These Guidelines have been updated as part of the first stage of the harmonisation between the GL Noble Denton and DNV heritage marine services requirements.

Refer also to DNVGL-SE-0080 Noble Denton marine services – Marine Warranty Survey for further details.

All references to GL Noble Denton apply to the legal entity trading under the DNV GL or GL Noble Denton name which is contracted to carry out the scope of work and issues a Certificate of Approval, or provides a marine related advisory or assurance service.

Once downloaded this document becomes UNCONTROLLED.

Please check the website below for the current version.

http://www.dnvgl.com/
PREFACE

This document has been drawn with care to address what are considered to be the primary issues in relation to the contents based on the experience of the GL Noble Denton Group of Companies (“the Group”). This should not, however, be taken to mean that this document deals comprehensively with all of the issues which will need to be addressed or even, where a particular matter is addressed, that this document sets out a definitive view for all situations. In using this document, it should be treated as giving guidelines for sound and prudent practice, but guidelines must be reviewed in each particular case by the responsible organisation 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 guidance given is sound and comprehensive.

Reasonable precaution has been taken in the preparation of this document to seek to ensure that the content is correct and error free. However, no company in the Group

- shall be liable for any loss or damage incurred resulting from the use of the information contained herein or
- shall voluntarily assume a responsibility in tort to any party or
- shall owe a duty of care to any party other than to its contracting customer entity (subject always to the terms of contract between such Group company and subcontracting customer entity).

This document must be read in its entirety and is subject to any assumptions and qualifications expressed therein as well as in any other relevant communications by the Group in connection with it. Elements of this document contain detailed technical data which is intended for analysis only by persons possessing requisite expertise in its subject matter.

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SUMMARY

1.1 This document sets out the Guidelines on which GL Noble Denton approval of pipeline installation by laying, pulling or towing, would be based. GL Noble Denton approval is primarily concerned with ensuring that marine activities involved in pipeline installations are carried out in accordance with sound standards and practice.

1.2 Such marine activities could include:

- The load-out, marine transportation and handling of line pipe, flexible pipe and umbilicals
- Marine pipelay operations, including vessel mooring or station keeping on DP, pipe handling, start-up, lay-down and recovery, pipeline and cable crossings, above water tie-ins (AWTI) and landfalls as appropriate for rigid pipe
- Marine pipelay operations as above but as appropriate for the laying of flexible lines
- Burial of the pipeline by trenching and backfill, jetting or rock placement or dumping
- The installation of flexible or rigid risers into external clamps or J-tubes, and steel catenary risers and flexible risers between subsea structures and floating units, including riser arches or other buoyancy units
- Installation of deep water Steel Catenary Risers (SCR), including transfer operations from pipelay vessel to host facility.
- Launch, towage and installation of towed pipelines
- Installation of PLETs (Pipeline End Terminations) and Inline Structures as an integral part of pipe line catenary. Installation of PLETs and Inline Structures by lifting is covered in 0027/ND, Ref. [4].
- Shore pull and offshore pull, which are often used for shore crossings (see Section 10.2).

1.3 These guidelines do not cover production aspects of pipeline construction or of certain other specifics such as:

- Manufacture, fabrication and coating of line pipe, flexible pipe, umbilicals and cables and their permanent appurtenances (although protection of the integrity of the pipe /flexible /umbilical /cable during installation is covered by these guidelines)
- Welding, non-destructive testing, field joint coating or anodes for cathodic protection. These guidelines do not cover these aspects in detail. However, information on these activities needs to be submitted with details of inspections and QC procedures for approval of pipelay operations.
- Diving procedures
- Tunnelled and drilled shore crossings.

1.4 These guidelines refers to other GL Noble Denton guideline documents, covering load-outs, vessel surveys, marine transportation and lifting, which should be read in conjunction with this document for additional guidance where referenced. In particular reference should be made to 0001/ND “General Guidelines for Marine Projects”, Ref. [1].

1.5 This Revision 1 replaces Revision 0 of 22 June 2013. Major changes are described in Section 2.4.1

1.6 The document discusses the process of approval, and when required by an Insurance Warranty, the issue of Certificates of Approval and their limitations.

1.7 Criteria for specific non-standard operations should be discussed individually with GL Noble Denton.
2 INTRODUCTION

2.1 SCOPE

2.1.1 This document is intended to cover the technical and marine requirements of the GL Noble Denton Group for the approval of offshore pipeline installation works. Such an approval is primarily concerned with ensuring that marine activities involved in pipeline installations are carried out in accordance with sound standards and practice. It specifically excludes production and production control activities (welding, NDT, field joint coating), which are essentially independent of the marine function, and does not represent any approval of fitness for purpose of the completed pipeline.

2.1.2 These guidelines cover such requirements for:

- “S” lay or “J” lay of rigid single or multiple pipelines using laying vessels assembling the line from joints of pipe and held on station by moorings or dynamic positioning
- Reel lay of rigid single pipes or multiple pipelines where a straightener is used
- Laying products such as flexible pipelines, risers and jumpers, umbilicals and cables using vessels which carry the completed product on reel(s) or carousel(s). These can be laid using chutes or purpose built lay towers where no straightener is used
- The launch, tow and installation of towed rigid pipelines and bundles
- Shore and offshore pulls.

2.1.3 These guidelines also cover other marine aspects of the installation work including seabed survey, line-pipe transportation, burial of the line when required, and the installation of risers and other tie-in spools or jumpers.

2.1.4 Special consideration will be required for the installation of pipelines in Arctic and other cold regions that are subject to similar sea ice, iceberg and icing conditions.

2.2 OTHER GL NOBLE DENTON DOCUMENTS

2.2.1 This document refers to, and should be read in conjunction with, other GL Noble Denton Guideline Documents. In particular reference should be made to 0001/ND “General Guidelines for Marine Projects”, Ref. [1] for

- the approval process
- Health, Safety & Environment
- Organisation, Planning and Documentation
- Weather criteria
- Weight control and structural strength.

2.3 NATIONAL CODES AND LEGISLATION

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

2.3.2 Care should be taken that the pipeline installation operation complies with relevant national codes and legislation. Note that international pipelines may need to comply with two or more sets of codes, standards, and statutory requirements.
2.4 UPDATES
2.4.1 This Revision 1 supersedes Revision 0 of 22 June 2013, and the main changes, marked with a line in the right hand margin, include changes to:
- Definition of GL Noble Denton in Section 3
- Route radii in Section 5.3.1
- Start up rigging strength in Section 10.3.4
- Sling safety factors in Section 10.3.8
- Strength of towhead and attachments in Section 10.10.12

2.5 DOWNLOADS & FEEDBACK
2.5.1 Electronic versions of GL Noble Denton Guidelines are available on:

2.5.2 Please contact the Technical Standards Committee Secretary at TSC@dnvgl.com with any queries or feedback.
3 DEFINITIONS

3.1 For the purposes of this Document and the GL Noble Denton approval process, the following definitions apply. Referenced definitions are underlined.

<table>
<thead>
<tr>
<th>Term or Acronym</th>
<th>Definition</th>
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<tr>
<td>Alpha Factor</td>
<td>The maximum ratio of operational criteria / design environmental condition to allow for weather forecasting inaccuracies. See Section 7.4.8 of 0001/ND, Ref. [1].</td>
</tr>
<tr>
<td>A&amp;R Winch</td>
<td>The Abandonment and Retrieval winch on a lay vessel whose primary purpose is to lower the pipeline to the seabed and to retrieve it back to the lay vessel with sufficient working tension to control the pipe catenary within safe code limits at all stages.</td>
</tr>
<tr>
<td>Approval</td>
<td>The act, by the designated GL Noble Denton representative, of issuing a Certificate of Approval.</td>
</tr>
<tr>
<td>AUT</td>
<td>Automatic Ultrasonic Testing</td>
</tr>
<tr>
<td>AWTI</td>
<td>Above Water Tie-In</td>
</tr>
<tr>
<td>Barge</td>
<td>A non-propelled vessel commonly used to carry cargo or equipment. (For the purposes of this document, the term Barge can be considered to include Pontoon, Ship or Vessel where appropriate).</td>
</tr>
<tr>
<td>Bend Restrictor</td>
<td>A device with several interlocking elements that lock when a design radius is achieved.</td>
</tr>
<tr>
<td>Bend Stiffener</td>
<td>A device for limiting the bend radius of the umbilical by providing a localised increase in bending stiffness.</td>
</tr>
<tr>
<td>Bird Caging</td>
<td>A phenomenon whereby armour wires locally rearrange with an increase and/or decrease in pitch circle diameter as a result of accumulated axial and radial stresses in the armour layer(s).</td>
</tr>
<tr>
<td>BSR / Bend Strain Reliever</td>
<td>A tapered plastic sleeve fitted to a flexible pipe, umbilical or cable at the transition between a stiff section (typically an end fitting or connector) and the normal body of the pipe, umbilical or cable.</td>
</tr>
<tr>
<td>Buckle “Wet” / “Dry”</td>
<td>A local collapse of pipe cross section in the span of pipe between the lay vessel and the seabed. “Dry” means that the pipe wall is not breached and “Wet” means that the pipe wall is breached and seawater floods into the pipe.</td>
</tr>
<tr>
<td>Bundle</td>
<td>A configuration of two or more pipelines joined together and either strapped or contained within a carrier or sleeve pipe.</td>
</tr>
<tr>
<td>Carrier or Sleeve pipe</td>
<td>The outer casing of a bundle or pipe-in-pipe.</td>
</tr>
<tr>
<td>CDT / Controlled Depth Tow</td>
<td>A special tow operation where the pipe string or bundle is made almost buoyant and towed at a controlled depth within the water column, suspended between a lead and trail tug.</td>
</tr>
<tr>
<td>Certificate of Approval</td>
<td>A formal document issued by GL Noble Denton stating that, in its judgement and opinion, all reasonable checks, preparations and precautions have been taken to keep risks within acceptable limits, and an operation may proceed.</td>
</tr>
<tr>
<td>Chinese Fingers</td>
<td>Also known as pulling socks are used to pull or support cables and pipes. They work on the principle of the harder the pull, the tighter the grip.</td>
</tr>
<tr>
<td>Term or Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------------------</td>
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</tr>
<tr>
<td>Client</td>
<td>The company to which GL Noble Denton is contracted to perform marine warranty or consultancy activities.</td>
</tr>
<tr>
<td>Competent person</td>
<td>Someone who has sufficient training and experience or knowledge and other qualities that allow them to assist you properly. The level of competence required will depend on the complexity of the situation and the particular help required.</td>
</tr>
<tr>
<td>DMA / Dead Man Anchor</td>
<td>Anchor or multiple anchors (which may be clump weights, sometimes buried), typically used to initiate pipelay.</td>
</tr>
<tr>
<td>DP</td>
<td>Dynamic Positioning or Dynamically Positioned</td>
</tr>
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<td>ECA</td>
<td>Engineering Criticality Assessment</td>
</tr>
<tr>
<td>FAT</td>
<td>Factory Acceptance Test</td>
</tr>
<tr>
<td>FBE</td>
<td>Fusion Bonded Epoxy</td>
</tr>
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<td>FEA</td>
<td>Finite Element Analysis</td>
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<tr>
<td>FGSO</td>
<td>Floating Gas Storage and Offloading Vessel</td>
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<tr>
<td>FJC</td>
<td>Field Joint Coating (FJC) refers to single or multiple layers of coating applied to girth welds and associated cutback of the line pipe coating. Coating can be applied in factory or field.</td>
</tr>
<tr>
<td>FMECA or FMEA</td>
<td>Failure Modes Effects Analysis or Failure Modes Effects and Criticality Analysis</td>
</tr>
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<td>FPS / Floating Production System</td>
<td>Including FPV, FPU, FPSO, FGSO, spar (buoy) or TLP</td>
</tr>
<tr>
<td>FPSO</td>
<td>Floating Production, Storage and Offloading Vessel</td>
</tr>
<tr>
<td>FPU or FPV</td>
<td>Floating Production Unit or Floating Production Vessel</td>
</tr>
<tr>
<td>GL Noble Denton</td>
<td>The legal entity trading under the DNV GL or GL Noble Denton name which is contracted to carry out the scope of work and issues a Certificate of Approval, or provides a marine related advisory or assurance service.</td>
</tr>
<tr>
<td>GPS / Global Positioning System</td>
<td>A satellite based system providing geographic co-ordinate location.</td>
</tr>
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<td>HAZOP</td>
<td>HAZards and OPerability study</td>
</tr>
<tr>
<td>HIRA</td>
<td>Hazard Identification and Risk Assessment</td>
</tr>
<tr>
<td>HSEQ</td>
<td>Health, Safety, Environment and Quality</td>
</tr>
<tr>
<td>Hydrotest</td>
<td>A pressure test at a pressure normally at 1.25 to 1.5 times the pipeline design pressure (for rigid pipelines), which is made after installation operations are substantially or wholly completed, to provide proof of pressure and strength integrity of the pipeline and spools.</td>
</tr>
<tr>
<td>IMCA</td>
<td>International Marine Contractors Association</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>Insurance Warranty</td>
<td>A clause in the insurance policy for a particular venture, requiring the assured to seek approval of a marine operation by a specified independent survey house.</td>
</tr>
<tr>
<td>Term or Acronym</td>
<td>Definition</td>
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<tr>
<td>IP / Intersection Point</td>
<td>The point at which two straight sections or tangents to a pipeline curve meet when extended.</td>
</tr>
<tr>
<td>J-Lay</td>
<td>A laying method where the pipe joints are raised to a nearly vertical angle in a tower mounted on a pipelay vessel in a tower, assembled and lowered, curved through approximately 90° (J shape) to lie horizontally on the sea-bed.</td>
</tr>
<tr>
<td>KP / Kilometre Point</td>
<td>The position of on pipeline route at a given distance from an agreed reference point, typically at or near one end.</td>
</tr>
<tr>
<td>LAT</td>
<td>Lowest Astronomical Tide.</td>
</tr>
<tr>
<td>Lay Back</td>
<td>The horizontal offset from the last pipe support on the lay vessel to the touch down point on the seabed.</td>
</tr>
<tr>
<td>Line pipe</td>
<td>Joints of pipe before being welded together to form a pipeline.</td>
</tr>
<tr>
<td>Load-out</td>
<td>The transfer of an assembly, module, pipes or component onto a barge, e.g. by horizontal movement or by lifting.</td>
</tr>
<tr>
<td>MAOP</td>
<td>Maximum Allowable Operating Pressure</td>
</tr>
<tr>
<td>LS2 / Limit State 2</td>
<td>A design condition where the loading is dominated by environmental / storm loads, e.g. at the 10- or 50-year return period level or, for weather-restricted operations, where an Alpha Factor according to Section 7.3.3 of 0001/ND, Ref [1], is to be applied.</td>
</tr>
<tr>
<td>MBL</td>
<td>The minimum allowable value of breaking load for a particular sling, grommet, wire or chain etc.</td>
</tr>
<tr>
<td>MBR / Minimum Bending Radius</td>
<td>Specified by the manufacturer of a flexible pipe, umbilical or cable. T. This is the minimum radius to which a flexible, umbilical or cable can be bent without compromising its integrity.</td>
</tr>
<tr>
<td>NDT / Non Destructive Test</td>
<td>Ultrasonic scanning, magnetic particle inspection, eddy current inspection or radiographic imaging or similar. May include visual inspection.</td>
</tr>
<tr>
<td>Offshore pull</td>
<td>The pulling of a pipeline away from the shore using a lay barge /vessel</td>
</tr>
<tr>
<td>Operation Duration</td>
<td>The planned duration of the operation from the forecast prior to the Point of No Return to a condition when the operations /structures can safely withstand a seasonal design storm (also termed “safe to safe” duration); this excludes the contingency period.</td>
</tr>
<tr>
<td>Operational reference period</td>
<td>The Operation Duration, plus the contingency period</td>
</tr>
<tr>
<td>OSS</td>
<td>Out of Straightness Survey (see Section 6.6.2)</td>
</tr>
<tr>
<td>Pipe burial</td>
<td>The operation of covering the pipeline with graded granular soil or rock, e.g. rock-dump, or by transferring adjacent seabed soils onto the pipe.</td>
</tr>
<tr>
<td>Pipe transportation</td>
<td>The operation of transporting sections of pipe, generally from a shore base to the pipelay vessel.</td>
</tr>
<tr>
<td>Pipe trenching</td>
<td>The operation of lowering the level of the pipeline below the seabed by jetting, ploughing or by use of a cutting machine. The trench may be made before pipelay or after pipelay.</td>
</tr>
<tr>
<td>Pipe-in-Pipe</td>
<td>A single rigid pipe held within a carrier pipe by spacers and/or solid filler.</td>
</tr>
<tr>
<td>Term or Acronym</td>
<td>Definition</td>
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<tr>
<td>-----------------</td>
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</tr>
<tr>
<td>Pipelay</td>
<td>The operation of assembling and laying the pipeline on the seabed, from start-up point to lay-down point.</td>
</tr>
<tr>
<td>Pipeline</td>
<td>Any marine pipeline system for the carriage of oil, gas, water or other process fluids. It may be of rigid material or flexible layered construction. For the purposes of this document the term pipeline includes flowlines as defined in API RP 1111, Ref. [8].</td>
</tr>
<tr>
<td>PLET</td>
<td>Pipeline End Termination</td>
</tr>
<tr>
<td>PNR / Point of No Return</td>
<td>The last point in time, or a geographical point along a route, at which an operation could be aborted and returned to a safe condition.</td>
</tr>
<tr>
<td>Product</td>
<td>A generic term used within these guidelines to reference flexible pipelines, risers, jumpers, umbilicals and submarine cables.</td>
</tr>
<tr>
<td>PRT</td>
<td>Pipeline Recovery Tooling/Tool</td>
</tr>
<tr>
<td>QC</td>
<td>Quality Control</td>
</tr>
<tr>
<td>QCFAT</td>
<td>Quality Control Factory Acceptance Test</td>
</tr>
<tr>
<td>Reel Lay (for rigid pipe)</td>
<td>A laying method where the pipeline is pre-assembled into long strings or stalks and wound onto a large reel with the pipe experiencing plastic deformation when wound on and off the reel and straightened when reeled off. Typical lay angles of 20 to 90 degrees are achieved.</td>
</tr>
<tr>
<td>ROV / Remotely (Controlled) Operated Vehicle</td>
<td>A device deployed subsea on a tether or umbilical, typically equipped with a subsurface acoustic navigation system and thrusters, to control its location and attitude, and a lighting and video system. Additional devices such as manipulators, acoustic scanning for touch down monitoring, etc., may also be provided.</td>
</tr>
<tr>
<td>SCR</td>
<td>Steel Catenary Riser</td>
</tr>
<tr>
<td>Shore pull</td>
<td>The pulling of a pipeline to the shore from a lay barge /vessel</td>
</tr>
<tr>
<td>S–Lay</td>
<td>A laying method where the pipe is assembled horizontally, fed out of the stern or bow of the barge or vessel, typically over a stinger. Can also be without stinger at certain depths or at the end of the shore pull before the water depth increases to a depth where stinger becomes necessary, and then makes a double curve (shallow S shape) to lie horizontally on the sea-bed.</td>
</tr>
<tr>
<td>SMYS / Specified Minimum Yield Stress.</td>
<td>The minimum yield stress specified in standard or specification used for purchasing the material.</td>
</tr>
<tr>
<td>Statement of Acceptability</td>
<td>A document issued by GL Noble Denton when the relevant procedure documents and supporting calculations have been reviewed and found appropriate to the proposed operation. It does not imply any approval of the actual operation.</td>
</tr>
<tr>
<td>Survey</td>
<td>Attendance and inspection by a GL Noble Denton representative. Other surveys which may be required for a marine operation, including suitability, dimensional, structural, navigational and Class surveys.</td>
</tr>
<tr>
<td>Term or Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Surveyor</td>
<td>The GL Noble Denton representative carrying out a survey. An employee of a contractor or Classification Society performing, for instance, a suitability, dimensional, structural, navigational and Class survey.</td>
</tr>
<tr>
<td>SWL / Safe Working Load</td>
<td>SWL is a derated value of WLL, following an assessment by a competent person of the maximum static load the item can sustain under the conditions in which the item is being used.</td>
</tr>
<tr>
<td>T/S dip</td>
<td>Temperature /Salinity dip (required for its effect on the speed of sound in water)</td>
</tr>
<tr>
<td>TLP</td>
<td>Tension Leg Platform</td>
</tr>
<tr>
<td>Towed bundle</td>
<td>A pipeline system comprising one or more pipelines, tubes or cables contained within a carrier pipe, and fitted with towing and trailing heads. The bundle is usually assembled on land and launched. The bundle may be towed off-bottom, on surface, or at an intermediate controlled depth.</td>
</tr>
<tr>
<td>TP / Tangent Point</td>
<td>The point where the bend of a pipeline begins or ends.</td>
</tr>
<tr>
<td>UKC</td>
<td>Under Keel Clearance (see Section 10.12.10)</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>Vessel</td>
<td>A marine craft designed for the purpose of transportation by sea or construction activities offshore. See Barge</td>
</tr>
<tr>
<td>Weather restricted operation</td>
<td>A marine operation which can be completed within the limits of an operational reference period with a weather forecast not exceeding the operational criteria. The operational reference period (which includes contingencies) is generally less than 72 hours. The design environmental condition need not reflect the statistical extremes for the area and season. An alpha factor shall be accounted for in defining the design environmental condition. See Section 7.4.8 of 0001/ND, Ref [1].</td>
</tr>
<tr>
<td>Weather unrestricted operation</td>
<td>An operation with an operational reference period greater than the reliable limits of a weather forecast. The operational reference period (which includes contingencies) is generally more than 72 hours. The design weather conditions must reflect the statistical extremes for the area and season. The design weather is defined in Section 7.3 of 0001/ND, Ref [1].</td>
</tr>
<tr>
<td>WLL / Working Load Limit</td>
<td>The maximum force which a product is authorized to sustain in general service when the rigging and connection arrangements are in accordance with the design. See SWL.</td>
</tr>
</tbody>
</table>
4 THE APPROVAL PROCESS

4.1 GENERAL

4.1.1 Further information on the approval process appears in DNVGL-SE-0080 - Noble Denton marine services – Marine Warranty Survey, Ref [16].

4.1.2 In the case of pipeline transport, installation of and related operations, Certificates of Approval may include, but are not necessarily limited to the following, dependent upon the contents of the Insurance Warranty, and/or Client's specific requirements:

4.2 CERTIFICATE(S) OF APPROVAL

4.2.1 Pipe joint or reel load-out: normally issued when preparations for pipe load-out including inspection of the vessel, crane and rigging have been completed.

4.2.2 Pipe joint or reel transportation: normally issued when the preparations including seafastening and ballasting are complete, the transport vessel has been inspected, and the actual and forecast weather is suitable for departure. Such transports are normally on self-propelled vessels, but where appropriate, tug, cargo barge and towing gear will also be inspected.

4.2.3 Pipelay operations: normally issued when

- the pipeline route surveys, general and specific mooring or dynamic positioning procedures, general and specific pipelay procedures, and procedures and calculations in respect of start-up, lay-down and pipe and cable crossings have been reviewed and accepted,
- the pipelay vessel and its equipments have been inspected, and found to be complete in accordance with the specification, and
- All necessary operational preparations have been reviewed and are satisfactory
- the weather conditions and forecast are suitable for the proposed operations.

4.2.4 Pipe or cable crossing operations: issued when required by warranty or a client or pipe / cable owner when:

- procedures and any relevant calculations have been approved,
- the preparations have been made, including gravel dumping or mattress laying and associated surveys,
- the lay vessel is ready to start to lay over the crossing area, and
- prior to positioning the first anchor over the crossed pipe or cable, or (for a DP lay vessel) approaches the crossing point.

4.2.5 Trenching or burial operations: normally issued after completion of as laid survey when procedures and supporting calculations in respect of the trenching or burial operations have been reviewed and accepted and the vessel and its equipment have been inspected. In addition, preparations for deployment and controlling of the plough and stress monitoring procedure of the pipe also need to be confirmed as satisfactory prior to issue of the Certificate of Approval.

4.2.6 Installation of risers or tie-ins: normally issued when calculations and procedures in respect of the operation have been reviewed and accepted, the vessel cranes or davits and rigging have been inspected, the installation guides are in place and the weather conditions for the operation are satisfactory.

4.2.7 Launch of a towed pipeline: normally issued when calculations, drawings and procedures have been reviewed and accepted, the launch, tow, trail, command and guard vessels and equipment have been inspected, the towing head connected to the pipeline and all launch rigging has been connected, checked, and tidal conditions and actual and forecast weather conditions are deemed satisfactory.

4.2.8 Pipeline towage: normally issued when the tow and trail heads have been trimmed and the pipeline has been satisfactorily ballasted for tow, the launch, tow and trail tug, command and guard vessels inspected, tow vessel connected to the tow head of the pipeline, and actual and forecast weather
conditions are deemed satisfactory. The tow is deemed to be complete on the lay-down of the pipeline at the parking area in the vicinity of the final installation location.

4.2.9 **Towed pipeline installation**: normally issued when preparations have been made for the moving of the towed pipeline from the parking area, calculations, drawings and procedures accepted and actual and forecast weather conditions are deemed satisfactory.

4.2.10 **Shore or offshore pull installation**: normally issued when

- calculations, drawings and procedures have been reviewed and accepted,
- the strings, the launch supports, holding back wall, trench, vessels, equipment and tools such as linear winches, tensioner, floating devices etc. have been inspected,
- the pulling head connected to the pipeline, the pull wire connected to the pull head and all necessary rigging has been connected,
- tidal conditions and actual forecast weather conditions are checked and deemed satisfactory.

4.2.11 **Hydrotest**: normally issued when test procedures and calculations have been reviewed and other prior inspections have been completed.

4.2.12 Depending on the Insurance Warranty and Client’s requirements, additional Certificates of Approval may be required. These may include approval of supporting marine operations such as load-out and transport of line-pipe, risers, valves and sub-sea structures. Guidelines for such operations may be found in the GL Noble Denton documents:

- 0013/ND - Guidelines for Load-Outs, Ref. [2].
- 0021/ND - Guidelines for the Approval of Towing Vessels, Ref. [3].
- 0030/ND - Guidelines for Marine Transportations, Ref. [5].
- 0032/ND – Guidelines for Moorings, Ref. [6].


4.2.13 Agreement should be sought with the Client as to the necessary extent of attendance during approved operations to comply with the terms of his Insurance Warranty. Attendance is required for the activities listed in the following Section 4.3.

4.3 **SCOPE OF WORK LEADING TO APPROVALS**

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

a. Pipeline design and construction as related to marine installation activities (see Section 5)
b. Pipeline route and surveys (see Section 6)
c. Pipe handling and transportation (see Section 7)
d. Lay vessel and equipment suitability (see Section 8)
e. Lay vessel station keeping procedures, including mooring or dynamic positioning (see Section 9 and in particular Section 9.7.3)
f. General and project-specific laying procedures including emergency laydown
g. Start-up and lay-down procedures (see Section 10.3)
h. Pipelay abandonment and recovery, including from a wet or dry buckle (see Section 10.5)
i. Umbilical installation (see Section 10.9)
j. Pipeline taws (see Sections 10.10 to 10.14)
k. Pipeline crossing procedures (see Section 10.15)
l. Trenching and/or burial procedures (see Section 10.16)
m. Riser and subsea tie-in installation (see Sections 10.20 to 10.23)
n. Flooding, hydrotesting, leak testing, dewatering and pigging and/or gauging procedures.
o. Contingency procedures for all other offshore operations.
p. Safety review requirements (see Section 8.4)

4.4 SURVEYS
Surveys carried out as part of GL Noble Denton’s scope of work typically include:

4.4.1 Suitability surveys of pipe transport vessels or barges, land-based pipe-handling equipment and cranes, towing vessels, survey vessels, lay vessels and equipment, trenching and burial equipment and support vessels, anchor handling vessels and diving support vessels. These are usually carried out prior to mobilisation to highlight any deficiencies in condition, equipment or documentation which may need rectification before the start of the operations.

4.4.2 Calibration surveys or acceptance tests of load cells, tensioners, subsea positioning systems, DP systems, T/S (Temperature/Salinity) dip frequency.

4.4.3 Surveys to establish the readiness to start any marine operation. These are carried out in advance of the decision to proceed with the operation and are to:
   • Ascertain that the equipment as presented complies with that shown in the procedures and associated specifications
   • Ascertain that the procedures as written are fit-for-purpose in practice
   • Check the readiness of all equipment, materials and personnel before commencement, and witness the actual performance of the equipment
   • Check that forecast and actual weather conditions are within limits for any weather sensitive operations.

4.4.4 If required by the Client, attendance by GL Noble Denton during certain marine operations may be undertaken to verify that operations are carried out in accordance with the approved documentation and to assess proposed changes to the approved procedures.

4.5 LIMITATION OF APPROVAL
The following limitations are in addition to those in DNVGL-SE-0080 - Noble Denton marine services – Marine Warranty Survey, Ref [16].

4.5.1 A Certificate of Approval is not to be construed as a general statement of the fitness for purpose of the completed pipeline system.

4.5.2 A Certificate of Witness of Hydrotest is a statement of fact only, and is not to be construed as a statement of fitness for purpose of the line or section so tested.
5 PIPELINE DESIGN FOR INSTALLATION

5.1 GENERAL

5.1.1 The specification and design of the pipeline is only of direct concern to the approval process in that the pipeline design must be capable of being installed at the specified location using the designated marine spread, within the specified environmental conditions, and that the installation operation can be completed satisfactorily in accordance with the approved procedures and good industry practice.

5.1.2 The basic strength design and material selection of the pipeline is generally determined by the normal operational throughput, internal and external pressure, fluid properties, water depth and environmental constraints. However, wall thickness and material properties are frequently influenced by lay method. Similarly, pipeline protection coatings are influenced by the chosen installation method. In the case of pipe-in-pipe and carrier pipe bundles, the installation method largely determines the carrier pipeline system design.

5.1.3 The design shall verify adequate strength during all relevant installation phases and for all installation techniques to be used; generally, this will include:

- Initiation of pipe lay
- Normal continuous lay
- Laydown/termination of laying operation
- Flooding and hydrotest
- Contingency procedures
- Pipe lay abandonment and retrieval (empty and flooded case)
- Tow out operations (bottom tow, off-bottom, controlled depth tow and surface tow)
- Pipeline reeling and unreeling
- Trenching and back-filling
- Tie-in operations
- Riser and spool installation
- Laying of in-line structures
- Shore pull and offshore pull
- Landfalls (if applicable)

5.1.4 The configuration of the pipeline shall be determined from the laying vessel to its final position on the seabed. It shall be demonstrated that under this configuration, the stress/strain levels are acceptable when all relevant load effects are taken into account.

5.1.5 In addition to loads generated due to installation operations, the pipeline should also be demonstrated to be adequate for other temporary conditions experienced. These will include confirmation that the product’s on-bottom stability is acceptable for any relevant temporary condition (e.g. untrenched, air filled, etc.) and that the on-bottom roughness and free span limits are not exceeded. The applicable project-specific design basis should identify the relevant recognised codes to be satisfied in this regard.

5.1.6 An operation can be defined as weather-restricted operation if it is anticipated to take place within a suitable good weather forecast period, typically less than 72 hours to complete from “safe to safe” condition. It may commence based on reliable weather forecasts less than the established operating limits, with due consideration given to uncertainty in weather forecast for the operational period required (0001/ND, Ref. [1], Section 7.3, gives appropriate guidance on relationship between operational and design seastates).

5.1.7 An operation can be defined as weather-restricted even if the operational time is longer than 72 hours, provided that it can be stopped and put into safe condition.

5.1.8 Typically a pipelay analysis will address and define the limiting seastates for all critical operations, including initiation, normal lay, second end laydown and abandonment/recovery. Limiting seastates
should be defined for various vessel headings and water depths along the route. Any operational restrictions should be clearly identified.

5.1.9 Installation analyses may vary from static linear elastic to dynamic, stochastic non-linear elasto-plastic modelling. The sophistication of the analyses, and hence software, needs to be appropriate to the criticality of the operations, recognising technical complexity or novelty, reserves of strength and stability in the pipe and in the equipment involved and prior industry experience.

5.2 ALLOWABLE LOADS

5.2.1 Allowable levels of stress and strain for pipelines during installation shall in general comply with the requirements of an appropriate code such as API RP 1111, Ref. [8], API RP 2RD, Ref. [9], BS EN 14161, Ref. [11], or DNV OS-F101, Ref. [13], or for bulkheads and flange connections ASME VIII, Ref. [10], or BS PD 5500, Ref. [12]. It is preferable that a coherent set of criteria are adopted throughout, for example an allowable stress or limit state basis. It is required that the selected criteria are set out in an Installation Design Basis / Premise which may be subject to review and approval by the Surveyor.

5.2.2 When considering the design loads during installation operation, the most unfavourable relevant combination of position and direction of simultaneously acting environmental loads, including the effects of temperature gradient, shall be used when demonstrating the integrity of the product during its installation.

5.2.3 Consideration should be given to strength, buckling, strain introduced and fatigue damage incurred during any part of the installation operation. Where pipeline components such as in-line bulkheads, connectors and minor structures are to be included in the pipeline, consideration shall also be given to the response of these elements and their effect on the adjacent pipe due to change in stiffness or load.

5.2.4 Similarly, changes in pipeline properties (section, weight, etc.) should be considered. Any significant increase in stiffness due to the coating should be accounted for. Any change of SMYS and stiffness for any inline structure should be accounted for in lay analyses.

5.2.5 The applied tension, bearing loads and bending radii for flexible pipelines and umbilicals shall comply with the limits specified by their manufacturer. Where tensioners transfer load by bearing and friction into the core of a flexible, loads in individual layers need to be considered for the range of load cases feasible during the installation operation. If a tensioner is to be used, demonstration tests are usually required to confirm the product will be unharmed during installation.

5.2.6 Design environment for the installation operations shall be appropriate to the location, the season and the expected duration of the installation operations. Guidance should be taken from DNV OS-F101, Ref. [13], noting the concepts of Weather-Restricted and Unrestricted Operations in Section 7.3 of 0001/ND, Ref. [1].

5.2.7 Most J-lay and S-lay pipelay operations will be many days in duration so will fall into the category of Weather Restricted Operations. Operations will have weather limitations determined by the equipment and the parameters of the pipeline, water depth and any local currents. Such operations should require the as-laid line on the seabed to be stable on the seabed in the 1 year seasonal design environment.

5.2.8 A fatigue check is required to account for periods when laying is halted (e.g. for extended welding, weather downtime, mechanical failure) and the product is subject to vessel motions.

5.3 INSTALLATION-SPECIFIC: S-LAY & J-LAY

5.3.1 S-lay may limit the minimum pipeline route radii, and the proximity of any turns in the route to the ends of the pipeline, due to potential lateral slip over the seabed at the tangent points. Checks are required for the pipeline tension at the touch-down and the pipe-soil interaction to assure that curvatures are not too great or too close to pipeline ends. Route radii, $R$, to be greater than the minimum stable radius, i.e.

$$ R \geq \frac{\text{safety factor (Tension at touchdown point)}}{\text{(submerged weight/unit length x friction coefficient + Passive soil resistance)}} $$

Where passive soil resistance can be calculated based on DNV-RP-F109, Ref. [15], Section 3.4.6. The safety factor should reflect consequences of sliding.
5.3.2 Checks are required for potential local buckling during pipelay and for subsequent propagation buckling initiation and running. The external pressure should be checked against the propagation pressure, DNV-OS-F101, Ref. [13] gives guidance. Where propagation is expected, appropriate buckle arrestors shall be installed.

5.3.3 Installation analyses need to cover the expected range of water depths, environmental conditions, lay vessel draughts, trims, ramp/roller/angle settings and upper and lower tensioner ranges (corresponding to the upper and lower tensioner control settings), and any variations in pipe stiffness and weight. Modern codes (e.g. DNV OS-F101, Ref. [13]) allow the controlled yielding of the pipe in the section supported by the stinger. This needs care as residual flattening, torsion or twisting will thereby be formed in the pipe during installation. Plastic strain history will need to be recognised for design of parts of the line which will or may experience fatigue loading during operation.

5.3.4 A sensitivity analysis is required of the sagbend stress which can be subject to significant increase relative to a small loss of tension. The objective is to document the safe operating tension range.

5.3.5 Analysis of the frictional forces between the pipeline coating and the tensioner pads is required to ensure adequate holding forces for all conditions. This may require load testing of pipeline joints in the tensioner prior to the pipelay operations.

5.3.6 Anti-corrosion coatings and concrete weight coatings need to be specified and proven to be resistant to the range of shear and crushing loads applied at the pipelay tensioners and support rollers. Pipe tensioners impart very high loads into the pipeline which need to be analysed and/or pre-qualified prior to implementing them in the field.

5.3.7 The following items shall be checked and documented:

- Soil friction for route curvatures mid-line and in proximity to pipeline ends (see Section 5.3.1)
- Local buckling strength at seabed touchdown recognising bending and hydrostatic loads and ovalisation from manufacturing tolerance and plastic bending strain from passage through the stinger (see Section 5.3.2).
- Propagation buckling initiation pressure and sustained running pressure (see Section 5.3.2).
- Requirement and extent of buckle arrestor provision based upon initiation and running pressures and hydrostatic pressures along the route (see Section 5.3.2).
- Quasi-static pipelay analyses for the load cases combining tension ranges, water depth ranges, trim, draught, current, pipe weight and effects of concrete stiffness (where applicable) to determine critical cases for over-bend stress/strain on the stinger, and sagbend stress near the touchdown (see Section 5.3.3).
- Dynamic pipelay analyses for critical stress cases that determine weather limits for stress/strain in the pipe and other limit states such as pipe dynamics in the stinger due to wave motions and plastic strain history limits (see Section 5.3.3).
- Analysis of bearing loads in the concrete weight coating (where applicable) from tensioner pads and tracks and for inter-coating shear between the concrete coating and the underlying anti-corrosion coating (see Section 5.3.5).

5.3.8 J-Lay. Similar considerations and the same checks apply for J-Lay as for S-Lay above. Individual tensioner loads are likely to be higher so it is important that inter-coating shear bond and crush strengths are specified, and demonstrated by project specific or prior representative qualification testing.

5.4 INSTALLATION-SPECIFIC: CAROUSEL & REEL-LAY

5.4.1 Reel-lay presents additional design and material requirements for the pipe to those above for S-Lay and J-Lay. The main considerations are:

- The pipe and coatings’ suitability for the strain cycling for reeling onto and off the vessel’s reel,
- Limiting the D/t ratio to prevent buckling when reeling and
- Resistance to collapse and propagation buckling due to residual flattening of the pipe section following reeling, un-reeling and straightening.
5.4.2 Alternative proprietary bases may be offered by the installation contractor which will need to be proven by testing or prior successful application. DNV OS-F101, Ref. [13], provides guidance to determine ovalisation due to bend strain. The installation contractor may offer other bases for determination of ovalisation due to reeling, and for the extent or recovery from ovalisation from straightening, which need to be supported by documented testing or by successful prior application.

5.4.3 Residual ovalisation needs to be accounted for in the pipelay strength, buckling analyses and in the analyses for operating conditions.

5.4.4 The total strain shall be assessed. With reel lay, the pipe is yielded 4 times prior to being laid: reeling on (1 time), and reeling off (3 times: at span after reel, at aligner and at straightener) and this will have an impact on the potential for crack growth. The assessment requirement is normally as follows, from DNV-OS-F101, Ref. [13]:

- If total strain ≤0.4% → no additional requirements.
- If total strain >0.4% → ECA (Engineering Criticality Assessment).
- If total strain >1% → additional tests per Ref. [13].

5.4.5 Installation strain history needs to be recognised in analyses of any fatigue loadings during operation. Total strain induced at reeling and laying must be accounted for in the fatigue design as reeling reduces the fatigue life. This point is therefore particularly important for SCR whose design is primarily governed / limited by fatigue design issues.

5.4.6 Sufficient line pipe needs to be available for lead and tail sections for reeling onto and off the vessel and for straightening trials to confirm straightener settings. Note that the elastic-plastic bending behaviour between the reel and straightener is highly non-linear and sometimes highly susceptible to changes in stiffness of the pipe.

5.4.7 Anode attachments shall be made at circular doubler pads, matching the line pipe material and welded at the neutral axis of the pipe on the reel.

5.4.8 A pipeline that is reeled onto a spool will be subjected to large plastic strains. When two abutting pipe joints have dissimilar tangential stiffness, due to different wall thickness, varying material properties or thick insulation coatings, a discontinuity will occur with increased potential for buckles to occur local to the field joint in this situation. It is recommended that appropriate tests are performed to demonstrate that any such discontinuity will not result in a buckle during reeling operations.

5.4.9 For reel lay of flexibles and umbilicals it is important that the Minimum Bend Radii, maximum allowable tension, bearing and crushing loads of the product are compatible with the installation processes. These are normally outlined in the purchase specification to the manufacturer of the product then detailed in the manufacturer’s manufacturing databooks. The storage Minimum Bend Radius (MBR) for controlled curvature (such as on a reel or roller), the unconstrained MBR for free bending and a dynamic MBR are normally all specified. For deepwater flexibles, a table or plot of allowable curvature /bending radius for is usually provided for different tensions.

5.4.10 Where lay tension is applied to the line via tensioners, the load transfer needs to be considered and verified against strength of the line to resist the crushing and tension transfer through the sheaths to the internal armouring. In instances of high loading, for instance in deep water, the manufacturer should confirm strength by qualification testing.

5.4.11 Where the line is installed strapped to another load carrying line, such as a pipeline or stronger flexible, loads from the strapping/clamping on the subject line need to be checked against capacity of the line.

5.4.12 The following items should be checked, in addition to those above for S-Lay:

- Linepipe steel qualification testing by strain age testing to confirm suitable toughness for reeling strains on the intended installation vessel
- Coatings’ qualification testing to demonstrate suitability for the strain cycles on the intended installation vessel
- Strength against local buckling at the maximum reeling strain
- Total strain and requirements for ECA or additional tests
- Cumulative ovalisation and partial recovery of circular section through reeling, un-reeling and straightening
- Local buckling strength at seabed touchdown recognising bending and hydrostatic loads and ovalisation from manufacturing tolerance and residual ovalisation from reeling
- Propagation buckling initiation pressure and sustained running pressure (recognising that it is not practical to include buckle arrestors in a reeled pipe)
- Anode doubler plates shall be circular, matching the pipe material
- Pipe carcass collapse strength at seabed with atmospheric internal pressure in the pipe
- Quasi-static pipelay analyses for the load cases combining tension ranges, water depth ranges, trim, draught, ramp angles, current and pipe weight to determine critical cases for peak and minimum axial tension in the product and maximum curvatures
- Dynamic pipelay analyses for critical stress cases that determine weather limits for axial tension in the pipe and other limit states such as pipe dynamics in the stinger or overboarding chute/roller due to wave motions and MBR limitations
- Analysis of crushing and shear loads in the product from tensioner pads and tracks and for inter-layer shear within the product
- Analysis of crushing and shear loads in the product at any straps or clamps attaching to other lines or installation aids.

5.5 INSTALLATION-SPECIFIC: MULTIPLE LINES

5.5.1 Strapped bundles laid by any of the above methods are subject to the same considerations as single lines. In most cases one of the lines in the bundle will carry the installation loads as it is convenient to use only one tension system. The strapping/clamping loads and load transfer from the carried line to the carrying pipe may determine the strength requirements of the pipe.

5.5.2 Pipe-in-pipe and sleeved bundles are required to be designed as a system, recognising the installation loads and processes from the outset. For these systems, the system design is most likely to be tailored to a single installation method and the detailed designer will need to define and analyse generic installation loads prior to finalisation of the line pipe and components’ (such as spacers, internal and end bulkheads) specifications. Prior to installation, the installation contractor may be required to clarify the detailed design analyses, incorporating further detail and the details of his own equipment into the installation analyses to confirm the designer’s generic assumptions or to perform tests to confirm design assumptions (e.g. test the centralisers to maximum expected tension).

5.6 INSTALLATION-SPECIFIC: PIPE TOWS

5.6.1 Pipe tow methods are wide ranging in approach. The simplest and longest standing method is bottom tow. Other methods involve increasing complexity of construction and execution with the most sophisticated being Controlled Depth Tow (CDT) where a bundle of lines, sometimes including hydraulic and electrical control and service lines, are housed in a carrier pipe. The bundle is generally fitted with a towhead and trailhead with ballasting and production system functions.

5.6.2 Other tow methods generally require a system-dependent approach to the design to make the pipe suitable for the intended installation method.
- **Bottom (or on-bottom) tows** when lengths of ballast chain drag on the seabed. At higher tow speeds the uplift from the towline and hydrodynamic lift forces makes this become an off-bottom tow.
- **Off-bottom** and **CDT** tow methods require great care to control the control the submerged weights of the assembly within a narrow band.
- **Surface tow, near-surface tow** and **CDT** generate greater fatigue loadings in the installation phase which control axial design strength of the carrier pipe.
5.6.3 For the simplest methods the main considerations affecting pipe design are tow depth, which may be greater than that at the destination site so may control collapse and buckle strength design, and tow force which may control axial design strength of the pipe.

5.6.4 **Coatings** and **anodes** for bottom towed pipe need care in selection and testing as they need to resist abrasion from the seabed during tow out.

5.6.5 **Fatigue life** utilisation during the tow needs to be consistent with the assumptions of the pipeline designer's assumptions regarding fatigue life allocation to the various phases of the life of the pipeline. DNV-OS-F101, Ref. [13], Section 5, Clause D800 provides guidance on allowable fatigue utilization during the construction phase for various safety categories of pipeline safety criticality.

5.7 **INSTALLATION-SPECIFIC: SHORE AND OFFSHORE PULL**

5.7.1 Shore and offshore pull are mainly used for shore crossing. Depending on sea traffic, the water depth, pull distance and other environmental loads such as current, wave etc., the pipeline or bundle may be pulled on the surface or on the bottom.

- **Surface pull** when the pipeline is made to float on the surface assisted by floating devices such as individual buoyancy tanks (e.g. kraken) etc. This method is commonly used for short distance crossings in a calm sea environment and for relative fast fabrication (welding).

- **Bottom pull** is often performed in a trench to mitigate the impact of lateral load due to current and wave. This method may also be performed from shore to shore, crossing the strait, bay or river.
6 PIPELINE-ROUTE & SURVEY REQUIREMENTS

6.1 ROUTE

6.1.1 The intended route of the pipeline shall be clearly identified on alignment sheets showing all relevant details of the area, including but not limited to: shoreline, bathymetry, existing and projected platforms, subsea structures, wellheads, pipelines and cables, and any obstructions such as wrecks, rock or coral outcrops, glacier scars, seabed poch-marks, sand wave or mudslide areas, fault lines, dumping grounds, unexploded ordnance and areas where free-spanning may occur. The drawings shall be to a suitable scale, and all locations shall be to a common co-ordinate system such as UTM and geodetic datum (e.g. European Datum 1950 or World Geodetic System 1984).

6.1.2 The alignment sheets should also identify Third Party concession owners, fishing, anchoring, naval exercise, munitions dumping and other restricted areas as appropriate.

6.1.3 The route on the alignment sheets shall be clearly defined by co-ordinate points and straight and curved sections, KP (Kilometre Points), TP (Tangent Points) and IP (Intersection Points) as necessary. All existing structures, crossed lines and the target areas or target box for the start-up and lay-down locations shall be clearly identified.

6.1.4 In the case of bottom or other towed installations, the tow route corridor shall also be clearly identified and surveyed. Contingency parking areas along the route and landing areas at the end of the tow (prior to the installation location) shall be clearly defined at spacing and locations appropriate to the weather and operational risks for the tow.

6.2 DESIGN CORRIDOR SURVEY

6.2.1 The design corridor and tow corridor, if applicable, shall be surveyed during the design process to ensure that the corridor is clear of obstructions and any such obstructions should be recorded on the approved for construction revision of the alignment sheets. The survey shall measure the seabed bathymetry extending, typically, at least 200 metres each side of the nominal route centreline mapping contours at, typically, 1 metre intervals with all depths reduced to LAT or other prescribed datum. The surveyed corridor width will typically increase in undeveloped areas or blocks where the topography and soils are not already well defined. Parts of the route which may give rise to free-spans in the line should be identified during the survey and the bathymetric data intensified there.

6.2.2 Environmental data for the area, including statistics for sea and air temperatures, wind, wave, current and tidal range shall be established, measured over 3 or 4 years as a minimum. Unusual risks such as subsea mud slides, earthquakes, shore erosion, beach movement, scour, etc., should be identified. Seawater sampling and analysis may be required where local conditions are uncertain or unknown.

6.3 GEOTECHNICAL SURVEY

6.3.1 A geotechnical survey shall be carried out in sufficient detail during the detailed design phase to establish the nature of the seabed along the chosen pipeline route and, if applicable, in the designated parking areas for towed pipelines or bundles.

6.3.2 If the pipe is to be laid on the seabed without burial this survey may be limited to ensure general seabed soil characteristics and stability and to identify rock or coral and any presence of sulphate reducing bacteria or other aggressive soil conditions.

6.3.3 If the pipe is to be trenched or trenched and buried, detailed information on the soil characteristics shall be presented to justify the burial procedures and the plough tow force expected.

6.3.4 For bottom and off-bottom tows, the soil characteristics are needed to evaluate the maximum anticipated tow force.
6.4 PIPE CROSSING SURVEYS
6.4.1 Third Party operated pipelines and cables crossing the proposed route need to be identified at an early stage. Their location and condition needs to be established in detail in order that agreement can be reached on the most effective means to protect the existing line and the new line during installation and future operating conditions. If the existing line is buried it may have to be located by means of acoustic or magnetic tools deployed to the seabed or from prior surveys.

6.5 PRE-LAY SURVEY
6.5.1 The scope of work of the installation contractor should include a pre-lay survey to confirm the general topology as shown in the design survey, and to check for new obstructions, dropped objects, etc., that will require removal to protect the pipe or a partial route deviation. Pre-lay survey should not be conducted more than three weeks before laying of the pipeline.

6.6 POST-LAY SURVEYS
6.6.1 The scope of work of the installation contractor should include post lay survey(s) to confirm the as-laid route and the visible condition of the pipe and any freespans, their length and height so that they can be assessed as suitable or needing support or protection. Subsequent surveys may be required after trenching to confirm pipe disposition and condition in the trench and the elevation profile of the pipeline relative to the seabed.
6.6.2 Further detail on the pipeline’s elevation relative to LAT and Out of Straightness Survey (OSS) may need to be obtained for lines susceptible to upheaval buckling in order to determine surcharge loading or backfill required to inhibit upheaval. Following such surcharge, another survey may be required to confirm surcharge depth achieved.

6.7 AS-BUILT SURVEY
6.7.1 The last of the above post-lay surveys, or the accumulation of them, will constitute the as-built survey. The results of the survey(s) are normally required to be captured on video and on as-built alignment sheets for issue to the Client, together with comprehensive as-built documentation of the full construction and installation phase.
7 PIPE, UMBILICAL AND CABLE HANDLING AND TRANSPORTATION

7.1 GENERAL

7.1.1 The load-out and shipment of pipeline system components will generally be subject to review and/or approval by the Marine Warranty Surveyor. Such pipeline components may include: line pipe joints; and/or rigid pipe stalks or strings for reeling onto Reel Lay vessels; and/or strings of umbilical/cable; and/or reels of flexible pipe, umbilical or cable; spools of flexible pipe; and/or umbilicals or cable on carousels or flaked onto lifting frames; and/or hard pipe riser or seabed spools; and or pipe fittings or assemblies for mid or end of line placement.

7.2 LOAD-OUT

7.2.1 The general requirements for load-outs are contained in 0013/ND, Ref. [2]. For general requirements for lifted load-outs refer to 0027/ND, Ref. [4]. All operations shall be made in accordance with an approved project Installation Procedures Manual.

7.2.2 The arrangement for lifting shall be such that the stress in the pipe/piping does not exceed the normal basic allowable stress for the pipe/coating material and/or of its associated structure, as should be defined in the approved Design Premise/Basis for the operation.

7.2.3 Where flexible product is being handled, the product shall be moved over rollers or bodily lifted, without dragging. Tension and minimum bend radii shall be controlled by means of lift and transfer arrangements and procedures that are proven not to exceed the allowable loads for the product. Outer sheath damage of flexible product should be guarded against by use of soft facings on all parts coming into contact with the product, including rollers, tensioners / cable engines, reel drums and flanges. In addition, bolts and fixtures with potential to contact the flexible shall be recessed and inspected regularly.

7.2.4 Flexible product on reels loaded out onto the transport or installation vessel by crane shall be controlled with normal lifting precautions applying – refer to 0027/ND, Ref. [4].

7.2.5 Portable reels for flexible product which will be operated on marine vessels should be of the driven spindle type. However, in the case of under-roller type reels being employed, it should be highlighted that extra care to be taken during its operation to ensure slip and escape from the turning mechanism does not occur.

7.2.6 In some spooling locations, the vessel has to actively maintain station during the operation. If the installation vessel is moored for load-out, its moorings should be arranged and sized for the reactions required during the load-out or spooling operation. Allowable offsets, heading variations and tidal range should be determined with reference to pipe spans and stresses so that these can be monitored during the spooling operation.

7.2.7 Where long strings or stalks of rigid pipeline are being moved, they should do so on soft faced rollers or soft faced pipe racks demonstrated to be arranged so as not to over stress the pipe and to ensure no damage is feasible to the pipe coatings, with forward and aftward control of the pipe movement / tension.

7.2.8 For the load-out of long lengths of pipe onto a reel ship or barge, the pipe will be required to deform plastically, but the bend radius on the reel should not be such as to cause local pipe buckling or coating failure - see Section 5.2.5.

7.2.9 Lifting of individual joints of line pipe shall be made using proven suitably rated and currently certified systems that do not damage the coatings or prepared pipe ends (normally bevelled but occasionally plain ended) such as:

- soft faced hooks
- soft slings.
- suitable spreader bars
- certified electro-magnets

7.2.10 Lifting magnets shall only be used when certified and approved for the work and proven not to permanently magnetize the pipe, unless a controlled de-gaussing is planned to remove residual
magnetisation prior to offshore welding. It is preferable that the pipe bevels and plastic end closers, if fitted, remain fitted. If not fitted, plastic end closers should be fitted prior to load-out for long marine transport via tropical conditions, in particular, as experience has shown that significant corrosion can occur in the pipe bore in these circumstances.

7.2.11 Individual pipe lengths shall be identified and manifested, as they are stowed into or on the marine transport vessel, to ensure traceability. Stowing and stacking shall be made in accordance with API RP 5LW, Ref. [7], and 0030/ND, Ref. [5], as appropriate, for transit loads. In addition, where vessel motions are expected to be severe or the journey lengthy, and the pipe is bare or coated with a hard slick product such as FBE (Fusion Bonded Epoxy) or polyethylene, the Installation Contractor shall demonstrate that adequate friction against axial pipe movement is available or provide restraint against such movement – some guidance is given in 0030/ND, Ref. [5].

7.2.12 In the case of control umbilicals (containing control and monitoring systems) it is required that each system is adequately system tested following load-out, prior to and post installation to demonstrate the umbilicals' control / monitoring integrity.

7.3 TRANSPORTATION

7.3.1 General requirements for the transportation of the components of the pipeline, their stowage, seafastening, motions and stability are contained within 0030/ND, Ref. [5].

7.4 OFFSHORE TRANSFER

7.4.1 Offshore transfer from the transport vessel to the installation or lay vessel shall generally be in accordance with the applicable sections of 0027/ND, Ref. [4]. In practice, the height of the pipe joints stack should be restricted by the potential for damage to coatings / concrete and by vessel constraints.

7.4.2 Access to the top of the pipe stack needs to be managed to minimise risk of injuries for riggers working there.
8 INSTALLATION VESSEL AND PROCEDURE REQUIREMENTS

8.1 GENERAL

8.1.1 The vessel(s) must be fit for purpose for the intended operation, and shall comply with local National Regulations, governing International Regulations and all project requirements.

8.1.2 The requirements apply to all vessels performing pipeline, riser and umbilical installation and supporting operations, including trenching and burial. All vessels shall have valid class with a recognised classification society.

8.1.3 Specific requirements for installation equipment onboard vessels are given in Sections 9 and 9.7.3 below, relevant to the particular method of installation.

8.1.4 A comprehensive Installation Manual shall be available sufficiently prior to mobilisation to allow for thorough review and approval by the Surveyor, as may be required.

8.1.5 Communications interfaces and emergency co-ordination shall be established and agreed by all performing parties prior to mobilisation and documented in a section of an overall Installation Manual. This may include a bridging document, for the interfaces between parties’ established Safety Management Systems, with identification of primacy where their operating boundaries overlap.

8.1.6 The positioning equipment system accuracy and redundancy shall be as defined and agreed in the Installation Manual as appropriate to the Work being undertaken by each particular vessel. System accuracy shall be suitable for congested areas or where dimensional tolerances become tighter, e.g. for tie-ins. System redundancy needs to be appropriate to safety criticality and operational criticality requirements.

8.1.7 Sub-surface positioning of ROV’s or other targets needs to interface with the surface positioning system and should display on the same equipment. Subsea acoustic transceivers/beacons need to be separately identifiable and on co-ordinated channels. Survey systems using line-of-sight shall recognise and cater for crossing surface vessels possibly occluding the system. Survey systems should be commissioned and calibrated prior to start of installation operations.

8.1.8 In some instances, the lay vessel may have a structural upgrade, addition or modification to cater for a specific project, e.g. a larger stinger or a J-Lay tower. Such new facilities will require a separate specific survey to verify their suitability.

8.2 VESSEL INFORMATION REQUIREMENTS

8.2.1 Sufficient information should be provided to approve the above, including but not limited to the information listed in Appendix A.6. In addition, equipment safety, operating and maintenance manuals and safety and critical and key equipment maintenance records with any current backlog listing should be available for review.

8.3 VESSEL CERTIFICATION

8.3.1 The installation vessels shall have on board all relevant certification, and a full set of procedural and safety manuals for the operation of their equipment. In general some or all of the documentation listed in Table 6-1 of 0001/ND, Ref. [1], will be required.

8.4 INSTALLATION PROCEDURES

8.4.1 The Installation Manual shall provide a full suite of documentation for the project and comprise manuals, specifications, method statements, procedures, drawings, calculations, records, certificates, etc., necessary to fully define the safe execution of the operations. Normal, contingency and emergency procedures should be available.

8.4.2 For pipelay, pipe flattening induced by the installation process on the lay vessel, in particular from reeling and any plastic straining on a stinger, shall be specifically addressed in the pipelay analysis and Installation Manual. Buckling consequences and mitigations shall be clearly documented including control and recovery measures for collapse and buckle propagation.

8.4.3 HSEQ Plans shall be identified and available to the Surveyor for reference.
8.4.4 Results of risk assessments (e.g. FMEA, HAZOP and HIRA) should be agreed with GL Noble Denton with evidence of action closures. As a minimum, a formal HIRA review shall be performed when all key drawings and procedures are near final revision. Ideally, GL Noble Denton should participate in the HAZOP and HIRA.

8.4.5 Equipment and pipe component limitations imposed by structural strength or equipment rating should be identified in the procedures.

8.4.6 Limitations on operations imposed by environmental conditions should be identified in the procedures.

8.4.7 Procedure changes required by events in the field shall be controlled by a suitable Management of Change procedure as set out in the Installation Manual. Any modifications to a document that was initially approved by GL Noble Denton shall be approved by GL Noble Denton before being implemented offshore.

8.5 COMPETENCE AND ORGANISATION

8.5.1 The organisation of key vessels and their key personnel with defined roles and responsibilities shall be established and agreed prior to mobilisation.

8.5.2 All key personnel shall be qualified for their roles and shall have sufficient verbal communications skills in the common language formally identified for the operations.

8.5.3 Manning levels should comply with IMO's Resolution A.890(21) - Principles of Safe Manning, Ref. [19]. The principles of this resolution should also be applied to the construction crew on board any installation vessel.

8.5.4 Key personnel to the lay operations shall be qualified and suitably experienced in the particular vessel being worked and in similar vessels. Personnel including the Barge or Vessel Superintendent, Barge or Vessel Master and Supervisors, DP Operators and the Survey Party Chief should hold core competencies in the operation of the installation vessel and its support vessels. Roles and responsibilities shall be formally defined in accordance with the requirements of the Installation Manual and IMCA's M 117 The Training and Experience of Key DP Personnel, Ref. [17].
9 REQUIREMENTS FOR LAY VESSEL OPERATIONS

9.1 GENERAL

9.1.1 The lay vessel may have a conventional mooring system (See Sections 9.5 and 9.6) or be dynamically positioned (see Section 9.7). Either system is acceptable subject to fitness for purpose for the proposed operation.

9.2 PIPELAY EQUIPMENT

9.2.1 The pipe shall be supported on the vessel on rollers and/or tracks that allow the pipe to move axially. The pipelay vessel’s stern ramp and stinger geometry, buoyancy, mass and stiffness shall be set to suit the planned lay with roller heights set to suit also. Pipe tensioners, welding stations, NDT stations and field joint coating stations shall be located and set to the lay parameters determined by the pipelay analyses and per the Installation Manual. Pipe handling systems and any multiple jointing stations shall also be set up per the Installation Manual.

9.2.2 Rollers and tracks shall be faced with a material that will not damage the pipe coating, field joint coatings or anodes.

9.2.3 The height and spacing of the rollers shall be adjusted to ensure a smooth transition from the vessel to water column. The rollers should be spaced and their heights set to maintain loads in the pipe within the limits given in the pipelay analyses. Hence controlling the stresses or strains in accordance with the Installation Design Premise/Basis and related Codes and Standards. Condition of rollers should be checked and maintenance records provided if possible. In particular, rollers should be in good “rolling” order to avoid damage to the line pipe coating and/or to the FJC.

9.2.4 Pipe supports in the stinger should be similar to those on the lay vessel, set to the spacing and height determined for the particular lay operation. The stinger should be equipped with load cells and video cameras feeding back to the control room to confirm that the pipe is not experiencing high point or dynamic contact loads at the end of the stinger. Cameras are only required on the last roller to monitor the clearance with the last roller.

9.2.5 In the case of a reel barge, the pipe straightener shall be set on the line per the Installation Manual and its settings proven by trial conducted at the spooling yard.

9.2.6 Any pipe components such as tees or valves built into the pipeline shall be inserted into the pipe on the vessel at a location such that sufficient active tensioners or pipe anchors remain available to control pipelay stresses and strains.

9.2.7 It is preferable to make the lift-off point of the pipeline at the next to last roller, so that in case of small loss of tension, the contact of the pipe will be with the next to last roller and the last roller could also provide support to the pipe, thereby avoiding excessive bending at the last roller. With the camera at the last roller, if the separation between the pipe and the last roller is seen to be too small, the tension can be increased to maintain an acceptable lay curvature of the line.

9.2.8 Pipe tensioner track faces bearing on the pipe shall be maintained with adequate bearing area. Bearing loads on the pipe shall be monitored and fed back to the control room and kept within their documented operating limits. Tensioner control systems shall be set to the dead band limits documented in the Installation Manual. Tensioner brakes shall be fail-safe and rated to hold the heaviest (usually flooded) pipe contingency case.

9.2.9 Both the tensioner and the pipe anchor support at the stern ramp of a pipelay vessel need to be fail-safe and rated to hold the heaviest flooded pipe contingency case.

9.2.10 Flexible product lay vessels typically use a stern roller, roller set, ramp or an over boarding chute. The radius of the chute/roller/ramp shall be larger than the specified dynamic MBR of the flexible. If a stinger is used, it shall be fitted with chutes or roller assemblies such that the dynamic MBR limits are not exceeded during overboarding.

9.2.11 For flexible pipe, umbilical, and cable lay the touch down lay back (i.e. the horizontal distance from the last vessel support to the touch down on the seabed) must be maintained within determined limits, otherwise pig-tailing or bird-nesting may occur in the product from axial compression loading.
9.2.12 **Pipe buckle detection**, normally by means of a buckle sensor pulled along the bore of the pipe on a cable, located just beyond the touch down, should be provided and continuously monitored in the control room as additional assurance that the pipe has been laid safely on the seabed.

9.2.13 Some installation contractors are reluctant to use traditional in-line buckle detection methods, especially in deepwater installations due to the hazards introduced by breakage of the line connecting the buckle arrestor to the pipelay vessel. In the absence of using a buckle detector, suitable alternatives for buckle detection/prevention, e.g.

- increased factor of safety against buckling using design guidance given in DNV-OS- F101, Ref. [13], clause D700 section 10,
- continuous ROV monitoring at touch down, parameter control and
- monitoring of pipeline string configuration

may be acceptable. This should be discussed and agreed with GL Noble Denton in advance.

9.3 **PIPELAY PROCEDURES**

9.3.1 Pipelay procedures should be developed from analysis which demonstrate that the stresses remain within acceptable values for the abandonment starting with the highest tension requirement in empty condition.

9.3.2 Pipelay procedures shall cover the whole range of water depths and environmental cases up to the marginal environmental condition at which abandonment and lay down will commence using the A&R winch. Lay down and recovery procedures are also required, addressing the controlled step-wise operation to abandon and return to normal lay conditions. The weather threshold required prior to recovery operations commencing shall also be documented in the Installation Manual.

9.3.3 Unless covered by valid certificates, the following should be done before the start of pipelay:

- the pipe tensioner control systems and redundancy shall be confirmed by test pulls to simulate forward motion on the mooring or DP systems, single tensioner power loss and total power failure.
- the tensioner load cells should be calibrated.
- the A&R winch and pipe support load cells should be calibrated.
- Proof load test for tensioner and A&R winches should be performed with 1.1 times the maximum expected load during lay.

9.3.4 Pipe touch down monitoring should be accomplished by ROV or other means to ensure the pipe configuration in the touch down zone remains within the identified limits.

9.3.5 During normal lay and as much as is practically possible, all tensioners should be closed and utilised so that failure of one tensioner will not cause the pipeline to slip (or at least slippage will be limited).

9.3.6 Operational environmental limits shall be defined in the Installation Manual at which pipelay will be abandoned in a controlled manner. Such conditions shall be demonstrated by pipelay analyses which underpin the Installation Manual. Dynamic movement in the stinger, such as loss of pipe contact with the supports, may determine this threshold rather than overloading, noting that such dynamics can cause pipe overbending, fatigue or cracking or damage to the pipe coatings or anodes.

9.3.7 Contingency step-wise procedures are required to address dry buckle lay down and retrieval and wet buckle lay down and retrieval.

9.3.8 Provision of Pipeline Recovery Tooling (PRT), dewatering equipment and pipeline cutting tools shall be defined at the start of the project in consultation with the client and insurer. The cost of mobilising PRT, cutting tool and other necessary equipment to recover and repair a wet buckle before continuing laying operations have to be compared with the additional cost of remobilisation for another campaign should a wet buckle occur.

9.4 **ABANDONMENT & RECOVERY**

9.4.1 The A&R winch, wire and lay-down head shall be in serviceable condition with valid certification with line out and tension read-outs calibrated. Tension capacities should exceed highest tension expected to hold the heaviest pipe (heaviest section with coating) in the flooded condition (in the greatest water
9.4.2 If vessel is capable of laying and abandoning empty pipe (for highest tension requirement) but not able to abandon flooded pipe (for the highest tension requirement), alternative procedures need to be developed to show that the vessel can safely lower a flooded pipe.

9.4.3 The A&R rigging connecting the abandonment head to the A&R winch should then be designed in accordance with the required minimum capacity of the A&R winch (i.e. 1.2 times the highest tension requirement for empty condition or 1.1 times the highest tension requirement in the flooded condition).

9.5 MOORING EQUIPMENT

9.5.1 All mooring equipment including but not limited to, mooring winches, control system, mooring wires, anchors, pennant wires, buoys, and ancillary fittings, shall be in serviceable condition with valid certification in place as appropriate.

9.5.2 The lay vessel should have a centralised mooring control system, monitoring and displaying winch operational status with tested alarms of line out and line tension reporting into a central control room.

9.6 MOORING PROCEDURES

9.6.1 The pipelay contractor shall justify by calculations the mooring spread used during laying and the maximum environmental conditions that can be tolerated. Critical configurations and load cases shall be determined for the pipeline route and addressed, allowing for planned anchor retrieval and re-lay operations. Consideration shall be given to contingency cases with reference to allowable vessel offsets and anchor holding. Both maximum pipelay conditions and maximum mooring system integrity conditions to be identified. Mooring equipment and mooring spread should be in accordance with 0032/ND – Guidelines for Mooring, Ref. [6].

9.6.2 A mooring sequence shall be developed prior to mobilisation with every anchor location pre-defined along the pipe route. Arrangements and procedures for mooring crossings over existing pipelines, cables, wellheads, etc., shall be agreed with the Owners of the equipment.

9.6.3 Pipelay mooring operations involve near-continuous process of moving moorings and the lay vessel will normally be attended by two or more anchor handling vessels facilitating adjustment of the mooring pattern.

9.6.4 Clearances around mooring lines and anchors should comply with the requirements of GL Noble Denton Mooring Guidelines, 0032/ND, Ref. [6]. If any of the clearances specified within 0032/ND are impractical because of the mooring configuration or seabed layout, a risk assessment shall be carried out and special precautions taken as necessary, noting that agreement will be required for any affected third party equipment owners for such risks.

9.6.5 Operators and contractors may have their own requirements which may differ from those stated within 0032/ND, Ref. [6], and should govern if more conservative.

9.6.6 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, providing that it is acceptable to the pipeline operator / owner and that it can it be demonstrated that the mooring will not cause frictional damage or abrasion.

9.6.7 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.
9.7  DP EQUIPMENT, PROCEDURES AND COMPETENCE

9.7.1  Pipelay operations using DP will be considered on a case by case basis, taking into account the following:
- The general requirements for DP operations in Section 13 of 0001/ND, Ref. [1].
- The vessel should have DP equipment class 2 but it may not be appropriate for it to be operating under those settings at all times.
- DP capability analysis should include cases which take account of the horizontal pipe load component.

9.7.2  For J-Lay and S-Lay the DP system must be able to operate and switch-over between locked mode and lay tension control mode. When in locked mode an anchor or brake is applied to the pipe/flexible on the vessel and in tension control mode the pipe/flexible is able to move inboard and outboard through the tensioners.

9.7.3  In the event that the lay vessel requires a change of heading under high wind or current conditions, it may not be feasible for the DP centre of rotation to remain at the product overboarding point (or equivalent remote location). Such an operation must be carefully planned to avoid vessel movement causing damage to the product.
10 INSTALLATION OPERATIONS AND EQUIPMENT REQUIREMENTS

10.1 GENERAL

10.1.1 The following sections provide guidance on discrete installation operations.

10.1.2 Towed pipe installation is also addressed, as it is often used for relatively small lengths of pipeline and can be treated as a specialised DP vessel operation.

10.2 SHORE CROSSINGS

10.2.1 Shore crossings are made by one of the following methods:
- Pipe pull from shore (Offshore pull)
- Pipe pull to shore (Shore pull)

Pipe pulls will require trenching or dredging operations before or after the pipeline is in position and backfill to stabilise and protect the pipe against the environment and against other traffic in the area.

10.2.2 The pipe pull loads are essentially static forces but the pipe span between the seabed and the lay vessel will be dynamic. Depending upon the equipment used and the local ocean environment, the dynamics may need to be modelled. The maximum static pull load includes the following components:
- Leading rigging friction, including in any sheaves
- Leading pull head friction
- Pipe friction on launchway, shore and seabed
- Any hold back tension

10.2.3 A significant part of the rigging will rest on the seabed. Coefficients of friction as listed below may be used when computing installation loads:

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Breakout</th>
<th>Running</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull wires on seabed and shore</td>
<td>1.0</td>
<td>0.85</td>
</tr>
<tr>
<td>Pipe on seabed and shore</td>
<td>1.2</td>
<td>0.85</td>
</tr>
<tr>
<td>Wheel bogies on rail track</td>
<td>0.01</td>
<td>0.008</td>
</tr>
<tr>
<td>Pull wires on sleepers</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

10.2.4 For pull, a load factor of 1.3 should be applied to the computed total static force to account for uncertainties.

10.2.5 The MBL of the pull wire should be twice the calculated factored static load.

10.2.6 Shackles and other certified rigging items should have an MBL at least 10% greater than the pull wire.

10.2.7 Structural steel items such as padeyes and the load path through the pull head to the pipe should have an Ultimate Load Capacity not less than pull wire MBL x 1.25.

10.2.8 In the event of the pull stopping due to a build-up of soil ahead of the pull head or on top of the pipe, the peak allowable pull load may be increased to 60% of the MBL of the weakest part of the launch rigging. This upper limit should be clearly stated in the pull procedure as a contingency case. It may only be used subject to accurate monitoring of the actual force required. Any such operation should be subject to a risk assessment.

10.2.9 Calculations shall be provided to justify the strength of the pipe during pull, including axial and bending stresses. Pipe stresses shall be determined and calculations provided to justify strength allowing for the curvature of the pipe over the seabed during pull. Calculated effects should include maximum rigging forces, maximum stresses in the pipe, including dynamic stresses in the span from the pull or lay vessel to the seabed touch-down, the accumulation of fatigue damage from pull through to installation, and the definition of limiting weather criteria for the operational phases.
10.2.10 Calculation shall be provided to justify the sufficiency of the structure or equipment (i.e. walls made of sheet piles, mooring lines etc.) used for holding back tension.

10.2.11 All calculations shall be in accordance with an approved Installation Design Premise / Basis supplemented as required by good industry practice.

10.2.12 The specification, method and limitations of any analysis software program should be submitted to GL Noble Denton for review and acceptance.

10.2.13 The maximum on-bottom nominal pipe weight should be used, with a 5% allowance for concrete weight coating growth for seawater absorption.

10.2.14 The pipeline designer’s assumptions regarding:
- Weather limited installation operations, or installation season,
- The extent of any shielding of the product from sea currents by the trench,
- Requirements for buoyancy aids, etc,

shall during the pull operation be followed. Any deviations from the designer’s assumptions shall be subject to re-calculation. Lateral pipeline stability, in particular, shall be maintained.

10.2.15 In cases where the use of buoyancy aids is required, a sensitivity analysis shall be performed to demonstrate the integrity of the product with lost buoyancy considering as a minimum the 25% loss cases described in Section 10.14.4.

10.3 START-UP OR LAY-DOWN: 1ST END PULL OR 2ND END LAY

10.3.1 The considerations here apply to either end of a line lay offshore at a fixed surface asset, (such as a platform or an FPS), or at a subsea asset (such as a wellhead, DMA or a manifold assembly), or at a pipeline interconnection on the seabed or from a previously laid pipeline section on the seabed.

10.3.2 The start-up and lay-down targets are normally rectangular boxes whose centre is the nominal co-ordinate for the as-laid location of a particular pipe spool or flange face where tie-in connection will be made. Lateral and axial tolerances on this co-ordinate set in the approved design drawings define the target box size.

10.3.3 Pull-in loads shall evaluate the frictional soil loads, as discussed in Section 10.2, and the back-tension from the pipe tensioners.

10.3.4 If platform or subsea asset mounted start-up rigging is to be used the following shall apply:
- All padeyes, fairleads and support structures shall be designed to have a WLL of at least 1.5 x the characteristic bottom tension during start-up prior to commencement of lay operation when the structure is assessed to the LS2 condition.
- Sheaves should be compatible with the winch wire with regard to overall wire diameters, and should have a WLL not less than the required start-up tension or 0.5 x the MBL of the winch wire (this is based on sheaves having a normal factor of safety of 5 x rating for lifting duties, and 2.5 x being acceptable for pulling). Note that in all cases the actual loads on the sheaves and padeyes will need to be assessed in connection with actual line lead angles.

10.3.5 If a start-up pile is used the following shall apply:
- All padeyes, sheaves, structural connections and pipe steel as in Section 10.3.4 above.
- Geotechnical design of pile shall be for a load of 4 x required start-up tension, equivalent to a load on the pile of 2.0 x total imposed force assuming effective double parting. The pile should be proof tested in the field to a load of 3 x start-up tension, equivalent to a line load of 1.5 x start-up tension.
- Initiation wire length should be long enough to be tangential or landed on the seabed at the pile.

10.3.6 If a Dead Man Anchor (DMA - drag anchor or clump) is used, the following shall apply:
- All padeyes, sheaves and structural connections as in Section 10.3.4 above.
- The anchor shall be sized to hold at 4 x required start-up tension, and field proof tested after laying to a load of 3 x start-up tension at the anchor, equivalent to a line load of 1.5 x the start-
up tension, where start-up tension is maximum dynamic bottom tension of the pipeline obtained from initiation analyses.

- Initiation wire length should be long enough to be tangential or landed on the seabed at the anchor or clump

10.3.7 The pipeline pulling head shall be designed for loads as follows:

- Padeyes – ultimate load capacity of 3 x start-up tension or 1.5 x MBL of the wire, whichever is the greater, with an additional 10% of the calculated load out of the plane of the padeye and an additional 20% of the calculated load in the plane of the padeye.
- Connection of head to line pipe - normal allowable stress at 2 x start-up tension (however line construction and hydrotreat may rule).
- Pulling head fitted with valves, flanges, stabs etc. (used afterwards for pigging etc.) should be protected to eliminate the risk of entrapment in the soil/seabed.

10.3.8 Safety factors for the design of slings shall be applied according to the following Table

<table>
<thead>
<tr>
<th>Factor</th>
<th>Synthetic</th>
<th>Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Empty pipe /</td>
<td>Accidental flooding</td>
</tr>
<tr>
<td>Load Factor</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Material Factor</td>
<td>4.0(^{[1]})</td>
<td>4.0(^{[1]})</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5.2</td>
<td>4.0</td>
</tr>
</tbody>
</table>

\(^{[1]}\) May be reduced to 2.25 if the certification is in accordance with a standard industry practice (such as API RP 2SM) by bodies approved by an IACS member or other recognised certification body accepted by GL Noble Denton.

The subtotal factors above should then be divided by the following termination factors

- Hand spliced wire 0.75
- Steel ferrules on wire 0.8
- Fibre rope sling splices 0.9
- Resin sockets or swage fittings on wire 1.0

and (for wires) where applicable multiplied by the bending factors in Section 7.8 of 0027/ND, Ref. [4].

10.4 ABANDONMENT AND RECOVERY

10.4.1 Operating weather condition limits shall be established in the Installation Manual. The operating limits shall be based upon pipeline stress or strain analyses and vessel station keeping capability. Objective, measured criteria shall be used to identify the limiting criteria so that a timely decision can be made to suspend lay, prepare for abandonment and abandon the line to the seabed in accordance with predetermined procedures in the Installation Manual.

10.4.2 Reliable and respected weather forecasts shall be available each day to assist in planning abandonment and recovery timing.

10.4.3 A detailed abandonment and recovery procedure is required in the Installation Manual, covering the full range of water depth and pipe weight cases that may be required over the route. This procedure shall define in stages the:

- required A&R winch tension,
- A&R line-out,
- lay back,
- lay-down head depth and
to get the pipe safely down to the seabed. The pipelay analysis defines the steps for abandonment and recovery with the aforementioned parameters and must show that the corresponding stress levels are acceptable and the procedure should present the same steps with the same tensions, line-out, layback distance and head depth.

10.4.4 The tension at the beginning of the abandonment analysis should be the same as the normal lay tension used for the water depth being analysed. The recovery is the reverse of the abandonment, but (for S-lay,) the tension may be slightly increased (approx. 10% more) when the head approaches the stinger to increase the clearance of the head with the stinger in order to avoid the risk of clash between the A&R head and the stinger. There should be sufficient steps to ensure a smooth reduction (abandonment) or increase of tension (for recovery). Good practice is to change the tension in 5 to 10 tonne-steps.

10.4.5 A&R analysis should be repeated for several water depths (typically steps of 50m depth up to 500m and 10% of the maximum water depth beyond that) to be encountered along the route. The reference point for the A&R line-out (length of cable being paid out) should be clearly specified in the analysis/procedure and this reference should be available /directly readable by the Superintendent or winch operators so that the tension can be reduced/increased in accordance with the steps defined in the analysis.

10.4.6 The laydown areas should be defined as it may not be possible to abandon the pipeline within the lay corridor. Areas of the route where abandonment is not possible, due to seabed conditions, shall be defined in the Installation manual.

10.4.7 Prior to abandonment of the pipeline, all internal equipment should be removed from the pipeline and all welds filled sufficiently to achieve the strength determined for abandonment and recovery. If a buckle detector is being used it may be left in the line with its cable made secure to the abandonment head. The abandonment and recovery head shall be fully welded to the line and tested.

10.4.8 Should it be necessary to release the A&R wire to the sea, a buoy and pennant shall be fitted to the wire for subsequent recovery. Alternatively, an ROV hooking loop may be used on the wire end.

10.4.9 Prior to recovery the pipeline shall be surveyed by ROV to establish its condition and ensure there has been no damage or buckling anywhere between the location of the touch-down point prior to abandonment and the lay-down head.

10.4.10 The A&R head and its connection to the pipe should be designed with the same load factors, etc., as the 1st end head - see Section 10.3. The emergency A&R head shall be designed for the maximum tension expected.

10.5 BUCKLE LAY-DOWN (EMERGENCY ABANDONMENT) AND RECOVERY

10.5.1 Due diligence should be exercised to ensure such events do not occur. A small residual risk will remain that a pipe will buckle during installation. Procedures and equipment are required to be in place to safely and efficiently recover from such an event. The presence of a buckle should be detected and signalled to the vessel by the buckle detector or by ROV monitoring at the pipe touchdown if this considered adequate to detect a buckle.

10.5.2 The installation manual shall contain a set of contingency procedures, defining methods for abandonment and recovery from wet and dry buckles.

10.5.3 For major pipeline projects in deep water, the procedures and equipment availability may extend to a full standby spread of pigging and air compression equipment to de-water the pipeline, to enable rapid recovery and repair of a wet buckle.

10.6 ABOVE WATER TIE IN (AWTI) OPERATIONS

10.6.1 For pipeline Above Water Tie-In (AWTI) operations, procedures and engineering calculations shall be provided to demonstrate suitability of the following:

- The capacity of the lifting davits and/or cranes to be within allowable limits
- The capacity of any lifting slings and lifting appliances involved in the operation to be within allowable limits
The capacity of any temporary supports for the pipeline sections during tie-in operations to be within allowable limits.

The capacity of the pipeline to be within its LS2 (environmental load dominated) capacity under lifting and temporary support operations including all dynamic lift-lowering effects.

Procedures for the AWTI operation including an hourly time schedule.

Limiting criteria for recovery and abandonment of the pipeline sections.

Barge station keeping analyses.

10.7 S-LAY AND J-LAY

10.7.1 If the vessel includes a tensioner or friction clamp that can transfer more than 50 tonnes tension load into the pipe, the pipe capacity for the load shall be verified by qualification testing of representative material samples and calculation, for bearing (under the tensioner's pads or the clamp) and for crushing and shear through the pipe coatings to the pipe. Where such loads exceed 100 tonnes, qualification testing shall also include trial pipe joint(s) in the actual tensioner or clamp for the range of materials and thicknesses intended to be laid with loads applied as proposed for the pipelay operation.

10.7.2 S-Lay. If the vessel includes a hinged buoyant stinger, specific analysis by a time domain analysis is required to verify that the stinger will provide the support required and to determine the weather threshold for abandonment of pipelay operations. The limiting seastate shall be set below the conditions which cause the pipe to lift off and bump onto the support rollers in the stinger.

10.7.3 J-Lay. Where the system requires collars to be built into the pipe, such that one is available in the pipeline under every butt weld in order to suspend the pipe tension from it, the collar system shall be designed for a load capacity equal to 1.25 times the greatest planned pipelay tension (including the wet buckle lay down case).

10.8 CAROUSEL & REEL LAY

10.8.1 As stated above in Section 5.4 there are a number of material, design and deformation issues which need to be given attention to at the design and material purchasing stage. These shall be re-addressed and further developed at installation design stage for the reeling, unreeling and straightening process and for the pipelay.

10.8.2 The optimum balance between lay tension applied at the tensioner and on the drum needs to be assessed, included in the pipelay analyses and installation procedures and controlled during reeling.

10.8.3 Transition spools between differing pipe sections will need to be analysed in detail. Abrupt wall thickness changes, such as at joints between internally lined/clad pipe strings need careful design and analysis to assure gross strains or fractures do not occur during un-reeling. Detailed non-linear elasto-plastic analyses are required of any transitions between pipe joints of differing dimensions (greater than mill tolerance on the specified wall thickness either side of the joint) or through a tapering transition piece or at differing yield strengths (differing by more than 5% of the lesser) and at any pipe joints containing internal or external design geometry changes. Analyses shall extend to one wrap on the reel and through the straightener.

10.9 FLEXIBLE PIPE, UMBILICAL AND CABLE LAY

10.9.1 The bending stiffness of flexibles can be very important, particularly where the line is going into compression. Clear manufacturer guidance on this should be provided. The manufacturer’s Minimum Bending Radius (MBR) shall be strictly observed, for constrained and unconstrained /dynamic bending. For unconstrained bending, the manufacturers normally advise the MBR be factored by 1.5. Sometimes the MBR is expressed as a multiple of O.D. (outside diameter) of the product, e.g. 9 x O.D. for static storage, 12 x O.D. for a static operating bend and 15 x O.D. for dynamic operating bending. A safe working load tension has also to be specified by the manufacturer for the product, in addition to maximum allowable crushing and shearing loads being identified.

10.9.2 The installation procedure should be supported by analyses that demonstrate that the MBR is protected, particularly in the touch-down zone and at over-boarding chutes or rollers and that the lay tensions do not exceed the maximum allowable for the product or become zero or compressive at the
touch-down. Compressive loads may cause a sudden local buckle or sharp curvature so need to be controlled to predefined limits.

10.9.3 Contingency procedures for suspension of lay part way between end fittings for unexpected weather or other incident shall be defined in the Installation Manual. Such procedures need to include steps for protection of the product from fatigue bending at the over-boarding chute or roller and at the touch down zone. This can be by paying out or in to move fresh product into the dynamic sections and place the hard worked sections into more static conditions. Where several positions of the over boarding chute and laying equipment can be adopted (stern, SB, PS), the location of the chute must be decided depending on the prevailing current direction that may pose a risk of cable ingestion by the vessel's thrusters. If possible spans and twists must be avoided by: continuous monitoring of the cable catenary (e.g. visual check by camera + ROV), continuous current monitoring (direction and speed), and careful control of the cable grip exerted by the tensioners. The vessel should also have enough thrust power to rapidly move and correct an undesired cable lay curvature, and also to avoid the risk of cable ingestion in case the cable comes close to the vessel's thrusters.

10.10  BOTTOM AND OFF-BOTTOM TOW - GENERAL

10.10.1 Further to the general pipeline design requirements for tow methods provided above in Section 5.6, this section addresses tows where the pipe is towed by a tug and the pipe is dragged on the seabed or buoyed off the seabed with intermittent ballast chains attached to it dragging on the seabed.

10.10.2 The pipe itself shall be proven to be acceptably loaded during all phases of the operation. Calculations shall be provided to justify strength during launch, including axial and bending stresses, sag bending as the towing head moves forward, and any reverse bending at the water line.

10.10.3 Calculated effects should include maximum rigging forces, maximum stresses in the pipe, the accumulation of fatigue damage from launch through to installation, and the definition of limiting weather criteria for the tow operation.

10.10.4 The specification, method and limitations of the analysis program should be submitted to GL Noble Denton for review and acceptance.

10.10.5 Launch and installation loads are essentially static forces. The maximum static launch load is based on the largest structure, generally the leading towhead, just leaving the launchway, and includes the following components:

- Leading towhead friction (towhead just left launchway)
- Bundle friction (bogies on rails)
- In-line friction, if any (bogies on rails)
- Trailing towhead friction (bogies on rails)
- Trailing rigging friction (wire on sleepers)
- Hold back tension.

10.10.6 The maximum static launch load in the rigging consists of the towhead load as detailed above, plus the leading rigging friction. A significant part of the leading rigging will rest on the seabed.

10.10.7 The maximum static installation (final positioning) load at the towhead and trail head should allow for movement in both forward and reverse directions, allowing for the following:

- Ballast chain friction
- Trailing rigging friction (if any)
- Hold back tension.
10.10.8 Coefficients of friction as listed below should be taken into account when computing launch and installation loads (noting that those below are not true for all locations and projects, project specific values if available should be used instead):

**Table 10-3** Typical Friction Coefficients for Launch & Installation

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Breakout</th>
<th>Running</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch/tow wires on seabed</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Towhead on seabed</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Towhead skids on launchway rails</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>Wheel bogies on rail track</td>
<td>0.01</td>
<td>0.008</td>
</tr>
<tr>
<td>Holdback wire on track sleepers</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Ballast chains on seabed</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

10.10.9 For launch, a load factor as shown below should be applied to the computed total static force to account for uncertainties:

**Table 10-4** Load Factor for Uncertainties during Launch

<table>
<thead>
<tr>
<th>Computed load (L)</th>
<th>Load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>L &lt; 150 tonnes</td>
<td>1.5</td>
</tr>
<tr>
<td>150 &lt; L &lt; 300 tonnes</td>
<td>1.5 - 0.002*(L - 150)</td>
</tr>
<tr>
<td>L &gt; 300 tonnes</td>
<td>1.2</td>
</tr>
</tbody>
</table>

The minimum factored static load at either end for launch should normally be taken as 100 tonnes.

For installation (final positioning), a load factor of 1.0 may be applied, subject to assumptions for chain and wire friction against the seabed being conservative.

10.10.10 Shackles and other certified rigging items should have an MBL 10% greater than the launch or tow wire.

10.10.11 The Minimum Breaking Load of the tow rigging should be calculated by multiplying the factored static tow force by a factor of 2.0.

10.10.12 Structural steel items such as tri-plates, padeyes and the load path through the towhead shall have a MBL not less than 1.3 times the MBL of the towline.

**10.11 BOTTOM AND OFF-BOTTOM TOW - LAUNCH PHASE**

10.11.1 For off-bottom tow, the entry of the towing head, pipe string and trailing head into the water should be monitored by divers and, if necessary, by an inshore survey boat. Internal pressures should be checked after launch during the ballasting and trimming operations.

10.11.2 For off-bottom tow, all connections of towing equipment and drag chains should be checked by ROV or divers after launch. The launch bridle and pennant should not be used for the tow if the launch procedure may have caused mechanical damage or overstressing of the gear, or the post-launch checks reveal actual damage.

10.11.3 The launch starts on a weather forecast with assurance that it will reach a safe condition within the foreseeable forecast, taking into account local conditions, currents and pipe string deflection. Following completion of launch, a decision will be taken on whether to commence tow to field or to “park” the pipe string.

10.11.4 A maximum tug efficiency of 80% of the continuous bollard pull should be assumed for the tug(s) used for launch, assuming calm conditions - see 0030/ND, Ref. [5], Section 12.2.

10.11.5 In the event of the launch stopping due to build-up of sand ahead of the towhead, the peak load may be increased to 60% of the MBL of the weakest part of the launch rigging. This upper limit should be...
clearly stated in the launch procedure as a contingency case. It may only be used subject to accurate monitoring of the actual force applied and full briefing of all personnel involved.

**10.12 BOTTOM AND OFF-BOTTOM TOW - TOWAGE PHASE**

**10.12.1** A tow route corridor pre-survey is required and should be made prior to detailed design completion. This survey should provide seabed bathymetry and side scan seabed images (or a swathe survey) of the whole transit corridor, and soil type and soil stiffness properties measured at regular intervals along the corridor. If this survey was made in more than 90 days before the tow, a follow-up survey is needed no more than 90 days prior to the tow operation with a swathe or side scan to confirm the route is clear of debris and other construction activity.

**10.12.2** Pipe towages should in general comply with the requirements of 0030/ND, Ref. [5], except that tow wires are generally relatively short, and cannot comply with the requirements of 0030/ND Section 13.3. The motion of the tug in waves will cause dynamic loads to be applied to the towheads. A dynamic analysis should be carried out, which will normally result in limitations being placed on the seastates in which the pipe can be towed.

**10.12.3** For off-bottom tow it is usual to provide buoyancy tanks attached to both tow and trail heads. These and any along the pipe are to be subdivided so that loss of any single compartment does not lead to an irrecoverable situation. Buoyancy tanks should be pressurised to the maximum water depth likely to be encountered during towage. Consideration shall be given to possible loss of buoyancy tanks in analysis and procedure (25% loss of buoyancy should be considered).

**10.12.4** In cases where the bollard pull of the tug may exceed 50% of the MBL of any of the wires through which the tug is connected to the pipe, the following requirements shall be incorporated into the operational procedures:

- The tug shall have a recently calibrated and operational means of displaying the actual toline force. If this is based on winch torque, then compensation shall be included for the layer on the winch from which the rope is being pulled.
- The peak load applied by the tug shall not be allowed to exceed 50% of the MBL of the weakest link through which it is connected to the bundle.
- The master of the tug shall be fully briefed on the permissible peak load which may be applied.

**10.12.5** It is essential that:

- Advance notice of the operation should be given through Notices to Mariners, or local equivalent, and military and fishing interests should be advised well ahead of the proposed date of the operation.
- The tow must be accompanied by a guard vessel at all times.
- The towing vessels must display shapes and lights in accordance with IMO “Convention on the International Regulations for Preventing Collisions at Sea”, Ref. [18]

**10.12.6** Weather for the tow shall be limited to that in which the towing/trail tugs can maintain the required tension to keep the tow string within the tow corridor. In practice, the weather may be limited by the ability of the trail tug to maintain station relative to the position of the pipe.

**10.12.7** The limiting seastate, current, wind speed, etc., for the operation should be clearly defined and suitable contingencies included to account for forecast and analytical uncertainty. The towage should move from place of safety to place of safety (usually predefined parking areas) within a foreseeable weather window.

**10.12.8** The required weather window shall be documented in detail for comparison with forecasts.
10.12.9 In order to control the attitude and position during tow, instrumentation must be provided, including as a minimum:

- Transponder/Depth and Hydroacoustic Positioning Reference sensors on tow and trail heads, and at least three distributed along the line to monitor the position and configuration of the line. The system should have sufficient redundancy to ensure that loss of any one transponder does not prejudice the capabilities of the system to determine the position of the bundle.
- Pressure gauges on all pressurised compartments and lines, with transducers fitted at the lay-down points within the tow and trail head structures.
- All positioning and monitoring equipment should be centrally monitored on the command vessel. Positioning equipment should be capable of giving good visual and plotted indication of the bundle position, shape and depth at all times.

10.12.10 The minimum required Under Keel Clearance (UKC, between the lowest part of the pipeline and LAT), apart from bottom tows, will depend on the controllability of the tow depth. This needs to be determined and agreed with GL Noble Denton at an early stage of the project but will typically be at least 10 metres.

10.12.11 The towing vessels are to be highly constrained and must keep their position accurately with respect to each other and the towing and trailing heads so that the tow string is maintained in the tow corridor and at the required tow depth. Particular care is being taken during alterations of course.

10.12.12 It may be necessary for planned or contingency reasons to park the tow string at a designated parking position.

10.12.13 For the off-bottom tow string, consideration should be given to the fatigue damage that may be experienced in any parking position allowing for foreseeable spells of waiting on weather.

10.12.14 Steady state and dynamic towing forces should generally be computed using a suitable dynamic analysis. The analysis should include the effects of waves, currents and forces induced in the pipe by the trail tug.

10.12.15 The required bollard pull of the lead tow tug(s) should be derived using the estimated efficiency factors shown in 0030/ND, Ref. [5], Section 12.2, taking into account the defined limiting weather criteria.

10.12.16 In the absence of vessel-specific data, the reduction in available towline pull at the required towing speed should be taken into account as follows:

<table>
<thead>
<tr>
<th>Certified Continuous Bollard Pull (BP), tonnes</th>
<th>Reduction in Bollard Pull with Speed (tonnes/knot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP ≤ 120 tonnes</td>
<td>7 tonnes/knot</td>
</tr>
<tr>
<td>120 &lt; BP &lt; 280 tonnes</td>
<td>7 + 0.03125*(BP - 120) tonnes/knot</td>
</tr>
<tr>
<td>BP &gt; 280 tonnes</td>
<td>12 tonnes/knot</td>
</tr>
</tbody>
</table>

10.12.17 The MBL of the tow rigging shall be calculated using the peak dynamic tow force multiplied by a factor of 2.0. Shackles and other certified rigging items shall have an MBL at least 10% greater than that required for the tow wire.

10.12.18 Structural steel items such as padeyes and the load path from through the towhead should have an Ultimate Load Capacity not less than the lesser of:

- Tow wire required MBL + 40 tonnes, (for MBL ≥ 160 tonnes) or
- Tow wire required MBL x 1.25 (for MBL ≤ 160 tonnes)
10.12.19 Trail end tug behaviour is not currently amenable to dynamic analysis; therefore the following assumptions are often used:
- Steady hold back force = 30 tonnes
- Dynamic hold back force = 90 tonnes
- MBL of trail tow rigging = 180 tonnes
- MBL of shackles and other certified rigging items = 10% greater than tow wire
- Structural steel items shall be in accordance with the same principles as the towhead

10.12.20 Cumulative fatigue damage in the pipe also needs to be assessed, recognising stress cycling from traversing the seabed bottom over the tow route. Note that fatigue of partial penetration butt welds used in one application caused failure of a tow.

10.13 CONTROLLED DEPTH TOW (CDT)

10.13.1 Further to the general pipeline design requirements for tow methods provided above in Sections 5.6 and 10.12 for on and off-bottom tows, this section addresses the additional specifics for tows where the pipe buoyancy is engineered to enable the pipe assembly to be towed suspended between trail and lead tugs at a controlled depth.

10.13.2 The towage should move from place of safety to place of safety within a foreseeable weather window.

10.13.3 The position survey package must be carefully developed to ensure it will meet the needs of the operations. In particular it shall demonstrate the clearance to any fixed hazards at the location and shall always include transponders fitted to the string that allow its profile to be identified in three dimensions.

10.13.4 Bundle stresses shall be determined and calculations provided to show adequate strength allowing for the curvature of the bundle during towage. Effective bundle stiffness and local stresses at bulkheads are to be determined.

10.13.5 Considerations should be given to pipeline crossings in terms of checks and vessel status.

10.13.6 Trail tug motion characteristics should be considered as a criterion for obtaining operational limits.

10.13.7 Suitability of ROV support vessel and associated equipment to be thoroughly checked via vessel assurance survey or similar.

10.13.8 The Towmaster and Marine Representatives should have clear understanding of the behaviour and response of the bundle to the various corrective actions that may be undertaken during the tow.

10.13.9 The bundle profile should be continuously monitored and any remedial actions taken in a timely manner.

10.13.10 Manning on-board all the vessels in the tow fleet should be reviewed before the tow to ensure that there is adequate cover to allow the tow to be constantly monitored and that no person is overloaded with several tasks.

10.13.11 Consideration to be given as to whether the Guard Vessel can be utilised to monitor the bundle attitude in the event of a failure onboard the ROV support vessel.

10.14 SURFACE AND NEAR-SURFACE TOW

10.14.1 Further to the general pipeline design requirements for tow methods provided above in Section 5 and in Section 10.12 for bottom and off-bottom tows, this section addresses the additional requirements for tows where the pipe is floated and held between trail and lead tugs.

10.14.2 Removal of buoyancy elements is a calm-weather operation that must be carefully addressed, to avoid loss of control of pipe or elements.

10.14.3 Pipe stresses and fatigue need particular attention as the string will experience a large number of stress cycles if left at the surface for some time in all but sheltered waters.

10.14.4 The following information will normally be required for approval:
- Fatigue life calculations for the tow, with assumptions made.
- A clearly documented heavy weather procedure shall be presented for review and acceptance.
The full and comprehensive leak testing of all buoyancy elements and pipeline closures
A minimum overall reserve buoyancy of 25%
The ability to withstand the loss of 25% of the buoyancy elements including any four adjacent elements
All connections between the buoyancy elements and the pipeline are to be completed with robust connections that are not sensitive to fatigue
All tensile connections are to be subject to 100% NDT
A suitable work class ROV must be present in the field during installation operations with a package of spares

10.15 PIPELINE AND CABLE CROSSINGS

10.15.1 The key principle for crossings is to demonstrate that the existing line will be protected from harm and continue to operate without interruption.

10.15.2 Crossing designs require a physical separation to be provided between the crossed and crossing lines. Minimum separation is typically specified by the pipeline operators and is often in excess of the 0.3m value typically required by codes. Separation between the lines is required so that the new line does not bear directly upon the crossed line and so that their cathodic protection systems are isolated from each other.

10.15.3 Installation procedures are required, supported by analyses to ensure that:

- the crossed line is not overstressed by any movement or loading (recognising the operational status at the time)
- the crossing line is not overstressed by the geometry and supports of the crossing or any movement or loading (recognising the flooded and/or empty conditions of the line at the time) Span to be checked with axial loading only as the bending stress imposed by installation/laying curvature will be much higher.
- the materials forming the crossing are placed in a controlled manner such that they themselves are not overloaded and all lifts are made at an offset from the crossed and crossing line with only the final lowering made above them

10.15.4 As-built records and visual and written records of the construction sequence shall be made to provide evidence of the conditions with respect to the crossed line.

10.15.5 Sufficient transponders should be installed to obtain an accurate positioning of the pipeline (crossing line) respectively to the crossed line. Where the crossing is close to the final end/laydown area, the numbers of transponders that are required to obtain an accurate positioning at the crossing area and to ensure that the pipeline will also land in the target box must be anticipated and stated in the procedure.

10.16 TRENCHING AND BACK-FILL

10.16.1 Trenching is usually carried out in order to lower a product away from the seabed environmental loadings, and away from harm by fishing activity or for ecological reasons or to mitigate seabed topography e.g. to pass through a high point.

10.16.2 Pre-trenching is where a trench is cut in the seabed into which the product is later installed. Pre-trenching is the preferred method when pipelines are to be installed by the bottom pull or bottom-tow methods.

10.16.3 Post-trenching can be used when pre-trenching is not advisable e.g. for laying pipe in deep water, when it is difficult to control the position of the touchdown point, or where bottom currents may cause material to fall back into the trench before the pipe can be lowered into it.

10.16.4 Checks should be made to ensure that the pipe is not over stressed during trenching operations for four conditions i.e. pick-up, transition-in, normal trenching and transition-out, either at pick-up or entry into the trencher. In addition, the as-built transition into the trench and out again should not induce over-long pipe free-spans at the ends of the trench. The pipeline should also be checked in both empty and flooded condition if flooding/cleaning of pipe is to be carried out prior to trenching (or
between passes). Generally, one condition (e.g. pick up for 2nd pass in flooded condition) is more
critical than the others and may govern the analysis.

10.16.5 Another important consideration is protection of the pipe from damaging contact with the trencher, its
cutters or the hydraulic jets. Instrumentation on the trencher shall be comprehensive and calibrated to
ensure that the pipeline is not overloaded or contacted inadvertently. In particular, the configuration of
the rollers, grabs and boxes should be set up so as to not create any damage to the line pipe coating
or to the FJC.

10.16.6 Video is normally available but once trenching starts it can be blinded by the fines in the soil so GPS
and subsea acoustic positioning shall be utilised. Load cells, sonar and electromagnetic transducers
are required to provide required information on the pipe and its route, machine and seabed
configuration to the trencher equipment control room.

10.16.7 Where moving cutters are involved, pipe position sensing equipment shall be provided and alarmed
and an automatic trip provided to cut-out the power to the cutters and to forward motion if they get too
close to the pipe. These sensors and the alarm and trip should be calibrated against the project pipe
immediately prior to mobilisation which shall be witnessed by a 3rd party or the Surveyor.

10.16.8 Where the pipe is lifted from the seabed to pass through the trencher or the trencher has the potential
to grossly deflect the pipeline laterally, the vertical and horizontal loads on the pipe shall be monitored
by calibrated load cells with alarms and trips on the motive power to the trencher, if applicable. In the
case of towed ploughs these alarms should be relayed by fail-safe radio telemetry to the tug(s) to call
an all-stop. These alarms should be calibrated and tested in the presence of a 3rd party witness or the
Surveyor.

10.16.9 Unexpected or sudden changes in the soil will affect the performance of the trencher and can damage
the trencher and perhaps the pipeline. Buried debris and glacial rocks in clay are examples of the
hazards which require constant diligence from the operators of the trenching equipment to adjust or
stop operations as these are encountered.

10.16.10 Similar considerations to those in Section 10.16.4 above apply to cables and umbilicals, with an
additional constraint being that the MBR of the line shall not be exceeded in its passage through the
trenching equipment.

10.16.11 Deployment and recovery of the trenching or backfilling equipment shall be managed as any overside
lift in the proximity of seabed facilities. Some equipment is both bulky and heavy and can be difficult or
dangerous to recover in poor weather. Weather thresholds shall be established in approved
procedures that will govern when operations shall cease for recovery of the equipment. Similarly,
weather limits shall be set for commencement of deployment. For some equipment spreads it may be
permissible to leave the equipment on the seabed and wait for the storm to pass – this should be
established in approved procedures before mobilisation.

10.16.12 A post trench survey (reduced to LAT) should be made to measure depth and profile of cover to the
top of the pipe and to provide a seabed sectional profile from an acoustic scan at intervals of 1 – 5
metres along the line to confirm that the pipe is at specified depth below the seabed level. All
instruments should be calibrated at mobilisation. A video survey record should also be made to
confirm the pipe’s condition and to measure any free spans in the trench. A 3-camera video is
normally required to view the crown and both sides of the pipe simultaneously.

10.16.13 A calibrated electromagnetic pipe tracker should be passed over the centreline of the pipe after
backfilling to confirm that there is sufficient cover to the line. A sectional seabed profile from an
acoustic scan at intervals of 1 – 5 metres along the line should also be provided to confirm the trench
is filled to specification.

10.16.14 Maximum expected tow force for soil conditions to tow the plough shall be evaluated and compared
against bollard pull of vessel to assess if one or more passes will be needed. The toline between
vessel and plough is to be designed in accordance with 0030/ND, Ref. [5].

10.16.15 As-built survey after trenching & backfilling needed for upheaval buckling assessment in order to
identify the areas where mitigation by rock-dumping or mattressing is necessary.
10.17 ROCK AND GRAVEL DUMPING

10.17.1 These terms apply to graded crushed rock and to gravel that has been won from quarries. The graded material should conform to a specified percentage passing a series of screen sizes with density, hardness, durability and freedom from contaminants also applying.

10.17.2 From a pipeline, cable or umbilical’s perspective, the important considerations are to ensure that the line is not over loaded by an uncontrolled mass of rock-dump landing dynamically upon it. In this regard; the rock-dump grading is to be controlled so that the maximum individual rock size is not able to damage the coating or the structure of the line.

10.17.3 The rock-dump berm is to be stable in the design marine environment.

10.17.4 Effective DP, heave compensation and ROV control of the bottom of the fall pipe are all critical to ensure that the fall pipe system does not damage the pipeline. The heave compensation system should be checked prior to mobilisation to assure its condition and settings of the hydraulic systems and wires. Instrumentation on the ROV at the base of the fall pipe shall include: video; acoustic profilers; electromagnetic pipe tracker and acoustic responder for subsurface positioning. All ROV instrumentation shall be verified to be effective at mobilisation.

10.17.5 GPS and subsea acoustic positioning shall be interfaced, and sonar and pipe tracker data also, to provide data and displays of the pipeline route, fall pipe ROV and seabed configuration to the bridge.

10.18 PIPELINE MATTRESSING AND GROUT BAGGING

10.18.1 Mattressing (or matting) is used extensively to protect lines (from dropped objects and fishing or other interference) at their approach to fixed seabed facilities and to fixed installations.

10.18.2 The main concerns are safe lifting, handling and positioning of the mattresses. Approved procedures should be provided to control these matters with appropriate weather limits identified. Prior to deployment the lifting loops should be checked to confirm that they are not damaged and that their condition is good, noting that ultra violet from sunshine degrades plastic fibre rope.

10.19 J-TUBE PULL-IN

10.19.1 The dimensions of the J-tube are such that a rigid riser pipe will be plastically strained as it passes through each bend in the J-tube, acquiring residual plastic and elastic bending after each bend, and large contact/bearing loads will set up in the middle and each side of these bends during the pull-in. The mechanism can be simplified to calculate the pull-in loads and are required to be analysed using FEA models. For calculation of the pull-in loads for a rigid riser pipe reference may be made to Ref. [20] or to Ref. 0.

10.19.2 For flexible pipe, umbilical and cable pull-ins, classical theory for the tension amplification around a frictional bollard and elastic beam bending theory are usually sufficient for the purpose.

10.19.3 No matter how the pull loads are calculated, uncertainty will remain due to the assumptions concerning friction coefficients for the sliding contacts within the J-tube during the pull-in. Default indicative coefficients are provided on Table 10-6 below. Application-specific test results should be used to justify use of any other values.

<table>
<thead>
<tr>
<th>Friction Interface</th>
<th>Static Coefficient</th>
<th>Sliding Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Bare pipe or pullhead</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>FBE (Fusion Bonded Epoxy) coated pipe</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>PP (Polypropylene) coated pipe</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Nylon, PE (Polyethylene) or Polyurethane sheath</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

10.19.4 It is recommended that the J-tube be proven open and round by means of a gauge plate run prior to pull-in of the riser. The gauge plate should be sized slightly below the minimum J-tube bore, e.g. 98%
of the I.D., according to its fabrication tolerances. Also, if the J-tube has been in place for several years, its internal condition should be assured by means of spot check remote visual inspection.

10.19.5 Strength of the J-tube and its attachment to its host structure shall be confirmed capable of carrying the maximum loads placed upon it during riser pull-in.

10.19.6 Cumulative rigid pipe riser ovalisation due to bending shall be checked and documented in the Installation Manual to ensure that local buckling or collapse is not a risk, particularly at the deepest bends in the J-tube. Similarly, the riser pipe material shall be verified as suitable for the strains accumulated, including those in the J-tube pull-in. For a J-tube pull-in after a reel lay, the pipe will be deformed plastically twice more. It is important to document the total accumulated strain and compare it with the requirement for ECA or additional tests.

10.19.7 Pull-in rigging and components, including the pull head, loaded by the pull-in shall be checked in accordance with the criteria in Sections 10.3.4 and 10.3.7 above, noting that the peak calculated pull-in load shall be used in place of start-up load and if the J-tube geometry is not in a single vertical plane, the pullhead may require to be designed for equal strength about its axis.

10.20 FLEXIBLE PIPE RISER AND DYNAMIC UMBILICAL / CABLE RISER INSTALLATION

10.20.1 These products are treated similarly during installation. The finished configuration and green field versus brown field conditions have a major bearing on installation procedure. From the product’s point of view, careful handling to protect the outer sheath, protection against over bending (versus the MBR) and protection against axial and crushing overload are the prime considerations. Installation lifts and transfer of the product requires application of 0027/ND – Guidelines for Marine Lifting Operations, Ref. [4]. Static analyses and selective dynamic analyses should be made for the most critical phases of the transfer of the product from the installation vessel to its final location.

10.20.2 Pull-in winch and rigging capacity on the receiving installation requires a practical margin. 5 tonnes contingency on 25 tonnes would be typically acceptable, between the predicted peak pull load and the nominal capacity, subject to any uncertainties governing assumed friction loads. Note that the nominal rating may be for an empty drum whereas the peak pull load is likely to be with the drum full of wire. Prior to mobilisation this winch and rigging should be load and function tested.

10.20.3 The path of the riser top through the installation needs to be guided through cones and smooth bores of known dimensions and tolerances, as far as practicable, to avoid hang-ups. Also, consideration of the approach angle off-vertical or wire offset from centre of pull-tubes/I-tubes, etc., shall be included in the planning and procedure to avoid hang-up of the riser. Catenary geometry at these critical locations and vessel offset to achieve them shall be documented in supporting analyses of the installation.

10.20.4 Vessel stand-off or offset at all stages of the installation needs to be defined and drawn to scale in plan, and elevation if necessary, to demonstrate that the installation is clash free from any adjacent risers or moorings or other facilities and to guide the vessel crew. Such drawings need to be included in the installation procedures.

10.20.5 Contingency procedures for safe rapid disconnection of the installation vessel from the riser shall be established and approved for the duration of physical connection, by wires rigging or the riser itself, of the installation vessel to the receiving installation. Procedures for recovery from circumstances such as dead ship, DP run-off or failed winches shall be established and approved prior to mobilisation.

10.20.6 Attachments to the product to lift it shall be made at strong points such as end fittings by use of padeyes on bullnoses or pullheads or by clamping or webbing strops choked around the bend strain reliever (BSR) adjacent to the end fitting. Where it is necessary to attach to the line between hard points, this should be by means of purpose made clamps or by suitably sized and rated Chinese fingers.

10.20.7 Chinese fingers should only be used for axial and minor lateral loadings. Similarly, soft webbing strops choked around the body of the line may be used in instances of minor loading or restraint such as for tag lines or small air bag attachment for final positioning. Attachment of Chinese fingers should be made in accordance with manufacturer's instructions included with the installation procedure. After attachment, Chinese fingers should be subject to a test lift for a 5-minute minimum duration before continuing with the lift.
For un-bonded flexible pipe risers, annulus pressure relieving vents at end fittings shall be confirmed fitted and in good condition, prior to over-boarding the riser.

At all flexible pipe riser connections subsea, one of the flanges of a mating pair should be a swivel ring to enable bolt alignment to be made.

Umbilical and cable electrical connector end caps need to be fitted carefully to protect them from water ingress and to provide a continuity testing path for post installation testing purposes.

In the case of installation into a floating installation such as an FPSO which is free to rotate around a turret mooring, specific procedures and controls of the weather-vaning shall be provided if the installation vessel is to enter the swing circle (swep envelope created by the weather-vaning installation and its maximum radial excursion on its mooring system).

**STEEL CATENARY RISER (SCR) INSTALLATION**

Steel catenary risers are only feasible in deep water (generally greater than 500m) where there is sufficient water depth for the riser to flex to follow the surface installation without overstressing. They are installed as part of the pipeline using the same vessels and methods as the rigid pipe laid to the location and so are subject to the same general considerations in Sections 10.7 to 10.8 above.

The weight of thick walled SCRs is an issue for installation. There are only a limited number of installation vessels able to install thick walled SCRs in deep water and the number of suitable installation vessels diminishes rapidly with increasing depth and pipe wall thickness.

In this application the pipelay process is more critically important to the available life of the system and its performance. Residual strains, strain history, residual torque, residual ovalisation, stress raisers and fatigue life consumption from the installation process are key and have to be compared to the allowances provided by the system designers. The applicable design codes for SCR’s are API RP 2RD, Ref. [9], and DNV-OS-F201, Ref. [14].

DNV-OS-F101, Ref. [13], Section 5, Clause D800 provides guidance on allowable fatigue utilization during the construction phase for various safety categories of pipeline safety criticality.

A flexible joint or taper stress joint is often provided at the top of the riser as the connection to the host facility. This joint is vulnerable to any locked in torque left in the pipeline and riser so the load needs to be determined by the installation analysis and confirmed to be within the design specification of the joint.

The use of SCRs in deepwater results in thick wall risers with complex welding procedure requirements for the offshore field joints. Automatic Ultrasonic Testing (AUT) is typically employed as part of the offshore NDT program and is considered one of the most effective methods of inspection offshore to detect critical flaw sizes as small as 0.5 to 1.0 mm in height, which is a possible requirement for fatigue sensitive SCR welds. Note: extensive testing prior to offshore installation is required to ensure that the AUT procedures and personnel involved are qualified, as there is a limited track record in its use on thick walled SCRs.

In general SCRs need to be installed once the host facility is in place. This requires a complex handover operation between the pipelay vessel and host, with the pipelay vessel working in close proximity.

During assembly of the SCR, typically there will be a point beyond which the SCR cannot be abandoned (the “Point of No Return” or PNR) as it would interfere with the host platform’s field architecture (moorings, in-field pipeline, wells, templates, etc.). Abandonment beyond this point will first require the SCR to be cut back before it is abandoned. The key factor for the final transfer phase is to ensure an adequate weather window is in place to successfully complete the SCR assembly and its subsequent transfer to the host facility. Typically at a deepwater facility, the SCR installation can take up to five days. This is longer than currently available weather forecasts. Therefore, the installation time from the point of no return to final handover and hang off of the SCR onto the host facility needs to be kept to a minimum.

Generally, SCR transfer operations are prepared based on an empty SCR. However, should the SCR accidentally become flooded during this operation, the installation aids should be sized such as to preclude a catastrophic event. Installation aids should have enough capacity to hold flooded SCR. The capacity of SCR porch to hold flooded SCR should also be checked. In case the porch does not
have enough capacity to hold flooded SCR contingency procedure for laying down SCR in flooded condition and subsequent recovery should be submitted for GL Noble Denton approval.

10.22 RIGID PIPE SPOOL INSTALLATION

10.22.1 This section covers rigid piping (including any in-line valves and fittings) that is to be installed on the seabed and attached to another spool, a pipeline or seabed structure.

10.22.2 Short spools will be accommodated and seafastened on deck by lashings or weldments and clamps as appropriate. Large spools may have to be cantilevered or carried on over-side seafastenings welded to the installation vessel or to a transport barge. Transportation and seafastening of spools over-side of the vessel requires application of 0030/ND – Guidelines for Marine Transportations, Ref. [5]. Lifting of all but the shortest spools requires application of 0027/ND – Guidelines for Marine Lifting Operations & Lowering, Ref. [4].

10.22.3 Lift rigging and lifting aids should normally comply with the requirements of 0027/ND, Ref. [4].

10.22.4 Lifting points should not be welded directly to the pipe. Note that for long spools there may be a need to assemble the spool in the field. The lifting design should cover all phases of the spool lifting and fabrication operations.

10.23 FLEXIBLE PIPE SPOOL AND UMBILICAL / CABLE JUMPER INSTALLATION

10.23.1 These products are treated similarly during installation. Installation requirements are similar to those for flexible pipe risers and dynamic umbilical /cable risers as described in Sections 10.20.1, 10.20.4, 10.20.10 and 10.20.11.

10.23.2 Baskets and pallet structures used to transfer the line to the seabed need to be accompanied by load test certificates that remain valid and fully certificated rigging. Lift points and rigging will require to be checked for condition prior to use. The lift should be analysed and proven suitable for the weather and vessel.

10.23.3 For flexible pipe spools it should be clear in the procedures and drawings that the line is being installed sealed closed or free-flooding and arrangements made to suit.
REFERENCES
Care should be taken to refer to the latest editions of these references.

[3] GL Noble Denton 0021/ND - Guidelines for the Approval of Towing Vessels
[7] API RP 5LW - Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
[9] API RP 2RD - Design of Risers for Floating Production Systems (FPSs) and Tension-leg Platforms (TLPs)
[10] ASME VIII Boiler and Pressure Vessel Code
[11] BS EN 14161 Petroleum and Natural Gas Industries - Pipeline Transportation Systems
[14] DNV OS-F201 Dynamic Risers
[17] IMCA M 117 The Training and Experience of Key DP Personnel
[18] IMO Convention on the International Regulations for Preventing Collisions at Sea
All GL Noble Denton Guidelines can be downloaded from 
APPENDIX A - INFORMATION REQUIRED FOR APPROVAL

A.1 GENERAL
A.1.1 In order to issue a Certificate of Approval, GL Noble Denton will consider the topics listed in Section 4.3, either by reviewing submitted calculations, procedures and drawings, or by independent check calculations as deemed appropriate. The information normally required to carry out the reviews is listed in this Appendix, but additional information may be required for specific projects.

A.2 PIPELINE DESIGN AND CONSTRUCTION AS RELATED TO MARINE ACTIVITIES

- Internal and external diameter and wall thickness
- Design environmental conditions
- Design, operating and test pressures
- Structural design during installation and commissioning load cases, stresses and buckling
- Pipeline material specification
- Pipeline corrosion and weight coating and field joint coatings. FJC procedure should be submitted for approval as often the procedure does not clearly reflect the manufacturer's specification, particularly for the temperature of application which is of paramount importance. Procedure to also clearly show how linepipe coating is prepared to provide adequate adherence of FJC to linepipe coating and ensure continuity of protection. Clear method for FJC inspection should also be presented.
- Anode type and method of fixing
- Piggyback lines
- On bottom pipeline stability analysis for temporary conditions
- Free spans analysis
- Free spans and rectification procedures
- Trenching/burial requirements.

A.3 PIPELINE ROUTE

Defined by a series of alignment sheets showing as a minimum:
- Start-up and lay-down target areas
- Pipeline route between the target areas, clearly showing the theoretical route, straight and curved sections, radii and tangent points, existing platform(s), pipelines, cables, and shoreline if applicable
- Lay corridor
- Alignment with predominant current and wave headings
- Shipping lanes and other restricted areas due to military or political reasons.
- Presence of any submarine exercise areas, fishing, mine fields, dredging and wrecks
- If applicable, levels and type of fishing activity
- Mooring line/riser crossings
- Minimum distance from existing subsea assets
- Minimum distance to existing fixed/floating platforms and platform approach drawings
- Hydrographic survey
- Sidescan sonar survey
- Geotechnical survey
• Any other potential hazards or obstructions, such as mines or munitions dumping areas
• Seabed features such as possible huge and multiple spans, coral growths, rock outcrops, soft liquefiable soils, sand dunes, pockmarks, ice berg plow marks and other seafloor obstructions such as boulder fields

A.4 HYDROGRAPHIC & SIDESCAN SURVEY OF ROUTE SHOWING:
• Water depth along the route and general seabed topography
• Any obstacles within the proposed corridor
• Any areas where free-spanning is anticipated, or where scour or sand waves are anticipated

A.5 GEOTECHNICAL SURVEY OF ROUTE DEMONSTRATING:
• General seabed composition and stability
• Identification of rock or coral outcrops, sand waves or mudslide areas
• Sufficient subsurface information to justify trenching and/or burial procedures

A.6 LAY VESSEL INFORMATION
• General Arrangement of vessel, principal dimensions and operational draught
• Deck layout of all permanent and moveable equipment items
• Outline specification of vessel, accommodation and machinery
• Cranes – including load-radius covers, winches including abandonment and recovery (A&R) and records of maintenance
• Stinger, Lay tower or ramp geometry and rating
• Reel lay system or Reel Drive System
• Carousels capacity and drive systems
• Structures (PLET/ILT) handling systems
• Tensioner capacity and settings
• Full details of the mooring system, winches, anchors, control and monitoring system, a mooring procedures manual, mooring lines certificates and records of maintenance
• Dynamic positioning system information
• DP vessels shall submit the last annual DP trials including recommendations and close-outs, the latest DP FMEA detailing single point failures.
• ROV Class and capacities
• ROV handling system
• Rollers, load cell arrangement
• Video, and other control and monitoring equipment.
• Weather or motion limitations for laying and records of maintenance
• Motion response characteristics, preferably as tabulated response amplitude operators (RAO’s) against frequency and vessel heading
• MRUs and Motion Measurement System
• Current Meters
• Where available, the latest Common Marine Inspection Document
• Certification as appropriate, including:
  o Certificate of class for hull and machinery
GUIDELINES FOR SUBMARINE PIPELINE INSTALLATION

- Registry, loadline and tonnage certificates
- Safety construction, safety equipment and safety radio certificate
- Certificates for cranes, davits, winches, rigging and other items relevant to the operation such as DMA/initiation cable not covered by the normal classification requirements.

A.7 MOORING/DP PROCEDURES

- The mooring procedure manual, which shall be available on board the lay vessel during operations, shall demonstrate:
  - General procedures for mooring and anchor handling
  - General anchor patterns and catenary curves during straight lay and on radius
  - Specific procedures for working anchors close to shore
  - Specific anchor patterns during start-up and lay-down, crossing points and where working close to existing structures and pipelines, risers, subsea assets and other prohibited zones
  - Command structure, communications and working frequencies, anchor movement logging procedures and proformas
  - Contingency procedures for bad weather, mooring failure, power failure of positioning system, etc
  - Details of anchor handling vessels
  - Dynamic Positioning specification
  - Vessel position survey procedures
  - Survey equipment calibration procedures
  - Survey equipment specifications

A.8 GENERAL LAYING PROCEDURES

- Laying procedure
- Governing weather criteria
- Provisions for weather forecasting
- Line installation stress and fatigue calculations
- Welding, NDT and field joint coating procedures. FJC procedure should be submitted for approval as explained above in Appendix A2
- Special procedures for laying and attaching piggyback line
- Procedures for attachment of anodes, etc
- Procedures and analyses for installation of Hot Tap Tee, In-line Tee, Wyes, Pipeline End Tees and other structures in the line
- Installation aids and their structural design
- Start-up procedures and analyses
- Calculations for start-up sheave or pile and rigging
- Touch Down Monitoring (TDM) procedures
- Buckle detection procedures
- Pipeline lateral buckling and walking mitigation procedure
- Dry and wet buckle contingencies
- Lay-down procedures and analyses
- Emergency lay-down and recovery procedures and analyses
- Contingency protection methods in the event of temporary abandonment
GUIDELINES FOR SUBMARINE PIPELINE INSTALLATION

• Free span limitations and as-laid survey procedure
• Pigging and hydrotect procedure

A.9 MOORING /DP PROCEDURES
• General procedures and justification
• General anchor pattern during laying
• Specific anchor patterns for start-up, lay-down and crossing points
• Anchor handler details
• Equipment certification
• Dynamic Positioning specification
• Vessel position survey procedures
• Survey equipment calibration procedures
• Survey equipment specifications

A.10 PIPELINE AND CABLE CROSSINGS
The following information should be submitted:
• Check crossing procedure including inspection and monitoring.
• Overall chart of crossing location, identifying coordinates of the crossing point (UTM), crossing angle and sizes of crossed and crossing cables and pipelines
• Specification of minimum cover between and above crossed and crossing cables and pipelines
• Geometry of supporting structures, methods to be used for protection, seabed morphology and soil characteristics at the crossing location
• Mooring procedures whilst anchors and mooring lines are in the vicinity of the crossed cable or pipeline
• Check of stress and span at crossing location

A.11 TRENCHING AND/OR BURIAL (IF APPLICABLE)
• Specification for burial
• Post lay gauge pig and hydrotect acceptance criteria
• Specification of plough, trenching machine, jet sled and support vessel as applicable
• Available bollard pull and tow force
• Deployment/recovery procedures and analyses of Plough/Sled/Trencher
• Trenching and backfilling procedures and analyses
• Monitoring procedures
• Stress analysis to confirm pipe is not overstressed during trenching operations i.e. pick-up, transition-in, normal trenching and transition-out.
• Confirming that transition in and out of the trench will not induce over-long free spans at the ends of trench.
• Protection against contact with trencher specifically for piggyback lines or gross lateral deflection
• Protection against cutter coming in contact or too close to pipe
• Contingency procedures
• Upheaval buckling assessment
• Rock dumping /placement vessel specification and operating procedures
A.12 RISER OR SUBSEA TIE-IN INSTALLATION
- Vessel suitability (lay barge or DSV)
- Vessel cranes or davits and rigging have been inspected, the installation guides are in place and weather conditions suitable for operation.
- Mooring at platform or DP procedures
- Check tie-in equipment, including inspection, monitoring & testing
- Riser installation procedures
- Calculations for riser clamps and rigging
- Stress analysis where pipe is to be lifted for connection.
- Welding and NDT procedures for approval in the situation where welding will be performed under a suspended load in order to see how this is addressed. This should normally be risk-assessed
- Bolting procedures
- Temporary hang-off procedures
- Riser, subsea spool and/or structure configuration, weight and COG

A.13 TOWED PIPELINE
- Detailed route survey from launch to installation target area including lay-down, parking and standby areas along the tow corridor
- Drawings and specifications of carrier pipe, spacers, diaphragms and bulkheads
- Drawings and specification of towing and trailing heads
- Calculation of pipe, towing head and trailing head weight and buoyancy
- Details of additional buoyancy and buoyancy control devices such as drag chains
- Drawings, specification and certification of all padeyes and towing gear (including emergency tow gear)
- Details of tow and trail tugs, guard and command vessels, launching vessels (such as pull barges), any special equipment, and manning arrangements
- Towing procedures, including contingency procedures
- Details of all positioning and tow monitoring equipment
- Drawings and specifications of all land based works including soil conditions, foundations, rollers or trackways and trolleys, support structures, etc
- Launch procedures
- Trimming procedures
- Lifting procedures and craneage for towing and trailing heads
- Installation procedures at destination site
- Launch analysis
- Dynamic towage analysis
- Installation analysis

A.14 FLOODING, HYDROTESTING AND LEAK TESTING
- Internal and external diameter and wall thickness
- Design, operating and test pressures
- Gauge pigging procedures and proformas and gauge plate diameter and dimensions
- Details of pulling heads, pig receivers, end caps, etc
- Hydrotest specification and procedures
- Leak test specification and procedures

A.15 REEL LAY
- Reeling procedure and analysis
- Strain history

A.16 SHORE AND OFFSHORE PULL
- Pulling procedure
- Governing weather criteria, tide tables
- Pipeline pulling analysis
- Stringing, Welding, NDT and field joint coating procedures. FJC procedure should be submitted for approval as explained above in Appendix A.2
- Details of launching supports on land, vessels (such as pull barges), any special equipment, and manning arrangements
- Special procedures for messenger and pull wire laying and attaching installation aids such as buoyancy tank etc.
- Installation aids (pull head, riggings etc.) and their structural design
- Contingency protection methods in the event of temporary abandonment
- Holding back tension analysis for structure or mooring lines.
- Dredging and pre-trenching procedure.