

RECOMMENDED PRACTICE

No. DNV-RP-H101

RISK MANAGEMENT IN MARINE - AND SUBSEA OPERATIONS

JANUARY 2003

DET NORSKE VERITAS

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- H) Marine Operations

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- Gard Services AS
- Norsk Hydro AS
- Statoil ASA

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As part of publishing this RP, a draft copy was sent for hearing to several additional companies. Constructive feedback and comments were obtained through this process. DNV appreciate time and effort given to the hearing by these companies.

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CONTENTS

1.	Introduction	4	B.5	System HAZOP	21
1.1	General	4	B.6	FMEA/FMECA	22
1.2	Principles of Risk Management	4	B.7	Procedure HAZOP	23
1.3	Terminology and Definitions	6	B.8	Semi-Quantitative Risk Assessments	25
2.	Risk Management Planning	7	B.9	Safe Job Analysis	25
2.1	General	7	App. C.	Risk Reducing Activities	29
2.2	Risk Management Plan	8	C.1	General	29
3.	References	14	C.2	Operational Feasibility Assessments	29
App. A.	General Quality Assurance Activities	15	C.3	Document Verification	29
A.1	Objectives	15	C.4	Familiarisation	29
A.2	HSE&Q Activities	15	C.5	Personnel Safety Plans	30
A.3	Pre-Qualification of Marine Operations Contractors	15	C.6	Emergency Preparedness	30
A.4	Planning and Scheduling	15	C.7	Marine Readiness Verification	31
A.5	Personnel Qualifications and Job Descriptions	16	C.8	Inspection and Testing	31
A.6	Deviation handling	16	C.9	Survey of Vessels	32
A.7	Non-Conformance Reporting	17	C.10	Toolbox Talk	32
A.8	Near-Miss Reporting	17	C.11	Survey of Operations	33
A.9	Incident and Accident Reporting	17	App. D.	Miscellaneous	34
A.10	Experience Transfer	18	D.1	Document Basis - Cross References	34
App. B.	Hazard Identification Activities	19	D.2	Methodology - Flow Chart	35
B.1	General	19	D.3	Risk Accept Criteria Form (Sample)	36
B.2	HAZID	19	D.4	Risk Management Plan - Check List (Sample)	37
B.3	Early Procedure HAZOP	20	D.5	Risk Category Assessment Forms (Samples)	39
B.4	Design Review	20	D.6	Appendix Risk Management Plan (Sample)	41

1. Introduction

1.1 General

1.1.1 Objectives

The overall objective with this Recommended Practice is to establish guidelines and recommendations for the process required to reach an acceptable and controlled exposure to risk during *marine operations*, for *personnel*, *environment*, *assets and reputation*.

The Recommended Practice aim at zero accidents, incidents or losses through promoting safe, robust and efficient marine operations, and through application of the principles of ALARP.

It is further the ambition that this document shall influence the overall awareness and consciousness of the exposure to risks during marine operations, as well as provide a basis for consistent and uniform understandings and applications of processes, tools and methods commonly used for managing and controlling these risks.

A *Risk Management Plan* is recommended to describe, communicate and document the *objectives*, *responsibilities and activities* specified for assessing and reducing risk to an acceptable level.

1.1.2 Application

This Recommended Practice should be used as a support document for the Risk Management Process required for Marine Operations. Marine Operations in this context are defined as:

“Non-routine operations of a limited defined duration carried out for overall handling of an object at sea (offshore, inshore and at shore). Marine Operations are normally related to handling of objects during temporary phases from or to the quay side or construction sites to its final destination or installation site. Marine operations include activities such as load transfer operations, transport, installation, sub sea operations, decommissioning and deconstruction, rig moves and pipe laying”.

The Recommended Practice is considered applicable world wide, for simple single operations as well as larger complex development projects, from the need for a marine operation is realised, through the project period, until the operation is completed.

1.1.3 Basis

Basis for this Recommended Practice are principles and recommendations given in references /1/, /2/ and /3/.

1.1.4 Use and users of this Recommended Practices

Principles, methods and tools described in this Recommended Practice are foreseen used as:

- Guidance for assessing risks during marine operations.

- Basis for tendering (through specification and/or definition of required processes and/or indicated risk levels).
- As a contract reference, providing descriptions/specifications for the risk management process

Foreseen users of this document are:

- Oil companies, object owners, other responsible parties
- Insurance companies
- Marine operation contractors/sub-contractors
- Other involved parties.

1.1.5 Alternative Methods

This document describes a practice recommended by DNV. This should not inhibit use of other alternative approaches meeting the overall ambitions and objectives.

1.2 Principles of Risk Management

1.2.1 Risk Assessment Principles

DNV recommends that risk within marine operations are assessed against criteria for:

- Personnel safety
- Environment
- Assets and/or lost production
- Reputation

Defined criteria should comply with company and projects policies, and be specific for each of the area above.

Assessment of risk is recommended performed according to the principles of qualitative risk assessments, and through assessment of minimum the parameters listed in *Table 1.1*.

January 2003

Table 1.1 – Assessment Parameters

Assessment Parameter	Keywords for assessment
Personnel exposure	<ul style="list-style-type: none"> Qualification and experience of personnel Organisation Required presence Shift arrangements Deputy and backup arrangements
Overall project particulars	<ul style="list-style-type: none"> Delay Replacement time/cost Repair possibilities No. of interfaces and contractors or subcontractors Project development period
Existing field infrastructure	<ul style="list-style-type: none"> Infrastructure – surface Infrastructure – subsea
Handled object	<ul style="list-style-type: none"> Value Structural Strength/Robustness
Marine operation method	<ul style="list-style-type: none"> Novelty and feasibility Robustness Type of operations Previous experience Installability
Equipment used	<ul style="list-style-type: none"> Margins/robustness Condition/Maintenance Previous experience Suitability Experience with operators or contractors (track record)
Operational aspects	<ul style="list-style-type: none"> Cost of mobilised equipment and spread Language barriers/hindrance Season/Environmental conditions Local marine traffic Proximity to shore

1.2.2 Overall Methodology

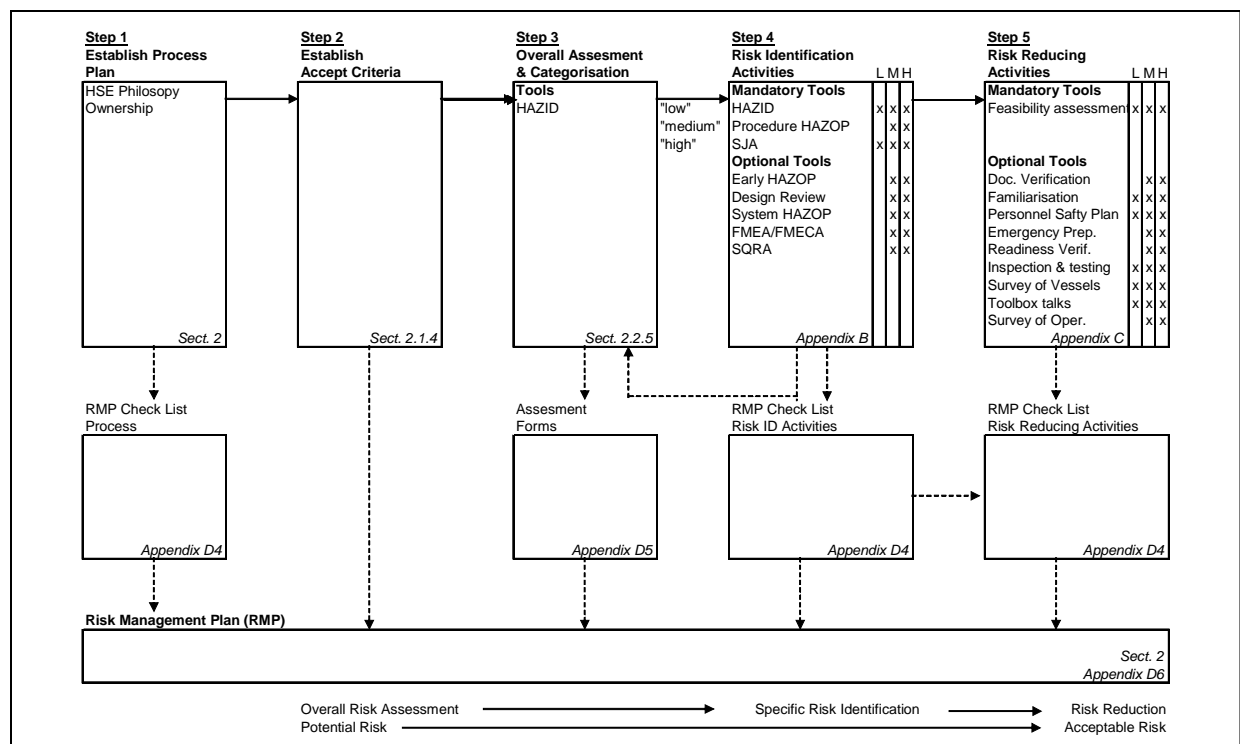
DNV recommends a basic three-step process for management of risks within marine operations:

- An overall risk assessment of the operations to define them within low (L), medium (M) or high (H) potential risk categories - *ref. Step 3, figure 1.*
- Based on concluded potential risk category a detailed risk identification program should be established - *ref. Step 4, figure 1.*
- Based on risk category and findings from the risk identification program, the potential risk is reduced to an acceptable level through specific actions and risk reducing activities - *ref. Step 5, figure 1.*

Pre-activities for planning and establishing accept-, and screening criteria are included as step 1 and 2 in figure 1.

The process is also illustrated through a flowchart in Appendix D2.

Figure 1 – Methodology



1.3 Terminology and Definitions

1.3.1 Definitions

The terminology used in this document are defined below as found relevant.

<i>Accident</i>	Event that which cause injury, illness and/or damage/loss to assets, environment or third parties
<i>Company</i>	The organisation having the overall responsibility for the development project and/or marine operations.
<i>Contractor</i>	The organisation being contracted by Company to perform a specific work-scope.
<i>Guidewords</i>	Used to facilitate a systematic and structured examination and search for possible deviations from the design intent. The list of guidewords is used in conjunction with a list of physical parameters associated with the applicable activity or medium, system conditions and dynamics.
<i>Hazard</i>	Potential source of harm
<i>Hazards Register</i>	Register listing potential Hazards
<i>Incident</i>	Event or chain of events which could have caused, injury, illness and/or damage/loss to assets, the environment or third parties
<i>Marine Readiness</i>	Activity normally performed close to the mobilisation for an operation
<i>Verification</i>	in order to verify adequate preparations and that all relevant actions have been closed
<i>Risk</i>	Product of probability of an event and the consequences of the event.
<i>Risk analysis</i>	Use of available information to identify hazards and to estimate risk
<i>Risk assessment</i>	Overall process of risk analysis and risk evaluation
<i>Risk Management Plan</i>	Document describing <i>objectives, responsibilities and activities</i> for identifying, controlling and reducing project risk
<i>Risk Register</i>	Register listing potential risks. See also Hazard Register
<i>Zero mindset</i>	A culture for always seeking solutions, design, methods etc. satisfying a zero accidents, incidents or loss philosophy, and additionally increase margins and robustness through application of the principles of ALARP.

HAZOP

Hazard and Operability study. The HAZOP is not only focused of possible hazards, but also on issues related to the operability of an activity or operation, the plant or system, including possible improvements, *see also Appendix B3, B5 and B7.*

HAZID

Hazard Identification Analysis, *see Appendix B2.*

HSE

Health Safety and Environment

IFC

Issued for Construction

ITT

Invitation to Tender

MRI

Marine Readiness Inspection

MRV

Marine Readiness Verification

MDR

Master Document Register

NC

Non Conformance

SJA

Safe Job Analysis, *see Appendix B9.*

SQRA

Semi-Quantitative Risk Analysis, *see Appendix B8.*

RMP

Risk Management Plan

RP

DNV Recommended Practice

1.3.2 Terms and Abbreviations

Terms and abbreviations used in this document are listed below.

<i>ALARP</i>	As Low As Reasonably Practicable, <i>see 2.1.2.</i>
<i>CAR</i>	Corrective Action Request
<i>DR</i>	Design Review, <i>see Appendix B4</i>
<i>EPH</i>	Early Procedure HAZOP, <i>see Appendix B3.</i>
<i>FEED</i>	Front End Engineering Design
<i>FMEA</i>	Failure Modes and Effect Analysis, <i>see Appendix B6.</i>
<i>FMECA</i>	Failure Modes, Effect and Criticality Analysis, <i>see Appendix B6.</i>

January 2003

2. Risk Management Planning

2.1 General

2.1.1 Planning of Marine Operations

It is considered essential that marine operations, including all support activities are thoroughly assessed already at conceptual design stages. Risk management and quality assurance processes will then be a positive influence rather than a restrictive constraint on progress. Marine operations and the handled objects should be designed with due consideration to resisting characteristic loads and conditions as well as be practicable and safe. The planning process should address redundancy and backup philosophies as stated in /1/, as well as all other activities required to reach an acceptable risk level.

The planning process should include assessment of personnel exposure and possibilities for reducing this through use of remotely operated tools and handling systems.

2.1.2 HSE Zero Mindset

Basis for this RP is a zero accident, incident and loss philosophy. To satisfy this philosophy a "zero mindset" should be promoted and supported. One important element in the "zero mindset" is the understanding and implementation of the principles of ALARP.

The principles of ALARP are in this document understood as minimising all risks as far as practicable (also below the formally defined accept levels) after having assessed foreseen failure modes, consequences and possible risk-reducing actions. ALARP shall be used both to minimise the probability for an undesired event and the consequences, should such an undesired event happen.

In practise this principle means that all personnel participating in preparations and execution of marine operations should actively seek to minimise risk as far as practicable through preventive operational planning, selecting safe solutions, robust designs etc. Principles of ALARP are considered a mindset. Risk reducing means and actions should be based on subjective cost-benefit assessments.

Illustrative, and as examples are dimensions or particulars of critical low cost components such as padeyes and lifting gear, familiarisation and hazard awareness for personnel involved during operations, limiting number of personnel in potentially hazardous areas such as areas with wires under tension (or use of safety barriers), etc.

2.1.3 HSE Policy and Strategy

As a basis for the risk management process a project specific HSE Policy and Strategy, anchored in the company HSE goals and relevant statutory regulations, should be formulated.

The HSE policy should state specific targets for:

- Personnel safety
- Environment
- Assets
- Reputation

2.1.4 Risk Accept Criteria

Risk is defined as the product of probability of occurrence and consequence, *ref. Appendix D3*.

Consequence Categories

Consequence should be divided into categories. Each category should have specific criteria in compliance with the HSE policy and goals.

Probability Categories

The probability categories should be qualitatively described, with supplementary guidance if needed. Guidance is recommended related (subjectively) to experiences from similar type of operations, *ref. Appendix D3*.

Risk Categories

The consequence and probability categories will define risk. This RP recommends the following terms for categorisation of marine operation risk:

- High
- Medium
- Low

Acceptable Risk

Low Risk category is considered acceptable subject to application of the principle of ALARP and activities as specified in this RP.

For the risk categories "Medium" and "High", specified risk identification activities, the principles of ALARP, and risk-reducing activities are required to ensure performance of the operations with an acceptable risk level.

2.1.5 Personnel Qualifications

Key personnel involved in defining criteria, assessing risk, categorising of operations and establishing and maintaining the Risk Management Plan should be familiar with the practical and theoretical aspects of intended marine operations. Marine operation personnel should be represented.

For kick off sessions, reviews, verifications, etc. a larger group may be applicable. Size of team and fields of experience should reflect complexity and criticality of the intended operations. Representatives from company (responsible party), contractors, independent third parties, HSE management, critical disciplines and insurance may be considered. Personnel participating should be familiar with the planned marine operations.

2.2 Risk Management Plan

2.2.1 Objectives

The overall objectives for the Risk Management Plan (RMP) are to *describe*, *communicate* and *document* activities and processes necessary for managing, through all project phases, the risks involved in the planned marine operations. All processes and activities found required in order to manage risks during marine operations should be reflected in this document.

The RMP should define and allocate responsibilities and be a tool for monitoring status of the risk management process.

The document should be established early, and be continuously maintained to reflect the project status through its various stages.

Volume and complexity is foreseen to vary depending on project complexity and nature of intended operations, from 3 to 4 A4 pages for single low risk operations to more comprehensive documents for larger complex development projects.

2.2.2 Process

The activities required for establishing the RMP should be defined early with clearly assigned responsibilities. The activities defined are recommended controlled through a checklist tool (a sample checklist is included in *Appendix D4*).

The checklist is recommended to include the following main sections:

- Establish HSE policy and strategy, ref. 2.1.2 and 2.1.3.
- Establish acceptance criteria, ref. 2.1.4.
- Define objects, and operations for each object, ref. 2.2.4.
- Categorise the potential risk for each operation, ref. 2.2.5.
- Define required risk identification and risk reducing activities, ref. 2.2.6.
- Establish follow up and close out routines, ref. 2.2.7.

2.2.3 Structure and Revisions

It is recommended that the RMP is project specific, with company (or other responsible party) having the overall responsibility.

If several contractors or subcontractors are involved the document could be structured hierarchically, with involved contractors having a sub-document for his area of responsibility. Contractors/Sub-contractor's RMP should as far as possible be based on plans and systems already established and in-place.

A first revision of the RMP is recommended established as soon as the need for a marine operation is realised. Further revisions of the document should reflect the different project phases and stages. Example of possible revisions is given below.

- Rev. 01 – At Project Definition
Purpose of Issue
Define responsibilities for the Risk Management Process and its initial activities.
- Rev. 02 – At completion of overall assessment
Purpose of Issue
Communicate potential risk categories for planned operations.
- Rev. 03 – When Risk Identification and Risk Reducing activities are defined and/or when a marine operation contractor is nominated.
Purpose of Issue
Define details of all required risk identification and risk reducing activities, allocate responsibilities for these, position them in time and maintain an updated status.
- Rev. 04 – At project completion
Purpose of Issue
Document completion and records from planned activities.

Number of revisions and versions should reflect complexity and criticality of the planned operations, as well as number of involved contractors. A proposed index for a Risk Management Plan is given in *Table 2.1*. A sample RMP is enclosed in *Appendix D6*.

January 2003

Table 2.1 – Risk Management Plan – Main Sections

	<i>Index</i>	<i>Rev. 01</i>	<i>Rev. 02</i>	<i>Rev. 03</i>	<i>Rev. 04</i>
1.	Introduction				
1.1	Objectives	X	X	X	X
1.2	Application	X	X	X	X
1.3	Overall Responsibility	X	X	X	X
2.	HSE Philosophy and Strategy				
2.1	HSE Goals	X	X	X	X
2.2	HSE Philosophy	X	X	X	X
2.3	QA and QS Philosophy	X (draft)	X	X	X
2.4	Risk Accept Criteria		X	X	X
3.	Organisation and Resp.				
3.1	Organisation	X (draft)	X	X	X
3.x	Key Personnel	X (draft)	X	X	X
4.	Object and Operation	X	X	X	X
4.1	Defined Objects and Operations				
4.2	Overall Risk Assessment and Risk Category		X	X	X
5.	Process, Risk Identification and Risk Reducing Activities				
5.1	Process Activities	X	X	X	X
5.2	General QA Activities			X	X
5.3	Risk Identification Activities			X	X
5.4	Risk Reducing Activities			X	X
5.5	Close Out				X

2.2.4 Defined Objects and Operations

The planned project should be reviewed and assessed in order to identify objects and operations to be considered in the risk management process.

An overview should be updated regularly, reflecting new objects and/or revised methods/operations. In the RMP each operation should have define *start* and *end points*, main responsibilities, and (when overall assessment is completed) the potential risk category.

2.2.5 Categorisations of Operations

According to the defined HSE policy, and as basis for specifying required QA activities, risk identification activities and risk reducing activities for the planned operations should be categorised into the following potential risk categories:

- Low
- Medium
- High

The categorisation should be made according to the principles as described in 1.2.1. Records of concerns, highlights and/or comments identified during the assessment with respect to risk, feasibility, installability or performance of the operations should be made.

Qualifications for personnel participating in the assessment should comply with 2.1.5. A group sized to reflect the complexity of the operations should perform the assessment. Too large groups should be avoided.

A proposed Assessment Form is included in *Appendix D5*.

2.2.6 Hazard Identification and Risk Reducing Activities

The overall assessment and following categorisation is performed to create a basis for definition of further risk identification and risk reducing activities. Tables below list recommended activities as a function of potential risk categories. Listed activities are further described in *appendix A, B and C*.

Generally QA activities are assumed based on the already established QA system. The activities listed in *Table 2.2* are meant as emphasis of activities considered of particular importance.

Activities found required for the specific operation should be included in checklists specifying responsibilities, deadlines, status, etc. for each activity. These lists will be part of the RMP, and tools for monitoring and maintaining status for specified activities. A proposed format for the checklists is given in *Appendix D4*. The checklists are recommended to include the following main sections;

- General QA activities, ref. *Table 2.2*
- Risk identification activities (for object & operation), ref. *Table 2.3*
- Risk reducing activities (for object & operations), ref. *Table 2.4*.

Table 2.2 - General QA Activities

Activity	Potential Risk Category/Descriptions		
	Low	Medium*	High
HSE and Q activities Ref. Appendix A2	ISO requirements apply, see ref. /2/.	ISO requirements apply, see ref./2/. Project specific targets, objectives, responsibilities, safety systems and activities (e.g. audits) shall be described/planned Performed at project initiation	
Pre-qualification of Marine Contractors Ref. Appendix A3	To be assessed and documented. Part of ITT		To be assessed and documented. Assessment group to include MO specialists Part of ITT
Planning and Scheduling Ref. Appendix A4	Schedule shall be developed. Document register shall be prepared Milestones shall be stated.	Schedule shall be developed. Master Document Register shall be developed Milestones shall be stated. Timing of contract awards shall be described. Critical decisions to be identified and placed in time Document IFC dates to be identified. Scheduling initiated at concept stage, to be updated as required	
Personnel qualifications and Job descriptions Ref. Appendix A5	Statutory requirements apply.	Statutory requirements apply. Personnel Qualifications defined and described. Management shall prepare work descriptions for all key personnel.	
On site/field Deviation Handling Ref. Appendix A6	Deviation to be logged in e.g. vessel log.	Formal procedures and routines to be developed. SJA normally to be performed. Deviation to be logged and reported. Routines for deviation handling established well before performance of operations	Formal procedures and routines to be developed. Acceptance by required parties to be documented SJA to be performed. Deviation to be logged and reported. Routines for deviation handling established well before performance of operations
Non-conformance reporting Near-miss reporting and registration Incident reporting and registration Experience transfer Ref. Appendix A7,A8, A9, A10	Procedure shall be established and formal routines be followed. Non-conformances, near-misses and incidents to be logged in e.g. vessel log. ISO and NORSOK requirements apply, see ref. /2/, /4/ and /5/.	Procedure shall be established and formal routines be followed. Non-conformances, near-misses and incidents to be logged in vessel log, daily report and project register, and discussed in daily meetings. Reports and meetings shall be listed.	
(*) For a series of similar, repetitive "medium risk" type operations the requirements to "low risk" operations apply after the first typical operation is performed.			

January 2003

Table 2.3 - Hazard Identification Activities

Activity	Potential Risk Category/Descriptions		
	Low	Medium*	High
HAZID Ref. Appendix B2	At concept stage as part of categorisation	At concept stage as part of categorisation After Early HAZOP, before procedures are finalised. May form basis for project risk register	
Early Procedure HAZOP Ref. Appendix B3	NA	When draft procedure or preliminary system design is available	
Design Review Ref. Appendix B4	NA	To be performed for identified critical components and/ or structure (when preliminary design is available) When preliminary design is available	
System HAZOP Ref. Appendix B5	NA	Before detailed design is finalised. To be used if critical and/or complex systems are used during marine operations (e.g. ballast and load transfer systems)	
FMEA/FMECA Ref. Appendix B6	NA	After early HAZOP, before detailed design is finalised To be used if critical and/or complex systems are used during marine operations (e.g. ballast and load transfer systems) Supplementary Tool to HAZID and HAZOP	
Procedure HAZOP Ref. Appendix B7	NA	3 - 4 weeks before mobilisation	4 - 6 weeks before mobilisation
Semi-Quantitative Risk Analysis Ref. Appendix B8	Supplementary Tool to HAZID and HAZOP.		
Safe Job Analysis (SJA) Ref. Appendix B9	As required (before start of activity)		
(*) For a series of similar, repetitive "medium risk" type operations the requirements to "low risk" operations apply after the first typical operation is performed			

Table 2.4 – Risk Reducing Activities

Activity		Potential Risk Category/Descriptions	
	Low	Medium*	High
Operational feasibility assessment <i>Ref. Appendix C2</i>	To be documented. Performed at concept stage	To be documented. Assessment to involve experienced Marine Operation Personnel Performed at concept stage	To be documented. Assessment to involve experienced Marine Operation Personnel Third parties should be represented Performed at concept stage
Document Verifications <i>Ref. Appendix C3</i>	Internal verification.	Internal verification Verification by independent third party company. All documents subject to review shall be identified and listed as soon document register is established	
Familiarisation <i>Ref. Appendix C4</i>	Familiarisation meeting before start of operation with all key personnel involved.	Familiarisation meeting minimum one week before start of the operation with all key personnel involved. Handouts covering key issues shall be distributed. Toolbox talks to be performed.	Familiarisation meeting minimum one week before start of the operation with all key personnel involved. Handouts covering key issues shall be distributed. Meetings and activities shall be planned and listed. Toolbox talks to be performed
Personnel Safety Plans <i>Ref. Appendix C5</i>	Statutory requirements and general routines apply.	Statutory requirements and general routines apply. Project specific planes/routines to be established	
Emergency preparedness <i>Ref. Appendix C6</i>	Statutory requirements apply and general routines apply.	Statutory requirements apply. Safety bridging document to be prepared. Communication checks before start of operation shall be performed. Table-top analysis and/or emergency preparedness drill to be performed.	Statutory requirements apply. Safety bridging document to be prepared. Communication checks before start of operation shall be performed. Table-top analysis and/or emergency preparedness drill to be performed. Documents, exercises and drills shall be planned and listed
Marine Readiness Verification <i>Ref. Appendix C7</i>	Pre-mobilisation activities to be defined.	Pre-mobilisation activities to be defined. Detailed Marine Readiness Verification 1 - 2 months prior to operation	
Inspection and testing <i>Ref. Appendix C8</i>	Temporary structure to be inspected. Temporary systems and equipment to be inspected and tested for functionality and capacity. Permanent systems to be function tested.	Temporary structure to be inspected. Temporary systems and equipment to be fully inspected and tested for functionality and capacity. Permanent systems to be function tested. Systems and equipment subject to inspection shall be listed and records and results from inspection/testing documented (e.g. in checklists). Timing should allow possible corrective actions, recommended 1 - 3 weeks prior to operation.	
Surveys of vessels <i>Ref. Appendix C9</i>	Surveys by Contractor (if applicable). Immediately prior to operation.	Survey by Contractor. Survey by independent third party/company should be considered. Vessels, type of survey, survey scope, records and results to be based on/documented in checklists. Performed 1 -10 days prior to operation	Survey by Contractor. Survey by independent third party/company Vessels, type of survey, survey scope, records and results to be based on/documented in checklists. Performed 1 -3 weeks prior to operation
Toolbox Talk <i>Ref. Appendix C10</i>	Performed prior to each work task		

January 2003

Activity		Potential Risk Category/Descriptions	
	Low	Medium*	High
Surveys of operations Ref. Appendix C11	Surveys by Contractor.	Survey by independent third party company. Operations subject to survey shall be listed Survey scope, records and results to be based on/documented in checklists. Certificate of Approval to be issued for the operation.	
(*) For a series of similar, repetitive "medium risk" type operations the requirements to "low risk" operations apply after the first typical operation is performed.			

2.2.7 Follow-up and closeout

All planned activities relevant for specific operation should be checked out with an acceptable status by a formal signature of responsible for operations before start.

3. References

/1/ "DNV Rules for Planning and Execution of Marine Operations"

/2/ ISO 9001-2000, "Quality Management Systems Requirements"

/3/ NS-ISO 17776, "Petroleum and natural gas industries, Offshore Production Installations, Guidelines on Tools and Techniques for Hazard Identification and Risk Assessment"

Other References

/4/ S-012N, NORSOK "Helse, miljø og Sikkerhet (HMS) ved Byggerelatert Virksomhet"

/5/ Z-013 NORSOK Standard "Risk and Emergency Preparedness Analysis."

/6/ NPD - Forskrift om Helse Miljø og Sikkerhet i Petroleumsvirksomhet, Rammeforskriften 31. august 2001.

Appendix A. - General Quality Assurance Activities

Appendix B. - Hazard Identification Activities

Appendix C. - Risk Reducing Activities

Appendix D. - Miscellaneous.