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RECOMMENDED PRACTICE  
DNV-RP-H102

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MARINE OPERATIONS DURING  
REMOVAL OF  
OFFSHORE INSTALLATIONS

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APRIL 2004

DET NORSKE VERITAS

# FOREWORD

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## 1. Introduction

### 1.1 Objective

The objective with this RP (Recommended Practice) is to establish technical guidelines and recommendations that would result in an acceptable low risk of failure for the marine operations needed during removal of offshore installations. See the DNV Rules for Planning and Execution of Marine Operations, Pt.0 Ch.1 Sec.1.1.

Reference to the DNV Rules for Planning and Execution of Marine Operations will be given in the form of: “the rules” and by “Pt. Ch. Sec.”.

### 1.2 Clarifications

This RP, including references (see Section 4), gives detailed requirements for:

- a) content of test and operational procedures
- b) loads and load effects to be considered
- c) strength and or capacity, condition and contingency or back-up of equipment and vessels
- d) strength, quality and redundancy of temporary structures
- e) condition and strength verification of the object to be removed.

This is in order to ensure that the operation is planned and executed in a manner that fulfils the objective.

By following the recommendations in this RP it is assumed that the safety of personnel and an acceptable working environment are ensured in general. However, specific personnel safety issues are not covered in any detail in this RP. Relaxations in the personnel HSE regulations applicable for marine operations during transport and installation of offshore structures shall not be allowed.

If a removal operation involves risk of pollution, damage to live platforms or vessels not involved in the operation, additional requirements, i.e. not given in detail in this RP, will normally be applicable. See also 2.1.4 and 2.1.8.

This RP does not accept a lower safety level for removal operations than those for other marine operations, see Pt.0 Ch.1 Sec.1.1.2. However, the structural strength acceptance criteria for the removed object can often be relaxed.

### 1.3 Application

This RP (Recommended Practice) is applicable for the removal of offshore installations, such as:

- a) topsides
- b) steel jacket substructures
- c) loading columns
- d) subsea installations.

The basis for this RP is the principles and recommendations given in the rules. The relationship between this RP and the rules is clarified in 1.4.

Gravity base structures or removal by so-called “single lift” vessels are not covered, in particular, in this RP.

### 1.4 The relationship between this RP and the rules

This RP should be considered as a guideline describing how to apply the requirements of the rules in connection with removal operations.

This RP has been divided into one general section and one operation specific section, and in general follows the layout in the rules.

In addition to the many specific references to the rules, this RP

mainly gives:

- A summary of the items in the rules that are considered most important for removal operations.
- Elaborates on items that will be different for “traditional” marine operations and removal operations.
- Includes items of importance for removal operations that are not covered in the rules.
- Pin-points items which are due for revision in the rules.

### 1.5 Classification of objects

Objects that are removed will normally be either re-used or scrapped. Hence, this RP recommends classifying the objects into the two types:

- Objects to be re-used (REUSE)
- Objects to be safely scrapped (SCRAP)

If parts (e.g. equipment) of a SCRAP shall be re-used this should be especially considered.

The classification of the object will to some extent define the limit states and or failure modes to be checked and the acceptance criteria, see 2.5.8 and 2.5.9, as well as design factors to be used, see e.g. Table 3-2.

### 1.6 Alternative methods

This document describes the practice recommended by DNV, but this does not inhibit the use of other alternative approaches which meet the overall objective. Generally, if alternative methods are used it shall be documented that:

- The main objective described in 1.1 is fulfilled.
- Operational control and redundancy are equal or greater than obtained by following the guidelines and recommendations in this RP.

### 1.7 Terminology and definitions

Terminology used in this document are defined below as found relevant.

<i>Company</i>	The organisation having the overall responsibility for the decommissioning project and/or marine operations.
<i>Contractor</i>	The organisation contracted by <i>Company</i> to perform a specific scope.
<i>Decommissioning</i>	The work following cessation of production activities on offshore installations, usually including partly or complete removal of obsolete installations.
<i>Marine operation</i>	Non-routine operation of a limited defined duration carried out for overall handling of an object at sea (offshore, sub-sea, inshore and to/from shore). Marine Operations are normally related to handling of objects during temporary phases from/to the quay side/construction sites to/from its final destination/installation site.
<i>May</i>	The term “may” has in this document the meaning as “An equivalent alternative for satisfying stated requirement”
<i>Owner</i>	The respective owner (or hirer with responsibility for any damage) of objects, equipment and vessels.
<i>Point of no return</i>	PNR - The latest point in time during an operation where the object can be halted in a safe condition, or the operation reversed to a safe condition within the available weather window.
<i>Removal operation</i>	A marine operation carried out during decommissioning.

<i>Safe Condition</i>	A (support) condition for which it is documented that the object fulfil the design requirements applying the applicable unrestricted, see 2.2.1, environmental loads. The environmental loads shall be based on extreme value statistics, see Pt.1 Ch.3. Sec.2, considering the expected maximum duration of the “safe condition” and, if relevant, the actual season.	MBL MWS	Minimum Breaking Load Marine Warranty Surveyor (Could for removal operations also mean an independent “marine verification” body)
<i>Shall</i>	The term “shall” has in this document the meaning as: “the only alternative for satisfying stated requirements”	NDT NDE	Non-Destructive Testing Non-Destructive Examination (i.e. NDT + Visual inspection)
<i>Should</i>	The term “should” has in this document the meaning as “a recommended alternative for satisfying stated requirement”	PNR ROV RP SKL SLS SMYS SSCV STF SQL	Point of No Return Remotely Operated Vehicle DNV Recommended Practice SKew Load factor Serviceability Limit State Specified Minimum Yield Strength Semi-Submersible Crane Vessel Storm Factor, i.e. Hmax/Hs Steel Quality Level
Terms and abbreviations used in this document are listed below.			
ALS	Accidental Limit State	T <sub>R</sub>	Operation reference period
ALARP	As Low As Reasonable Practicable	T <sub>POP</sub>	Planned operation period
C <sub>o</sub>	weather forecasted operation criteria (denoted “operation criteria” in the rules)	ULS	Ultimate Limit State
CoB	Centre of Buoyancy	WLL	Work Load Limit (Also named: SWL – Safe working load)
CoG	Centre of Gravity	WROV	Work-class Remotely Operated Vehicle
DC	Design Class	μ	Friction coefficient
DP	Dynamic Positioning	<b>1.8 Removal and installation – differences</b>	
FLS	Fatigue Limit State	The main objective of this section is to give the reader a fast overview of the main differences described in this RP between “traditional” marine operations and removal operations. In Table 1-1 the main differences have been listed. Sections in this RP, which are included as general information and only summarise, copy or emphasise recommendations in the rules, are not included in the table.	
HAZOP	HAZard and OPERability study, see DNV-RP H101		
HAZID	HAZard IDENTification analysis, see DNV-RP H101		
HLV	Heavy Lift Vessel, also called Heavy Lift Carrier, see Pt.2 Ch.3 Sec.5		

Section(s)	Subject	Reason for included
2.1.3 and 2.1.5	Documentation of object particulars and or conditions	Further emphasise uncertainties in CoG/CoB/structural condition.
	Risk	See DNV-RP H101
2.1.6/7/8	Planning	Clarify relevant items not mentioned in the rules.
2.2.2	Operation reference period	Clarify the requirements in the rules, and give some recommendations applicable for removal operations.
2.2.3	Operation limitations	Clarify and modify the requirements in the rules.
2.2.4	Weather forecast uncertainty	Detail and relax the requirements in the rules.
2.3.4	STF – “Storm factor”	STF reduced for short operations.
2.3.7	Weight estimate	Modify and elaborate requirements in the rules.
2.3.8	Marine growth	Not mentioned in the rules as not relevant for installation.
2.4.3	Characteristic loads	Not included in the rules and no other rules show the two categories of E-loads.
2.5.4	Failure Modes	Relax and clarify requirements in the rules.
2.5.5	Load factors	Open for a possible reduction of the load factor on unrestricted E-loads from 1.3 to 1.15 and clarify the criteria for using 1.2 load factors on G and Q loads.
2.5.9	Accept criteria SCRAP	Not included in the rules.
2.6	Materials and Fabrication	Modified and elaborated content in the rules.
2.7.1 and 2.7.3	Equipment requirements	Give a fast overview of the guidelines and requirements in the rules.
2.7.4	Seafastening and grillage	Guidelines regarding friction and FLS included.
3.1.4	Design Conditions	Reduction in requirements for SCRAP.
3.2.2	Load Cases	Not defined in the rules.
3.2.4	Trapped water	Not mentioned in the rules.
3.2.6 and 3.2.7	Subsea cutting	Not mentioned in the rules.
3.3	Back loading	Refers to applicable requirements in the rules and gives new guidelines and requirements.
3.4	Transport from offshore	Give guidelines how to consider the requirements in the rules for transports (to offshore).
3.5.1 and 3.5.2	Onshore transfer	Reduction in requirements to accept criteria and design conditions for SCRAP

## 2. Part I – General Requirements

### 2.1 Planning

#### 2.1.1 General

The general requirements for planning of marine operations are described in Pt.1 Ch.2 Sec.2.

For removal operations it could be difficult to establish reliable input parameters. This should be duly considered in the planning.

It is recommended to adopt a sequence for the planning and design process and to establish a design basis as described in Pt.1 Ch.2 Sec.2.1.2/3.

As the owner to some extent, could define the acceptance criteria related to failure of the removed object, it will be important to establish a detailed design basis for removal operations as early as possible in the planning process. Preferably this design basis should at this early phase be accepted by all involved parties, including the MWS.

#### 2.1.2 Planning principles

The planning philosophy recommended in the rules will in general apply for removal operations. This philosophy is expressed as indicated below.

- a) Marine operations shall be planned and prepared to bring an object from one defined safe condition to another according to safe and sound practice, and according to defined codes and standards.
- b) Risk management, see 2.1.4, should be included in the planning.
- c) Planning of marine operations shall be according to fail safe principles, i.e. the handled object shall remain in a stable and controlled condition if a failure situation should occur.
- d) It should be possible to recover the object into a safe condition, or interrupt the operations in case of a possible failure situation.
- e) For operations passing a point where the operation cannot be reversed, a point of no return (PNR) shall be defined. Safe conditions after passing a point of no return shall be defined and considered in the planning.
- f) All possible contingency situations shall be identified, and contingency plans or actions shall be prepared for these situations. Such plans shall consider redundancy, back-up equipment, supporting personnel, emergency procedures and other relevant preventive measures and actions. Contingency situations may be defined or excluded based on conclusions from risk evaluations, see 2.1.4.
- g) Design and planning for marine operations shall, as far as possible, be based on well proven principles, techniques, systems, and equipment. If new or existing technology in a new environment is used, this technology should be qualified, see DNV-RP A203.

#### 2.1.3 Documentation

An important part of the planning of marine operations is to document acceptable characteristics for the handled object and all equipment, temporary or permanent structures, vessels etc. involved in the operation. Requirements to this documentation are given in Pt.1 Ch.2 Sec.2.2.

To obtain reliable documentation of the characteristics and condition of the handled object during removal operations could be challenging. Emphasis shall be put on collecting all available and minimum required documentation regarding:

- a) Weight and CoG.
- b) Buoyancy and CoB.

- c) Structural condition, see 2.5.2.
- d) Current status, see 2.1.7

The environmental data to be used as basis for defining the design conditions shall be thoroughly documented.

#### 2.1.4 Risk evaluations and management

Risk evaluations shall be carried out for all removal operations in order to reveal all possible hazards and their potential consequences. The type and extent of risk evaluations should be based on the complexity of each removal operation. It is recommended that risk management planning according to DNV-RP H101 is performed in order to ensure a systematic evaluation and handling of risk.

In Pt.1 Ch.2 Sec.2.3 risk evaluations are further described. Normally contingency situations with a probability of occurrence less than  $10^{-4}$  per operation do not need to be considered. However, it is recommended that all removal operations are based on the ALARP principle.

For most removal operations local damage to the handled object and surrounding structures can be tolerated. This could be considered in the evaluations of acceptable risk.

If the removal operation could involve risk of pollution, damage to live platforms, pipelines, subsea structures or vessels not involved in the operation risk analysis covering these aspects should be carried out. Any recommendations from such analysis shall be considered in the operational planning and procedures.

#### 2.1.5 Weight, CoG, buoyancy and CoB

In the rules it is stated that “Weight and position of centre of gravity should preferably be determined by weighing”. Hence, it is also generally recommended to carry out weighing of objects to be handled in removal operations. If weighing is not found feasible the weight and centre of gravity should be established based upon data from construction and installation of the platform and information from the operator gathered during its lifetime.

For many handled objects it could be difficult to obtain reliable weight/CoG and buoyancy/CoB (if applicable) data. Hence, the confidence level of the weight and buoyancy data obtained must be taken into account in planning of the removal operations.

Application of “conservative” weight and buoyancy inaccuracy factors in the planning and engineering of removal operations will in many cases be an insufficient way to consider the weight and buoyancy inaccuracies. In addition to such factors at least all possible effects of;

- a) “extreme” positions of CoG and CoB in all three directions,
- b) an object weight equal to the lowest possible weight and
- c) buoyancy equal to the maximum feasible buoyancy,

need to be considered. See also 2.3.7 and 2.3.9.

In general the recommendations in Pt.1 Ch.3 Sec.3.5 and Sec.3.6 apply.

#### 2.1.6 Operation period and environmental criteria

To define the (sub) operations as either unrestricted- or restricted (see 2.2.1) could have a great impact on the safety and cost of the removal work. Hence, type of operation should, if possible, be defined early in the planning process.

It should be noted that the methods given in Pt.1 Ch.3 Sec.2.2.2 (wind) and Pt.1 Ch.3 Sec.2.3.3 (waves) for defining environmental design loads consider the duration of the (unrestricted) operation. However, for unrestricted removal operations with duration less than 5 days, i.e.  $T_R \leq 120$  hours, a reduction in the

design wind speed and wave height found by pure statistical methods could be considered. The magnitude of applicable reduction need to be agreed with all involved parties, including the MWS, considering:

- a) Proven reliability of weather forecasts for the actual season and area.
- b) Available contingency procedures in case of deteriorating weather conditions.
- c) The consequences of exceeding the defined environmental conditions.

The operation manual shall clearly express the actions needed due to such reduced environmental design criteria.

### 2.1.7 Surveys

In this section all types of pre-surveys, inspections, etc., done in order to collect information about the status of the object(s) to be removed and if applicable surrounding installations, are called surveys. Surveys are normally a significant part of the planning process for removal operations. A systematic survey program shall be made and verified, i.e. agreed between the parties.

Due consideration should be paid to the scheduling of the surveys. I.e. the survey information needs to be received early enough to be included properly in the planning process, but it should not be too old to be reliable. See also 2.2.7.

Survey methods should be selected based on equipment availability, cost and the required accuracy of the results.

The main scope of the surveys related to the removal operation is to;

- confirm that design basis data used in the original design documentation still are valid or to gather required data that are not available (see 2.5.2),
- check all items (e.g. dimensions and possible obstructions) that need to be considered in the planning and/or during the operation, and
- identify items (e.g. hazardous materials and loose items) that could represent a safety risk.

For design basis data that are not covered by the surveys conservative assumptions should be made. Possible inaccuracies in the applied survey methods should be duly considered by applying corresponding contingency factors.

Operational planning and procedures shall take into account the items that could represent a safety risk. See also 2.2.8.

### 2.1.8 Project specific requirements

All project specific requirements relevant for the removal operation have to be identified. Such requirements need to be reviewed (and if necessary discussed) and recognised by the involved parties, and could e.g. be related to:

- a) Emergency procedures (bridging document).
- b) HSE regulations (Company, contractors and/or onboard vessels).
- c) Identification and handling of hazardous materials.
- d) Preservation of the environment (e.g. use of explosives, handling of items that can be partly contaminated by drilling mud, produced oil, etc.).
- e) Other ongoing operations in the field.
- f) Design verifications, see e.g. 2.5.4
- g) Operational methods (e.g. divers allowed or not)
- h) Status after removal, e.g. level of leg/pile cutting, plugging of wells, cleaning, final survey.

The identified requirements shall be considered in the planning

and execution of the removal operation(s).

## 2.2 Operations

### 2.2.1 General

The general operational requirements for marine operations described in Pt.1 Ch.2 Sec.3 will normally be applicable also for removal operations. The following sub-sections include a summary with emphasis on the most important items for removal operations.

The rules classify marine operations either as “weather restricted” (see Pt.1 Ch.2 Sec.3.1.2) or as “unrestricted” (see Pt.1 Ch.2. Sec.3.1.3). The main difference between these operations is how the environmental loads are selected, see Table 2-5. A weather restricted operation shall be of limited duration, i.e. normally  $T_R \leq 72$  hours.

### 2.2.2 Operation reference period

As stated in Pt.1 Ch.2 Sec.3.1 an operational reference period ( $T_R$ ) needs to be established. For weather restricted operations  $T_R$  shall be taken greater or equal to the maximum estimated time required to bring the object from one safe to another safe condition, see 1.7.  $T_R$  is defined as the planned operation period ( $T_{POP}$ ) plus estimated contingency time ( $T_C$ ).

For removal operations a realistic schedule could be difficult to establish due to the inherent uncertainty by handling “old” objects. For weather restricted operations the risk due to this uncertainty should be reduced as much as possible by:

- a) Carry out the preparations in such a way that the tasks needed to be done within the  $T_{POP}$  are reduced to a minimum.
- b) Simplify the tasks that need to be done within the  $T_{POP}$  as much as possible, e.g. by preparing as much as imaginable of the seafastening before a lift and back-loading operation commences, see 3.4.8.
- c) Include ample contingency time in the planning. Note that a  $T_R$  greater than twice (see Pt.1 Ch.2 Sec.3.1.1.3) the  $T_{POP}$  could be applicable for removal operations. Risk analysis should be used as an assisting tool to establish realistic contingency times.
- d) Consider the uncertainty in the weather forecasts, see 2.2.4.

If it is documented that the operation could, if required, be safely halted, see e.g. 3.3.3 – last paragraph, this could be considered when the minimum  $T_R$  is established.

### 2.2.3 Operational limiting criteria

Operational environmental limiting criteria ( $OP_{LIM}$ ) shall be established and clearly described in the operation manual. The  $OP_{LIM}$  shall never be taken greater than the minimum of, as applicable:

- a) Applied environmental design criteria (denoted “ $C_D$ ” in the rules).
- b) Maximum wind and waves for safe working- or transfer conditions for personnel.
- c) Equipment (e.g. ROV and cranes) weather restrictions. The relevance of specified equipment weather restrictions could be evaluated based on items as criticality, back-up equipment and contingency procedures.
- d) Limiting weather conditions of diving system (if any).
- e) Any limitations identified in e.g. HAZID/HAZOP based on operational experience with involved vessel(s) etc.

### 2.2.4 Forecasted and monitored operational limits

Uncertainty in both monitoring- and forecasting of the environmental conditions shall be considered. It is recommended

that this is done by defining a forecasted (and monitored) operational criteria (denoted “ $C_O$ ” in Pt.1 Ch.2 Sec.3.1.2) as  $C_O = \alpha \times OP_{LIM}$ . The following should be used as guidelines for selecting the appropriate factor for waves, see also Table 2-1:

- a) The expected uncertainty in the weather forecast should be calculated based on statistical data for the actual site. For the North Sea the figures in Table 3.1 in Pt.1 Ch.2 Sec.3 normally apply.
- b) If applicable special considerations should be made regarding uncertainty in the swell period (and height).

- c) If a reliable wave and/or vessel response monitoring system is used in combination with the weather forecast,  $\alpha = 1.0$  is normally acceptable for operations with  $T_{POP} \leq 6$  hours. However, for very sensitive operations with “design  $H_s$ ”  $\leq 2$  m,  $\alpha = 0.9$  is recommended. For  $T_{POP} > 6$  hours the factor found according to item a. above could be increased by 10%.
- d) If weather forecast level A, see 2.2.5, is applied the factor found according to item a. above could be increased by 10%.

**Table 2-1 Recommended factor for waves in the North Sea**

Operational Period [h]	Wave/response monitoring (Mon.)? Weather forecast level A (WF-A)?	Design Wave Height [m]		
		$1 < H_s \leq 2$	$2 < H_s \leq 4$	$H_s > 4$
$T_{POP} \leq 6$	Mon. = yes	0.9	1.0	1.0
$T_{POP} \leq 12$	Mon. = yes and WF-A = yes	0.82	0.92	0.97
	Mon. = yes or WF-A = yes	0.75	0.84	0.88
	Mon. = no and WF-A = no	0.68	0.76	0.80
$T_{POP} \leq 24$	Mon. = yes and WF-A = yes	0.76	0.86	0.91
	Mon. = yes or WF-A = yes	0.69	0.78	0.83
	Mon. = no and WF-A = no	0.63	0.71	0.75
$T_{POP} \leq 48$	Mon. = yes and WF-A = yes	0.68	0.77	0.81
	Mon. = yes or WF-A = yes	0.62	0.70	0.74
	Mon. = no and WF-A = no	0.56	0.64	0.67
$T_{POP} \leq 72$	Mon. = yes and WF-A = yes	0.62	0.71	0.76
	Mon. = yes or WF-A = yes	0.56	0.65	0.69
	Mon. = no and WF-A = no	0.51	0.59	0.63

Note 1: The grey shaded rows correspond to Table 3.1 in Pt.1 Ch.2. However, in Table 3.1 the operational period is defined by  $T_R$ .

Note 2: The factor  $\alpha$  could be assumed to vary in time for one operation.  
E.g. for an operation with  $T_{POP} = 36$  hours,  $H_s = 3.0$  m, Mon. = no and WF-A = yes; the factor  $\alpha$  is 0.84 for the first 12 hours, 0.78 for the next 12 hours and 0.70 for the last 12 hours of the operation.

An appropriate factor  $\alpha$  for wind shall also be used. It is recommended that this factor is duly considered based on the operational period, weather forecast reliability and the criticality of exceeding the design wind speed. In the rules a factor  $\alpha$  for wind of 0.8 is indicated.

### 2.2.5 Weather forecasting

Arrangements for receiving weather forecasts at regular intervals prior to, and during the marine operations shall be made. Such weather forecasts shall be obtained from recognised sources. See Pt.1 Ch.2 Sec.3.2.1 for detailed requirements for weather forecasting.

Based on evaluations of the operational sensitivity to weather conditions, a categorisation of the operation into weather forecast levels A, B or C shall be made, see Pt.1 Ch.2 Sec.3.2.2. For removal operations the following levels would normally apply:

- Level A for weather sensitive offshore operations or tows with  $T_R > 24$  hours.
- Level B for weather sensitive offshore operations or tows with  $T_R \leq 24$  hours.
- Level C for non weather sensitive offshore operations or tows and inshore operations.

A weather forecast is acceptable for start of marine operations if all relevant items listed in Pt.1 Ch.2 Sec.3.2.1.3 are within the defined limitation  $C_O$  for the complete operation reference period ( $T_R$ ).

For swell sensitive operations it is recommended that the forecast includes a table and/or graph grouping swell heights with corresponding periods and directions.

The weather report should also provide details of likely precip-

itation (rain/snow), mist and fog as these conditions will tend to hinder operations such as welding, which particularly important for the sea-fastening phase.

### 2.2.6 Organisation

Organisation charts and lines of command of key personnel involved in the removal operation shall be established, see Pt.1 Ch.2 Sec.3.3. Also, the decision making process for the off-shore phases must be clearly described, and in particular cover passing of PNR’s and commencement of transport to shore of the removed object (see 3.4.8).

### 2.2.7 Preparation and testing

General requirements to preparations and testing are given in Pt.1 Ch.2 Sec.3.4.

Surveys, see 2.1.7, may have been carried out well in advance of the operation. Hence, re-checking of items included in these surveys shall be considered.

### 2.2.8 Status of object

It will in some cases not be feasible to fully document the status of the object to be removed. Hence there could be items with uncertainties at the start of the removal operation. Such items that could influence the safety and/or operational feasibility shall be identified and acceptable (possible) corrective actions to be described in the operational procedures.

### 2.2.9 Marine operation manuals

The operational procedures shall be described in a Marine Operation Manual covering all aspects of the operations including contingency planning, see Sec.4 /1/ Pt.1 Ch.2 Sec.3.5 for details.

## 2.3 Loads

### 2.3.1 General

See Pt.1 Ch.3 Sec.1 for some general information regarding loads and load effects for marine operations.

Loads and load effects are in this RP categorised into the following groups;

- Permanent Loads – G, (Note that the term P is used for these loads in the rules),
- Variable Functional Loads – Q (Note that these loads are called Live Loads – L in the rules),
- Environmental Loads – E,
- Accidental Loads – A, and
- Deformation Loads – D.

In the following subsections the loads normally considered applicable for removal operations have been categorised. See also Pt.1 Ch.3 Sec.3.1 and Sec.3 in DNV-OS-C401 regarding typical loads in each category.

### 2.3.2 Permanent loads – G

Permanent loads are loads that will not vary in magnitude, position or direction during the period considered. Examples are;

- weight of structure, equipment and permanent ballast (see 2.3.7),
- weight of marine growth (see 2.3.8), and
- buoyancy (see 2.3.9).

### 2.3.3 Variable functional loads – Q

Variable functional loads are loads that may vary in magnitude, position or direction during the period considered. Examples are;

- ballasting/de-ballasting,
- operational impact loads,
- winch operational loads, and
- stored items.

### 2.3.4 Environmental loads – E

All loads caused by environmental phenomena shall be categorised as environmental loads.

Environmental conditions to be considered are described in Pt.1 Ch.3 Sec.2. Wave-, wind- and current loads are defined in Pt.1 Ch.3 Sec.3.3 and Sec.3.4.

Loads due to the gravity components in plan parallel or perpendicular to deck, caused by motions due to wind and waves of a floating object, shall be categorised as environmental loads.

The STF (“storm factor”), i.e.  $H_{max}/H_s$  is, in the rules, defined as  $STF = 2.0$  for weather restricted operations for all  $T_R$  (see 2.2.2) up to 72 hours. For (parts of) removal operations of short duration, as set down on barge, the STF could be defined as indicated in Table 2-2.

$T_R$ – Operation Reference Period	STF
$T_R < 10$ min.	1.6
$10$ min. $\leq T_R < 30$ min.	1.7
$30$ min. $\leq T_R < 1$ hour	1.8
$1$ hour $\leq T_R < 3$ hours	1.9
$3$ hours $\leq T_R < 72$ hours	2.0

### 2.3.5 Accidental Loads – A

Accidental loads are loads related to abnormal operations or technical failure. Examples of accidental loads are loads caused by;

- accidental impact loads (collisions, dropped objects, etc.),

- unintended change in ballast distribution,
- flooding of hull compartment(s),
- failure of mooring line(s) or loss of DP control, and
- loss of internal pressure.

Characteristic accidental loads shall be based on realistic accidental scenarios. See Pt.1 Ch.3 Sec.3.8.

### 2.3.6 Deformation loads – D

Deformation loads are due to imposed deformations. Examples of deformation loads are loads caused by;

- tolerances on set down supports,
- structural restraints between structures (see Pt.1 Ch.3 Sec.3.7),
- differential settlements, and
- temperature.

Offshore strengthening and/or joining/uncoupling of modules could cause restraint loads that need to be considered.

Calculations of characteristic deformation loads shall be based on maximum and/or minimum values of tolerances, deflections, settlements, temperature, etc.

### 2.3.7 Weight and CoG estimates/calculations

See 2.1.5 regarding weight and CoG considerations in the planning phase.

According to recognised codes (and Table 2-5) the characteristic value for the weight should be taken as the “expected weight”. Normal practice is to define the “expected weight” as “maximum (or minimum) expected weight”. Hence, it is recommended that the “expected weight” is taken as the “best estimate” weight multiplied (or divided, see 2.1.5) by a contingency factor. The factors indicated in Table 2-3 should, if lower factors have not been documented, be regarded as minimum contingency factors. For (parts of) objects with weight control systems that are not covered by Table 2-3, relevant contingency factors should be found by;

- a) Identify the “best estimate” (BE) weight of (the part of) the object.
- b) Estimate by reasonable conservative assumptions the “maximum (minimum) expected weight” (MW).
- c) Calculate the weight contingency factor as  $MW/BE$ .

Description of weight control system/ weight calculation method	Part of Object	WCF
Weighing with tolerance $< \pm 3\%$	All	1.0
Weighed weight at installation and weight control during the lifetime.	All	1.05
Estimated weight, see Pt.1 Ch.3 Sec.3.5.2, for objects where no modifications during the lifetime has taken place.	All	1.1
Review of as built drawings including all modifications during the lifetime and thorough inspections to verify drawings.	Structural	1.05
Review of as built drawings and records of history.	Structural	1.1
Well documented installation weights and thorough inspections.	Equipment and accessories	1.1
Documented installation weights not available, but thorough inspections.	Equipment and accessories	1.2
Calculated based on that all possible members/tanks are flooded.	Entrapped water	1.0
Calculated according to NORSOK, see 2.3.8.	Marine Growth	1.0
Estimated based on surveys.	Marine Growth	1.2

The weight uncertainties for the different parts of an object

could vary considerably. Accordingly, it would normally be applicable to apply different contingency factors for each part. Attention shall be paid to possible additional weights due to e.g. equipment/structural modifications, new piping/electrical cables, concrete fillings, flooded members, and tank residual.

Extreme positions of the CoG should be calculated based on an unfavourable distribution of maximum and minimum expected weight of parts of the object. However the joint probability of extreme CoG positions and maximum (minimum) weight could be considered.

### 2.3.8 Marine growth

It is recommended that the extent of marine growth is assessed based on surveys. If reliable survey data are not available the marine growth could be calculated based on NORSOK N-003. See also Ch.2 Sec.1 B 700 in DNV-OS-E301.

Weight (and buoyancy) of marine growth is in NORSOK N-003 defined as a Q load. However, the weight will not vary during a removal operation and weight of marine growth is hence defined as a G load in this RP. The effect of increased drag and added mass shall be regarded as an E load.

### 2.3.9 Buoyancy

Buoyancy (hydrostatic external load) is normally counteracting another load and shall be categorised accordingly.

For removal operations special attention, if applicable, shall be paid to the buoyancy. Normally the buoyancy of the object should be determined on the basis of an accurate geometric model. However, for removal operations such a model may not be available. In addition buoyant members/compartments could have been water filled. Hence, it is recommended that "worst case" scenarios regarding the buoyancy are considered, see 2.1.5.

## 2.4 Load Analyses

### 2.4.1 General

All loads and load effects which during the removal operation may influence operational procedure, design or the dimensioning of structures shall be analysed and considered in the planning and preparation.

For marine (and removal) operations possible effects of;

- a) dynamics, see Pt.1 Ch.3 Sec.3.2.3,
- b) non-linearity, see Pt.1 Ch.3 Sec.3.2.4,
- c) friction, see 2.4.2,
- d) soil resistance, see 3.2.8, and

- e) specified tolerances (e.g. on sling lengths), see Pt.1 Ch.3 Sec.3.2.6,

could be of great importance. Hence, such effects shall be evaluated and included in the load analysis if it is not documented that they may be disregarded.

In order to determine load effects results from both model and other tests (e.g. of friction) should be considered whenever possible. See Pt.1 Ch.3 Sec.3.2.7 and Pt. 1 Ch.4 Sec 3.3.

### 2.4.2 Friction

Possible additional loads (reaction forces) due to effect of friction shall always be evaluated, see Pt.1 Ch.3 Sec.3.2.5. If documented a reduction in the design load, e.g. for seafastening, may be considered due to friction effects.

The design friction effect (reaction force) shall be calculated as the maximum (or minimum) design reaction normal to the (friction) surface multiplied with the friction coefficient.

Friction coefficients ( $\mu$ ) applied shall be documented. Upper bound  $\mu$  for some (lubricated) surfaces conditions are shown in Table 2.2 in Pt.2 Ch.1. If no relevant documentation is available the lower bound  $\mu$  for calculation of favourable friction effects shall be taken as maximum the value found in Table 2-4.

Surface 1	Surface 2	Condition	$\mu$
Steel	Steel	Wet	0.0
Steel	Steel	Dry	0.1
Steel	Timber (wood)	Wet	0.2
Steel	Timber (wood)	Dry	0.3
Steel	Rubber	Wet and dry	0.3

Note: The table is based on recommendations in IMO re. A.714(17). It is assumed that the friction surfaces are free from oil or other lubricating fluids

Dynamic friction coefficients are recommended used for all vessel transports in open sea. This because hull vibrations (e.g. due to wave impacts) and deflections (e.g. due to hogging and sagging) normally could initiate movements at the friction surfaces. Hence, if higher factors than shown in Table 2-4 are used these should normally not be taken greater than the documented minimum dynamic friction coefficients.

### 2.4.3 Characteristic loads

A characteristic value shall be selected as indicated in Table 2-5 for all applicable loads. See 1.7, 2.3.1 and 2.5.3 for clarifications of terminology.

Load category	Limit states – temporary design conditions				
	ULS	FLS	ALS		SLS
			Intact structure	Damaged structure	
Permanent (G)	Expected value (weight/buoyancy)				
Variable (Q)	Specified value	Specified load history	Specified value		
Environmental (E) – Weather Restricted Operations	Specified value	Specified load history		Specified value	Specified value
Environmental (E) – Unrestricted Operations	Based on statistical data <sup>1)</sup>	Expected load history		Based on statistical data <sup>1)</sup> and <sup>2)</sup>	
Accidental (A)			Specified value		
Deformation (D)	Expected extreme value	Expected load history	Specified value		

1) See Pt.1 Ch.3 Sec.2.2.2, Sec.2.2.3, Sec.2.3.6 and Sec.2.4.1.  
2) Joint probability of accident and environmental condition may be considered.

#### 2.4.4 Sensitivity studies

Parametric sensitivity studies should be performed if any load or operational parameters significantly affect the design or the selection of method and equipment. See Pt.1 Ch.3 Sec.3.2.2 and Pt.1 Ch.4 Sec.2.2.2.

For removal operations sensitivity studies should, as applicable, be considered for items as:

- a) Buoyancy and CoB variations.
- b) Weight and CoG variations.
- c) Random reaction force because cutting not complete.
- d) Unexpected soil suction loads.
- e) Set down outside specified tolerances.

### 2.5 Structural analysis and capacity checks

#### 2.5.1 General

For removal operations the structural analysis for the removed object will in many cases be limited to checking of an existing structure. The design recommendations given in this section shall be considered applicable for this type of analysis.

It shall normally be documented that the requirements in Pt.1 Ch.4 are fulfilled. However, Pt.1 Ch.4 does not specify detailed requirements for design calculations. Accordingly, Pt.1 Ch.4 shall be used together with acceptable publications describing additional requirements for design, e.g.:

- DNV-OS-C101
- Eurocode 3 – ENV 1993-1-1 – Design of Steel Structures
- NORSOK N-001 and N-004
- NS3472 – Design of Steel Structures
- API – RP-2A-LRFD

#### 2.5.2 Design considerations

Design considerations for marine and removal operations are described in Pt.1 Ch.4 Sec.2.1. If any of the design considerations mentioned in the rules are not fulfilled by existing structures it should be carefully evaluated if this is acceptable.

See especially Pt.1 Ch.4 Sec.2.1.4 regarding existing structures. For removal operations it will be important to inspect and evaluate the most critical parts of the structure in particular for modifications (e.g. removed temporary structures for installation), damage, integrity of repairs and corrosion incurred during the lifetime of the installation. At least the redundancy of the structural system during operation shall be investigated and the critical elements (none or poor redundancy) shall be identified. Inspection of those elements shall as a minimum be performed. See also 2.1.7.

For members that are not thoroughly inspected conservative assumptions should be made. Corrosion allowance as per design for the structure should at least be taken into account for these members.

Modifications, damage and corrosion of significance must be taken into account in the structural analysis. Guidelines regarding how to consider corrosion and damages on members are

given in Section 10 of NORSOK-N-004.

#### 2.5.3 Method

Design verification methods are described in Pt.1 Ch.4 Sec.3, which recommends the partial coefficient method for verification of structural strength. Load and material factors specified in this sub-section are according to the principles of the partial coefficient method.

A limit state is commonly defined as a state in which the structure ceases to fulfil the function, or to satisfy the conditions, for which it was designed. The following groups of limit states shall be considered in the strength verification:

- The Ultimate Limit States (ULS), corresponding to the ultimate resistance for carrying loads.
- The Fatigue Limit States (FLS), related to failure due to effect of cyclic loading.
- The Accidental Limit States (ALS), is both related to failure due to an accidental event or an operational fault, and to failure due to the effect of a possible local damage or a defined failure (i.e. “one line broken” in mooring systems) of a selected (single) element. Note that ALS is denoted PLS in the rules.
- The Serviceability Limit States (SLS), corresponding to the criteria applicable to normal use or durability.

The format of the partial coefficient method implies that strength analysis of structures or structural element involves the following steps:

- a) Identify all relevant failure modes and the corresponding group(s) of limit states, see 2.5.4.
- b) For each failure mode, determine the design load cases and conditions, see 2.5.5.
- c) For each failure mode, determine the design load effects, see 2.5.6.
- d) For each failure mode, determine the design resistance, see 2.5.7.
- e) Ensure adequate safety by proving that the design loads or effects does not exceed the design resistance, see 2.5.8 and 2.5.9.

#### 2.5.4 Failure modes

All relevant failure modes shall be investigated. See Pt.1 Ch.4 Sec.2.3.2. A failure mode is relevant if it is considered possible and the anticipated consequence(s) of the failure can not be disregarded.

Table 2-6 gives advice on relevance for some failure modes to be considered for the listed elements or objects. Where applicable the limit state group and a (“normally applied”) accept criteria have been indicated or it has been referred to where guidelines for defining the accept criteria may be found. Note that the table should be regarded rather as examples than as a complete list. Hence, for “standard” structural failure modes, (see e.g. DNV-OS-C101), have not been included.

**Table 2-6 Examples of failure modes for removal operations**

<i>Elements or objects and operations as indicated</i>	<i>Failure Mode</i>	<i>Limit state group(s) and accept criteria (ref.)</i>
Jackets and piled subsea structures after the piles are (partly) cut	Overturning – on bottom stability	ULS/FLS – No overturning <sup>1)</sup>
All objects transported on seagoing vessels	Overturning of cargo	ULS – No uplift <sup>2)</sup>
All vessels and self floating objects	Loss of hydrostatic/-dynamic stability	ULS and ALS – See Pt.1 Ch.2 Sec.4
REUSE all operations	Unacceptable damages	ULS/FLS/SLS – See 2.5.8
SCRAP all operations	Excessive deformations	ULS/FLS – See 2.5.9
SCRAP all lifts	Dropped load	ULS – See 2.5.9, 2.7.2 and 2.7.3
All lifts in water	Slack slings; DAF > 2.0	ULS <sup>3)</sup> – No slack, DAF 2.0
Seafastening	Sliding of object	ULS – See 2.7.4
Seafastening	Overturning of object	ULS – See 2.7.4
Seafastening	Unacceptable cracks	FLS – See 2.7.4
Grillage	Unacceptable damage to transport vessel	ULS – See 2.7.4
Guides and bumpers	Exceeding “allowable” stresses	Not relevant for design according to the rules, but see 3.3.5.
Guides and bumpers	Excessive deformations	Fulfilment of functional requirements to be documented

- 1) Neither caused by excessive uplift nor soil or structural failure.  
 2) See 2.7.4, guidance note.  
 3) This check is often done without load (safety) factors, i.e. a SLS case. This is not acceptable as the only check to verify that  $DAF \leq 2.0$ .

**2.5.5 Design loads and conditions**

The design loads are found by multiplying the characteristic loads, see 2.4.3, by appropriate load factors. Design load cases (note the “basis” conditions a) and b) for ULS, see also Pt.1 Ch.4 Sec.3.5.2.1) are established by combining all design loads with physically possible simultaneously occurrence in all possible directions. Joint probability and statistically independence may be considered, see Pt.1 Ch.4 Sec.2.2. Load factors -  $\gamma_f$  for ULS shall be taken according to Table 2-7.

**Table 2-7 Load factors -  $\gamma_f$  for ULS**

<i>Combination of design loads</i>	<i>Load categories</i>			
	<i>G</i>	<i>Q</i>	<i>E</i>	<i>D</i>
Condition a)	1.3, 1.2 <sup>1)</sup> or 1.0 <sup>2)</sup>	1.3, 1.2 <sup>1)</sup> or 1.0 <sup>2)</sup>	0.7	1.0
Condition b)	1.0	1.0	1.3 or 1.15 <sup>3)</sup>	1.0

1) For loads and load effects that are well controlled a reduced load coefficient  $\gamma_f = 1.2$  may be used for the G and Q, loads. Hence, if compliance with this RP is confirmed by 3<sup>rd</sup> party verification  $\gamma_f = 1.2$  is normally acceptable.  
 2) Where a load G or Q (e.g. self weight or hydrostatic pressure) causes favourably load effects a load coefficient  $\gamma_f = 1.0$  shall be used for this load.  
 3) Normally, if negligible risk for human life,  $\gamma_f = 1.15$  is acceptable for “unrestricted” (see 2.2.1) removal operations.

Load factors  $\gamma_f$  for FLS, SLS and ALS could normally be taken equal to 1.0. However the following shall be noted:

- In FLS an adequate safety level is obtained by using “lower bound” SN-curves and appropriate DFF (Design Fatigue Factors), see DNV-OS-C101 Sec.6 A200. See also Pt.1 Ch.4 Table 3.3 showing 1/DFF values.
- In SLS the object (or equipment/vessel) owner is free to define accept criteria and load factors to be used.
- The characteristic loads combined with the assumed design condition in ALS are normally considered to have a very small probability of occurrence. Hence, if an ALS load or condition is not considered to have a sufficient low probability a load factor greater than 1.0 could be relevant.

**2.5.6 Design analysis**

Design analysis is carried out in order to find the design load effects. A design load effect is the most unfavourable combined load effect derived from the design loads.

The analytic models used for evaluation of responses, structural behaviour and resistance must be relevant considering the design philosophy, type of operation and possible failure modes. They should satisfactorily simulate the behaviour of the structures, its supports, and the environment.

Sections 5 through 9 in DNV-OS-C101 indicate methods and requirements for structural strength analysis.

**2.5.7 Structural resistance**

The structural resistance shall be determined in accordance with a recognised code or standard, see 2.5.1. A design resistance ( $R_d$ ) is obtained by dividing the characteristic resistance ( $R_c$  – see Pt.1 Ch.4 Sec.4.1.2) by a material coefficient ( $\gamma_m$  – see Pt.1 Ch.4 Sec.4.1.3/4/5/6), i.e.  $R_d = R_c / \gamma_m$ .

**2.5.8 Accept criteria – general**

The level of safety of a structural element is considered to be satisfactory if the design load effect ( $S_d$ ) does not exceed the design resistance ( $R_d$ ), i.e.  $S_d \leq R_d$ . The equation:  $S_d = R_d$  defines a limit state.

As indicated in 2.5.4,  $S_d \leq R_d$  has to be verified for all relevant failure modes. Structural analysis for marine operations is normally verifying the ULS by linear elastic analysis (see however) 2.4.1 allowing stresses above yield in limited areas only. Hence, such analysis will implicitly also cover failure modes as:

- Failure of critical components of the structure caused by exceeding the ultimate resistance, in some cases reduced by repeated loads, or the ultimate deformation of the components.
- Transformation of the structure into a mechanism, i.e. collapse or excessive deformation.
- FLS (for most details considering the limited number of cycles).
- SLS checks (failure modes).

If not otherwise agreed with Company, it is for REUSE (see 1.5) recommended that the normally used accept criteria for marine operations also are adopted for removal operations.

## 2.5.9 Accept criteria – SCRAP

For SCRAP (see 1.5) it is acceptable in ULS to consider large plastic deformations and failure (loss of structural resistance) of single members if it can be documented that:

- The structure will not transform into a mechanism, i.e. collapse.
- Failure of critical members/components (e.g. pad eyes) will not occur when considering any possible re-distribution of loads.
- Possible re-distribution of loads will not overload supporting equipment (e.g. lifting slings) or structures (e.g. grillages/sea-fastening).
- FLS does not represent a relevant failure mode considering that a limited number of cycles could be critical if large deformations are allowed.
- Any possible SLS (e.g. deformation limitations to ease object handling or not damage equipment that will be re-used) specified by the owner is satisfied.

## 2.6 Materials and fabrication

### 2.6.1 General

Requirements for materials and fabrication are described in Pt.1 Ch.4 Sec.4.2. Note that the references in the rules to the “DNV Rules for Classification of Mobile Offshore Units” will be replaced with references to DNV-OS-C101 (Section 4) and DNV-OS-C401 (especially section 3 – testing of welds), in the next issue of the rules. See also DNV-OS-B101.

### 2.6.2 Existing materials

Existing materials in objects to be removed should be documented based on original fabrication documentation and/or material testing. Accept criteria could be based on the applicable codes and standards at the time of installation.

If neither reliable documentation nor test results are available (or possible to obtain) the minimum material (strength) properties as considered possible should be assumed.

Testing in order to find the material properties should be done with methods capable of detecting the needed properties with sufficient accuracy. The determination of characteristic yield strength should be in accordance with the evaluation procedure in NS-ENV 1993-1-1, annex Z.

### 2.6.3 Selection of new materials

Guidelines for selection of new materials for offshore steel structures can be found in DNV-OS-C101 (Section 4). For materials in temporary structures used for removal operations the following apply:

- The design temperature, see DNV-OS-C101 (Section 4B) should be defined based on the season and location of the removal operation. Note that a design temperature above 0°C could be applicable.
- See Table 2-8 for guidelines regarding selection of Structural Category. See also DNV-OS-C101 (Section 4C).
- For materials that will be welded on vessels offshore it is not recommended to specify yield strength (SMYS) above 355 Mpa.

Selection criteria for structural category		Examples for typical structures involved in removal operations	Recommended Structural Category		Insp. Cat. See DNV-OS-C101
Failure consequence	Structural part		DNV See DNV-OS-C101	NORSOK See NORSOK -N-004	
Substantial and the structure possesses limited residual <sup>2)</sup> strength.	Complex <sup>1)</sup> joints	<ul style="list-style-type: none"> <li>— Pad eyes and other lifting points</li> <li>— Seafastening elements without redundancy</li> <li>— Spreader bars</li> </ul>	Special	DC1 – SQL1	I
	Simple joints and members		Primary (Special) <sup>3)</sup>	DC2 – SQL2 (SQL1) <sup>3)</sup>	
Not substantial as the structure possesses residual <sup>2)</sup> strength.	Complex <sup>1)</sup> joints	<ul style="list-style-type: none"> <li>— Structures for connection of mooring- and towing lines</li> <li>— Grillages</li> <li>— Redundant <sup>2)</sup> seafastening elements</li> </ul>	Primary (Special) <sup>3)</sup>	DC3 – SQL2 (SQL1) <sup>3)</sup>	II
	Simple joints and members		Primary (Special) <sup>3)</sup>	DC4 – SQL3 (SQL1) <sup>3)</sup>	
Any structural part where failure will be without substantial consequences		<ul style="list-style-type: none"> <li>— Bumpers and guides</li> <li>— Fender structures</li> <li>— Redundant <sup>2)</sup> (parts of) grillages</li> </ul>	Secondary	DC5 – SQL4	III

1) Complex joints mean joints where the geometry of connected elements and weld type leads to high restraint and to triaxial stress pattern.

2) Residual strength (redundant) means that the structure meets requirements corresponding to the damaged condition in the check for ALS, with failure in the actual joint or component as the defined damage.

3) Selection where the joint strength is based on transference of tensile stresses in the through thickness direction of the plate.

### 2.6.4 Tolerances

DNV-OS-C401 (Ch.2 Sec.2E) indicates normally acceptable fabrication tolerances.

Due to limited accuracy of guiding systems and time squeeze, especially requirement(s) for maximum misalignment could be difficult to meet during a removal operation. Hence, it should be duly considered to define and document less strict tolerances than indicated in DNV-OS-C401.

### 2.6.5 Assembly and welding

Guidelines regarding assembly and welding may be found in DNV-OS-C401 (Ch.2 Sec.2 F).

Environmental conditions during removal work could be unfavourable and the time available is often limited. Also accurate fit-up could be difficult to obtain, e.g. to a dented barge deck. Hence, the following special precautions are recommended:

- Welding procedure specifications to be qualified by a welding procedure tests carried out under conditions representative of the actual working environment, see DNV-OS-C401 (Ch.2 Sec.1 B500).
- Thorough inspections of fit-up and welding to be planned for.

- c) Weather conditions and forecast to indicate acceptable conditions for welding considering the welding method and available shelter at the welding locations.
- d) Increased weld size in order to compensate for inaccurate (too big gaps) fit-up to be considered.
- e) Robust and well proven welding methods and procedures to be applied.
- f) Material with improved weldability, see DNV-OS-C101 (Section 4 D200), to be considered.

### 2.6.6 Weld Inspection

Requirements for Non-Destructive Testing (NDT) of welds may be found in DNV-OS-C401 (Ch.2 Sec.3C). Minimum extent of inspection should be as shown in DNV-OS-C401 (Ch.2 Sec.3 Table C1) with "Inspection Category" as defined in Table 2-8. See also Table 2-10 for a summary of the required minimum extent of NDE.

Normally final inspection and NDT of welds shall not be carried out before 48 hours after completion. However, for materials with yields strength of 355 MPa or lower this could be reduced to 24 hours. See NORSOK-M-101 (Section 9.1) and DNV-OS-C401 (Ch.2 Sec.3 C100) for further details.

For removal operations with weld inspection on critical path minimum waiting time could be selected according to Table 2-9. Note that decreased waiting time according to Table 2-10 should not be used if the precautions listed in 2.6.5 are not fulfilled.

**Table 2-9 Minimum Extent of NDE and Waiting Time**

Inspection Category	Minimum extent of NDE		Minimum waiting time before NDE	
	Visual	NDT <sup>1)</sup>	SMYS <sup>2)</sup> 355 MPa	SMYS > 355 MPa
I	100%	100%	24 hours <sup>5)</sup>	48 hours <sup>5)</sup>
II	100%	20% <sup>4)</sup>	Cold weld <sup>3)</sup>	24 hours <sup>5)</sup>
III	100%	5% <sup>4)</sup>	Cold weld <sup>3)</sup>	24 hours <sup>5)</sup>

1) Test method to be selected according to the type of connection, see DNV-OS-C401 (Ch.2 Sec.3 Table C1).

2) SMYS to be defined according to the specification for the actual material used and not according to the minimum required design value.

3) The NDT could start when the weld is cold, but it is recommended to wait as long as practicable.

4) An increased % rate shall be evaluated if defects are found and/or weld conditions and precautions, see 2.6.5, are not fully satisfactory.

5) The use of PWHT (post weld heat treatment) could (will) reduce the required waiting time.

## 2.7 Equipment, systems and vessels

### 2.7.1 General

Normally requirements for equipment, systems and vessels used in marine operations will also be applicable for removal operations.

This section gives an overview of the requirements for stability as well as to functional-, strength-, and capacity verifications of equipment, systems and vessels that are not (fully) covered by the requirements in 2.5, i.e.:

- a) Miscellaneous systems, see Pt.1 Ch.2 Sec.5.1.
- b) Cranes, see 2.7.2.
- c) Lifting equipment, see 2.7.3 and 3.1.3.
- d) Guiding and positioning systems (structures), see Pt.1 Ch.2 Sec.5.4.
- e) Cutting equipment/systems, see 3.2.6.
- f) Stability and reserve buoyancy of self floating objects, see Pt.1 Ch.2 Sec.4.1 and 4.3.
- g) Buoyancy elements, see Pt.2 Ch.3 Sec.4.1.7.2 and Pt.2 Ch.4 Sec.3.2.2.2/3.
- h) Barge and vessel stability, see Pt.1 Ch.2 Sec.4.1, 4.2 and 4.5.
- i) Barges (vessels) strength, see Pt.2 Ch.2 Sec.2.3.3/4.
- j) Towing equipment/systems, see 2.7.3 and Pt.2 Ch.2 Sec.3.
- k) Seafastening and grillages, see 2.7.3 and 2.7.4.
- l) Ballasting equipment/systems, see Pt.2 Ch.1 Sec.2.5.5/6/7 and Sec.4.5.2.
- m) Pull/push equipment/systems, see Pt.2 Ch.1 Sec.2.5.2.
- n) Trailers/rollers/skidding equipment, see Pt.2 Ch.1 Sec.2.5.3/4.
- o) Mooring equipment/systems, see 2.7.3 and Pt.1 Ch.2 Sec.5.3.

For general requirements to functionality and back-up of equipment, systems and vessels see Pt.1 Ch.2 Sec. 5.1/5.2.

### 2.7.2 Cranes

Requirements for condition and documentation for cranes (and crane vessels) are given in Pt.2 Ch.5 Sec. 5.1.

As the lift weight and/or the status (i.e. not complete) of cutting could be uncertain for removal operations it would normally be important that:

- a) The crane load monitoring system could be trusted, i.e. it is accurate (better than +/-5%) and recently calibrated.
- b) There is made an operational contingency procedure covering the possibility that the crane load monitoring indicates overload.

### 2.7.3 Equipment with certified WLL (SWL) or MBL

The accept criteria for equipment, including wire ropes and chains, with certified WLL or/and MBL is in the rules depending on the use of the equipment. It is recommended that the same accept criteria for equipment is used also for removal operations, see Table 2-10 for guidance.

**Table 2-10 Summary - accept criteria for equipment**

Type	Use	Cert. <sup>1)</sup>	Design Load	SF	Comment/Ref.
Shackle	Lifting	SWL	Static load, no load factor	≥ 1.0	Both these criteria to be fulfilled, see Pt.2 Ch.5 Sec.3.2
Shackle	Lifting	MBL	Dynamic load, no load factor	≥ 3.3	
Shackle <sup>2)</sup>	Towing	MBL	Towline MBL	≥ 1.0 <sup>3)</sup>	See Pt.2 Ch.2 Sec.3.1.3.2
Shackle <sup>2)</sup>	Towing	SWL	Towline MBL		Used if cert. MBL not available
Shackle <sup>2)</sup>	Mooring	No specific criteria given in the rules			Use requirement to towing based on MBL of mooring/seafastening <sup>4)</sup>
Shackle <sup>2)</sup>	Seaf.	No specific criteria given in the rules			
Wire rope sling	Lifting	MBL	Dynamic load, no load factor	≥ 3.0 (2.3)	See 3.1.3.
Wire rope and Chain	Mooring	MBL	ULS design Load	≥ 1.5	See Pt.1 Ch.2 Sec.5.3.5 (Note: Capacity reduction if bending)
Wire rope and Chain	Mooring	MBL	ALS design Load	≥ 1.3	
Wire rope and Chain	Seaf.	MBL	ULS design Load incl. SKL	≥ 1.5	See Pt.2 Ch.3 Sec.2.1.6
Fibre slings	Lifting	MBL	Dynamic load, no load factor	≥ 3.0	Normally $\mu_m \geq 3.0$ , hence SF $\gg 3.0$ Proof loading required in the rules <sup>5)</sup> .
Fibre rope	Towing	MBL	Towline MBL	≥ 1.5 – 2.3	See Pt.2 Ch.2 Sec.3.1.3.7
Fibre rope	Mooring	MBL	See Pt.1 Ch.2 Sec.5.3.55) and DNV-OS-E301		
1) Certified capacity. Note that “catalogue” values for MBL should not be used without additional documentation. 2) The accept criteria for shackles is normally also applicable for equipment as rings, deck eyes, turnbuckles, etc. 3) Normally minimum 1.3 is recommended. 4) For long term use, i.e. if FLS verification required, see DNV-OS-E301 (Ch.2 Sec.4H). 5) Note that the requirements to fibre slings and ropes in the rules are under review and will be revised.					

### 2.7.4 Seafastening and grillage

General guidelines for seafastening and grillage are given in Pt.2 Ch.2 Sec.2.3.2. Internal seafastening is covered in Pt.2 Ch.2 Sec.4.1.3.

Friction may be taken into account in the seafastening design provided there are bearing surfaces with documented friction coefficients, see 2.4.2, between transported object and vessel deck/grillage. Friction shall not be considered as a mean of seafastening if rigid steel elements (roll/pitch stoppers) are welded between the offshore structure and the vessel. Friction force mobilised at wooden cribbing elements higher than 50% of their width can be considered to act longitudinally only, and not transverse of the element.

For seafastening and grillage made of steel structures the design and fabrication requirements in 2.5 and 2.6 apply. FLS, see Pt.1 Ch.4 Sec.3.2.7, does not normally need to be included in the design calculations for short transports if the following are documented:

- Possible strain (loading) in seafastening due to global deflections of transport vessel has been thoroughly evaluated and if relevant included in the ULS loads.
- ULS acceptable without allowing plastic deformations causing significant redistribution of loads.

Seafastening for ship transports is often made by chain (or wire rope) and is covered in Pt.2 Ch.3 Sec.2.1.6. See also Table 2-10 for accept criteria.

#### Guidance note:

A requirement to install uplift seafastening if no uplift is calculated exists neither in the rules nor in this RP. However, if “first uplift” represents an ULS, it is recommended to apply an additional safety factor corresponding to a “material factor”. This could be done by applying a load factor of 0.85 on G loads in the uplift load case(s).

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## 3. Part II – Operation Specific Recommendations

### 3.1 Offshore crane lift operations

#### 3.1.1 General

Pt.2 Ch.5 gives specific guidance and recommendations for well controlled lifting operations, onshore, inshore and offshore, of objects with weight exceeding 50 tonnes. A summary with emphasize on items applicable for removal lift operations, is given in the following sub-sections.

#### 3.1.2 Loads

The loads to be considered for a lift are described in Pt.2 Ch.5 Sec. 2. Table 3-1 includes a load summary.

Load definition	Pt.2 Ch.5	Comment
Basic Loads	Sec. 2.1	Special attention to uncertainties in weight and CoG for removal operations needed, see 2.1.5. Rigging- and special loads to be considered as for any lift.
Dynamic Loads	Sec. 2.2	Special attention to dynamic effects during set down on vessels offshore needed, see 3.3.4.
Skew Loads	Sec. 2.3	Fabrication tolerances for lift points used during removal could be excessive, see 3.1.5. This should be considered in the skew load calculations. For SCRAP it could be applicable to use $SKL_{sl} = 1.0$ , see 3.1.4.
Loadcases	Sec. 2.4	Impact loads on grillages (and guides) during set-down need to be specially considered.

### 3.1.3 Lifting equipment

The lifting equipment shall in general have the same quality and strength as for installation lifts. Hence, the requirements in Pt.2 Ch.5 Sec. 3 normally apply. However, the following could be applicable:

- a) Load factor of 1.2 if the lift weight is determined by weighing or “conservatively” calculated.
- b) A consequence factor lower than 1.3.
- c) A nominal safety factor lower than 3.0 (note that 3.0 will be replaced with 2.3 in Pt.2 Ch.5 Eq. 3-3 in the next issue of the rules.

Regarding strength calculations of spreader bars/frames see also Pt.2 Ch.5 Sec. 4.1.4.

### 3.1.4 Design conditions, structures

General recommendations regarding structural design are given in 2.5. For design of pad eyes and other structural elements, additional design factors as described in Table 3-2 should be applied.

Tolerances which may result in an excessive lateral load components or skew loads should be avoided. Applying the partial coefficient method for the design, the load combination “a”, see 2.5.5, will be governing. In addition to the standard 1.3 (or 1.2, see Table 2-7) load factor ( $\gamma_f$ ) a consequence factor ( $\gamma_c$ ) shall be applied.

<i>Element category</i> <sup>1)</sup>	$\gamma_c$
Lift points including attachments to object	1.3
Lifting equipment (e.g. spreader frames or beams, plate shackles).	1.3
Main elements supporting the lift point.	1.15
Other elements of lifted object.	1.0
Elements not contributing to the overall structural integrity of a lifted object that will be scrapped - (SCRAP), see 1.5.	$\leq 0.8$ <sup>2)</sup>
1) $\gamma_c$ is meant to account for severe consequences of single element failure. Categorisation of elements according to the table above should hence duly consider redundancy of elements.	
2) Any factor $\gamma_c$ could in principle be agreed with the owner for these elements.	

For global lift analysis of SCRAP the  $SKL_{sl}$  (see Pt.2 Ch.5 Sec.2.3.2) for a statically indeterminate 4 points lift with “matched slings”, could normally be taken equal to 1.0. However, for local strength calculations of lift points and their supporting members the  $SKL_{sl}$  should be as recommended in the rules.

### 3.1.5 Lift points

The recommendations regarding lift points in Pt.2 Ch.5 Sec.4.1.3 and Sec. 4.2.1 should be considered for removal operations. In case the recommended design considerations and/or material quality are not fulfilled by existing lift points this needs to be carefully evaluated, see 2.5.2.

For existing “old” lift points it is recommended that, as a minimum, NDT are carried out in order to detect surface breaking defects.

To connect slings to other structural elements than purpose built lift points could be acceptable, but need to be carefully evaluated in each case.

If not purpose built lift points or “old” lift points with neither detailed drawings (of e.g. lift point geometry and original rigging) nor accurate inspection possibilities (subsea) are used, skew- and sideways loads need to be carefully evaluated.

### 3.1.6 Lift operation

The recommendations in Pt.2 Ch.5 Sec.5 are normally applicable for removal operations. For removal operations the need for detailed contingency procedures in case of, e.g.;

- possible substantial delays (and weather deteriorating),
- unacceptable object tilt at lift-off, or
- crane hook load reading is (too) high, see 2.7.2,

shall be carefully evaluated.

## 3.2 Subsea operations

### 3.2.1 General

In this section removal of subsea structures by lifting are described. Guidelines for preparations, load cases and operations are given. Sec.3.1 includes general requirements to offshore lifting.

### 3.2.2 Load cases

A lift operation for subsea structure does not represent one well defined load case, see Pt.2 Ch.5. Sec. 2.4.1. The following basic load cases should be considered:

- a) Lift-off or pull-out, from the bottom.
- b) Lifting through the water with the object completely submerged.
- c) Lifting through the splash zone.
- d) Lifting in air.
- e) Set down on transport vessel.

For each basic load case it could be required to analyse several object positions and load combinations.

### 3.2.3 Design loads

Pt.2 Ch.6 Sec.2 presents recommendations for determination of operational and environmental load effects. The following motions/loads are described:

- a) Crane tip motion.
- b) Hydrodynamic forces in the splash zone.
- c) Hydrodynamic forces on submerged objects.
- d) Other loads, e.g. “Pull down and pull in”, “Mating and impact forces”, “Off-lead and side lead forces” and “current forces on ROV”.

### 3.2.4 Trapped water

Possible effects of trapped water as;

- a) considerable increase in crane hook load,
- b) unacceptable tilt of lift due to change in CoG, and
- c) reduced lift stability due to free surface effects combined with changed CoG,

during lifting out of water should be duly considered.

If necessary the lifted subsea structure should be perforated before the removal lift in order to reduce the effect of trapped water.

### 3.2.5 Preparations and operations

All subsea operations should be planned to be carried out to as great extent as practicable by WROV’s and equipment operated by WROV’s. The contingency planning must take into account loss or malfunction of ROV at all phases of the subsea operations. This may compel at least two WROV spreads available during time critical (weather restricted) operations, e.g. final cut of jacket legs/piles after passing a PNR. See 2.1.2 f) regarding redundancy and back-up planning, and also Pt.2 Ch.6 Sec.4.1 and 4.2.

### 3.2.6 Subsea cutting

Subsea cutting of structures should primarily be planned to be performed by WROV operated or other means of remote operated equipment with proven usage record. See also Pt.2 Ch.6 Sec.4.4.

If cutting is performed after a PNR the redundancy and back-up of cutting equipment must be thoroughly considered during planning.

For the operation succeeding the cutting; the platform structure must comply with “unrestricted” environmental conditions with respect to strength and on-bottom stability (see Table 2-6 and Guidance Note 2 below), unless the cut out part is immediately, i.e. within the same weather window as the cutting operation, removed.

Guidance Note 1:

**Guidance note:**

For removal of a jacket the above implies that after cutting of all piles the jacket must either;

- be lifted to the transport vessel, sufficiently secured and if not sea-fastened for an “unrestricted” weather condition (see 2.2.1), transported to shore in the same weather window (see also 3.4.8), or
- the on-bottom stability must be sufficient to withstand the seasonal storm for an unrestricted operation, i.e. the jacket shall be in a “safe condition”, see 1.7. The lifting to the transport vessel and seafastening of the jacket may then be performed later in new weather window.

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Guidance Note 2:

**Guidance note:**

If sufficient structural strength and/or on bottom stability after cutting can not be documented for a complete cut situation this may be obtained by e.g. keeping the structure partly cut or by applying temporary securing.

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### 3.2.7 Verification of cutting

Prior to commencement of lifting an object from the platform structure or from the foundation piles, it should be verified that the planned cut has been achieved. Hence, if the applied cutting method does not guarantee the planned cut, the planned cutting need to be verified. The verification method(s) should be duly evaluated based on their documented reliability and the importance of verifying the planned cut accurately. This could imply that in some cases at least two independent methods for verification of planned cut should be used.

### 3.2.8 Soil resistance

Removal of objects and structures from the seabed, requires consideration being given to the resistance from the surrounding soil. This resistance will be a function of several parameters, like soil conditions, presence of grout, foundation geometry, lifting velocity, exposure time, contact pressure, etc.

In particular for seabed structures equipped with skirts or buckets the retraction resistance may be several times higher than the force required at the time of installation.

When removal involves objects temporarily positioned on the seabed to aid the operation, the capacity of such elements requires consideration to be given to the soil capacity for the prevailing load conditions.

In Pt.2 Ch.6 Sec.3 advice on how to determine soil capacities is given. For removal operations note especially the requirements in “Section 3.2 – Pull out Forces”.

For removal of seabed structures by means of overpressure in skirt compartment(s) in combination with lifting force, the sequence of the two may have an impact on the total resistance and the safety of the operation. Generally, it is recommended

to fix the lifting force within safe limits and then gradually increase the overpressure until the soil resistance is exceeded, rather than the other way around.

The effect of any other items, as e.g. existence of a pile of drilling cuttings, on the maximum lift loads should be assessed.

## 3.3 Back-loading offshore

### 3.3.1 General

General recommendations for load transfer operations are given in Pt.2 Ch.1, but they are not intended for back-loading operations off-shore. Hence, applicable recommendations for back-loading by lifting have been given in the sub-sections below. Requirements to the lift itself are given in 3.1.

For all back-loading the following should be considered and documented:

- a) Detailed operational procedures, see 2.2.9.
- b) Acceptable weather conditions.
- c) Required crane radii and clearances.
- d) Deck lay-out, including safe positions for personnel during lifting.
- e) Dynamic/impact set-down loads, see 3.3.4.
- f) Proper guiding system(s), see 3.3.5, and tugger lines.
- g) Temporary securing after set down, see 3.3.6.
- h) Seafastening, grillages and deck strength of receiving vessel.
- i) Safe positioning (anchors/DP) of lifting vessel.
- j) Required ballasting of lifting vessel.

### 3.3.2 To deck of crane vessel

Back-loading to the deck of the crane vessel may be regarded as a “standard” marine operation. See 3.3.1 for items to be documented. For seafastening and friction see 3.4.8 and 2.4.2.

### 3.3.3 To deck of transport vessel

The transport vessels considered in this section are; barges, supply vessels, cargo ships and HLV - “Heavy Lift Vessels”.

Back-loading of objects with limited weight to supply vessels could be regarded as a standard operation. However, for heavier objects special considerations are needed. In addition to the items in 3.3.1 at least the following should be documented:

- a) Safe positioning (DP/moorings/fendering/tugs) of transport vessel.
- b) Any modifications needed to lifting vessel positioning system, e.g. due to interference of anchor lines or - DP reference systems for the two vessels.
- c) Stability of transport vessel, see 3.4.9.
- d) Ballasting requirements, during and/or after load transfer, of transport vessel.

For single crane removal lifts it could be applicable to plan for, either as “base case” or as a contingency, an intermediate back loading to the crane vessel deck. In this case the back loading will normally be planned as two operations. Hence, the seafastening and grillage design on the crane vessel need to fulfil the requirements to an unrestricted operation, see 2.2.1.

### 3.3.4 Dynamic set down loads

Both horizontal and vertical dynamic set down loads need to be documented. Both simplified (conservative) calculations, advanced analysis (e.g. time domain analysis by SIMO) and/or model tests could be applicable. Type of documentation method should be selected based on thorough evaluations (risk analysis) of operational critically, structural margins and accept

criteria, e.g. if damage is allowed or not.

Any documentation method should at least discuss and consider if applicable the effect of:

- a) Motions of transport vessel.
- b) Motions of crane vessel.
- c) Crane lowering speed.
- d) Required time and operational procedure for load transfer.
- e) Tilt of object.
- f) Design details of support points (and guiding system).
- g) Effective stiffness of support points; considering transport vessel hydrostatics in addition to mass inertia and structural (local) stiffness of vessel and removed object.
- h) Effective stiffness of lifting system; considering crane vessel hydrostatics and mass inertia, and stiffness of hoisting system.

**Guidance note:**

The Decommissioning Technology Forum report No. GM 44159-0401-47192, gives advice, mainly for a large topside structure, regarding method of analysis and typical values of expected set down loads.

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**3.3.5 Guiding systems**

Design requirements for guiding (and positioning) systems are given in Pt.1 Ch.2 Sec.5.4. These requirements imply that the dynamic design loads need to be calculated. However, normal practice for installation guides and bumpers is to use empirical “static” design loads given as a fixed per cent of the lifted object weight. For set down on transport vessels (see 3.3.3) it is recommended to use the former (the rules) approach, while the latter (i.e. in % of weight) could be used for set down on the crane vessel deck and for “lift-out” guides.

The size, lay-out and design of the guiding system should be detailed considering, as applicable:

- a) Functional requirements.
- b) Strength requirements, see Table 2-6 and Pt.1 Ch.2 Sec.5.4.1.2. Plastic deformations of the lifted object could normally be allowed.
- c) Operational procedure and details, e.g. tugger lines.
- d) Maximum calculated relative movements between object and transport vessel (or platform for lift-out guides).
- e) Maximum calculated or allowable tilt of the object in all relevant directions.
- f) Uncertainties in dimensions, especially if the object is a subsea structure without purpose built bumpers.
- g) Final position tolerances for the object on the transport vessel, see also 2.6.4.
- h) Any requirement to the guides to function as (temporary) seafastening after set down, see 3.3.6.

If empirical “static” loads are used as basis for the design, characteristic loads (e.g. as % of weight), limit state group(s), applicable failure mode(s) and acceptance criteria should be defined in a design brief.

**Guidance note:**

Single crane lift with the available contingency of temporary storage on the lift vessel deck or a second crane to assist guide reinstatement can allow barge guiding system design to less stringent criteria. I.e. an increased risk of guide failure could be accepted as they could be reinstated. Note that due attention need to be paid to the increased  $T_R$  this may imply.

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**3.3.6 Temporary securing**

After set down it shall be documented that the object is secure against sliding and overturning until the “permanent” seafastening has been installed. The design loads should be based on motion response analysis, wind loads and any planned heel and trim of vessel.

Possible accidental loads arising from unexpected heel and trim and impacts should be considered.

**Guidance note:**

Overturning restraints are part of the seafastening which normally are not operational directly after set-down, and the sliding resistance could be limited. Hence, the limiting ULS design condition for this phase need to be identified and duly reflected in the operations restrictions.

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**3.4 Transport from offshore locations**

**3.4.1 General**

The transport of the platform structure shall be planned and prepared according to philosophies and requirements in 2. Operation and design criteria are dealt with in 2.2. The following sub-sections include a summary of applicable requirements in the rules with emphasis on the most important items for transports from offshore locations.

**3.4.2 Transport (design) criteria**

It could be feasible to weather route (see Pt.2 Ch.2 Sec.2.1.2 and 2.1.6) the transport if the operation reference period,  $T_R$ , (see 2.2.1) does not exceed 72 hours. I.e. a weather routed transport to shore may be allowed if it can be documented that  $T_R \leq 72$  hours considering:

- ample contingency time, see 2.2.2 c), on the preceding offshore weather restricted removal activities,
- minimum documented transit speed (time) with the most unfavourable operational environmental conditions, and
- estimated contingency transit time taking into account available backup and/or redundancy of propulsion system(s) and tugs.

Documented safe havens along the route could be considered.

The transport to shore may always, and if it is not documented that  $T_R \leq 72$  hours it shall, be planned and designed as an unrestricted operation.

A heading controlled transport may be allowed if manoeuvrability and reliable backup and/or redundancy of propulsion system(s) and tugs can be documented. The transport shall in this case as a minimum sustain head- and quartering seas, i.e. wave headings from 315° through 0° to 45° in ULS. For self-propelled vessel it could be acceptable to limit the ULS design heading to head seas +/- 30 degrees, see Pt.2 Ch.3 Sec.5.1.4.2.

All sea directions not included in the ULS shall normally be considered as accidental cases (ALS), but see note 2) to Table 2-5. As a minimum the acceptable weather conditions from all directions have to be assessed and the implied operational restrictions should be thoroughly described in the transport manual.

A transit operation may be both weather restricted and heading controlled. However, it shall be considered that the requirements to “heading control” could increase the length of the feasible tow route and accordingly the operation time.

**3.4.3 Manuals and procedures**

The transport shall be described in a Marine Operation Manual covering all aspects, see 2.2.9. For transports from offshore location the following items shall be described in detail:

- a) Operational environmental criteria for seafastening phase and transport including any heading limitations.
- b) Seafastening installation procedure.
- c) Tow routes including water depths and ports of refuge/holding areas, and berthing/connection to mooring at in-shore location.

### 3.4.4 Transport on crane vessel

Transport on a fully self propelled single hull crane vessel should be regarded as a ship transport, see 3.4.5. A towed or tug assisted single hull crane vessel should be regarded as a manned barge, see 3.4.6.

A transport on a semi-submersible type crane vessel shall comply with the applicable requirements in Pt.2 Ch.7 Sec.3. Transit could, considering the restrictions indicated in 3.4.5, commence immediately after back-loading. However, possible effects, e.g. increased motions or (accidental) heel, of ballast from operational to transit draft should be considered.

Design accelerations should be based on motion response analysis for both (as applicable) transit- and survival/operation draught for the vessel.

If the design criteria for the “transit draught” is “weather restricted” this shall be reflected in the transport manual.

### 3.4.5 Ship transport

See Pt.2 Ch.3 Sec.2 for general recommendations for ship transports.

Design accelerations should normally be based on motion response analysis for the ship. However, it may be feasible to obtain transport design accelerations by simplified methods given by the Classification Society of the ship or in IMO Resolution A.714(17) (1994 amendments).

The transit to shore may commence immediately after back-loading of the platform structure to the vessel, provided the effect of waves, speed and motions of the vessel do not hamper the sea-fastening work or endanger the safety of the seafastening personnel.

Recommendations regarding design and installation of seafastening are given 3.4.8. For smaller cargo elements carried in ship’s hold, normal procedures and arrangements for securing of cargo apply.

### 3.4.6 Barge transport

See Pt.2 Ch.2 for general recommendations for towing.

The transport of the platform structure to shore on an unmanned barge shall not commence before completion of the seafastening work.

Towing force for open sea towing shall normally be sufficient to maintain zero speed under the following conditions;

- sustained wind velocity  $V_w = 20$  [m/s],
- head current velocity  $V_c = 1.0$  [m/s], and
- significant wave height  $H_s = 5.0$  [m].

A relaxation of the above criteria could be applicable based on the tow restrictions (i.e. weather routed tow) and/or statistical seasonal environmental data for the tow route.

Towing force for coastal towing and towing in narrow or shallow waters representing a danger for grounding shall be sufficient to maintain a speed over ground, in safe direction, of minimum 1.0 m/s under defined environmental design conditions. This recommendation may imply additional tug(s) to be connected to the barge when approaching such areas along the towing route.

Above recommendations are based on the necessity to control the tow offshore, and to ensure adequate manoeuvrability in-shore and in narrow waters.

The request for rapid transit to shore, in particular for weather routed and/or heading controlled barge tow (see 3.4.2), may demand more bollard pull than the minimum calculated based on the above criteria. This should be accounted for in planning, towing arrangement and towing equipment.

More detailed recommendations for minimum tug bollard pull, tug efficiency, tugs, towing equipment and barges are given in Pt.2 Ch.2. Sec.3 and 4.

### 3.4.7 Self floating transport

See Pt.2 Ch.3 Sec.4 for general recommendations for self floating towing.

Offshore structures like jackets may be provided with additional buoyancy means before cut-loose from the sea-bed to become self floating. Buoyancy tanks/elements and their connections to the offshore structure must be designed to withstand buoyancy forces and environmental loads, including wave slamming loads. Air pressurisation of the tanks/elements may be allowed provided acceptable arrangement, control and redundancy in the pressurisation system.

The self floating transport of the offshore structure shall be included as a load case in the structural checks described in 2.5. For design of the connections between a buoyancy element and the structure an additional design/consequence factor ( $\gamma_c$ ) of 1.3 should be used if loss of that buoyancy element is deemed critical. Loss of one buoyancy element shall not sink the structure, see 3.4.9.

Towing arrangement, equipment and necessary towing force shall be designed according to the towing resistance of the floating structure. See 3.4.6 and Pt.2 Ch.2 sec.3.

A self floating offshore structure will normally have to be dry-docked for dismantling, thus the minimum draught of the structure must comply with the restrictions for entering the actual dry-dock.

### 3.4.8 Seafastening procedure

Securing of the platform structure on the transport vessel has to be performed in the same weather window as the offshore lifting or back-loading operation, see 3.1 and 3.2. Therefore, the seafastening should be designed for a minimum time needed for their offshore installation after back-loading of the structure part onto the vessel. This may imply maximum prefabrication and installation on the vessel prior to the operation as well as use of non-welded final connections. Novel seafastening methods and arrangements aiming at shortening the offshore installation time must be well documented and/or tested.

Maximum wave height during installation of seafastening must allow personnel working on deck of the transport vessel/barge and should be considered when establishing operation limiting criteria, see 2.2.3. The seafastening may be designed either for an unrestricted operation or for a weather restricted operation, see 3.4.1.

The design and installation of the sea-fastening may take into account one or more “partial” completed stages of installation, allowing the transport to shore to commence before the “full” sea-fastening stage is reached. Such “partial” stage must correspond to the seafastening loads in a defined environmental condition (wave height and wind speed). Upon completing the “partial” sea-fastening stage the transport to shore may commence provided the updated weather forecast, see 2.2.4, for the transport route are acceptable considering the “partial” design condition, see 2.2.3, for the  $T_R$  defined for the transport phase. If the weather forecast at this point in time is not acceptable, the “full” sea-fastening has to be installed prior to transport to shore.

See 2.7.4 for design and fabrication requirements for seafastening and grillage.

**Guidance note:**

For example, Decommissioning Technology Forum Report No. GM-44314-0702-47330, describes some technical and commercial investigations of two new seafastening concepts for tow to shore of a large topside structure after lift onto a barge by SSCV.

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### 3.4.9 Stability

The stability of a transport vessel with a back-loaded offshore structure shall comply with relevant national and/or international stability criteria.

The stability criteria given in Pt.1 Ch.2 Sec.4.2 may be applied for barge transport.

The intact stability criteria given in Pt.1 Ch.2 Sec.4.3.2 may be applied for a self floating structure. In addition it shall remain in a stable floating condition after flooding or loss of at least one buoyant compartment or buoyancy element.

### 3.5 Onshore transfer

#### 3.5.1 General

Various methods for transfer of the offshore structure from the transport vessel to shore are feasible. All such load transfer operations shall be planned and performed according to 2 - Part I - General Requirements. With respect to safety of personnel normal marine industry practice should be followed, see also 1.2.

For SCRAP, see 1.5, local damage (plastic deformations) are acceptable during the transfer operations. Load transfer operations are covered in Pt.2 Ch.1.

#### 3.5.2 Skidding or trailers

See Pt.2 Ch.1 Sec.2. Skew load effects, see Pt.2 Ch.1 Sec.2.2.6 could normally be disregarded for SCRAP.

#### 3.5.3 Lift-off

See Pt.2 Ch.1 Sec.4 and Sec.5.

#### 3.5.4 Crane lifting

For floating cranes see 3.1 and Pt.2 Ch.5 Sec.5. If the transfer is made by onshore cranes see Pt.2 Ch.5 Sec.6.

#### 3.5.5 Moorings

The mooring of the transport vessel during onshore transfer of the offshore structure shall normally be designed for the 10 year return period seasonal condition at the onshore site. Any one line broken condition shall be complied with. Stand by tugs of sufficient thrust capacity may compensate a deficient mooring system.

Detailed recommendations for mooring systems are given in Pt.1 Ch.2 Sec.5.3.

### 3.6 Dismantling

#### 3.6.1 General

Note that dismantling is not covered in any detail neither in

the rules nor in this RP.

Dismantling of offshore installations implies manual work and handling of heavy equipment and steel parts, often in confined spaces. Such activities have inherent dangers for injuries and fatalities, offshore and onshore, and shall therefore be well planned and use well trained personnel.

Procedures for handling of contaminated (LSA, asbestos, hydrocarbons, chemicals, etc.) materials shall, if relevant, be made. Company will normally have the responsibility of hazardous material identification. See also 2.1.7 and 2.1.8.

#### 3.6.2 Offshore dismantling

Offshore dismantling operations must in particular focus on personnel safety, and will normally have to comply with national HSE requirements. See also 2 regarding planning and in particular 2.1.4 regarding risk evaluations. The requirements in 3.1 apply for all lifts carried out by crane vessels during dismantling.

#### 3.6.3 Onshore dismantling

Onshore dismantling operations will normally be covered by national HSE requirements.

Lifting operations shall be carried out considering the requirements in Pt.2 Ch.5 Sec.6.

## 4. References

- /1/ DNV - Rules for Planning and Execution of Marine Operations – 1996/2000.
- /2/ DNV – RP H101 – Risk Management in Marine- and Subsea Operations, January 2003.
- /3/ DNV – Offshore Standard DNV-OS-C101, Design of Offshore Steel Structures, General, October 2000.
- /4/ DNV – Offshore Standard DNV-OS-C401, Fabrication and Testing of Offshore Structures, January 2001.
- /5/ DNV – Offshore Standard DNV-OS-B101, Metallic Materials, January 2001.
- /6/ DNV – Offshore Standard DNV-OS-E301, Positioning Mooring, June 2001.
- /7/ DNV – RP – A203 – Qualification Procedures for New Technology.
- /8/ NORSOK – N-004 - Design of Steel Structures, December 1998.
- /9/ NORSOK – M-101 - Structural Steel Fabrication, December 2000.
- /10/ NS-ENV 1993-1-1 (Eurocode 3, Section 1-1)
- /11/ Decommissioning Technology Forum Report No. GM-44159-0401-47192 - “Platform Decommissioning - Backloading Study”.
- /12/ Decommissioning Technology Forum Report No. GM-44314-0702-47330 - “Platform Decommissioning - Backloading Study, Phase 2”.
- /13/ Task Force Industry Study – Jacket Removal, July 2003.
- /14/ IMO Resolution A.714(17) – Code of Safe Practice for Cargo Stowage and Securing (1994 Amendments).

