NOBLE DENTON

TECHNICAL POLICY BOARD

GUIDELINES FOR MARINE LIFTING OPERATIONS

0027/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 document provides guidelines on which the design and approval of marine lifting operations may be based.

1.2 This document supersedes the previous revision, document No. 0027/NDI Rev 7 dated 15th April 2009. The change is described in Section 2.11. 8

1.3 These guidelines cover lifting operations by floating crane vessels, including crane barges, crane ships, semi-submersible crane vessels and jack-up crane vessels. They may also be applied to lifting operations by land-based cranes for the purpose of loadout. They are intended to lead to an approval by Noble Denton, which may be required where an operation is the subject of an insurance warranty, or where an independent third party review is required.

1.4 A description of the approval process is given for those projects which are the subject of an insurance warranty.

1.5 The report includes guidelines for the load and safety factors to be applied at the design stage.

1.6 Comments on the practical aspects of the management of the operation are also offered.

2 INTRODUCTION

2.1 This report provides guidelines on which the design and approval of marine lifting operations may be based.

2.2 It covers lifting operations by floating crane vessels, including crane barges, crane ships, semi-submersible crane vessels and jack-up crane vessels. It refers to lifting operations inshore and offshore. Reference is also made to lifting operations by land-based cranes for the purpose of loadout onto a barge or other transportation vessel.

2.3 The guidelines and calculation methods set out in this report represent the views of Noble Denton and are considered to be sound and in accordance with offshore industry practice. Operators should also consider national and local regulations, which may be more stringent.

2.4 The Report includes guidelines for the safety factors to be applied, comments on safe rigging practice and the information and documentation to be produced by others in order to obtain Noble Denton approval.

2.5 Revision 2 superseded and replaced the previous version, Revision 1, dated 11th August 1993. Principal changes in Revision 2 included:

- Reference to the ISO Draft Standard on weight control
- Reserves specified on weights as calculated or measured according to the ISO/DIS
- Limitations of Noble Denton Approval clarified
- Changes to the required clearances on pipelines and other subsea assets
- Addition to a section on heave-compensated lifts
- Addition of a section on lifts using Dynamic Positioning.

2.6 Revision 3 superseded and replaced Revision 2, and includes additional clarification on safety factors for shackles, and testing and certification requirements.

2.7 Revision 4 superseded and replaced Revision 3, and includes:

- Changes to referenced documents (Sections 2.8 and References)
- Some changes to definitions (Section 3)
- Changes to Dynamic Amplification Factors, to eliminate discontinuities (Section 5.6)
- Elimination of an anomaly in the definition of Hook Load (Section 5.3)
- Inclusion of consideration of fibre slings (Sections 5.10, 5.15 and 12)
- Elimination of an anomaly in the treatment of spreader bars and frames (Sections 5.16 and 7.4)
- Modification of the flow chart (old Section 5.16)
- Changes to the derivation of bumper and guide design forces (Section 10.3).

2.8 Revision 5 superseded and replaced Revision 4, and corrected typographical errors in Table 5-1.

2.9 Revision 6 superseded and replaces Revision 5, and made the following principal revisions, highlighted by a line in the right hand margin:

- The Guideline refers as appropriate to other standards, including
    - ISO International Standard ISO2408 - Steel wire ropes for General Purposes - Characteristics [Ref. 4]
    - ISO International Standard ISO 7531 - Wire Rope slings for General Purposes - Characteristics and Specifications [Ref.5].
- Definitions in Section 3 were generally revised and expanded.
- Section 4.1.2 added for the Certificate of Approval
- Section 5 was re-ordered, Figure 5.1 revised, DAF's expanded to include submerged lifts, guidelines for 1 crane-2 hook lifts added, yaw factor for inshore lifts deleted, use of alternative codes added, minimum sling angles included
- Old Section 11 (Underwater Lifting) moved into Section 5.6.5
- Section 5.6.7 added for inshore lifts made by jack-up crane vessels.
- Section 5.6.8 expanded to include weather forecast levels.
- Section 5.7.6 added: SKL for multi hook lifts. 6
- Table 5-4: consequence factors revised.
- Section 5.12.6 added: sling eye design.
- Sections 6.1.5 and 8.7 added.
- Old Section 12 (Heave compensated lifts) moved to Section 6.1.6
- Section 8.5 expanded to include trunnions and sling retainers.
- Clearances in Section 9.3 generally updated and expanded.
- Dimensional control requirements added to 10.3 and design requirements in Section 10.5.4.
- Sections 9.2.6 - 9.2.8 added: bumper and guide clearances and dropped objects.
- Limitation on number of chained shackles and shackle orientation added in Section 11.11.
- Section 12 updated, showing requirements for sling certificates, doubled sling restrictions and requirements for wire/sling type.
- Old Section 13 (Lifts using DP) moved to Sections 12.7.1 and 12.8.9.
- Sections 12.8.7 and 12.8.8 amended for in field environmental condition monitoring.
- Section 12.8.10 added for risk assessments and HAZOPs
- General text changes and revisions made.

2.10 Revision 7 superseded and replaced Revision 6. The changes are the removal of “by Floating Crane Vessels” in the document title and a correction in Section 5.14.1. 7

2.11 This Revision 8 supersedes and replaces Revision 7. The change is a correction in Section 5.12.5.

2.12 All Noble Denton Guidelines can be downloaded from www.nobledenton.com.

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, normally non-propelled, on which the ‘structure’ is transported. (For the purposes of this document, the term barge can be considered to include vessel or ship where appropriate).	
Bending reduction factor E_B	The reduction factor applied to the breaking load of a rope or cable to take account of the reduction in strength caused by bending round a shackle, trunnion or crane hook.	
Calculated Grommet Breaking Load (CGBL)	The load at which a grommet will break, calculated in accordance with one of the methods shown in Ref. [3].	
Calculated Rope Breaking Load (CRBL)	The load at which a cable laid rope will break, calculated in accordance with one of the methods shown in Ref. [3].	6
Calculated Sling Breaking Load (CSBL)	The load at which a sling will break, calculated in accordance with one of the methods shown in Ref. [3]. The breaking load for a sling takes into account the ‘Termination Efficiency Factor’	
Cable-laid sling	A cable made up of 6 ropes laid up over a core rope, as shown in Ref. [3], with terminations at each end.	
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.	
Consequence Factor	A factor to ensure that main structural members, lift points and spreader bars /frames have an increased factor of safety (including lateral loads) related to the consequence of their failure.	6
Crane vessel	The vessel, ship or barge on which lifting equipment is mounted. For the purposes of this report it is considered to include: crane barge, crane ship, derrick barge, floating shear-leg, heavy lift vessel, semi-submersible crane vessel (SSCV) and jack-up crane vessel.	
Determinate lift	A lift where the slinging arrangement is such that the sling loads are statically determinate, and are not significantly affected by minor differences in sling length or elasticity	
DP	Dynamic Positioning	
Dynamic Amplification Factor (DAF)	The factor by which the ‘gross weight’ is multiplied, to account for accelerations and impacts during the lifting operation	
FMEA	Failure Modes and Effects Analysis	

Term or Acronym	Definition	
Grommet	A grommet is comprised of a single length of unit rope laid up 6 times over a core, as shown in Ref. [3] to form an endless loop	
Gross weight	The calculated or weighed weight of the structure to be lifted including a weight contingency factor and excluding lift rigging. See also NTE weight.	6
Hook load	The hook load is the 'gross weight' or NTE weight plus the 'rigging weight'	
Indeterminate lift	Any lift where the sling loads are not statically determinate	
Insurance Warranty	A clause in the insurance policy for a particular venture, requiring the approval of a marine operation by a specified independent surveyor	
LAT	Lowest Astronomical Tide	
Lift point	The connection between the 'rigging' and the 'structure' to be lifted. May include 'padear', 'padeye' or 'trunnion'	
Loadin	The transfer of a major assembly or a module from a barge onto land by horizontal movement or by lifting	
Loadout	The transfer of a major assembly or a module from land onto a barge by horizontal movement or by lifting	
Matched pair of slings	A matched pair of slings are fabricated or designed so that the difference does not exceed 0.5d, where d is the nominal diameter of the sling or grommet, Ref [3]	
Mechanical Termination	A sling eye termination formed by use of a ferrule that is mechanically swaged onto the rope, Ref. [4] and [5].	6
Minimum Breaking Load (MBL)	The minimum allowable value of 'breaking load' for a particular sling or grommet.	
Nett weight	The calculated or weighed weight of a structure, with no contingency or weighing allowance	
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'	
NTE Weight	A Not To Exceed weight, sometimes used in projects to define the maximum possible weight of a particular structure.	
Operational reference period	The planned duration of the operation, including a contingency period	
Padear	A lift point consisting of a central member, which may be of tubular or flat plate form, with horizontal trunnions round which a sling or grommet may be passed	
Padeye	A lift point consisting essentially of a plate, reinforced by cheek plates if necessary, with a hole through which a shackle may be connected	
Rigging	The slings, shackles and other devices including spreaders used to connect the structure to be lifted to the crane	
Rigging weight	The total weight of rigging, including slings, shackles and spreaders, including contingency.	

Term or Acronym	Definition	
Rope	The unit rope from which a cable laid sling or grommet may be constructed, made from either 6 or 8 strands around a steel core, as indicated in Ref [3], [4] and [5]	
SLS	A design condition defined as a normal Serviceability Limit State / normal operating case.	6
Safe Working Load (SWL)	See Working Load Limit (WLL).	
Seafastenings	The system used to attach a structure to a barge or vessel for transportation	
Skew Load Factor (SKL)	The factor by which the load on any lift point or pair of lift points and rigging is multiplied to account for sling length mis-match in a statically indeterminate lift	
Single Laid Sling	A cable made up of 6 ropes laid up over a core rope, as shown in Ref. [4] and [5], with terminations each end.	
Sling breaking load	The breaking load of a 'sling', being the calculated breaking load reduced by 'termination efficiency factor' or 'bending reduction factor' as appropriate.	
Sling eye	A loop at each end of a sling, either formed by a splice or mechanical termination	
Splice	That length of sling where the rope is connected back into itself by tucking the tails of the unit ropes back through the main body of the rope, after forming the sling eye	
Spreader bar (frame)	A spreader bar or frame is a structure designed to resist the compression forces induced by angled slings, by altering the line of action of the force on a lift point into a vertical plane. The structure shall also resist bending moments due to geometry and tolerances.	
Structure	The object to be lifted	
Survey	Attendance and inspection by a Noble Denton representative of a vessel or a marine operation. 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 or a contractor carrying out, for instance, a dimensional or non-destructive testing survey	
Termination efficiency factor E_T	The factor by which the breaking load of a wire or cable is multiplied to take account of the reduction of breaking load caused by a splice or mechanical termination.	
Trunnion	A lift point consisting of a horizontal tubular cantilever, round which a sling or grommet may be passed. An upending trunnion is used to rotate a structure from horizontal to vertical, or vice versa, and the trunnion forms a bearing round which the sling, grommet or another structure will rotate.	
ULS	A design condition defined as Ultimate Limit State / survival storm case.	6

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.	
Working Load Limit (WLL)	The maximum load that rigging equipment is certified to raise, lower or suspend	
9-Part sling	A sling made from a single laid sling braided nine times with the single laid sling eyes forming each eye of the 9-part sling.	6
50/50 weight estimate	The value representing the median value in the probability distribution of weight	

4 THE APPROVAL PROCESS

4.1 NOBLE DENTON APPROVAL

4.1.1 Noble Denton approval may be sought where the lift forms part of a marine operation covered by an insurance warranty, or where an independent third party review is required.

4.1.2 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.

4.1.3 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 Approval may be given for such operations as:

- Installation of liftable jackets
- Hook-assisted installation of launched or lifted jackets
- Installation of templates and other sub-sea equipment
- Handling of piles
- Installation of decks, topsides modules, bridges and flare towers/booms
- Shore to barge loadouts
- Transfer of items from a transport barge to the deck of a crane vessel.

4.1.5 Lifts may be by a variety of crane configurations, including single cranes, two cranes on a single vessel, two or more cranes on separate vessels, single crane multi-hook sheerleg vessels, cranes mounted on jack-up vessels, or by one or more land based cranes.

4.1.6 Noble Denton approval may be given for the operation, 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 lifting vessel
- 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. This will be issued on site, immediately prior to the lift taking place.

4.2.2 For an offshore lift, the Certificate will normally be issued after lift rigging and tuggers have been connected / inspected and prior to cutting the seafastenings on 6
the transport barge or vessel. Consideration shall be given where a partial seafastening removal is proposed to be carried out in parallel with rigging up operations. The lifting operation will be deemed to have commenced when seafastening cutting starts. The lift will be deemed to be completed when the load is landed in its final position, and the crane(s) has been disconnected.

4.3 SCOPE OF WORK LEADING TO AN APPROVAL

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

- The strength of the structure to be lifted, including the strength of the lift points.
- The capacity of the crane, taking into account the radius at which the lift will take place, whether the crane will be fixed or revolving and whether any down-rating is required for operations in a specified design and operational seastate.
- The capacity of the crane in the event that multiple hooks are used to suspend /upend a load.
- The rigging arrangement, including slings, shackles and any spreader frames or beams, and the certification of the rigging components.
- The mooring arrangements for the crane vessel, as outlined in Section 4.4.
- The limiting weather conditions proposed, and the anticipated behaviour of the crane vessel in those conditions.
- The arrangements for handling and mooring the transport barge or vessel alongside the crane vessel.
- The arrangements for cutting seafastenings prior to lifting.
- The management structure for the operations and Management of Change procedures. 6
- Risk assessments, HAZOP /HAZID studies carried out by Contractor involving all parties.
- Simultaneous Marine Operations (SIMOPS).

4.3.2 The information required in order to issue a Certificate of Approval is discussed in more detail in Section 12.

4.4 APPROVAL OF MOORINGS

4.4.1 A lift may normally be considered a weather restricted operation. Limiting weather conditions for the lift operation shall be defined, taking into account:

- the forecast reliability for the area
- the duration of the operation, including a suitability contingency period
- the exposure of the site
- the time required for any operations before or after the lift operation, including crane vessel and transport barge movements.
- currents on the lifting vessel/transport barge during the lift.
- currents on the lifted structure during lowering through the water column.

4.4.2 An approval of a lift will normally include the approval of the crane vessel and transport barge moorings in the limiting weather conditions specified for the lifting operation. When operating alongside an offshore installation, procedures should be submitted which show that the crane vessel and transport barge can and will be removed to a safe distance when the weather conditions exceed a specified level. An approval of a lift does not include approval of the vessel moorings in extreme weather conditions).

4.4.3 Similarly, an approval of a lifted loadout will include the approval of the crane vessel and transport barge moorings at the loadout quay in the limiting weather conditions specified for loadout. It does not necessarily include approval of either moorings in extreme weather conditions. Note that for approval of loadouts, reference should also be made to Noble Denton Report 0013/ND - Guidelines for Loadouts Ref. [1].

4.4.4 Additionally, and if specifically requested, Noble Denton will study and issue an approval of the moorings of the crane vessel or the transport barge, for a more extended period.

4.5 LIMITATION OF APPROVAL

4.5.1 A Certificate of Approval is issued for a particular lift only.

4.5.2 A Certificate of Approval is issued based on external conditions observed by the attending surveyor of hull(s) machinery and equipment, without removal, exposure or testing of parts.

4.5.3 A Certificate of Approval for a lift covers the marine operations involved in the lift only. A lift is normally deemed to start offshore when cutting of seafastenings starts, and after the crane is connected and slings tensioned. It is normally deemed to be completed when the lifted object is set down in its intended position. For completion of lifted loadouts see Ref. [1].

4.5.4 Unless specifically included, a Certificate of Approval for a lift excludes moorings of the crane vessel and transport barge outside the period of the immediate lift, as defined in Section 4.4.2.

4.5.5 Any alterations to the surveyed items or agreed procedures after issue of the Certificate of Approval may render the Certificate invalid unless the changes are approved in writing by Noble Denton.

5 LOAD AND SAFETY FACTORS

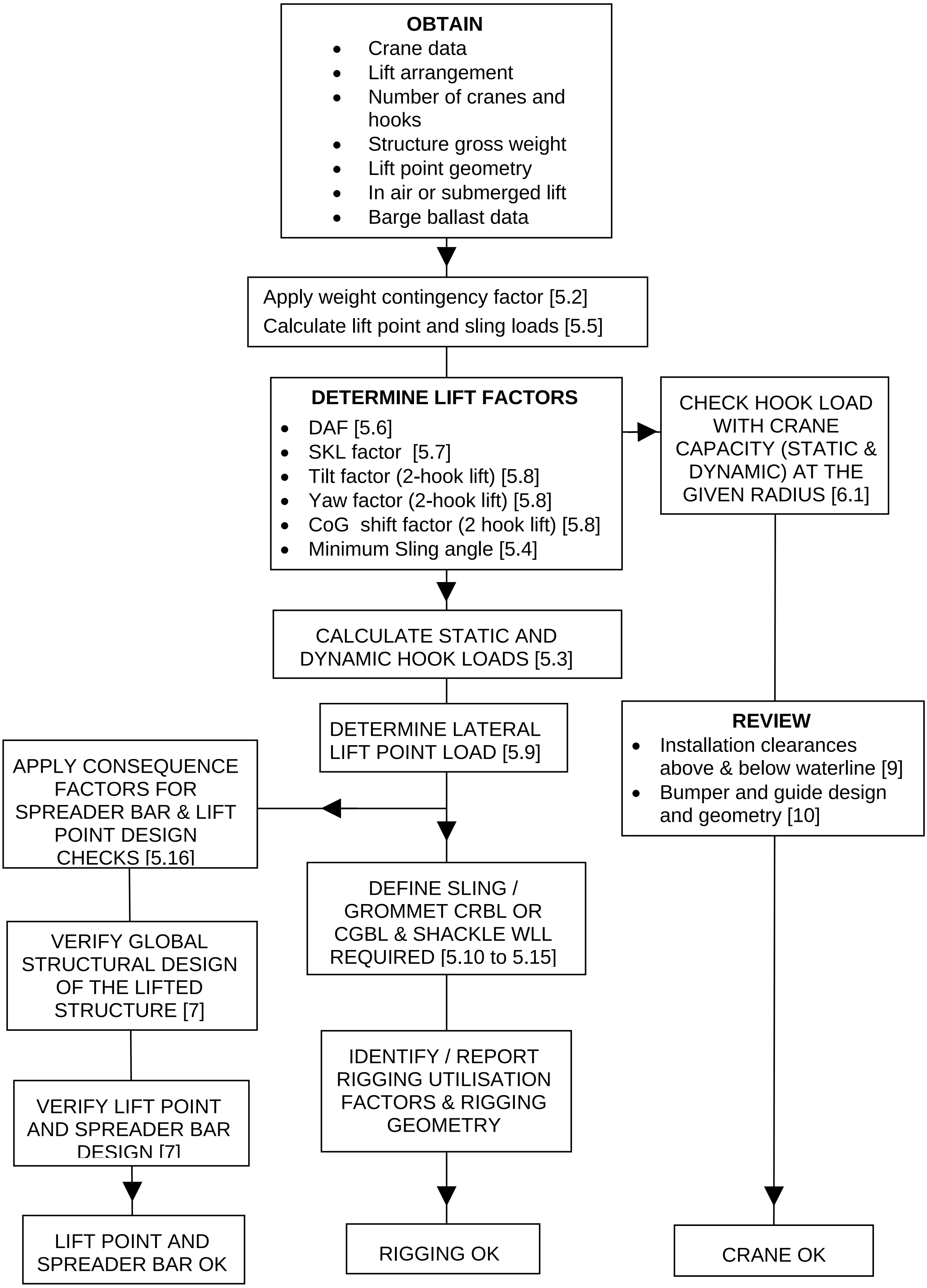
5.1 INTRODUCTION

5.1.1 For any lift, the calculations carried out shall include allowances, safety factors, loads and load effects as described in these guidelines.

5.1.2 The various factors and their application are illustrated in Figure 5.1. This flowchart is for guidance only, and is not intended to cover every case. In case of any conflict between the flowchart and the text, the text shall govern. Figures in parentheses relate to sections in these guidelines.

5.1.3 Use of other recognised offshore codes of practice relating to lift engineering can also be considered, but care should be taken since not all other codes are 6
exhaustive in determining the actual behaviour of lifting systems.

Figure 5.1 - Lift Calculation Flowchart



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5.2 WEIGHT CONTINGENCY FACTORS

5.2.1 Weight control shall be performed by means of a well defined, documented system, in accordance with current good practice, such as ISO International Standard ISO 19901-5:2003 – Petroleum and natural gas industries – specific requirements for offshore structures – Part 5: Weight control during engineering and construction Ref. [2], in order to derive correct loads for the design of rigging and lift points.

5.2.2 In relation to weight control classes, Reference [2] states (inter alia) that:

- "Class A shall apply if the project is weight or CoG-sensitive for lifting and marine operations or during operation (with the addition of temporaries) or has many contractors with which to interface. Project may also require this high definition if risk gives cause for concern".
- "Class B weight control definition shall apply to projects where the focus on weight and CoG is less critical for lifting and marine operations".
- "Class C weight control definition shall apply to projects where the requirement for weight and CoG data are not critical".

5.2.3 Unless it can be shown that a particular structure and specific lift operation are not weight or CoG sensitive, then Class A weight control definition will be needed, as shown in Ref [2], Section 4.2. If the 50/50 weight estimate as defined in Ref. [2] is derived, then an appropriate weight contingency factor, which shall be not less than 1.05, shall be applied to the Nett Weight. The extremes of the CoG envelope (if used) shall be used.

5.2.4 For Class B and C structure lifts, the minimum weight contingency factor shall be 1.10 applied to the Nett Weight for rigging and lift point design. 6

5.2.5 A weight contingency factor of not less than 1.03 shall generally be applied to the final weighed weight. This may be reduced if a Certificate is produced from a Competent Body stating, for the specific case in question, that the weighing accuracy is better than 3%. The contingency factor shall never be less than 1.01.

5.3 HOOK LOADS

5.3.1 In general, when considering the loading on a lift point or the structure, the hook load including contingency should be used. Loads in lift points and slings, and the total loading on the crane should be based on hook loads, where: 6

Static Hook load = (gross weight or NTE weight) + (rigging weight)

Dynamic Hook load = Static Hook Load x DAF

5.3.2 Rigging weight includes all items between the lift points and the crane hook, including slings, shackles and spreaders as appropriate.

5.3.3 For twin hook lifts whether cranes are on the same vessel, or multiple vessels, or the structure is suspended from two hooks on the same crane on the same vessel, the factors as described in Section 5.8 shall be used to derive individual hook loads.

5.4 RIGGING GEOMETRY

5.4.1 The rigging geometry shall normally be configured so that the maximum tilt of the structure does not exceed 2 degrees. 6

5.4.2 In special circumstances (e.g. flare booms, flare towers and cantilevered modules) the design angle of tilt may require to be greater than 2 degrees to permit the effective use of installation aids. These structures shall be reviewed as special cases.

5.5 LIFT POINT AND SLING LOADS

5.5.1 The basic vertical lift point load is the load at a lift point, taking into account the structure gross weight proportioned by the geometric distance of the centre of gravity from each of the lift points. The basic lift point load is further increased by the factors as listed in Figure 5.1 as appropriate for the lifting arrangement under consideration.

5.5.2 Where the allowable centre of gravity position is specified as a cruciform or other geometric envelope, then the most conservative centre of gravity position within the envelope should be taken. Where a CoG envelope is used, an additional factor of 1.03 should be added, to account for errors in the final CoG location.

5.5.3 The sling load is the vertical lift point load resolved by the sling angle to determine the direct (axial) load in the sling and lift point using the minimum possible sling angle.

5.5.4 A minimum sling angle of sixty degrees is recommended, but a lower sling angle is possible, taking due account of the forces on the lift points, the structure and the crane hook(s). 6

5.5.5 For lift point design, the rigging weight shall not form part of the lift point load.

5.6 DYNAMIC AMPLIFICATION FACTORS

5.6.1 Unless operation-specific calculations show otherwise, for lifts by a single crane in air, the DAF shall be derived from the following Table.

Table 5-1 In Air Dynamic Amplification Factors (DAF)

<table>
<tr><th rowspan="3">Gross weight, W (tonnes)</th><th colspan="4">DAF</th></tr>
<tr><th rowspan="2">Offshore</th><th rowspan="2">Inshore</th><th colspan="2">Onshore</th></tr>
<tr><th>Moving</th><th>Static</th></tr>
<tr><td>W ≤100</td><td>1.30</td><td colspan="2">1.15</td><td>1.00</td></tr>
<tr><td>100 < W ≤ 1,000</td><td>1.20</td><td colspan="2">1.10</td><td>1.00</td></tr>
<tr><td>1,000 < W ≤ 2,500</td><td>1.15</td><td colspan="2">1.05</td><td>1.00</td></tr>
<tr><td>2,500 < W ≤ 10,000</td><td>1.10</td><td colspan="2">1.05</td><td>1.00</td></tr>
</table>

5.6.2 The DAF as indicated in Table 5-1 above shall also apply to the following lift combinations of vessels, cranes and locations:

- For lifts by 2 cranes on the same vessel
- For inshore lifts, in totally sheltered waters, by 2 or more vessels
- For onshore lifts by 2 or more cranes 6
- For offshore lifts by 2 or more hooks on the same crane boom

5.6.3 For offshore lifts by 2 or more vessels, the DAF shall be found by dynamic analysis.

5.6.4 For onshore lifts, where the crane(s) may move horizontally, the "Moving" column of Table 5-1 shall apply. The "Static" column shall only apply if there is no crane movement other than lifting or lowering.

5.6.5 If any part of the lifting operation includes lifting or lowering through water, analyses shall be submitted, which either:

- Show how the total in-water lifting loads are derived, taking into account weight, buoyancy, entrained mass, boom-tip velocities and accelerations, inertia and drag forces, or;
- Calculate the dynamic sling and hookloads to document that slack slings do not occur and provide limiting seastate data for the offshore operation.
- Calculate slamming loads on the structure being lifted. 6
- The dynamic analysis results for a submerged or partially submerged lift may restrict the operability of an operation that is subject to the issue of a Certificate of Approval, depending on the DAF used for rigging and structure design.

5.6.6 As an alternative to the DAF's in Table 5-1, the DAF may be derived from a suitable calculation or model test. Where the lift is from or onto a barge or vessel alongside the crane vessel, then the barge or vessel motions must be taken into account as well as the crane boom-tip motions.

5.6.7 For lifts from floating barges/vessels made by Jack-up crane vessels at an inshore location the DAF as indicated in Table 5-1 Inshore column shall apply.

5.6.8 Where a DAF is derived by calculation or model tests, the limiting operational seastate from this analysis shall recognise the uncertainties in weather forecasts when determining critical operational durations. Weather forecasting uncertainties can be mitigated by in-field wave monitoring and/or in-field meteorologists. The limiting design seastate shall be reduced based on Table 5-2 below for marine operations with an operational duration of 24 hours.

Table 5-2 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

For marine operations with an operational duration less than 24 hours, special consideration (DAF analysis results, water depth, lift vessel type/class, object form, rigging system, weather forecast provision, exposure period, lowering procedure) shall be given to the reduction factors in Table 5-2. 6

5.7 SKEW LOAD FACTOR (SKL)

5.7.1 Skew load is a load distribution factor based on sling length manufacturing tolerances, rigging arrangement and geometry, fabrication tolerances for lift points, sling elongation, and should be considered for any rigging arrangement and structure (Section 7.1) that is not 100% determinate. A significantly higher SKL factor may be required for new slings used together with existing slings as one sling may exhibit more elongation than the others.

5.7.2 For indeterminate 4-sling lifts using matched pairs of slings, a Skew Load Factor (SKL) of 1.25 shall be applied to each diagonally opposite pair of lift points in turn.

5.7.3 For determinate lifts the SKL may be taken to be 1.0, provided it can be demonstrated that sling length errors do not significantly affect the load attitude or lift system geometry. The permitted length tolerance on matched pairs of slings is defined according to Ref. [3].

5.7.4 For a lift system incorporating spreader bars using matched pairs of slings a SKL of 1.10 is applicable.

5.7.5 For a lift system incorporating a single spreader bar using matched pairs of slings a SKL of 1.05 is applicable. 6

5.7.6 For multi hook lifts where the hook elevation can be shown to be individually controlled, a lower skew load factor than stated above may be applicable, subject to evaluation of sling length tolerances, rigging arrangement and crane operating procedures.

5.8 2-HOOK LIFT FACTORS

5.8.1 For a 2-hook lift (hooks on the same vessel) the individual gross weight at each hook shall be multiplied by the following factors, to account for increased loads due to the tolerances of the elevation in the crane hooks:

Centre of gravity shift factor = 1.03

Tilt factor = 1.03

Reduced factors to those defined above may be used, subject to supporting analyses, limiting seastate criteria and installation procedure steps/controls.

5.8.2 For a 2-hook lift, with 2 slings to each hook, the load to each lift point shall be multiplied by a yaw factor, to account for tolerances in lift radii of the 2 hooks:

Yaw factor = 1.05

Yaw factors for 2-hook lifts with other rigging arrangements will require special consideration. 6

5.8.3 For 2 hook lifts where the crane hooks are located on separate vessels the factors in Sections 5.8.1 and 5.8.2 shall be applied for inshore lifts, and be subject to calculation for offshore lifts.

5.8.4 For 2 hook lifts where the hooks are on the same crane, the factors in Sections 5.8.1 and 5.8.2 shall be applied.

5.9 LATERAL LIFT POINT LOAD

5.9.1 Provided the lift-point is correctly orientated with the sling direction, then a horizontal force equal to 5% of the resolved lift point load shall be applied, acting through the centreline and along the axis of the padeye pin-hole or trunnion /padear geometric centre.

5.9.2 If the lift point is not correctly orientated with the sling direction, then the computed forces acting transverse to the major lift point axis of the pin-hole or trunnion /padear geometric centre shall be added to the lateral lift point load as defined in Section 5.9.1 above.

5.10 2-PART SLING FACTOR

5.10.1 Where a 2-part sling or grommet passes over, round or through a shackle, trunnion, padear or crane hook, other than at a termination, the total sling force shall be distributed into each part in the ratio 45:55 to account for frictional losses over the bend.

5.10.2 Where a 2-part sling or grommet passes over a rotating greased sheave on a trunnion the total sling force shall be distributed into each part in the ratio 49:51 to account for the frictional losses over the rotating sheave on the trunnion.

5.11 TERMINATION EFFICIENCY FACTOR

5.11.1 The breaking load of a sling ending in a termination shall be the calculated rope breaking load multiplied by a factor as follows:

- For hand splices, including fibre slings: 0.75
- For resin sockets: 1.00
- Swage fittings, e.g. “Superloop or Flemish Eye”: 1.00
- Steel ferrules (mechanical termination): 0.80

Other methods of termination (i.e. 9-part slings) will require special consideration.

5.12 BENDING EFFICIENCY FACTOR

5.12.1 Where any wire rope sling or grommet is bent round a shackle, trunnion, padear or crane hook, the breaking load shall be assumed to be the calculated breaking load multiplied by a bending efficiency factor in accordance with Ref. [3]:

Bending efficiency factor = 1 - 0.5/√(D/d),

where: **d** = the sling or cable laid rope diameter

D = the minimum diameter over which the sling body, sling eye, or grommet is bent.

5.12.2 For wire rope slings and grommets, this results in the bending efficiency factors detailed in the following Table 5-3.

Table 5-3 Bending Efficiency Factors

D/d	<1.0	1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0
Factor	Not Advised	0.50	0.59	0.65	0.71	0.75	0.78	0.80	0.81

5.12.3 For fibre rope slings, the bending efficiency may normally be taken as 1.00, provided the bending diameter is not less than the minimum specified by the manufacturer.

5.12.4 It should be noted that termination and bending factors should not be applied simultaneously. The one which results in the lower value of breaking load will govern, and should be used.

5.12.5 Under no circumstances should the sling or grommet body contact any surface where the radius is less than 0.5d to maintain the sling in good condition under load. Bending in way of splices shall be avoided. 8

5.12.6 In certain circumstances, it will be necessary to check sling eye bending losses around a shackle or trunnion, where the D/d ratio is less that 4.0. 6

5.13 SLING OR GROMMET SAFETY FACTORS

5.13.1 The minimum safety factor on sling or grommet breaking load shall be calculated after:

- resolution of the load based on centre of gravity position and sling angle, and
- consideration of the factors shown in Sections 5.2 to 5.12 as appropriate.

5.13.2 For steel slings and grommets the minimum safety factor shall be not less than 2.25.

5.13.3 For fibre slings and grommets the minimum safety factor shall be not less than 4.75.

5.13.4 Further safety factors shall be applied to the sling design based on termination and sling bending efficiency and sling usage.

5.14 SHACKLE SAFETY FACTORS

5.14.1 The shackle WLL should not be less than the static sling load. 7

5.14.2 In addition to Section 5.14.1 above, the dynamic sling load (static sling load x DAF) shall not exceed the sling MBL divided by a safety factor equal to 3.3. 6

5.14.3 Where the shackle is at the lower end of the rigging, the weight of the rigging components above the shackle, (including effects of the DAF and taking account of sling angle) may be deducted from the shackle load.

5.15 GROMMETS

5.15.1 Grommets require special consideration, to ensure that the rope breaking load and bending efficiency have been correctly taken into account. It is assumed that grommets are constructed and used in accordance with Ref. [3].

5.15.2 The load in a grommet shall be distributed into each part in the ratio 45:55, as indicated by Section 5.10.

5.15.3 The core of a grommet should be discounted when computing breaking load. The breaking load of a grommet is determined in accordance with Ref. [3].

5.15.4 The bending efficiency factors at each end of a grommet may differ, and the more severe value should be taken. Bending efficiency is derived as in Section 5.12 where rope diameter is the single part grommet diameter.

5.15.5 Bending in way of grommet butt and tuck positions shall be avoided. The location of the butt connection shall be marked.

5.16 CONSEQUENCE FACTORS

5.16.1 The following consequence factors shall be further applied to the structure including lift points and the lateral load effects on lift points, and their attachments into the structure:

Table 5-4 Consequence Factors 6

Lift points including spreader bars and frames	1.30
Attachments of lift points to structure	1.30
Members directly supporting or framing into the lift points	1.15
Other structural members	1.00

5.16.2 The consequence factors shown in Table 5-4 shall be applied based on the calculated lift point loads after consideration of all the factors shown in Sections 5.2 through 5.10. If a partial load factor design is used then the consequence factors in Table 5-4 shall also be applied to the partial load factors for structural design. Consequence factors in Table 5-4 shall also be applied to lift point lateral loads.

6 THE CRANE AND CRANE VESSEL

6.1 HOOK LOAD

6.1.1 The hook load shall be shown not to exceed the allowable crane capacity as taken from the load-radius curves. Crane curves are generally expressed as safe working loads or static capacities. Information should be obtained to document this. 6

6.1.2 The allowable load-radius curves as presented may sometimes include a dynamic effect allowance. If a suitable statement is received to this effect, the hook load may, for comparison with the load-radius curves, be derived from the dynamic hook load as defined in Section 5.3.

6.1.3 Some crane curves specify different allowable load curves for different seastates. These may similarly be taken to include dynamic effects. A seastate representing the probable limits for the operation should be chosen, and the gross weight used.

6.1.4 If the DAF included in the crane curves differs from the operation-specific value derived from Section 5.6, then the allowable load should be adjusted accordingly.

6.1.5 For offshore lifts by 2 or more hooks on the same crane boom, total load on the crane boom structure shall be documented by structural and dynamic analyses, based on Table 5-1 DAF's increased by 1.10 unless certified crane curves for this specific application can be provided.

6.1.6 Where heave compensated lifts are planned, then the following information on the crane or cranes shall be obtained:

- Crane technical description and operating procedures,
- Load radius curves in heave compensated mode plus limiting seastates and boom slew angles, 6
- Crane de-rating curves,
- FMEA for the crane system,
- DAF analysis in heave compensated mode
- Verify engine room/deck mechanics maintenance logs

6.2 DOCUMENTATION

6.2.1 Where Approval is required, the documentation as stated in Section 12 shall be submitted.

7 STRUCTURAL CALCULATIONS

7.1 LOAD CASES AND STRUCTURAL MODELLING

7.1.1 Structural calculations, based on the load factors discussed above, shall include adequate loadcases to justify the structure. For example, for an indeterminate, 4-point lift the following loadcases should normally be considered:

a. Base case, using gross or NTE weight, resolved to the lift points, but with no skew load factor.

b. Gross or NTE weight, with skew load factor applied to one diagonal.

c. Gross or NTE weight, with skew load factor applied to the other diagonal.

7.1.2 In all cases the correct or minimum sling angle and point of action, and any offset or torsional loading imposed by the slings shall be considered.

7.2 STRUCTURE

7.2.1 The overall structure shall be analysed for the loadings shown in Section 7.1.

7.2.2 The primary supporting members shall be analysed using the most severe loading resulting from Section 7.1, with a consequence factor applied (see Section 5.16).

7.3 LIFT POINTS

7.3.1 An analysis of the lift points and attachments to the structure shall be performed, using the most severe load resulting from Section 7.1 and all the factors as appropriate from Section 5.

7.3.2 Where the lift point forms an integral part of the structural node, then the lift point calculations shall also include the effects of loads imposed by the members framing into the lift point.

7.4 SPREADER BARS OR FRAMES

7.4.1 Spreader bars or frames, if used, should be similarly treated, with loadcases as above. A consequence factor shall be applied to spreader bars and frames, in accordance with Section 5.16.

7.5 ALLOWABLE STRESSES

7.5.1 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 and API RP2A have also been 6
considered a reference code - see Note 1 in Section 7.5.3 regarding its applicability.

7.5.2 Except for sacrificial bumpers and guides, the loading shall be treated as a normal serviceability limit state (SLS) / Normal operating case.

7.5.3 Infrequent load cases on sacrificial bumpers and guides should be treated as an ultimate limit state (ULS)/Survival storm case. This does not apply to:

- Steelwork subject to deterioration and/or limited initial NDT unless the condition of the entire loadpath has been verified, for example the underdeck members of a barge or ship
- Steelwork subject to NDT prior to elapse of the recommended cooling and waiting time as defined by the Welding Procedure Specification (WPS) and NDT procedures. In cases where this cannot be avoided by means of a suitable WPS, it may be necessary to impose a reduction on the design/permissible seastate
- Steelwork supporting sacrificial bumpers and guides 6
- Spreader bars, lift points and primary steelwork of lifted items
- Structures during a load-out.

Note 1:

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:

	WSD Option	**LRFD Option**
SLS:	1.00	1.60
ULS:	0.75	1.20

8 LIFT POINT DESIGN

8.1 INTRODUCTION

8.1.1 In addition to the structural requirements shown in Sections 5 and 7, the following should be taken into account in the lift point design:

8.2 SLING OVALISATION

8.2.1 Adequate clearance is required between cheek plates, shackle pins or inside 6
trunnion keeper plates, to allow for ovalisation under load. In general, the width available for the sling shall be not less than (1.25D + 25mm), where D is nominal sling diameter. However, the practical aspects of the rigging and de-rigging operations may demand a greater clearance than this.

8.2.2 For cast padears the geometry of the padear shall be configured to fully support and maintain the sling geometry and shape under load.

8.3 PLATE ROLLING AND LOADING DIRECTION

8.3.1 In general, for fabricated lift points, the direction of loading should be in line with the plate rolling direction. Lift point drawings should show the rolling direction.

8.3.2 Through thickness loading of lift points and their attachments to the structure should be avoided if possible. If such loading cannot be avoided, the material used shall be documented to be free of laminations, with a recognised through-thickness designation.

8.4 PIN HOLES

8.4.1 Pin-holes should be bored /reamed, and should be designed to suit the shackle proposed. Adequate spacer plates should be provided to centralise shackles. Pin hole clearances shall be 3% of the pin diameter or 3mm, whichever is the greater.

8.5 CAST PADEARS AND WELDED TRUNNIONS 6

8.5.1 Cast padears and trunnions shall be designed taking into account the following aspects:

- The geometrical considerations as indicated in Section 8.2.
- The stress analysis and finite element design process (modelling and load application).
- Load paths, trunnion geometry and space and support for slings. And grommets
- The manufacturing process and quality control.
- Sling keeper plates shall be incorporated into the padear/trunnions design to prevent the loss of sling or grommets during load application and lifting. These devices shall be proportioned to allow easy rigging and de-rigging 6 whilst being capable of supporting the weight of the sling section during transportation.

8.6 NON-DESTRUCTIVE TESTING

8.6.1 The extent of non-destructive testing shall be submitted for review.

8.6.2 Where repeated use is to be made of a lift point, a procedure should be presented for re-inspection after each lift.

8.7 CHEEK PLATES

8.7.1 Individual cheek plate thicknesses shall not exceed 50% of the main plate thickness to maintain the primacy of the main plate in load transfer to the structure, and to provide robustness to lateral loads.

8.7.2 Non-load bearing spacer plates may be used to centralise shackle pins, by effectively increasing the padeye thickness. The diameter of the internal hole in 6
such spacer plates shall be greater than the pin hole diameter. Spacer plates, if used, shall provide a 20-30mm clearance to the inside width of the shackle.

8.7.3 Cheek plate welds shall be proportioned and designed with due regard to possible uneven bearing across the padeye/cheek plate thickness due to combined nominal (5%) and actual lateral loads.

9 CLEARANCES

9.1 INTRODUCTION

9.1.1 The required clearances will depend on the nature of the lift, the proposed limiting weather conditions, the arrangement of bumpers and guides and the size and motion characteristics of the crane vessel and the transport barge.

9.1.2 Subject to the above, for offshore lifts, the following clearances should normally be maintained at each stage of the operation. Smaller clearances may be acceptable for inshore or onshore lifts. Clearances are based on a level lift (no tilt) of each structure. Additional clearances may be required for structures with a prescribed tilt.

9.2 CLEARANCES AROUND LIFTED OBJECT

9.2.1 3 metres between any part of the lifted object (including spreaders and lift points) and crane boom.

9.2.2 3 metres vertical clearance between the underside of the lifted object and any other previously installed structure, except in the immediate vicinity of the proposed landing area or installation aid where 1.5m clearance shall be adequate.

9.2.3 5 metres between the lifted object and other structures on the same transport barge unless bumpers and guides are used for lift-off. 6

9.2.4 3 metres horizontal clearance between the lifted object and any other previously installed structure, unless purpose-built guides or bumpers are fitted.

9.2.5 3 metres remaining travel between travelling block and fixed block at maximum load elevation with the lift vessel at LAT.

9.2.6 Where a structure is securely engaged within a bumper/guide or pin/bucket system, clearance between the extremities of the structure and the host structure must be demonstrated to be positive, considering the worst possible combinations of tilt. This may require dimensional control surveys to be carried out on the host structure and the structure to be installed.

9.2.7 Lift arrangement drawings shall clearly show all clearances as defined above.

9.2.8 Clearances above for lifts by floating crane vessels onto floating structures (e.g. spars, FPSO's) will need special consideration. It is expected that these clearances will need to be larger than those stated above, and is dependent on the transient motion of the floating structure and the lifting vessel. 6

9.2.9 Consideration should be given when lifting and overboarding structures over or in the vicinity of a subsea asset to provide sufficient horizontal clearance for dropped objects.

9.3 CLEARANCES AROUND CRANE VESSEL

9.3.1 Where the crane vessel is moored adjacent to an existing fixed platform the following clearances apply, for an intact mooring system:

- 3m between any part of the crane vessel/crane and the fixed platform on lifted structure;
- 5m between any part of the crane vessel hull extremity and the fixed platform or submerged lift;
- 10 m between any anchor line and the fixed platform.

9.3.2 Where the crane vessel is dynamically positioned in accordance with class 3 DP regulations, a 5m nominal clearance between any part of the crane vessel and the fixed platform shall be maintained.

9.3.3 3m between crane vessel keel (including thrusters) and seabed, after taking account of tidal conditions, vessel motions, increased draft and changed heel or trim during the lift.

9.3.4 Clearances around the crane vessel either moored or dynamically positioned and any floating platform, drilling rig or submersible, shall be determined as special cases based on the station keeping analysis of the floating structure and the lifting vessel. Positioning equipment and procedures shall be defined to maintain minimum clearances for specific operations and minimum durations. 6

9.4 CLEARANCES AROUND MOORING LINES AND ANCHORS

9.4.1 The clearances stated below are given as guidelines to good practice. The specific requirements and clearances should be defined for each project and operation, taking into account particular circumstances such as:

- water depth
- proximity of subsea assets
- survey accuracy
- the station keeping ability of the anchor handling vessel
- seabed conditions
- estimated anchor drag during embedment
- single mooring line failure in the vessel stand-off position
- the probable weather conditions during anchor installation.

9.4.2 Operators may have their own requirements which may differ from those stated below, and should govern if more conservative.

9.4.3 Clearances should take into account the possible working and stand-off positions of the crane vessel.

9.4.4 Moorings should never be laid in such a way that they could be in contact with any subsea asset. This may be relaxed when the subsea asset is a trenched pipeline, provided it can be demonstrated that the mooring will not cause frictional damage or abrasion to coating systems.

9.4.5 Moorings shall never be run over the top of a subsea completion or wellhead.

9.4.6 Whenever an anchor is run out over a pipeline, flowline or umbilical, the anchor shall be securely stowed on the deck of the anchor handling vessel. In circumstances where either gravity anchors or closed stern tugs are used, and anchors cannot be stowed on deck, the anchors shall be double secured through the additional use of a safety strap or similar.

9.4.7 The vertical clearance between any anchor line and any subsea asset should be not less than 20 metres in water depths exceeding 40 metres, and 50% of water depth in depths of less than 40 metres.

9.4.8 Clearance between any mooring line and any structure other than a subsea asset should not be less than 10 metres.

9.4.9 When an anchor is placed on the same side of a subsea asset as the crane vessel, it should not be placed closer than 100 metres to the subsea asset.

9.4.10 When the subsea asset lies between the anchor and the crane vessel, the final anchor position should be no less than 200 metres from the subsea asset.

9.4.11 During lifting operations, crossed mooring situations should be avoided wherever practical. Where crossed moorings cannot be avoided, the separation between active catenaries should be no less than 30 metres in water depths exceeding 100 metres, and 30% of water depth in water depths less than 100 metres.

9.4.12 If any of the clearances specified in Sections 9.4.7 to 9.4.11 are impractical because of the mooring configuration or seabed layout, a risk assessment shall be carried out and special precautions taken as necessary.

9.4.13 Temporary lay-down of an anchor wire (but not chain) over a pipeline, umbilical, spool or cable may be acceptable subject to all of the following being submitted to this office:

a. Evidence that there is no other practicable anchor pattern that would avoid the lay-down.

b. The status of a pipeline or spool (e.g. trenched, live, rock-dumped, on surface) and its contents (e.g. oil, gas, water) and internal pressure.

c. Procedures clearly stating the maximum duration that the anchor wire is in contact with the pipeline, umbilical, spool or cable and the reason for the contact. 6

d. Written evidence that the pipeline owner accepts the laying down of the anchor wire over the pipeline, umbilical, spool or cable.

e. Evidence that the anchor wire will be completely slack i.e. no variation in tension.

f. Evidence that the seastate during the lay-down will be restricted to an acceptable value.

g. Documentation demonstrating that the anchor wire or its weight will not overstress or damage the coating on the pipeline, umbilical, spool or cable.

10 BUMPERS AND GUIDES

10.1 INTRODUCTION

10.1.1 For module installation the arrangement and design philosophy for bumpers and guides shall be submitted, where applicable. In general, bumpers and guides should be designed in accordance with the following:

10.2 MODULE MOVEMENT

10.2.1 The maximum module movement during installation should be defined. In general the module motions should be limited to:

- Vertical movement: ± 0.75 m
- Horizontal movement: + 1.50 m
- Longitudinal tilt: 2 degrees
- Transverse tilt: 2 degrees
- Plan rotation: 3 degrees.

10.2.2 The plan rotation limit is only applicable prior to engagement on the bumper/guide or pin/bucket system, and when the module is close to its final position or adjacent to another structure on a cargo barge. 6

10.3 POSITION OF BUMPERS AND GUIDES

10.3.1 The position of bumpers and guides shall be determined taking into account acceptable support points on the module.

10.3.2 Dimensional control reports shall be reviewed of the as-built bumper and guide system to ensure fit up offshore.

10.3.3 Nominal clearances between bumpers/guides and pins/buckets shall be +/-25mm to account for fabrication and installation tolerances. These may be reduced based on trial fits and/or a more stringent dimensional control regime. 6

10.4 BUMPER AND GUIDE FORCES

10.4.1 For offshore lifts, bumpers and guides should be designed to the following forces (where W = static hook load):

a. <u>Vertical sliding bumpers</u>

Horizontal force in plane of bumper:	0.10 x W
Horizontal (friction) force, out of plane of bumper:	0.05 x W
Vertical (friction) force:	0.01 x W

Forces in all 3 directions will be combined to establish the worst design case.

b. <u>Pin/bucket guides</u>

Horizontal force on cone/end of pin:	0.05 x W
Vertical force on cone/end of pin:	0.10 x W

Horizontal force in any direction will be combined with the vertical force to establish the worst design case.

c. Horizontal "cow-horn" type bumpers with vertical guide

Horizontal force in any direction:	0.10 x W
Vertical (friction) force:	0.01 x W

Horizontal force in any direction will be combined with the vertical force to establish the worst design case.

d. Vertical "cow-horn" type guide with horizontal bumper

Horizontal force in any direction:	0.05 x W
Vertical force on inclined guide-face:	0.10 x W

Horizontal force in any direction will be combined with the vertical force to establish the worst design case.

10.4.2 For inshore lifts under controlled conditions, bumpers and guides may be designed to 50% of the forces shown in Section 10.4.1. 6

10.5 DESIGN CONSIDERATIONS

10.5.1 The connection into the module, and the members framing the bumper or guide location, should be at least as strong as the bumper or guide.

10.5.2 The stiffness of bumper and guide members should be as low as possible, in order that they may deflect appreciably without yielding.

10.5.3 Design of bumpers and guides should cater for easy sliding motion of the guide in contact with bumper. Sloping members should be at an acute angle to the vertical. Ledges and sharp corners should be avoided on areas of possible contact, and weld beads should be ground flush.

10.5.4 With reference to Section 7.5.1, the strength of bumpers and guides that are deemed to be "sacrificial" should be assessed to the ultimate limit state (ULS). The bumper and guide connection to the supporting structure shall be assessed to the normal serviceability limit state (SLS). 6

11 PRACTICAL CONSIDERATIONS

11.1 Adequate and safe access and working platforms should be provided for connection of slings, particularly where connection or disconnection is required offshore or underwater.

11.2 Seafastening on the transport barge should be designed:

- To minimise offshore cutting
- To provide restraint after cutting
- To allow lift off without fouling.

11.3 All cut lines should be clearly marked. Where a 2-stage lift is planned - e.g. barge to lift vessel, then lift vessel to final position, involving 2 sets of cut lines, these should preferably be in different colours.

11.4 Adequate equipment must be available on the transport barge, including as appropriate:

- Burning sets
- Tuggers and lifting gear
- Means of securing loose seafastening material
- Lighting for night operations
- Safety equipment for personnel.
- Safe access to and from the transport barge.

11.5 All loose equipment, machinery, pipework and scaffolding shall be secured against movement during the lift, and the weights and positions allowed for in the gross weight.

11.6 Prior to the start of the lift, a forecast of suitable weather shall be received, of a duration adequate to complete the operation, with contingencies, and taking into account any subsequent critical marine operations.

11.7 The sling laydown arrangement shall show that:

a. The slinging arrangement is in accordance with acceptable good practice.

b. Large diameter slings and grommets shall be painted with a white line along the length to monitor twisting during handling and laydown. 6

c. The slings are matched as accurately as possible, unless the rigging arrangement is deliberately non-symmetrical to take account of centre of gravity offset, in which case matched pairs of slings should normally be used. Where minor mismatch in sling length exists, the slings should be arranged to minimise skew loads.

d. The slings are adequately secured against barge motions, prior to the start of the lift.

e. The slings will not foul obstructions such as walkways and handrails when lifted, and any unavoidable obstructions are properly protected.

f. The slings will not kink when lifted.

g. After the lift the slings (and spreaders if used) can be safely laid down again, without damage.

h. In the event that a single sling attached to a single lift point is planned, it should be doubled to prevent the sling unwinding under load.

11.8 Slings with hand spliced terminations must be prevented from rotation.

11.9 No bending is allowed at or close to a termination.

11.10 It is permissible to shackle slings together end-to-end to increase the length. However, slings of opposite lay should never be connected together.

11.11 It is permissible to increase the length of a sling by inserting an extra shackle or specifically designed link plates. Any shackle to shackle connections should be bow-to-bow, not pin-to-pin or pin-to-bow so that shackles remain centred under load and also the load take-up. 6

11.12 Crane vessel motions should be monitored in the period prior to the lift, to confirm that the dynamic behaviour is acceptable, taking into account the weight and size of the lifted object, the clearances for lifting off the transport barge, the hoisting speed, the clearances for installation and the installation tolerances.

11.13 Transport barge motions should be similarly monitored prior to the start of the lift. The change in attitude of the transport barge when the weight is removed should be taken into account.

12 INFORMATION REQUIRED FOR APPROVAL

12.1 GENERAL INFORMATION REQUIRED

12.1.1 Where approval is required, a package shall be submitted to Noble Denton for review, consisting of:

a. Justification of weight and centre of gravity, by Weight Control Report or weighing report.

b. Structural analysis report for structure to be lifted, including lift points and spreaders, as set out in Section 7.

c. Rigging arrangement package, showing sling geometry, computed sling loads, required breaking loads, tabulation of slings and shackles proposed, certificates for slings and shackles.

d. Crane details, including load-radius curve with lift superimposed, and details of vertical and horizontal clearances, and mooring arrangements.

e. The management structure and marine procedures.

12.2 THE STRUCTURE TO BE LIFTED

12.2.1 Calculations shall be presented for the structure to be lifted, demonstrating its capacity to withstand, without overstress, the loads imposed by the lift operation, with the load and safety factors stated in Section 5, and the loadcases discussed in Section 7.

12.2.2 The calculation package shall present, as a minimum:

a. Plans, elevations and sections showing main structural members

b. The structural model. This should account for the proposed lifting geometry, including any offset of the lift points

c. The weight and centre of gravity

d. The steel grades and properties

e. The loadcases imposed

f. The Codes used

g. A tabulation of member and joint Unity Checks greater than 0.8

h. Justification, or proposal for redesign, for any members with a Unity Check in excess of 1.0.

i. Copies of existing sling certificates planned to be used (consolidation and dimensional conformity certificates). 6

12.2.3 An analysis or equivalent justification shall be presented for all lift points, including padeyes, padears and trunnions, to demonstrate that each lift point, and its attachment into the structure, is adequate for the loads and factors set out in Sections 5 and 7.

12.2.4 A similar analysis shall be presented for spreader bars, beams and frames.

12.3 INDEPENDENT ANALYSIS

12.3.1 Alternatively, Noble Denton will, if instructed, perform an independent analysis of the structure to be lifted, including the lift points, on receipt of the necessary information.

12.4 CODES AND SPECIFICATIONS

12.4.1 For analysis of the structure to be lifted and the lift points, an accepted offshore structural design code shall be used as described in Section 7.5.

12.4.2 Adequate specifications for material properties, construction, welding, casting, inspection and testing shall be used.

12.5 EVIDENCE OF SATISFACTORY CONSTRUCTION

Confirmation shall be presented, from a Certifying Authority, Classification Society or similar, that the structure including the lift points and their attachments has been constructed in accordance with the drawings and specifications.

12.6 RIGGING ARRANGEMENTS

12.6.1 A proposal shall be presented showing:

a. The proposed rigging geometry showing dimensions of the structure, centre of gravity position, lift points, crane hook, sling lengths and angles, including shackle dimensions and "lost" length around hook and trunnions.

b. A computation of the sling and shackle loads and required breaking loads, taking into account the factors set out in Section 5.

c. A list of actual slings and shackles proposed, tabulating:

- Position on structure
- Sling/shackle identification number
- Sling length and diameter
- Rigging utilisation factor summaries 6
- CSBL, CRBL for slings or CGBL for grommets,
- SWL or WLL for shackles
- Construction
- Direction of lay
- Wire grade and wire type (bright or galvanised). 6

d. Copies of inspection/test Certificates for all rigging components.

12.6.2 Slings and grommets should be manufactured and inspected in accordance with the International Marine Contractors Association Guidance on Cable laid slings and grommets Ref. [3], or similar acceptable standard. A thorough examination shall be carried out as required by that document for all rigging components whether new or existing.

12.6.3 Shackles manufactured by an industry-recognised manufacturer, shall be covered by a test certificate not exceeding 6 months old, and if not new, a report of an inspection by a competent person since the last lift. 6

12.6.4 Where 9-part slings are proposed for use in a lifting system, certification of these slings shall be given special consideration.

12.6.5 Where an existing sling has been used doubled and this sling shows a permanent kink, it shall not be used in a single configuration. 6

12.7 THE CRANE VESSEL

12.7.1 Information shall be submitted on the crane vessel and the crane. This shall include, as appropriate:

- Vessel general arrangement drawings and specification
- Details of registry and class
- Mooring system and anchors
- Vessel station keeping procedures
- DP operating and positioning procedures (as applicable) and station keeping analyses/rosettes 6
- Vessel DP system FMEA
- Operating and survival drafts
- Crane specification and operating curves (including where necessary the dynamic crane capacity / curve). 6
- Details of any ballasting operations required during the lift.

12.7.2 The mooring arrangement for the operation and stand-off position shall be submitted. This should include the lengths and specifications of all mooring wires and anchors, and a mooring plan showing adequate horizontal clearances on all platforms, pipelines and any other seabed obstructions. An elevation of the catenary for each mooring line, for upper and lower tension limits, shall demonstrate adequate vertical clearance over pipelines and horizontal clearance to fixed installations and the structure being lifted.

12.8 PROCEDURES AND MANAGEMENT

12.8.1 Sufficient management and resources shall be provided to carry out the operation efficiently and safely.

12.8.2 Quality, safety and environmental hazards shall be managed by a formal Quality Management system.

12.8.3 The management structure for the operation, including reporting and communication systems, and links to safety and emergency services shall be demonstrated.

12.8.4 The anticipated timing and duration of each operation shall be submitted.

12.8.5 The arrangements for control, manoeuvring and mooring of barges and/or other craft alongside the crane vessel shall be submitted.

12.8.6 A weather forecast from an approved source, predicting that conditions will be within the prescribed limits, shall be received prior to the start of the operation, and at 12 hourly intervals thereafter, until the operation is deemed complete, in accordance with Section 4.5.3.

12.8.7 In field monitoring of waves (height, direction and period) should be considered to enhance the 12 hourly forecast for each specific lift operation where a Certificate of Approval is required.

12.8.8 In field monitoring of currents (speed and direction) for subsea lifts in areas where it is known that high currents exist in the water column should be considered to enhance the 12 hourly forecast where a Certificate of Approval is required. 6

12.8.9 For marine operations that are planned to carried out in close proximity to fixed or moored installations, appropriate risk assessments and vessel audits shall be carried out prior to issue of a certificate of approval. This may include attendance at vessel annual DP trials and witnessing of in-field DP checks that are scheduled for a specific marine operation.

12.8.10 Risk assessments, HAZOP/HAZID studies shall be carried out by Contractor in the presence of Client, MWS and actual Contractor's operational personnel. These studies shall be completed at an early stage so that the findings can be incorporated into the operational procedures.

12.9 SURVEYS

12.9.1 Where Noble Denton approval is required the surveys shown in Table 12-1 will usually be needed:

Table 12-1 Typically Required Surveys

Survey	Time	Place
Sighting of inspection/test. certificates for slings and shackles	Prior to departure of structure from shore	ND /client's office or fabrication yard
Sighting of inspection /test certificates or release notes for lift points and attachments	Prior to departure of structure from shore	ND /client's office or fabrication yard.
Inspection of rigging laydown and seafastening	Prior to departure of structure from shore	Fabrication yard
Inspection of securing of loose items inside module	Prior to departure of structure from shore	Fabrication yard
Suitability survey of crane vessel, if required	Prior to start of marine operations	As available
Inspection of preparations for lift, and issue of Certificate of Approval	Immediately prior to cutting seafastening	At lift site

REFERENCES

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

[2] ISO International Standard ISO 19901-5:2003 – Petroleum and natural gas industries – specific requirements for offshore structures – Part 5: Weight control during engineering and construction.

[3] The International Marine Contractors Association - Guidance on the Use of Cable Laid Slings and Grommets - IMCA M 179 August 2005.

[4] ISO International Standard ISO2408 - Steel wire ropes for General Purposes - Characteristics 6

[5] ISO International Standard ISO 7531 - Wire Rope slings for General Purposes - Characteristics and Specifications.