NOBLE DENTON

TECHNICAL POLICY BOARD

GUIDELINES FOR THE TRANSPORTATION AND INSTALLATION OF STEEL JACKETS

0028/ND

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PREFACE

This document has been drawn with care to address what are likely to be the main concerns based on the experience of the Noble Denton organisation. This should not, however, be taken to mean that this document deals comprehensively with all of the concerns which will need to be addressed or even, where a particular matter is addressed, that this document sets out the definitive view of the organisation for all situations. In using this document, it should be treated as giving guidelines for sound and prudent practice on which our advice should be based, but guidelines should be reviewed in each particular case by the responsible person in each project to ensure that the particular circumstances of that project are addressed in a way which is adequate and appropriate to ensure that the overall advice given is sound and comprehensive.

Whilst great care and reasonable precaution has been taken in the preparation of this document to ensure that the content is correct and error free, no responsibility or liability can be accepted by Noble Denton for any damage or loss incurred resulting from the use of the information contained herein.

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1 SUMMARY

1.1 This report sets out the guidelines on which Noble Denton approval of the transportation and installation of steel offshore jacket structures would be based.

1.2 The report refers to other Noble Denton guideline documents, covering loadouts, marine transportations, tug approval and lifting, which should be read in conjunction with this document.

1.3 The report discusses the process of approval, when required by an Insurance Warranty, the issue of a Certificate of Approval and its limitations. The scope of work leading to the issue of a Certificate is also discussed.

1.4 Transportation criteria are largely referenced to another document, but the particular concerns of jacket transportation are addressed, including the issue of reduced meteorological criteria for a short duration towage.

1.5 Criteria are presented for installation by launching and lifting. Lifting is referred to in another document, except for the particular issues associated with jacket installation.

1.6 Pile installation, including the stability of unpiled or partly piled jackets, is discussed.

1.7 Unpiled jackets that rely on gravity or skirt penetration are also covered.

1.8 Revision 1 was a reformat of Revision 0 dated 22 March 1994, with minor changes of text.

1.9 Revision 2 included amendments to Revision 1, with references to other revised Noble Denton Guidelines, greater emphasis on transportation on self-propelled vessels, relaxation of some seafastening requirements, addition of a caution on heave-compensated lifts, relaxation of buoyancy requirements for jacket installation and deletion of an Appendix on reduced exposure criteria.

1.10 Revision 3 includes amendments to Revision 2 including, specification of jacket buoyancy requirements, on-bottom stability and jacket clearances as described in Section 2.1.5. 3

2 INTRODUCTION

2.1 GENERAL

2.1.1 This report is intended to cover the technical and marine requirements of the Noble Denton Group for approval of the transportation and installation of steel jacket structures.

2.1.2 A jacket may be transported on a barge towed by a tug, on a self-propelled heavy lift cargo vessel, or on its own buoyancy. For convenience in this report the term "towage" includes "voyage", and "barge" includes “vessel” or "ship", as applicable.

2.1.3 Revision 1 was a reformat of Revision 0 dated 22 March 1994, previously titled “General Guidelines for the Transportation and Installation of Steel Jackets” with minor changes of text. A new Section 3 – Definitions, was added, and subsequent sections re-numbered.

2.1.4 Revision 2 included the following amendments to Revision 1:

- References to other revised Noble Denton Guidelines, particularly related to transportation and lifting (throughout)
- Greater emphasis on transportation on self-propelled vessels (throughout)
- Relaxation of seafastening requirements for small items temporarily transferred to the deck of an SSCV (Section 6.8.6)
- Addition of a caution on heave-compensated lifts (Section 9.2.4)
- Relaxation of intact buoyancy requirements for jackets in water (Section 10.2)
- Deletion of Appendix on reduced exposure towage criteria, to avoid overlap/clash with referenced document.

2.1.5 Revision 3 includes the following main amendments to Revision 2:

- Inclusion of Section 7.9.6, Compartment buoyancy requirements and monitoring.
- Inclusion of Section 7.9.7, pile installation required as part of un-piled stability.
- Inclusion of Section 8.1.3, Clearances to appurtenances.
- Inclusion of Section 8.6, Jacket compartmentation, appurtenance sealing and pressure monitoring. 3
- Inclusion of Section 9.5, Free floating lifted jackets.
- Inclusion of Sections 11.1.7, Clearances between subsea assets, and 11.3.2, Clearances between the jacket and a pre-installed template.
- Revision to Sections 2.3.2, 4.2.3 4.3.1, 4.3.3, 6.7.4 to 6.7.7, 7.5.1, 10.1, 11.1.1 and 13.4.1.
- General revision to Section 13 - Un-piled stability.

2.2 START AND COMPLETION OF OPERATIONS

2.2.1 Transportation is defined as starting when all preparations for sailaway have been completed, the Certificate of Approval has been issued, and the removal of mooring lines has started.

2.2.2 Transportation is defined as being completed when either:

a. The towage or transportation has arrived at a sheltered location and the approved tug has been disconnected, or:

b. Installation has started at the installation site (within a 500m zone).

2.2.3 Installation is generally defined as starting when all preparations for launch or lift at the offshore location have been completed, an acceptable prevailing and forecast weather forecast has been received, the Certificate of Approval has been issued, and cutting of seafastenings has started. In specific cases, the start of installation may be defined as the point of handover or control of the transportation barge or vessel to the offshore installation spread. 3

2.2.4 Installation is generally defined as being completed when the jacket is positioned on the seabed within the agreed installation position tolerances, and sufficient piles have been installed to enable the jacket to withstand the 10-year seasonal storm. However, Noble Denton's scope of work may include approval of pile handling, pile installation, jacket levelling and grouting beyond this point.

2.2.5 OTHER NOBLE DENTON GUIDELINE DOCUMENTS

This report refers to, and should be read in conjunction with other Noble Denton Guideline documents, particularly:

- 0013/ND - Guidelines for Loadouts (Reference [1])
- 0021/ND - Guidelines for the Approval of Towing Vessels (Reference [2])
- 0027/ND - Guidelines for Lifting Operations by Floating Crane Vessels (Reference [3])
- 0030/ND - Guidelines for Marine Transportation (Reference [4])

2.2.6 Care should be taken when referring to any Noble Denton guideline document that the latest revision is being referenced.

2.3 NATIONAL CODES AND LEGISLATION

2.3.1 These guidelines are intended to lead to an approval of a specific operation by Noble Denton. Such approval does not itself imply that approval by regulatory bodies, harbour authorities and/or any other involved parties would be given.

2.3.2 Care should be taken that the design and planning of installation operation complies with relevant national codes and legislation, i.e. established offshore structure design codes (API, NORSOK, ISO, DNV etc.), suitably augmented as necessary for 3 local conditions by project specific design briefs.

3 DEFINITIONS

3.1 Referenced definitions are underlined.

Term or Acronym	Definition
Approval	The act, by the designated Noble Denton representative, of issuing a 'Certificate of Approval'
Barge	The floating vessel, propelled or non-propelled, on which the structure is to be transported. (For the purposes of this document, the term barge can be considered to include vessel or ship where appropriate.)
Certificate of Approval	The formal document issued by Noble Denton when, in its judgement and opinion, all reasonable checks, preparations and precautions have been taken, and an operation may proceed.
Insurance Warranty	A clause in the insurance policy for a particular venture, requiring the approval of a marine operation by a specified independent surveyor.
Jacket	A sub-structure, positioned on the seabed, generally of tubular steel construction and secured by piles, designed to support topsides facilities.
Loadout	The transfer of a major assembly or a module from land onto a barge by horizontal movement or by lifting.
NDT	Non-Destructive Testing
Noble Denton	Any company within the Noble Denton Group including any associated company which carries out the scope of work and issues a Certificate of Approval.
Operational reference period	The planned duration of the operation, including a contingency period.
Reduced exposure	A computation which considers that although the operation is an "unrestricted operation", the exposure is sufficiently short for the design extremes to be reduced.
Seafastenings	The system used to attach the 'Structure' to the barge, for in-harbour moves or offshore transport
SLS	A design condition defined as a normal Serviceability Limit State / normal operating case.
SSCV	Semi-submersible crane vessel
Structure	The object to be transported and installed.
Survey	Attendance and inspection by a Noble Denton representative. Other surveys which may be required, including structural, non-destructive testing or dimensional surveys
Surveyor	The Noble Denton representative carrying out a 'Survey'. An employee of a contractor carrying out, for instance a dimensional or non-destructive testing survey.
ULS	A design condition defined as Ultimate Limit State / survival storm case.

Term or Acronym	Definition
Un-restricted operation	A marine operation which cannot be completed within the limits of a favourable weather forecast (generally less than 72 hours). The design weather conditions must reflect the statistical extremes for the area and season.
Vessel	See 'Barge'.
Weather restricted operation	A marine operation which can be completed within the limits of a favourable weather forecast (generally less than 72 hours), taking contingencies into account. The design weather conditions need not reflect the statistical extremes for the area and season. A suitable factor should be applied between the design weather conditions and the operational weather limits.

4 THE APPROVAL PROCESS

4.1 NOBLE DENTON APPROVAL

4.1.1 By Noble Denton is meant any company within the Noble Denton Group including any associated company which carries out the scope of work and issues a Certificate of Approval.

4.1.2 Noble Denton approval may be sought where an operation is the subject of an Insurance Warranty, or where an independent third party review is required.

4.1.3 An Insurance Warranty is a clause in the insurance policy for a particular venture, requiring the approval of a marine operation by a specified independent surveyor. The requirement is normally satisfied by the issue of a Certificate of Approval. Responsibility for interpreting the terms of the Warranty so that an appropriate Scope of Work can be defined rests with the Client.

4.1.4 Noble Denton approval may be given for the loadout, transportation and installation operations, including reviews of marine and engineering calculations and procedures, and consideration of:

- The actual and forecast weather conditions
- The suitability and readiness of all equipment
- The behaviour of the transportation and installation vessels
- Any site changes in procedures
- The general conduct of the preparations for the operation.

4.2 CERTIFICATE OF APPROVAL

4.2.1 The deliverable of the approval process will generally be a Certificate of Approval.

4.2.2 The Certificate of Approval is the formal document issued by Noble Denton when, in its judgement and opinion, all reasonable checks, preparations and precautions have been taken, and an operation may proceed.

4.2.3 The Certificate of Approval for transportation will normally be issued when all preparations including seafastening and ballasting are complete, the tug and towing connections have been inspected, and the actual and forecast weather are suitable for departure. When the tow and installation are planned within the same weather window, then confirmation should also be received that the offshore spread will be ready on arrival of the jacket. In the event that the jacket barge does not sail directly to the installation site, but sails to a standby location, the mooring plans and mooring design shall be included as part of the transportation procedure.

4.2.4 The Certificate of Approval for an installation operation will normally be issued by the attending surveyor, immediately prior to the defined "point of no return" for the operation, such as starting to cut seafastenings, when all preparations are complete, and the actual and forecast weather are suitable for installation and are not expected to be exceeded for the planned installation operation or operations. 3

4.2.5 Depending on the contractual arrangements and schedules, pile installation may be included under the jacket installation Certificate, or separate Certificates may be required. In general, where the installation is a continuous sequence of operations, and the jacket is at risk until a number of piles have been installed, one Certificate should cover the overall operation. Where there are discrete breaks in the operation, with decision points, then a separate Certificate may be required at each decision point.

4.2.6 Agreement is required on the end-point of the Certificate of Approval. Unless agreed otherwise the definitions of "completion" shown in Sections 2.2.2 and 2.2.4 shall apply for transportation and installation respectively.

4.3 SCOPE OF WORK LEADING TO AN APPROVAL

4.3.1 In order to issue Certificates of Approval, Noble Denton will typically require to consider the following topics:

a. **Loadout**
- Loadout approvals are covered in Reference [1].

b. **Transportation**
- Transportation approvals are covered in Reference [4]

c. **Installation**
- Details and survey reports of installation location including pipeline and subsea asset layouts at the time of installation
- Installation method
- Installation vessel anchoring or DP operation methods and procedures 3
- Loads and stress in jacket during installation
- Simultaneous Marine Operations (SIMOPS)
- For a **launched jacket**:
  - the launching method
  - launching analysis and/or model test report
  - allowable rocker reactions and barge submergence
  - barge bending moment and shear force during launch
  - dive depth and seabed clearances
  - jacket stresses during launch
  - stability during and after launch
  - buoyancy tank removal
  - contingency procedures for critical operations 3
- For a **lifted jacket**, lifting operations are covered in Ref [3], but include:
  - the lifting/upending method/procedure
  - Dynamic analyses of lifting operations (as applicable)
  - jacket and lift point stresses during lift
  - rigging arrangement
  - crane vessel specification
  - clearances to crane vessel and seabed
  - buoyancy tank removal
  - contingency procedures for critical operations 3
- Jacket ballasting system including water tight compartments and integrity.
- Positioning systems (crane vessel and seabed)
- Pile handling method
- Pile installation sequence
- Jacket local and global capacity under maximum levelling loads 3
- Stability of jacket in unpiled/partly piled condition
- Installation procedures and detailed installation schedule
- Risk assessments and HAZOPS for marine installation operations 3
- Anchor running procedures

- Installation vessel mooring analyses
- Cargo barge mooring and stability (ballasting) lift off (multiple barge loadings. 3

4.3.2 Technical studies leading to the issue of a Certificate of Approval may consist of reviews of procedures and calculations submitted by the client or his contractors, or independent analyses carried out by Noble Denton to verify the feasibility of the proposals, or a combination of third party reviews and independent analyses.

4.3.3 Surveys carried out as part of Noble Denton's scope of work typically include:

a. Suitability survey of the transport barge or vessel. This is carried out before loadout, and is intended to assess the technical suitability and highlight any deficiencies in condition, equipment or documentation which may need attention before the start of the operation.

b. Loadout survey and attendance (outside the scope of this document).

c. Preliminary survey of the jacket and seafastenings, normally carried out onshore during the loadout phase.

d. Tug suitability survey. For tugs registered in the Noble Denton Towing Vessel Approvability Scheme, this is normally carried out immediately prior to sailaway. Unknown vessels may require a preliminary survey in advance.

e. Final sailaway survey. This is carried out immediately prior to sailaway, and would typically include inspection of the seafastenings and NDT reports, barge equipment, towing connections and towing arrangements as applicable. It would also include a review of actual and forecast weather for departure, including the conditions for installation if appropriate. Equipment required offshore for installation, and carried on the barge, would also be inspected at this stage.

f. Survey of the lifting rigging and rigging certificates, where appropriate. This is normally carried out onshore during the loadout and sailaway phase.

g. Survey of installation crane vessel. For vessels well known and generally acceptable to Noble Denton this is usually carried out offshore immediately prior to installation, although a review of documentation may be made in advance. Attendance at crane vessel annual DP trials (as applicable) may be required. Vessels unknown to Noble Denton should be surveyed in advance. 3

h. Surveys to establish the readiness to start the operation. This is carried out offshore immediately prior to the decision to proceed. A review of actual and forecast weather is made at this time.

i. Witnessing of the operation, including pile installation.

4.3.4 Further information on data required for review is contained in Appendix A.

4.4 LIMITATION OF APPROVAL

4.4.1 A Certificate of Approval is issued for a particular operation only.

4.4.2 A Certificate of Approval is issued based on external conditions observed by the attending surveyor of the jacket, hulls, machinery and equipment, without removal, exposure or testing of parts.

4.4.3 No responsibility is accepted by Noble Denton for the way in which a transportation is conducted after departure.

4.4.4 Fatigue damage is excluded from a transportation Certificate unless specific instructions are received from the client to include it in the scope of work.

4.4.5 Any alterations in the surveyed items or agreed procedures after issue of the Certificate of Approval may render the Certificate void unless approved by Noble Denton.

4.4.6 A Certificate of Approval for transportation does not cover any moorings prior to the start of transportation, or at any intermediate shelter port or arrival port, unless specifically approved by Noble Denton.

4.4.7 A Certificate of Approval for installation applies to the safety of the jacket during the defined installation period. It does not imply that the completed jacket will be fit for purpose.

5 LOADOUT

Loadout operations shall be carried out in accordance with Noble Denton document number 0013/ND - Guidelines for Loadouts (Reference [1]).

6 TRANSPORTATION

6.1 GENERAL

6.1.1 Except as modified or amplified by this document transportation operations shall be in accordance with other Noble Denton guidelines as referenced below.

6.1.2 Transportations shall be carried out in accordance with Reference [4]

6.1.3 Tug selection and approval shall be carried out in accordance with Reference [2]

6.2 DESIGN ENVIRONMENTAL CONDITIONS

6.2.1 The design environmental conditions for the transportation route shall be derived as indicated in Reference [4] Section 6.

6.2.2 If any port or sheltered area along the route is proposed to reduce the exposure, then the tow or transportation vessel must proceed towards and enter the port or area, unless a suitable further weather forecast is received to proceed on the next route sector.

6.2.3 Similarly, there must be a suitable port or sheltered area, sufficiently close to the installation location, so that the jacket can wait in shelter until a suitable installation window is forecast.

6.2.4 If shelter is planned as indicated in Sections 6.2.2 or 6.2.3, then, it must be shown that it is feasible to enter the port or area in deteriorating weather, and that a suitable safe berth, mooring or protected holding area is available.

6.2.5 If, on arrival at location, the actual weather is unsuitable for installation, but within the transportation criteria, the jacket may wait close to the location, but must depart for shelter if the weather is forecast to approach or exceed the transportation criteria.

6.2.6 Marine procedures for transportation and installation shall reflect the requirements of Sections 6.2.2 through 6.2.5.

6.2.7 Unless the provisions of above can be complied with, then the transportation shall be considered an Un-restricted Operation (See Section 3), and the design storm shall be the 10 year return period storm for the area and season.

6.3 STRESSES IN JACKET, BARGE AND SEAFASTENING

6.3.1 Loadcases to be considered shall include, but are not limited to, those shown in Reference [4] Sections 7 and 8, as appropriate.

6.3.2 The computation of the transportation stresses shall take into account, on a case by case basis, the flexibility of the barge or vessel and the interaction between the jacket and the barge or vessel, as transmitted by the grillages and seafastening.

6.3.3 Attention shall be paid to the stresses in the barge or vessel in way of the jacket support points and the seafastening reaction points.

6.3.4 So far as is practical, seafastening connections should be made with the barge or vessel in the transportation ballast condition, or a condition giving a similar longitudinal bending situation. If not practical, then the additional stresses which may be caused by the change in ballast condition shall be considered.

6.4 WAVE SLAM

6.4.1 Exposed parts of the jacket, particularly those overhanging or close to the bow of the barge, including buoyancy tanks and mud mats, shall be designed to withstand wave impact.

6.5 VORTEX SHEDDING

6.5.1 It may be necessary to consider vortex shedding for some structural members during transportation.

6.5.2 A means of determining whether vortex shedding could be critical for any particular member is contained in Dynamics of Fixed Marine Structures - Barltrop and Adams Reference [5], Section 7.2.

6.6 FATIGUE

6.6.1 For a long distance transportation it may be necessary to consider the effects of fatigue. Section 4.4.4 should be noted.

6.7 INTERNAL SEAFASTENINGS

6.7.1 Equipment which does not form part of the permanent jacket structure shall be seafastened to withstand the same motion criteria as the jacket.

6.7.2 Piles or similar items carried in pile sleeves or guides shall be secured so that movement does not cause fatigue of the attachments. Wooden wedges shall not be assumed to prevent movement.

6.7.3 Rigging platforms, and their attachments to the jacket, shall be designed to support their own weight and the weight of all rigging attached to them. The de-rigging case, when high impact loads may be expected, shall also be considered.

6.7.4 Rigging shall be adequately secured to rigging platform structural members or jacket members.

6.7.5 Items which could be exposed to wave action during either transportation or launch shall be suitably secured and protected against the expected loadings.

6.7.6 Flexible control lines and cables for the ballast and/or grout systems should not be exposed to wave action. 3

6.7.7 Valves and pressure gauges should be tested and checked closed prior to sailaway.

6.8 TRANSPORT ON DECK OF CRANE VESSEL

6.8.1 Jackets and piles are sometimes transferred to the deck of the crane vessel for final transport to the installation location, or at the location itself to facilitate installation.

6.8.2 Lifting operations should be carried out in accordance with Reference [3]. Since grillage and seafastening structures may be transferred with the jacket, this may represent the governing lift case.

6.8.3 Seafastening loads should be derived taking into account the motions of the crane vessel and wind loads. It should be demonstrated that these are no more severe than the transportation design loads.

6.8.4 The seastate for deriving the crane vessel motions shall be the 10 year return period monthly extreme storm for the route or location, whichever is the more severe. Reduced exposure criteria shall not be applied for transport or awaiting installation on the crane vessel.

6.8.5 If the draught of the crane vessel requires to be changed to minimise motions and limit loads on the jacket or seafastenings, this shall be incorporated into the marine procedures.

6.8.6 For relatively small and inherently stable items temporarily transferred to the deck of an SSCV, it may be practical to dispense with seafastening provided the seastate is below, and is forecast to remain below, a defined limit. If so, this shall be incorporated into the marine procedures.

7 INSTALLATION - LAUNCHING

7.1 ANALYSIS METHODS

Notes on analysis methods are contained in Appendix B.

7.2 BARGE STRENGTH

Calculations should demonstrate that the following parameters are within the specified allowable values for the barge:

- Rocker arm reactions
- Barge stern submergence
- Loads on skidways and barge structure
- Barge longitudinal bending and shear force.

7.3 BOTTOM CLEARANCES DURING AND AFTER LAUNCH

7.3.1 Minimum clearance during launch is shown in Section 10.3.

7.3.2 The seabed topography shall be demonstrated to be suitable for the launch and free of obstructions, by means of bathymetric and side-scan surveys, as shown in Section 11.1. The limits of the surveyed area shall be clearly delineated. 3

7.3.3 At no stage during the upending (including jacket weight and CoG variations) can the outstand of any jacket appurtenance be permitted to contact the seabed at LAT.

7.4 LIMITING WIND AND SEA-STATE

7.4.1 The seastate for launch shall be limited to the lesser of:

a. The maximum seastate allowed by jacket stresses, rocker arm reactions and dive depth, or

b. The seastate which permits safe transfer of personnel to the launch barge and operation of tugs and workboats.

7.4.2 The limiting wind speed for launch shall be compatible with the limiting seastate. It shall be demonstrated that this wind speed does not causes unacceptable additional stresses or heel angles during launch.

7.5 LOADS ON JACKET MEMBERS AND BUOYANCY TANKS

7.5.1 The members and joints of the jacket and attached items should be checked for relevant combinations of self weight, buoyancy, inertial, hydrostatic and
hydrodynamic loading due to launch (as well as transportation, upending and 3
upended) conditions.

7.5.2 Additionally members should be verified against slam loading and slender members should be checked to ensure that vortex induced vibrations will not cause damage.

7.6 STABILITY DURING AND AFTER LAUNCH

7.6.1 Prior to the initiation of jacket sliding, the stability of the jacket/barge combination shall comply with the following:

a. Minimum range of static stability shall be not less than 20 degrees.

b. The area under the righting moment curve to the second intercept of the righting moment and wind overturning moment curves or the downflooding angle, whichever is less, shall be not less than 40% in excess of the area under the wind overturning moment curve to the same limiting angle. Wind velocity used shall be 25 metres/second, or the design wind speed for the towage to location if less.

7.6.2 After initiation of jacket sliding, until the jacket starts to rotate relative to the barge, the stability of the jacket/barge combination shall comply with the following:

a. Metacentric height of the jacket/barge combination shall be positive.

b. Angle of heel caused by 1.5 times the limiting launch wind speed shall be shown to be acceptable.

7.6.3 After launch, except for self-upending jackets, it shall be demonstrated that the jacket will adopt a stable attitude, as shown in Section 10.4. The accidental flooding of any one jacket member or buoyancy tank shall not cause a situation where the jacket cannot be satisfactorily upended.

7.7 MODEL TESTS

7.7.1 Model tests of the launch may be performed:

a. To validate computer analyses,

b. To quantify parameters which are difficult to derive analytically,

c. To confirm that no important operational facet of the operation has been overlooked.

7.7.2 Further information on launch model tests is contained in Appendix C.

7.8 WINCHING, JACKING AND JACKET HANDLING SYSTEMS

7.8.1 Winching or jacking systems shall be capable of initiating jacket launch, taking into account the anticipated range of friction coefficients, as shown in Table B.1, and at the initial barge trim angle, after failure of any one system component.

7.8.2 The final release system shall be designed to hold the jacket at the planned trim angle, in the maximum launch seastate with the minimum friction coefficient used, and be capable of being quickly released once the launch decision is taken.

7.8.3 If wires and winches are used for initiating launch, the wires shall be shown to release cleanly from the jacket, when self-launching begins.

7.8.4 All wires, shackles, attachment points, winches and other components, including handling and towing wires to be used after launch shall be designed so that the breaking load of any component is not less than 3 times the maximum anticipated load. Alternatively, the maximum anticipated load shall not exceed the Certified Safe Working Load of any component.

7.8.5 Wires and connections used for handling after launch shall be capable of withstanding loads from all relevant directions.

7.9 PRACTICAL ASPECTS

7.9.1 As a minimum, the barge shall be provided with the following:

a. Adequate boarding ladders on both sides of the barge, clear of any jacket overhangs, for transferring launching crew in safety.

b. Safety equipment for all launching crew members.

c. Adequate tools and equipment for cutting, removing, handling and securing seafastening members.

d. Lights for night-time working.

e. VHF radios for communication between work parties, and with the installation vessel, tugs and supporting vessels.

f. Equipment necessary to re-pressurise a compartment whose buoyancy is 3
required for the jacket in the free floating condition.

7.9.2 Barge ballasting and seafastening cutting shall be in accordance with a plan having defined stages. Operations may take place simultaneously, but shall be planned, and equipment provided, so as to minimise intrusion into the installation weather window. Operations should be synchronised, with due regard to the safety of personnel cutting the aft seafastenings.

7.9.3 The towing tug should generally remain connected, and should maintain the barge heading into the wind and sea. Tugs for handling the jacket after launch shall be pre-connected to handling wires before initiating launch.

7.9.4 The masters of all tugs should be aware of the predicted jacket and barge behaviour after launch.

7.9.5 Equipment required for subsequent operations, such as lifting equipment, piles and pile hammers, should be available before starting to cut seafastenings.

7.9.6 Any major compartment (jacket leg compartment, buoyancy, tank, pile sleeve), whose buoyancy is required for intact and damaged stability, shall be pressurised to a minimum of 5 psi. Compartment pressures shall be monitored for a period of
three days prior to jacket sailaway, and immediately prior to sailaway and 3
immediately upon arrival at the installation site. The method of monitoring the pressures shall be stated.

7.9.7 Should the installation of piles be required to augment jacket un-piled stability, these piles shall be in the field (on a barge or on the crane vessel) prior to commencing jacket installation.

8 UPENDING AFTER LAUNCH

8.1 SEA-BED CLEARANCE

8.1.1 The clearance between the jacket and the seabed shall be as shown in Section 10.3.

8.1.2 The seabed topography shall be demonstrated to be suitable for upend and free of obstructions, by means of bathymetric and side-scan surveys, as shown in Section 11.1. The limits of the surveyed area shall be clearly delineated.

8.1.3 At no stage during the upending (including jacket weight and CoG variations) can the outstand of any jacket appurtenance be permitted to contact the seabed with operations planned for LAT. 3

8.2 BALLASTING SYSTEM

8.2.1 The ballasting system shall be designed to be fail-safe - the installation operation should not be endangered or unduly delayed by the failure of any one component to operate.

8.2.2 Ideally, the system should be controllable at all stages. For a one-off operation reversibility, although desirable, is not a requirement. De-ballasting may be required to assist with jacket levelling.

8.2.3 Systems operated by telemetry should be duplicated, or have a manual, umbilical or ROV back-up.

8.2.4 Umbilical systems should have a manual or ROV back-up.

8.2.5 Common system failure modes should be investigated and provisions made against failure.

8.2.6 Remotely operated flood valves should be duplicated in parallel, or an alternative flooding system provided.

8.2.7 Remote valves which require to be closed to halt the flooding should be duplicated in series, unless the compartment being ballasted can fill completely without serious consequences.

8.2.8 The ballasting systems, upending analyses and procedures should include alternatives to allow installation after accidental flooding of any one jacket member or buoyant element.

8.2.9 Power reserves should be sufficient to achieve not less than twice the anticipated number of valve operations.

8.2.10 Except for the simplest systems, the ballast system should be subjected to a formal system investigation by means of FMEA and HAZOP techniques.

8.2.11 Alternatives to the above may be considered, provided the overall level of risk has been formally shown to be acceptable.

8.3 STABILITY

8.3.1 Stability of the jacket shall be as shown in Section 10.4.

8.3.2 Damage conditions shall consider the effects of damage to any one jacket compartment or buoyant element.

8.4 SELF-UPENDING JACKETS

8.4.1 A self-upending jacket is one that after launch rotates to a near-vertical attitude without an intermediate horizontal phase. This may be achieved by distribution of buoyancy and/ or free-flooding compartments.

8.4.2 This system has no intermediate stages for checks and control, and is inherently irreversible. Therefore the calculations for launch and upending must cover all reasonable variations of jacket weight, centre of gravity, and damage conditions.

8.4.3 The integrity of the jacket after launch can only be assessed by jacket draught readings once the stable near-upright condition is achieved. Calculations should be carried out, and a suitable tabular and/or diagrammatic presentation be included in the Installation Manual so that a rapid assessment can be made of jacket weight and status from the post-upend draught readings.

8.4.4 Provision for contingency air de-ballast of critical compartments may be required to ensure adequate emplacement behaviour under all circumstances, but should not normally be relied on for the "base case" undamaged operation.

8.5 CRANE-ASSISTED UPEND

8.5.1 Where a crane is used to assist the upend, guidance on rigging, lift points and practical issues can be found in Section 9 and Reference [3].

8.6 JACKET COMPARTMENTATION

8.6.1 Jacket compartmentation shall be determined and arranged to suit a range of jacket weights, centre of gravity and buoyancy, so that the jacket with a damaged single compartment can be shown to have sufficient reserve buoyancy and stability. For each compartment that may be become damaged, an upending procedure shall be engineered so show that hook loads, reserve buoyancy, stability and bottom 3
clearances can still be maintained as required by Section 10. The attitude of the jacket in this damaged condition should be such that access to rigging, ballast control centres and valves can still be maintained.

8.6.2 Ideally, jacket and buoyancy tank compartmentation shall be arranged so that compartments are either full or empty during intact ballasting stages.

8.6.3 In the event that jacket appurtenances (risers, conductors, J-tubes) are required to provide buoyancy to the jacket in the free floating or launch condition, the methods of sealing and monitoring pressures in these appurtenances shall be provided.

8.6.4 Rigging platforms shall be adequately secured for all possible combinations of trim and heel angles and against transportation loadings which ever is the greater. Safe and adequate access to and from the rigging platforms for all possible trim and heel angles and jacket freeboards shall be provided for the maximum planned installation seastate.

9 INSTALLATION - LIFTING

9.1 LIFTING GENERAL

9.1.1 Operations, including design of lifting arrangements, lift points, rigging and crane capacity, should be in accordance with Reference [3], as amplified below.

9.2 IN-WATER DYNAMIC BEHAVIOUR

9.2.1 For the phase when part of the jacket is in the water, the requirements of Reference [3], Section 11 - Underwater lifting, may require careful attention.

9.2.2 Information should be submitted which either:

a. Shows how the total in-water lifting loads are derived, taking into account the weight, buoyancy, entrained mass, boom-tip velocities and accelerations, inertia and drag forces, or:

b. Demonstrates that the in-water case is not critical.

9.2.3 During the in-water phase, the sling loads should not be allowed to reduce to zero, except when connecting or disconnecting.

9.2.4 Lifts which are to be performed under heave compensation should be reviewed with great care to ensure that the limitations of the equipment and procedures have been correctly identified. In determining limiting seastates, any single point failure of the heave compensation system or its operation should be justified as an accidental load case.

9.3 UNDERWATER DISCONNECTION

9.3.1 Where a remotely operated system for disconnection of rigging is used, a back-up system shall be available.

9.4 RE-USE OF LIFTING EQUIPMENT

9.4.1 Where lifting rigging and lift points have been used prior to the installation operation, for loadout or transfer to the crane vessel, all rigging and lift points shall be visually re-inspected by a competent person before re-use. At the discretion of the attending surveyor, additional NDT inspection of lift points may be required.

9.5 FREE FLOATING LIFTED JACKETS

9.5.1 Where a jacket is lifted from the transportation barge and relies on buoyancy for a period of time (upending and/or jacket re-rigging) then the principals outlined in Sections 7.4 to 7.6, 7.9, 8.2 and 10 apply. 3

10 RESERVE BUOYANCY, BOTTOM CLEARANCES AND STABILITY DURING LAUNCH AND UPEND

10.1 INTACT AND DAMAGE CONDITIONS

10.1.1 The intact condition for the jacket shall take into account the most severe combination of tolerances on jacket weight and centre of gravity, buoyancy and centre of buoyancy, and water density.

10.1.2 For computing clearances the tidal level and tolerance on water depth measurement shall also be taken into account. If the survey of the launch or upending area is to be done at a late stage then care must be taken that a suitable area exists to comply with the upending clearances in Table 10-1 and Table 10-2. 3

10.1.3 The damage condition shall assume flooding or emptying of any one jacket member or buoyancy element, considering the most severe combinations of tolerances as indicated above.

10.1.4 Parametric studies may be required to determine the most severe combinations of tolerances and damaged element.

10.2 RESERVE BUOYANCY

Reserve buoyancy shall be shown to be not less than that shown in Table 10-1, based on nominal total intact buoyancy:

Table 10-1 Reserve Buoyancy

Case	Intact	Damaged
Jacket after launch	>5%	5%
During upend by ballasting, without crane assistance	Sufficient to maintain required seabed clearance (see Table 10-2)	
Horizontal 2-crane lifted jacket, if required to re-rig prior to upend	>5%	5%

10.3 SEABED CLEARANCE

Clearance during launch and upend operations, between the lowest jacket member or appurtenance and the seabed shall be shown by calculations and/or model tests to be not less than that shown in Table 10-2. The lowest predicted tide condition during the installation window shall be considered.

Table 10-2 Seabed Clearance

Case	Clearance after allowing for all tolerances (including weight, tide, CoG & site survey)	
	Intact	Damaged
During launch	Greatest of 10% of water depth or 5m*.	> 0m
During upend by controlled ballasting, with or without crane assist	3m	> 0m
Self- upending jacket during upend	Greatest of 10% of water depth or 5m*.	> 0m

10.4 MINIMUM STABILITY

10.4.1 The minimum metacentric height after launch and during upend should be not less than that shown in Table 10-3:

Table 10-3 Minimum Stability

Case	Intact	Damaged
During launch	See Section 7.6	
After launch, transverse and longitudinal	0.5m	0.2m
During upend, transverse	0.5m	0.2m
During upend, longitudinal	> 0 m*	> 0 m*
After upending, before final positioning, both directions	0.5m	0.2m

*- see Section 10.4.3

10.4.2 The sensitivity of the jacket to the effects of tolerances as shown in Section 10.1.1 may require investigation, to demonstrate that minor changes of weight or buoyancy, or one-compartment damage, do not cause an unacceptable jacket attitude, which would hinder subsequent operations, e.g. by making lift points or flooding valves inaccessible. For hook assisted up-end operations the hook load should be considered in the calculation.

10.4.3 A limited period during upend when the jacket is metastable or unstable longitudinally may be acceptable, provided the behaviour has been investigated and all interested parties are aware of it. Practical problems which may be encountered with attending vessels, or rigging and handling lines should be resolved.

11 JACKET POSITIONING

11.1 SURVEYS

11.1.1 Bathymetric, sidescan and ROV surveys shall be carried out (a maximum of 3 weeks prior to installation) to establish the water depth and identify any obstructions in an area around the location compatible with the jacket, maximum footprint, associated installation tolerances, water depth and installation method. 3

11.1.2 In selecting the area for survey, positioning errors during site investigation and jacket installation should be taken into account.

11.1.3 The jacket landing area shall be shown to be within tolerances, and free from debris likely to cause problems with the installation.

11.1.4 Consideration should be given to the effects of local depressions such as pockmarks or jack-up footing imprints.

11.1.5 The effects of sand-wave mobility between initial surveys and installation should be considered.

11.1.6 Installation planning should be based on the geotechnical characteristics of the site. The data should be acquired with due regard to installation requirements. The investigation should provide information on the surface and sub-surface conditions within the zone influenced by the installation. In addition to establishing the soil profile, strength and deformation characteristics, information should be acquired with which to assess risks during the installation phase from mudslides, shallow gas and sediment transport.

11.1.7 Clearances between subsea assets (pipelines, templates) shall be a minimum of 5m after all positioning tolerances (jacket base motion and positioning equipment errors) have been taken into account. 3

11.2 POSITIONING SYSTEMS

11.2.1 Jacket positioning systems shall be fit for purpose to achieve the specified tolerances on position and orientation. The repeatability of positioning should be determined, with regard to previous surveys.

11.2.2 Two independent positioning systems shall be provided. One of them shall be independent of visibility.

11.3 POSITIONING OVER TEMPLATE

11.3.1 When the jacket is to be docked over a template, wellhead docking piles or similar, a docking analysis shall be carried out to determine:

a. The jacket behaviour during docking

b. The loads and stresses on docking piles and jacket members

c. The limiting seastate and current speed for installation, taking into account the crane vessel behaviour.

11.3.2 Clearances between the jacket and a pre-installed template shall generally be in accordance with Section 11.1.7, unless docking piles are used for jacket positioning 3

12 BUOYANCY TANK REMOVAL

12.1 REMOVAL SCHEDULE

12.1.1 Where options exist, removal of buoyancy tanks should be scheduled into the installation sequence so that jacket safety is optimised. Early removal may delay pile installation. Late removal may mean increased wave forces on the jacket. Ballasted buoyancy tanks will assist resistance against overturning, but may overload the soil under the mudmats.

12.2 REMOVAL METHOD

12.2.1 The method of removal will depend on the design of the buoyancy tanks, their attachments and the equipment available. Removal is generally by lifting or floating.

12.3 DISCONNECTION FROM JACKET

12.3.1 Separation from the jacket should be in a controlled manner. In general, where disconnection is by means of remotely pulling connecting pins or burning, the tank should be in a neutrally buoyant state at the instant of disconnection. Where remotely operated pins are used a back-up method or system should be available.

12.4 BALLAST AND AIR SYSTEMS

12.4.1 Where adjustment of buoyancy by means of ballast or compressed air is needed, then a back-up method or system should be available.

12.5 REMOVAL BY LIFTING

12.5.1 Removal by lifting should be in accordance with Reference [3], taking account of crane vessel dynamics and in-water loads.

12.6 REMOVAL BY FLOATING

12.6.1 Where the tanks are floated up and towed clear, sufficient control must exist to avoid impact with the jacket. The tank must have adequate intact stability at all stages in accordance with Section 10. 3

12.7 HANDLING AND CONTROL WIRES AND ATTACHMENTS

12.7.1 Wires and attachments shall be designed to the requirements of Section 7.8.4.

13 INSTALLATION - UNPILED & PARTIALLY PILED STABILITY

13.1 GENERAL

13.1.1 The loads and behaviour of the jacket after positioning and during installation shall be investigated to determine the resistance of the jacket to sliding, tilting or over-penetration during the installation process. Installation includes pile installation, penetration and ballasting as appropriate.

13.1.2 The objective is that the jacket should achieve the ability to resist the 10 year seasonal storm loading as quickly as possible, preferably within the jacket installation weather window.

13.1.3 Where it is not feasible to achieve the 10 year seasonal storm loading within the installation weather window, then the installation sequence should be optimised to:

a. minimise the time taken to achieve the 10 year storm capability

b. maximise the short term capability of the jacket, should a forecast be received during the installation period which indicates severe weather.

13.1.4 Installation planning should anticipate construction problems with appropriate contingency measures. Remedial measures which could adversely affect the final pile capacity should not normally be considered.

13.2 UNPILED AND PARTLY PILED STABILITY

13.2.1 The capability of the jacket to resist environmental loadings in the un-piled or partly piled condition should be determined. For each phase of the installation, it should be demonstrated that adequate safety factors can be obtained against the failure modes, as shown in Table 13-1.

Table 13-1 Unpiled & Partly Piled Stability Failure Modes & Safety Factors

Mode	Safety Factor
Tilting/uplift of weather side legs (soil failure)	1.0
Sliding (soil failure)	1.5
Mud-mat over-penetration (soil failure)	1.5

Tilting/uplift implies that that there shall be no tension under the mudmat that cannot be resisted by skin friction on mudmat skirts and/or suction. Particular attention should be paid to tripod jackets in terms of stability. 3

13.2.2 The structural strength of high quality structural steelwork with full material certification and NDT inspection certificates showing appropriate levels of inspection shall be assessed using the methodology of a recognised and applicable offshore code including the associated load and resistance factors for LRFD codes or safety factors for ASD/WSD codes. Traditionally AISC has also been considered a reference code - see the Note in Section 13.2.4 regarding its applicability.

13.2.3 Load cases for on-bottom stability shall be treated as a normal ultimate limit state (ULS) / Normal operating cases, for un-restricted operations (i.e. storm/survival conditions).

13.2.4 The temporary load case for on-bottom stability may be treated as a serviceability limit state (SLS) for restricted operations (i.e. for specific environmental conditions).

Note:

If the AISC 13th Edition is used, the allowables shall be compared against member stresses determined using a load factor on both dead and live loads of no less than: 3

	WSD option	LRFD Option
SLS:	1.0	1.60
ULS:	0.75	1.20

13.2.5 Where applicable, calculations shall take into account changes in environmental loads, jacket minimum weight and centre of gravity due to the following:

a. Ballasting

b. Water levels

c. Penetration

d. Removal of buoyancy tanks

e. Pile stick-up

f. Hammer weight

g. Pile hang-off.

13.2.6 The limiting seastate to maintain the safety factors shown in Section 13.2.1 should generally be equivalent to the 10 year seasonal return environmental conditions at the jacket location. In any case this limiting seastate shall exceed the maximum forecast seastate during the installation weather window by a suitable factor, selected based on Table 13-2.

Table 13-2 Design Seastate Reduction Factor

Weather Forecast Provision	Reduction Factor
No specific forecast	0.50
One forecast	0.65
One forecast plus in-field wave monitoring (wave rider buoy)	0.70
One forecast plus in-field wave monitoring and offshore meteorologist	0.75

3

For marine operations with an operational duration less than 24 hours, special consideration (number of pile hammers, whether piles have add-ons, detailed pile installation schedule and sequence, sequential piling sequence for correcting jacket level) shall be given to the reduction factors in Table 13-2.

13.2.7 In the absence of the one year seasonal return environmental conditions, the following wave heights (with associated range of wave periods) should be considered for guidance:

- Benign areas Hs = 2.5m
- Non benign areas Hs = 5.0m

13.2.8 Wind forces shall be included, using a wind speed compatible with the seastate considered in each case. The 1-minute averaging period should be used for computation of wind forces.

13.3 PILE HANDLING

13.3.1 Pile lifting should be carried out in accordance with Reference [3].

13.3.2 Specialised tools for pile lifting and upending, and welding of add-ons should be shown to be fit for purpose and properly commissioned.

13.4 PILE STRUCTURAL ANALYSIS

13.4.1 Piles should be analysed to demonstrate that stresses during installation are within offshore design code limits. Lifting, upending and stabbing the pile, placing and supporting a hammer on the pile top, and the effect of any free standing pile length should not induce pile wall stresses in excess of the allowable value for static conditions. Consideration shall be given to the maximum inclination of the un-driven pile in the pile sleeve and the maximum possible inclination of the jacket when performing pile stick-up analyses. 3

13.4.2 It may be necessary to consider wave and/or current induced oscillation and vortex shedding during this phase - see Reference [5]. Vertical skirt piles driven through the splash zone may need special consideration.

13.4.3 Dynamic stress caused by pile driving should be assessed using wave propagation analysis. The sum of the static and dynamic driving stresses should not exceed the specified minimum yield strength.

13.5 SELF-PENETRATION OF PILES

13.5.1 Particular attention should be paid to soil conditions which may result in sudden self-penetration of piles.

REFERENCES

[1] Noble Denton report 0013/ND - Guidelines for Loadouts

[2] Noble Denton report 0021/ND - Guidelines for the Approval of Towing Vessels

[3] Noble Denton report 0027/ND - Guidelines for Lifting Operations by Floating Crane Vessels

[4] Noble Denton report 0030/ND - Guidelines for Marine Transportations

[5] N D P Barltrop and A J Adams, “Dynamics of Fixed Marine Structures”, third edition - (Butterworth and Heinemann Ltd, 1991). ISBN 0 7506 1046 8.

APPENDIX A - INFORMATION REQUIRED FOR REVIEW

APPENDIX A – INFORMATION REQUIRED FOR REVIEW

A.1 JACKET INFORMATION

A.1.1 Drawings showing plans, elevations and details

A.1.2 Weight report

A.1.3 Compartmentation and ballasting

A.1.4 Jacket arrangement on barge

A.1.5 Grillage and seafastening drawings

A.1.6 Details of any buoyancy tanks, piles or other equipment carried on the jacket, including attachment details

A.1.7 Details of jacket ballast and control systems, including manual and remote operation systems and back-up systems, and compartment status-monitoring systems.

A.2 TRANSPORT BARGE OR VESSEL

A.2.1 General arrangement drawing

A.2.2 Compartmentation plan

A.2.3 Plating, framing and skidway details in way of jacket support points and seafastenings

A.2.4 Jacket grillage and seafastening details

A.2.5 Allowable rocker arm loads, if applicable

A.2.6 Allowable stern submergence, for launch barges

A.2.7 Allowable bending moment and shear force

A.2.8 Lightship details, including rocker arms and launchways

A.2.9 Certification package

A.2.10 Pumping and ballasting specification

A.2.11 Hydrostatics

A.2.12 Towing connections where applicable.

A.3 LOADOUT

A.3.1 Information required for loadout approval is listed in Reference [1].

A.4 TRANSPORTATION ROUTE

A.4.1 Transportation departure point, arrival point and preferred route, with available shelter points and standby mooring arrangements.

A.4.2 Design storm wind and seastate.

A.4.3 Towing vessel(s) specification.

A.4.4 Metocean study for the transportation route.

A.5 MOTION RESPONSE

A.5.1 Motion response calculation report, and/or model test results for jacket and appurtenance structural integrity and grillage and seafastening designs. Alternatively, statement of standard motion criteria adopted.

A.6 TRANSPORTATION LOADS AND STRESSES

A.6.1 Loading conditions for jacket, barge/vessel and seafastenings arising from motion responses in the design sea state.

A.6.2 Stress analysis reports for jacket, barge/vessel, grillage and seafastenings.

A.7 STABILITY

A.7.1 Righting arm and wind overturning arm curves for jacket-barge/vessel combination in chosen transportation condition.

A.8 TOWING RESISTANCE

A.8.1 Towing resistance calculations, showing towline pull required, bollard pull, still water towing speed and towing speed in mean sea conditions.

A.9 LAUNCHING, IF APPLICABLE

A.9.1 Launching analysis report, as described in Appendix B.

A.9.2 Jacket launch stress analysis report, showing overall and local loads and stresses.

A.9.3 Jacket member hydrostatic check.

A.10 LIFTING, IF APPLICABLE

A.10.1 Lifting and upending analysis reports, in accordance with Reference [3].

A.11 UNPILED/PARTLY PILED STABILITY

A.11.1 Report demonstrating adequate unpiled and partly piled stability, in accordance with Section 13.

A.11.2 Ten year seasonal environmental data.

A.11.3 Outline jacket and pile installation procedures and equipment. 3

A.11.4 Jacket levelling procedures and equipment and their effects on the local and global capacity of the jacket.

APPENDIX B - NOTES ON LAUNCH ANALYSIS METHODS

APPENDIX B – NOTES ON LAUNCH ANALYSIS METHODS

B.1 GENERAL

B.1.1 The launch analysis should be carried out using a 3-D computer program so that all degrees of freedom are included. The computer program and available post-processing and associated analyses should be capable of identifying:

- The jacket and barge trajectories, including attitude after launch
- The launchway and rocker arm loads
- The barge stern submergence
- The maximum jacket dive depth
- Loads for transfer to local and global structural analysis
- Jacket transitional and rotational velocities
- Relative motions between jacket and barge
- Details of the clearances during separation
- Stability during launch.

B.2 JACKET MODELLING

B.2.1 The jacket hydrodynamic, buoyancy and mass model should account for all items including main members, buoyancy tanks, secondary members, and 'non-structural items' such as caissons, pile guides etc.

B.2.2 It should be ensured that the jacket buoyancy model is not over-buoyant due to over-simplistic modelling of the overlap of members at the joints.

B.2.3 Careful consideration should be given to the drag coefficients applied, especially for dense areas of the structure or those with small aspect ratios (such as some buoyancy tanks). The drag coefficients should be selected accounting for Reynolds Number effects and should be realistic for the surface finish of the members.

B.2.4 Note: For a given Reynolds Number the drag coefficients will typically be larger than for deterministic wave loading analysis as the coefficients used for that analysis are normally reduced from measured values of 1.0 - 1.1 to 0.6 - 0.7 to allow for the over prediction of kinematics in standard wave theories.

B.3 BARGE MODELLING

B.3.1 The barge model should account for all items contributing to the barge mass and buoyancy. It is important that items such as rocker arms and skidways are included even though they may not be strictly buoyant (due to small drain holes etc). As many launch programs do not allow accurate modelling of the barge it is appropriate that:

1) The buoyancy model is verified as being reasonably accurate over the range of draughts and trims encountered during the launch by comparison with the hydrostatic results from a more detailed (stability) program model.

2) The added mass and drag modelling is verified against alternative data (e.g. motion response program added mass etc).

B.4 LAUNCH ANALYSIS AND SENSITIVITY STUDIES

B.4.1 The launch analysis should investigate the sensitivity to the following parameters:

- Hydrodynamic coefficients (jacket and barge)
- Static and dynamic friction coefficients (See Table B.1)
- Initial trim
- Initial draught
- Jacket mass and COG
- Start position (where applicable).

B.4.2 The prime objective of the sensitivity analysis is to build a better picture of the physics of a particular launch configuration and to establish that the configuration is not unduly sensitive to variations in any particular parameter. A secondary benefit is the possibility of selecting the optimum launch configuration.

B.5 FRICTION COEFFICIENTS

B.5.1 The friction coefficients shown in Table B.1 should be taken into account for design of winching or jacking systems, and for derivation of jacket behaviour and loadings during launch:

Table B-1 Friction Coefficients

Type	Static			Moving		
Surface	Min	Typical	Max	Min	Typical	Max
Wood-grease-steel	0.1	0.2	0.28	0.05	0.1	0.15
Wood-grease-Teflon	0.08	0.14	0.25	0.03	0.05	0.08

B.6 STRUCTURAL CHECKS

B.6.1 The jacket, skidways, rocker arms and barge structure should be analysed to verify their structural adequacy at various stages of the launch procedure, allowing for their relative stiffnesses and including loads due to weight, buoyancy, hydrodynamics and inertia. Where appropriate, an allowance should be made for additional loads due to wave-induced motions.

B.6.2 When selecting the load cases for analysis it is important that the pre-launch ballast condition is considered, in conjunction with the allowable launch seastate, as this may lead to the most onerous case for jacket-barge loads at the jacket nodes nearest the bow of the barge. The barge strength should also be verified for the post-launch condition.

B.6.3 The barge stern should be verified as structurally adequate for the maximum predicted stern submergence.

B.7 VERIFICATION

B.7.1 The launch analysis should be validated by model tests and/or independent analysis using a different program. Such independent validation is essential when analysis indicates that the design is approaching the limits of acceptability or credibility.

APPENDIX C - NOTES ON LAUNCH MODEL TESTS

APPENDIX C – NOTES ON LAUNCH MODEL TESTS

C.1.1 Model scale should be not less than 1/100, and preferably greater than 1/60.

C.1.2 Jacket and barge models should represent accurately the prototypes in weight, location of centre of gravity, and radii of gyration. It may be necessary to test a range of jacket weights and centre of gravity positions.

C.1.3 In general, models are more rigid than the prototypes and have lower structural damping. This should be taken into account in interpretation of measurements of accelerations and rocker arm loads.

C.1.4 Instrumentation should be provided to measure:

a. Draught, trim and heel of the barge

b. Trim and heel of jacket

c. Distance run by jacket

d. Rocker arm reactions and rotations.

C.1.5 Real time facilities are required to provide:

a. Controlled adjustment of dynamic friction coefficient

b. Computer calculation of maximum barge submergence, maximum submergence at top and bottom of jacket launch rail face

c. Quantification of maximum rocker arm reactions.

C.1.6 Seakeeping tests should be performed in the design launch seastate in head, quartering and beam seas, for the selected barge condition, to quantify the dynamic magnification of rocker arm forces.

C.1.7 The model test report should include, as a minimum:

a. All relevant prototype and model parameters

b. Statistical summary of each test, to include initial barge trim, friction coefficient, seastate and heading, maximum rocker reaction, minimum seabed clearance or maximum dive depth, maximum barge stern immersion

c. Jacket and barge trajectories

d. Rocker reaction and rotation time histories.