PROCEDURAL SPECIFICATION

SITE SPECIFIC ASSESSMENT OF MOBILE OFFSHORE JACK-UP UNITS
(AMENDMENTS/SUPPLEMENTS TO THE SNAME GUIDELINE AND RECOMMENDED PRACTICE)

DEP 37.11.00.30-Gen.

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DESIGN AND ENGINEERING PRACTICE

USED BY

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PREFACE

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The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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PART I INTRODUCTION

1.1 SCOPE

This new DEP provides guidance on engineering principles and practices relating to the site specific structural assessment of mobile offshore jack-up units.

This DEP is based on the industry Guideline and Recommended Practice for Site Specific Assessment of Mobile Jack-up Units, published by the American Society of Naval Architects and Marine Engineers, SNAME. Part II of this DEP amends, supplements or replaces the various sections of the Guideline. Part III provides amendments, supplements and replacements to the various sections of the Recommended Practice (RP). Detailed amendments are not provided to the RP Commentaries, but instead general comment is provided in Part IV.

This DEP does not cover the design of jack-up structures.

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in offshore exploration and production.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Principal and/or the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1. General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

NOTE: In the definitions of the Principal and the Contractor, the "project" and its "design, engineering, construction, etc." means the "assessment".

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

The section numbering used in Part II of this DEP corresponds with that used in the industry Guideline, except that the letter G has been placed in front of the numbers. The section numbering in Part III corresponds with that of the Recommended Practice, with the prefix RP. Other documents referenced by this DEP are listed in Part V.

PART II AMENDMENTS/SUPPLEMENTS TO THE SNAME GUIDELINE

G 1.3 Applicability and Limitations

G 1.3.1 In the first sentence, replace "should" by "shall".

Add to this section:

Verification of the structural adequacy of a jack-up involves three key activities: the site specific analysis, the condition assessment and condition monitoring; see EP 90-3490. The objectives of these activities are as follows:

i) The site specific structural analysis aims to check that the jack-up theoretical design strength, based on assumptions regarding the condition of the jack-up structure, satisfies the criteria set in this DEP.

ii) The objective of the condition assessment is to validate that the actual condition of the jack-up structure is in line with the assumptions made in the site specific structural analysis; see also G.1.3.4.

iii) Condition monitoring aims to provide early warning of any significant reduction in the jack-up's structural integrity during the operations with the jack-up.

Maintenance and inspection are **not** the responsibility of the Principal and reference to existing records is encouraged, whenever possible.

G 1.4 Typical Approach to Site Assessment

G 1.4.1 Add to this section:

All reference calculations and assumptions shall be in accordance with this DEP.

G 2.3 Environmental Data

G 2.3.2 Add to this section:

The environmental conditions (e.g. wave height, current velocity and wind speed) to be used in the assessment will normally be provided by the Principal. These conditions may be based on the combination of 50 year return period wave, 50 year return period current and 50 year return period wind when used in conjunction with the procedures and acceptance criteria in accordance with this DEP. However, an alternative reliability based approach should be taken. Hence, for areas where information on joint occurrence of wind, current and waves is available, this data should be used to establish long term load statistics. These may then be used to justify alternative combinations, which, in combination with the load factor, give more appropriate and consistent structural reliability levels; see also G. 4.1.2.

G 3.2 Airgap

G 3.2.1 Add to this section:

Very large forces will occur if the wave crest hits the hull and therefore the probability of the wave crest elevation exceeding the elevation of the underside of the hull may control the overall structural reliability. The wave crest elevation with a return period equal to the reciprocal of the minimum acceptable failure rate of the jack-up structure should be examined and the airgap should be determined such that these waves do not hit the hull.

G 4.1 Loading Cases

G 4.1.2 Add to this section:

Alternatively, for areas where information on wind, current and waves with regard to their joint occurrence in time and direction is available, this information may be used to establish long term load statistics in a reliability based approach; see also G.2.3.2.

PART III AMENDMENTS/SUPPLEMENTS TO THE SNAME RECOMMENDED PRACTICE

RP 3.3 Environmental Conditions - General

Add the following new section:

RP 3.3.4 For some sea areas, substantial databases are becoming available with which it is possible to establish statistics of joint occurrence of wind, wave and current magnitudes and directions. When such a database is available, it is recommended that this should be used to develop environmental conditions based on joint occurrence, which provide the 100 year return period environmental load. The load factors used in conjunction with this environmental load should be determined using structural reliability analysis principles to ensure that an appropriate structural reliability is achieved. This approach is recommended since it provides more consistent reliability for different geographic areas than has been provided by the existing practice of using separate (marginal) statistics of winds, currents and waves.

RP 3.5 Waves

RP 3.5.1.2 Add the following note to this section:

NOTE: Wave kinematics may be calculated using deterministic (traditional regular periodic wave theory) or stochastic theory. The traditional regular periodic wave theory overestimates the kinematics and in the Recommended Practice this is compensated for by using a reduced wave height H_{det} in the calculations.

RP 3.5.2 Add the following note to this section:

NOTE: The NEWWAVE theory shall not be used to determine the required deck elevation.

RP 4.1 Introduction

Add the following new section:

RP 4.1.4 Two - Dimensional Wave Kinematics: Breaking waves may occur in storm conditions in shallow water and when the ratio of wave height to water depth is large. The type of breaking wave (e.g. plunging or spilling) and the wave height/water depth limits are dependent on local environmental and topographical conditions such as the presence of current and seabed slope.

RP 4.2 Wind Force Calculations

Add the following new section:

RP 4.2.4 The WINDOS program provides an alternative method, which accounts in an approximate manner for shielding and interaction effects. Guidance on the WINDOS program for calculating wind loads on jack-ups is given in EP 93-1815.

RP 4.3 Hydrodynamic Forces

RP 4.3.2 Add to this section:

This criterion (uTn/Di $\geq$ 20) is considered unconservative for determining if the relative velocity formulation of the Morison equation may be used. It should be replaced with the following:

Relative velocity may only be used for stochastic/random wave force analysis when a relevant measure of member displacement amplitude (which may be taken to be twice the standard deviation of the time varying displacement of the member) at the waterline, normal to the member axis and in the direction of Vn, is larger than one chord diameter.

Explanatory note:

The Morison equation is a semi-empirical formula derived from experiments on isolated vertical piles in periodic waves. Since its introduction (some 40 years ago) the equation has been modified and generalised for applications including inclined and horizontal members, current and relative velocities in cases where members move instead of being stationary. The relative velocity generalisation, although it may intuitively appear quite reasonable, is the most stretching of these generalisations. This is mainly due to two uncertainties. These are:

i) member movements should be large enough to create vortex shedding and a drag force mechanism comparable to that of currents and/or waves past a stationary member;

ii) member movements are in most cases associated with a frequency range different from the wave frequencies and it is hence questionable whether the two physically different flow conditions can simply be added together.

Therefore, in some cases circumstances are such that the use of relative velocity is judged to be an acceptable engineering approximation of the physical reality, while in other cases the use of absolute water particle velocities is judged to be far more realistic. In addition to affecting the magnitude of the exciting force, the relative velocity formulation also introduces an uncontrolled amount of damping and will always result in lower responses. Hence, in view of the absence of conclusive proof, it is considered prudent to adopt a cautious approach towards the use of relative velocity formulation for the hydrodynamic force calculations.

Add the following new section:

RP 4.3.4 A key feature of the RP wave load recipe is the adoption of drag and inertia force coefficients, which are consistent with the values measured in various laboratories and full scale measurement programmes conducted in recent years. The traditional values for the drag coefficient of 0.6 to 0.7 for a circular cylinder are replaced by higher values, which are acknowledged as being appropriate for the real flow conditions in the offshore environment. The drag coefficient for rough (marine fouled) members takes a value of 1.00 or higher depending on Reynolds number and Keulegan Carpenter number. Compatible values for the inertia force coefficient have also been adopted with a reduction from the traditional value of 2.0 to a value of 1.8 for rough tubulars, as listed in Section 4.7 of the RP.

The NEWWAVE Approach (see EP 94-0161)

Wave loading research within the Group in recent years has confirmed that higher drag coefficients are required to provide consistency of calculation results with laboratory and full scale measurements in realistic flow conditions. However, the use of a regular periodic wave theory for representing realistic random wave conditions has also been found to be inappropriate, generally overpredicting the kinematics in extreme storms. Group research has therefore also been focused on more appropriate models for wave kinematics to replace the traditional regular wave theories.

Real sea conditions comprise random rather than regular waves. They are composed of a complex system of individual "wavelets" of different amplitudes and periods, travelling at different speeds and in different directions. As an alternative to using a regular periodic wave, time domain simulations of random waves in an extreme storm can be performed. The full range of amplitudes, periods and directions are included in the simulations, and the extreme conditions extracted represent the actual superposition of individual "wavelets" to produce a maximum at a particular time. Wave kinematics and loads produced by such random directional wave load models have been extensively validated against offshore measurements and laboratory experiments and have provided excellent agreement when used in conjunction with realistic force coefficients. However, application of random time domain methods for routine analyses is in general not practical due to the extensive computer and manpower effort required.

As an alternative, NEWWAVE theory has been developed, which uses a statistically based superposition of random linear waves to define a deterministic wave profile and associated kinematics representing the most probable maximum wave condition in a real random seastate. The wave kinematics calculated using NEWWAVE are corrected to account for wave directionality and are combined with current speeds reduced to account for blockage. NEWWAVE is valid in the range of waterdepths where Stokes V order wave theory is also valid.

The loads produced using NEWWAVE theory have been validated against time domain simulations of random waves and against offshore measurements. This validation was focused on drag dominant structures for which maximum wave forces occur with the wave crest positioned at the structure and has demonstrated good agreement. NEWWAVE theory, used in conjunction with realistic force coefficients, is therefore the method that should be used for calculating extreme wave loads for such structures.

RP 4.4 Wave Theories and Analysis Methods

RP 4.4.1 Add the following sentence:

See also new Section 4.4.4.

Add the following new section:

RP 4.4.4 Recommended Static Wave Analysis: Section 4.4.1 addresses the calculation of wave kinematics for establishing the deterministic static wave load based on a traditional regular periodic wave theory. An alternative wave theory called NEWWAVE has been developed within the Group to provide wave kinematics which more accurately represent the maximum conditions in a realistic complex random sea. NEWWAVE theory has been validated for calculating extreme wave loads for drag dominant structures for which the maximum wave load occurs with the wave crest positioned at the structure. For such structures NEWWAVE should be used instead of the provisions of Section 4.4.1 to calculate the deterministic static wave load for design. NEWWAVE is valid in the range of water depths where the Stokes V order wave theory is valid. EP 94-0161 gives a detailed description of the application of NEWWAVE to spaceframe substructures.

RP 4.8 Other Considerations

Replace the last sentence with the following:

The Morison equation (see Section 4.3 of the RP) accounts for mean in-line drag and inertia forces, but not for the oscillating in-line and cross-flow forces due to periodic vortex shedding from the downstream side of the member. These periodic forces can cause significant member vibrations when the shedding frequency coincides with the natural frequencies of the member. Vortex shedding forces can be disregarded in the calculation of global structural loads; however, they should be considered in the calculation of local member forces and responses. Vortex induced vibrations can occur on long spans due to wind during transportation, as well as due to waves and currents on the jack-up in place. Guidance on methods to assess vortex shedding is given in EP 93-0455.

RP 6.3 Foundation Stability Assessment

RP 6.3.1 Approach

Replace the last sentence with the following:

For the assessment of the stability of the leeward spudcan which is partially penetrated (e.g. in sandy soils), the consequence of additional penetration will be to increase the effective bearing area of the footing. This may result in a considerable increase in capacity. In this instance, it may be appropriate to repeat the calculations for the leeward leg foundation based upon the new, increased effective area of the spudcan.

RP 6.3.3.1 Ultimate vertical/horizontal bearing capacity envelopes for spudcan footings in sand

Replace the first sentence with the following:

The ultimate vertical/horizontal bearing capacity envelope for jack-up footings in sand, both for the windward and leeward leg, may be determined as follows:

Delete the last sentence (from "The sliding capacity ..... etc.," to the end).

RP 7. CALCULATION METHODS - DETERMINATION OF RESPONSES

Add new section:

RP 7.1.8 The dynamic analysis method that should be used whenever possible is the inertial loadset approach based on random (frequency domain) analysis, as outlined in Section RP 7.3.6.3. It is considered that 5% is an appropriate percentage of global critical damping (7%, as suggested in the Recommended Practice, is considered too high). Refer also to Section RP 7.3.7 for the breakdown of the sources of global damping.

RP 7.3.6.1 The classical SDOF analogy

Add to this section:

This simple method may lead to unconservative or conservative results depending on the case specific circumstances as outlined in the RP. The method presented in Section RP 7.3.6.3 should be used in preference to the method in this section. For all assessments where dynamics have a contribution to the overall response corresponding with a DAF > 1.15, the method in Section RP 7.3.6.3 shall be adopted.

RP 7.3.6.2 Other SDOF approaches

Delete this section:

NOTE: Contrary to the classical SDOF method, this method has not been tested, nor has it been calibrated against the Group dynamic analysis practice.

RP 7.3.6.3 Inertial loadset based on random analysis

Add new paragraph at the beginning of this section:

This section and the referenced sections of the commentary (Section C7.B.2) describe the method for dynamic analysis that shall be adopted whenever possible. Guidance on how to perform the analysis using the SESAM and FREERISE programs is given in EP 93-0440 and EP 92-0070 respectively.

RP 7.3.7 Detailed Dynamic Analysis Methods

Add the following two paragraphs to the introductory text of this section:

In special cases non-linear random dynamic time domain analysis may be required. In such cases the time domain analysis should be carried out in accordance with the procedures given in EP 94-0605. The statistical post-processing of the results to determine the most probable maximum extreme (MPME) response should be in accordance with EP 94-0610.

The percentages of critical damping in Table 7.1 of the Recommended Practice and the accompanying notes may be applied, except that the hydrodynamic damping of 3% is considered too high. 1% hydrodynamic damping should be adopted. Hence, the total global damping may be taken as 5% of critical.

RP 7.4 Fatigue

RP 7.4.4 General description of analysis

Add to this section:

Report EP 93-2005 provides guidance on fatigue analysis for steel fixed offshore structures, and its general principles are also applicable to jack-up units.

RP 8. ACCEPTANCE CRITERIA

Add the following paragraph at end of opening section:

For some sea areas, substantial databases are becoming available with which it is possible to establish joint occurrence of wind, wave and current magnitudes and directions. When such a database is available, it should be used to develop combinations of environmental conditions based on joint occurrence, which provide the 100-year return period environmental load. This 100-year return period environmental load shall be determined following the procedures developed by the Group. The load factors used in conjunction with this environmental load should be determined using structural reliability analysis principles to ensure that an appropriate structural reliability is achieved. This approach provides a more consistent reliability for different geographic areas than has been provided by existing practice of using separate (marginal) statistics of winds, currents and waves (refer EP 94-0430).

RP 8.3.1.5 Step 1b - Sliding Resistance - Windward Legs(s)

Replace the first part of the first sentence with the following:

a) For undrained soils (clays), the sliding capacity of the windward leg should be checked for ...., etc.

Delete in paragraph b):

ϕ_{Hfc} = 0.80 (effective stress - sand/drained)

Add following paragraph:

c) For drained (sandy) soils, the foundation capacity of the windward leg should be checked in accordance with the equations and requirements of Section 8.3.2.1 and Section 8.3.2.2, where

   ϕ_{VH} = 0.8 (effective stress - sand/drained)

Add the following to sections RP 8.1.3, RP 8.2.2, RP 8.3.1.2, RP 8.3.1.5, RP 8.3.2.1 and RP 8.3.3.1:

The environmental load factor γ_3 = 1.25 may be used in the analysis. The load factors should be applied in such a way that the second order effects are also factored.

NOTE: Different environmental and inertial load factors may have to be used when the assessment is based on reliability principles; see the additional paragraph to RP 8.

RP 8.7 Structure Condition Assessment

Add the following paragraph at the end of this section:

Group experience has shown that valid class certification does not necessarily guarantee adequacy of the jack-up condition from the structural assessment viewpoint. The jack-up structure condition should be validated on the basis of the guidance provided in EP 90-3490.

PART IV RP COMMENTARIES

The commentaries to the Recommended Practice contain considerable information that in many cases provides useful background, explanation or alternatives to the various RP sections. However, the commentaries can never be construed to override the stipulations in the RP.

It should further be recognised that the commentaries will contain material that is not in every respect supported by the best opinion in the Group and may exceptionally even be in conflict with this. No attempt has been made to identify such places and provide amendments or supplements to the commentaries sections in a similar manner as for the RP sections. However, the user of this DEP is warned to be careful in this regard. Particularly, commentaries with RP sections that have been amended in this DEP might be invalidated and shall be treated with care.

PART V REFERENCES

In this DEP, reference is made to the following publications.

NOTE: Unless specifically designated by date the latest edition of each publication shall be used together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.

INDUSTRY PUBLICATIONS

Guideline for site specific assessment of mobile jack-up units and Recommended Practice for site specific assessment of mobile jack-up units	SNAME, Technical and Research Bulletin. First edition, May 1994

Published by:
The Society of Naval Architects and Marine Engineers
601 Pavonia Avenue
Jersey City, NJ 07306
USA

BIBLIOGRAPHY

NOTE: The following documents are for information only and do not form an integral part of this DEP.

Jack-up structure condition assessment and condition monitoring	EP 90-3490
Jack-up worksheet: A spreadsheet for determining the inertial load for a dynamically responding jack-up	EP 92-0070
Random dynamic frequency domain analyses for jack-up units using SESAM	EP 93-0440
Practice for the assessment of vortex-induced vibrations of structural members	EP 93-0455
The evaluation of WINDOS for the wind load analysis of jack-up units	EP 93-1815
Practice for the fatigue analysis of steel substructures for fixed offshore platforms	EP 93-2005
NEWWAVE and current blockage: Their implementation and application within SESAM, February 1994	EP 94-0161
Extreme storm loading on steel space frame structures - an improved methodology	EP 94-0430
Nonlinear random time domain analysis of jack-up units using SESAM/Fenris	EP 94-0605
Statistical interpretation of random time domain series for drag-dominant structures	EP 94-0610