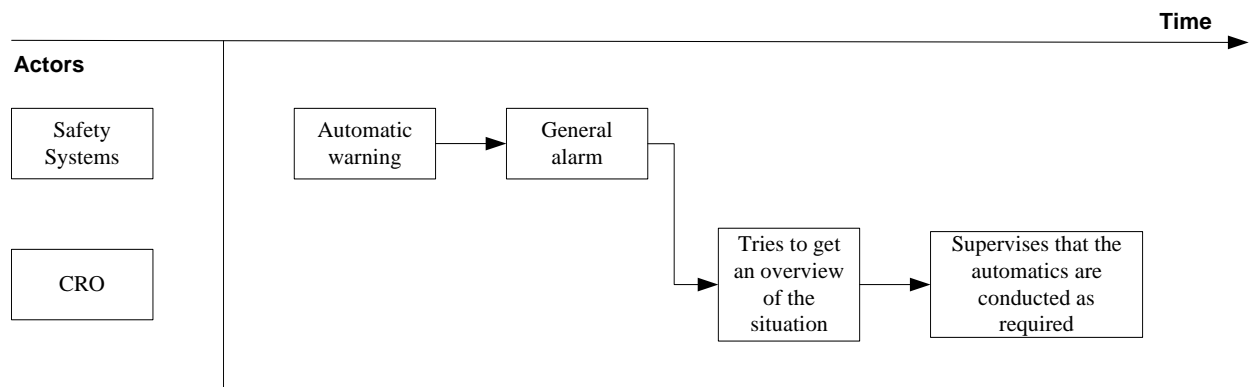
Scenario Description

There has been a manual release of the ESD button. This scenario should at least be combined with a fire or an explosion. Emergency preparedness (ref. FR § 29) should be evaluated and the safety zone (ref. FR §§ 33 - 40) should be assessed.

Main Steps of the Scenario

1. Automatic warning
2. General alarm
3. CRO tries to get an overview of the situation
4. CRO supervises that the automatics are conducted as required

STEP



Scenario 5 – Blackout

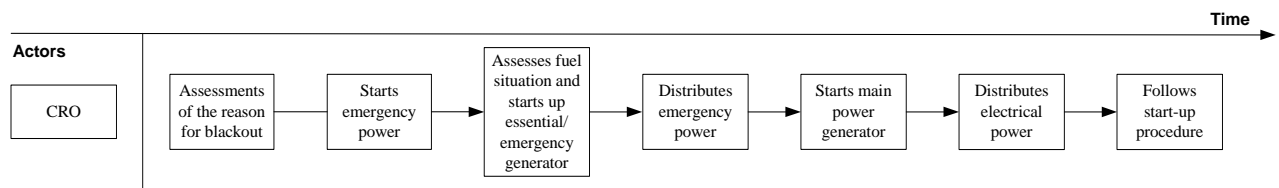
Scenario Description

The platform has been running for a longer period (1 year +) when there is a complete blackout. No systems are operational except the UPS system and its consumers, which normally have enough power to operate for a maximum of 30 minutes. The initial factor may cause other problems later in the scenario.

Main Steps of the Scenario

1. Assessment of reason for blackout
2. CRO starts emergency power
3. CRO assesses fuel situation and starts up essential/emergency generator
4. CRO distributes emergency power
5. CRO starts main power generator
6. CRO distribute electrical power
7. Follow start-up procedure

STEP



Scenario 6 – Sudden Listing

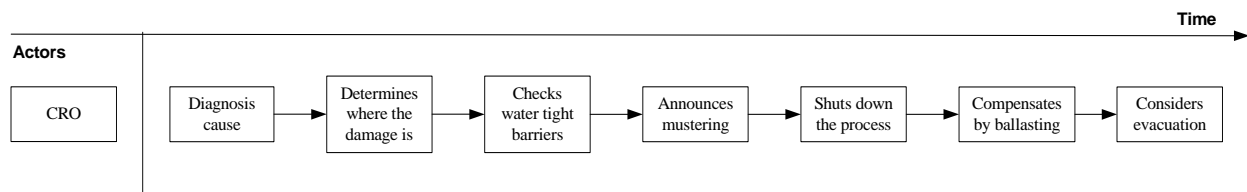
Scenario Description

A ship has run into the side of the platform and caused two leaks; one above and one below the water line. The listing is caused by the leak below the water line. For fixed platforms the scenario can be limited to structural damage. Check that the floating construction can be quickly relocated in the event of an accident or incident. (See FA § 64).

Main Steps of the Scenario

1. CRO diagnoses cause
2. CRO determines where the damage is
3. CRO checks water tight barriers
4. CRO announces mustering
5. CRO shuts down the process
6. CRO compensates by ballasting
7. CRO considers evacuation

STEP



Scenario 7 – ICT and SAS systems breakdown and loss of communication

Scenario Description

The ICT system and main part of the SAS system have a common failure.

The common failure could be loss of power, loss of communication or stop of several critical systems.

The failure could be due to someone connecting faulty or misconfigured ICT equipment to the network or equipment infected with a virus. The faulty equipment could be a PC with an error flooding the network with unanticipated traffic.

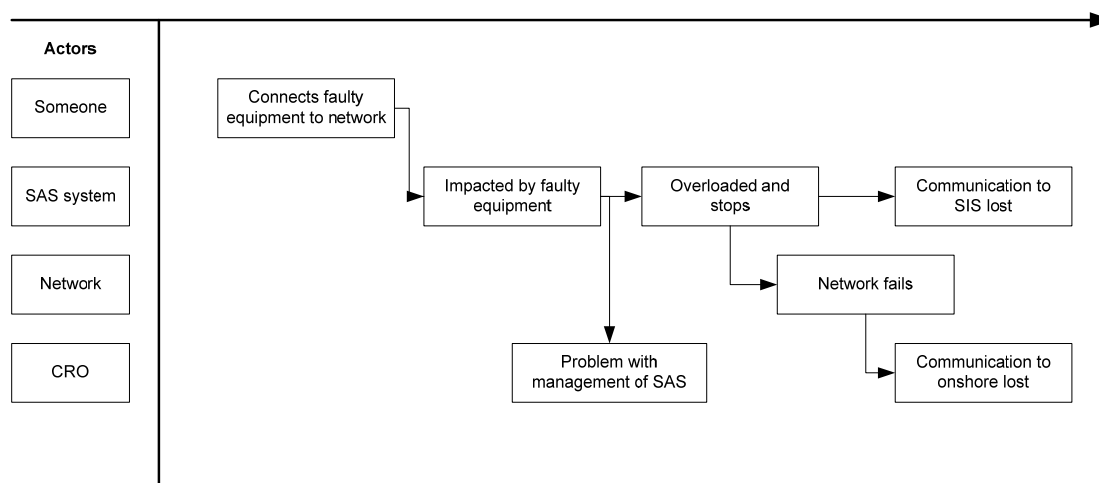
The result could be network overload (denial of service) or virus being spread from the infected equipment, impacting several systems and/or infrastructure such as the communication network. The scenario could impact and stop the safety and automation system (SAS) or impact safety instrumented systems (SIS). Communication based on high speed data network between onshore and offshore could be lost, influencing ICT systems, video communication and telephony.

The CRO may lose control of part of the process, and some part of the system may degrade to an unsafe condition. The breakdown could influence common situational awareness among the different actors involved and lead to serious errors.

Main Steps of the Scenario

1. Someone connecting faulty equipment (e.g. PC) into the network
2. SAS system is impacted and parts of the system stops
3. CRO has problems with management of the SAS system
4. SAS system stops, problem with communication to SIS
5. Network fails and high speed data network between onshore and offshore is closed down
6. Communication onshore (ICT, Video, telephony) lost

STEP



Scenario example

Scenario Description

During a start-up after revision, a gas leak is detected by a line detector (25% LEL) in area 1A. The area responsible reports back to CCR that she or he can hear and see the gas, but due to noise and gas the area responsible is not able to detect the leak source. Since the leakage is located in the outer part of the platform, no more detectors are activated. However, CCR decides to activate the ESD 2 manually. After a while area responsible detects the leak source, and a blowdown of the system is manually activated from CCR. During the day the source of the leakage is repaired, tested and found to be in order. Early evening the same day, the platform is ready for a second attempt of the revision start-up. During this second start-up, a condensation leakage in a flange is detected by a field operator. She or he reports back to CCR about a big leak in area 1B. No gas detectors have been activated and CRO believes the leakage to be located in the same area as the first gas leak detected earlier that morning. Due to this, CRO performs no actions but sends area responsible to area 1B to get a confirmation of the condensate leak. Area responsible confirms the leakage and CCR closes the emergency shutdown valve upstream the leakage and overrides the gas detectors in the area to avoid an emergency shutdown. While the area responsible is isolating the leakage, there is a discussion if the ignition sources should be disconnected, however CCR chooses not to do this since the leakage is under control and decreasing.

Main Steps of the Scenario

1. CRO is busy with a start-up of the plant
2. Gas detector alarms CRO (25% LEL)
3. Area responsible reports back to CCR
4. CRO activates ESD 2 manually
5. Area responsible detects the leak source
6. CRO manually activates a blowdown of the system
7. Shift hand over meeting in the CCR
8. CRO is handling a second start-up of the plant
9. Field operator observes a big leak and reports to CCR
10. CRO believes there must be a misunderstanding and sends area responsible to get a confirmation
11. Area responsible confirms the leak
12. CRO closes the emergency valve upstream of the leak
13. Area responsible isolates the leak
14. CRO chooses not to disconnect ignition sources

STEP

