OFFSHORE STANDARD

DNV-OS-H101

Marine Operations, General

OCTOBER 2011

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DET NORSKE VERITAS AS

FOREWORD

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— *Recommended Practices.* Guidance.

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B) Materials Technology
C) Structures
D) Systems
E) Special Facilities
F) Pipelines and Risers
G) Asset Operation
H) Marine Operations
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O) Subsea Systems

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SECTION 1 INTRODUCTION

A. Objectives of the Standard

A 100 General

101 All the DNV offshore standards covering marine operation, i.e. this standard (DNV-OS-H101), DNV-OS-H102 and DNV-OS-H201 through DNV-OS-H206, are called the "VMO Standard".

Guidance note:
The "VMO Standard" is substituting "DNV - Rules for Planning and Execution of Marine Operations". See also Table 1-2.

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102 The overall objective of the VMO Standard is to ensure that marine operations are performed within defined and recognised safety levels.

103 Marine operation is defined in D100.

104 The VMO Standard does not consider conventional shipping activities and is not applicable for regular classification- or certification services.

A 200 Safety levels

201 The intention of the load-, safety- and material factors in the VMO Standard is to ensure a probability for structural failure less than 1/10000 per operation (10^{-4}-probability).

202 Note that above stated probability level defines a structural capacity reference. When also considering the probability of operational errors, the total probability of failure may increase.

Guidance note:
When including operational errors, the level of probability of total loss per operation can not be accurately defined. However, the recommendations and guidance given in the VMO Standard are introduced in order to obtain a probability of total loss as low as reasonable practicable (ALARP principle).

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A 300 Alternative methods

301 It is the intention that the VMO Standard shall not inhibit use of the best available theoretical approaches and practical solutions.

302 Other methods and approaches than those described herein may be used provided quality and safety equivalent or higher is documented, see 201.

303 Deviations from requirements and recommendations given in the VMO Standard shall be based on detailed evaluations of inherent assumptions, data, analysis, theory and practical experience. Any deviations shall be thoroughly documented.

B. Application

B 100 General

101 This Standard DNV-OS-H101 gives general requirements and recommendations for planning, preparations and performance of marine operations.

102 Recommendations and requirements in this Standard shall be considered in relation to the structural and operational complexity and sensitivity as well as type of marine operation to be performed.

103 Execution of operations not adequately covered by the VMO Standard shall be specially considered in each case.

B 200 Conditions for use

201 Users of the VMO Standard should be familiar with its scope, objectives and content.

202 Fulfilment of all requirements in the VMO Standard does not guarantee that international and national (statutory) regulations, rules, etc. covering the same subjects/operations have been satisfied.

203 The user agrees that application of the VMO Standard shall be at the user's sole risk, and accepts by use that DNV's liability for claims arising from omissions, faults or inconsistencies in the Standard shall be limited to the amount charged for the Standard.

204 DNV disclaims any liability and/or responsibility resulting from any or all deviations from given requirements and/or recommendations unless such deviations have been approved by DNV beforehand.

B 300 Complementary standards and codes

301 Recommendations and requirements for load selection and for structural verification are given in DNV-OS-H102.

302 Operation specific requirements and recommendations are given in DNV-OS-H201 through DNV-OS-H206.

303 This Standard should if required be used together with other recognised codes or standards applicable for marine operations.

304 In case of conflict between other codes or standards and this document, the latter shall be governing if this provides a higher level of safety or serviceability.

305 By recognised codes or standards are meant national or international codes or standards applied by the majority of professionals and institutions in the marine and offshore industry.

Guidance note:
Examples of applicable international rules and regulations, codes or standards are;

— SOLAS,
— MARPOL,
— IMO regulations,
— ISO standards,
— DNV Offshore Codes,
— DNV Rules for Classification of Ships.
— Other DNV publications, i.e. Guidelines, Classification Notes, Standards for Certification and Rules for other Objects.

Examples of applicable national (Norwegian) rules and regulations, codes or standards are;

— NMD (Norwegian Maritime Directorate) Rules and Regulations (in Norway – equivalent in other countries),
— PSA (Petroleum Safety Authority Norway) Regulations (in Norway - equivalent in other countries),
— NORSOK (Norway) standards.

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C. References

C 100 Numbering and cross references

101 Numbering according to Table 1-1 is used throughout this standard.

Table 1-1 Numbering

Level	*Numbering*
Sections	Section 1, 2, 3…
Sub-sections	A., B., C.….
Sub-section element	A 100, A 200, A 300…
Items	101, 102.., 201, 202.., 301, 302…

102 Cross references are made as short as practicable, i.e. according to the following format;

— between sections: Sec.1 A101
— to a section: Section 1
— between sub-sections: A101
— to a sub-section: Sub-section A
— within a sub-section: 101

103 External cross references are written in italic style. Cross references of informative type are given in parenthesis.

C 200 Normative references

201 The documents listed in Table 1-2 include provisions that, through references in this text, constitute provisions of this standard.

202 The referred revision of the normative references has been indicated in Table 1-2. Any modifications in later revisions shall be considered and normally used unless otherwise agreed.

Table 1-2 Normative references

Reference	*Revision*	*Title*
DNV-OS-C101	April 2011	Design of Offshore Steel Structures, General (LRFD Method)
DNV-OS-C401	October 2010	Fabrication and Testing of Offshore Structures
DNV-OS-H102	See note below	Marine Operations, Design & Fabrication
DNV-OS-H201	See note below	Load Transfer Operations
DNV-OS-H202	See note below	Sea Transports
DNV-OS-H203	See note below	Transit and Positioning of Mobile Offshore Units
DNV-OS-H204	See note below	Offshore Installation Operations
DNV-OS-H205	See note below	Lifting Operations
DNV-OS-H206	See note below	Sub Sea Operations

Note:

The DNV-OS H-series are planned issued in the period October 2011 through April 2012. Each OS will enter into force (see A101 GN) at the date of publication. Until the OS is published the relevant requirements in “DNV - Rules for Planning and Execution of Marine Operations” shall be considered governing.

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C 300 Informative references

301 The documents listed in Table 1-3 include information that through references in this text, clarify and indicate acceptable methods of fulfilling the requirements given in this standard.

Table 1-3 Informative references

Reference	*Title*
DNV-RP-H101	Risk Management in Marine- and Subsea Operations
DNV-RP-H102	Marine Operations during Removal of Offshore Installations
DNV-RP-H103	Modelling and Analysis of Marine Operations
DNV-RP-A203	Qualification Procedure for New Technology
DNV-RP-C204	Design Against Accidental Loads
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV-OS-C301	Stability and Watertight Integrity
DNV-OS-E301	Positioning Mooring
DNV-OS-E302	Offshore Mooring Chain
DNV-OS-E303	Offshore Mooring Fibre Ropes
DNV-OS-E304	Offshore Mooring Steel Wire Ropes
DNV-RP-E301	Design and Installation of Fluke Anchors in Clay
DNV-RP-E302	Design and Installation of Plate Anchors in Clay
DNV Ship Rules	Rules for Classification of Ships
DNV CN 20.1	Classification Note 20.1 - Stability Documentation for Approval
DNV CN 22.2	Lifting Appliances
ISO 19901-6	Petroleum and natural gas industries – Specific requirements for offshore structures – Part 6: Marine operations
NORSOK N-003	Action and Action Effects
OCIMF[1)]	Mooring Equipment Guidelines, 3rd Edition
ICLL 1966	International Convention on Load Lines
SOLAS 1974	International Convention for Safety of Life at Sea
IMO - Intact Stability Code	The International Code on Intact Stability, 2008, as adopted with Res. MSC.267(85) on 4 December 2008
1) Oil Companies International Marine Forum	

D. Definitions

D 100 Verbal forms

101 Verbal forms of special importance are defined as indicated below in this standard.

102 *Shall:* Indicates a mandatory requirement to be followed for fulfilment or compliance with the present standard. Deviations are not permitted unless formally and rigorously justified, and accepted by all relevant contracting parties.

Should: Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard where agreed between contracting parties but shall be justified and documented.

D 200 Terminology

201 Terms of special importance are defined as indicated below in this standard.

Characteristic condition: A condition which has a defined probability of being exceeded within a defined time period. (See Sec.3 A300).

Characteristic load: The reference value of a load to be used in the determination of load effects. The characteristic load is normally based upon a defined fractile in the upper end of the distribution function for the load.

Design: An activity to create or form layouts, concepts, arrangements or structures.

Design criteria: The criteria applied for verification of systems, equipment, structures etc. for the planned marine operation.

Design load: A load or load condition which forms basis for design and design verification.

Emergency: An unplanned situation where there is a high risk of (further) extensive damages and/or personnel injuries/casualties.

Fail safe: A configuration which upon failure of elements remains in a controllable and safe condition.

Gust wind: Average wind speed during a specified time interval less than one minute.

Independent third party verification: Verification activities performed by a competent body independent from company and contractor.

Light displacement: The mass of the vessel/object including permanent equipment, but excluding cargo, fuel, non-permanent ballast and other variable loads.

Long term: A period of time where environmental conditions are non-stationary.

Marine operation: Non-routine operation of a limited defined duration related to handling of object(s) and/or vessel(s) in the marine environment during temporary phases. In this context the marine environment is defined as construction sites, quay areas, inshore/offshore waters or sub-sea.

Marine Operation Declaration: A written confirmation stating compliance with the VMO Standard of equipment, temporary and permanent structures, handled object, procedure, preparations etc.

Mean wind velocity: The average wind velocity within a specified time interval.

Object: The structure handled during the marine operation, typically a module, deck structure, jacket, GBS, sub-sea structures, risers, pipes, etc.

Operation: Used as a short form for marine operation in this standard.

Safe condition: A condition where the object is considered exposed to normal risk for damage or loss. (See also Guidance Note in Sec.2 A102).

Short term: A period of time wherein statistical environmental parameters may be assumed stationary. This period is normally taken as 3 hours.

Significant wave height: Four times the standard deviation of the surface elevation in a short term wave condition (close to the average of the one third highest waves).

Single critical element: Non-redundant element, for which failure constitutes failure of the structure/system.

Unrestricted operations: Operations with characteristic environmental conditions estimated according to long term statistics.

Verification: Activity to confirm that a design, product/equipment, structure or procedure complies with defined standards and/or specifications. Verification may be documented by calculations, analysis, certificates, survey reports and inspection reports.

Vessel: Barge, ship, tug, mobile offshore unit, crane vessel or other vessel involved in the marine operation.

VMO (Veritas Marine Operations): The unit(s) within Det Norske Veritas providing marine warranty survey and marine advisory services.

VMO Standard: All the DNV offshore standards covering marine operation, i.e. this standard *(DNV-OS-H101), DNV-OS-H102 and DNV-OS-H201 through DNV-OS-H206*.

Wave height: The crest-to-trough height of a wave.

Weather restricted operations: Operations with defined restrictions to the characteristic environmental conditions, planned performed within the period for reliable weather forecasts.

D 300 Symbols and Abbreviations

The list below defines the symbols used in this standard:

A	Weibull scale parameter for wind.
A_{c0}	Current volume, mean water level.
A_{c1}	Current volume, top of wave.
A_{CC}	Current volume, bottom of wave.
ALS	Accidental limit states.
C_D	Design criteria.
CoG	Centre of gravity.
d_n	Operation period in days.
F_{coll}	Collision load.
F_x	Force component, X direction.
F_y	Force component, Y direction.
F_z	Force component, Z direction.
F_{wx}	Wind force component, X direction.
F_{wy}	Wind force component, Y direction.
FLS	Fatigue limit states.
$f(\varphi)$	Directional function.
f_{wf}	Weather forecast uncertainty factor.
GBS	Gravity Base Structure.
GM	Initial metacentric height.
GZ	Righting arm, a function of heel angle.
g	Acceleration of gravity.
H	Wave height.
H_s	Significant wave height.
H_c	Characteristic wave height.
$H_{s,c}$	Characteristic significant wave height.
H_{max}	Maximum wave height.
$H_{max,c}$	Maximum characteristic wave height.
H_1	Weibull scale parameter for waves.
h	Water depth.
h_0	Reference water depth.
L_{min}	Anchor line length.
MBL	Minimum Breaking Load.
MWS	Marine Warranty Surveyor
N	Number of occurrences.
NDT	Non-destructive testing. Also called NDE (non destructive examination).
OP_{LIM}	Operational environmental limiting criteria. See Sec.4 B600.
OP_{WF}	Forecasted (monitored) operation criteria.
$S(\omega)$	Wave spectrum.
$S(\omega,\varphi)$	Directional wave spectrum.
STF	Storm factor.
T	Wave period.
T_A	Period with stationary wind conditions.
T_c	Estimated contingency time.
T_d	Return (design) period.
T_{POP}	Planned operation period.
T_p	Wave spectrum peak period.
T_R	Operation reference period.
T_z	Mean zero up-crossing period.
t_{mean}	Average period for wind.
$t_{r,mean}$	Reference average period for wind = 10 min.
$U(z_r,t_{r,mean})$	Reference wind velocity.
$U_{c,max}(z,t_{mean})$	Characteristic max. wind velocity.
$U(z,t_{mean})$	Max. mean wind velocity within a period T_A.
ULS	Ultimate limit states.
v	Current velocity.
v_{c0}	Current velocity, mean water level.
v_{c1}	Current velocity, top of wave.
v_{c2}	Current velocity, bottom of wave
v_{tide}	Tide generated current velocity.
v_{wind}	Wind generated current velocity.
W	Loads due to self weight.
WLL	Working Load Limit
W_{sub}	Submerged weight per meter.

Z_{max}	Max. wave amplitude.
z	Height or depth.
z_r	Reference height for wind, typically 10 m.
α	Factor accounting for uncertainty in weather forecast.
γ_m	Material factor.
γ	Wave spectrum peakedness parameter.
δ_{tot}	Total displacement.
δ_{mean}	Mean displacement.
δ_{motion}	First order motion due to waves.
λ	Wave length.
σ	Spectral width parameter.
φ	Wave spreading angle.
ϕ	Roll (heel) angle
ϕ_{max}	Maximum dynamic roll (heel) angle due to wind and waves.
ω	Angular wave frequency.
ω_p	Angular spectral peak frequency.

SECTION 2 PLANNING

A. Planning Principles

A 100 Philosophy

101 Marine operations shall be planned according to safe and sound practice, and according to defined codes and standards.

102 A marine operation shall be designed to bring an object from one defined safe condition to another.

Guidance note:

"Safe Condition" is defined as a condition where the object is considered exposed to normal risk (i.e. similar risk as expected during in-place condition) for damage or loss.

Normally this will imply a (support) condition for which it is documented that the object fulfils the design requirements applying the relevant unrestricted (see Sec.4 B801) environmental loads. Hence, the environmental loads shall be based on extreme value statistics considering the expected maximum duration of the safe condition and, if relevant, the actual season.

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103 Risk management, see sub-section C, should normally be included in the planning.

A 200 Type of operation

201 To define the (sub) operations as either unrestricted or restricted may have a great impact on the safety and cost of the operation. Hence, type of operation should, if possible, be defined early in the planning process. (See also Sec.4 B500 and Sec.4 B800).

202 The planning and design of marine operations should normally be based on the assumption that it may be necessary to halt the operation and bring the object to a safe condition e.g. by reversing the operation.

203 For operations passing a point where the operation can not be reversed, a point of no return shall be defined. The first safe condition after passing a point of no return shall be defined and considered in the planning.

A 300 New technology

301 Design and planning of marine operations shall as far as feasible be based on well proven principles, techniques, systems and equipment.

302 If new technology or existing technology in a new environment is used, this technology should be documented through an acceptable qualification process. See e.g. *DNV-RP-A203*.

A 400 Contingency planning

401 All possible contingency situations shall be identified, and contingency plans or actions shall be prepared for these situations. Contingency plans shall consider redundancy, back-up equipment, supporting personnel, emergency procedures and other relevant preventive measures and actions.

402 Contingency situations may be defined or excluded based on conclusions from risk identifying activities, see C200.

A 500 Planning and design sequence

501 It is recommended to adopt the following sequence for the planning and design process:

1) Identify relevant and applicable regulations, rules, company specifications, codes and standards, both statutory and self-elected.
2) Identify physical limitations. This may involve pre-surveys of structures, local conditions and soil parameters.
3) Overall planning of operation i.e. evaluate operational concepts, available equipment, limitations, economical consequences, etc.
4) Develop a design basis describing environmental conditions and physical limitations applicable for the operation.
5) Develop design briefs describing activities planned in order to verify the operation, i.e. available tools, planned analysis including method and particulars, applicable codes, acceptance criteria, etc.
6) Carry out engineering and design analyses.
7) Develop operation procedures.

502 The indicated sequence is illustrated in Figure 1. Planning and design should be considered as an iterative process.

503 Applicable input and planned output documentation should be defined as early as possible, see also B400 and B500.

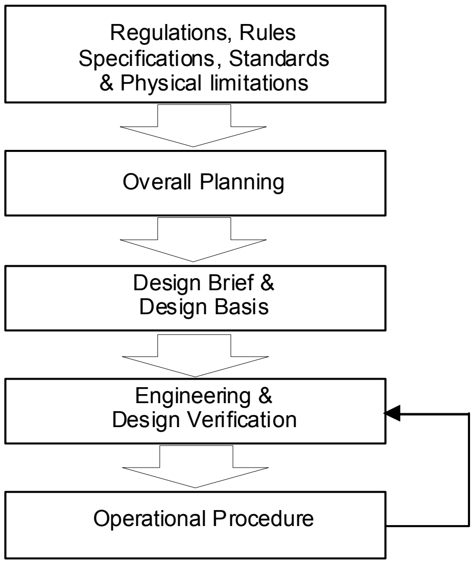

Figure 1
Planning and design sequence

A 600 Design basis and design brief

601 It is recommended to develop a design basis and/or a design brief in order to obtain a common basis and understanding for all parties involved during design, engineering and verification.

602 The design basis should describe the basic input parameters, characteristic environmental conditions, characteristic loads/load effects, load combinations and load cases.

603 The design brief should describe the planned verification activities, analysis methods, software tools, input specifications, acceptance criteria, etc.

Guidance note 1:

The Design Basis and the Design Brief may be combined and issued as one document.

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Guidance note 2:

It is recommended to include the Design Basis and the Design Briefs as part of the formal documentation for the operation, and subject for review and approval according to project/operation requirements.

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B. Documentation

B 100 General

101 Fulfilment of all the requirements in the VMO Standard applicable for the considered marine operation shall be properly documented. Guidance on required documentation is given throughout the VMO Standard. However, it shall always be thoroughly evaluated if additional documentation is required.

102 See Sec.4 G regarding documentation on site.

103 A system/procedure ensuring that all required documentation is produced in due time and distributed according to plan, should be implemented.

Guidance note:

A document plan describing document hierarchy, issuance schedule and scope for each document is recommended for major marine operations.

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104 It shall be ensured that the documentation has been accepted by the relevant parties (e.g. Company, MWS and authorities) before any operation commences.

B 200 Documentation requirement

201 A document clearly expressing the design basis shall be available, see A600.

202 Acceptable properties shall be documented for the handled object and all equipment, temporary or permanent structures, vessels etc. involved in the operation.

Guidance note:

Note that all elements of the marine operation shall be documented. This also includes onshore facilities such as quays, bollards and foundations.

Properties for object, equipment, structures, vessels etc. may be documented with recognised certificates (e.g. classification documents). The basis for the certification shall then be clearly stated, i.e. acceptance standard, basic assumptions, design loads including dynamics, limitations, etc., and comply with the philosophy and intentions of the VMO Standard.

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203 Environmental conditions for the actual area shall be documented by reliable statistical data, see Sec.3 A400.

204 Design calculations/analysis shall be documented by design reports and drawings.

205 Acceptable condition of all involved equipment, structures and vessels shall be documented as relevant by certificates, test-, survey- and NDE reports.

206 Operational aspects shall be documented in form of operation manuals and records.

207 Relevant qualifications of key personnel shall be documented.

208 Required 3rd Party verification, e.g. to fulfil the warranty clause, shall be properly documented. See also C400.

B 300 Documentation quality and schedule

301 The documentation shall demonstrate that philosophies, principles and requirements of the VMO Standard are complied with.

302 Documentation for marine operations shall be self contained, or clearly refer to other relevant documents.

303 The quality and details of the documentation shall be such that it allows for independent reviews of plans, procedures and calculations, for all parts of the operation.

304 All significant updates shall be clearly identified in revised documents.

305 The document schedule should allow for required (agreed) time for independent reviews.

306 Vessel- and equipment certificates and NDT reports (originals) shall be available for review at the site before the start of the operation.

Guidance note:

In order to avoid possible delays due to unacceptable or incomplete documentation it is recommended that such documentation (copies) is submitted for review as soon as possible.

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B 400 Input documentation

401 Applicable input documentation, such as;

- statutory regulations
- company specifications
- standards and codes
- concept descriptions
- basic engineering results (drawings, calculations, etc.) and
- relevant parts of contractual documents

should be identified before any design work is performed.

B 500 Output documentation

501 Necessary documentation shall be prepared to prove that all relevant design- and operational requirements are fulfilled. Typical output documentation is:

- Planning documents including design briefs and basis, schedules, concept evaluations, general arrangement drawings and specifications.
- Design documentation including motion analysis, load analysis, global strength analysis, local design strength calculations, stability and ballast calculations and structural drawings.
- Operational manuals, see Sec.4 G200.
- Operational records, see Sec.4 G300.

C. Risk Management

C 100 General

101 Risk management shall be applied to the project, and the overall responsibility for risk management shall be clearly defined when planning marine operations.

Guidance note:
It is recommended that risk management is performed according to DNV-RP-H101 in order to ensure a systematic evaluation and handling of risk.

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102 Risk evaluations shall be carried out at an early stage for all marine operations in order to define the extent of risk management required.

Guidance note:
The type and amount of risk evaluations should be based on the complexity of each marine operation. *DNV-RP-H101, Appendix D.5* gives advice on how to carry out initial risk evaluations. The effect of (planned) redundancy, back-up, safety barriers, and emergency procedures should be taken into account in the (initial) risk estimates. Contingency situations with a documented probability of occurrence less than 10^{-4} per operation may be disregarded.

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C 200 Hazard identification activities

201 Risk identification techniques and methods shall be used as applicable for the intended operation. Examples of applicable techniques and methods are:

a) Preliminary risk assessment in order to assess concepts and methods
b) Hazard Identification Analysis (HAZID)
c) Early Procedure HAZOP (EPH)
d) Hazard Identification and Risk Assessment (HIRA)
e) Design Review (DR)
f) System HAZOP
g) FMEA/FMECA
h) Procedure HAZOP
i) Semi-Quantitative Risk Analysis (SQRA)
j) Safe Job Analysis (SJA)

Guidance note:
DNV-RP-H101, Appendix B defines and describes most of the above listed risk identifying activities in detail.

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202 All identified possible hazards shall be reported and properly managed.

C 300 Risk reducing activities

301 Relevant corrective actions from the risk identifying activities shall be implemented in planning and execution of the operations.

302 The following risk reducing activities for marine operations shall be used as applicable for the intended operation:

a) Operational feasibility assessments
b) Document verification
c) Familiarisation
d) Personnel safety plans
e) Emergency preparedness
f) Marine readiness verification
g) Inspection and testing
h) Survey of vessels
i) Toolbox talk
j) Survey of operations

Guidance note:
DNV-RP-H101, Appendix C describes the above listed risk reducing activities in detail.

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C 400 3rd Party Verification and Marine Warranty Survey

401 As a part of the risk management the requirements to 3rd Party verification of calculations, procedures, vessels, equipment, etc. and survey of the operations shall be defined.

402 If applicable a Marine Warranty Surveyor shall be contracted to ensure that the marine warranty clause is fulfilled.

403 It shall be ensured that the marine warranty surveyors (minimum) scope of work has been adequately defined to fulfil the intension of the marine warranty clause.

404 Thorough knowledge about the VMO Standard, see Sec.1 B201, shall be documented in order to carry out marine warranty survey with the intention of confirming compliance with the VMO Standard.

SECTION 3
ENVIRONMENTAL CONDITIONS

A. General

A 100 Other codes

101 DNV-RP-C205 provides the basic background for environmental conditions applied in DNV's Offshore Codes and is considered to be a supplement to relevant national (i.e. NORSOK) and international (i.e. ISO) rules and regulations.

A 200 Environmental conditions

201 Environmental conditions are natural phenomena which contribute to structural stress and strain, impose operational limitations/restrictions or navigational considerations. Phenomena of general importance are;

— wind,
— waves/swell
— currents and
— tide.

202 Phenomena which may be of importance are;

— soil conditions,
— ice and snow,
— temperature,
— fouling,
— visibility/fog,
— heavy rain, and
— earthquake.

203 Environmental phenomena, not reflected properly in statistical data, shall be investigated. Such effects may be;

— local tide variations,
— local swell or wave conditions (e.g. due to current against the waves),
— local wind variations/conditions,
— strong winds due to squalls and polar lows,
— current variations, and
— tsunami.

Guidance note 1:

Local harbour authorities, pilots etc. may be sources for information about local variations.

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Guidance note 2:

This standard does not require that forces due to possible tsunami waves are included in calculations/analysis.

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A 300 Characteristic conditions

301 Characteristic conditions are environmental conditions with a defined probability of being exceeded within a defined period of time.

302 The characteristic conditions defined in this section should be used as basis for calculation of characteristic environmental loads, *see DNV-OS-H102*.

Guidance note:

Note that this Standard adopts an alternative approach to the traditional (fixed) return period design philosophy. A fixed return period design will have a varying probability of failure depending on the duration of the operation, while this Standard aims at a constant probability of failure *per operation*.

I.e. by applying a fixed return period (e.g. 10 years) an operation would have the same characteristic condition both for a three days and a three months planned duration. A three months period would however expose the object for a longer period, with a corresponding higher probability of failure compared to the three days operation. See also Table 3-3.

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A 400 Environmental statistics

401 Environmental phenomena are usually described by physical variables of statistical nature. Statistical data should as far as possible be used to establish characteristic environmental conditions. The statistical description should reveal the extreme conditions as well as the long- and short-term variations.

402 Statistical data used as basis for establishing characteristic environmental criteria shall cover a sufficiently long time period.

Guidance note:

For meteorological and oceanographic data a minimum of three to four years of data collection is recommended. When using seasonal data longer periods are required. See RP- C205 for more info.

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403 The validity of old (typically more than 20 years) statistical data should be carefully considered both with respect to monitoring methods/accuracy and possible long term climate changes.

404 The environmental design data should be representative for the geographical area or site and operation in question.

405 If statistical environmental data are assumed to follow a two-parameter Weibull distribution, the regression analysis should be performed with emphasis on a correct representation of the extreme values.

Guidance note:

Regression analysis of two-parameter Weibull distributions are recommended based on the 30% highest data points, i.e. $P(x > X) = 0.3$.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 500 Seasonal variations

501 Seasonal variations of environmental conditions may be taken into account for marine operations of limited duration.

502 Characteristic environmental conditions considering seasonal variations shall normally be based on statistical data covering the planned operation schedule with an ample margin.

Guidance note:

The following applies regarding the required margin:

- Quality of the applied statistical data base, see e.g. 402, shall be duly considered.
- Uncertainty in the operation schedule shall be conservatively assessed.
- Normally data for the calendar month of the operation and the succeeding month should be used.
- For operations that will be carried out within the beginning (first 10 days) of a month data for the preceding month should be included as well. However, in this case data from the succeeding month may be omitted.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

503 If a return period approach is used, see C600, including seasonal variations shall not impose a shorter considered return period.

Guidance note:

It should be noted that applying the normal definition of seasonal return period will give a less actual return period than required by this standard. In order to obtain a “one year return” period (as defined in this Standard) based on the data for a selected period of the year, the considered data basis shall be one year with the same weather as the selected period. This should be done in order to avoid that the length of the selected period directly influences the return period.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B. Wind Conditions

B 100 Mean wind period

101 The averaged wind velocity over a defined period is referred to as mean wind.

Guidance note:

Forecasted wind velocity is normally given as 10 minutes mean wind (t_{mean} = 10 min) at reference height 10 metres (z = 10 m).

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 The characteristic mean wind period for static wind force calculations shall consider the system response period and size of the wind loaded area.

Guidance note 1:

The following periods are meant as examples;

- Fixed structures L < 50 m	3	[s]
- Fixed structures L > 50 m	15	[s]
- For any structure if wave load dominating	1	[minute]
- Quay mooring, small vessels/objects	15	[s]
- Quay mooring, large (Wind area > 2000 m^2) vessels/objects	1	[minute]
- Stability calculations, normally	1	[minute]
- Catenary mooring of vessels/objects	10	[minutes]
- Catenary mooring of GBS	60	[minutes]

Guidance note 2:

OCIMF (2007) gives further guidance with respect to mean wind periods to be used for quay mooring of vessels. For static wind calculations on lifted objects the recommendations for fixed structures above normally apply. See also *DNV CN 2.22, Appendix A.*

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 For dynamic wind analysis the mean wind period recommended for the applied wind spectrum should be used. See B500.

B 200 Characteristic wind velocity

201 The statistical behaviour of maximum mean wind velocities, $U_{max}(z,t_{mean})$, within a short term period (T_A) may be described by a Weibull distribution;

$$F_U(u) = 1 - e^{-\left(\frac{u}{A}\right)^k}$$

$F_U(u)$ = Cumulative probability of $U_{max}(z,t_{mean})$.
U = $U_{max}(z,t_{mean})$, maximum mean wind speed.
A = Weibull scale parameter (A > 0).
k = Weibull shape parameter (k > 0).

Guidance note:

In areas where tropical hurricanes occur, the Weibull distribution as determined from available 10-minute wind speed records may not provide an adequate representation of the upper tail of the true distribution of U10. In such areas, the upper tail of the distribution of U10 needs to be determined on the basis of hurricane data.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 For unrestricted operations the characteristic wind velocity may be calculated according to the following equation:

$$U_{c,\max}(z, t_{mean}) = \frac{A}{1.22 \cdot k} \ln\left(\frac{T}{T_A} \cdot 10^4\right)$$

Where:

$U_{c,max}$ = Characteristic maximum wind speed.
T = Exposure time.
T_A = Period for which wind conditions are assumed stationary (usually 1 hour) or maximum wind observation period. Alternatively, characteristic wind velocities may be calculated based on the return periods indicated in Table 3-1. The exposure period is normally equal to the operation reference period, T_R, see Sec.4 B200.

Guidance note:

Wind velocities exceeding 41 m/s, t_{mean} = 10 min, z = 10 m need normally not be considered on the Norwegian continental shelf.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Table 3-1 Acceptable return periods for (characteristic) wind velocities

Reference Period, T_R	*Return Period, T_d*
$T_R \leq 30$ days	$T_d \geq 10$ years
$T_R > 30$ days	$T_d \geq 100$ years

B 300 Weather restricted operations

301 For weather restricted operations the design wind could be selected independent of statistical data.

Guidance note:

Characteristic wind velocities less than 10 m/s are generally not recommended. See also C300 for general guidance.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 Requirement to ratio between forecasted wind and design wind is given in Table 4-6.

B 400 Effect of height and mean wind period

401 Wind velocity varies with time and height above the sea surface or height above ground (yard lift). For these reasons, the averaging time for wind speeds and the reference height must always be specified.

402 The wind velocity profile in open sea may be related to a reference height (z_r) and mean time period ($t_{r,mean}$) according to the equation below, see also Table 3-2.

$$U(z,t_{mean}) = U(z_r, t_{r,mean})\left[1 + 0.137\ln\left(\frac{z}{z_r}\right) - 0.047\ln\left(\frac{t_{mean}}{t_{r,mean}}\right)\right]$$

Where:

z = Height above sea surface.
z_r = Reference height 10 [m].
t_{mean} = Averaging time for design.
$t_{r,mean}$ = Reference averaging time 10 [minutes].
$U(z,t_{mean})$ = Average wind velocity.
$U(z_r,t_{r,mean})$ = Reference wind speed.

Table 3-2 Wind profile, $U(z,t_{mean})/U(z_r,t_{r,mean})$

z (m)	*Averaging time*				
	3 s	*15 s*	*1 min.*	*10 min.*	*1 hour*
1	0.93	0.86	0.79	0.69	0.60
5	1.15	1.08	1.01	0.91	0.82
10	1.25	1.17	1.11	1.00	0.92
20	1.34	1.27	1.20	1.10	1.01
50	1.47	1.39	1.33	1.22	1.14
100	1.56	1.49	1.42	1.32	1.23

Guidance note:

The wind profile given in Table 3-2 is for open sea and should not be considered valid for (partly) sheltered inshore locations. Wind profiles for such locations should be selected based on local data.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B 500 Gust wind

501 For elements or systems sensitive to wind oscillations (e.g. where dynamics or fatigue may be governing for the design) the short and long term wind variations should be considered.

502 The wind variations may be described by a wind spectrum. *See e.g. DNV-RP-C205 or NORSOK N-003.*

B 600 Squalls

601 If squalls are possible during a marine operation maximum realistic (in the actual area) characteristic wind speeds during squalls shall be considered in the planning and execution of the operation. See also Sec.4 B713.

Guidance note:

Squalls are strong winds characterised by a sudden onset, duration of the order of 10-60 minutes, and then a rather sudden decrease in speed. Squalls are caused by advancing cold air and are associated with active weather such as thunderstorms. Their formation is related to atmospheric instability and is subject to seasonality.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C. Wave Conditions

C 100 Wind seas and swell

101 All possible combinations of wind seas and swell should be considered.

Guidance note:

The wave conditions in a sea state can be divided into two classes, i.e. wind seas and swell. Wind seas are generated by local wind, while swell have no relationship to the local wind. Swells are waves that have travelled out of the areas where they were generated. Note that several swell components may be present at a given location.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C 200 Design methods

201 Wave conditions are defined by characteristic wave height, H_c, or the significant wave height, $H_{s,c}$, and corresponding periods.

202 Wave conditions for design may be described either by a deterministic design wave method, see C700, or by a stochastic method see C800.

203 With the deterministic method the design sea states are represented by regular periodic waves characterised by wave length (or period), wave height and possible shape parameters.

204 With the stochastic method the design sea states are represented by wave energy spectra characterised by main parameters H_s and T_z or T_p.

C 300 Weather restricted operations

301 Wave conditions for weather restricted operations, i.e. operations with wave heights (and/or periods) selected independent of statistical data (see Sec.4 B500), should be as described by C800.

302 The significant wave height(s) and associated period(s) should be selected considering:

a) Feasibility and safety of the planned operation.
b) Typical weather conditions at the site.
c) Operation period, see Sec.4 B200.
d) Uncertainties in weather forecasts, see Sec.4 B700.

Guidance note:

Other factors as how much delay that could be accepted due to waiting on weather, and possible contractual obligations should be considered as found relevant.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 Maximum wave height for weather restricted operations should be calculated according to the following equation:

$$H_{max} = STF \times H_s$$

where

STF = 2.0 for all reference periods.

Guidance note:

For short reference periods STF < 2.0 may be acceptable. See *DNV-RP-H102, Table 2.2* for guidelines.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C 400 Unrestricted operations, general

401 Characteristic wave conditions for unrestricted operations shall be based on long term statistical data.

402 Long term variations of waves may be described by a set of sea states characterised by the wave spectrum parameters.

C 500 Unrestricted, characteristic waves

501 Characteristic significant wave height, $H_{s,c}$ may be taken according to 504. Corresponding maximum wave height, $H_{max,c}$, may be taken according to 505.

502 Characteristic values shall be based on the defined operation reference period, see Sec.4 B200. Periods less than 3 days shall not be used.

Guidance note:

The $H_{max,c}$ corresponds to an approximate 10% probability of exceeding this individual wave height during the anticipated operation duration. If an alternative method is applied it should be documented that this corresponds to an equal or less probability.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

503 In the absence of site specific wave data the Weibull parameters in Table A-1 (Appendix A) may be used.

Guidance note:

For operations/transports passing through several areas, the extreme value distribution may be based on an accumulated distribution of individual wave heights considering the exposure period in the individual area. A simplified approach would be to estimate $H_{max,c}$ based on exposure in the worst area for the whole operation period.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

504 Characteristic significant wave height for the exposure period may be taken as:

$$H_{s,c} = \alpha \left(\frac{2}{2+\beta} f_1 \right)^{1/\beta}$$

where

$$f_1 = \ln(R \cdot N) + (d-1)\ln[\ln(R \cdot N)]$$

$$R = \frac{\sqrt{2\pi}}{\Gamma\left(d - \frac{1}{2}\right)} \left(\frac{2}{\beta}\right)^{d-1} \left(\frac{\beta}{\beta+2}\right)^{d-\frac{1}{2}}$$

$\Gamma(\,)$ = Gamma function, see Appendix A

d = $\frac{3}{2} - \frac{1}{2\beta}$

α, β = Weibull parameters for the probability function of the observed significant wave heights, see also 503.

N = 14400 d_n where d_n is the number of days within the design operation period.

505 Maximum characteristic wave height, $H_{max,c}$, for a defined exposure period may be taken as:

$$H_{max,c} = 1.8\, Z_{max}$$

where

$$Z_{max} = D\left(f_{0.1}\right)^{1/k}$$

$$D = \frac{\alpha}{\sqrt{8}} \left(\frac{k}{2}\right)^{1/k} \left(\frac{2}{\beta}\right)^{1/\beta}$$

$$f_{0.1} = \ln(10 \cdot R \cdot N) + (d-1)\ln[\ln(10 \cdot R \cdot N)]$$

$$k = \frac{2\beta}{2+\beta}$$

Reference is made to 504 for definitions of symbols.

C 600 Unrestricted, alternative method

601 The characteristic significant wave height ($H_{s,c}$) may be defined as the most probable largest $H_{s,c}$ in a time period equal to the design (i.e. return) period.

602 The (minimum) acceptable return period, T_d, should be defined according to the operation reference period, T_R – see Sec.4 B200, as shown in Table 3-3.

Table 3-3 Acceptable return periods for H_s

Reference Period, T_R	*Return Period, T_d*
$T_R \leq 3$ days	$T_d \geq 1$ month
3 days < $T_R \leq 7$ days	$T_d \geq 3$ months
7 days < $T_R \leq 30$ days	$T_d \geq 1$ year
30 days < $T_R \leq 180$ days	$T_d \geq 10$ years
$T_R > 180$ days	$T_d \geq 100$ years

603 For $T_R \le 1$ year seasonal variations could be considered. However, see A503.

604 When applying this alternative method the characteristic maximum wave height should be calculated according to the following equation:

$$H_{max} = 1.9 \times H_{s,c}$$

C 700 Design wave method

701 Design waves should be selected so that the load giving the largest response is covered. It is recommended to define more than one design wave to ensure that the largest response is covered.

702 Regular design waves representing a design sea state defined by H_s and T_p are found on the equal probability contour given by:

$$T = T_1 \left[C_1 \pm C_2 \frac{H_s}{H} \sqrt{2 \left[\frac{H_{max}^2 - H^2}{(\alpha_H H_s)^2} \right] - 2 \ln\left(\frac{H_{max}}{H} \right)} \right]$$

where

H_{max} is according to 505 and H_s is according to 504 or C600.

T_1 = mean wave period, see DNV-RP-C205

$\alpha_H^2 = 0.4013 + 0.0131\gamma - 0.0012\gamma^2 + 0.00005\gamma^3$

where γ is the peak enhancement factor in Jonswap spectrum.

$$C_1 = 1 + \frac{\nu^2}{(1+\nu^2)^{3/2}} \quad ; \quad C_2 = \frac{1}{2} \frac{\nu}{1+\nu^2}$$

$\nu = \sqrt{\left(\frac{T_1}{T_z} \right)^2 - 1}$; see DNV-RP-C205

Guidance note:

$T_{Hmax} = T(H_{max})$ should correspond to known resonance periods of the system. Two additional regular waves should be selected, one *with* T less than the derived T_{Hmax} and one with T larger than the derived T_{Hmax}.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

703 The dispersion relationship gives the relationship between wave period T and wave length λ. For linear waves in finite water depth $h < 0.5\lambda$.

$$T = \left[\frac{g}{2\pi\lambda} \tanh\left(\frac{2\pi h}{\lambda} \right) \right]^{-1/2}$$

Figure 1 shows the wave length as a function of wave period for various water depths h.

704 For most practical purposes the kinematics of regular deterministic waves may be described by the following theories:

$h/\lambda \le 0.1$	Solitary wave theory for particularly shallow water
$0.1 < h/\lambda \le 0.3$	Stokes 5th order wave theory or Stream Function wave theory.
$h/\lambda > 0.3$	Linear wave theory (or Stokes 5th order)

where

h = water depth.

λ = wave length.

For more information on kinematics of regular waves, reference is made to DNV-RP-C205.

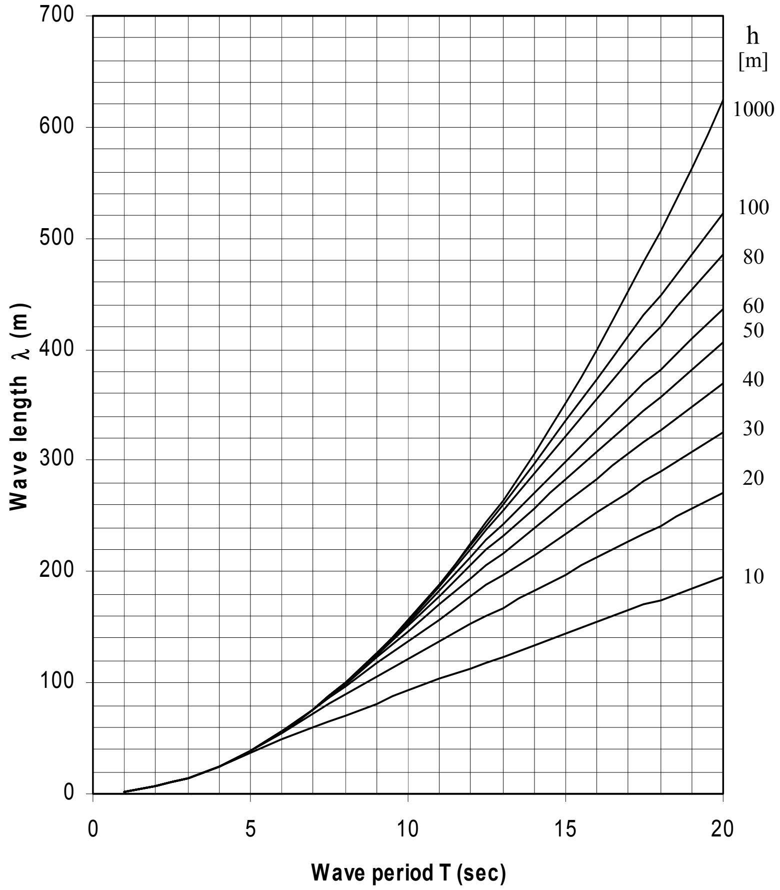

Figure 1
Wave lengths

C 800 Design spectra (stochastic) method

801 The design spectra method is based on calculation of motion and load responses in sea states characterised by a wave spectrum $S(\omega,\theta)$.

802 Characteristic significant and maximum responses are identified by investigating a range of T_z periods according to 803. The wave spectrum may be taken according to 804.

803 For the design sea spectra method the following periods should be considered:

$$8.9\sqrt{\frac{H_{s,c}}{g}} \leq T_z \leq 13 \qquad H_{s,c} \leq 5.7\,[\mathrm{m}]$$

$$8.9\sqrt{\frac{H_{s,c}}{g}} \leq T_z \leq 17\sqrt{\frac{H_{s,c}}{g}} \qquad H_{s,c} > 5.7\,[\mathrm{m}]$$

Guidance note:

The above equations could be regarded to give extreme limits for the T_Z range. A reduced range (and/or wave height) could be considered based on:

- Joint probability of period and wave height applying scatter diagrams for the actual sea area.
- Defined operational limitations in the period.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

804 Wave spectra defined by the Jonswap or the Pierson-Moskowitz spectra are most frequently used. Wave conditions with combined wind sea and swell may be described by a double peak wave spectrum. See DNV-RP-C205 for further guidance.

C 900 Short crested sea

901 A directional short crested wave spectrum, *see the below equation*, may be applied based on non-directional spectra.

$$S(\omega,\theta) = S(\omega) \cdot D(\theta)$$

where

θ	=	Angle between direction of elementary wave trains and the main direction of the short crested wave system.
$S(\omega,\theta)$	=	Directional short crested wave power density spectrum.
$D(\theta)$	=	Directional function.

902 Energy conservation requires that the directional function fulfils;

$$\int_{\theta_{min}}^{\theta_{max}} D(\theta)\,d\theta = 1$$

In absence of more reliable data the following directional function may be applied for wind sea,

$$D(\theta) = \frac{\Gamma(1+n/2)}{\sqrt{\pi}\,\Gamma(1/2+n/2)}\cos^n\theta \qquad -\pi/2 \le \theta \le \pi/2$$

$$D(\theta) = 0 \qquad \text{elsewhere}$$

where

$\Gamma(\,)$ is the gamma function. Due consideration should be taken to reflect an accurate correlation between the actual sea-state and the constant n. Typical values for wind sea are $n = 2$ to $n = 4$. If used for swell, $n \ge 6$ is more appropriate.

Guidance note:

In general the constant n can be taken as the low value (2) for low sea states and increasing (to 4) for higher sea states. See DNV-OS-H202 and DNV-OS-H206 for recommended values of n for different types of analysis.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

903 Short crested seas should not be considered for significant wave heights exceeding 10 m.

C 1000 Swell

1001 Swell type waves should be considered for operations sensitive to long period motion or loads.

1002 Swell type waves may be assumed regular in period and height, and may normally also be assumed independent of wind generated waves.

1003 Critical swell periods should be identified and considered in the design verification.

1004 Characteristic height(s) and period(s) for swell type waves for restricted operations may be selected independently of statistical data. However, see 302.

1005 Characteristic height(s) and period(s) for swell type waves for unrestricted operations should be based on statistical data, see A400, and the return periods indicated in Table 3-3.

D. Current and Tide Conditions

D 100 Current

101 Characteristic current velocity shall be based on local statistical data and experiences. Unless more detailed evaluations of current velocity are made the characteristic current shall be the taken as the 10 year return value.

Guidance note:

For short operations, i.e. weather restricted, it could be applicable to define maximum operation limiting current velocity. In this case current predictions and -monitoring during operation are necessary in order to ensure that the limiting current velocity is not exceeded during the operation.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 Variations in current velocity due to tide shall be considered for inshore operations.

Guidance note:

Significant local variations in current velocity due to tide may occur. If site specific data are not available current variations should be monitored prior to and during the operation, see Sec.4 D200.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 Effects of simultaneous occurrence of current and waves shall be considered.

Guidance note:

Although the tidal current velocity can be measured, and the wind generated current velocity can be calculated, the resulting current in the extreme storm condition is a rather uncertain quantity. Note that errors in the estimation of current velocity are often considered to represent one of the most critical uncertainties in the load analysis.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

104 It is normally assumed that waves and current are coincident in direction.

Guidance note:

See 101 GN, for short operations it could be applicable to include also current direction(s) in the defined maximum operation limiting current velocity.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

105 In open areas the characteristic wind-generated current velocities at still water level may, if statistical data are not available, be taken as;

$$v_{C,wind} = 0.03 \cdot U(z, t_{mean})$$

where

$U(z,t_{mean})$ is the wind velocity according to B200.
z = 10 [m]
t_{mean} = 1 [hr]

106 The total current velocity at a given location should be taken as the vector sum of each current component present, see DNV RP-C205 for further guidance. The most common categories of currents are;

— wind generated current
— ocean current
— tidal current
— freshwater outflow (river generated)
— loop and eddy current
— soliton and topographical current
— alongshore current and
— bottom current.

107 Variation in current profile with variation in water depth due to wave action shall be accounted for. Variations in the current profile may for regular waves, and as a simplified approach, be considered by stretching the current profile vertically. The current velocity at any proportion of the instantaneous depth is kept constant, see Figure 2. By this method the surface current component shall remain constant.

108 Stretching is expressed formally by introducing a stretched coordinate z_s such that the current velocity $v(z)$ at depth z in the still water profile is at the stretched coordinate z_s. Linear stretching is defined by:

$$z_s = (h+\eta)(1+z/h)-h \quad ; \quad -h \le z_s \le \eta$$

where η is the water surface elevation and h is the still water depth. The stretched current velocity profile $\tilde{v}(z_s)$ is then given by:

$$\tilde{v}(z_s) = v(z)$$

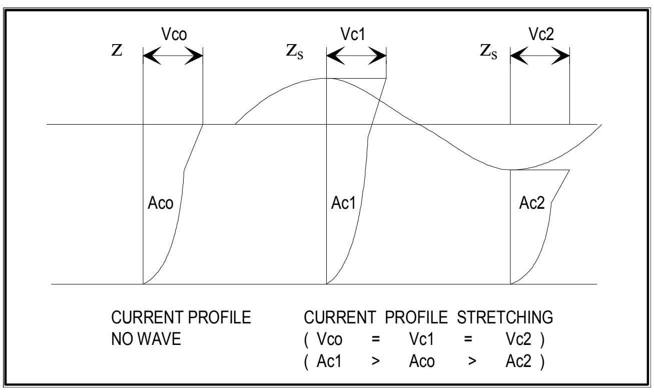

Figure 2
Current stretching method

D 200 Tide

201 The astronomical tidal range is defined as the range between the highest astronomical tide, HAT, and the lowest astronomical tide, LAT, see Figure 3.

202 Mean water (sea) level, MWL (MSL), is defined as the mean level between the highest astronomical tide and the lowest astronomical tide.

203 Storm surge includes wind induced and atmospheric pressure induced effects. Variations due to storm surge shall be considered.

Characteristic water levels shall be taken as expected astronomical tide variations plus/minus storm surge effects. Both maximum and minimum characteristic water levels shall be defined for operations sensitive to tidal variations, see Figure 3.

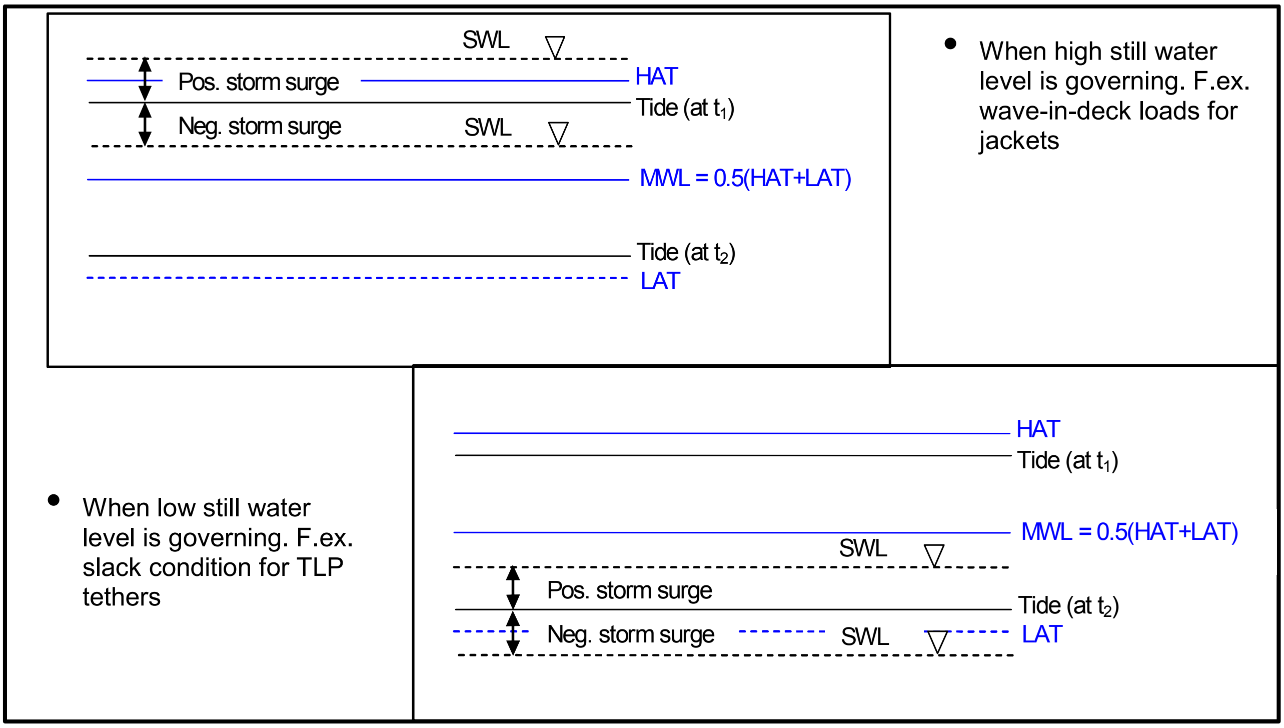

Figure 3
Definition of water levels

SECTION 4
OPERATIONAL REQUIREMENTS

A. General

A 100 Introduction

101 Marine operations shall be executed ensuring that the assumptions made in the planning and design process are fulfilled.

Guidance note:

The purpose of the operational requirements defined in this section is to ensure that:

- the (environmental) design criteria are not exceeded during the operation
- the operation is properly manned and organised
- adequate surveys are performed before- and during the operation
- the operation is properly documented.

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102 Personnel safety shall be duly considered throughout the marine operation.

Guidance note:

By following the recommendations in this section (and the other relevant requirements in the VMO Standard) 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.

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B. Operation- and Design Criteria

B 100 Type of operation

101 Marine operations may either be classified as weather restricted (see B500) or as unrestricted (see B800).

Guidance note:

The main difference between these operations is how the environmental loads are selected. *See DNV-OS-H102, Table 3-1.*

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 A weather restricted operation shall be of limited duration.

B 200 Operation reference period - T_R

201 The duration of marine operations shall be defined by an operation reference period, T_R:

$$T_R = T_{POP} + T_C$$

where

T_R = Operation reference period
T_{POP} = Planned operation period
T_C = Estimated maximum contingency time.

202 The start- and completion points for the intended operation or parts of the operation shall be clearly defined. See also 502 and 503.

B 300 Planned operation period - T_{POP}

301 The planned operation period (T_{POP}) should normally be based on a detailed schedule for the operation.

Guidance note:

In cases (e.g. in the early planning phase) were a detailed schedule is not available T_{POP} could be based on experience with similar operations.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 Estimated time for each task in the schedule should be based on reasonable conservative assessment of experience with same or similar tasks.

Guidance note:

Normally a probability of (maximum) 10-20% of exceeding T_{POP} during the actual operations should be aimed at.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 Frequently experienced time delaying incidents should be included in the T_{POP}.

B 400 Estimated contingency time - T_C

401 Contingency time, T_C, shall be added to cover:

— General uncertainty in the planned operation time, T_{POP}.
— Possible contingency situations, see Sec.2 C200, that will require additional time to complete the operation.

Guidance note:

It is not required to add the estimated additional time from several (two) rare independent contingency situations. I.e. the estimated joint probability of the considered contingency situations does not need to be less than 10^{-4}.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

402 If T_{POP} uncertainties and required time for contingency situations is not assessed in detail the reference period should normally at least be taken as twice the planned operation period, i.e. $T_R \geq 2 \times T_{POP}$.

Guidance note:

A contingency time T_C of 50% of T_{POP} may normally be accepted for:

— Operations with an extensive experience basis from similar operations, e.g. positioning (anchoring) of MOUs.
— Towing operations with redundant tug(s) and properly assessed towing speed, see DNV-OS-H202 for more information.
— Repetitive operations where T_{POP} has been accurately defined based on experience with the actual operation and vessel.

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403 An applied contingency time (T_C) less than 6 hours is normally not acceptable.

Guidance note:

For short simple marine operations involving only robust equipment $T_C < 6$ hours could be considered if thoroughly documented.

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B 500 Weather restricted operations

501 Marine operations with a reference period (T_R) less than 96 hours and a planned operation time (T_{POP}) less than 72 hours may normally be defined as weather restricted. However, in areas and/or seasons where a corresponding reliable weather forecast is not considered realistic a shorter limiting T_R shall be applied. See also 711.

502 The planned operation period start point for a weather restricted operation shall normally be defined at the issuance of the last weather forecast. See Figure 1.

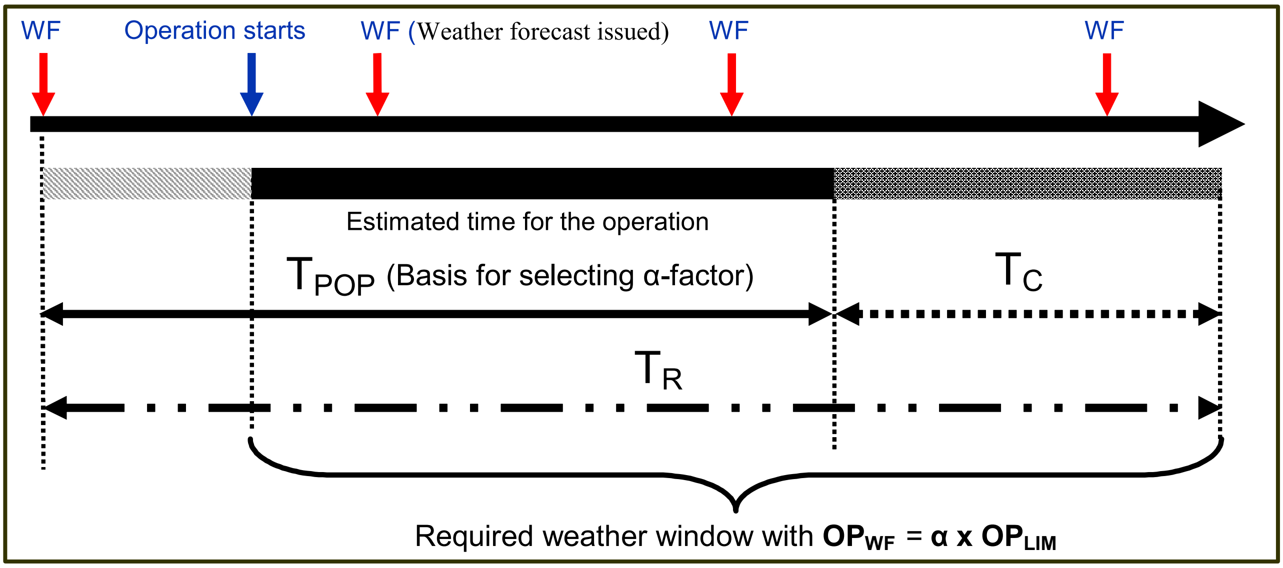

Figure 1
Operation Periods

503 The operation shall only be considered completed when the object is in a safe condition. See Sec.2 A102.

504 Restricted operations may be planned with environmental design conditions selected independent of statistical data, i.e. set by owner, operator or contractor.

Guidance note:

Environmental conditions should be selected based on an overall evaluation. Too strict environmental conditions should be avoided. See also Sec.3 B300 and Sec.3 C302.

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505 Start of weather restricted operations is conditional to acceptable weather forecast, see sub-section C.

506 Operations with too long duration to be planned as weather restricted, see 501, may still be defined as weather restricted if a continuous surveillance of actual and forecasted weather conditions are implemented, and the operation can be halted and the handled object brought into a safe condition within the maximum allowable period for a weather restricted operation. See *flowchart* in Figure 2.

Guidance note:

Note that the indicated *maximum allowable period* is a theoretical value. For most continuous operations a considerably shorter period should be documented in order to make the operation feasible without risking too much delay.

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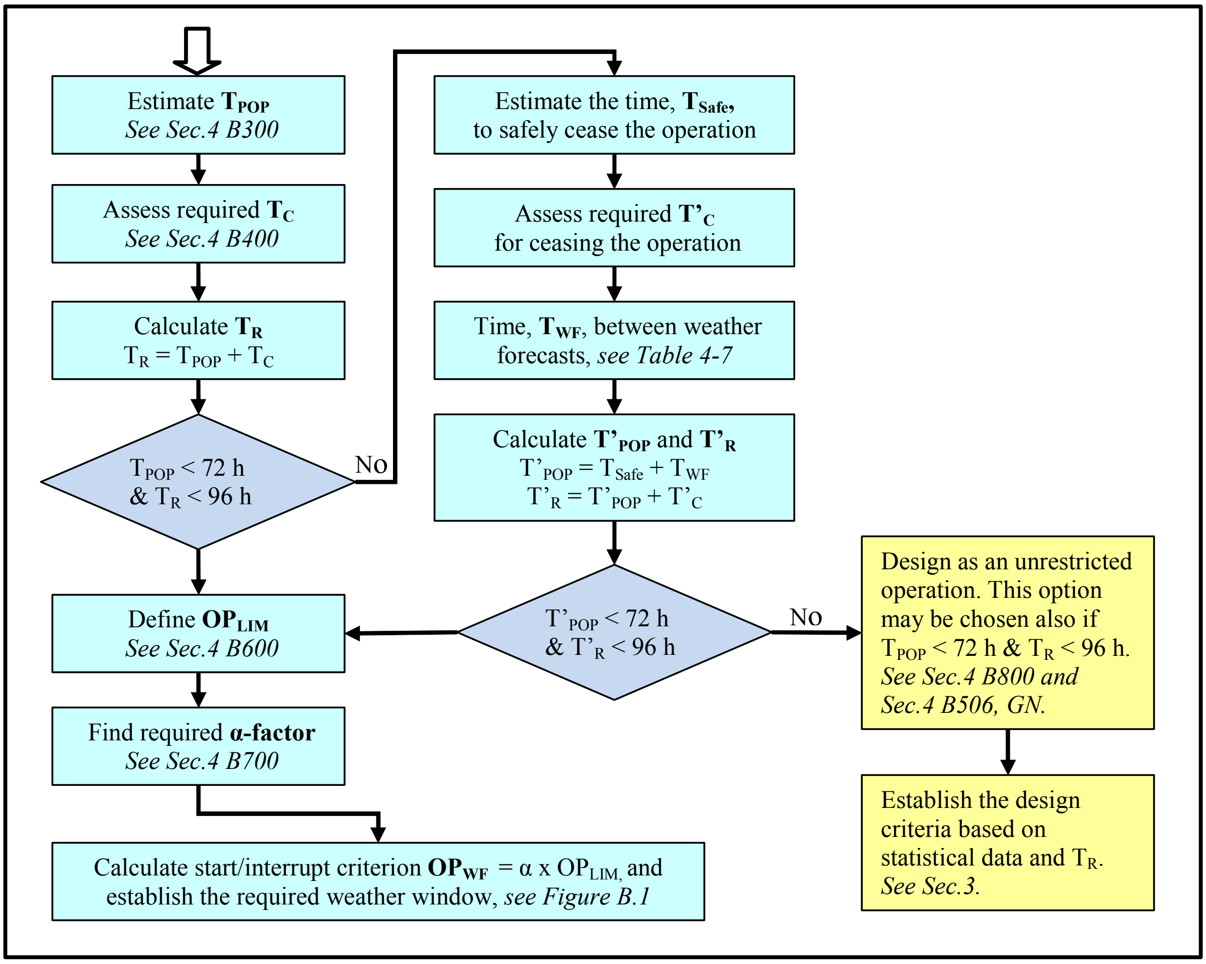

Figure 2
Restricted or Unrestricted Operation

B 600 Operational limiting criteria

601 Limiting operational environmental criteria (OP_{LIM}) shall be established and clearly described in the marine operation manual.

602 The OP_{LIM} shall not be taken greater than the minimum of:

a) The environmental design criteria. See Sec.3 B300 and Sec.3 C300.

b) Maximum wind and waves for safe working- (e.g. at vessel deck) or transfer conditions for personnel.

c) Equipment (e.g. ROV and cranes) specified weather restrictions.

Guidance note:
Specified equipment weather restrictions could be re-assessed based on items as criticality, back-up equipment and contingency procedures.

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d) Limiting weather conditions of diving system (if any).

e) Limiting conditions for position keeping systems.

f) Any limitations identified, e.g. in HAZID/HAZOP, based on operational experience with involved vessel(s), equipment, etc.

g) Limiting weather conditions for carrying out identified contingency plans.

B 700 Forecasted- and monitored operational limits, Alpha factor

701 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, if applicable, monitored at the operation start) operational criteria - OP_{WF}, defined as $OP_{WF} = \alpha \times OP_{LIM}$.

Guidance note:
To ensemble weather forecasts which identify the expected 'spread' of weather conditions and assess the probability of particular weather events could be an alternative for applying the tabulated alpha factors. Such weather forecasts will anyhow give useful additional information to evaluate uncertain weather situations.

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702 The planned operation time (T_{POP}, see B300) from issuance of the weather forecast to the operation is completed shall be used as the minimum time for selection of the α-factor. See Figure 1.

703 For operations that could be halted, see 506, the α-factor could normally be selected based on a T_{POP} defined as the time between weather forecasts (e.g. 12 hours) plus the required time to safely cease the operation and bring the handled object into a safe condition.

Guidance note:
If a proper procedure based on continuously reliable (see D300) monitoring readings, is established the time between weather forecasts could normally be disregarded in the estimation of T_{POP}. However, the maximum expected reaction time from monitoring readings above OP_{WF} to initiation of ceasing of the operation, shall in this case be included in T_{POP}. A reaction time below 2 hours should normally not be considered.

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704 The following should be used as guidelines for selecting the appropriate α-factor for waves:

a) The expected uncertainty in the weather forecast should be calculated based on statistical data for the actual site and the operation schedule, i.e. T_{POP}.

Guidance note:
The α-factor should be calibrated to ensure that the probability of exceeding the operational environmental limiting criteria (OP_{LIM}) with more than 50% is less than 10^{-4}.

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b) Reliable wave- and/or vessel response monitoring system(s) and applied weather forecast level, see C200, could be taken into account.

705 In the North Sea and the Norwegian Sea the α-factor should normally be selected according to the relevant Table 4-1 through Table 4-5. Table 4-1is applicable if one weather forecast (Level C) or the mean value of two or more forecasts is applied, while Table 4-2 through Table 4-5 cover special cases. The table(s) should also be used as a guideline for other offshore areas.

Guidance note:
The tabulated alpha factors are based on the work performed in a Joint Industry Project during the years 2005-2007 with the aim to establish a revised set of α-factors for European waters. For details of the JIP is referred to DNV Report 2006_1756 Rev. 03, "DNV Marine Operation Rules, Revised Alpha Factor JIP Project".

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Table 4-1 α-factor for waves, base case							
Operational Period [h]	*Design Wave Height [m]*						
	$H_s = 1$	$1 < H_s < 2$	$H_s =2= 2$	$2 < H_s < 4$	$H_s = 4$	$4 < H_s < 6$	$H_s \geq 6$
$T_{POP} \leq 12$	0.65	Linear Interpolation	0.76	Linear Interpolation	0.79	Linear Interpolation	0.80
$T_{POP} \leq 24$	0.63		0.73		0.76		0.78
$T_{POP} \leq 36$	0.62		0.71		0.73		0.76
$T_{POP} \leq 48$	0.60		0.68		0.71		0.74
$T_{POP} \leq 72$	0.55		0.63		0.68		0.72

Note 1: Note that the operational period used as basis for finding the α-factor may be defined by T_{POP}. However, required forecasted length of weather windows for the operations shall be defined by the operation reference period - TR. *See* Figure 1.

Note 2: The α-factor could be assumed to vary in time for one operation. E.g. for an operation with T_{POP} = 36 hours, H_s = 4.0 m, the α-factor is 0.79 for the first 12 hours, 0.76 for the next 12 hours and 0.73 for the last 12 hours of the operation.

Note 3: Design wave heights less than one (1) meter are normally not applicable for offshore operations. If a smaller design wave height nevertheless has been applied the alpha factor should be duly considered in each case.

706 Special considerations should be made regarding uncertainty in the wave periods. I.e. if the operation is particularly sensitive to some wave periods (e.g. swell), also uncertainty in the forecasted wave periods shall be considered.

707 If the available weather forecasting services could be regarded as level B, and the highest forecasted wave height(s) from at least two recognized and pre-defined sources is (are) considered, the α-factors could be taken according to Table 4-2. The notes to Table 4-1 apply.

Table 4-2 α-factor for waves, Level B highest forecast							
Operational Period [h]	*Design Wave Height [m]*						
	$H_s = 1$	$1 < H_s < 2$	$H_s = 2$	$2 < H_s < 4$	$H_s = 4$	$4 < H_s < 6$	$H_s \geq 6$
$T_{POP} \leq 12$	0.68	Linear Interpolation	0.80	Linear Interpolation	0.83	Linear Interpolation	0.84
$T_{POP} \leq 24$	0.66		0.77		0.80		0.82
$T_{POP} \leq 36$	0.65		0.75		0.77		0.80
$T_{POP} \leq 48$	0.63		0.71		0.75		0.78
$T_{POP} \leq 72$	0.58		0.66		0.71		0.76

708 If the weather forecasting services are Level A including a meteorologist at site that issues/verifies the weather forecast, the α-factors could be taken according to Table 4-3. The notes to Table 4-1 apply.

Table 4-3 α-factor for waves, Level A with meteorologist at site							
Operational Period [h]	*Design Wave Height [m]*						
	$H_s = 1$	$1 < H_s < 2$	$H_s = 2$	$2 < H_s < 4$	$H_s = 4$	$4 < H_s < 6$	$H_s \geq 6$
$T_{POP} \leq 12$	0.72	Linear Interpolation	0.84	Linear Interpolation	0.87	Linear Interpolation	0.88
$T_{POP} \leq 24$	0.69		0.80		0.84		0.86
$T_{POP} \leq 36$	0.68		0.78		0.80		0.84
$T_{POP} \leq 48$	0.66		0.75		0.78		0.81
$T_{POP} \leq 72$	0.61		0.69		0.75		0.79

709 If the weather forecast(s) are properly calibrated based on monitoring as described in D300, the α-factors could be taken according to Table 4-4. The notes to Table 4-1 apply.

Table 4-4 α-factor for waves, monitoring							
Operational Period [h]	*Design Wave Height [m]*						
	$H_s = 1$	$1 < H_s < 2$	$H_s = 2$	$2 < H_s < 4$	$H_s = 4$	$4 < H_s < 6$	$H_s \geq 6$
$T_{POP} \leq 4$	0.9	Linear Inter-polation	0.95	Linear Inter-polation	1.0	Linear Inter-polation	1.0
$T_{POP} \leq 12$	0.72		0.84		0.87		0.88
$T_{POP} \leq 24$	0.66		0.77		0.80		0.82
$T_{POP} > 24$	According to Table 4-1 or Table 4-2 as applicable						

710 If the weather forecast(s) are properly calibrated based on monitoring as described in D300, and the weather forecast is issued/verified by a meteorologist at site the α-factors could be taken according to Table 4-5. The notes to Table 4-1 apply.

Table 4-5 α-factor for waves, monitoring & Level A with meteorologist							
Operational Period [h]	*Design Wave Height [m]*						
	$H_s = 1$	$1 < H_s < 2$	$H_s = 2$	$2 < H_s < 4$	$H_s = 4$	$4 < H_s < 6$	$H_s \geq 6$
$T_{POP} \leq 4$	0.9	Linear Inter-polation	0.95	Linear Inter-polation	1.0	Linear Inter-polation	1.0
$T_{POP} \leq 12$	0.78		0.91		0.95		0.96
$T_{POP} \leq 24$	0.72		0.84		0.87		0.90
$T_{POP} > 24$	According to Table 4-3						

711 The appropriate α-factor for wind should be selected (estimated) considering the items listed below.

— Statistical data and local experience for the actual site.
— Planned operation period from issuance of weather forecast, T_{POP}.
— Applied wind speed compared with the maximum possible wind speed, i.e. 10 year return wind speed.
— Criticality of exceeding the design wind speed, e.g. by considering the contribution from wind on the total design load.

712 If no reliable data is available the α-factors indicated in Table 4-6 shall be considered as the maximum allowable.

Table 4-6 Recommended α-factor for wind		
Operational Period	*Design Wind Speed – V_d*	
	$V_d < 0.5 \times V_{10\ year\ return}$	$V_d > 0.5 \times V_{10\ year\ return}$
$T_{POP} \leq 24$ hours	0.80	0.85
$T_{POP} \leq 48$ hours	0.75	0.80
$T_{POP} \leq 72$ hours	0.70	0.75

713 The possibility for unpredictable strong wind, e.g. squalls and polar lows, should be duly considered in the selected α-factor for wind (and if relevant also for waves). Alternatively, if possible, operational contingency actions that sufficiently reduce the criticality of such wind, could be planned.

B 800 Unrestricted operations

801 Marine operations of longer duration than indicated in B500 shall be defined as unrestricted operations. Environmental criteria for these operations should be based on extreme value statistics. If found beneficial also shorter operations may be defined as unrestricted.

Guidance note:

A reduction in the weather criteria found based on extreme value statistics could in some situations be acceptable based on active use of the (long term) weather forecast. Such typical situations are:

- Operations in area and seasons where it is documented that the long term weather forecasts can predict any extreme weather conditions within the defined T_R for the operation.
- Open (Ocean) sea transports were the vessel speed is sufficient to avoid extreme weather conditions.

Such a reduction in the design criteria may be accepted by DNV, but normally an accidental load case (ALS) considering extreme value statistics should be included.

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802 For operations with design criteria based on extreme value statistics the forecasted operational limiting criteria may theoretically be taken equal to the characteristic environmental conditions. However, it is normally not recommended to start an operation if extreme weather conditions are expected, and a start criterion may apply.

Guidance note:

Note that certain operations require a start criterion although designed for unrestricted conditions. Further information is given for the respective operations in *DNV-OS-H201* to *DNV-OS-H206.*

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C. Weather Forecast

C 100 General

101 Arrangements for receiving weather forecasts at regular intervals prior to, and during the marine operations shall be made. Such weather forecasts shall be from recognised sources.

102 The weather forecasts (WF) shall be area/route specific. It shall be ensured that weather forecasts issued for a sea transport comprise the position (at the time of the WF) of the transport vessel and any (all alternatives) route that may be chosen in the period covered by the weather forecast.

103 Weather forecast procedures should consider the nature and duration of the planned operation, see 201.

104 The weather forecasts shall be in writing and the confidence level(s) should be stated.

105 In addition to a general description of the weather situation and the predicted development, the weather forecast shall, as relevant, include;

— wind speed and direction,
— waves and swell, significant and maximum height, mean or peak period and direction,
— rain, snow, lightning, ice etc.,
— tide variations and/or storm surge,
— visibility,
— temperature, and
— barometric pressure.

for each 12 hours for minimum the T_R plus 24 hours. In addition an outlook for at least the next 24 hours should normally be included.

106 The forecast shall clearly define forecasted parameters, e.g. average time and height for wind, characteristic wave periods (T_z or T_p).

Guidance note:
It is recommended that the content and format of the weather forecast are agreed with the meteorologist in due time before the operation starts.

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C 200 Weather forecast levels

201 Based on evaluations of the operational sensitivity to weather conditions and the operation reference period (T_R), a categorisation of the operation into weather forecast levels A, B or C shall be made.

202 Level A - Weather forecast level A applies to major marine operations sensitive to environmental conditions. Typical “level A” operations may be;

— mating operations,
— offshore float over,
— multi barge towing,
— GBS tow out operations,
— offshore installation operations, and
— jack-up rig moves.

203 Level B - Weather forecast level B applies to environmental sensitive operations of significant importance with regard to value and consequences. Typical “level B” operations may be;

— float-out operations,
— offshore lifting,
— subsea installation, and
— sensitive barge towing,

204 Level C - Weather forecast level C applies to conventional marine operations less sensitive to weather conditions, and carried out on a regular basis. Typical “level C” operations may be;

— onshore/inshore lifting,
— loadout operations,
— tows in sheltered waters/harbour tows and
— standard barge tow without wave restrictions.

205 Based on selected weather forecast level, a forecast procedure complying with requirements in Table 4-7 should be established.

Table 4-7 Weather forecast levels

Weather Forecast Level	*Meteorologist required on site?*	*Independent WF sources*	*Maximum WF interval*
A	Yes[1)]	2[2)]	12 hours[3)]
B	No[4)]	2[5)]	12 hours
C	No	1	12 hours

1) There should be a dedicated meteorologist, but it may be acceptable that he/she is not physically present at site. The meteorologist opinion regarding his preferable location should be duly considered. It is anyhow mandatory that the dedicated meteorologist has continuous access to weather information from the site and that he/she is familiar with any local phenomena that may influence the weather conditions. Note also that the meteorologist shall be on site in order to use alpha factors from Table 4-3 and Table 4-5.

2) It is assumed that the dedicated meteorologist (and other involved key personnel) will consider weather information/forecasts from several (all available) sources.

3) Based on sensitivity with regards to weather conditions smaller intervals may be required. However, see 305.

4) Meteorologist shall be conferred if the weather situation is unstable and/or close to the defined limit.

5) The most severe weather forecast to be used.

Guidance note:

Independence between weather forecast sources is satisfied if there are organisational independence between the sources, i.e. it is acceptable to obtain the forecasts from a national and a local source (relevant for the actual area).

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C 300 Accept criteria

301 Acceptance criteria for the weather forecast(s) shall clearly define the applicable limitations, see B700 and the minimum required weather window, see B200 and Figure 1. The acceptance criteria shall be included in the marine operation manual (see G200).

302 If the weather forecasts received from the two sources (See Table 4-7) do not agree the most severe weather forecast should, if not otherwise justified, be considered governing.

Guidance note:

If the discrepancy between the forecasts is significant it should be carefully evaluated if the weather situation is too uncertain to safely commence an operation. See also 303.

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303 Based on the available weather forecasts the weather situation shall be assessed according to a worst case scenario development. This is particularly important for unstable weather situations and for forecasts which are stated (considered) to be of low confidence.

304 Uncertainties in forecasted weather window duration shall be duly considered. I.e. the forecasted weather window duration should be conservatively assessed.

305 Weather forecasts are based on extensive computer analyses. In cases where frequent (i.e. with intervals less than 12 hours) forecast updates are made it shall be documented that the updates are based on sufficient data to be considered adequate.

D. Monitoring

D 100 General

101 Monitoring of design parameters (assumptions) should be used to as great extent as practicable during marine operations.

102 The applied monitoring methods should duly reflect the required accuracy (i.e. acceptable monitoring tolerances).

103 Target values and maximum deviations from target values, i.e. tolerances, for monitoring should be clearly defined.

Guidance note:

Maximum allowable measured deviations should normally be within 75% of ‘deviations considered in the design’ minus ‘monitoring tolerance’.

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104 General requirements to monitoring instrumentation systems are given in Sec.6 A100.

D 200 Environmental conditions

201 Monitoring of environmental conditions could be both direct monitoring of environmental conditions and monitoring of responses caused by environmental effects.

202 For marine operations particularly sensitive to certain environmental conditions such as waves, swell, current, tide etc., systematic monitoring of these conditions prior to and during the operation should be arranged.

203 Expected values, for the remaining time of the operation, of significant environmental conditions should be continuously predicted during execution of a marine operation. Such predictions should, as relevant, be based on the monitored variations, tabulated values and weather forecasts.

D 300 Alpha factor related monitoring

301 It shall be documented that monitoring systems and procedures used as a means to increase the α-factor for waves have adequate accuracy and reliability. Normally this implies fulfilment of all the following basic requirements:

- Continuous monitoring.
- Documented monitoring accuracy better than +/- 5% of the measured values.
- Statistical treatment of the results which continuously indicate the expected maximum value within a define time period (normally 3 hours).
- It should be possible to relate the response monitoring results to the wave conditions. See also *DNV-OS-H102, Sec.2, E500*.
- A secondary system and/or procedure that will detect any significant erroneous results produced by the primary system.

302 A procedure describing how to handle the interface between monitoring results and weather forecasts shall be made.

Guidance note:

The following should at least be covered in the procedure:

- Discrepancies between weather forecast for the present time and monitoring results.
- How to calibrate the weather forecast for the coming hours based on the monitoring results.

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D 400 Tide monitoring

401 Tide behaviour could in some areas vary considerably locally. A local tide variation curve should then be established based on extensive tide monitoring including at least one period with the same lunar phase as for the planned operation.

Guidance note:

Tide variations should be plotted against established astronomical tide curves. Any discrepancies should be evaluated, considering barometric pressure and other weather effects.

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D 500 Monitoring procedure

501 A monitoring procedure describing at least monitoring methods and intervals, responsibilities, reporting and recording shall be prepared.

502 Any unforeseen monitoring results shall be reported without delay.

503 Essential monitoring systems shall have back-up systems.

Guidance note:

If the back-up system does not have the same accuracy as the original system this should be considered in the contingency planning.

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E. Organisation

E 100 Organisation and responsibility

101 Organisation and responsibility of key personnel involved in marine operations shall be established and described prior to execution of marine operations.

102 Organisation charts, including names and functional titles of key personnel, shall be included in the marine operations manual. Authority during the operation shall be clearly defined.

103 CVs for supervisors and key personnel involved in major marine operations shall be presented.

104 Supervisors shall possess a thorough knowledge, and have experience with the actual operation type, see also E200.

105 Key personnel shall have knowledge, and experience within their area of responsibility.

106 Vessel manning and personnel qualifications shall as a minimum fulfil statutory requirements. Additional manning shall be considered for complex operations or to satisfy specific project requirements.

107 Operations shall be carried out in accordance with the conditions for design, the approved documentation, and sound practice, such that unnecessary risks are avoided. This is the responsibility of the operation superintendent or manager.

108 Responsibilities in possible emergency situations shall be described.

109 Access to the area for the operation should be restricted. Only authorised personnel should be allowed into the operation area.

E 200 Familiarisation and briefing

201 Operation supervisors shall familiarise themselves with all aspects of the planned operations and possess a thorough knowledge with respect to limitations and assumptions for the design.

202 Key personnel shall familiarise themselves with the operations. A thorough briefing by the supervisors regarding responsibilities, communication, work procedures, safety etc. shall be performed.

Guidance note:
Briefings are recommended both for familiarisation with the planned operation and as a team building effort.

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203 Other personnel participating in the operations shall be briefed about the operation with emphasis on their assigned tasks/responsibilities and safety.

E 300 Communication and reporting

301 Communication lines and primary and secondary means of communication shall be defined, preferably in a communication chart.

302 The communication system(s) should normally be used only for information needed for managing and controlling the operation. Important information should be given dedicated lines/channels.

Guidance note:
To avoid interference between internal and/or external users it is recommended to allocate VHF/UHF channels as early as possible.

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303 The planned flow of information during the operation shall be described.

Guidance note:
The communication chart shall reflect the actual communication lines that will be used during the operation.

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304 A common language understood by all personnel involved should be used for VHF/UHF communication.

Guidance note:
If a common language could lead to misunderstandings it could be acceptable to use two or more languages. Such communication need to be duly planned and rehearsed.

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305 Communication of important information that may be misunderstood, e.g. monitoring results, should be confirmed in writing.

306 All communication and reporting, should normally be made available for continuous monitoring by client and, if applicable, MWS during the operation. (See also G300).

E 400 Shift plan

401 For operations with a planned duration exceeding 12 hours, a shift plan shall be established.

F. Surveys and Testing

F 100 General

101 General requirements including testing and survey of equipments, systems and vessels are given in Section 1.

102 Surveys during the operation shall include a systematic review and evaluation of monitoring results. See sub-section D.

F 200 Test program

201 The required surveys and tests both in the preparation phase and during the operation should be described in a test and survey program.

202 The test and inspection results should be documented.

Guidance note:

The inspections and testing can be documented by survey and inspection reports, filled in test check lists, test reports, etc.

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203 For larger operations it is recommended to develop a test/commissioning program specifying the planned inspections and tests. The test program should indicate expected characteristics, and state acceptance criteria based on the design assumptions.

Guidance note:

Acceptance criteria for tests may also be functional requirements.

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F 300 Equipment and structures

301 All equipment and structures involved in marine operations shall be inspected and tested in order to confirm compliance with specifications, functional requirements and assumptions for the design.

F 400 Systems

401 All systems and their back-up shall be tested before the start of an operation. Such tests shall demonstrate the reliability and the capacities of the systems.

402 Change over from a primary to a secondary system shall be tested.

403 Instrumentation systems shall be calibrated and tested prior to the operation. The calibration procedure may be subject for review.

404 Essential systems shall be function and capacity tested in their final configuration and connected to the same power supply/HPU as intended to be used during operation. If several consumers are connected to the same power supply/HPU, the test should be performed realistically with all consumers running in order to test capacity.

405 Emergency systems/functions, fail safe configurations should as far as practicable possible be tested in a realistic scenario and with adequate loading.

F 500 Communication

501 Primary and secondary means of communication shall be tested prior to operation.

502 For operations with complex communication and reporting procedures, or where proper information flow is vital, a run-through of communication routines is recommended.

Guidance note:

This rehearsal should be performed with the nominated personnel and under conditions similar to what are expected during the actual operation. See also E304 – Guidance Note.

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G. Documentation on Site

G 100 General

101 All relevant documentation shall be available on site during execution of the operation.

Guidance note:

Normally at least the documentation mentioned in Sec.2 B306 and Sec.2 B500 shall be available.

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G 200 Marine operation manuals

201 An operational procedure shall be developed for the planned operation, and shall reflect characteristic environmental conditions, physical limitations, design assumptions and tolerances. The operational procedures shall be described in a marine operation manual covering all aspects of the operations.

202 The Manual shall include descriptions (text, drawings, diagrams, etc.) of, as applicable;

— organisation
— communication routines and systems

— general arrangement
— operational procedure/(detailed) task plan(s)
— operation schedule
— contingency planning and emergency procedures
— permissible load conditions
— environmental operation criteria
— monitoring during the operation
— tolerances
— permissible draughts, trim, and heel and corresponding ballasting plan
— systems and equipment including layout
— systems and equipment operational instructions
— vessels involved
— tow routes and ports of refuge
— navigation
— weather (forecast) and current/wave reporting
— safety equipment
— recording and reporting routines
— sample forms
— check lists for preparation and performance of the operation and
— test and commissioning plans.

203 Limiting operational criteria for marine operations or parts thereof shall be clearly stated in the Manual.

204 Documentation in the form of certificates, release notes and classification documents for all equipment and vessels involved in the marine operation shall be enclosed and/or listed in the Manual.

G 300 Operation records

301 Execution of marine operations shall be logged. Samples of planned recording forms shall be included in the marine operations manual.

302 The following should as a minimum be recorded during the operation:

— log of (main) tasks carried out
— any modifications in the agreed procedure
— weather conditions and
— monitoring results.

303 Communication to client on site for larger projects should be confirmed in writing, e.g. by daily reports.

304 Operation records from earlier use of equipment that has conditions for safe use, should be available.

SECTION 5
STABILITY REQUIREMENTS

A. General Requirements

A 100 Stability and reserve buoyancy

101 Sufficient stability and reserve buoyancy shall be ensured for all vessels and floating objects in all stages of the marine operations.

102 All classed vessels shall comply with the intact and damage stability requirements according to their approved documentation. The approved stability calculations shall be presented upon request prior to the operation.

103 Both intact and damage stability shall be documented.

104 Dynamic effects shall be considered if relevant. See D100.

105 The requirements to damage stability shall be evaluated considering the operation procedure, environmental loads and responses, duration of operation, consequences of possible damage, etc.

106 Attention shall be paid to ingress of water caused by e.g.

— impact loads from vessels, dropped objects, etc.
— mechanical system failure
— accumulation of spray water
— operational errors and
— deteriorating weather conditions.

107 Sufficient stability should normally not include the up-righting contribution from (occasionally) submerged cargo elements such as jacket legs hanging over the barge sides. This contribution may, however, be included in special cases for the requirement given in B202 upon careful examination of the operational parameters. The contribution of the buoyancy of cargo elements in the stability calculations must be accounted for in the seafastening loads.

108 Drainage openings to avoid accumulation of water should be considered. If drainage openings are impractical, the stability shall be calculated considering the effect of accumulated water.

A 200 Temporary closing elements

201 Temporary water tight closing devices that may be submerged and/or exposed to slamming, sloshing or other impact loads shall be designed and verified for such effects/loads.

Guidance note:

In addition to adequate strength of the devices themselves a safe and robust securing of these devices shall be documented.

Type of sealing (gaskets) shall be carefully considered. Relative movement between closing device and supporting structure shall be considered. See *DNV Ship Rules Pt.3 Ch.3 Sec.6* for further advice.

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202 All openings between buoyant compartments that may cause progressive flooding of the object should be closed during operations.

203 Regular inspections or gauging of air pressure, water level, draught, heel, trim, etc. in search for leakage should be carried out during operations.

A 300 Watertight integrity

301 The number of openings in watertight bulkheads and decks shall be kept to a minimum.

302 Where penetrations of watertight decks, outer walls, and bulkheads are necessary for access, piping, ventilation, electrical cables, etc., arrangements shall be made to maintain the watertight integrity.

303 Testing of watertight integrity shall be carried out before critical operations, e.g. mating, if such integrity can not be adequately documented by other means.

A 400 Stability calculations

401 During the calculations of stability and reserve buoyancy, due allowance shall be included to account for uncertainty in mass, centre of gravity location, density of ballast and ballasting water, and density of the sea.

402 Correction for free surface effects in tanks and cargo containing liquids shall be included.

403 For operations where stability and/or reserve buoyancy at some stage is critical, special consideration shall be given to the duration of the critical condition, possible hazards and to the mobilisation time for - and amount of - back-up systems.

404 Calculations of motions and effect of wind as input to B202 and B203 shall be for the decisive design condition as defined in Section 2. If not otherwise specified, the 1 minute average wind velocity shall be applied in the stability calculations.

Guidance note 1:

For unrestricted operations in the North Sea area, wind velocities exceeding 41 m/s (10 m above sea level) normally do not need to be considered.

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Guidance note 2:

The load factor for stability considerations can be taken as 1.0 when calculating wind heeling moments.

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A 500 Inclining tests

501 Inclining test(s) should be carried out if deemed necessary in order to determine the vertical centre of gravity of the floating object with an acceptable accuracy.

Guidance note:

Inclining tests may not be required for barge arrangements or floating objects complying with the intact and damage stability requirements in B or C when applying gross conservative estimates of structure weight and vertical centre of gravity in the stability calculations, for all phases of floating construction, towing and installation.

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502 If inclining tests is recommended according to 501 they shall normally be performed at various stages during construction afloat and prior to major marine operations to confirm the parameters influencing the stability.

Guidance note:

Inclining tests should be performed according to guidelines in IMO Intact Stability Code 2008- Part B Annex1. Upon completion of the inclining test, a report containing measurements/readings and corresponding calculations of displacement (and light displacement if relevant), metacentric height (GM), and the position of the centre of gravity of the structure, should be prepared. See DNV CN 20.1 - Appendix A for further information.

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503 A proper weight control system should be enforced from the inclining test until the relevant marine operation is completed.

504 For floating objects with extremely large metacentric height, an inclining test may not give sufficient accurate results. The stability calculations may then be based on the calculated weight and centre of gravity and/or on results from a thorough weight control system enforced during the construction.

B. Barge Transports

B 100 Safety against entry of water

101 The requirements of ICLL 1966 should be complied with as applicable with respect to air pipes, overboard and inlet pipes through hull, and weather tight securing of doors, hatches and other openings.

102 All doors, hatches, windows and ventilators shall be closed with their closing appliances, except where use of such openings is necessary for a riding crew. In this case, the closing appliances for the openings in use shall be stored close to their respective openings. Manholes to tanks should be closed. All water tight doors in bulkheads should be closed.

103 Valves on the barge sides and bottom not in use during the voyage should be closed. Pipelines leading overboard without any closing appliances should be blanked off.

104 All bilges should be clean and dry on departure.

105 Dry compartments and empty or slack tanks which contribute significantly to the buoyancy of the barge shall be fitted with sounding facilities.

B 200 Intact stability requirements

201 For single- and multi barge tows the requirements both in 202 and 203 should normally be met during all stages of sea transportation operations.

202 The minimum range of stability should be fulfilling at least one of the below criteria ‘a’ or ‘b’:

a) $\phi \geq (\phi_{env} + 15 + 15/GM)$ degrees provided $\phi_{env} \leq \phi_{top}$

b) $\phi \geq 40$ degrees for barges with L < 70 m and $\phi \geq 36$ degrees for L ≥ 90 m. Linear between.

where;

ϕ_{env} = The dynamic roll (heel) angle in degrees including wind heel effect, calculated for the design environmental condition, see A404.
ϕ_{top} = Heel angle where the maximum transverse righting moment occurs.
GM = Initial metacentric height in metres.

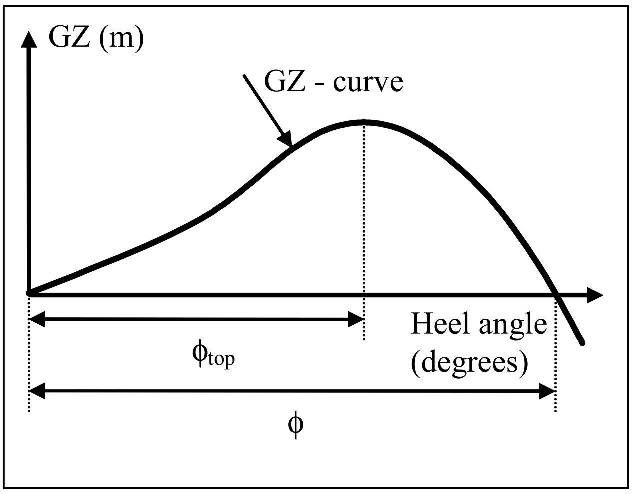

Figure 1
Illustration of stability terms

203 The area under the righting moment curve should not be less than 1.4 times the area under the wind heeling moment curve. This stability requirement (A+B) ≥ 1.4 (B+C) is illustrated in Figure 2.

204 The areas under the righting moment curve and the wind heeling moment curve should be calculated up to an angle of heel which is the least of;

— the angle corresponding to the second intercept of the two curves,
— the angle of progressive flooding, or
— the angle at which overloading of a structural member, including seafastening and grillage, occurs.

205 For marine operations of very short duration (for instance harbour moves and out of dock operations) covered by reliable weather forecasts, an exemption from the requirements given in 202 may be acceptable provided that adequate safety is ensured. (See also D100.)

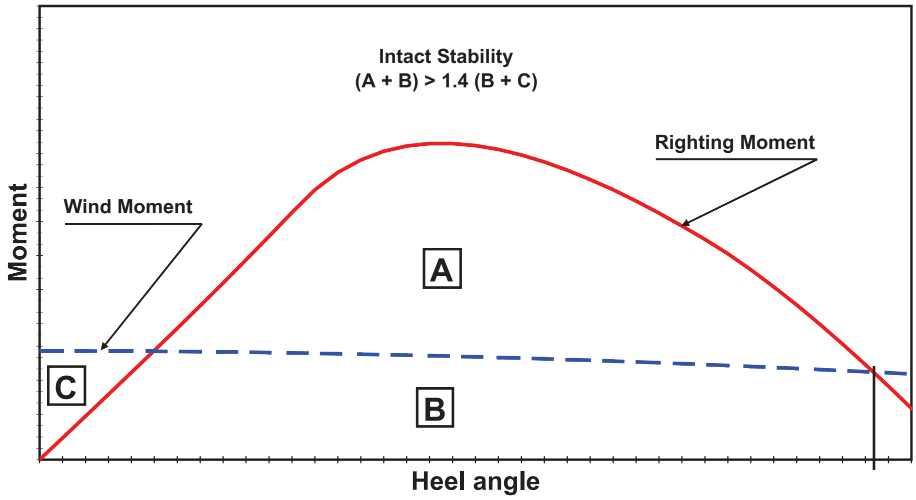

Figure 2
Intact stability requirement

B 300 Single barge damage stability requirements

301 Damage stability evaluations shall be based on damage scenarios according to identified contingency situations, see A100. Collision, leakage and operational failure situations shall be evaluated.

Guidance note:
As a minimum the barge should have an acceptable stability and reserve buoyancy, and remain floating in an acceptable manner with any one submerged or partly submerged compartment flooded.

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302 The acceptable floating condition is determined by the following:

— The design resistance of any part of the barge, cargo seafastening or grillage should not be exceeded.
— The barge should have sufficient freeboard considering environmental effects to any open compartment, where flooding may occur.
— The area under the righting moment curve should be greater than the minimum area under the wind heeling moment curve up to;

  — the second intercept, or
  — the down flooding angle, whichever is less, see Figure 3.

303 The consequences of a damage stability situation should be thoroughly evaluated, in particular with respect to;

— progressive flooding,
— local strength of watertight boundaries and
— loads on seafastening.

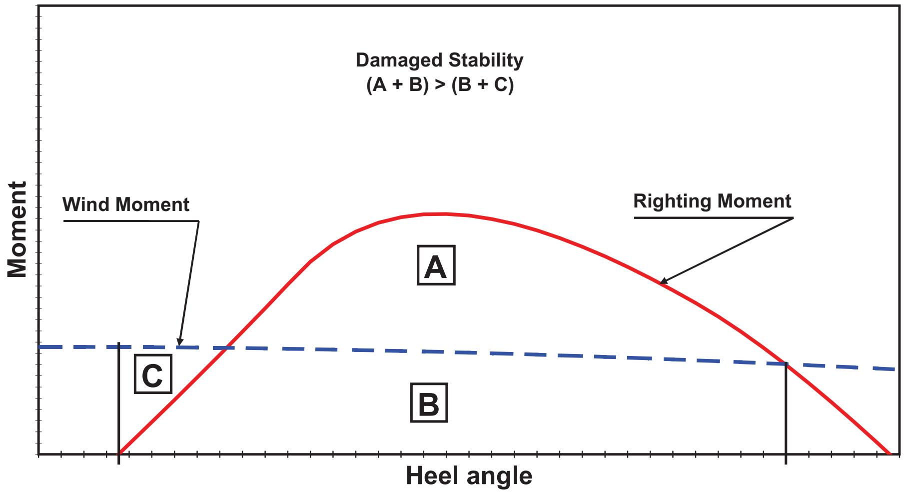

Figure 3
Damage stability requirements

B 400 Multi barge damage stability requirements

401 The same general requirement as for single barge damage stability applies, see 301.

402 The acceptable floating condition is determined by the following:

— The requirements of 302 apply.
— The steady angle of heel or pitch caused by the damage and wind pressure should not immerse any non-watertight closures in the hull.
— It shall be demonstrated by calculation that the flooding of any one compartment will not cause the damaged barge to change its heel or trim angle relative to the overall heel or trim of the barge unit, i.e., the damaged barge should not pivot around any of the deck supports and thus loose contact with the deck at other support(s).

C. Self Floating Structures

C 100 General

101 This sub-section applies to objects such as gravity base structures, jackets, offshore towers, etc. which are supported by their own buoyancy during construction, towing and installation

102 The requirements in B100 apply.

103 Inclining tests for the floating object may have to be performed prior to marine operation to confirm the position of centre of gravity, see A500.

C 200 Intact stability requirements

201 The following requirements should be met by the self-floating object:

- The metacentric height, GM, corrected for free surface effects and effect of possible air cushion should be at least 1.0 m.
- The requirements to intact stability in B200 apply. For large concrete gravity base structures a reduced ratio of 1.3 between righting moment and heeling moment is normally acceptable.
- Special consideration should be given to the hydrostatic stability and motions during transfer of heavy loads to a floating structure both under normal conditions and in case of an accidental load transfer.

C 300 Damage stability requirements

301 General requirements to damage stability given in B300 apply.

302 Damage stability evaluations shall be based on damage scenarios according to identified contingency situations, see A100. Collision, leakage and operational failure situations shall be evaluated.

303 As a minimum the self-floating object shall normally remain afloat in a stable equilibrium with sufficient freeboard to preclude progressive flooding with any one compartment open to the sea, as given in 302.

304 Exemptions from the damage stability requirement are not acceptable unless adequate, approved precautions are taken. The precautions should ensure acceptable safety, for instance as given in 305 and/or 306.

Guidance note:

Upon thorough evaluations exemptions could be granted for compartments with very small risk of leakage. E.g. jacket legs with no penetrations.

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305 If 301 cannot be complied with, the structure shall withstand relevant collision loads on the whole exposed circumference of the structure from 5 metres below to 5 metres above any operation waterline without ingress of water. See *DNV-OS-H102 Sec.3 F* and *DNV-RP-C204* for guidelines regarding relevant collision loads.

306 During moored construction phases, compliance with 305 may be obtained by sufficient fendering in the waterline area.

D. Special Cases

D 100 Dynamic effects

101 Special attention should be paid to stability, including possible dynamic effects, of self floating objects during launching, upending, lifting into water or float-off/on to heavy lift vessels.

102 Dynamic effects from tow wire should be considered when performing tow of an object with marginal stability such as launching/upending, harbour tow and out of dock operations.

D 200 Stability during loadout operations

201 Loadout operations shall be performed with a GM $\geq$ 1.0 m. Note also B205 and the general requirement in B203.

Guidance note:

Note that the accuracy requirements to ballasting will tend to increase with decreasing GM.

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202 Special attention shall be paid to the influence of slack tanks on stability afloat during the loadout operations.

203 Due attention shall be paid to stability during quay operations (e.g. loadouts) with transport vessels own crane(s).

D 300 Partly completed vessels

301 Towing of partly completed vessels may need special stability considerations, as full watertight subdivision and deckhouses may not be installed. As a minimum the following should be complied with:

- Watertight hull plating up to freeboard deck.
- Openings in freeboard deck to comply with ICLL 1966, Regulations 12 – 21.
- Penetrations in hull plating shall be of watertight standard.
- Collision bulkhead installed and made watertight.

302 The intact stability should comply with IMO Intact Stability Code 2008, Chapter 2, or equivalent.

303 If an inclining test is not performed prior to the towing operation, the stability calculations should be based upon a gross conservative estimate of vertical centre of gravity of the vessel.

SECTION 6
SYSTEMS, EQUIPMENT AND VESSELS

A. System and Equipment Design

A 100 General

101 Systems and equipment shall be designed, fabricated, installed, and tested in accordance with relevant codes and standards, see Sec.1 B.

102 Systems and equipment shall as far as possible be designed to be fail safe and so arranged that a single failure in one system or unit can not spread to another unit. The most probable failures e.g. loss of power or electrical failures, shall result in the least critical of any possible new conditions.

103 Alarm system should be incorporated for essential functions and be audible/visible at operators' station.

104 Work stations shall be arranged to provide the user with good visibility and easy access to controls required for the operations.

105 Systems and equipment shall be selected based on a thorough consideration of functional and operational requirements for the complete operation. Emphasis shall be placed on reliability and the expected behaviour in possible contingency situations.

106 Depending on the complexity and duration of the operation, and the structure itself, risk evaluations may be required to determine the systems and equipment required for a safe operation, see Sec.2 C. Such studies shall include normal operations as well as emergency situations.

Guidance note:
The following systems shall be considered where applicable;

- power supply
- fuel supply
- electrical distribution systems
- machinery control systems
- alarm systems
- valve control systems
- bilge and ballast systems
- compressed air systems
- fire fighting systems
- ROV systems
- lifting systems
- communications systems and
- instrumentation systems for monitoring of;
    - loads and/or deformations
    - environmental conditions
    - ballast and stability conditions
    - heel, trim, and draught
    - position (navigation)
    - under-keel clearance and
    - penetration/settlements.

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107 Computerised control or data acquisition systems should be equipped with uninterruptible power supply system (UPS).

108 All systems shall be tested according to Sec.4 F.

A 200 Back-up

201 All essential systems, part of systems or equipment shall have back-up or back-up alternatives. Necessary time for a change over to the back-up system (equipment) shall be assessed.

Guidance note:
It is recommended to include a list in the marine operation manual of main spare parts available on site. It is also recommended to assess the necessity of having repair- or service personnel available on site during operations.

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202 All back-up systems should be designed and fabricated to the same standard as the primary systems. Back-up systems can when found feasible be an integrated part of the primary systems.

203 For systems consisting of multiple independent units back-up may be provided by having a sufficient number of available spare units available on site.

204 Automatic control systems shall be provided with a possibility for manual overriding.

B. Mooring Systems

B 100 General

101 This sub section applies to design and verification of:

- Quay mooring of vessels (e.g. barges during load-out).
- Inshore mooring systems combining long and short lines.
- Weather restricted offshore mooring systems.

Guidance note:

For verification of other mooring systems, reference is made to other recognized codes, e.g. DNV-OS-E301. See also DNV-OS-H203 that covers the activities required to position (anchor) a unit/vessel at an offshore location and the planning, analyses and testing required to document a safe condition of the unit/vessel at that location.

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102 For quay moorings special attention should be paid to mooring line (loads) effects due to vessel vertical motions, e.g. due to tide variations and waves from passing vessels and also to other possible effects due to local conditions, e.g. increase in current force due to limited under keel clearance.

Guidance note:

See *DNV-OS-H102* for applicable requirements to load calculations and *OCIMF* (2008) for general guidelines for quay mooring of vessels.

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103 Characteristic mooring loads should be calculated according to *DNV-OS-H102.* See *Section 3* for environmental conditions to be considered.

104 For thruster assisted moorings the requirements in *DNV-OS-E301, Section 3* should be considered.

105 For certification of chain, fibre ropes and steel wire ropes for offshore mooring, reference is made to *DNV-OS-E302*, *DNV-OS-E303* and *DNV-OS-E304* respectively.

106 Mooring lines shall be in good condition and inspected regularly.

Guidance note:

Normally an inspection program considering redundancy of the system, calculated safety factors, type of mooring lines, variations in loads, other activity in the area and weather conditions, should be established. If relevant it is also recommended that systematic monitoring (and recording) of mooring line tension are used as input to the inspection requirements.

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B 200 ULS conditions

201 All relevant combinations of characteristic loads and directions should be evaluated in the ULS case.

202 Characteristic tension in anchors and mooring lines should be calculated based on the characteristic mooring loads, vessel response, characteristic line and fender stiffness, and the local path of displacement.

203 A dynamic analysis of the system behaviour is preferable. A quasi-static analysis may be acceptable upon consideration of natural frequencies of the system and its individual components.

Guidance note:

Quasi-static analyses imply that wind, current, and mean wave drift forces are considered as static forces. Forces resulting from wave induced motions are then added to the static forces.

The stiffness characteristics should be determined from recognised theory.

The moored structure will take an equilibrium position at which the restoring force from the mooring system equals the sum of static forces. The distance from this position to a position corresponding to zero environmental forces is called the mean quasi-static displacement. Due to the wave induced forces, the structure will oscillate around the equilibrium position.

The total quasi-static displacement is assumed to be the sum of the mean quasi-static displacement and the oscillatory amplitude:

$$\delta_{\text{total}} = \delta_{\text{mean}} + \delta_{\text{motion}}$$

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204 If relevant, local dynamics of individual mooring lines should be included.

Guidance note:

The line may be excited by the time varying motions at the upper end (found from the dynamic system analysis) and by wave and current induced vortex shedding.

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205 Special considerations shall be made to the load distribution in mooring lines for systems with several short lines and/or lines with significantly different characteristics arranged in an undetermined pattern.

Guidance note:

It is normally not recommended to combine mooring line with different characteristics. (i.e. chain and polyester). If this never less is found necessary maximum possible variations in line stiffness and pre-tensions need to be considered.

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206 Mooring line load combinations and design loads should be defined according to *DNV-OS-H102*.

Guidance note:

Effect of pretension and external loads, e.g. from pull/push systems, may be categorized as variable functional loads.

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B 300 ALS conditions

301 The mooring system shall be verified for relevant ALS cases, as defined based on 302, 303, 304 and 305. ALS cases do not normally need to be combined.

302 Possible additional mooring line loads due to accidental situations as impacts (collisions), operational errors (e.g. ballasting, maximum possible loads from push systems) and damages causing vessels heel/trim and exceptional environmental conditions should be considered.

303 If in use thruster or thruster system failure should be considered.

304 Loss of a buoy or a clump weight due to failure of the connection to the mooring line should be investigated.

305 The ALS cases should normally at least include conditions with any one line broken.

Guidance note:

If the line utilization factors are maximum 0.7 in ULS, omitting verification of one line failure may in the following cases be found acceptable:

- Tug(s) is (are) standing by at the mooring site, and the system allows the tug(s) to provide sufficient thrust in directions necessary to replace any one line within an acceptable time span. See also 606.
- The mooring is for a weather restricted operation/period and the possibility of accidental damage to mooring lines is found neglectable. The mooring lines shall consist of certified ropes and equipment.

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306 Loading conditions ‘c’ and ‘d’, *see DNV-OS-H102 Table 5.3,* should be investigated for the defined ALS case(s). No adjustment of line pretension after the initial line failure shall be considered in the analysis.

307 Loading condition ‘c’ shall include additional line tensions due to transient motion. The consequence of displacements should be evaluated.

Guidance note:

The transient response immediately after the initial failure might be expected to lead to high line tensions. However, as Environmental loads (E) do not to need to be included according to *DNV-OS-H102 Table 5.3,* this case will normally not be governing. However, if unusually high line tensions are required for some special operations in relatively calm weather, then it is advisable to also consider the transient case.

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308 For loading condition ‘d’ it shall be documented that with any one defined (ALS case) failure, the remaining system is able to resist expected loads with acceptable displacements and rotations until repaired.

B 400 FLS conditions

401 For permanent mooring systems of long design life and with serious failure consequences, fatigue data should be established for the relevant environment and a fatigue investigation carried out. The investigation should be based on the load history of the equipment.

402 For chain cable and steel wire ropes, fatigue data should be based on statements from manufacturers and available research results.

Guidance note:

For synthetic fibre ropes specific fatigue calculations are normally not required. A condition for this is that the various components will be replaced at certain intervals. A program for such replacements should be prepared in each separate case. Besides ordinary fatigue, the effect of external and internal wear, ageing, temperature-rise due to cyclic loading, stress rupture or creep failure should be taken into account when deciding replacement intervals. See also *DNV-OS-E301* for further information.

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B 500 Mooring line strength

501 The mooring line design capacity may be found by dividing the characteristic strength by the appropriate material factor, see 504 and 505.

502 The characteristic strength of mooring lines may be assumed to be the minimum breaking strength documented by the fabricator.

503 Reductions in line capacity due to bending and/or end terminations, see e.g. 711, shall be considered. See also *DNV-OS-H205, Section 3 A.*

504 The material factors for certified steel wire ropes and chains are normally taken as:

$\gamma_{m\text{-}ULS}$ = 1.5 for ULS

$\gamma_{m\text{-}ALS} = \gamma_{m\text{-}ULS}$ / 1.15 for ALS

Guidance note 1:

Mooring arrangements with planned duration’s less than 30 days and arranged with new certified wire ropes may be verified with a reduced material factor; $\gamma_{m\text{-}ULS}$= 1.35 (ULS).

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Guidance note 2:

Wire ropes without a certified MBL may be acceptable for mooring purposes. Design calculations for these systems should be based on the fabricators specified MBL and a material factor: $\gamma_{m\text{-}ULS} \geq 1.65$ (ULS).

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505 The adequate material factors for fibre ropes will depend on the material and relevant failure mode. Hence, another material factor than stated below may be relevant based on thorough evaluations of the material(s) used in the rope. The following minimum factors apply for ULS:

Guidance note:

- Polyester: $\gamma_{m\text{-}ULS}$ = 1.65
- HMPE and Aramid: $\gamma_{m\text{-}ULS}$ = 2.0
- Other fibre materials: $\gamma_{m\text{-}ULS}$ = 2.5

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506 In ALS the material factor for synthetic ropes may be taken as $\gamma_{m\text{-}ALS} = \gamma_{m\text{-}ULS}$ / 1.15 where $\gamma_{m\text{-}ULS}$ is defined in 505 above.

507 Special attention shall be made to the possibilities of chafing if synthetic fibre ropes are used.

B 600 Fenders and Tugs

601 Type and lay-out of fenders should be suitable for the mooring system. Any operations (e.g. loadout, heavy lifts) that will take place should be considered.

602 The fender capacity shall be adequate for the maximum calculated loading.

603 The fender stiffness (load-deformation graph) should be documented and used in the mooring analysis if relevant.

604 Special attention should be given to the effect of vertical movements of the moored object (see 102) on the fender system.

605 Fenders should be properly secured for horizontal and vertical loading due to friction forces.

606 It should be documented that tugs used as a part of the mooring system are suitable for the task and they should be operated according to an agreed procedure.

Guidance note:

Care should be exercised when high horsepower tugs are engaged to keep a vessel alongside a jetty. The application of excessive power can result in over-compression of the fenders and damage to the ship's side. To minimise the possibility of damage, tug push points should be clearly marked on the ship's hull. It must also be recognised that tugs have certain operating limits and that, particularly in berths subject to waves, these limits are likely to be exceeded.

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B 700 Mooring attachment points

701 Mooring line attachment points shall be designed so that failures due to overloading will not result in any critical damage to the main structure.

702 Submerged mooring brackets shall be designed in such a way that they will not cause leakage in case of excessive loading of the bracket.

703 Characteristic loads for mooring attachments should be taken as minimum 1.2 times the characteristic mooring line load.

704 In the cases were two or more lines are connected to a single mooring attachment point an additional consequence factor of 1.2 should be applied unless failure of the bollard is included as an ALS case.

705 Structural strength verification of mooring line connections shall comply with requirements in *DNV-OS-H102* including appropriate load factors in ULS and ALS.

706 Due attention shall be paid to the under deck strength in way of bollards and fairleads.

Guidance note:

Note that strength verification of mooring fittings, including under deck strengthening is not necessarily included in the class approval. E.g. in DNV class approval of such items has been mandatory only from 2005.

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707 Strength reduction due to corrosion and wear shall be considered.

Guidance note:

Special considerations shall be given to condition of (barge) bollards older than 10 years.

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708 Bollards, bitts, etc. used for redirection of mooring lines should be verified for the resultant load. Load factors etc. should be as for similar type mooring attachment points.

709 Acceptable strength of shackles and other equipment used in mooring connections should be documented by certificates.

710 The WLL (SWL) of shackles and other equipment used in mooring connections shall normally be greater than the line minimum breaking load divided by 3 (three). I.e. WLL ≥ MBL/3.

Guidance note:

For equipment documented by the strength requirement above the manufacturer stated “Safety Factor, i.e. MBL/WLL, should at least be 5 (five).

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711 If mooring lines are arranged with wire clamps these shall be installed, and regularly inspected, according to fabricators instructions and procedure. Special considerations shall be made to the required number of clamps, clamp orientation/positions and tensioning control procedure.

B 800 Onshore bollards

801 The strength of onshore bollards, including their foundation, should be documented by a certificate.

Guidance note:

- A bollard certificate should as a minimum include:
- Allowable loading – WLL (SWL).
- Applied characteristic load(s), if different from WLL, in the design calculations.
- Design code(s) used and/or information about applied design- and material factors.
- Allowable load directions (horizontally and vertically).
- Applied verification of design calculations and fabrication.
- Expiring date and/or requirements to inspection (and maintenance) for keeping the certificate valid.

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802 It should also be verified that the bollard is in acceptable condition and that no modifications have been carried out.

803 For bollards with a certificate that is older than 10 years, the condition should normally be documented by an inspection report. If acceptable condition can not be confirmed by visual (and NDT) inspection a load test should be done, see 807.

804 The allowable bollard loading should consider the applied design factors, see 801 GN. Normally the characteristic mooring line load should be less than the bollard;

— WLL × 1.0 in ULS, and
— WLL × 1.5 in ALS.

805 See 708 for requirements to onshore bollards used for redirection of lines.

806 The requirement in 704 is also valid for onshore bollards.

Guidance note:

I.e. the total (worst combination of the connected lines) bollard loading should not exceed the allowable loading defined in 804 above divided by 1.2.

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807 Onshore bollards without a certificate from a recognised Certifying Body should be tested before use. The test load, which should be sustained for minimum 10 minutes and have similar direction(s) as allowed during use, should be at least the maximum of:

— 1.3 times the characteristic ULS line load.
— 0.9 times the characteristic ALS line load.

B 900 Anchors

901 The soil and seabed conditions at the anchor location should be taken into account in the selection of the anchor type.

Guidance note:

Requirements to soil investigations for design of anchors are provided e.g. in *DNV-RP-E302, Sec.6 and Appendix G*. These guidelines may be used as a basis for planning the soil investigations also for other types of anchors.

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902 Characteristic anchor forces should be determined in accordance with B200 or B300.

Guidance note:

For catenary mooring systems characteristic anchor forces for the ULS and ALS could be determined in accordance with *DNV-OS-E301*, *Ch.2 Sec.2*, *B400* and *B500*, respectively.

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903 The characteristic resistance of fluke anchors and plate anchors in clay should be calculated in accordance with *DNV-RP-E301 and DNV-RP-E302*, respectively. Other types of anchors, not covered by similar design codes, should be designed and installed according to *DNV-OS-E301, Ch.2 Sec.4*, supplemented by *DNV-OS-C101, Sec.11*, and recognised industry practice.

Guidance note:

For anchors of drag embedment type, like fluke anchors, and certain drag-in plate anchors which behave as fluke anchors, the installation tension will be a crucial measure for assessment of the long-term anchor resistance. The minimum installation tension of fluke anchors should be calculated according to *DNV-RP-E301*, *Sec.5.5* and the installation should be documented by measurements as outlined in Appendix C.

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904 For anchors not designed to carry vertical loads the length of anchor line should be such that no vertical force will occur in any loading condition. For fluke anchors an uplift angle at the seabed will be acceptable on the conditions outlined in *DNV-RP-E301, Appendix F*.

Guidance note:

Assuming a line load equal to (or less) than 50% of the line MBL the minimum anchor line length, L_{min}, could be could be estimated with the following equation:

$$L_{\min} = \sqrt{\frac{MBL \times h}{W_{sub}}} \quad [\mathrm{m}]$$

where:

- h is water depth in meters [m]
- W_{sub} is submerged weight per meter [kN/m]
- Units for MBL is kN

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905 Anchors without adequate theoretical calculations of holding power and required installation tension, shall be tested at each installed location before use. The test load, which should be sustained for minimum 15 minutes and have similar direction as during use, should be at least the maximum of:

— 1.3 times the characteristic ULS line load.
— 0.9 times the characteristic ALS line load.

C. Guiding and Positioning Systems

C 100 General

101 This sub section applies for design and verification of guiding and positioning systems to be used for marine operations.

102 Guides and bumpers shall have sufficient strength and ductility to resist impact and guiding loads during positioning without causing operational problems (e.g. excessive positioning tolerances), and without overloading members of the supporting structure. Plastic deformation of guides and bumpers due to impact loads may be allowed.

Guidance note 1:
A factor not less than 1.3 between design loads of supporting structure and guide/bumper strength is recommended.

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Guidance note 2:
Guiding systems are often designed with a primary and secondary system. The primary system is normally designed to absorb possible impact energy, and provide guiding onto the secondary system. The secondary system is normally designed to ensure accurate and controlled positioning of the object.

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103 The possibility and consequences of multiple impacts shall be considered.

104 Guides and bumpers shall after the design impact(s) be able to resist loads due to the environmental conditions during operation, and operational loads from tugger lines, mooring lines etc.

105 Guides and bumpers shall after the design impact(s) also provide a positive clearance towards neighbouring and supporting structure, and maintain their functionality.

106 *DNV-RP-H102, Sec. 3.3.5* contains more recommendations and guidelines especially related to guiding systems used during removal of offshore platforms.

C 200 Characteristic loads

201 Characteristic impact loads for bumpers should be based on impact and deformation energy considerations.

202 Realistic impact velocities, impact positions and deformation patterns shall be assumed.

203 Characteristic loads for the guiding and positioning phase shall be based on environmental conditions during operation, in addition to operational loads from tugger lines, mooring lines etc. Combination of horizontal and vertical loads during guiding shall be considered in the design load cases. Realistic friction coefficients shall be used.

204 Characteristic loads for positioning lines (tugger lines, mooring lines etc.) and attachments (padeyes, brackets etc.) shall be the expected maximum line tension. Possible dynamic effects shall be considered.

C 300 Design verification

301 Design loads and load cases for the guiding and positioning phase should be established according to ULS requirements.

302 Structural strength of guiding and positioning systems should be verified according to *DNV-OS-H102*.

303 Positioning padeyes should be designed to behave in a ductile manner in case of overloading.

304 For submerged brackets or padeyes the requirement in B702 applies.

C 400 ALS conditions

401 If greater impact loads (velocities) than used in the ULS verification is considered possible the guide system should be verified for ALS.

402 If the considered ALS (impact) load may cause failure (extensive damage) in the guiding system it should be documented that installation of the object still will be feasible. Alternatively it should be possible to reverse the operation and get the object in safe condition.

D. Vessels

D 100 General

101 This section includes general requirements to vessels involved in marine operations. Further requirements to vessels are given as found applicable for each type of operation and vessel in *DNV-OS-H201* to *DNV-OS-H206*.

102 Vessel shall satisfy the relevant hydrostatic stability requirements given in Section 5.

103 General description of vessel systems to be used shall be presented. Ballast and towing equipment/ systems shall be described in detail if used.

104 The vessel should be suitable for its planned tasks during the operation.

Guidance note:
If there is any doubt about the vessel suitability for a specific operation it is recommended to carry out an independent suitability survey of the vessel.

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105 See DNV-OS-H203, Section 5 for further requirements to Dynamic Positioned vessels.

D 200 Condition and inspections

201 All vessels shall be in good condition and with valid certificates, see D500.

202 All vessels involved in the operations should be inspected prior to the operation to confirm compliance with design assumptions, validity of certificates, suitability (see 104) and general condition.

203 The vessels global and local condition with respect to corrosion shall be confirmed and considered in strength verifications.

D 300 Structural strength

301 Adequate global and local structural strength shall be documented for all vessels.

Guidance note:

The strength may be documented by either ensuring that the vessel is operated within the Class requirements, see D400, or by calculating the strength according to the relevant requirements in *DNV-OS-H102*.

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302 If allowable deck load is based on load charts, limitations and conditions for these with respect to number of loads and simultaneousness of loads shall be clearly stated. Applied design factors shall be specified.

D 400 Class requirements

401 Vessels classed by a Classification Society shall be operated in accordance with requirements from this Society. The limitations for Class as given in "Appendix to Class Certificate" or similar shall be presented.

402 For Mobile Offshore Unites the following annexes (or similar) to the maritime certificates shall be presented;

- Annex I - Operational limitations,
- Annex II - Resolutions according to which the unit has been surveyed, and possible deviations from these.

403 Valid recommendations given by the Classification Society shall be presented.

Guidance note:

Modifications to vessel structure or equipment may require approval from the Classification Society.

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404 If a vessel or its equipment (e.g. crane) is planned used outside limitations stated by Class, a statement of acceptance from Class shall be presented.

D 500 Certificates

501 All required certificates should be valid, or relevant exemptions shall be presented.

Guidance note:

Which documents (certificates) to be carried onboard different types of vessels could be found in IMO FAL.2/Circ.87-MEPC/Circ.426-MSC/Circ.1151.

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D 600 Navigational lights and shapes

601 The vessel or towed object shall display navigational lights and shapes in accordance with IMO codes and local regulations.

602 Sufficient energy supply for the navigational lights to last for minimum 1.5 times the expected duration of the voyage should be provided.

D 700 Contingency situations

701 All vessels shall be selected with due consideration to possible contingency situations.

Guidance note:

This could e.g. be to require a redundant (twin screw) tugs for towing operations in narrow waters. See also operation specific requirements in the applicable standard DNV-OS-H201 through DNV-OS-H206 for further guidance.

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702 Where several tugs (vessels) are involved, a stand-by tug to assist or remove vessels in case of black-out, engine failure, etc. should be considered.

APPENDIX A
WAVE PARAMETERS

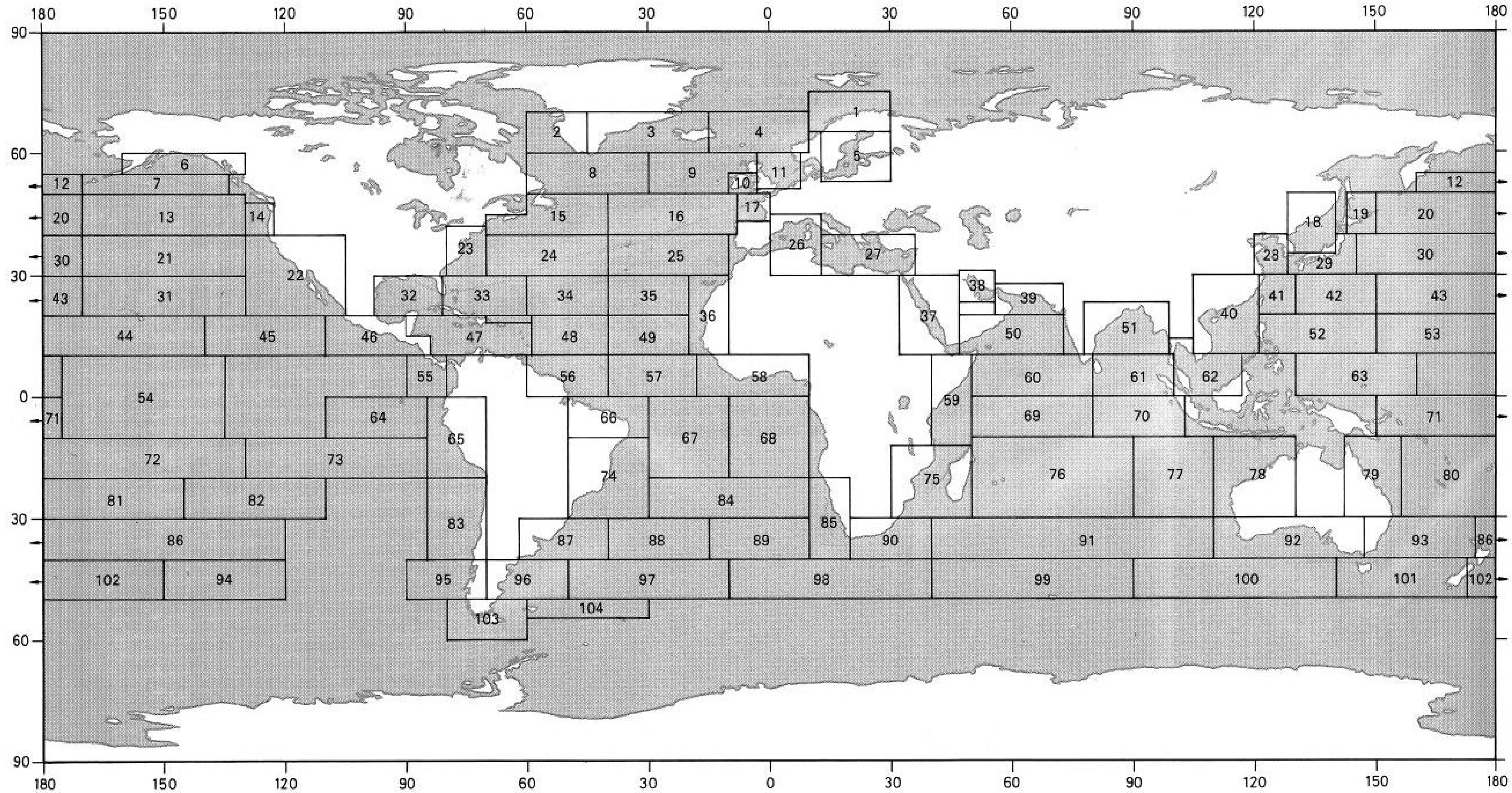

Figure 1
Definition of nautical zones for estimation of long term wave distribution parameters.

Table A-1 Weibull parameters α and β.

Weibull parameters α and β for the long-term probability distribution of the significant wave height. The data refer to the zones in Fig.1.

Area	α	β	*Area*	α	β
1	2.33	1.33	53	2.56	1.93
2	1.96	1.34	54	2.45	2.19
3	2.74	1.35	55	1.83	1.96
4	2.84	1.53	56	2.40	2.18
5	1.76	1.59	57	2.17	2.19
6	2.76	1.45	58	1.85	2.08
7	3.39	1.75	59	2.02	1.76
8	3.47	1.57	60	1.93	1.39
9	3.56	1.61	61	2.10	1.82
10	2.45	1.37	62	1.73	1.39
11	2.19	1.26	63	1.88	1.70
12	3.31	1.56	64	2.34	2.16
13	3.18	1.64	65	2.02	1.90
14	2.62	1.46	66	2.33	2.15
15	3.09	1.50	67	2.43	2.21
16	3.42	1.56	68	2.42	2.16
17	2.77	1.41	69	2.23	1.89
18	1.66	1.14	70	2.32	1.84
19	2.48	1.35	71	1.79	1.69
20	3.15	1.48	72	2.44	1.93
21	2.97	1.69	73	2.80	2.26
22	2.29	1.72	74	2.23	1.69
23	2.23	1.39	75	2.69	1.67
24	2.95	1.48	76	2.86	1.77
25	2.90	1.61	77	3.04	1.83
26	1.81	1.30	78	2.60	1.70
27	1.76	1.30	79	2.18	1.53
28	1.81	1.28	80	2.54	1.70
29	2.31	1.38	81	2.83	1.71
30	3.14	1.56	82	2.84	1.94
31	2.62	1.79	83	2.60	1.83
32	1.81	1.47	84	2.92	2.10
33	2.17	1.66	85	3.32	1.94
34	2.46	1.70	86	2.91	1.54
35	2.74	2.05	87	2.43	1.40
36	2.32	1.82	88	3.35	1.75
37	1.66	1.53	89	3.02	1.45
38	1.23	1.24	90	3.35	1.59
39	1.74	1.37	91	3.54	1.68
40	2.36	1.42	92	3.42	1.71
41	2.47	1.50	93	2.66	1.45
42	2.32	1.41	94	3.89	1.69
43	2.78	1.78	95	3.71	1.93
44	2.83	2.17	96	2.65	1.47
45	2.60	2.07	97	3.61	1.63
46	1.76	1.44	98	3.53	1.70
47	2.30	1.78	99	4.07	1.77
48	2.55	2.20	100	3.76	1.54
49	2.50	2.13	101	3.21	1.57
50	2.05	1.28	102	3.08	1.60
51	1.78	1.44	103	3.52	1.58
52	2.14	1.50	104	2.97	1.57

Table A-2 Gamma function values

Gamma Function Values					
α	$\Gamma(\alpha)$	α	$\Gamma(\alpha)$	α	$\Gamma(\alpha)$
0.50	1.7725	1.02	0.9888	1.54	0.8882
0.52	1.7058	1.04	0.9784	1.56	0.8896
0.54	1.6448	1.06	0.9687	1.58	0.8914
0.56	1.5886	1.08	0.9597	1.60	0.8935
0.58	1.5369	1.10	0.9514	1.62	0.8959
0.60	1.4892	1.12	0.9436	1.64	0.8986
0.62	1.4450	1.14	0.9364	1.66	0.9017
0.64	1.4041	1.16	0.9298	1.68	0.9050
0.66	1.3662	1.18	0.9237	1.70	0.9086
0.68	1.3309	1.20	0.9182	1.72	0.9126
0.70	1.2981	1.22	0.9131	1.74	0.9168
0.72	1.2675	1.24	0.9085	1.76	0.9214
0.74	1.2390	1.26	0.9044	1.78	0.9262
0.76	1.2123	1.28	0.9007	1.80	0.9314
0.78	1.1875	1.30	0.8975	1.82	0.9368
0.80	1.1642	1.32	0.8946	1.84	0.9426
0.82	1.1425	1.34	0.8922	1.86	0.9487
0.84	1.1222	1.36	0.8902	1.88	0.9551
0.86	1.1031	1.38	0.8885	1.90	0.9618
0.88	1.0853	1.40	0.8873	1.92	0.9688
0.90	1.0686	1.42	0.8864	1.94	0.9761
0.92	1.0530	1.44	0.8858	1.96	0.9837
0.94	1.0384	1.46	0.8856	1.98	0.9917
0.96	1.0247	1.48	0.8857	2.00	1.0000
0.98	1.0119	1.50	0.8862		
1.00	1.0000	1.52	0.8870		