

## TECHNICAL POLICY BOARD

# SELF-ELEVATING PLATFORMS GUIDELINES FOR ELEVATED OPERATIONS

0009/ND

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| <b>Date</b> | <b>Revision</b> | <b>Prepared by</b> | <b>Authorised by</b>   |

## PREFACE

This document has been drawn with care to address what are likely to be the main concerns based on the experience of the GL 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.

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## **1 SUMMARY**

### **1.1 CONTENT AND SCOPE**

1.1.1 These guidelines will be used by GL Noble Denton for the assessment of self-elevating platforms in the elevated condition. They address:

- General feasibility studies, including optional checks for punch-through resistance and fatigue; such studies may result in a Statement of Compliance.
- Assessment for specific locations; such studies may result in a Certificate of Approval.

1.1.2 This document is intended to apply to self-elevating units of all types.

1.1.3 Where a unit is not Classed for elevated operations, additional requirements apply.

1.1.4 Revision 1 did not cover self-elevating platforms when afloat, as this is now covered by the companion Guideline 0030, Ref. [1]. The guidance for elevated operations was addressed in greater detail, and referenced SNAME T&RB 5-5A, Ref. [3]

1.1.5 Revision 2 of this document superseded Revision 1, with the inclusion of deviations to additional sections of SNAME T&R Bulletin 5-5A.

1.1.6 Revision 3 superseded Revision 2. The principal change was a re-wording of Section 5.2.1. The pagination was improved.

1.1.7 Revision 4 superseded Revision 3. The principal change was reformatting and removing references to NDI (Noble Denton International).

1.1.8 Revision 5 superseded Revision 4. The principal change was rebranding as GL Noble Denton.

1.1.9 This Revision 6 supersedes Revision 5 of this document. The principal change is updating to accommodate the changes made in Revision 3 of SNAME T&R Bulletin 5-5A, dated January 2008, but issued in July 2009. Section 5.8.2 has been clarified. Appendices C and D have been added to incorporate Good Practice Recommendations in relation to Preloading and Punch-through recovery.

1.1.10 It should be noted that this document cannot cover every case for all types of jack-up. The reader should satisfy himself that the guidelines used are fit for purpose for the situation under consideration.

1.1.11 These Guidelines are not intended to exclude alternative methods, new technology and new equipment, provided an equivalent level of safety can be demonstrated.

### **1.2 THE APPROVAL PROCESS**

1.2.1 A description of the Approval Process is included, for projects where GL Noble Denton is acting as a Warranty Surveyor. The extent and limitations of the approval given are discussed.

### **1.3 ASSESSMENT FOR ELEVATED OPERATIONS**

1.3.1 Guidelines are presented for the assessment of elevated operations. Subject to the specific variations and additions set forth herein this document refers to the SNAME T&R5-5A for the data requirements, calculation methodology and acceptance criteria to be applied.

### **1.4 DATA TO BE SUBMITTED**

1.4.1 The data to be submitted is summarised in the Appendices.

## 2 INTRODUCTION

- 2.1 This document provides guidelines for the operation of self elevating platforms (jack-ups). It refers to engineering studies that are complementary to inspection of the unit and the acquisition of applicable site data, refer to 0016/ND 'Seabed and Sub-Seabed Data Required for Approvals of Mobile Offshore Units (MOU)', Ref. [2]. The towage and transportation of jack-ups is addressed in the GL Noble Denton Guideline 'Guidelines for Marine Transportations' 0030/ND, Ref. [1].
- 2.2 Where approval by GL Noble Denton is required, sufficient information should be submitted by the client in order to allow confirmation that the unit meets the criteria.
- 2.3 These guidelines are intended to cover the structural design and site specific assessment of the unit. However, the sea bed conditions and the structural design or assessment of the unit are closely inter-related, so references to sea bed conditions are made in this document. Any approval for operations indicated by compliance with these guidelines is subject to the sea bed conditions, and the normal marine and operational recommendations of GL Noble Denton offices.
- 2.4 Revision 1 of these guidelines dated 02 August 2006 superseded those contained in Revision 0 of this document dated 12 December 1986. The principal changes and revisions were:
- Deletion of sections referencing towage and transportation.
  - Reference to SNAME T&R Bulletin 5-5A as the basis for the assessment of elevated operations, subject to the deviations as set out herein.
- 2.5 Revision 2 superseded the guidelines contained in Revision 1 of this document dated 02 August 2006. The principal revisions are the inclusion of deviations to the following additional sections of SNAME T&R Bulletin 5-5A:
- 3.9 Marine Growth;
  - 5.4 Leg Inclination;
  - 5.7.1 / C5.7.1 Hull sag.
- 2.6 Revision 3 superseded Revision 2. The principal change was a re-wording of Section 5.2.1. The pagination was improved.
- 2.7 Revision 4 superseded Revision 3 of this document. The principal change was reformatting and removing references to NDI (Noble Denton International).
- 2.8 Revision 5 superseded Revision 4 of this document. The principal change was rebranding as GL Noble Denton.
- 2.9 This Revision 6 supersedes Revision 5 of this document. The principal change is updating to accommodate the changes made in Revision 3 of SNAME T&R Bulletin 5-5A, dated January 2008, but issued in July 2009. Section 5.8.2 has been clarified. Appendices C and D have been added to incorporate Good Practice Recommendations in relation to Preloading and Punch-through recovery.
- 2.10 These guidelines are intended to lead to an approval by GL Noble Denton. Such approval does not imply that approval would be given by designers, regulatory bodies, harbour authorities and/or any other party.
- 2.11 All GL Noble Denton Guidelines can be downloaded from [www.gl-nobledenton.com](http://www.gl-nobledenton.com).

3 DEFINITIONS

3.1 Referenced definitions are underlined.

| Term or Acronym                    | Definition   |
|------------------------------------|--|
| API                                | American Petroleum Institute   |
| Assured                            | The Assured is the person who has been insured by some insurance company, or underwriter, against losses or perils mentioned in the policy of insurance.   |
| Assessment environmental condition | The <u>metocean</u> conditions applicable to the site specific assessment. Either the 50-year individual extremes or the 100 year joint probability values. Directionality and seasonality may be used where applicable.   |
| Assessment significant wave height | Either the 50-year individual extreme significant wave height, or the 100 year joint probability significant wave height for the season of the particular <u>operation</u> .   |
| Certificate of Approval            | A formal document issued by <u>GL Noble Denton</u> stating that, in its judgement and opinion, all reasonable checks, preparations and precautions have been taken to keep risks within acceptable limits, and an <u>operation</u> may proceed.  |
| Class                              | A system of ensuring floating vessels are built and maintained in accordance with the Rules of a particular Classification Society. Although not an absolute legal requirement the advantages (especially as regards insurance) mean that almost all vessels are maintained in Class.  |
| GL Noble Denton                    | Any company within the GL Noble Denton Group including any associated company which carries out the scope of work and issues a <u>Certificate of Approval</u> , or provides advice, recommendations or designs as a consultancy service.   |
| Independent leg jack-up            | A <u>jack-up</u> where the legs may be raised or lowered independently of each other.  |
| Insurance Warranty                 | A clause in the insurance policy for a particular venture, requiring the approval of a marine operation by a specified independent survey house.   |
| Jack-up                            | A self-elevating <u>MODU</u> , <u>MOU</u> or similar, equipped with legs and jacking systems capable of lifting the hull clear of the water.   |
| Marine Warranty Surveyor           | Has no executive authority on the unit and attends to monitor the manner in which the move, jacking and preloading operations are performed. Where necessary he may submit recommendations to the unit's owner or senior crew in order that the unit is always operated in a safe and proper manner, in accordance with the operating manual except where alternative recommendations are made in the Certificate of Approval and / or approved rig move procedures. |
| Mat-supported jack-up              | A <u>jack-up</u> which is supported in the operating mode on a mat structure, into which the legs are connected and which therefore may not be raised or lowered independently of each other.  |
| MODU                               | See <u>MOU</u>   |
| MOU                                | Mobile Offshore Unit. For the purposes of this document, the term may include mobile offshore drilling units ( <u>MODUs</u> ), and non-drilling mobile units such as accommodation, construction, lifting or production units  |

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## **4 THE APPROVAL PROCESS**

### **4.1 GENERAL**

4.1.1 GL Noble Denton may act as a Warranty Surveyor, giving Approval to a particular operation, or as a Consultant, providing advice, recommendations, calculations and/or designs as part of the Scope of Work. These functions are not necessarily mutually exclusive.

### **4.2 GL NOBLE DENTON APPROVAL**

4.2.1 GL Noble Denton means any company within the GL Noble Denton Group including any associated company which carries out the scope of work and issues a Certificate of Approval.

4.2.2 GL 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.

4.2.3 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 survey house. 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 Assured.

### **4.3 CERTIFICATE OF APPROVAL**

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

4.3.2 The Location Certificate of Approval is the formal document issued by GL Noble Denton when, in its judgement and opinion, all significant location-specific hazards for the unit have been identified. The unit is approved to operate at the location subject to compliance with the recommendations in the Certificate.

4.3.3 A location approval Certificate will normally be issued by the approving office well in advance of the move to the location.

## **4.4 SCOPE OF WORK LEADING TO A LOCATION APPROVAL**

### **4.4.1 CERTIFICATE OF APPROVAL**

4.4.1.1 In order to issue a Certificate of Approval, GL Noble Denton will typically consider, as applicable, the following topics:

- Site-specific environmental data
- Site-specific geotechnical data
- Seabed survey
- Previous jack-up installations
- Adjacent structures
- Rig capability:
- Overturning Stability
- Foundation capacity (bearing/sliding)
- Leg strength
- Holding system strength.

4.4.1.2 Fatigue damage is excluded from any GL Noble Denton approval, unless specific instructions are received from the client to include it in the scope of work or the unit will not be Classed by an IACS member body for elevated operations during the planned period on location.

#### 4.4.2 STATEMENT OF ACCEPTABILITY

4.4.2.1 In cases where GL Noble Denton is requested to study the general feasibility of a unit a Statement of Acceptability would be issued. The scope would typically encompass one or more of the following topics:

- Rig capability elevated (based on pinned footings or assumed soil(s) condition(s). These may be to the criteria set out herein and/or other criteria such as Class requirements, SNAME T&R Bulletin 5-5A, etc.

NOTE: Whilst a unit may be shown to comply with Class requirements, these may not be sufficient for the unit to be approved by GL Noble Denton.

- Limitations for going on and off location.
- Stability afloat.\*
- Leg strength afloat.\*
- Dry transportation feasibility.\*
- Towing equipment and recommendations.\*
- Fatigue.
- Accidental scenarios such as punch-through, vessel impact, etc.

\* These topics are addressed in the GL Noble Denton 'Guidelines for Marine Transportations' 0030/ND.

## 5 OPERATING CONDITION

### 5.1 REFERENCE DOCUMENT AND DEVIATIONS THEREFROM

5.1.1 The calculations to assess the elevated operational suitability of a jack-up shall be carried out in accordance with the current revision of SNAME T&R Bulletin 5-5A, Ref. [3], (which comprises a Guideline, Recommended Practice and Commentary).

5.1.2 Specific deviations from the requirements of SNAME are as follows.

### 5.2 ENVIRONMENTAL RETURN PERIOD FOR TROPICAL REVOLVING STORM AREAS (Revises Guideline Section 2.3.2)

5.2.1 50-year return period individual maximum extremes shall be considered unless the unit is to operate under conditions in which it will be unmanned or de-manned. In such cases an agreed lower return period, typically 10-years, may be used if ALL of the following conditions apply:

- a. The unit is operating in a tropical revolving storm area.
- b. A proven storm warning system is in operation which gives an expected 3 days' notice of tropical revolving storms which may pass within 200 nautical miles of the location.
- c. Support systems are in existence to evacuate all personnel prior to arrival of the storm, bearing in mind the requirements of other platforms affected.
- d. All personnel are evacuated prior to the arrival of the storm, having rendered the well safe and placed the rig in storm survival mode.
- e. Such evacuation procedures are contained in the operations manual, and are communicated to all personnel aboard.
- f. Where the unit is the subject of an approval by GL Noble Denton for insurance purposes, the limitations of the unit are disclosed to underwriters and operators.

5.2.2 Notwithstanding the above:

- a. The air gap shall equal or exceed the value required for 50 year return period conditions.
- b. The unit shall be capable of sustaining, to SNAME limits as modified by this Guideline, non tropical revolving storms with a 50-year return period and tropical revolving storms that may arise too rapidly for evacuation to be take place (in the Gulf of Mexico, these would be termed 'sudden hurricanes').

### 5.3 MARINE GROWTH (Revises Practice Sections 3.9 and 4.7.3)

5.3.1 For short term operations, marine growth may be ignored unless required by the client or known to pre-exist (the SNAME default value is 12.5mm on radius). For the avoidance of doubt, the leg should nevertheless be considered rough below MWL + 2.0m.

### 5.4 LEG INCLINATION (Revises Practice Section 5.4)

5.4.1 The effects of leg inclination may be ignored, unless there are specific reasons for it to exist (the SNAME Rev 2 default value is 0.5% of leg length, and it is normally taken into account by increasing the lower guide moment of each leg by the leg inclination offset multiplied by the factored footing reaction of that leg).

- 5.5 **HULL SAGGING (Revises Practice Section 5.7.1 / Commentary 5.3.3)**
- 5.5.1 The effects of hull sagging may be ignored, unless there are specific reasons for it to be included. (The SNAME default value from the commentary is 25-50% of the theoretical maximum). Given normal guide clearances and operating procedures we consider that the hull sag moments carried by the legs will normally be negligible.
- 5.6 **ENVIRONMENTAL LOAD FACTOR (Revises Practice Section 8)**
- 5.6.1 Unless otherwise specified by the client, the environmental load factor may be reduced to 1.0 (from the SNAME value of 1.15).
- 5.7 **OVERTURNING SAFETY FACTOR (Revises Practice Section 8.2)**
- 5.7.1 For independent leg units, overturning safety factor is to be computed as:
- $$\frac{\text{Factored Righting moment}}{\text{Unfactored Overturning moment}}$$
- The resistance factor for the righting moment shall be no larger than 0.909 (giving a factor of safety of 1.1).
- 5.7.2 For mat supported units the reaction point shall be assumed to be at the underside of the mat bottom plating.
- 5.7.3 For mat supported units, the positive downward gravity loading on the mat shall be sufficient to withstand the overturning moment for the 50-year loading without the loss of positive bearing on any part of the mat.
- 5.8 **BEARING CAPACITY AND RESISTANCE TO SLIDING (Revises Practice Section 8.3)**
- 5.8.1 The combinations of vertical and horizontal load shall be checked against a bearing capacity envelope. The resistance factor may be taken as 1.0 when the load-penetration curve indicates significant additional capacity for acceptable levels of additional settlement. Settlement exceeding the operations manual limits may be acceptable provided that:
1. the structure can withstand the storm loading together with the effects of the inclination,
  2. the lateral deflections will not result contact with adjacent structures and/or impairment of the well and
  3. the unit is expected to be jackable afterwards.
- 5.8.2 In locations where this is not the case, or where punch-through is a possibility, a safety factor no less than 1.5 shall be applied to the SNAME V-H bearing capacity vector check. This is to guard against 'abnormal events' i.e. environmental loads with a return period typically in the order of 1,000 to 10,000 years.
- NOTE: The above implicitly checks that the preload is adequate.
- 5.8.3 Mat supported units shall be demonstrated to have a factor of safety against sliding of not less than 1.0 for the 50-year storm condition. The bearing/overturning capacity shall also be checked. Where these checks indicate that the unit may move then limits for de-manning shall be established and the requirements of Sections 5.2.1.b) - f) and 5.2.2.a) shall be followed.
- 5.9 **LEG AND HOLDING SYSTEM STRENGTH (Revises Practice Section 8.1 and 8.5)**
- 5.9.1 In the absence of more stringent requirements from the client, the leg and holding system shall be checked as follows:
- Stress levels computed for 50-year storm loadings shall not exceed the yield stress of the material, accounting for buckling where appropriate e.g. by using the AISC ASD formulations, Ref [4], but with all safety factors removed. Alternatively, the SNAME LRFD methods may be considered using the resistance factors stipulated by SNAME.
- NOTE: The intent is to prevent damage or deformation severe enough to prevent jacking the unit into the water and towage to a safe location.

## 6 OTHER CONSIDERATIONS

### 6.1 RESISTANCE TO PUNCH-THROUGH

When it is desired to evaluate the resistance of a unit to punch-through the legs of independent leg, three-legged units, shall be shown not to be loaded beyond the yield stress of the material, accounting for buckling where appropriate when the unit suffers a punch-through during preloading under the following conditions:-

- a. The rig is carrying the maximum allowable variable load for jacking operations;
- b. Maximum allowable preload water for the variable load in (a) above is on board;
- c. Leg length below the hull for this calculation shall be the sum of :-
  - Maximum allowable water depth including tidal rise, or any lesser water depth, plus
  - Maximum final penetration allowable at the water depth, up to a maximum of 30 metres, plus:
  - 2 metres.
- d. A sudden increased penetration of any one leg has occurred such that the hull takes an inclination to the horizontal of 5 degrees, or the additional penetration equals 4 metres, whichever is the lesser.
- e. Hull buoyancy may be taken into account in the calculation, assuming an initial airgap of 2.0m.
- f. For specific cases site- and operation-specific parameters may be taken into account e.g. positive buoyancy and leg-by-leg preloading.

The analysis shall consider two cases:

1. where the distance between the legs at the seabed remains constant (all three legs carry approximately equal shear and moment) and
2. where the punch-through leg penetrates vertically such that the leg separation increases and the 'up-hill' legs carry increased shear and moment.

### 6.2 EARTHQUAKE AREAS

Operations in areas subject to seismic activity may need special consideration, and a study of earthquake loadings shall be carried out where appropriate.

### 6.3 ICE AREAS

Operations in areas affected by fast- or sea-ice are not covered by this document, and would require special consideration.

The effects of ice accretion should be taken into account in the loadings on the structure.

### 6.4 FATIGUE

When:

1. Required by the client (see Section 4.4.1.2) or;
2. The unit will not be Classed by an IACS member body for elevated operations during the planned period on location;

the effects of fatigue on structural areas subject to continuous cyclic loading, such as the leg to spudcan or leg to mat connection, shall be considered. Where such a unit is intended to operate for a long period in water depths such that the same leg sections are within or near the guides, the effects of fatigue on the legs near the guides and splash zone shall also be considered.

### 6.5 GOOD PRACTICE RECOMMENDATIONS FOR PRELOADING AT DIFFICULT LOCATIONS

Guidance is given in Appendix C.

- 6.6 **GOOD PRACTICE RECOMMENDATIONS FOR RECOVERING FROM PUNCH-THROUGH**  
Guidance is given in Appendix D.

## REFERENCES

- [1] GL Noble Denton document 0030/ND - Guidelines for Marine Transportations
- [2] GL Noble Denton document 0016/ND - Seabed and sub-seabed data required for approvals of Mobile Offshore Units (MOU)
- [3] SNAME Technical and Research Bulletin 5-5A, latest revision, "Site Specific Assessment of Mobile Jack-Up Units".
- [4] AISC Allowable Stress Design and Plastic Design, July 1, 1989, with Supplement 1

All GL Noble Denton Guidelines can be downloaded from [www.gl-nobledenton.com](http://www.gl-nobledenton.com)

## APPENDIX A - DATA TO BE SUBMITTED

### A.1. DRAWINGS AND TECHNICAL INFORMATION

For any generalised approval in principle, the following information should be submitted to GL Noble Denton:

- A.1.1 Designers' general specifications for unit
- A.1.2 Current Operations Manual (see Appendix B) if available. If not available, details of fixed and moveable hull light weights, leg and footing weights, variable load to be considered and individual and combined CoG's. These details to include weights and centres of gravity for:
- Hull
  - Fixed Load (machinery and outfitting)
  - Moveable Load (Cantilever, substructure, derrick and draw-works)
  - Legs
  - Spudcans and can water (or mat and ballast as appropriate)
  - Maximum allowable variable load for elevating, lowering, operating, survival
  - Maximum preload that can be applied to each leg through the elevating system. Where applicable values for regular and leg-by-leg preloading should be provided.
- A.1.3 General arrangement plans and elevations showing the hull, jackhouses, accommodation, etc., and deck mounted equipment.
- A.1.4 Leg structural drawings.
- A.1.5 Spudcan arrangements and structure.
- A.1.6 Details of significant leg and/or hull appurtenances e.g., raw water structures and their guides.
- A.1.7 Jackhouse or jack frame structure, showing connection into hull.
- A.1.8 Upper and lower guide structural drawings.
- A.1.9 Jacking and holding system arrangements and specifications and principles of operation, including:
- Stiffness of jacks and, where fitted, holding system,
  - Jack capacities for elevating, lowering, preloading, and the basis on which these are quoted,
  - Jack system ultimate capacity and where applicable jack slip load,
  - Holding system ultimate capacity.
- A.1.10 Hull drawings showing scantlings of the decks, bulkheads and framing.
- A.1.11 If not described in the Operations Manual (see Appendix B), or this is not available, Tank arrangements including capacities and positions or total preload and CoG, associated variable load & CoG, Lightship CoG, Preloading details/procedure and limiting feature e.g. tank capacity, elevating system or spudcan/mat bearing pressure.
- A.1.12 Hydrostatic and stability information
- A.1.13 Material specifications.
- A.1.14 Area and season of operation, or water depth, wave height, current speed and wind speed combinations for which approval is required.

**A.2. SITE SPECIFIC INFORMATION**

For the assessment or approval of the unit and its foundation at a specific location the following information should additionally be submitted to GL Noble Denton:

- A.2.1 Location name/designation and coordinates.
- A.2.2 Water depth with Datum.
- A.2.3 Geotechnical data.
- A.2.4 Proposed airgap (if other than minimum safe).
- A.2.5 Proposed rig heading.
- A.2.6 Proposed season for operations.
- A.2.7 Details of any intended deviations from the operations manual e.g. revised variable load and/or CoG, revised windage due to deck equipment, support of more than one conductor, etc.

**APPENDIX B - OPERATIONS MANUAL**

- B.1. A copy of the Operations Manual should be submitted to GL Noble Denton for information. This should contain all information relevant to the safety of the unit, personnel and major items of equipment on board the unit, including but not limited to:
  - B.1.1 General specification, setting out limitations on operating water depths and corresponding environmental conditions
  - B.1.2 General arrangement plans and elevations
  - B.1.3 Compartmentation and piping systems
  - B.1.4 Weights and centres of gravity of hull and equipment, skid unit, legs and spudcans
  - B.1.5 Loading instructions, giving limitations on weight and centre of gravity, with worked examples of loading calculations for elevated and afloat conditions
  - B.1.6 Details of jacking system, stating maximum elevating, lowering and holding loads and all necessary checks before jacking operations, including where applicable the required torque and brake clearance for each motor
  - B.1.7 Variable load capacities
  - B.1.8 Tank calibration tables
  - B.1.9 Details of propulsion units (if any)
  - B.1.10 Details of critical downflooding openings, means of closure, and instructions for ensuring closed under tow
  - B.1.11 Limitations for going on and off location
  - B.1.12 Critical motion curves for towage for relevant leg lengths and positions
  - B.1.13 Preloading instructions
  - B.1.14 Maximum and minimum permitted penetration, and reasons for any restrictions
  - B.1.15 Instructions for filling and emptying spudcans
  - B.1.16 Jetting system layout and operation
  - B.1.17 Maintenance schedules for machinery and systems. Inspection schedules for structure
  - B.1.18 Reference to more detailed manuals for machinery and systems
  - B.1.19 Allowable loadings and positions of cantilever and substructure for operating and survival conditions.

**APPENDIX C - GOOD PRACTICE RECOMMENDATIONS FOR PRELOADING AT  
"DIFFICULT" LOCATIONS**

(2 pages)

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| <b>ALERT</b>                                   |   | GPR.01 Rev 0 April 10 |
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| <b>FOR PRELOADING AT "DIFFICULT" LOCATIONS</b> |   |                       |
| Issued by: Noble Denton Consultants Ltd        | Status: Release to field & office staff handling jack-ups |                       |
| Author: M.J.R. Hoyle                           | Confidentiality: Can be released to clients               |                       |

At locations where there is the possibility of rapid settlement, leg-runs or punch-through during installation, or where the anticipated load-penetration response is not known, the following points **MUST** be considered when discussing / reviewing the preload plan:

- 1) At locations where there is a risk of leg runs, rapid penetration or punch-through a cautious approach should be taken during the rig installation. The initial preload should be leg-by-leg with the hull in the water (in some circumstances a minimal airgap may be acceptable). It is recommended that, if the unit is to be placed near to a fixed structure, the leg furthest from the structure be preloaded first so that any unexpected spudcan penetrations result in hull movements away from the structure. At open locations the leg preloaded first should be the leg (for a 3 leg unit) or one of the legs (for a 4 leg unit) with the greatest distance to the axis through the centres of the other two legs.
- 2) When single leg preloading, set a fixed tilt angle of 0.5 to 1.0 degrees (refer to the operations manual for guidance) above which **any** jacking will be stopped whilst there is still preload on board. This limit should apply at all times i.e. both when at airgap and when in the water. It is particularly important that jacking is stopped at or before the limiting tilt angle when lowering the high side to try to keep the hull level during the early stages of a leg-run (sometimes termed "chasing the punch-through leg). Refer to GL Noble Denton's good practice recommendations for punch-through recovery (GPR.02) if significant inclinations are experienced.
- 3) To mitigate the potential for damage, the optimal draught is such that bilge radii, stern rakes, etc are immersed. However there are many rigs where tank limitations would not allow the application of full preload at draught. Where available, rig systems should be used to confirm that the load applied to the legs (allowing for hull buoyancy) achieves the target values. It is crucial that an accurate record is maintained of draught and that account taken of changes in draught due to tidal effects and changes in penetration.
- 4) Once full load has been achieved, final single leg preload should be held for at least 1 hour **AFTER** penetration/settlement has ceased. Under some circumstances, geotechnical advice can be that longer hold times are required (perhaps 3 or 6 hours). Such longer hold times are typically required at locations where there is a high risk of punch through and in very soft formations when leg penetrations are in slow increments.

NOTE 1: At locations where there is potential for "set-up" of the soil strength in layers above the final penetration depth it may be recommended that each leg is driven past such zones in turn. The final preload and holding should then be undertaken in a second preloading cycle.

NOTE 2: There can be practical difficulties when (a) working through punch-through or set-up zones and (b) when holding preload at draught. Careful planning is therefore required, especially in areas where the tidal variation is significant.

- 5) If the penetrations achieved after completing leg-by-leg preloading are such that the load-penetration predictions indicate potential for further leg settlement / leg runs / possible punch-through (a 'hang-up' scenario), then simultaneous preloading at airgap should **NOT** be undertaken as it unnecessarily exposes the unit to the same risks that single leg preloading is intended to mitigate, with no factor of safety on footing loads. If preload holding at airgap is desired (and GL Noble Denton would generally not recommend it), we strongly recommend that it is undertaken:
  - One leg at a time,
  - At minimal airgap and

With the total load applied to the seabed reduced below that applied with the hull in the water (after deductions of buoyancy) by about 300 tonnes (660 kips) per leg. The intention is to provide sufficient margin that there is no risk of adverse penetration behaviour, as the effects would be much worse when at airgap.

This is to ensure that the load applied at airgap is less than that applied in the water, allowing for the possible influences of: environmental loads (weather), calculation errors, minor shifts of VDL, loads from mooring or towing lines, etc.

- 6) On no account preload all 3 legs together unless the penetrations achieved indicate that all the footings have passed through all the rapid-settlement zones, and the anticipated load-penetration curve(s) show a firm foundation with little or no further penetration expected. Under such circumstances regular simultaneous leg preloading and preload holding at minimum airgap are considered acceptable.

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7) Impact on the Engineering Site Assessment.

- a) Due to tank limitations, the consequence of leg-by-leg preloading at draught is that the preload that can be relied upon in the engineering calculations can be less than that possible in a regular minimum airgap preload scenario. However, it is often the case that single leg preloading can achieve higher individual leg loads than simultaneous leg preloading, so this shortfall may not be as significant as might first be expected.
- b) If the preload holding load to be applied with the hull in the water is known with confidence, then it can be used as the basis for the site-specific engineering assessment undertaken prior to going onto location. If it is not known with confidence, then a view will need to be taken as to the appropriate preload to use in the engineering assessment. The greatest cause of uncertainty is likely to be the determination of buoyancy from the draught marks, especially in areas where the tidal range is significant.
- c) The achievable preload in the water may result in the necessity for extra precautions, e.g. CoG control, VDL reduction, directional assessment, seasonal operation, etc.

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**APPENDIX D - GOOD PRACTICE RECOMMENDATIONS FOR JACK-UP RECOVERY  
FROM PUNCH-THROUGH, ETC.**

(5 pages)

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## Introduction

These good practice recommendations address the following aspects of Punch-Through recovery:

- 1) The actions to be taken after the incident and before any levelling takes place.
- 2) The data that should be gathered and provided to the Controlling Person or Office onshore, if the inclination exceeds threshold limits.
- 3) The approach to levelling if the inclination is below threshold limits.
- 4) Precautions to be taken when jacking when the hull is inclined.
- 5) Summary of responsibilities.

Each topic is addressed in further detail below.

### 1) The actions to be taken after the incident and before any levelling takes place.

Before undertaking any levelling:

- a) Assess and record the situation and allow it to stabilise.
- b) Dump / pump-out all preload, or as much as possible. When the tank level is above the sea level, use the dump valves. If it is not, or when the hull is submerged and/or the inclination takes the preload ballast away from the dump valve use the bilge pumps and eductors and/or portable pumps.
- c) Dump or back-load liquid VDL once the preload ballast has been dumped/pumped; generally drill water can be pumped overboard. If the rig's inclinations do not exceed the operating limits of the cranes, then it may also be possible to back-load non-liquid VDL.

### 2) The data that should be gathered and provided to the Controlling Person ashore or Office, if the inclination exceeds threshold limits.

If the inclination is less than the threshold limits for the rig type (see Table 1), go to 3) below. Otherwise, when the inclination is greater than the threshold limits, advise the designated Controlling Person ashore or Office, who should mobilise engineering support, of the details of the event, which should include the following:

- a) Confirm rig heading and whether at stand-off or alongside position
- b) Location details and geotechnical data (where these are not already on file in London).
- c) Proximity of hazards (Platforms, pipelines, etc), and details of any contact already experienced or likely to be experienced, and the (anticipated) consequences thereof.
- d) Load-penetration history & assessment of where the legs are positioned within the soil strata.
- e) Time, loading condition & total load on each leg when punch-through started.
- f) RPDs when punch-through started and RPD's after the event.
- g) Airgap/draught, penetrations and heel and trim when punch-through started.
- h) Details of any jacking after start of punch-through, including chasing the punch-through leg and the heel and trim inclinations at which jacking was stopped.
- i) Positions of each leg wrt hull (leg markings) before and after the event.
- j) Airgap/draught at each leg (or other clearly specified reference points) and inclinations after the event.
- k) Tidal level at the time of the event and tidal predictions for the next few days.
- l) Predicted and estimated peak current speeds and directions of flow wrt punch-through.
- m) Present weather and weather forecasts (these will be a key to the decision making process).
- n) Lie of the leg in the guides (locate where contacts occur at upper and lower guides).
- o) Confirm that all pinions are in contact on the upper flanks of rack teeth (if not please provide details).
- p) If available provide torque/load readings for pinions.
- q) Details of any damage (including to legs, guides/wear-plates, jack-house/frame, elevating system and hull in the way of tanks around the leg-well) and any non-standard leg-hull contact.

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And then await further advice, whilst reducing the VDL by as much as is feasible. In general it is faster to dump / remove liquids first and, as noted in Aspect 1), this will be the only option if the cranes cannot be used.

In the event of deteriorating weather, then it may become necessary to proceed as in 3) below, so preparation of an on-board plan is a valuable activity, even if it is subsequently superseded by a plan from the shore. In any event, it is necessary to ensure that there are sufficient personnel to monitor and report the general leg behaviour and measure the RPD on each chord of the legs to be jacked, and that they are fully briefed and equipped.

Table 1 - Indicative "threshold inclinations" by rig type (*assuming minimal buoyancy pick-up*)

| Rig Type & Threshold Classes  | Approx. Water Depth + Penetration |             |             |
|---|-----------------------------------|-------------|-------------|
|   | 100ft / 30m                       | 200ft / 60m | 300ft / 90m |
| Rack chock / slender bracings e.g. L780 Mod 2<br>Opposed non-floating pinions / slender bracings e.g. MODEC 300,                          | 1.5°                              | 1.0°        | 0.7°        |
| Rack chock / stout bracings e.g. MSC CJ70; LeT Super Gorilla<br>Opposed non-floating pinions / stout bracings (examples to be identified) | 3.5°                              | 2.2°        | 1.5°        |
| Other (un-opposed pinion; floating jacking system, etc.).<br>e.g. LeTourneau with teardrop chords.  | * 2.5°                            | 1.5°        | * 1.0°      |

\* based on 116C calcs for surviving the initial event - generally the chords are critical.

Greater inclinations than those shown above can often be sustained successfully *if* the airgap immediately before the punch-through was very small, or negative, and the tide has not fallen significantly i.e. there is positive draught after the event.

3) The approach to levelling if the inclination is below threshold limits.

Consider levelling the hull without external advice, only if the inclination is not more than the threshold limits for the rig type (see Table 1), and:

- a) As much preload and VDL as possible has been removed.
- b) There is no observed damage.
- c) The RPD's are within limits.
- d) There is no adverse leg-hull interference.

However, before proceeding, ensure that a plan has been prepared, that there are sufficient personnel to monitor and report the general leg behaviour and measure the RPD on each chord of the leg(s) to be jacked, and that they are fully briefed and equipped. Such levelling is generally best done by jacking on the one leg that will result in the greatest initial improvement in the situation. This will generally be by jacking the hull up the leg that has punched through - especially if the rig has gained buoyancy.

NOTE 1: The typical recommendation in Operating Manuals to lower the high side is usually not appropriate for the larger angles of inclination considered here. This is because the tendency will be for the moments on the jacked legs to transfer to any leg that is not jacked. Furthermore, at significant angles of inclination there should be buoyancy at the punch-through leg that will assist the jacking effort. Nevertheless, should such an approach be adopted, all jacking should follow the guidance in 4) below.

NOTE 2: In some instances, the personnel on board may have sufficient understanding, capability and experience such that alternative strategies may be considered. It is important to ensure that experience is not inappropriately extrapolated. For example, a strategy that was successful in shallow water may not be applicable in deeper water.

It is first necessary to determine the expected leg loads after removal of ballast and back-loading/dumping of variable load. This determination should account for the effects of inclination and any buoyancy (see Appendix). Where feasible, the data computed on board should be verified ashore. If the loads on the leg to be jacked exceed the rated capacity for jacking on that leg, then only jack on it if:

- a) It can be confirmed that the actual capacity is sufficiently in excess of the rated capacity,
- b) Or, if the rated capacity is not sufficient, the hull presently has (or will have at high tide) sufficient buoyancy to make good the deficit,
- c) And/or if the deficit can be made good by utilising righting assistance from attending tugs.

If it is not possible to jack to raise the low corner, then it may be necessary to lower the high side. In such cases it is normally best to jack the hull down each of the high-side legs in turn, following the recommendations of 4). If recovering from a large

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inclination, then the high-side legs could be addressed alternately, after say each 1m (3ft) of cumulative jacking in small increments [see 4 c) below].

4) Precautions to be taken when jacking when the hull is inclined

When jacking:

- a) Do not equalise torques before jacking as this is likely to result in immediate increases in RPD, and consequent leg damage.
- b) Jack on only one leg at a time, with the leg being jacked monitored continuously by a team supervised by a competent person.
- c) Any jacking should be done in small increments (typically 0.15m / 15-20 seconds); smaller increments (typically 0.05m / 5 seconds) are appropriate for units with high-slip electric jacking motors, linked hydraulic jacking motors or other means of equalising the pinion loads between the chords of one leg). The objectives of incremental jacking are (1) to minimise any increase in RPD, (2) to allow adverse behaviour to be detected and resolved before damage results.
- d) If anything adverse is observed by the team monitoring the jacked leg during, or after, jacking (e.g. unusual levels of material removal from the guide wear-plates, rack or pinion tooth tip chipping, legs coming out of guides / pinion-rack mis-alignment / near contact of the legs with adjacent tanks), then stop immediately and re-evaluate.
- e) After each increment, measure the RPDs and apply control as appropriate, e.g. by means of single chord jacking, noting that there is a trade-off between excess RPD and brace damage and lower RPD with the potential for pinion overload.
- f) Rack chocks should not be used in such recovery situations unless either the Operations Manual gives specific recommendations to do so, or their use has been recommended by Engineering Support.

NOTE: The deployment of rack-chocks can have undesired consequences including (1) problems removing them if they have picked up significant load, (2) pinion overload and/or rapid increase in RPD once they have been removed.

5) Summary of responsibilities.

- a) The OIM and rig owner are ultimately responsible for the rig and MWS actions / recommendations are made to best assist the situation.
- b) Whilst the key concern of an MWS is minimising the exposure of the jack-up, situations can arise where it is appropriate to accept damage to the jack-up in the interests of protecting people, adjacent assets and the environment.
- c) Note that the decision making process will be dependent upon risk assessments which take due account of the prevailing and forecast weather conditions.

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### Appendix

Figure A-1 shows the relationship between hull movement / inclination. The remainder of this Appendix gives guidance on the changes in the leg loads due to hull sway and buoyancy.

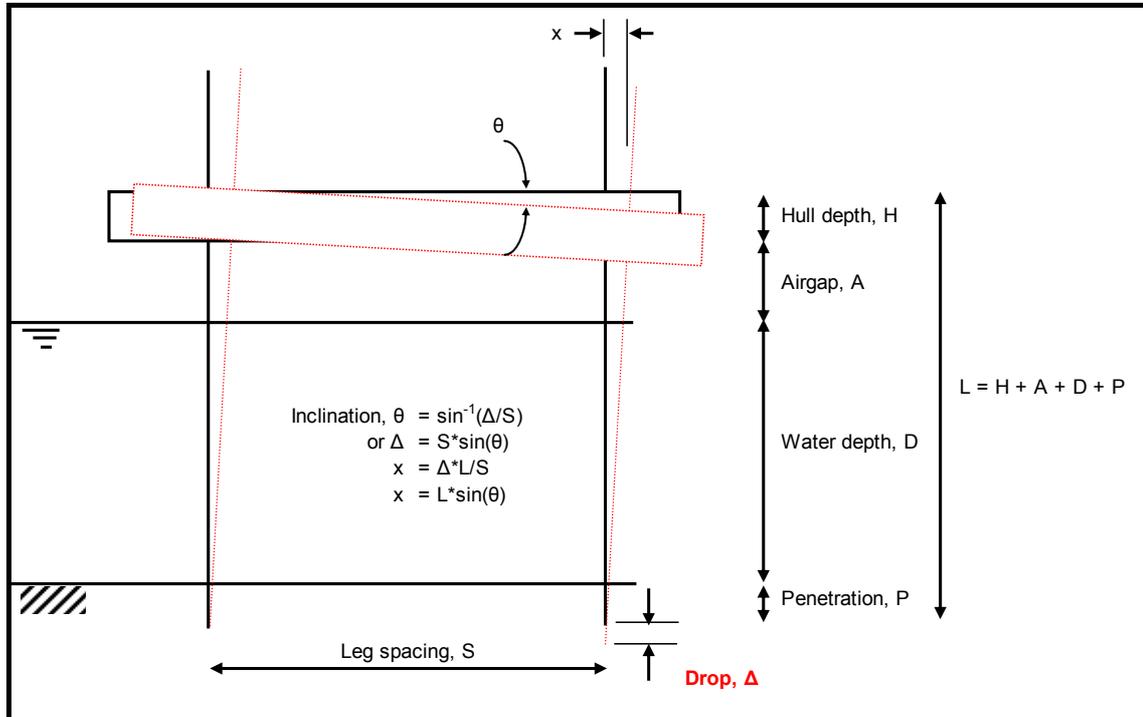


Figure A-1 - Single leg punch-through

The effect of inclination is to increase the axial load in the leg supporting the low corner of the hull, and reduce the axial load in the other legs. To a first approximation:

|  |                           |
|--|---------------------------|
| The increase in axial load on the punch-through leg              | $= x \cdot W/S$           |
| The reduction in axial load on the non-punch-through legs (each) | $= x \cdot W/(2 \cdot S)$ |

where:

W is the total weight of the hull (including all preload, variable, etc.) plus the weight of the legs above the hull, plus half the weight of the legs below the hull.

The effect of buoyancy is to reduce the axial load in all the legs, predominantly in the leg supporting the low corner of the hull. This can only be determined accurately by means of detailed calculations or a stability programme. However, the following approach (or refinements thereof) can be used give an indicative estimate of the reduction in load on the punch-through leg. This is achieved by dividing the submerged area into simple sections, determining the volume and centre of buoyancy of each, and then adding them. For example, with reference to Figure A-2 which shows the definition of the variables, a typical jack-up corner can be divided into two wedges plus a central strip, from which the leg well can be deducted:

|                            | Volume                                      | CoB aft of bow |
|----------------------------|---|----------------|
| Side wedge, P              | $X^2 \sin(\theta) Y_1 / 3$                  | $3X / 4$       |
| Volume of central wedge, C | $X^2 \sin(\theta) Y_2 / 2$                  | $2X / 3$       |
| Side wedge, S              | $X^2 \sin(\theta) Y_1 / 3$                  | $3X / 4$       |
| Leg well cylinder, L       | $-(X - X_L - D/2) \sin(\theta) \pi D^2 / 4$ | $X_L$          |
| Leg well wedge, L          | $-\pi D^3 \sin(\theta) / 8$                 | $X_L - D / 8$  |

If it is assumed that the total volume obtained from the calculations above is V and the overall CoB aft of the bow is X<sub>B</sub>:

|  |                              |
|--|------------------------------|
| The reduction in axial load on the punch-through leg             | $= V(S + X_L - X_B)/S$       |
| The reduction in axial load on the non-punch-through legs (each) | $= V(X_B - X_L)/(2 \cdot S)$ |

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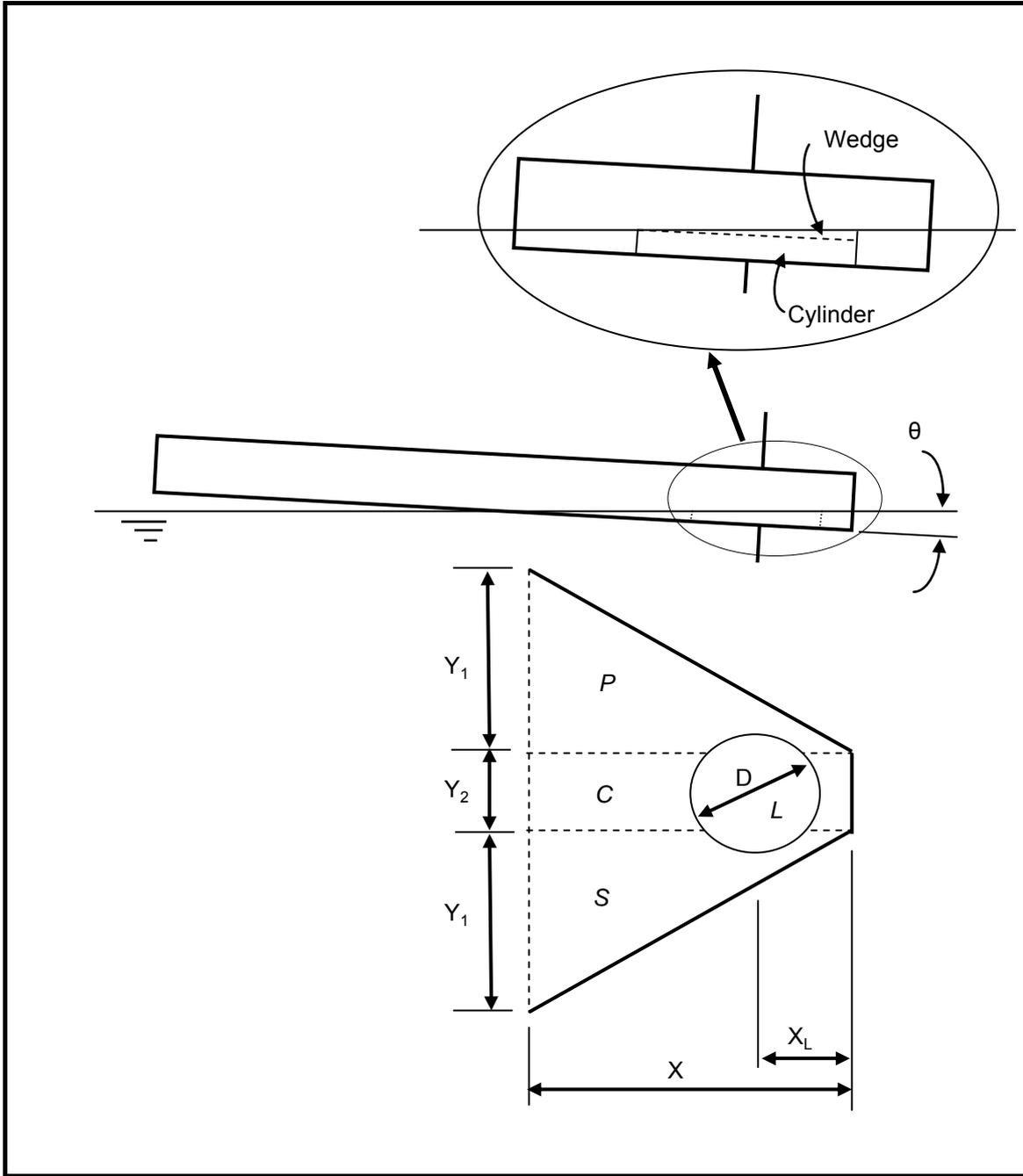


Figure A-2 - Variables used in Buoyancy Estimation