Rules and Regulations for the Classification of a Floating Offshore Installation at a Fixed Location

Part 3
Functional Unit Types and Special Features
June 2013
## Chapter Contents

<table>
<thead>
<tr>
<th>PART</th>
<th>Chapter</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>REGULATIONS</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>RULES FOR THE MANUFACTURE, TESTING AND CERTIFICATION OF MATERIALS</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>FUNCTIONAL UNIT TYPES AND SPECIAL FEATURES</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>General Requirements for Offshore Units</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Buoys, Deep Draught Caissons, Turrets and Special Structures</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Production and Oil Storage Units</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Accommodation Units</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Riser Systems</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>Units for Transit and Operation in Ice</td>
</tr>
<tr>
<td></td>
<td>1.7</td>
<td>Drilling Plant Facility</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>Process Plant Facility</td>
</tr>
<tr>
<td></td>
<td>1.9</td>
<td>Dynamic Positioning Systems</td>
</tr>
<tr>
<td></td>
<td>1.10</td>
<td>Positional Mooring Systems</td>
</tr>
<tr>
<td></td>
<td>1.11</td>
<td>Lifting Appliances and Support Arrangements</td>
</tr>
<tr>
<td></td>
<td>1.12</td>
<td>Foundations</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Appendix A: Codes, Standards and Equipment Categories</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>STEEL UNIT STRUCTURES</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>MAIN AND AUXILIARY MACHINERY</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>CONTROL AND ELECTRICAL ENGINEERING</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>SAFETY SYSTEMS, HAZARDOUS AREAS AND FIRE</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>CORROSION CONTROL</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>CONCRETE UNIT STRUCTURES</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>SHIP UNITS</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>PRODUCTION, STORAGE AND OFFLOADING OF LIQUEFIED GASES IN BULK</td>
</tr>
</tbody>
</table>

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CHAPTER 1 GENERAL REQUIREMENTS FOR OFFSHORE UNITS

Section 1 Rule application
1.1 General

Section 2 Information required
2.1 General

Section 3 Operations manual
3.1 General
3.2 Information to be included

Section 4 Materials
4.1 General
4.2 Material selection
4.3 Structural categories
4.4 Minimum design temperature
4.5 Aluminium structure, fittings and paint

Section 5 Corrosion control
5.1 General

Section 6 Underwater marking
6.1 General

CHAPTER 2 BUOYS, DEEP DRAUGHT CAISSONS, TURRETS AND SPECIAL STRUCTURES

Section 1 General
1.1 Application
1.2 Definitions
1.3 Pipelines and power cables
1.4 Class notations
1.5 Scope
1.6 Installation layout and safety
1.7 Watertight and weathertight integrity
1.8 Plans and data submission

Section 2 Floating structures and subsea buoyant vessels
2.1 Floating structures
2.2 Permissible stresses
2.3 Subsea buoyant vessels

Section 3 Turret structures
3.1 General

Section 4 Mooring arms and towers
4.1 General

Section 5 Mooring hawsers and load monitoring
5.1 Mooring hawsers
5.2 Load monitoring
5.3 Spare parts and maintenance

Section 6 Mechanical items
6.1 General
6.2 Design
6.3 Bearings
6.4 Bearing support structures
6.5 Seals
6.6 Bolted joints
6.7 Swivel stack
6.8 Survey
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>7</th>
<th>Piping and piping systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.1</td>
<td>Plans and particulars</td>
</tr>
<tr>
<td></td>
<td>7.2</td>
<td>General requirements for piping systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>8</th>
<th>Hazardous areas and ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.1</td>
<td>Plans and particulars</td>
</tr>
<tr>
<td></td>
<td>8.2</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>9</th>
<th>Pollution prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.1</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>10</th>
<th>Swivel testing requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.1</td>
<td>General</td>
</tr>
</tbody>
</table>

### CHAPTER 3 PRODUCTION AND OIL STORAGE UNITS

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Class notations</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Scope</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Installation layout and safety</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Plans and data submission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>2</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1</td>
<td>Plans and data submission</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Drilling structures</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Permissible stresses</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>Well structure</td>
</tr>
<tr>
<td></td>
<td>2.6</td>
<td>Mud tanks</td>
</tr>
<tr>
<td></td>
<td>2.7</td>
<td>Deck-houses and modules</td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td>Pipe racks</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>Bulk storage vessels</td>
</tr>
<tr>
<td></td>
<td>2.10</td>
<td>Watertight and weathertight integrity</td>
</tr>
<tr>
<td></td>
<td>2.11</td>
<td>Access arrangements and closing appliances</td>
</tr>
<tr>
<td></td>
<td>2.12</td>
<td>Access to spaces in the oil storage area</td>
</tr>
<tr>
<td></td>
<td>2.13</td>
<td>Access hatchways to oil storage tanks</td>
</tr>
<tr>
<td></td>
<td>2.14</td>
<td>Loading of hot oil in storage tanks</td>
</tr>
<tr>
<td></td>
<td>2.15</td>
<td>Compartment minimum thickness</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>3</th>
<th>Hazardous areas and ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.1</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>4</th>
<th>Pollution prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1</td>
<td>General</td>
</tr>
</tbody>
</table>

### CHAPTER 4 ACCOMMODATION UNITS

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Class notations</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Scope</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Installation layout and safety</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Plans and data submission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>2</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1</td>
<td>Plans and data submission</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Watertight and weathertight integrity</td>
</tr>
</tbody>
</table>
### Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bilge systems and cross-flooding arrangements for accommodation units</td>
</tr>
<tr>
<td>4</td>
<td>Additional requirements for the electrical installation</td>
</tr>
<tr>
<td>5</td>
<td>RISER SYSTEMS</td>
</tr>
</tbody>
</table>

#### Section 3: Bilge systems and cross-flooding arrangements for accommodation units

3.1 Application
3.2 Location of bilge main and pumps
3.3 Arrangement and control of bilge system valves
3.4 Prevention of communication between compartments in the event of damage
3.5 Cross-flooding arrangements

#### Section 4: Additional requirements for the electrical installation

4.1 General
4.2 Emergency source of electrical power

#### CHAPTER 5: RISER SYSTEMS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
</tr>
<tr>
<td>2</td>
<td>Plans and data</td>
</tr>
<tr>
<td>3</td>
<td>Materials</td>
</tr>
<tr>
<td>4</td>
<td>Environmental considerations</td>
</tr>
<tr>
<td>5</td>
<td>Design loadings</td>
</tr>
<tr>
<td>6</td>
<td>Strength</td>
</tr>
</tbody>
</table>

#### Section 1: General

1.1 Application
1.2 Class notations
1.3 Definitions
1.4 Scope
1.5 Damage protection
1.6 Buoyancy elements
1.7 Emergency shut-down (ESD) system
1.8 Recognised Codes and Standards
1.9 Equipment categories
1.10 Equipment certification
1.11 Fabrication records
1.12 Site installation of riser systems
1.13 Maintenance and repair
1.14 Plans and data submissions

#### Section 2: Plans and data

2.1 General
2.2 Specifications
2.3 Plans and data to be submitted
2.4 Calculations and data
2.5 Operations Manual

#### Section 3: Materials

3.1 General

#### Section 4: Environmental considerations

4.1 General
4.2 Environmental factors
4.3 Waves
4.4 Current
4.5 Vortex shedding
4.6 Ice

#### Section 5: Design loadings

5.1 General
5.2 Dead loads
5.3 Live loads
5.4 Environmental loads and motions
5.5 Other loadings

#### Section 6: Strength

6.1 General
6.2 Structural analysis
6.3 Flexible risers and hoses
6.4 Welded steel risers
6.5 Pig trap
6.6 Riser supports and attachments
6.7 Mechanical items
### Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>7</th>
<th>Welding and fabrication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.1</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>8</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>8.2</td>
<td>Location Survey</td>
</tr>
<tr>
<td></td>
<td>8.3</td>
<td>Installation procedures</td>
</tr>
<tr>
<td></td>
<td>8.4</td>
<td>Completion Survey</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>9</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.1</td>
<td>Hydrostatic testing</td>
</tr>
<tr>
<td></td>
<td>9.2</td>
<td>Buckle detection</td>
</tr>
<tr>
<td></td>
<td>9.3</td>
<td>Testing of communications, controls and safety systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>10</th>
<th>Operation and repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.1</td>
<td>Operation procedures</td>
</tr>
<tr>
<td></td>
<td>10.2</td>
<td>Repairs</td>
</tr>
</tbody>
</table>

### Part 3

#### CHAPTER 6 UNITS FOR TRANSIT AND OPERATION IN ICE

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>2</th>
<th>Ice Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Definitions</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Ice Class notations</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>National Authority requirements</td>
</tr>
<tr>
<td></td>
<td>2.6</td>
<td>Ice conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>3</th>
<th>Air Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.1</td>
<td>Air temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>4</th>
<th>Icing Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1</td>
<td>Ice accretion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>5</th>
<th>Strengthening standard for navigation in ice – Application of requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.1</td>
<td>Additional strengthening</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>Plans and data submission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>6</th>
<th>Strengthening requirements for navigation in ice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.1</td>
<td>General</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>7</th>
<th>Operation in ice conditions at a fixed location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.1</td>
<td>General requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>8</th>
<th>Ice accretion and low temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.1</td>
<td>General requirements</td>
</tr>
</tbody>
</table>
### CHAPTER 7 DRILLING PLANT FACILITY

### Section 1 General
- 1.1 Application
- 1.2 Class notations
- 1.3 Scope
- 1.4 Plant design characteristics
- 1.5 Recognised Codes and Standards
- 1.6 Equipment categories
- 1.7 Equipment certification
- 1.8 Fabrication records
- 1.9 Installation of drilling plant equipment
- 1.10 Maintenance and repair
- 1.11 Plans and data submissions

### Section 2 Structure
- 2.1 Plans and data submissions
- 2.2 Materials
- 2.3 Miscellaneous structures
- 2.4 Drilling derrick
- 2.5 Water towers
- 2.6 Flare structures
- 2.7 Lifting appliances
- 2.8 Guard rails and ladders

### Section 3 Drilling plant systems
- 3.1 Plans and particulars
- 3.2 General requirements for piping systems
- 3.3 Flexible piping
- 3.4 General requirements for mechanical systems
- 3.5 Blow out preventer stack
- 3.6 Diverter
- 3.7 Choke manifold
- 3.8 Drill string
- 3.9 Well testing and flare system
- 3.10 Bulk storage and drilling fluid system

### Section 4 Pressure vessels and bulk storage
- 4.1 General

### Section 5 Rotary drilling equipment
- 5.1 General
- 5.2 Plans and data submissions
- 5.3 Equipment certification
- 5.4 Materials
- 5.5 Design and construction

### Section 6 Hoisting and pipe handling equipment
- 6.1 General
- 6.2 Plans and data submission
- 6.3 Equipment certification
- 6.4 Materials
- 6.5 Drawworks
- 6.6 Casing stabbing boards
- 6.7 Winches
- 6.8 Design and construction

### Section 7 Electrical installations
- 7.1 General

### Section 8 Control systems
- 8.1 General
## Contents

### Chapter 8: Process Plant Facility

#### Section 1 General
- 1.1 Application
- 1.2 Class notations
- 1.3 Scope
- 1.4 Plant design characteristics
- 1.5 Recognised Codes and Standards
- 1.6 Equipment categories
- 1.7 Equipment certification
- 1.8 Fabrication records
- 1.9 Installation of plant equipment
- 1.10 Maintenance and repair
- 1.11 Plans and data submissions

#### Section 2 Structure
- 2.1 Plans and data submissions
- 2.2 Materials
- 2.3 Miscellaneous structures
- 2.4 Flare structures
- 2.5 Lifting appliances
- 2.6 Guard rails and ladders

#### Section 3 Production, Process and Utility Systems
- 3.1 Plans and particulars
- 3.2 General requirements for piping systems
- 3.3 Flexible piping
- 3.4 Christmas tree
- 3.5 Protective pressure relief
- 3.6 Flaring arrangements
- 3.7 Depressurising system
- 3.8 Cold vents
- 3.9 Radiation levels
- 3.10 Firing arrangements for steam boilers, fired pressure vessels, heaters, etc.
- 3.11 Drain systems
- 3.12 Bilge and effluent arrangements

#### Section 4 Pressure Vessels and Bulk Storage
- 4.1 General
- 4.2 Plans and data submissions
- 4.3 Equipment Certification
- 4.4 Materials
- 4.5 Design pressure and temperature
- 4.6 Design safety factors
- 4.7 Construction and testing
- 4.8 Hydrostatic test pressure
- 4.9 Protective and pressure relief devices
- 4.10 Bulk storage vessels

#### Section 5 Mechanical Equipment
- 5.1 General
- 5.2 Plans and data submissions
- 5.3 Equipment certification
- 5.4 Materials
- 5.5 Design and construction

#### Section 6 Electrical Installations
- 6.1 General
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Control systems</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Fire, hazardous areas and ventilation</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Risers systems</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

## Chapter 9 Dynamic Positioning Systems

<table>
<thead>
<tr>
<th>Section</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Section</td>
<td>Class notation DP(CM)</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Section</td>
<td>Class notation DP(AM)</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>Section</td>
<td>Class notation DP(AA)</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>Section</td>
<td>Class notation DP(AAA)</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td>Section</td>
<td>Performance Capability Rating (PCR)</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
</tr>
<tr>
<td>Section</td>
<td>Testing</td>
</tr>
<tr>
<td></td>
<td>7.1</td>
</tr>
</tbody>
</table>

## Chapter 10 Positional Mooring Systems

<table>
<thead>
<tr>
<th>Section</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Section</td>
<td>Survey</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Section</td>
<td>Environmental conditions</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Section</td>
<td>Design aspects</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>4.6</td>
</tr>
</tbody>
</table>
## Contents

### Part 3

<table>
<thead>
<tr>
<th>Section</th>
<th>Design analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>General</td>
</tr>
<tr>
<td>5.2</td>
<td>Model testing</td>
</tr>
<tr>
<td>5.3</td>
<td>Analysis aspects</td>
</tr>
<tr>
<td>5.4</td>
<td>Analysis</td>
</tr>
<tr>
<td>5.5</td>
<td>Combination of low and high frequency components</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Anchor lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>General</td>
</tr>
<tr>
<td>6.2</td>
<td>Factors of safety – Strength</td>
</tr>
<tr>
<td>6.3</td>
<td>Fatigue life</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Wire ropes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>General</td>
</tr>
<tr>
<td>7.2</td>
<td>Rope construction</td>
</tr>
<tr>
<td>7.3</td>
<td>Design verification</td>
</tr>
<tr>
<td>7.4</td>
<td>Materials</td>
</tr>
<tr>
<td>7.5</td>
<td>Corrosion protection</td>
</tr>
<tr>
<td>7.6</td>
<td>Manufacture and testing</td>
</tr>
<tr>
<td>7.7</td>
<td>Identification</td>
</tr>
<tr>
<td>7.8</td>
<td>Certification</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Chains</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Chain grades</td>
</tr>
<tr>
<td>8.2</td>
<td>Corrosion and wear</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Provisional requirements for fibre ropes</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>General</td>
</tr>
<tr>
<td>9.2</td>
<td>Design aspects</td>
</tr>
<tr>
<td>9.3</td>
<td>Manufacture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Anchor points</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>Drag embedment anchors – Structural aspects</td>
</tr>
<tr>
<td>10.2</td>
<td>Drag embedment anchors – Holding capacity</td>
</tr>
<tr>
<td>10.3</td>
<td>Anchor piles</td>
</tr>
<tr>
<td>10.4</td>
<td>Suction anchor piles</td>
</tr>
<tr>
<td>10.5</td>
<td>Gravity anchors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Fairleads and cable stoppers</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1</td>
<td>General requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Anchor winches and windlasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1</td>
<td>General</td>
</tr>
<tr>
<td>12.2</td>
<td>Materials</td>
</tr>
<tr>
<td>12.3</td>
<td>Brakes</td>
</tr>
<tr>
<td>12.4</td>
<td>Stoppers</td>
</tr>
<tr>
<td>12.5</td>
<td>Winch/windlass performance</td>
</tr>
<tr>
<td>12.6</td>
<td>Strength</td>
</tr>
<tr>
<td>12.7</td>
<td>Testing</td>
</tr>
<tr>
<td>12.8</td>
<td>Type approval</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Electrical and control equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1</td>
<td>General</td>
</tr>
<tr>
<td>13.2</td>
<td>Controls, indications and alarms</td>
</tr>
<tr>
<td>13.3</td>
<td>Control aspects – Disconnectable mooring systems</td>
</tr>
<tr>
<td>13.4</td>
<td>Controls of winch and windlass systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Thruster-assisted positional mooring</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1</td>
<td>General</td>
</tr>
<tr>
<td>14.2</td>
<td>Thrust units</td>
</tr>
<tr>
<td>14.3</td>
<td>Electrical equipment</td>
</tr>
<tr>
<td>14.4</td>
<td>Control engineering systems – Additional requirements</td>
</tr>
<tr>
<td>Section</td>
<td>15</td>
</tr>
<tr>
<td>----------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>15.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>16</th>
<th>Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16.1</td>
<td>General</td>
</tr>
</tbody>
</table>

**CHAPTER 11** LIFTING APPLIANCES AND SUPPORT ARRANGEMENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>Rule application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Masts, derrick posts and crane pedestals</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Lifting appliances</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Crane boom rests</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Runway beams</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>Lifting padeyes</td>
</tr>
<tr>
<td></td>
<td>1.7</td>
<td>Access gangways</td>
</tr>
</tbody>
</table>

**CHAPTER 12** FOUNDATIONS

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Site investigation</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Stability of sloping sea beds</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Anchor point movements</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Earthquake loading</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>2</th>
<th>Site investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1</td>
<td>Extent of investigation</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Methods of investigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>3</th>
<th>Guidelines for site investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.1</td>
<td>Location control</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Bathymetric survey</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Geophysical survey</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>Observation at the sea bed</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>Preliminary geological appraisal of site</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>Scope of borehole sampling</td>
</tr>
<tr>
<td></td>
<td>3.7</td>
<td>In situ testing</td>
</tr>
<tr>
<td></td>
<td>3.8</td>
<td>Sampling</td>
</tr>
<tr>
<td></td>
<td>3.9</td>
<td>Sample storage</td>
</tr>
<tr>
<td></td>
<td>3.10</td>
<td>Sample description</td>
</tr>
<tr>
<td></td>
<td>3.11</td>
<td>Geological interpretation of cores and soil samples</td>
</tr>
<tr>
<td></td>
<td>3.12</td>
<td>Onboard testing</td>
</tr>
<tr>
<td></td>
<td>3.13</td>
<td>Laboratory index tests</td>
</tr>
<tr>
<td></td>
<td>3.14</td>
<td>Shear strength parameter determination – Cohesive soils</td>
</tr>
<tr>
<td></td>
<td>3.15</td>
<td>Shear strength parameter determination – Cohesionless soils</td>
</tr>
<tr>
<td></td>
<td>3.16</td>
<td>Special shear strength determination tests</td>
</tr>
<tr>
<td></td>
<td>3.17</td>
<td>Consolidation characteristics</td>
</tr>
<tr>
<td></td>
<td>3.18</td>
<td>Chemical tests</td>
</tr>
<tr>
<td></td>
<td>3.19</td>
<td>Permeability</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>4</th>
<th>Drag anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1</td>
<td>Drag anchor design</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Ultimate holding capacity, penetration and drag</td>
</tr>
</tbody>
</table>
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Anchor and suction anchor piles</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Anchor and suction anchor pile design</td>
</tr>
<tr>
<td>5.2</td>
<td>Axial and lateral capacity</td>
</tr>
<tr>
<td>5.3</td>
<td>Anchor and suction anchor pile response</td>
</tr>
<tr>
<td>5.4</td>
<td>Sea bed erosion</td>
</tr>
<tr>
<td>5.5</td>
<td>Installation – General</td>
</tr>
<tr>
<td>5.6</td>
<td>Installation of driven anchor piles</td>
</tr>
<tr>
<td>5.7</td>
<td>Installation of bored anchor piles</td>
</tr>
<tr>
<td>5.8</td>
<td>Suction – Installed anchor piles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Acceptable basis for anchor and suction anchor pile design</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Axial capacity</td>
</tr>
<tr>
<td>6.2</td>
<td>Skin friction in cohesive soils</td>
</tr>
<tr>
<td>6.3</td>
<td>End bearing in cohesive soils</td>
</tr>
<tr>
<td>6.4</td>
<td>Skin friction in cohesionless soils</td>
</tr>
<tr>
<td>6.5</td>
<td>End bearing in cohesionless soils</td>
</tr>
<tr>
<td>6.6</td>
<td>Skin friction and end bearing in rocks</td>
</tr>
<tr>
<td>6.7</td>
<td>Axial capacity of pile groups</td>
</tr>
<tr>
<td>6.8</td>
<td>Pile response and lateral capacity</td>
</tr>
<tr>
<td>6.9</td>
<td>Driving stresses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Gravity anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Scope</td>
</tr>
<tr>
<td>7.2</td>
<td>Gravity anchor foundation design</td>
</tr>
<tr>
<td>7.3</td>
<td>Foundation movements</td>
</tr>
<tr>
<td>7.4</td>
<td>Influence of cyclic loading</td>
</tr>
<tr>
<td>7.5</td>
<td>Sea bed erosion</td>
</tr>
<tr>
<td>7.6</td>
<td>Foundation contact pressure</td>
</tr>
<tr>
<td>7.7</td>
<td>Sea bed penetrating elements</td>
</tr>
<tr>
<td>7.8</td>
<td>Installation of gravity anchor foundations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Acceptable basis for gravity anchor design</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Bearing capacity</td>
</tr>
<tr>
<td>8.2</td>
<td>Sliding stability</td>
</tr>
<tr>
<td>8.3</td>
<td>Sea bed penetrating elements</td>
</tr>
<tr>
<td>8.4</td>
<td>Local soil reactions</td>
</tr>
<tr>
<td>8.5</td>
<td>Deformations</td>
</tr>
</tbody>
</table>

### APPENDIX A

#### CODES, STANDARDS AND EQUIPMENT CATEGORIES

<table>
<thead>
<tr>
<th>Section</th>
<th>Codes and Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.1</td>
<td>Abbreviations</td>
</tr>
<tr>
<td>A1.2</td>
<td>Recognised Codes and Standards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Equipment categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.1</td>
<td>Drilling equipment</td>
</tr>
<tr>
<td>A2.2</td>
<td>Miscellaneous equipment</td>
</tr>
<tr>
<td>A2.3</td>
<td>Production equipment</td>
</tr>
</tbody>
</table>
Section 1
Rule application

1.1 General

1.1.1 This Part is applicable to all types of offshore units as defined in Pt 1, Ch 2.2, including buoys and deep draught caissons and also covers the positional mooring systems and/or linking arrangements of all unit types. Units of unconventional type or form will receive individual consideration based on the general standards of these Rules.

1.1.2 In addition to the Rule requirements for Classification, attention is to be given to the relevant statutory Regulations of the National Administrations in the area of operation and also the country of registration, as applicable, see Pt 1, Ch 2.1.

1.1.3 In general, a floating unit which, due to its design and function, is intended to remain and operate at a fixed geographic location for its normal working life will be considered as an installation in accordance with these Rules.

1.1.4 Hull scantlings of ship units are to comply with Part 10. All aspects which relate to the specialised offshore function of the unit are to be considered on the basis of these Rules.

1.1.5 When requested by the Owner, column-stabilised and self-elevating units which can be moved to a new location without carrying out major works or structural modifications may also be assigned class in accordance with Rules and Regulations for the Classification of Mobile Offshore Units (hereinafter referred to as the Rules for Mobile Offshore Units), see also Pt 1, Ch 2.1.1.18.

1.1.6 Lifting appliances are to comply with the requirements of the Code for Lifting Appliances in a Marine Environment (LAME), see also Chapter 11.

1.1.7 The requirements stated in this Part for the particular unit types and special features class notations are supplementary to those stated in other Parts of these Rules.

Section 2
Information required

2.1 General

2.1.1 General requirements regarding information required are given in Pt 3, Ch 1.5 of the Rules for Ships, which are to be complied with as applicable.

2.1.2 Additional plans, documents and data are to be submitted for approval and information as required by the relevant Parts of these Rules, together with the additional information related to the unit type and its specialised function as defined in this Part.

2.1.3 Where an OIW class notation, for In-water Survey, is to be assigned, see Pt 1, Ch 2, plans and information covering the following items are to be submitted as applicable:

- Details showing how rudder pintle and bush clearances are to be measured and how the security of the pintles in their sockets is to be verified with the unit afloat.
- Details and arrangements for inspecting thrusters and sea chests.
- Details showing how stern bush clearances are to be inspected and measured with the unit afloat.
- Details of arrangements for servicing and unshipping thrusters.
- Details and arrangements for servicing sea inlet valves and checking sea chests.
- Details of underwater marking, see Section 6.
- Details of coating systems and cathodic protection, see Part 8.

2.1.4 Approved plans and information covering the items detailed in 2.1.3 are to be placed on board the unit.

Section 3
Operations manual

3.1 General

3.1.1 A manual of operating instructions is to be prepared and placed on board each unit and should be made readily available to all concerned in the safe operation of the unit, see also 3.2.4.

3.1.2 It is the responsibility of the Owner to provide in the Operations Manual all the necessary instructions and limits on the operation of the unit to ensure that the environmental and operating loading conditions on which the Classification is based will not be exceeded in service.

3.1.3 Where a National Administration has a specific requirement regarding the contents of the Operations Manual, it is the responsibility of the Owner to comply with such Regulations.
3.1.4 The Operations Manual is to be submitted when the plans of the unit are being approved by LR. The Operations Manual will be reviewed in respect of those aspects covered by Classification only.

3.1.5 Where a unit is modified during its service life, it is the Owner’s responsibility to update the Operations Manual, as necessary, and advise LR of any changes which may affect the Classification of the installation.

3.2 Information to be included

3.2.1 In general, the Operations Manual should include the following minimum information, as applicable:
- General description and particulars of the unit.
- Chain of command and general responsibilities during all normal operating modes and emergency operations.
- Limiting design data for each approved mode of operation, including design and variable loading, draughts, air gap, wave height, wave period, wind, current, minimum sea and air temperatures, assumed sea bed conditions, orientation, and any other applicable environmental factors, such as icing.
- A description of any inherent operational limitations for each mode of operation and for each change in mode of operation. For ship units, see also 3.2.4.
- Permissible deck loading plan.
- General arrangement plans showing watertight and weathertight boundaries.
- The location and type of watertight and weathertight closures, vents, air pipes, etc., and the location of downflooding points.
- The location, type and weights of permanent ballast installed on the unit.
- A description of the signals used in the general alarm, public address, fire and gas alarm systems.
- Hydrostatic curves, or equivalent data.
- A capacity plan showing the capacities and the centres of gravity of tanks and bulk material stowage spaces.
- Tank sounding tables or curves showing capacities, the centres of gravity in graduated intervals and the free surface data of each tank.
- Plans and description of the ballast system and instructions for ballasting.
- Plan indicating hazardous areas.
- Fire control and safety/evacuation plans.
- Lightship data based on the results of an inclining experiment, etc.
- Stability information in the form of maximum KG versus draught curve, or other suitable parameters, based upon compliance with the required intact and damaged stability criteria.
- Representative examples of loading conditions for each approved mode of operation, together with the means for evaluation of other loading conditions. For ship units, see also 3.2.4.
- Positional mooring system, and limiting conditions of operation.
- Description and limitations of any onboard computer used in operations such as ballasting, anchoring, dynamic positioning and in trim and stability calculations.
- Plan of towing arrangements and limiting conditions of operation.

4.1 Materials

4.1.1 The Rules relate in general to the construction of steel units of welded construction, although consideration will be given to the use of other materials. For concrete structures, see Part 9.

4.1.2 The materials used for the construction and repair of units and installed machinery are to be manufactured and tested in accordance with the requirements of the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).

4.1.3 As an alternative, materials which comply with National or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of the Rules for Materials or are approved for a specific application. Generally, survey and certification are to be carried out in accordance with the requirements of the Rules for Materials.

4.1.4 Materials for specialised areas of the unit, related to its function or special features class notation, are to be in accordance with the relevant Chapters of this Part, see also 4.3.
4.2 Material selection

4.2.1 Materials are to be selected in accordance with the requirements of the design in respect of static strength, fatigue strength, fracture resistance and corrosion resistance, as appropriate.

4.2.2 The grades of steel to be used in the construction of the unit are to be related to the thickness of the material, the location on the unit and the minimum design temperature, see 4.4.

4.2.3 The grades of steel to be used for the drilling plant and the production and process plant are to be in accordance with the requirements of Chapters 7 and 8 respectively.

4.2.4 The effects of corrosion, either from the environment or from the products handled on the unit or its associated plant and machinery, are to be taken into account in the design.

4.3 Structural categories

4.3.1 The structural categories for the hull construction and the corresponding grades of steel used in the structure are to be in accordance with Pt 4, Ch 2.

4.3.2 The structural categories for supporting structures for drilling plant and production and process plant are to be in accordance with Chapters 7 and 8 respectively.

4.4 Minimum design temperature

4.4.1 The minimum design temperature is a reference temperature used as a criterion for the selection of the grade of steel to be used.

4.4.2 The minimum design air and sea temperatures for exposed structure are to be taken as the lowest daily mean temperature for the unit’s proposed area of operation, based on the 100 year average return period. The temperature is to be rounded down to the nearest degree Celsius. For LNG installations, consideration of the minimum design temperature is required where the hull plating forms part of the secondary barrier.

4.4.3 The minimum design temperature (MDT) for drilling plant and production and process plant is to be defined by the designers/Builders, but when appropriate the MDT should not be higher than the MDT for the exposed structure defined in 4.4.2.

4.5 Aluminium structure, fittings and paint

4.5.1 The use of aluminium alloy is permitted for secondary structure, as defined in Pt 4, Ch 2.

4.5.2 Where aluminium alloy is used for secondary structure, the material is to conform with the requirements of Chapter 8 of the Rules for Materials.

4.5.3 The use of aluminium alloy for primary structure will be specially considered.

4.5.4 Where aluminium alloy is used in the construction of fire divisions, it is to be suitably insulated in accordance with the requirements of the appropriate National Administration, see 1.1.2.

4.5.5 Since aluminium alloys may, under certain circumstances, give rise to incendive sparking on impact with steel, the following requirements are to be complied with:

(a) Aluminium fittings in tanks used for the storage of oil, and in cofferdams and pump-rooms in oil storage units are to be avoided wherever possible.

(b) Where fitted, aluminium fittings, anodes and supports in tanks used for the storage of oil, cofferdams and pump-rooms are to satisfy the requirements specified in Pt 8, Ch 2.5 for aluminium anodes.

(c) The danger of mistaking aluminium anodes for zinc anodes must be emphasised. This gives rise to increased hazard if aluminium anodes are inadvertently fitted in unsuitable locations.

(d) The undersides of heavy portable aluminium structures such as gangways, etc., are to be protected by means of hard plastic or wood covers, in order to avoid the creation of smears when dragged or rubbed across steel, which if subsequently struck, may create an incendive spark. It is recommended that such protection be permanently and securely attached to the structures.

(e) Aluminium is not to be used in hazardous areas on drilling units and production and oil storage units unless adequately protected, and full details submitted for approval. Aluminium is not to be used for hatch covers to any openings to oil storage tanks.

4.5.6 For permissible locations of aluminium anodes, see Pt 8, Ch 2.5.

4.5.7 The use of aluminium paint is to comply with the requirements of Pt 8, Ch 3.1.

Section 5

Corrosion control

5.1 General

5.1.1 The corrosion control of steelwork on all units is to be in accordance with Part 8. The corrosion protection of mooring systems is to comply with Chapter 10.

5.1.2 The basic Rule scantlings of the external submerged steel structure of units which are derived from Pt 4, Ch 7 assume that appropriate coatings and an external cathodic protection system will be fitted. If the corrosion protection system of the submerged structure is not in accordance with the Rules the scantlings are to be suitably increased.

5.1.3 Ship units which are assigned an OIWS notation are to be fitted with external cathodic protection and external coating systems in accordance with Part 8.
Section 6
Underwater marking

6.1 General

6.1.1 Where an OIWS notation, for In-water Survey, is to be assigned, see Pt 1, Ch 2, the requirements of this Section are to be complied with.

6.1.2 The underwater structure of a unit intended to be surveyed on an In-water basis should have its main frames, bulkheads and joints, etc., clearly identified by suitable marking. Details are to be submitted for approval.

6.1.3 Marking should consist of raised lines, numerals and letters. In general, marking by welding is not to be used on ship units.

6.1.4 If marking is to be carried out by welding, the welds should be made with continuous runs and the quality of the workmanship should be to an equivalent standard as the main hull structure. Substantial runs should be laid, continuously, using large diameter electrodes and avoiding light runs as these are more likely to promote cracking. Sharp corners in the letters are to be avoided. Marking by welding is not permitted in highly stressed areas or over existing butts or seams. The welding procedures and consumables are to be submitted for approval.

6.1.5 On steel of Grade D or E or on higher tensile steel, low hydrogen electrodes should be used of a grade suitable for the steel. In the case of higher tensile steel, see Ch 3,3 of the Rules for Materials, pre-heating to about 100°C should be adopted.

6.1.6 Alternative arrangements to facilitate In-water Surveys will be considered; details are to be submitted to LR for approval.
RULES AND REGULATIONS FOR THE CLASSIFICATION OF A FLOATING OFFSHORE INSTALLATION AT A FIXED LOCATION, June 2013

Buoys, Deep Draught Caissons, Turrets and Special Structures

Part 3, Chapter 2

Section 1

1.1 Application

1.1.1 The requirements of this Chapter are supplementary to those given in the relevant Parts of the Rules, and apply to buoys, deep draught caissons, turrets and other special structures. Requirements are given in this Chapter for the following special structures which are used in association with floating units:
(a) Subsea buoyant vessels.
(b) Mooring towers.

1.1.2 The Rules also cover mooring yokes, loading arm arrangements, hinged joints and support structures on floating units.

1.1.3 These Rules assume that floating moored units will be tethered with catenary-type mooring cables attached to the sea bed by anchors, gravity blocks or piles. Proposals for the use of pivot arms or other methods of tethering will be specially considered, see Sections 4 and 6.

1.1.4 Requirements for positional mooring systems are given in Chapter 10.

1.1.5 Foundations for mooring systems are to comply with Chapter 12, see also 4.1.10.

1.1.6 Buoys and other floating units may be fitted with pipelines or risers for loading and unloading linked ship/unit and additionally be fitted with crude oil bulk storage tanks, process plant facility, power generating capability, accommodation modules and similar facilities.

1.2 Definitions

1.2.1 The definitions in this Chapter are stated for Rule application only and may not necessarily be valid in any other context.

1.2.2 Buoy. A floating mooring facility secured by a flexible tether or tethers to the sea bed, but excluding the other unit types defined in Pt 1, Ch 2, 2.1.

1.2.3 Deep draught caisson units are single column floating units which operate at a deep draught in relation to their overall depth.

1.2.4 Subsea buoyant vessel. A submerged structure with positive buoyancy secured by a flexible tether or tethers to the sea bed and used to support flexible risers.

1.2.5 Mooring tower. A structure for single point mooring which is attached directly to the sea bed. The tower may be a single or multiple member structure and can be fixed to the sea bed, or articulated by means of a universal joint attached to the sea bed.

1.2.6 Single-point mooring. An offshore mooring facility based on a single buoy or single tower. A single-point mooring will allow a moored ship/unit to weathervane, and is normally associated with the transfer of oil, gas, and other fluids to or from the ship/unit. The following are among the most common types of single point moorings:
• CALM – catenary anchor leg mooring.
• SALM – single anchor leg mooring.
• Mooring tower.
• Turret mooring.

1.2.7 Multi-point mooring. A mooring facility embodying a number of separate buoys or mooring points. A multi-point mooring terminal is used to hold a ship/unit on a general constant heading and can incorporate facilities for the transfer of oil, gas and other fluids.

1.2.8 Turret mooring. A single-point mooring variant where the slewing function, allowing complete or partial weathervaning, forms an integral part of the unit. Turret mooring is mainly applicable to permanently moored surface-type units.

1.2.9 Spread mooring. A multi-line mooring system designed to maintain an offshore unit on an approximately fixed heading.

1.2.10 Mooring hawser. A mooring rope connecting a ship/unit to a single-point mooring or buoy. Only a hawser permanently attached to a single-point mooring or buoy will be included in the classification of the installation.

1.2.11 Mooring yoke. A structural arm connecting a ship/unit to a single-point mooring or buoy. A yoke is normally used for permanently moored units.
RULES AND REGULATIONS FOR THE CLASSIFICATION OF A FLOATING OFFSHORE INSTALLATION AT A FIXED LOCATION, June 2013

Buoys, Deep Draught Caissons, Turrets and Special Structures

1.3 Pipelines and power cables

1.3.1 Where pipelines, power cables, etc., are incorporated into or trail from single-point mooring installations, details of their number, position, size and method of attachment are to be submitted in order that their effect on wave forces, etc., acting on the structure, and of any restraining forces that they may impose, can be assessed.

1.3.2 For units with production and process plant, the boundaries for classification are to be as defined in Ch 8,1.3.

1.3.3 Pipelines carrying high pressure fluids, cables carrying high energy electricity supplies and cables carrying control signals critical to the safety of the unit, or to its operational reliability, are to be located in suitable positions on the unit in order to avoid accidental damage by moored ships/units, maintenance craft, or other sources which may cause large impact loads. Where this is impracticable, they are to be adequately protected and the arrangements submitted for approval.

1.3.4 If a floating unit is to be tethered in way of an existing wellhead, pipelines or high energy power cables, sufficient plans and details are to be submitted to enable Lloyd’s Register (LR) to fully assess the following:
(a) The nature and size of the wellhead, pipeline or cable.
(b) The methods and arrangements to be employed to avoid accidental damage during the on-site installation.
(c) Method and means for emergency release.

NOTE
This information is required whether the pipework and cables are permanent or temporary and whether they are situated above water or subsea.

1.3.5 Where a caisson, buoy or mooring tower is fitted with risers/pipelines intended for the loading or discharge of oil or gas, the Rules consider the following as the main boundaries of the installation for classification, unless agreed otherwise with LR:
(a) Any part of the pipeline system located on the structure including the riser connector valves, but excluding the risers is considered part of the installation.
(b) The shut-down valve at the export outlet from the pipeline system to the storage or offloading facility.
(c) Where a floating or trailing riser is stowed on a reel, the Rules apply to the reel, but not the flexible riser, see also Chapter 5.

1.3.6 Where power cables are attached to the structure for the purpose of supplying electricity to a moored ship/unit, etc., the extent, if any, of cable included in the class of the structure will be specially considered by LR.

1.4 Class notations

1.4.1 The Regulations for classification, and the assignment of class notations, are given in Pt 1, Ch 2, to which reference should be made.

1.4.2 Buoys and single-point moorings complying with the requirements of this Chapter and the relevant Parts of the Rules, will be eligible for the assignment of one of the following type class notations, as applicable:
- Mooring buoy.
- Single-point mooring buoy.
- Tanker loading terminal.
- Mooring tower.
- Articulated mooring tower.

1.4.3 Deep draught caisson units will be eligible for the assignment of a type class notation in accordance with the unit’s function, see Chapter 3. In addition a descriptive note will be added in the ClassDirect Live website, e.g., ‘Deep draught caisson unit’.

1.4.4 Associated integral mooring equipment, including anchors, mooring lines and their connections to the sea bed, will generally be included in the class of an installation, see Pt 1, Ch 2, 2.1.2. For mooring hawsers, see Section 5.

1.4.5 In the case of ship units the following components will generally be considered from the Classification aspects as part of the installation:
- Internal and external turrets.
- Mooring arms and yokes.
- Associated mooring equipment and mooring lines attached to the unit, and their anchors or connections to the sea bed.

1.4.6 Units with oil bulk storage tanks or production/process plant may be assigned type class notations in accordance with Chapter 3.

1.4.7 Product riser systems which comply with the requirements of Chapter 5 will be eligible for the special features notation PRS.

1.4.8 When a unit is to be verified in accordance with the Regulations of a Coastal State Authority, an additional class notation may be assigned in accordance with Pt 1, Ch 2.

1.4.9 Vessels designed for offshore loading should have the arrangements for offshore loading designed and constructed in accordance with suitable standards. For vessels classed LR, the requirements are outlined in Pt 7, Ch 6 of the Rules for Ships.

1.5 Scope

1.5.1 The following additional topics applicable to the type class notation of buoys and special installations are covered by this Chapter:
- General arrangement.
- Structural arrangements.
- Supporting structures to mooring systems and marine risers.
- Structural arrangement of oil storage tanks.
- Piping and piping systems.
- Watertight subdivision.
- Subsea buoyant vessels.
- Mooring towers.
- Turret structures.
1.6 Installation layout and safety

1.6.1 In principle units engaged in production and/or crude oil storage are to be divided into main functional areas in accordance with the requirements of Chapter 3.

1.6.2 The requirements for fire safety are to be in accordance with the requirements of a National Administration. Additional requirements for the fire safety on units with production and process plant are given in Pt 7, Ch 3, see also Pt 1, Ch 2.1.

1.6.3 Additional requirements for safety systems and hazardous areas are given in Part 7.

1.6.4 Living quarters, lifeboats and other evacuation equipment are to be located in non-hazardous areas and be protected and separated from production and wellhead areas.

1.6.5 Suitable arrangements are to be incorporated in the design to enable supply and maintenance craft to come alongside as necessary and to moor safely while maintenance staff and equipment are being transferred to, or from, the installation.

1.6.6 Protection against damage which might otherwise be caused by impacts from moored ships/units over-riding the mooring installations or by supply and maintenance craft coming alongside is to be provided. This protection is to include suitable fendering, adequately reinforced landing platforms or their equivalent, see also Pt 4, Ch 3.4.16.

1.6.7 Proper means of access are to be provided for maintenance and survey. Arrangements are to include a suitable platform or other landing area. It is the Owner’s responsibility to provide suitable ladders, where the height of the deck is too great to facilitate direct access of personnel from maintenance craft.

1.7 Watertight and weathertight integrity

1.7.1 The general requirements for watertight and weathertight integrity are to be in accordance with Pt 4, Ch 8.

1.7.2 Floating units and subsea buoyant vessels are to have adequate buoyancy and stability in both intact and damage conditions, see Pt 4, Ch 8. They are to be sub-divided by watertight divisions, especially in zones where there is a risk of collision.

1.7.3 When requested, LR will give special consideration to the incorporation of equivalent approved means of protection against accidental sinking on buoys and subsea buoyant vessels. Where compartments are to be filled with foam, full details are to be submitted for approval.

1.7.4 The integrity of the weather deck of buoys and other floating structures is to be maintained. Where items of plant equipment penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the deck, their structural strength is to be equivalent to the Rule requirements for this purpose. Otherwise, such items are to be enclosed in deckhouses fully complying with the Rules. Full details are to be submitted for approval.

1.8 Plans and data submission

1.8.1 Plans are to be submitted for approval as required by the relevant Parts of the Rules together with applicable plans, calculations and information to cover the additional topics listed in this Chapter, as applicable.

1.8.2 A single copy of the following supporting plans, data, calculations or documents are to be submitted:

- Anchors and tether system components.
- Motion envelopes (single-point mooring, risers and tethers, as applicable).
- Floating stability.
- Strength and fatigue of structural and mechanical parts.
- Design specification.
- Environmental report.
- General arrangement.
- Materials specification.
- Model test report.
- Operating instructions.
- Loadout and site installation procedure.

Section 2

Floating structures and subsea buoyant vessels

2.1 Floating structures

2.1.1 The structural design and the general hull strength of buoys and deep draught caissons are to comply with the requirements of Part 4 taking into account the equipment weights and forces imposed on the structure.

2.1.2 The supporting structure below swivels and other equipment is to be designed for all operating conditions and environmental loads as defined in Part 4.

2.1.3 The structure and arrangement of units with crude oil bulk storage tanks and/or production and process plant are also to comply with the requirements of Chapters 3 and 8, as applicable.

2.1.4 Critical joints, depending upon transmission of tensile stresses through the thickness of the plating of one of the members (which may result in lamellar tearing), are to be avoided wherever possible. Where unavoidable, plate material with suitable through thickness properties will be required, see Ch 3.8 of the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).
2.1.5 Moored floating structures supporting multi-point mooring line arrangements are to be assessed for the maximum combined forces to which they may be subjected to in service.

2.1.6 Account is to be taken of wave slamming effects, where appropriate.

2.1.7 Floating structures, including highly stressed structural elements of mooring line attachments, chain stoppers and supporting structures are to be assessed for local strength as required in Part 10 and for fatigue damage due to cyclic loading in accordance with Pt 4, Ch 6.

2.1.8 For mechanical items for bearings and swivels, see Section 6.

2.2 Permissible stresses

2.2.1 The permissible stresses in floating structures are to comply with Pt 4, Ch 6, but the minimum scantlings of the local structure are to comply with Pt 4, Ch 7.

2.3 Subsea buoyant vessels

2.3.1 Where a classed installation is to be assigned the notation PRS in accordance with Chapter 5, riser systems incorporating subsea buoyant vessels are to comply with the requirements of this sub-Section.

2.3.2 Where subsea buoyant vessels are used in association with other systems, they will be specially considered from the classification aspects.

2.3.3 Subsea buoyant vessels are to be designed for all external operating loads and the maximum pressure head to which the structure may be subjected to in service or during installation, see Pt 4, Ch 3.4.14.

2.3.4 The scantlings of the shell boundaries and framing are to be determined from an internationally recognised Pressure Vessel Code.

2.3.5 All vessels are to have positive buoyancy, when subjected to their design external loads, when any one internal compartment is flooded. Special consideration will be given to vessels with compartments filled with foam, see 1.7.

2.3.6 The local structure is to be suitably reinforced in way of the loads imposed by riser systems, and other external loads and the requirements of 2.1.4 are to be complied with as applicable.

2.3.7 Internal watertight bulkheads are to withstand the flooding of any single compartment. The scantlings of watertight bulkheads are to comply with Pt 4, Ch 7, with \( h_4 \) determined in accordance with 2.3.3.

Section 3 Turret structures

3.1 General

3.1.1 Turret structures supporting multi-point mooring line arrangements are to be assessed for the maximum combined forces to which they may be subjected to in service. The turret structure is to be suitable for the appropriate maximum single-point mooring line loads and in addition the critical mooring line group loadings.

3.1.2 Environmental criteria and loading are in general to be in accordance with Part 10.

3.1.3 Account is to be taken of wave slamming effects, where appropriate.

3.1.4 When an internal turret is designed as a stiffened shell, the scantlings of plating and stiffeners are not to be less than required by Table 7.7.1 in Pt 4, Ch 7 as a deep tank bulkhead, using a load head \( h_4 \) measured vertically from the point of consideration to the top of the turret well.

3.1.5 Permissible stresses for direct calculations are to be in accordance with Pt 4, Ch 6.

3.1.6 The sealing arrangements, where fitted, between internal turrets and circumpit well bulkheads will be specially considered.

3.1.7 The turret structure, including structural supports in way of bearings and highly stressed structural elements of mooring line attachments, chain stoppers and supporting structures, are to be assessed for local strength as required in Part 10 and for fatigue damage due to cyclic loading in accordance with Pt 4, Ch 6.

3.1.8 Suitable access arrangements are to be provided to allow inspection and maintenance of turret structural and mooring system components during service. A planned procedure for the inspection of the structure and mooring system components is to be provided, as required by Pt 1, Ch 2.

3.1.9 Special consideration is to be given in design to load transfer together with the effect of hull deformations at the interface of the turret support structure with the main hull structure.

3.1.10 The scantlings of the circumpit well bulkheads, turret support arrangements and hull backup structure are to be in accordance with Part 10.

3.1.11 For mechanical items such as bearings and swivels see Section 6.

3.1.12 The structure of hawsepipes and their supports is to be designed to withstand the imposed static and dynamic loads. Plating and framing in way of hawsepipes are to be reinforced as necessary. All relevant loads as defined in Chapter 3 are to be considered and the permissible stresses due to overall and local effects are to be in accordance with Pt 4, Ch 6.
3.1.13 Hawsepipe components are to be of ample thickness and of a suitable size and arrangement to house the mooring cables efficiently. Due consideration is to be given, as far as practicable, to minimise the effects bending and chafing on the mooring cables.

Section 4
Mooring arms and towers

4.1 General

4.1.1 Mooring arms and towers are to be designed for the maximum mooring loads and direct wave loading to which they may be subjected in service, and design calculations are to be submitted. The loadings on lattice type structures are to be specially considered and agreed with LR.

4.1.2 The structure is to be designed for the most unfavourable of the following combined loading conditions:
(a) maximum gravity and functional loads.
(b) design environmental loads and associated gravity and functional loads.
(c) design environmental loads and associated gravity and functional loads after credible failures.

4.1.3 The structure is to be investigated for loading condition 4.1.2(c) to assess the effect of the failure of a single slender tubular (or similar) member. The permissible stress levels after credible failures are given in Pt 4, Ch 6.2.1.1(c). When stress levels in the structure exceed permissible levels the slender tubular member is considered to be ‘non-redundant’, see 4.1.4. This requirement does not apply to stiffened plate structures or mechanical items.

4.1.4 When the requirements of 4.1.3 are not met the structure is to be further investigated for loading condition 4.1.2(b) under the action of a 10,000 year return period mooring load and associated gravity and functional loads. Non-redundant slender tubular (or similar) members should in general have sufficient ductility to resist failure, i.e., strain up to 21 per cent. When this criterion is not met the following mitigating measures are required:
(a) clear identification of high stress areas.
(b) welding in high stress areas to be full penetration, as far as practicable.
(c) NDE in accordance with an agreed plan, see also Table 9.2.1 in Pt 4, Ch 9.
(d) minimum factor of safety of 2 on fatigue life, see Pt 4, Ch 6.5.6.
(e) inspection and test plans (fabrication and in-service) to be submitted for LR approval.
(f) operations manual to clearly specify critical areas and inspection requirements.

4.1.5 The permissible stresses in mooring arms and the attachment to floating units are to comply with Pt 4, Ch 6.

4.1.6 Attention is to be paid to the detail design in fatigue sensitive areas. Mooring arms, towers, articulated and sliding joints are to be assessed for fatigue damage due to cyclic loading in accordance with Pt 4, Ch 6.5.
5.1.5 The maximum mooring load used to determine the required strength of a mooring hawser will also be regarded as the maximum allowable peak mooring load in service. This allowable load will be included in the limiting design criteria on which classification is based.

5.2 Load monitoring

5.2.1 Single-point mooring (SPM) installations are to be provided with an approved means of monitoring the load occurring in the mooring hawser connecting the SPM to the ship/unit (alternatively such equipment can be provided on the attending vessel, see Pt 7, Ch 6,3 of the Rules for Ships). This equipment is to be designed so that automatic warning is given to the ship/unit in the event that tension in the mooring hawser exceeds designated limits, see 5.1.5. Warning is to be given by both visual indication and audible alarm. Consideration will be given to alternative proposals such as provision of a ‘weak link’. Full details of such proposals are to be submitted for LR approval.

5.2.2 The load level designated to initiate automatic warning is to be below the maximum allowable hawser load level by a sufficient margin to allow such steps to be taken as may be necessary, to prevent excessive loads, or to prepare for ship/unit disconnection from the SPM. It is recommended that two warning levels be incorporated, the first level at 60 per cent of allowable load and the second level at 80 per cent of allowable load. Where only one warning level is provided it should be set at no more than 70 per cent of allowable load.

5.2.3 The load level designated to initiate the automatic warning should be set giving due consideration to the safe working load of the chain stoppers fitted to the attending vessel.

5.3 Spare parts and maintenance

5.3.1 An adequate number of spare parts for the hawser system is to be provided on board a classed unit.

5.3.2 A planned maintenance and replacement scheme for mooring hawsers are to be submitted to LR and suitable instructions are to be included in the Operations Manual.

Section 6

Mechanical items

6.1 General

6.1.1 In general all machinery, control and electrical items are to comply with the requirements of the appropriate sections in Parts 5 and 6. For pressure vessels, see Ch 8,4.

6.1.2 This Section covers mechanical items of turrets and swivels including bearings, hinges, universal joints and seals, etc. Turret structures are to comply with Section 3.

6.1.3 Sufficient plans, data and specifications are to be submitted to enable the mechanical arrangements to be assessed and approved.

6.1.4 Plans and data covering the following items are to be submitted for approval, as relevant:

- Structural arrangements.
- Materials specification.
- Lubrication system.

6.1.5 The following supporting plans and documents are to be submitted:

- General arrangement.
- Design specification.
- Design calculations.
- Surveillance program.

6.2 Design

6.2.1 The design of joint and hinges should minimise any stress concentrations, particularly where significant dynamic loadings may occur.

6.2.2 Suitable strength and fatigue analyses of joint or hinge assemblies are to be carried out, where appropriate.

6.2.3 It is to be considered that vibration levels in the associated pipe work and structure of the swivel are to be kept to a minimum level to avoid bearing-associated failures.

6.3 Bearings

6.3.1 Components in swivel support systems are to be designed for the operating forces, moments and pressures intended, taking into account, where necessary, survival, tow out, damaged, fatigue and other operating conditions. Design calculations are to be submitted.

6.3.2 Rolling element, pad and journal bearings used in swivel units are to be designed for the static and dynamic loadings which are expected in service. Bearing pressure and fatigue life calculations are to be submitted.

6.3.3 Bearings, joints, etc., are to be suitable to withstand the application of all loads expected during service life. The maximum design loadings are to be determined in accordance with Pt 4, Ch 3,4.

6.3.4 The design of bearings, joints, etc., is to be in accordance with an acceptable design method or an internationally recognised Code or Standard. For acceptable Codes for roller and ball bearings, see Appendix A.

6.3.5 Bearing design is to include the effects of low and high frequency response loadings, where appropriate.

6.3.6 The effects of motions, for a range of typical operating modes, are to be considered in the design.
6.3.7 Where necessary, suitable lubricating arrangements are to be fitted to all adjacent bearing surfaces to maintain an adequate and continuous supply of lubricant to the surfaces during all unattended periods. Gravity-fed or non-power-operated systems are to be preferred for non-manned installations.

6.3.8 Consideration is to be given to monitoring turret roller bearings in service by condition monitoring the bearing lubrication fluid. Details to be submitted to LR.

6.3.9 Primary bearing surfaces are to be adequately protected from deterioration caused by the ingress of seawater and other contaminants by a system of seals or other suitable alternative methods. Sealing arrangements for bearing systems are to contain lubrication and are to be designed for their intended service life or field life of the installation as applicable.

6.3.10 Data should be submitted to substantiate the fitness of the bearing for the field life of the installation or 20 years, whichever is greater. Consideration will be given to the reduction of this life where an agreed change-out programme is implemented.

6.3.11 Classification will be based on a review of the designers calculations.

6.4 Bearing support structures

6.4.1 Bearing support structures are to be assessed for fatigue damage due to cyclic loading in accordance with Pt 4, Ch 6.5.

6.4.2 Permissible stress levels in supporting structure are to be in accordance with those specified in Pt 4, Ch 6.

6.4.3 A fatigue analysis of structural items is to be carried out in accordance with Pt 4, Ch 6.5. Factors of safety on fatigue life is to be determined after consideration of the redundancy of the structure, the accessibility of the item being considered, the consequence of failure, etc. Minimum required factors of safety are given in Pt 4, Ch 6.5.

6.4.4 Consideration is to be given to improve bearing support structure stiffness to prevent substantial increase in the bearing loading.

6.4.5 Consideration is to be given to the integrity of the weld attachments for the support structures.

6.4.6 Cracking of bearing housings at stress concentrators due to bearing wear is common in roller bearings and should be considered as a potential damage mechanism.

6.5 Seals

6.5.1 Leakage of lubrication fluid and subsequent ingress of seawater is to be prevented by installing a suitable system of seals.

6.5.2 The seals employed are to be of a suitable material for the intended service.

6.5.3 Sealing elements installed are to be capable of safely absorbing the required deflection or, alternatively, adequate provisions for slippage are to be incorporated in the design.

6.5.4 A lubrication leakage detection system is to be installed in order to monitor seal performance in service. The system is to provide early warning of seal deterioration to allow appropriate remedial action to be taken.

6.5.5 Swivels and sections in the swivel stack are to use seal arrangements which shall provide redundancy such that leaks can be detected before process fluid release occurs.

6.5.6 The seal fluid pressure is to be higher than the maximum well shut-in pressure and system surge pressure.

6.5.7 A continuous seal fluid leakage detection system is to be monitored to verify system availability and ensure hydrocarbons are not released. The system is to be fitted with alarms to detect early seal deterioration and allow appropriate remedial action to be taken.

6.5.8 In the event of a secondary seal failure, a production ESD is to be initiated and the leak detection system must be capable of precisely identifying the failed seal.

6.5.9 The supply of barrier seal oil for the swivel stack is to be from a dedicated HPU package with its own control panel and feedback to the main control room.

6.5.10 The seal seats and travelling surfaces should be corrosion-resistant and of sufficient hardness to prevent excessive abrasion and wear.
6.5.11 Care is to be taken to minimise the risk of explosive decompression of seal in the event of a catastrophic failure. Maximum decompression rates for the seal material are to be provided by the manufacturer.

6.5.12 Prevention of contamination to dynamic seals is crucial. Seals are to be fitted with a silt-barrier system to prevent sand or particles getting into the seals, where applicable.

6.6 Bolted joints

6.6.1 An acceptable method for the determination of flanged bolt loads is to be found in Verein Deutscher Ingenieure (VDI) 2230 – Systematic Calculation of High Duty Bolted Joints. Other suitable internationally recognised Codes or Standards may be used.

6.6.2 For joints subject to fatigue loading, the bolts are to be of ISO 898/1 Material Grade 8.8, 10.9 or 12.9, or equivalent. They are to be pretensioned by a controlled means to 70 to 90 per cent of their yield stress. For bolt sizes greater than M30, pre-tensioning must be carried out, in a rational order, by a hydraulic tensioning device.

6.6.3 The torque on all bolting on bearing housing, support structures and attachments is to be regularly inspected and checked. The maintenance plan is to be submitted to LR for review.

6.7 Swivel stack

6.7.1 The swivel stack is to be designed for the maximum combined operating forces, moments, internal pressures and thermal loading.

6.7.2 In general, the swivel stack is to be analysed by a three-dimensional finite element method unless agreed otherwise with LR. Design calculations, including details of the model, are to be submitted.

6.7.3 Permissible stress levels are to be in accordance with a recognised Code or standard.

6.7.4 Pressure piping attached to the swivel is to comply with Section 7.

6.7.5 Special consideration is to be given to torsional loading effects for the design of universal joints and other connections.

6.7.6 The fluid swivel is to be designed to withstand the maximum range of operating conditions, including maximum well shut-in pressure and pressure surge condition.

6.7.7 Torque arms are to be designed to the appropriate load cases in accordance with Pt 4, Ch 3.

6.8 Survey

6.8.1 Joint structures are to be included in the Periodical Classification Surveys, in accordance with the requirements contained in Part 1.

6.8.2 A comprehensive surveillance program, including detailed seal replacement and overhaul procedures, is to be developed by the Owner. A sufficient number of spare parts and required tools is to be provided for the installation.

Section 7

Piping and piping systems

7.1 Plans and particulars

7.1.1 Plans and particulars showing arrangement of oil and gas transport systems, marine machinery and piping for equipment listed in 1.5, are to be submitted in triplicate for approval.

7.2 General requirements for piping systems

7.2.1 Pipes, valves and fittings are to be constructed of steel or other approved materials suitable for the intended service. Where applicable, the materials are to comply with the requirements of Pt 5, Ch 12, or an acceptable Standard or Code.

7.2.2 Piping systems for the oil storage or process transport systems are, in general, to be separate and distinct from marine and utility piping systems essential to the safety of the unit. Substances which are known to present a hazard due to a reaction when mixed are to be kept entirely separate.

7.2.3 The oil process transport piping systems, piping and fittings forming parts of such systems are to comply with Chapter 8. For units with oil storage tanks, the requirements of Pt 5, Ch 15 are applicable.

7.2.4 The marine and utility piping systems, piping and fittings forming parts of such systems are to comply with Pt 5, Chapters 12, 13, 14 and 15, as applicable.

7.2.5 Loading and discharging hoses are to be designed in accordance with acceptable recognised Standards. The selected hose is to be designed and constructed such that it is suitable for its intended purpose, taking into account pressure, temperature, fluid compatibility and mechanical loading, see also Pt 5, Ch 15.3.4.

7.2.6 Instrument control isolation valves are to be in the locked open position.

7.2.7 Flexible hoses are to comply with the requirements of Pt 5, Ch 11.7.

7.2.8 Where valves of the piping systems are arranged for remote control and are power-operated, a secondary means of operating the valves is to be considered.
7.2.9 Watertight compartments are to be provided with power pump suction for dealing with their drainage. Special attention is to be given to compartments containing equipment which is essential to the safe operation of the installation. The drainage systems are to comply with the requirements of Pt 5, Ch 12.

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Section 8

Hazardous areas and ventilation

8.1 Plans and particulars

8.1.1 Plans and particulars showing the arrangements of area classification and ventilation systems applicable to the control of hazardous area are to be submitted for approval, as required by Pt 7, Ch 2.

8.2 General

8.2.1 For the application of hazardous area classification, see Pt 7, Ch 2.

8.2.2 Adequate ventilation is to be provided for all areas and enclosed compartments associated with hazardous fluids. The capacities of the ventilation systems are to comply, where applicable, with the requirements of Pt 7, Ch 2, or to an acceptable Code or Standard adapted to suit the marine environment and taking into account any additional requirements which may be necessary during start up of the plant.

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Section 9

Pollution prevention

9.1 General

9.1.1 Sumps and savealls are to be provided at potential spillage points, and drainage systems are to have adequate capacity and be designed for ease of cleaning.

9.1.2 In open areas, arrangements are to be such that oil spillage will be contained, and that suitable drainage and recovery provisions are made that comply with the requirements of National Administration Regulations and any International Convention in force.

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Section 10

Swivel testing requirements

10.1 General

10.1.1 Testing procedure should be specified (and agreed with the Owner/Operator) to ensure that casting, forgings and other items used in the fabrication of the fluid swivel system housing are in accordance with the Rules for Materials.

10.1.2 Seal designs and materials should be Type Approved by dynamic test which simulates a number of years of service under the conditions and with exposure to fluid representative of the design condition and depressurisation. The number of years of successful service to be proven by testing should be agreed with the Owner/Operator.

10.1.3 The following tests are to be performed on each swivel; however, test procedures should be developed by the manufacturers and approved by the Owner/Operator:

(a) Hydrostatic proof test.
(b) Pressure fluctuation test.
(c) Rapid decompression test (Gas Swivel).
(d) Cylcical loading test.

10.1.4 Full rotation tests in each direction and cyclic partial rotation tests should be performed at all operating pressures. Rotation speeds should model real-time conditions to represent accurately the intended application and also to prevent damage to the seals.

10.1.5 Testing is to be conducted in accordance with an approved test procedure in the presence of a Surveyor. The procedure is to address an acceptable leakage rate.
Production and Oil Storage Units

Part 3, Chapter 3
Section 1

1.2.2 In general, installations complying with the requirements of this Chapter and the relevant Parts of the Rules will be eligible for the assignment of one of the following type class notations:
- Production installation.
- Floating production installation.
- Floating production and oil storage installation.
- Floating oil storage installation.
Other type notations may be assigned when considered appropriate by the Classification Committee.

1.2.3 Type class notations for units with bulk storage tanks for liquefied gases or liquid chemicals will be specially considered by the Classification Committee.

1.2.4 When a unit is to be verified in accordance with Regulations of a Coastal State Authority, an additional class notation may be assigned in accordance with Pt 1, Ch 2.

1.2.5 Production units with an installed process plant facility, which comply with the requirements of Chapter 8, will be eligible for the assignment of the special features class notation PPF. For units with riser systems, see Chapter 5.

1.2.6 When a PPF notation is not assigned to a unit with a process plant facility, classification of the installation will be subject to the process plant being certified by LR, or by another acceptable organisation.

1.2.7 Production units without an installed process plant facility are to comply with the general requirements of Chapter 8, as applicable.

1.2.8 Units with an installed drilling plant facility, which comply with the requirements of Chapter 7, will be eligible for the assignment of the special features class notation DRILL.

1.2.9 When a DRILL notation is not assigned to a unit with a drilling plant facility, classification of the installation will be subject to the drilling plant being certified by LR, or by another acceptable organisation.

1.3 Scope

1.3.1 The following additional topics applicable to the type class notation are covered by this Chapter:
- General arrangement.
- Structural arrangement of the unit.
- Supporting structures below production and process plant equipment, flare structures, and marine risers.
- Deck-houses and modules related to production operations.
- Loading of hot oils.
- Structural arrangement of oil storage tanks, cofferdams and pump-rooms.
- Access arrangements.
- Compartment minimum thickness.
- Hazardous areas and ventilation.
- Pollution prevention.
1.3.2 Where the unit is fitted with drilling equipment, the following additional topics are covered by this Chapter, as applicable:
- Structural arrangements of the unit related to drilling operations.
- Supporting structures for drilling equipment, bulk storage and raw water towers.
- Drill floor and derrick substructure.
- Drilling cantilevers.
- Structural arrangements in way of drilling wells.
- Structural mud tanks or pits.
- Deck-houses and modules related to drilling operations.
- Pipe racks and supports.

1.4 Installation layout and safety

1.4.1 In principle, production units are to be divided into main functional areas to ensure that the following areas, as applicable, are separated and protected from each other:
(a) Production area:
- Wellhead area.
- Processing area.
(b) Drilling area:
- Drill floor area.
- Mud circulation and treatment area.
(c) Auxiliary equipment area.
(d) Living quarters’ area.

1.4.2 Attention is to be given to the relevant Statutory Regulations for fire safety of the National Administrations in the area of operation and/or the country of registration as applicable, see Pt 1, Ch 2.1 and Pt 7, Ch 3.

1.4.3 Additional requirements for safety systems and hazardous areas are given in Part 7.

1.4.4 Living quarters, lifeboats and other evacuation equipment are to be located in non-hazardous areas and be protected and separated from production and wellhead areas.

1.4.5 In general, production units with crude oil bulk storage tanks are to be designed so that the arrangement and separation of living quarters, storage tanks, machinery rooms, etc., are arranged in accordance with the International Convention for the Safety of Life at Sea 1974 as amended, Regulations 11-2/56. Where this is not practicable owing to the unconventional design construction of the unit, special consideration will be given to other arrangements which provide equivalent separation and protection, see also Pt 1, Ch 2.1.1.11. For ship units with crude oil bulk storage tanks, the general arrangement and separation of spaces are to comply with Pt 4, Ch 9 of the Rules for Ships, or equivalent arrangements provided.

1.4.6 The position of the process plant in relation to storage tanks for crude oil, gas or other products will be specially considered, and consideration will be given to the requirements with regard to the provision of effective separation, methods of storage, loading and discharging arrangements.

1.4.7 Provision is to be made for purging, gas freeing, inerting or otherwise rendering safe crude oil bulk storage tanks, process plant and process storage facilities before the unit moves to a new location.

Section 2
Structure

2.1 Plans and data submission

2.1.1 In addition to the structural plans and information as required by Pt 4, Ch 1, the following additional plans and information are to be submitted:
- General arrangement.
- General arrangement plans of the production plant and process equipment layout.
- Structural supports below plant equipment.
- Structural plans of oil bulk storage tanks, ballast tanks, cofferdams, void spaces, pump-rooms and machinery spaces.
- Deck-houses and modules.
- Supporting structures to marine risers and flare booms or flare tower.
- Positional mooring equipment and supporting structure.

2.1.2 When the unit is fitted with drilling equipment, the following additional plans are to be submitted, when applicable:
- General arrangement plans of drilling derrick and equipment.
- Structural plans of drill floor, drilling derrick supports, substructure, drilling equipment supports, pipe rack and supports.
- Structural arrangements in way of drilling wells.
- Hull supporting structures.
- Hull structural plans of mud compartments, mud tanks and pump-rooms.

2.2 General

2.2.1 The general hull strength is to comply with the requirements of Part 4, taking into account the type of unit, the imposed equipment weights and forces from the production and process plant, mooring forces and drilling plant, when fitted. Attention should be paid to loads resulting from hull flexural effects at support points.

2.2.2 The supporting structure below equipment is to be designed for all operating conditions, and the maximum design loadings from the production and process plant imposed on the structure are to be determined in accordance with Chapter 8.

2.2.3 Decks and other underdeck structures supporting the plant are to be suitable for the local loads at plant support points and an agreed uniformly distributed load acting on the deck, see Pt 4, Ch 7.2. The structure in way of marine risers is to be suitably reinforced for the imposed loads.
2.2.4 In general, all seatings, platform decks, girders and pillars supporting plant items are to be arranged to align with the main hull structure, which is to be suitably reinforced, where necessary, to carry the appropriate loads. Attention should be paid to the capability of support structures to withstand buckling, see Pt 4, Ch 6.4.

2.2.5 Structure in way of openings of unusual size, configuration and/or shape may require investigation by structural analysis when requested by LR.

2.2.6 Insert plates of adequate thickness and steel grade, appropriate to the stress concentrations and locations, may be required in way of openings and structural discontinuities in primary structure.

2.2.7 Critical joints depending upon transmission of tensile stresses through the thickness of the plating of one of the members (which may result in lamellar tearing) are to be avoided wherever possible. Where unavoidable, plate material with suitable through-thickness properties will be required, see Ch 3.8 of the Rules for Materials and Pt 4, Ch 6, 1.4.2.

2.2.8 Where blast walls are fitted on the unit, the primary supporting structure in way of the blast walls is to be designed for the maximum design blast force with the permissible stress levels in accordance with Pt 4, Ch 6.2.1.1(c). For the requirement for blast walls, see Pt 7, Ch 3.

2.2.9 Turret structures, swivel stacks, mooring arms and yoke structures, etc., are to comply with the requirements of Chapter 2.

2.3 Drilling structures

2.3.1 When a unit is fitted with a drilling derrick, the requirements of this sub-Section are to be complied with, as applicable.

2.3.2 The design loadings for the strength of the drill floor and substructure are to be defined by the designer/Builders, and calculations are to be submitted.

2.3.3 Strength calculations are to be submitted for movable drilling cantilevers, skid beams and their supports. The clearances between the cantilever support claw and the skidding guides is the responsibility of the designers/Builders.

2.3.4 The maximum reaction forces from the drilling derrick are to be determined from an acceptable National Code and should take into account the load effects from vessel motions, the drillpipe setback, hook load, rotary table and tensioning equipment, see Chapter 7.

2.3.5 When the unit is to operate in an area which could result in the build-up of ice on the drilling derrick and other structures, the effects of ice loading are to be included in the calculations, see Pt 4, Ch 3.4.

2.3.6 The local structure should be reinforced for the component forces from drilling equipment and tensioner forces, and the design loadings are to be determined in accordance with Chapter 7.

2.3.7 The supporting structure and attachments under large equipment items are to be designed for all operating conditions and for the emergency condition as defined in Ch 8,1.4.

2.3.8 Attention should be paid to the capability of support structures to withstand buckling, see Pt 4, Ch 6.4.

2.3.9 The requirements of 2.6 and 2.8 are to be complied with, as applicable.

2.4 Permissible stresses

2.4.1 In general, the permissible stresses in the structure in operating, transit and survival conditions are to comply with Pt 4, Ch 6.2 but the minimum scantlings of the local structure are to comply with Pt 4, Ch 7. For ship units, see Part 10.

2.4.2 Permissible stresses for lattice type structures may be determined for an acceptable Code, see Appendix A.

2.5 Well structure

2.5.1 The primary hull strength of the unit is to be maintained in way of turret openings, drilling wells, moonpools and other large deck openings and suitable compensation is to be fitted, as necessary. For ship units, the continuity of longitudinal material is to be maintained, as far as is practicable, in way of turret openings and wells and the minimum hull modulus is to satisfy the Rule requirements for longitudinal strength.

2.5.2 Arrangements are to be made to ensure continuity of strength at the ends of longitudinal and well side bulkheads. In general, the design should be such that the bulkheads are connected to bottom and deck girders by means of large, suitably shaped brackets arranged to give a good stress flow at their junctions with both the girders and bulkheads.

2.5.3 Circumturret bulkheads and the boundary bulkheads of drilling wells and moonpools are to be designed for the maximum forces imposed on the structure. For ship units, see Part 10. For other unit types, see Pt 4, Ch 7.

2.6 Mud tanks

2.6.1 The scantlings of structural mud tanks are not to be less than those required for tanks in Pt 4, Ch 7.7 using the design density of the mud. In no case is the relative density of wet mud to be taken less than 2.2 unless agreed otherwise with LR.

2.6.2 Divisions in mud tanks or pits are to be designed for one-sided loading and the scantlings are to comply with the requirements for tanks in Pt 4, Ch 7.7.
2.7 Deck-houses and modules

2.7.1 The scantlings of structural deck-houses are to comply with Pt 4, Ch 7.9. Where deck-houses support equipment loads, they are to be suitably reinforced.

2.7.2 The strength of containerised modules, which do not form part of the main hull structure, will be specially considered in association with the design loadings.

2.7.3 When containerised modules can be subjected to wave loading, the scantlings are not to be less than required by 2.7.1.

2.8 Pipe racks

2.8.1 The pipe rack is to be designed for the following normal operating loads as applicable:

- Gravity loads.
- Maximum dynamic loads due to wave induced unit motions.
- Direct wind loads.
- Ice and snow loads.
- Hull flexing due to hull girder bending.

2.8.2 The pipe rack supports are also to be designed for an emergency condition, as defined in Ch 8,1.4.

2.8.3 In general, the pipe rack supports are to be aligned with the primary underdeck structure. Where this is not practicable, additional underdeck supports are to be fitted. Deck girders and underdeck supports are to comply with Pt 4, Ch 7.4.

2.8.4 In the emergency condition, arrangements are to be made to restrain the pipes in their stowed position and details are to be submitted for approval.

2.9 Bulk storage vessels

2.9.1 Free standing bulk storage vessels are to comply with the requirements of Ch 8,4.

2.9.2 The deck supports under free standing bulk storage vessels are to comply with the requirements for local structure in Pt 4, Ch 7 taking into account the maximum design reaction forces.

2.9.3 Where bulk storage vessels penetrate watertight decks and can be subjected to external hydrostatic pressure due to progressive flooding in hull damage conditions, the bulk storage vessel is to be suitably reinforced and the permissible stress is not to exceed the Code stress in accordance with Ch 8,4.

2.10 Watertight and weathertight integrity

2.10.1 The general requirements for watertight and weathertight integrity are to be in accordance with Pt 4, Ch 8.

2.10.2 The integrity of the weather deck is to be maintained. Where items of plant equipment penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the deck, their structural strength is to be equivalent to the Rule requirements for this purpose. Otherwise such items are to be enclosed in superstructures or deck-houses fully complying with the Rules. Full details are to be submitted for approval.

2.10.3 Where items of plant equipment or pipes penetrate watertight boundaries, the watertight integrity is to be maintained and full details are to be submitted for approval. Free flooding pipes, which penetrate shell boundaries, are to have a wall thickness not less than the adjacent shell plating.

2.10.4 Where free standing bulk storage vessels penetrate watertight decks or flats, the arrangements to ensure watertight integrity will be specially considered, see 2.9.3.

2.11 Access arrangements and closing appliances

2.11.1 For requirements in respect of coamings and closing of deck openings, see Pt 4, Ch 8,7.

2.11.2 The access arrangements on ship units are to comply with 2.12. For other unit types, the general requirements of 2.12 are to be complied with, as applicable.

2.11.3 Ladders and platforms in tanks, pump-rooms, cofferdams, access trunks and void spaces are to be securely fastened to the structure, see also 2.12.12.

2.12 Access to spaces in the oil storage area

2.12.1 Access arrangements to tanks for the storage of oil in bulk and adjacent spaces including cofferdams, voids, vertical wing and double bottom ballast tanks, are to be direct from the open deck and such as to ensure their complete inspection.

2.12.2 In column-stabilised units where access from the open deck is not practical, access to oil storage tanks and adjacent spaces is to be from trunks which are mechanically ventilated in accordance with Section 3. Every space is to be provided with a separate access without passing through adjacent spaces.

2.12.3 Access to double bottom tanks in way of oil storage tanks, where wing ballast tanks are omitted, is to be provided by trunks from the exposed deck led down the bulkhead. Alternative proposals will, however, be considered provided the integrity of the inner bottom is maintained.

2.12.4 Access to double bottom spaces may also be through a cargo pump-room, pump-room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.

2.12.5 Where a duct keel or pipe tunnel is fitted, and access is normally required for operational purposes, access is to be provided at each end and at least one other location.
Production and Oil Storage Units

Part 3, Chapter 3

Section 2

at approximately mid-length. Access is to be directly from the exposed deck. Where an after access is to be provided from the pump-room to the duct keel, the access manhole from the pump-room to the duct keel is to be provided with an oiltight cover plate. Mechanical ventilation is to be provided and such spaces are to be adequately ventilated prior to entry. A notice board is to be fitted at each entrance to the pipe tunnel stating that before any attempt is made to enter, the ventilating fan must have been in operation for an adequate period. In addition, the atmosphere in the tunnel is to be sampled by a reliable gas monitor, and where an inert gas system is fitted in cargo tanks, an oxygen monitor is to be provided.

2.12.6 Every double bottom space is to be provided with separate access without passing through other neighbouring double bottom spaces.

2.12.7 Where the tanks are of confined or cellular construction, two separate means of access from the weather deck are to be provided, one to be provided at either end of the tank space.

2.12.8 For access through horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening is to be not less than 600 mm x 600 mm.

2.12.9 Where practicable, at least one horizontal access opening of 600 mm x 800 mm clear opening is to be fitted in each horizontal girder in all spaces and weather deck to assist in rescue operations.

2.12.10 For access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening is to be not less than 600mm x 800 mm at a height of not more than 600 mm from the bottom shell plating, unless gratings or other footholds are provided.

2.12.11 In double hull construction with the wing ballast tanks having restricted access through the vertical transverse webs, permanent arrangements are to be provided within the tanks to permit access for inspection at all heights in each bay. These arrangements which should comprise fixed platforms, or other means, are to provide sufficiently close access to carry out Close-Up Surveys, as defined in Pt 1, Ch 3, using limited portable equipment where appropriate. Details of these arrangements are to be submitted for approval.

2.12.12 On units with very large oil storage tanks, it is recommended that consideration be given to providing permanent facilities for staging the interior of tanks situated within the oil storage region and of large tanks elsewhere. Suitable provisions would be:

- Staging which can be carried on board and utilised in any tank, including power-operated lift or platform systems.
- Enlargement of structural members to form permanent, safe platforms, e.g., bulkhead longitudinals widened to form stringers (in association with manholes through primary members).
- Provision of inspection/rest platforms at intervals down the length of access ladders.
- Provision of manholes in upper deck for access to staging in cargo tanks.

2.13 Access hatchways to oil storage tanks

2.13.1 The general requirements of Pt 4, Ch 8,7 are to be complied with.

2.14 Loading of hot oil in storage tanks

2.14.1 Hot oil may be loaded in oil storage tanks at the temperatures given below, without the need for temperature distribution and thermal stress calculations, provided these temperatures are not exceeded during operations:

(a) 65°C for sea temperatures of 0°C and below;
(b) 75°C for sea temperatures of 5°C and above; and
(c) by linear interpolation between (a) and (b) above, for sea temperatures between 0°C and 5°C.

2.14.2 Where the stored oil is to be loaded or heated to higher temperatures to those specified in 2.14.1 before unloading, temperature distribution investigations and thermal stress calculations may be required. For ship units see Pt 4, Ch 9,12 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

2.15 Compartment minimum thickness

2.15.1 On semi-submersible units, within the oil storage tank region in oil storage units including wing ballast tanks and cofferdams at the ends of or between oil storage tanks, the thickness of primary member webs and face-plates, hull envelope and bulkhead plating is to be not less than 7,5 mm.

2.15.2 Pump-rooms and other adjacent compartments are also to comply with 2.15.1 and 2.15.2.

2.15.3 The minimum compartment thickness in deep draught caisson units and buoys will be specially considered but is not to be less than 7,5 mm.

2.15.4 The compartment minimum thickness in ship units is to comply with Part 10.
Section 3  
Hazardous areas and ventilation

3.1 General

3.1.1 For the application of hazardous area classification and related ventilation requirements, see Pt 7, Ch 2.

3.1.2 Adequate ventilation is to be provided for all areas and enclosed compartments associated with oil storage, production and process plant. The capacities of the ventilation systems are to comply, where applicable, with the requirements of Pt 7, Ch 2.6, or to an acceptable Code or Standard adapted to suit the marine environment and taking into account any additional requirements which may be necessary during start-up of the plant.

3.1.3 Ventilation in the vicinity of mud tanks is to be specially considered to ensure adequate dilution of any dangerous gases.

3.1.4 For units using oil-based mud, the tanks are to be provided with special ventilation arrangements, and for open systems, the maximum oil density in the air above the tanks is not to exceed 5 mg/m³. Ventilation of the enclosed spaces with open active mud tanks or pits is to be arranged for at least 30 air changes per hour for personnel comfort.

Section 4  
Pollution prevention

4.1 General

4.1.1 Sumps and savealls are to be provided at potential spillage points, and drainage systems are to have adequate capacity and be designed for ease of cleaning.

4.1.2 Production manifolds are to be located and installed so that in the event of leakage in an enclosed area, a leakage detection and shut-down system will be activated. In open areas, arrangements are to be such that oil spillage will be contained, and that suitable drainage or recovery provisions are made.

4.1.3 Maintenance of production and process systems and equipment is to be governed by a permit-to-work system with rigid control on spillage prevention when opening up or testing is being carried out.

4.1.4 The arrangements for the onboard storage, and the disposal of, bilge and effluent from the production and process plant areas and spaces is to be submitted for consideration.

4.1.5 Oil spillage systems are to have sufficient capacity for treatment of bilge and effluent water from the production and process plant areas and spaces.

4.1.6 When oil is added to the drilling mud, provision is to be made to limit the spread of oil on the unit, and to prevent the discharge of oil and oily residue into the sea by the provision of de-oilers and suitably alarmed oil monitoring devices.

4.1.7 Drilling bell nipples, flow lines, ditches, shale shakers, mud rooms and mud tanks and pumps are to be designed for maximum volume throughput without spillage. Equipment requiring maintenance is to have adequate spillage catchment arrangements.

4.1.8 Pollution prevention arrangements should be such that the unit can comply with the requirements of the relevant National Administrations in the area of operation and/or in the country of registration as applicable.
Accommodation Units

Part 3, Chapter 4

Sections 1 & 2

Section

1 General

2 Structure

3 Bilge systems and cross-flooding arrangements for accommodation units

4 Additional requirements for the electrical installation

1.3 Scope

1.3.1 The following additional topics applicable to the type class notation are covered by this Chapter:

- Strength of structure for accommodation.
- Supports for accommodation modules.
- Structure in way of diving installations.
- Bilge systems and cross-flooding arrangements on accommodation units.
- Electrical installations on accommodation units.

1.4 Installation layout and safety

1.4.1 Living quarters, lifeboats and other evacuation equipment are to be located in non-hazardous areas.

1.4.2 The requirements for fire safety are to be in accordance with the requirements of a National Administration, see Pt 1, Ch 2,1 and Pt 7, Ch 3.

1.4.3 Additional requirements for safety and communication systems are given in Part 7.

1.5 Plans and data submission

1.5.1 Plans, calculations and data are to be submitted as required by the relevant Parts of the Rules together with the additional plans and information listed in this Chapter.

Section 1

General

1.1 Application

1.1.1 The requirements of this Chapter apply, in general, to column-stabilised and tension leg units as defined in Pt 1, Ch 2,2 whose primary function is to provide accommodation for offshore personnel. Other types of units or units of unconventional design will be specially considered on the basis of this Chapter. Self-elevating units need not comply with Section 3.

1.1.2 The requirements in this Chapter are supplementary to those given in the relevant Parts of the Rules.

1.1.3 When accommodation units are to operate for prolonged periods adjacent to live offshore hydrocarbon exploration or production installations, it is the responsibility of the Owner/Operator to comply with the relevant regulations of the National Administrations in the area of operation and/or the country of registration, as applicable. Special consideration will be given to the safety requirements for classification purposes, see Pt 1, Ch 2,1.1.

1.1.4 Accommodation units which have a diving complex on board are to have the diving installation approved in accordance with LR's Rules and Regulations for the Construction and Classification of Submersibles and Underwater Systems, or an acceptable standard.

1.2 Class notations

1.2.1 The Regulations for classification and the assignment of class notations are given in Pt 1, Ch 2 to which reference should be made.

1.2.2 In general, units complying with the requirements of this Chapter and the relevant Parts of the Rules will be eligible for the assignment of the type class notation:

- Accommodation unit.

1.2.3 Lifting appliances are to comply with LR's Code for Lifting Appliances in a Marine Environment (LAME), see also Chapter 11.

Section 2

Structure

2.1 Plans and data submission

2.1.1 In addition to the structural plans and information, as required by Pt 4, Ch 1,4, the following additional plans and information are to be submitted, as applicable:

- Structural plans of the accommodation, including deck-houses and modules.
- Design calculations for containerised modules.
- Module support frames or skids and details of attachments.
- Structural arrangements and supports under diving installations.
- Structural arrangements in way of crane supports.

2.2 General

2.2.1 The general hull strength is to comply with the requirements of Part 4, taking into account the applied weights and forces due to the accommodation, diving installations and cranes, and the local structure is to be suitably reinforced. Attention should be paid to loads resulting from hull flexural effects at support points.

2.2.2 The scantlings of structural deck-houses are to comply with Pt 4, Ch 7,9.
Accommodation Units

Part 3, Chapter 4

Sections 2 & 3

2.2.3 The strength of containerised modules which do not form part of the main hull structure will be specially considered in association with the design loadings.

2.2.4 When containerised modules can be subjected to wave loading or protect openings leading into buoyant spaces, the scantlings are not to be less than required by 2.2.2.

2.2.5 The structural strength of the connections between containerised modules and the supporting frame or structure are to comply with the general strength requirements of Pt 4, Ch 7,9, taking into account the units, motions and marine environmental aspects.

2.2.6 The connections of containerised modules are also to satisfy an emergency static condition with an applied horizontal force, $F_H$, in any direction as follows:

$$ F_H = W \sin \theta \ N \text{ (tonne-f)} $$

where

$\theta = 25^\circ$

$W = \text{weight of the modules supported in N (tonne-f)}.$

2.2.7 In the emergency static condition defined in 2.2.6 the permissible stress levels are to be in accordance with Pt 4, Ch 6,2.1.1(c).

2.3 Watertight and weathertight integrity

3.1 Application

The requirements of this Section are only applicable to units with accommodation for more than 12 persons, who are not crew members.

3.2 Location of bilge main and pumps

3.2.1 The general requirements of Pt 5, Ch 13 are to be complied with, as applicable, unless otherwise specified in this Section.

3.2.2 The bilge main is to be arranged so that no part is situated nearer to the side of the unit than the damage penetration zone.

3.2.3 Where any bilge pump or its pipe connection to the bilge main is situated outboard of the damage penetration zone, a non-return valve is to be fitted at the pipe connection junction with the bilge main.

3.2.4 The emergency bilge pump and its connections to the bilge main are to be situated inboard of the damage penetration zone.

3.2.5 At least three power bilge pumps are to be provided. Where practicable, these pumps are to be placed in separate watertight compartments which will not be readily flooded by the same damage. In units where engines and auxiliary machinery are located in two or more watertight compartments, the bilge pumps are to be distributed throughout these compartments.

3.2.6 The bilge pumping units are to be located such that at least one power pump will be available in any condition where the unit may be flooded after damage. This requirement will be satisfied if:

(a) one of the pumps is an emergency pump of the submersible type, having a source of power situated above the bulkhead deck or maximum anticipated damage load line; or

(b) the pumps and their power sources are located throughout the length of the unit so that, under any conditions of flooding that the unit is required to withstand by Statutory Regulation, at least one pump in an unaffected compartment will be available.

3.3 Arrangement and control of bilge system valves

3.3.1 The valves and distribution boxes associated with the bilge pumping system are to be arranged to enable any one of the bilge pumps to pump out any compartment in the event of flooding. All the necessary valves for controlling the bilge suctions are to be capable of being operated from above the bulkhead deck or maximum anticipated damage load line. The controls for these valves are to be clearly marked and a means provided at their place of operation to indicate clearly whether they are open or closed.

3.3.2 Where, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of pumping out any compartment under flooding conditions. In this case, only the valves necessary for the operation of this emergency system need to be operable from above the bulkhead deck or maximum anticipated damage load line.

3.4 Prevention of communication between compartments in the event of damage

3.4.1 Provision is to be made to prevent any compartment served by a bilge suction pipe being flooded in the event of the pipe being damaged by collision or grounding in any other compartment. For this purpose, where any part of the pipe is situated outboard of the damage penetration zone, or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.
3.5 Cross-flooding arrangements

3.5.1 Cross-flooding arrangements are not permitted as a means of attaining the damage stability criteria in accordance with Pt 4, Ch 8.

3.5.2 Cross-flooding arrangements may be used under control to restore a situation after damage. Such arrangements are not to be automatic or self-acting. Controls are to be situated above the worst anticipated damage waterline.

Section 4

Additional requirements for the electrical installation

4.1 General

4.1.1 In general, electrical installations are to comply with the requirements of Pt 6, Ch 2.

4.1.2 The requirements of this Section are applicable to units with accommodation for more than 50 persons, who are not crew members.

4.2 Emergency source of electrical power

4.2.1 A self-contained emergency source of electrical power is to be provided.

4.2.2 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and be readily accessible from the open deck. They are not to be located forward of the collision bulkhead, where fitted on ship units.

4.2.3 The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard is to be such as to ensure that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of Category A, see Pt 7, Ch 3, will not interfere with the supply, control and distribution of emergency electrical power. The space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard is not to be contiguous to the boundaries of machinery spaces of Category A, see Pt 7, Ch 3, and those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard. Where this is not practicable, details of the proposed arrangements are to be submitted.

4.2.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

4.2.5 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(a) For a period of 36 hours, emergency lighting:
   (i) in all service and accommodation alleyways, stairways and exits, personnel lift cars;
   (ii) in alleyways, stairways and exits, giving access to the muster and embarkation stations;
   (iii) in the machinery spaces and main generating stations including their control positions;
   (iv) in all control stations, machinery control rooms, and at each main and emergency switchboard;
   (v) at all stowage positions for fireman’s outfits;
   (vi) at the steering gear;
   (vii) at the fire pump, the sprinkler pump and the emergency bilge pump and at the starting position of their motors;
   (viii) at every survival craft, muster and embarkation station;
   (ix) over the sides to illuminate the area of water into which survival craft are to be launched;
   (x) on helicopter decks.

(b) For a period of 36 hours:
   (i) the navigation lights, other lights and sound signals required by the International Regulations for the Prevention of Collisions at Sea, in force;
   (ii) the radio communications, as required by Amendments to SOLAS 1974, Chapter IV as applicable;
   (iii) the navigational aids as required by Amendments to SOLAS 1974 Regulation V/19, as applicable;
   (iv) general alarm and communication systems, as required, in an emergency;
   (v) intermittent operation of the daylight signalling lamp and the unit’s whistle;
   (vi) the fire and gas detection systems and their alarms;
   (vii) emergency fire pump, the automatic sprinkler pump, if any, and the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves;
   (viii) one of the refrigerated liquid carbon dioxide units intended for fire protection, where both are electrically driven;
   (ix) on column-stabilised and tension leg units: ballast valve control system, ballast valve position indicating system, draft level indicating system, tank level indicating system and the largest single ballast pump;
   (x) abandonment systems dependent on electric power.
PART 3, CHAPTER 4

Section 4

4.2.6 The emergency source of electrical power may be either a generator or an accumulator battery, which are to comply with the following:

(a) Where the emergency source of electrical power is a generator, it is to be:
   (i) driven by a suitable prime mover with an independent supply of fuel having a flashpoint (closed-cup test) of not less than 43°C;
   (ii) started automatically upon failure of the electrical supply from the main source of electrical power and is to be automatically connected to the emergency switchboard; those services referred to in 4.2.5 are then to be transferred automatically to the emergency generating set. The automatic starting system and the characteristics of the prime mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; and
   (iii) provided with a transitional source of emergency electrical power according to 4.2.7.

(b) Where the emergency source of electrical power is an accumulator battery, it is to be capable of:
   (i) carrying the emergency electrical power without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;
   (ii) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
   (iii) immediately supplying at least those services specified in 4.2.7.

4.2.7 The transitional source of emergency electrical power required by 4.2.6 is to consist of an accumulator battery suitably located for use in an emergency, which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage, and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

   (a) For half an hour:
      (i) the lighting required by 4.2.5(a) and 4.2.5(b)(i);
      (ii) all services required by 4.2.5(b)(iii), (iv) and (v), unless such services have an independent supply for the period specified from an accumulator battery suitable located for use in an emergency.

   (b) Power to operate the watertight doors at least three times (i.e. closed-open-closed), against an adverse list of 15°, but not necessarily all of them simultaneously, together with their control, indication and alarm circuits as required by 4.2.5(f)(ii).

4.2.8 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

4.2.9 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

4.2.10 No accumulator battery except for engine starting, fitted in accordance with this Section, is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged.

4.2.11 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short-circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short-circuit.

4.2.12 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power will be available to the emergency circuits.

4.2.13 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.
Riser Systems

Part 3, Chapter 5

Section 1

General

1.1 Application

1.1.1 The requirements of this Chapter apply to rigid and flexible risers, together with associated components, between the pipeline end manifold connection and the connection to the unit, see 1.4.2. The requirements of this Chapter are considered to be supplementary to the requirements in the relevant Parts of the Rules.

1.1.2 The requirements also apply to surface floating and suspended flexible loading hoses (as appropriate).

1.1.3 Submarine steel pipelines are to comply with the requirements contained in internationally recognised Codes and Standards.

1.1.4 The riser system will be considered for Classification on the basis of operating constraints and procedures specified by the Owner and recorded in the Operations Manual.

1.1.5 Risers may be arranged separately or in connected bundles comprising production risers together with other elements.

1.2 Class notations

1.2.1 The Regulations for classification and the assignment of class notations are given in Pt 1, Ch 2, to which reference should be made.

1.2.2 Offshore units connected to product riser systems which comply with the requirements of this Chapter will be eligible for the assignment of the special features class notation PRS.

1.2.3 The service limits on which approval of the riser system has been based are to be included in the Operations Manual, see 2.5.

1.3 Definitions

1.3.1 The definitions in this Chapter are stated for Rule application only, and may not necessarily be valid in any other context.

1.3.2 Riser system. The riser together with its supports, component parts and ancillary systems such as corrosion protection, mid water arch, bend stiffeners, buoyancy modules, bend restrictors, bend stiffener latching mechanisms, etc.

1.3.3 Riser. A subsea flexible hose or rigid pipe leading down from the connection on the unit to a sea bed termination structure. Risers may have a variety of functions including liquid and gas export, water injection, chemical injection and controls, etc.

1.3.4 Floating Pipe. A surface pipe between the single-point mooring or buoy and the ship manifold. The floating pipe is normally permanently attached to the single-point mooring.

1.3.5 Riser support. Any structural item used for connecting a part of the riser system to the unit.

1.3.6 Riser components. Valves, connections, etc., and similar apparatus incorporated in the riser system.

1.4 Scope

1.4.1 The following additional topics applicable to the special features class notation are covered by this Chapter:

- Welded steel risers.
- Flexible risers.
- Floating hoses.
- Pig traps.
- Valves, controls and fittings.
- Safety devices.
- Coverings and protection.
- Cathodic protection system.

1.4.2 Unless agreed otherwise with Lloyd’s Register (LR), the Rules consider the following as the main boundaries of the riser system:

- Any part of the riser system as defined in 1.3.2 from the sea bed termination to the first riser connector valves on the unit.
- The riser connector valves will normally be considered part of the offshore unit, unless agreed otherwise with LR.
Riser Systems

1.5 Damage protection

1.5.1 Wherever possible, risers should be protected from collision damage either by suitable positioning within the unit or by protective structure provided for this purpose.

1.5.2 The risk of damage arising from impact loads should form an integral part of the riser assessment. The assessment should evaluate the risk and consequences to the installation of a release of hydrocarbon from the riser.

1.5.3 Design of the riser system should consider the avoidance of collisions between individual risers and anchor lines, etc., with the positioning system intact and in a single fault damaged state under the appropriate environmental conditions. Contact may be allowed in a single fault damaged state provided special external armourey is fitted to the risers in the interference regions, or where appropriate calculations and/or tests indicate that no damage to the risers will occur.

1.5.4 Risers designed to be capable of rapid release should not be damaged in the course of such release, nor should they inflict critical damage on other components.

1.6 Buoyancy elements

1.6.1 Where subsea buoyant vessels are provided as an inherent part of the riser system design, the requirements of Ch 2.2.3 are to be complied with.

1.6.2 The loss of buoyancy of any one element is not to affect adversely the integrity of the riser system.

1.7 Emergency shut-down (ESD) system

1.7.1 An ESD system is to be provided to riser systems in accordance with Pt 7, Ch 1. This requirement is generally not applicable to conventional surface floating and suspended flexible loading hoses.

1.7.2 An ESD system philosophy should be developed for the installation based on appropriate hazard and safety assessments. Due consideration is to be given to the sequence of events in relation to overall installation safety.

1.7.3 To limit the quantity of flammable or toxic substances escaping in the event of damage to a riser, emergency shut-down valves are to be fitted. The valves and their control mechanisms should be positioned to offer the maximum protection to the unit in the event of damage.

1.7.4 Facilities are to be provided to make it possible at all times to isolate risers by means of valves.

1.7.5 Where appropriate, rapid disconnection of risers must be possible from at least one location. The assessment of how many locations to be provided, and where they should be situated, is to be based on the evaluation of various accident scenarios. Suitable fail-safe measures are to be provided to prevent inappropriate or inadvertent disconnection.

1.8 Recognised Codes and Standards

1.8.1 In general, the requirements in this Chapter are based on internationally recognised Codes and Standards for riser systems, as defined in Appendix A. Other Codes and National Standards may be used after special consideration and prior agreement with LR. When considered necessary, additional Rule requirements are also stated in this Chapter.

1.8.2 The agreed Codes and Standards may be used for design, construction and installation, but the additional requirements stated in the Rules are to be complied with. Where there is any conflict, the Rules will take precedence over the Codes or Standards.

1.8.3 The mixing of Codes or Standards for each equipment item or system is to be avoided. Deviation from the Code or Standard must be specially noted in the documentation and approved by LR.

1.8.4 Where National Administrations have specific requirements regarding riser systems, it is the responsibility of the Owner and Operators to comply with such regulations.

1.9 Equipment categories

1.9.1 The approval and certification of riser systems are to be based on equipment categories agreed with LR.

1.9.2 Riser systems including their associated components and valves are to be divided into equipment Categories 1A, 1B and II depending on their complexity of manufacture and their importance with regard to the safety of personnel and the installation and their possible effect on the environment.

1.9.3 The following equipment categories are used in the Rules:

1A Equipment of primary importance to safety, for which design verification and survey during fabrication are considered essential. Equipment in this category is of complicated design/manufacture and is not normally mass produced.

1B Equipment of primary importance to safety, for which design verification and witnessing the product quality are considered essential. Equipment in this category is normally mass produced and not included in Category 1A.

II Equipment related to safety, which is normally manufactured to recognised Codes and Standards and has proven reliability in service, but excluding equipment in Category 1A and 1B.

1.9.4 A guide to equipment and categories is given in Appendix A. A full list of equipment categories for the riser system is to be agreed with LR before manufacture. Minor equipment components need not be categorised.
1.10 Equipment certification

1.10.1 Equipment is to be certified in accordance with the following requirements:
(a) **Category 1A:**
   - Design verification and issue of certificate of design strength approval.
   - Pre-inspection meeting at the suppliers with agreement and marking of quality plan and inspection schedule.
   - Survey during fabrication and review of fabrication documentation.
   - Final inspection with monitoring of function/pressure/load tests and issue of a certificate of conformity.
(b) **Category 1B:**
   - Design verification and issue of certificate of design strength approval, where applicable, and review of fabrication documentation.
   - Final inspection with monitoring of function/pressure/load tests and issue of a certificate of conformity.
(c) **Category II:**
   - Supplier’s/manufacturer’s works certificate giving equipment data, limitations with regard to the use of the equipment and the supplier’s/manufacturer’s declaration that the equipment is designed and fabricated in accordance with recognised Standards or Codes.

1.10.2 All equipment recognised as being of importance for the safety of personnel and the riser system is to be documented by a data book.

1.11 Fabrication records

1.11.1 Fabrication records are to be made available for Categories 1A and 1B equipment for inspection and acceptance by LR Surveyors. These records should include the following:
   - Manufacturer’s statement of compliance;
   - Reference to design specification and plans;
   - Traceability of materials;
   - Welding procedure tests and welders’ qualifications;
   - Heat treatment records;
   - Records/details of non-destructive examinations;
   - Load, pressure and functional test reports.

1.12 Site installation of riser systems

1.12.1 The installation of riser systems is to be controlled by LR in accordance with the following principles:
   - All Category 1A and 1B equipment, when delivered to site, is to be accompanied by a certificate of design strength approval and an equipment certificate of conformity and all other documentation.
   - All Category II equipment, delivered to site, is to be accompanied by equipment data and a works’ certificate.
   - Control and follow-up of non-conformities/deviations specified in design certificates and certificate of conformity.

1.13 Maintenance and repair

1.13.1 It is the Owner’s/Operator’s responsibility to ensure that an installed riser system is maintained in a safe and efficient working condition in accordance with the manufacturer’s specification and design.

1.13.2 When it is necessary to repair or replace components of a riser system any repaired or spare part is to be subject to the equivalent certification as the original, see 10.2.

1.14 Plans and data submissions

1.14.1 Plans, calculations and data are to be submitted as required by the relevant Parts of the Rules together with the additional plans and information listed in this Chapter.

### Section 2

**Plans and data**

2.1 General

2.1.1 Sufficient plans and data are to be submitted to enable the design to be assessed and approved. The plans are also to be suitable for use during construction, installation, hydrotesting, survey and maintenance of the riser system.

2.1.2 In general, engineering drawings and documents should be submitted electronically.

2.2 Specifications

2.2.1 Adequate design specifications, appropriate in detail to the approval required, are to be submitted for information.

2.2.2 Specifications for the design, construction and fabrication of the riser system, structure and associated equipment are to be submitted. The specifications are to include details of materials, grades/standards, consumables, construction and installation procedures and modes of operation with applicable design criteria. The specifications are also to include the proposed design codes.

2.2.3 Specifications and documentation are to be submitted, covering all instrumentation and monitoring systems proposed to cover the fabrication, installation and operating phases of risers, fittings and equipment.
2.3 Plans and data to be submitted

2.3.1 Plans and data covering the following items are to be submitted for approval, as relevant:

- Bend stiffeners.
- Bend stiffening latching mechanisms.
- Bend restrictors.
- Bend restrictors, bend stiffener latching mechanisms, mid water arches, buoyancy modules, tether arrangements, end fittings.
- Buoyancy arches and fittings.
- Buoyancy modules.
- Construction and laying procedures.
- Corrosion protection system.
- Curvature bending stiffeners.
- Details of all attachments.
- Details of riser system control and communications.
- Details of sea bed.
- Emergency shut-down system and other safety devices, including pressure transient (surge) relief.
- End fittings.
- Instrumentation and communication line diagrams.
- Layout of risers and associated platform arrangements, including protection of risers.
- Leak detection system and hardware.
- Location survey showing name, latitude and longitude of terminal locations, location of isolating valves, position of platforms or other fabrications, shipping channels, presence of cables, pipelines and wellheads, etc.
- Mid water arches.
- Quality Control and NDE procedures.
- Riser dimensions.
- Riser material specifications, including appropriate test results.
- Riser support details.
- Riser wall thickness tolerances.
- Sizes and details of expansion loops, reducers, etc.
- Test schedules for communication systems, controls, emergency shut-down systems and other safety devices, which are to include the methods of testing and test facilities provided.
- Tether arrangements.
- Type and thickness of corrosion coating.
- Type and details of all pig traps, valves and control equipment, etc.
- Welding specification, details and procedures.

2.3.2 The following supporting plans and documents are to be submitted:

- Reference plans and listing of standard components, e.g., tees, reducers, connectors, valves, elbows, etc.
- Reference plans of anodes, sleeves, etc.
- Burst pressure of flexible risers.
- Calculations and documentation of all design loads covering: manufacture, installation and operation.
- Corrosive nature of line contents.
- Corrosive nature of sea-water and sea bed soils.
- Current, tidal current and storm surge velocities and directions.
- Design cathodic protection potential.
- Damaging tension of flexible risers.
- Design life.
- Design pressure and temperature.
- Design throughput.
- Fluid to be conveyed. (The maximum partial pressure and dew point of H₂S, CO₂ and H₂O for gas risers.)
- Ice conditions, which may affect riser system.
- Leak detection accuracy and response.
- Maximum and minimum operating temperatures including distributions along the riser.
- Maximum and minimum temperatures of water and air.
- Maximum operating pressure.
- Product density.
- Maximum Excursion Envelopes (MEEs) for riser system (in the x, y and z axes) to prevent damage. MEEs to be provided in the operational and survival conditions, with the mooring system in connected and disconnected (where appropriate) conditions.
- Marine growth density and thickness profiles (varying with water depth) plotted against time, over the field life.
- Sea bed geology and soil characteristics including stability and sand waves, etc.
- Sea bed topography and bathymetry in way of riser system and any possible deviation or future development.
- Seismic activity survey.
- Test pressure to be applied.
- Type, activity and magnitude of marine growth predicted.
- Wave heights, periods and directions.
- Wind velocities and directions.

2.4 Calculations and data

2.4.1 The following is to be submitted where relevant to the riser system:

- Analyses of riser system behaviour including: strength, buckling, vortex shedding, on-bottom stability, displacements, vibration, fatigue, fracture and buckle propagation and minimum bend radii.
- Buoyancy and stability data for all risers.

2.5 Operations Manual

2.5.1 The allowable modes of operation including the maximum and minimum internal pressure, product temperature and flow rate together with the operating and maximum environmental criteria on which classification is based are to be stated in the unit’s Operations Manual, as required by Ch 1.3.

2.5.2 The Manual is to contain instructions and guidance on any actions which need to be taken to satisfy environmental considerations and the safe operation of the riser system.
Section 3  
Materials

3.1  General

3.1.1  The type and grade of materials chosen for the risers, valves and associated equipment are to be in accordance with the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials) or a recognised National or International Standard. In cases when a specification is not covered by LR’s Rules, full details of the material specification, testing documentation and all properties are to be submitted for approval.

3.1.2  Materials are to be selected in accordance with the requirements of the design in respect of carriage of the product, strength, fatigue, fracture resistance and corrosion resistance.

3.1.3  Due consideration is to be given to temperature and other environmental conditions on the performance of the material, including toughness at the minimum operating temperature, the effects of corrosion, and other forms of deterioration both in service and whilst being stored or handled.

3.1.4  Riser material for H2S-contaminated products (sour service) is to comply with BS EN ISO 15156 Petroleum and natural gas industries - Materials for use in H2S-containing environments in oil and gas production.

3.1.5  Steel grades for operation in areas where the design air temperature is below minus 20°C and in severe ice conditions (e.g., arctic waters) will be specially considered.

3.1.6  An approved system of corrosion control is to be fitted, where appropriate. Full details are to be submitted, see Pt 8, Ch 1.

Section 4  
Environmental considerations

4.1  General

4.1.1  The Owner or designer is to specify the environmental criteria for which the riser system is to be approved. The extreme environmental conditions applicable to the location are to be defined, together with all relevant operating environmental limits. Full particulars are to be submitted with sufficient supporting information to demonstrate the validity of the environmental parameters.

4.1.2  The extreme environmental criteria to be taken into account in the riser system design are, in general, to be based on a return period of 100 years, see also Pt 4, Ch 3,4.

4.2  Environmental factors

4.2.1  The following environmental factors are to be considered in the design of the riser system:
- Air and sea temperatures.
- Current.
- Fouling.
- Ice.
- Water depth.
- Wave.
- Wind.

4.2.2  Environmental factors to be accounted for in the design loadings are contained in Pt 4, Ch 3,4 together with the additional considerations below.

4.3  Waves

4.3.1  When using acceptable wave theories to determine local wave velocities for smooth cylindrical members, appropriate hydrodynamic coefficients should be used. These values should be modified to account for proximity to the sea bed or structural members on the unit.

4.4  Current

4.4.1  Where a current acts simultaneously with waves, the effect of the current is to be included. The current velocity is to be added vectorially to the wave particle velocity. The resultant velocity is to be used to compute the total force.

4.4.2  In the absence of more detailed information, the distribution of current velocity with depth may be assumed to vary according to the 1/7th power law.

4.5  Vortex shedding

4.5.1  Consideration is to be given to the possibility of vibration of structural members due to von Karman vortex shedding. (This is to apply to wind on exposed risers, and to wave and current on immersed risers).

4.6  Ice

4.6.1  Riser systems intended for operation in ice are to be designed to minimise the effect of ice loading. Proposals are to be submitted for consideration.
Section 5
Design loadings

5.1 General

5.1.1 All modes of operation are to be investigated using realistic loading conditions, including buoyancy, unit motions and gravity loadings and operational loads (temperature, pressure, etc.) together with relevant environmental loadings due to the effects of wind, waves, currents, vibrations, ice, and where necessary, the effects of earthquake, sea bed supporting capabilities and friction, temperature, fouling, etc.

5.1.2 The design of the riser system is to take account of all loads which can be imposed during its service life.

5.1.3 The design is also to take account of loads related to the construction, transportation and site installation stages.

5.2 Dead loads

5.2.1 All gravity loadings are to be taken into account and should include self-weight of the riser system and attachments. The deadweight of contents is to be included.

5.2.2 Buoyancy of risers including attached equipment is to be taken into account.

5.2.3 Constraints and loads arising from supports and attachments should be taken into account. Also any scour or subsidence of sea bed should be assessed.

5.3 Live loads

5.3.1 Static pressure, pressure surge transients and any peak ‘hammer-blow’ effects are all to be considered, together with corresponding temperatures.

5.3.2 Dynamic inertial vibrations and flutter induced by any activation, including vortex shedding, are to be considered.

5.4 Environmental loads and motions

5.4.1 The environmental loading on a riser system and its motion responses are to be determined for at least the design environmental conditions given in Section 6. Dynamic effects are to be considered.

5.4.2 The loads and motions can be established by model testing or by suitable calculations or both. The possibility of resonant motion is to be fully investigated.

5.4.3 Account is to be taken of the effect of marine growth. Both increase in the dimensions and the change in surface characteristics are to be considered.

5.4.4 Where model testing is to be adopted:
(a) The test programme and the model test facilities are to be to LR’s satisfaction;

(b) The relative directions of wind, wave and current are to be varied as required to ensure that the most critical loadings and motions are determined;

(c) The tests are to be of sufficient duration to establish low frequency motion behaviour; and

(d) The model testing is required to give suitable data pertaining to both strength and fatigue design aspects of the riser system.

5.5 Other loadings

5.5.1 Loads imposed during site installation, including those due to motion of the laying ship/unit, are to be assessed and taken into account. The curvature taken up during laying and loads imposed thereby are to be assessed and arrangements made for laying procedures to avoid any damage or overstress.

5.5.2 Hydrostatic effects are to be included in the design. Hydrostatic loading can be taken as the difference between internal and external pressures, as appropriate.

5.5.3 The riser system design should also take account of accidental loading, where relevant, and required test loads, see Section 9.

5.5.4 The riser system is to be designed to withstand the most unfavourable combinations of pressure, temperature and environmental loadings under normal operating conditions combined with the effects of the most severe single fault that might arise in the positioning system.

5.5.5 Scouring effects are to be considered for the support conditions of steel flexible risers at the touchdown locations.

Section 6
Strength

6.1 General

6.1.1 This Section defines the strength requirements, including static and dynamic aspects, for welded steel riser systems, flexible riser systems and hoses.

6.1.2 The design is to be analysed in accordance with acceptable methods and procedures and the resultant stresses or factors of safety determined.

6.1.3 In general, the strength of the riser system is to be determined from a three-dimensional analysis. Only if it can be demonstrated that other methods are adequate will they be considered.

6.1.4 The riser system is to be designed such that under transient operating conditions the maximum allowable operating pressure may not be exceeded by more than 10 per cent.
6.2 Structural analysis

6.2.1 The loading combinations considered are to represent all modes of operation so that the critical design cases are established.

6.2.2 All loads applicable to the design, as defined in Section 5, are to be fully covered in the loading combinations.

6.2.3 A fully representative number of design cases is to be defined, each of which should be associated with appropriate environmental conditions and allowable yield ratios or factors of safety. The design cases are to cover all critical aspects of riser system installation, testing and operation.

6.2.4 A detailed analysis of the riser system, including interaction with pipeline and expansion loop, is to be carried out. This is to take account of thermal, hydrodynamic, gravity, buoyancy and pressure effects and vessel motions. Modelling is to describe riser geometry and stiffness, and soil interaction, including loss of contact.

6.2.5 Riser supports and stiffener bend restrictor forces are to be determined, and strength checks carried out.

6.3 Flexible risers and hoses

6.3.1 The design of flexible risers and associated appurtenances and fittings is to be based on sound engineering principles and practice, and is to be in accordance with recognised National or International Standards or Codes of Practice. Design calculations are to be submitted and, where considered necessary, LR will carry out independent analysis of the strength and stability of the steel risers, see Appendix A, A1.2.10.

6.3.2 For all critical loading combinations relevant to the design axial loading, internal/external pressure and radius of curvature are to be considered in a rational manner.

6.3.3 Other factors which adversely affect the integrity of the riser such as abrasion, ageing, corrosion, fatigue and fire are also to be considered.

6.3.4 For fatigue, see 6.4.6; however, endurance curves should also account for fluid permeation through polymers and potential accidental ingress of sea-water resulting from damage to the external sheath.

6.3.5 Special attention is to be given to riser end fittings to ensure effective bonding, pressure containment and load transfer.

6.3.6 In general, riser displacements are to achieve acceptable clearances with adjacent risers, mooring lines, unit structures and the sea bed. However, in extreme cases interference may be allowed, see 1.5.3.

6.3.7 Critical design parameters are to be demonstrated by means of appropriate tests and calculations.

6.4 Welded steel risers

6.4.1 The design of steel risers and associated appurtenances and fittings is to be based on sound engineering principles and practice, and is to be in accordance with recognised National or International Standards or Codes of Practice. Design calculations are to be submitted and, where considered necessary, LR will carry out independent analysis of the strength and stability of the steel risers, see Appendix A, A1.2.10.

6.4.2 Yielding: For any particular location, two stress intensity calculations will be required, as follows:

(a) Hoop stress calculations are to be made utilising the minimum specification wall thickness less corrosion allowance, as appropriate.

(b) All axial stresses arising from end load, bending moment, shear and torsion are to be combined with hoop stress to give an equivalent stress based on the Mises-Hencky criterion to conform with specified yield ratio limits.

6.4.3 Vortex shedding response:

(a) The effects of vortex-induced oscillations are to be accounted for. The effect of axial forces on natural frequency is to be included.

(b) The restraining effect of external spans, and relief due to wave and current directionality may be included provided that sufficient environmental data is available.

(c) In all cases, the effect of vortex shedding on fatigue life is to be checked.

6.4.4 Buckling. Local and overall buckling of the riser is to be checked for all locations and loading conditions for which free spans may arise. The worst combinations of axial and lateral loading are to be considered.

6.4.5 Stress concentrations. The effect of notches, stress raisers and local stress concentrations is to be taken into account in the design of the load carrying elements.

6.4.6 Fatigue:

(a) Fatigue damage due to cyclic loading is to be considered in the design of the riser. The cyclic loading due to internal (contents) pressure fluctuations is to be taken into account. The extent of the fatigue analysis will be dependent on the mode and area of operations.

(b) Fatigue design calculations are to be carried out in accordance with the analysis procedures and general principles given in Pt 4, Ch 6,5, or other acceptable method, and the fatigue life calculations are to be based on the relevant stress range/endurance curves applicable to the service environment incorporating appropriate stress concentration factors.

(c) The minimum factors of safety on fatigue life are not to be less than as required by Pt 4, Ch 6,5,6.

6.4.7 Plastic analysis (strain based design methods). Where plastic design methods are to be employed, the load factors will be specially considered.
Riser Systems

6.5 Pig traps

6.5.1 Pig traps are to be designed to the requirements of a recognised pressure vessel code and since they are considered as part of the riser and associated equipment the hoop stress is not to exceed 60 per cent of the minimum yield stress of the material.

6.6 Riser supports and attachments

6.6.1 The riser supports and other attachments are to be designed to meet suitable structural design codes. Where the supports are attached to the structure of the unit the permissible stresses in the structure are to comply with Pt 4, Ch 6-2.

6.7 Mechanical items

6.7.1 The design of components such as valves and similar apparatus is to be in accordance with an acceptable design method or recognised Code.

Section 7

Welding and fabrication

7.1 General

7.1.1 Welding, weld procedures and approval of welders are to be in accordance with the general requirements of Pt 4, Ch 9. When agreed with LR, the fabrication of riser systems may be in accordance with a recognised Code, see Appendix A.

7.1.2 The proposals for NDE procedures are to be agreed with LR prior to the commencement of construction.

7.1.3 All butt welds are to be subjected to 100 per cent NDE. Examination by radiography is to be to a Standard acceptable to LR, e.g., ISO 17636: Non-destructive testing of welds – Radiographic testing of fusion welded joints, with acceptance criteria as detailed in the Construction Code, or BS 4515: Specification for welding of steel pipelines on land and offshore, if not specified in the Code. Proposals for examination by ultrasonics are to be submitted for review and acceptance.

7.1.4 All defective sections of welds are to be cut out, carefully re-welded and re-examined.

7.1.5 Weld procedures for repairs and alterations are to be qualified and approved by LR.

Section 8

Installation

8.1 General

8.1.1 Specifications covering the site installation procedures are to be submitted for approval.

8.2 Location Survey

8.2.1 Specifications, plans and data are to comply with 2.3.1. Additional data is to be submitted specifying sea bed preparation, extent and means of execution and survey prior to installation.

8.2.2 The construction specification is to specify the tolerance within which the riser system is to be positioned.

8.3 Installation procedures

8.3.1 The equipment used for operations is to be agreed by LR for the processes specified.

8.3.2 Individual risers, equipment, fittings and sub-assemblies are to be handled and stored with care, especially components with anodes or heavy anode bracelets. No components are to be stored in a manner which will cause damage or deformation.

8.3.3 All components and sub-assemblies are to be inspected before installation and be approved to the satisfaction of the Surveyor.

8.3.4 The installation of the riser is not to introduce any unscheduled loading and the transfer of loading to riser supports is to be shown to be in accordance with design specifications.

8.3.5 All monitoring systems are to be operated and calibrated to the Surveyor’s satisfaction during all laying and installation operations.

8.4 Completion Survey

8.4.1 As soon as is practicable, following installation and prior to start-up, a survey of the entire riser system is to be carried out.

Section 9

Testing

9.1 Hydrostatic testing

9.1.1 The requirements of 1.10, 1.11 and 1.12 regarding certification and testing are to be complied with.
9.1.2 **Steel risers:**
(a) The riser system is to be hydrostatically tested after installation. Hydrostatic Testing Procedures are to comply with recognised International Codes and Standards.
(b) A written procedure is to be developed before hydrostatic testing commences. The acceptance criteria are to be agreed by LR.

9.1.3 **Flexible risers.** For flexible risers, pressure testing includes acceptance tests in the factory and hydrostatic test after installation. The acceptance test pressure should be in accordance with recognised international Codes and Standards for flexible risers.

9.1.4 It is permissible to have pressure variations during a hydrostatic test provided they can be explained in terms of temperature changes and/or motions of the riser system.

9.1.5 In order to calculate the effect of temperature on pressure, it is essential that the temperature of the fluid in the pipe is measured and recorded at the same time as each pressure measurement is made and recorded. Ambient air or sea-water temperature is not relevant.

9.1.6 As a minimum, the temperature is to be measured near each end of the riser. Preferably at least one transducer on the sea bed part of the riser should also be provided.

9.1.7 Temperature sensors attached to the outside of the steel wall of a riser and insulated from the thermal effects of the sea are acceptable provided the test medium has been in the riser for at least 24 hours before the test is started, in order to allow the temperature of the fluid and steel to stabilise.

9.1.8 When conducting a hydrostatic test of a riser, the following requirements are to be complied with:
(a) The pressure (and temperature, if applicable) is to be continuously recorded for the duration of the test on a chart recorder.
(b) The chart is to be signed by the Surveyor at the beginning and end of the test.
(c) Pressure (and temperature, if applicable) readings are to be made at intervals not greater than 30 minutes and tabulated.
(d) Where temperature readings are to be taken, the line is to be filled at least 24 hours before the test to enable the temperature to stabilise.
(e) The results of a hydrostatic test are to be recorded by a dossier containing the following:
   - Copies of all charts made during the test.
   - Copies of all tables of pressure readings (and temperature readings where applicable) made during the test.
   - Copies of calibration certificates for the pressure recorders used.
   - Calculations demonstrating temperature correction to pressure change where applicable.

9.1.9 The sections of riser are to be hydrostatically tested at the place of manufacture in accordance with Chapter 6 of the Rules for Materials, or the relevant National Standard.

9.1.10 Before a consent to start up a riser can be given, evidence of a satisfactory hydrostatic test is to be provided. The evidence is to relate to a test completed during the 12 months prior to the date of application for the consent to start up.

9.2 **Buckle detection**

9.2.1 An adequate examination is to be carried out to determine that the completed riser is free from buckles, dents or similar damage.

9.3 **Testing of communications, controls and safety systems**

9.3.1 Communication systems, remote and automatic controls, emergency shut-down systems and other safety devices are to be tested in accordance with the approved test schedules required by 2.3.1.

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Section 10

Operation and repairs

10.1 **Operation procedures**

10.1.1 A written operation procedure is to be prepared and issued prior to the riser system being put into operation. One operation procedure may, where applicable, cover several riser systems of the same type.

10.1.2 Where a riser system forms part of a system covering other lines, platforms, terminals, etc., the operating procedure is to embrace those parts of the entire system which are relevant to the operation of the riser system.

10.1.3 In order to minimise the risk of damage to the riser system, it is the Owner’s/Operator’s responsibility to ensure that supply boat approach routes to the installation are strictly controlled. A mooring procedure is to be produced which clearly indicates safe and hazardous anchoring areas.

10.1.4 Operation procedures are to be written in English with translations into other languages, as necessary, for the operating personnel involved.

10.2 **Repairs**

10.2.1 It is the Owner’s responsibility to inform LR of any defects found. The exact location, nature and extent of the defects are to be stated. The requirements of 1.13 are to be complied with.

10.2.2 Plans and particulars of any proposed repairs are to be submitted for approval. All repair work is to be carried out to the satisfaction of LR’s Surveyors.
Section 1

Scope

1.1 General

1.1.1 The following requirements are for units intended for operations in ice and cold conditions.

1.1.2 Guidance on the appropriate requirements and notations is provided in Table 6.1.1.

Table 6.1.1 Ice and cold operations

<table>
<thead>
<tr>
<th>Reference</th>
<th>Conditions</th>
<th>Description</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1</td>
<td>Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 2</td>
<td>Hull</td>
<td>General requirements</td>
<td>Applicable to all ice classes</td>
</tr>
<tr>
<td>Section 3</td>
<td>Machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 4</td>
<td>Hull</td>
<td>Light and very light ice conditions</td>
<td>Ice Class 1E</td>
</tr>
<tr>
<td>Section 5</td>
<td>Machinery</td>
<td>For ships with length less than 150 m</td>
<td>Ice Class 1D</td>
</tr>
<tr>
<td>Section 6</td>
<td>Hull</td>
<td>First-year ice conditions</td>
<td>Ice Class 1C FS, Ice Class 1B FS, Ice Class 1A FS, Ice Class 1AS FS</td>
</tr>
<tr>
<td>Section 7</td>
<td>Machinery</td>
<td>German-Swedish Ice Class Rules</td>
<td>Ice Class 1C FS(+), Ice Class 1B FS(+), Ice Class 1A FS(+), Ice Class 1AS FS(+), Ice Class 1C FS, Ice Class 1B FS, Ice Class 1A FS, Ice Class 1AS FS</td>
</tr>
<tr>
<td>Section 8</td>
<td>Hull</td>
<td>Multi-year ice conditions</td>
<td>IACS Polar Ship Rules</td>
</tr>
<tr>
<td>Section 9</td>
<td>Machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 10</td>
<td>Hull</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 11</td>
<td>Machinery</td>
<td></td>
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</tr>
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</table>

Cold Operations

<table>
<thead>
<tr>
<th>Provisional Rules for the Winterisation of Ships</th>
<th>Section 1</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 2</td>
<td>Hull materials</td>
<td>Low temperature operations</td>
</tr>
<tr>
<td>Section 3</td>
<td>Equipment and systems</td>
<td>Low temperature operations</td>
</tr>
</tbody>
</table>

Winterisation C(t) | Winterisation B(t) | Winterisation A(t)
Section 2
Ice Environment

2.1 General

2.1.1 This Section is intended to give assistance on the selection of a suitable ice class notation for the operation of units in ice-covered regions.

2.1.2 The Owner is to confirm which notation is most suitable for their requirements. Ultimately, the responsibility rests with the Operator of the unit and their assessment of the ice and temperature conditions at the time.

2.1.3 The documentation supplied to the unit is to contain the ice class notation adopted, any operation limits for the unit and guidance on the type of ice that can be navigated for the nominated ice class.

2.2 Definitions

2.2.1 The World Meteorological Organisation’s, WMO, definitions for sea ice thickness are given in Table 6.2.1.

Table 6.2.1 WMO definition of ice conditions

<table>
<thead>
<tr>
<th>Ice conditions</th>
<th>Ice thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium first-year</td>
<td>1.2 m</td>
</tr>
<tr>
<td>Thin first-year, second stage</td>
<td>0.7 m</td>
</tr>
<tr>
<td>Thin first-year, first stage</td>
<td>0.5 m</td>
</tr>
<tr>
<td>Grey-white</td>
<td>0.3 m</td>
</tr>
<tr>
<td>Grey</td>
<td>0.15 m</td>
</tr>
</tbody>
</table>

2.2.2 Table 6.2.2 defines the ice classes in relation to the Rules and the equivalent internationally recognised Standards.

Table 6.2.2 Comparison of ice standards

<table>
<thead>
<tr>
<th>Lloyd’s Register class notation</th>
<th>Finnish-Swedish Ice Class</th>
<th>Canadian type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Class 1AS FS (+)</td>
<td>IA Super</td>
<td>A</td>
</tr>
<tr>
<td>Ice Class IAS FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Class 1A FS (+)</td>
<td>IA</td>
<td>B</td>
</tr>
<tr>
<td>Ice Class 1A FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Class 1B FS (+)</td>
<td>IB</td>
<td>C</td>
</tr>
<tr>
<td>Ice Class 1B FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Class 1C FS (+)</td>
<td>IC</td>
<td>D</td>
</tr>
<tr>
<td>Ice Class 1C FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice Class 1D</td>
<td>—</td>
<td>D</td>
</tr>
<tr>
<td>Ice Class 1E</td>
<td>—</td>
<td>E</td>
</tr>
</tbody>
</table>

2.3 Application

2.3.1 The variable nature of ice conditions is such that the average limits of the conditions are not easily defined. However, it is possible to plot the probable limits of the ice floes and the ice edge for each season. See Figs. 6.2.1 to 6.2.4 and Table 6.2.3.

2.3.2 Operation with Ice Class 1C FS may be possible up to 150 nm inside the 7/10 region shown depending on the severity of the winter. Operation with Ice Class 1A FS may be possible up to 150 nm inside the medium first-year ice shown depending on the severity of the winter. Operation up to the multi-year ice is possible most years with Ice Class 1AS FS.

2.3.3 Operation in the region between 7/10 and 1/10 in the ice-covered regions is possible with due care for units with no ice class. For units operating for extended periods in these areas, it will be necessary to specify and design for a minimum temperature for the hull materials. To cover all situations for non-ice class units, the material requirements of The Provisional Rules for the Winterisation of Ships are recommended.

2.4 Ice Class notations

2.4.1 Where the requirements of Pt 8, Ch 2 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships) are complied with, the unit will be eligible for a special features notation, see also Table 6.1.1.

2.5 National Authority requirements

2.5.1 Certain areas of operation may require compliance or demonstration of equivalence with National Authority requirements. Table 6.2.2 gives the equivalence of National Authority requirements.

2.5.2 The standards of ice strengthening required by the Rules have been accepted by the Finnish and Swedish Boards of Navigation as being such as to warrant assignment of the Ice Classes given in Table 6.2.2.

2.5.3 Units intending to navigate in the Canadian Arctic must comply with the Canadian Arctic Shipping Pollution Prevention Regulations established by the Consolidated Regulations of Canada, 1978, Chapter 353, in respect of which Lloyd’s Register is authorised to issue Arctic Pollution Prevention Certificates.

2.5.4 The Canadian Arctic areas have been divided into zones relative to the severity of the ice conditions experienced and, in addition to geographic boundaries, each zone has seasonal limits affecting the necessary ice class notation required to permit operations at a particular time of year. It is the responsibility of the Owner to determine which notation is most suitable for their requirements.
2.6 Ice conditions

2.6.1 Charts and images for the current and recent ice conditions in all areas of the world plus information on icebergs can be found from the National Ice Centre on the worldwide web at: www.natice.noaa.gov.

2.6.2 Daily ice information and consultation is available from the Canadian ice service which is part of the Canadian department of the environment. Their website can be found at: www.ice-glaces.ec.gc.ca.
Fig. 6.2.2 Ice Limits for the Arctic Summer
Fig. 6.2.3 Ice Limits for the Antarctic Winter
Table 6.2.3  Concentration of ice

<table>
<thead>
<tr>
<th>Ice Type</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free ice</td>
<td>0/10</td>
</tr>
<tr>
<td>Open water</td>
<td>&lt; 1/10</td>
</tr>
<tr>
<td>Very open drift</td>
<td>1/10</td>
</tr>
<tr>
<td>Open drift</td>
<td>2/10</td>
</tr>
<tr>
<td></td>
<td>3/10</td>
</tr>
<tr>
<td>Close pack/drift</td>
<td>4/10</td>
</tr>
<tr>
<td></td>
<td>5/10</td>
</tr>
<tr>
<td></td>
<td>6/10</td>
</tr>
<tr>
<td>Very close pack</td>
<td>7/10</td>
</tr>
<tr>
<td></td>
<td>8/10</td>
</tr>
<tr>
<td>Compact/consolidated ice</td>
<td>9/10</td>
</tr>
<tr>
<td></td>
<td>9+/10</td>
</tr>
<tr>
<td></td>
<td>10/10</td>
</tr>
</tbody>
</table>
Section 3

Air Environment

3.1 Air temperature

3.1.1 For units intended to operate in cold regions, the temperature on exposed surfaces is to be considered. See The Provisional Rules for the Winterisation of Ships.

3.1.2 The average external design air temperature is to be taken as the lowest mean daily average air temperature in the area of operation:

\[
\text{Mean} = \text{statistical mean over a minimum of 20 years}
\]
\[
\text{Average} = \text{average during one day and one night}
\]
\[
\text{Lowest} = \text{lowest during the year}
\]
\[
\text{MDHT} = \text{Mean Daily High Temperature}
\]
\[
\text{MDAT} = \text{Mean Daily Average Temperature}
\]
\[
\text{MDLT} = \text{Mean Daily Low Temperature}
\]

Fig. 6.3.1 shows the definition graphically.

3.1.3 The lowest external design air temperature is to be taken as the lowest mean daily lowest air temperature in the area of operation. Where reliable environmental records for contemplated operational areas exist, the lowest external design air temperature may be obtained after the exclusion of all recorded values having a probability of occurrence of less than 3 per cent.

3.1.4 Lowest mean daily average air temperatures for the Arctic and Antarctic are provided in Figs. 6.3.2 to 6.3.3.
Temperature limits for Winter

Mean Daily lowest

Fig. 6.3.2  Lowest mean daily average air temperatures for the Arctic
Section 4

Icing Environment

4.1 Ice accretion

4.1.1 For units intended to operate in cold regions, the build-up of ice on exposed surfaces is to be considered. See The Provisional Rules for the Winterisation of Ships.

4.1.2 Icing is to be considered for units operating in the following areas, see Figs. 6.4.1 and 6.4.2.

- All sea areas north of the North American continent west of the areas defined in sub-paragraphs above.
- The Bering and Okhotsk Seas and the Tatar Strait during the icing season.
- South of latitude 60°S.

- The area north of latitude 65°30'N, between longitude 28°W and the west coast of Iceland; north of the north coast of Iceland; north of the rhumb line running from latitude 66°N, longitude 15°W to latitude 73°30'N, longitude 15°E, north of latitude 73°30'N between longitude 15°E and 35°E, and east of longitude 35°E, as well as north of latitude 56°N in the Baltic Sea.

- The area north of latitude 43°N bounded in the west by the North American coast and the east by the rhumb line running from latitude 43°N, longitude 48°W to latitude 63°N, longitude 28°W and thence along longitude 28°W.
Fig. 6.4.1  Ice accretion limits for the Arctic
Section 5
Strengthening standard for navigation in ice – Application of requirements

5.1 Additional strengthening

5.1.1 When disconnectable units are required to navigate in ice and additional strengthening is fitted in accordance with the requirements given in this Chapter, an appropriate special features notation will be assigned. It is the responsibility of the Owners to determine which notation is most suitable for their requirements.

5.1.2 For semi-submersible units with twin lower hulls the ice strengthening, as required by this Chapter, is to be carried out to both hulls. Where the exposed deck of the lower hulls is situated below the upper limit of the ice belt, the strengthening of the deck will be subject to special consideration and the deck thickness is not to be less than the shell plating in the main ice belt.

5.1.3 The extent of reinforcement on units of unconventional form will be specially considered.

5.2 Plans and data submission

5.2.1 Plans, calculations and data are to be submitted as required by the relevant Parts of these Rules together with the additional information required by Part 8 of the Rules for Ships.

Section 6
Strengthening requirements for navigation in ice

6.1 General

6.1.1 The strengthening requirements for navigation in ice are given in Pt 8, Ch 2 of the Rules for Ships which are to be complied with where applicable.
6.1.2 The requirements for strengthening for navigation in ice as given in Pt 8, Ch 2 of the Rules for Ships are intended for ships of conventional designs and arrangements. Units considered outside this applicability will be specially considered by LR and may require additional strengthening and structural analysis for the primary structure by direct calculation, or experimental verification. See also limits to the ship length and hull form contained in the engine power requirement in the Finnish-Swedish Ice Class Rules and icebreaking bow form for the Polar Ship Rules.

6.1.3 The requirements for strengthening for navigation in ice as given in Pt 8, Ch 2 of the Rules for Ships are intended for ships operating in typical ice voyages and harbour operations. The operation of units may require a rational analysis for determining the maximum operating ice pressures on the structure based on acceptable environmental data such as the design ice conditions, e.g., multi-year ice floe size and concentration, or whether assistance from icebreakers is anticipated.

6.1.4 When a unit operates in areas where there is the possibility of collision with icebergs, appropriate data is to be submitted and the structure suitably strengthened for the collision loads.

6.1.5 Special requirements will be required for sea inlet chests for machinery cooling and fire pump suction and reference should be made to the relevant text of Pt 8, Ch 2 of the Rules for Ships. The design and arrangement of sea inlet chests will be specially considered as applicable to the type of unit.

7.1.5 Special requirements will be required for sea inlet chests for machinery cooling and fire pump suction and reference should be made to the relevant text of Pt 8, Ch 2 of the Rules for Ships. The design and arrangement of sea inlet chests will be specially considered as applicable to the type of unit.

7.1.6 When a unit has been reinforced and approved by LR for operating in ice, a suitable descriptive note will be included in the ClassDirect Live website.

### Section 7

#### Operation in ice conditions at a fixed location

7.1 **General requirements**

7.1.1 When a unit is required to operate at a fixed location in ice conditions, the designer/Builder is required to submit a rational analysis for determining the maximum operating ice pressures on the structure based on acceptable environmental data.

7.1.2 The minimum design temperature of the structure and steel grades will be specially considered, see also Pt 4, Ch 2.

7.1.3 The extent of additional strengthening will be specially considered by LR and additional structural calculations for the primary structure will be required.

7.1.4 When a unit operates in areas where there is the possibility of collision with icebergs, appropriate data is to be submitted and the structure suitably strengthened for the collision loads.

8.1 **General requirements**

8.1.1 For units intended to operate in cold regions, the build-up of ice on exposed surfaces is to be considered. See The Provisional Rules for the Winterisation of Ships.

8.1.2 When units are fitted with riser systems the arrangements are to be designed to minimise the effect of ice loadings on the risers.

8.1.3 Suitable steam generating equipment or an equivalent means is to be provided, with outlets and hoses, to keep designated areas free of ice and snow such that operation and inspection/maintenance may be conducted safely. Such equipment is to be capable of being used in at least the following locations:

- The working areas.
- The helicopter deck.
- Walkways and escape routes.
- Lifeboat embarkation station.

8.1.4 In the case of self-elevating units where the design of the elevating machinery is required to operate in ice conditions, suitable de-icing equipment is to be provided.

8.1.5 The starting requirements of the emergency generators for low temperature operation is to be in accordance with Pt 5, Ch 2,8.5 of the Rules for Ships.

8.1.6 Electrical equipment and cables likely to be exposed to sustained low temperatures are to be suitably constructed for the ambient conditions in accordance with a recognised National or International Standard.
Drilling Plant Facility

1.2 Class notations

1.2.1 The Regulations for classification and the assignment of class notations are given in Pt 1, Ch 2, to which reference should be made.

1.2.2 Units fitted with an installed drilling plant facility which complies with the requirements of this Chapter, or recognised Codes and Standards agreed with LR, will be eligible for the assignment of the special features class notation DRILL.

1.2.3 When a unit is to be verified in accordance with the Regulations of a Coastal State Authority an additional descriptive note may be assigned in accordance with Pt 1, Ch 2.

1.3 Scope

1.3.1 The following additional topics applicable to the special features class notation are covered by this Chapter:
- Blow out preventer, hoisting and handling equipment.
- Bulk storage.
- Drilling fluids circulation and cementing equipment.
- Drilling derrick main structure.
- Derrick hoisting, rotation and pipe handling equipment.
- Heave compensation equipment.
- Miscellaneous structures and equipment considered as part of the drilling installation.
- Well protection valve and control systems.
- Well testing equipment.
- Flare structures.
- Water towers.

1.3.2 Unless agreed otherwise with Lloyd’s Register (LR) these Rules consider the following as the main boundaries of the drilling plant facility:
- Any part of the drilling equipment, structures and systems located on the unit, including the outlet from hydrocarbon flare and vent system, but excluding the subsea blow out preventer stack, risers and conductors.

1.4 Plant design characteristics

1.4.1 The design and arrangement of drilling plant, derricks and flare structures, etc., are to comply with the requirements of this Chapter and/or recognised Codes and Standards, see 1.5.

1.4.2 Attention is to be given to the relevant Statutory Regulations of the National Administrations in the area of operation and also the country of registration, as applicable.
1.4.3 The plant and supporting structures above the deck are to be designed for all operating and transit conditions in accordance with recognised and agreed Codes and Standards, suitably modified to take into account the unit’s motions and marine environmental aspects. Except for the emergency condition, as detailed in 1.4.4, the total stress in any component of the plant is not to exceed the Code or Standard value at the temperature concerned, unless expressly agreed otherwise by LR, whether the plant is operative or non-operative, when subjected to any of the following loads, as applicable:

- Static and dynamic loads due to wave-induced unit motions.
- Loads resulting from hull flexural effects at the plant support points, as appropriate.
- Direct wind loads.
- Normal gravity and functional loads.
- Thermal loads, as appropriate.
- Ice and snow loads, as appropriate.

1.4.4 In general, the plant and supporting structures above the deck are to be designed for an emergency static condition with the unit inclined to the following angle:

- Column-stabilised and tension leg units: 25° in any direction.
- Ship units: 22.5° heel, port and starboard, and trimmed to an angle of 10° beyond the maximum normal operating trim.
- Self-elevating units: 17° in any direction in transit conditions only.

These angles may be modified by LR in particular cases as considered necessary. The emergency static condition for other types of units will be specially considered. In no case is the inclined angle for the emergency static condition to be taken less than the maximum calculated angle in the worst damage condition in accordance with the appropriate damage stability criteria.

1.4.5 In the emergency condition defined in 1.4.4, the plant is to be assumed to have maximum operating weights, temperatures and pressures, unless agreed otherwise with LR. When applicable, the plant is also to be subjected to ice and snow loads. Wind loads need not be considered to be acting during this emergency condition. The total stress in any component of the plant or support structure above the deck is not to exceed the minimum yield stress of the material.

1.4.6 The permissible stresses in the primary hull structure below plant and equipment supports in transit, operating and emergency conditions are to be in accordance with Pt 4, Ch 6.

1.5 Recognised Codes and Standards

1.5.1 Installed drilling plant facility designed and constructed to standards other than the Rule requirements will be considered for classification subject to the alternative standards being agreed by LR to give an equivalent level of safety to the Rule requirements. It is essential that in such cases LR is informed of the Owner’s proposals at an early stage in order that a basis for acceptance of the standards may be agreed. Refer to Appendix A for applicable international Codes and Standards considered by LR as an equivalent level of safety to Rule requirements.

1.5.2 In general, the requirements in this Chapter are based on internationally recognised Codes and Standards for the drilling plant, structures and drilling related systems and equipment as defined in Appendix A. Other Codes and National Standards may be used after special consideration and prior agreement with LR. When considered necessary, additional Rule requirements are also stated in this Chapter.

1.5.3 Where necessary, the Codes and Standards are to be suitably modified and/or adapted to take into account all marine environmental aspects.

1.5.4 The agreed Codes and Standards may be used for design, construction and installation but where considered applicable by LR, compliance with the additional requirements stated in the Rules is required. Where there is any conflict the Rules will take precedence over the Codes or Standards.

1.5.5 The mixing of Codes or Standards for each equipment item or system is to be avoided. Deviation from the Code or Standard must be specially noted in the documentation and approved by LR.

1.6 Equipment categories

1.6.1 The approval and certification of drilling equipment is to be based on equipment categories agreed with LR.

1.6.2 Drilling equipment including their associated pipes and valves are to be divided into equipment Categories 1A, 1B and II depending on their complexity of manufacture and their importance with regard to the safety of personnel and the installation and their possible effect on the environment.

1.6.3 The following equipment categories are used in the Rules:

- **1A** Equipment of primary importance to safety, for which design verification and survey during fabrication are considered essential. Equipment in this category is of complicated design/manufacture and is not normally mass produced.

- **1B** Equipment of primary importance to safety, for which design verification and witnessing the product quality are considered essential. Equipment in this category is normally mass produced and not included in Category 1A.

- **II** Equipment related to safety, which is normally manufactured to recognised Codes and Standards and has proven reliability in service but excluding equipment in Category 1A and 1B.
1.6.4 A guide to equipment and categories is given in Appendix A. A full list of equipment categories for the drilling plant facility is to be agreed with LR before manufacture. Minor equipment components need not be categorised.

1.7 Equipment certification

1.7.1 Drilling equipment is to be certified in accordance with the following requirements:

(a) **Category 1A:**
- Design verification and issue of certificate of design strength approval.
- Pre-inspection meeting at the suppliers with agreement and marking of quality plan and inspection schedule.
- Survey during fabrication and review of fabrication documentation.
- Final inspection with monitoring of function/pressure/load tests and issue of a certificate of conformity.

(b) **Category 1B:**
- Design verification and issue of certificate of design strength approval, where applicable, and review of fabrication documentation.
- Final inspection with monitoring of function/pressure/load tests and issue of certificate of conformity.

(c) **Category II:**
- Supplier’s/manufacturer’s works certificate giving equipment data, limitations with regard to the use of the equipment and the supplier’s/manufacturer’s declaration that the equipment is designed and fabricated in accordance with recognised Standards or Codes.

1.7.2 All equipment recognised as being of importance for the safety of personnel and the drilling plant facility is to be documented by a data book.

1.8 Fabrication records

1.8.1 Fabrication records are to be made available for Categories 1A and 1B equipment for inspection and acceptance by LR Surveyors. These records are to include the following:
- Manufacturer’s statement of compliance.
- Reference to design specification and plans.
- Traceability of materials.
- Welding procedure tests and welders’ qualifications.
- Heat treatment records.
- Records/details of non-destructive examinations.
- Load, pressure and functional test reports.

1.9 Installation of drilling plant equipment

1.9.1 The installation of drilling equipment on board the unit is to be controlled by LR in accordance with the following principles:
- All Category 1A and 1B equipment, delivered to the unit, is to be accompanied by a certificate of design strength approval and an equipment certificate of conformity and all other necessary documentation.
- All Category II equipment, delivered to the unit, is to be accompanied by equipment data and a works’ certificate.
- Control and follow-up of non-conformities/deviations specified in design certificates and certificate of conformity.
- Ongoing survey and final inspection of the installed production and process plant.
- Monitoring of functional tests after installation on board in accordance with an approved test programme.
- Issue of a plant installation report.

1.10 Maintenance and repair

1.10.1 It is the Owner’s/Operator’s responsibility to ensure that installed drilling plant is maintained in a safe and efficient working condition in accordance with the manufacturer’s specifications.

1.10.2 When it is necessary to repair or replace installed drilling plant, any repaired or spare part is to be subject to the equivalent certification as the original part.

1.11 Plans and data submissions

1.11.1 Plans, calculations and data are to be submitted as required by the relevant Parts of the Rules, together with the additional plans and information listed in this Chapter.

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**Section 2**

**Structure**

2.1 Plans and data submissions

2.1.1 The following additional plans and information are to be submitted:
- General arrangement plans of the drilling plant.
- Drilling derrick primary structural plans and design calculations.
- Raw water towers structural plans and design calculations.
- Flare structures structural plans and design calculations.
- Structural plans of equipment skids, support stools and design calculations.
- Structural plans of supports to lifting appliances.
2.2 Materials

2.2.1 Materials are to comply with Ch 1,4 and material grades are to comply with Pt 4, Ch 2 using the Categories defined in this Section.

2.2.2 Support structures for the drilling plant are to be divided into the following categories:
- Primary structure.
- Secondary structure.

2.2.3 Some specific examples of structural elements which are considered as primary structure are as follows:
- Derrick legs and base plates.
- Derrick principle cross-bracing.
- Derrick crown block/water table supports.
- Derrick bolts.
- Support stools (attached to the main/upper deck).
- Main legs, chords and end connections.
- Foundation bolts.

2.3 Miscellaneous structures

2.3.1 The design loadings for all structures supporting plant including equipment skids and support stools are to be defined by the designers/Builders and calculations are to be submitted in accordance with an appropriate Code or Standard, see Appendix A.

2.3.2 The design of drilling facilities support structure should integrate with the primary hull underdeck structure.

2.3.3 The permissible stresses in the hull structure below the drilling plant are to be in accordance with Pt 4, Ch 6 and the local strength is to comply with Pt 4, Ch 7.

2.4 Drilling derrick

2.4.1 The structural design of drilling derricks is to be in accordance with a recognised Code of Practice, such as the American Petroleum Institute, see Appendix A. The design conditions defined in 1.4 are to be complied with.

2.4.2 When the unit is to operate in an area which could result in the build-up of ice on the drilling derrick, the effects of ice loading is to be included in the calculations, see Pt 4, Ch 3. The design criteria for this condition may be taken as a non-drilling condition with defined setback loading. The environmental criteria are to be agreed with LR, but in general, may be based on five-year return criteria for the operating location.

2.4.3 The structural design of the drilling derrick is to include the effect of fatigue loading, see Pt 4, Ch 6.

2.4.4 Fatigue damage calculations for individual components are to take account of the degree of redundancy and also the consequence of failure.

2.4.5 Where National Administrations give specific requirements with respect to fatigue design, it is the responsibility of the Owners to comply with such Regulations.

2.5 Water towers

2.5.1 Water towers on self-elevating units are to be designed in accordance with a recognised Code or Standard, modified to take into account the unit's motions and marine environmental aspects, see Appendix A. The design conditions defined in 1.4 are to be complied with.

2.5.2 The structural design of the tower is to include the effect of fatigue loading, see Pt 4, Ch 6.

2.5.3 Where National Administrations give specific requirements with respect to fatigue design, it is the responsibility of the Owners to comply with such Regulations.

2.5.4 For slender structures and components, the effects of wind induced cross-flow vortex vibrations are to be assessed.

2.5.5 Wind loads are to be calculated in accordance with the LAME Code, or a recognised Code or Standard, see Appendix A.

2.5.6 The permissible stresses in the hull structure below the tower are to be in accordance with Pt 4, Ch 6.

2.6 Flare structures

2.6.1 Flare structures are to be designed for an emergency condition and for normal operating conditions as defined in 1.4 and in accordance with an appropriate Code or Standard, see Appendix A.

2.6.2 The flare structures are also to be designed for the imposed loads due to handling the structure and when in the stowed position.

2.6.3 The designers/Builders are to specify the maximum weight of the burner and spreader and the design criteria defined in 1.4.

2.6.4 The structural design of flare structures is to include the effect of fatigue loading and the thermal loads during flaring, see Pt 4, Ch 6.

2.6.5 Where National Administrations give specific requirements with respect to fatigue design, it is the responsibility of the Owners to comply with such Regulations.

2.6.6 For slender structures and components, the effects of wind induced cross-flow vortex vibrations are to be assessed.

2.6.7 Wind loads are to be calculated in accordance with LR's Code for Lifting Appliances in a Marine Environment (LAME), or a recognised Code or Standard, see Appendix A.

2.6.8 Permissible stresses in the hull structure below the flare structure supports are to be in accordance with Pt 4, Ch 6.
2.7 Lifting appliances

2.7.1 Lifting appliances including those used for handling flare structures and blow out preventers, etc., are to comply with LR's LAME Code, see also Chapter 11.

2.8 Guard rails and ladders

2.8.1 It is the Owners’ responsibility to provide permanent access arrangements and protection by means of ladders and guard rails. It is recommended that such arrangements are designed in accordance with a recognised Code or Standard.

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## Section 3

### Drilling plant systems

3.1 Plans and particulars

3.1.1 Plans and particulars showing arrangement of drilling and wellhead mechanical equipment listed in 1.3, and diagrammatic plans of the associated piping systems, are to be submitted for approval.

3.2 General requirements for piping systems

3.2.1 The design and construction of the piping systems, piping and fittings forming parts of such systems are to be in accordance with an acceptable Code or Standard, see 1.5, and also to comply with the remainder of this Section.

3.2.2 Piping systems for the drilling and well-testing installations are, in general, to be separate and distinct from piping systems essential to the safety of the unit. Notwithstanding this requirement, this does not exclude the use of the installations main, auxiliary and/or essential services for drilling plant operations in suitable cases. Attention is drawn to the relevant Chapters of Part 5, Main and Auxiliary Machinery, when such services are to be utilised. Substances which are known to present a hazard due to a reaction when mixed are to be kept entirely separate.

3.2.3 Piping for services essential to the drilling operations, and piping containing hydrocarbon or other hazardous fluids is to be of steel or other approved metallic construction. Piping material for hydrogen sulphide-contaminated products (sour service) is to comply with ISO 15156: Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production, see Appendix A.

3.2.4 All piping systems are to be suitable for the service intended and for the maximum pressures and temperatures to which they are likely to be subjected.

3.2.5 In mud, cement or other systems, where the piping is likely to be subjected to considerable erosion, a suitable erosion allowance is to be specified to take the anticipated service conditions into account.

3.2.6 The number of detachable pipe connections in the drilling piping systems is to be limited to those which are essential for mounting and dismantling. Non-critical auxiliary systems such as water and air service may be attached with approved detachable couplings.

3.2.7 Valves used for the shutting down and control of equipment in an emergency, such as choke manifolds and standpipe manifolds, are to be provided with indicators to clearly show whether they are open or closed.

3.3 Flexible piping

3.3.1 Flexible piping elements approved for their intended use may be installed in locations where rigid piping is unsuitable or impracticable. Such flexible elements are to be accessible for inspection and replacement, and are to be secured and protected so that personnel will not be injured in the event of failure.

3.3.2 All flexible hoses used during drilling operations are to be manufactured to a recognised Code or Standard and a prototype hose with end fittings attached is to have been burst-tested to the minimum pressure stipulated by the appropriate Standard. Transfer, mud, hydraulic and pneumatic hoses which may be liable to heavy external wear are to be specially protected. Protection against mechanical damage and from crushing/compression is to be provided where necessary.

3.3.3 Means are to be provided to isolate flexible hoses, if used in systems where uncontrolled outflow would be critical.

3.3.4 Kill, choke and jumper hoses are to be capable of maintaining their design pressure for a minimum period of 30 minutes whilst being subjected to a minimum external temperature of 700°C.

3.3.5 Hydraulic control hoses serving well completion units and blow out preventers are to be capable of maintaining their design pressure for a period of time sufficient for the necessary operation of the blow out preventers, and in any case for a minimum period of five minutes, whilst being subjected to a minimum external temperature of 700°C.

3.3.6 Hydraulic control hoses serving well completion units which are fitted with valves of the fail-safe, spring-return type, and which utilise non-flammable hydraulic fluid, need not be of the fire-tested type, but must otherwise be suitable for the intended purpose.

3.4 General requirements for mechanical systems

3.4.1 Where drilling and related operations are carried out below the conductor casing a blow out preventer and a diverter system are to be installed.

3.4.2 Materials used in castings, forgings and fabricated components for wellhead equipment such as blow out preventers, wellhead completion units, pipes and headers subject to full well pressure are to have suitable Charpy V-notch impact properties.
3.4.3 As a minimum, unless specified by the applicable design specification, Charpy impact tests are required to be carried out at the minimum design temperature (MDT) and exhibit minimum impact energies as follows:
- **Mechanical components.** 34J for minimum specified yield strengths up to 360 MPa and 40J for higher yield strengths.
- **Piping and pressure-containing components.** 27J for yield strengths up to 360 MPa and 42J for higher yield strengths.

See also Pt 4, Ch 8, Pt 5, Ch 12 and Ch 17, and Chapter 13 of the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).

3.4.4 Where any component is likely to be exposed to H₂S-contaminated products, materials and welds shall meet the requirements of NACE MR0175/ISO 15156 – Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production.

### 3.5 Blow out preventer stack

3.5.1 The blow out preventer (BOP) stack is normally to consist of at least the following components:
- One annular preventer.
- One blind/shear ram preventer with a mechanical locking device in closed position.
- Two pipe ram preventers with a mechanical locking device in closed position.
- The necessary control equipment.

3.5.2 The BOP stack is to be designed so that fluid and gas can be conducted out of the system and that fluid can be pumped in.

3.5.3 Two remotely controlled valves are to be installed close to the BOP stack for each of the kill and choke lines. The valves are to be located so that they are protected from mechanical damage.

3.5.4 All valves associated with the BOP equipment are to be clearly labelled to indicate their specific function.

3.5.5 The hydraulic accumulators for the BOP rams and annulus are to have sufficient capacity for at least two closing actions and one resetting action. Closing times are, in general, to be less than 30 seconds. For annular preventers less than 500 mm diameter, the closing time is to be less than 45 seconds.

3.5.6 The hydraulic pumps are to have sufficient capacity to enable the annular preventer and the hydraulically operated choke line valve to be closed within two minutes without resorting to the hydraulic accumulators.

3.5.7 The hydraulic pumps are to be capable of providing a hydraulic gauge pressure of 14 bar above the normal charge pressure of the accumulators within two minutes.

3.5.8 Two independent sources of power are to be provided to drive the hydraulic pumps.

### 3.6 Diverter

3.6.1 Normally, two diverter lines are to be provided, each sized to take the predicted flow. The lines should be of straight steel pipe and should be led safely clear of the unit, preferably on opposite sides. Where bends cannot be avoided, the lines are to be firmly anchored. The design of such bends will be subject to special consideration and should take into account the likelihood of erosion during operation.

3.6.2 All valves in the diverter lines are to be of the full-opening type and should open automatically when the diverter is closed. Such valves should be capable of operating under the worst predictable conditions.

### 3.7 Choke manifold

3.7.1 The choke manifold is to be equipped with the following:
- (a) At least three chokes, one of which is to allow for remote control and one for manual adjustment. It is to be possible to isolate and change each choke while the manifold is in use.
- (b) One valve for each inlet and outlet line, so that lines to and from the manifold can be isolated. Where high pressure or low pressure lines meet the manifold system, two valves in series are to be installed. Manifolds for pressures of 345 bar or higher are to be equipped with a minimum of two valves before each of the chokes. The working pressure of the valves is to refer to the maximum working pressure of the choke manifold.

3.7.2 The high pressure side of the choke manifold, including all lines and hoses between the choke manifold and the BOP stack, is to have at least the same working pressure as the rated working pressure of the blow out preventer stack. All piping and connections to be used during a well-killing operation are to be pressure tested to above the calculated well kill pressure.

3.7.3 It is to be possible to pump mud through the choke and kill manifold up to the rated pressure of the blow out preventer stack.

3.7.4 Arrangements should be such that it will be possible to lead the returns from the choke manifold through a mud-gas separator.

3.7.5 The choke and kill manifold and lines are to be arranged so that pumping through one line can be carried out whilst simultaneously flowing back through the choke valves.

### 3.8 Drill string

3.8.1 An upper kelly cock is to be installed below the swivel and a lower kelly cock at the bottom of the kelly. The lower kelly cock is to be designed so that it can be run through the BOP stack.
3.8.2 An open/close drill string safety valve is to be located in an open position on the drillfloor ready for immediate use. The valve is to be of correct size and thread configuration to fit the pipe in use and be capable of withstanding the same well surface pressures as the installed BOPs.

3.9 Well testing and flare system

3.9.1 Steam return from heaters in well testing equipment is to be led via an observation tank on deck.

3.9.2 In by-passes of pressure reducing devices such as chokes, two valves in series are to be fitted.

3.9.3 Heat exchangers are to be fitted with safety valves.

3.9.4 The swivel and kelly hose are not to form part of the test line.

3.9.5 For requirements relating to flare systems, see Ch 8,3.6.

3.10 Bulk storage and drilling fluid system

3.10.1 Pressure vessels are to comply with the design requirements in Ch 8,4.

3.10.2 All bulk storage vessels are to be equipped with safety valves or bursting discs to prevent damage due to overpressure. Bursting discs may only be used for vessels located in open areas or, if fitted in conjunction with a relief line, the discharge must be led to an open area.

3.10.3 For bulk storage vessels in enclosed areas, testable safety valves which can be vented out of the area are to be used. The enclosed areas where bulk storage vessels are located are to be ventilated such that a build-up of pressure will not occur in the event of a break or leak in the air supply system.

3.10.4 Degasser and mud-gas separators are to be vented to a safe location. High pressure mud pumps are to be fitted with pulsation dampers and relief valves set at the maximum allowable pressure of the system. The mud relief line from the safety valve is to be self-draining.

3.10.5 Cementing units and associated high pressure pipes and manifolds are to be suitably designed and tested.

3.10.6 Bulk storage vessels which penetrate watertight decks or flats are to be suitably reinforced, see Ch 3,2.10.

Section 4

Pressure vessels and bulk storage

4.1 General

4.1.1 The requirements for fired and unfired pressure vessels associated with the drilling plant and bulk storage vessels are to comply with the general requirements of Ch 8,4.

4.1.2 Bulk storage and drilling fluid systems are to comply with Section 3.

Section 5

Rotary drilling equipment

5.1 General

5.1.1 The requirements of this Section are applicable to the following equipment:
- Top drive system.
- Drill string.
- Rotary table.
- Wire (dead-line) anchor.

5.1.2 Drilling equipment is to be designed in accordance with internationally recognised and agreed Codes and Standards and in accordance with the requirements of Section 1.

5.1.3 The list in Appendix A, A1.2 gives reference to some generally recognised Codes and Standards frequently specified for drilling equipment. These Codes and Standards may be used for certification, but the additional requirements given in these Rules apply and will take precedence over the Codes and Standards wherever conflict occurs.

5.1.4 Drilling equipment and systems are to be suitable for the service intended and for the maximum loads, pressures, temperatures and environmental conditions to which the system may be subjected.

5.2 Plans and data submissions

5.2.1 Design documentation for mechanical equipment is to be submitted in accordance with the equipment categories and certification requirements defined in Section 1.

5.2.2 The submitted information should include the following, as applicable, to the equipment categories:
- Design specification, including data of working medium and pressures.
- Minimum/maximum temperatures, corrosion allowance, environmental and external loads.
- Plans, including sufficient detail and dimensions to evaluate the design.
- Strength calculations as applicable.
- Material specifications and welding details.
5.2.3 Plans and calculations submitted in respect of the top drive system should include all torque transmitting components, gearing, shafting, clutch and brake components.

5.3 Equipment certification

5.3.1 Equipment categories and certification of drilling equipment are to be in accordance with the requirements of Section 1.

5.3.2 A general guide to specific equipment categories is given in Table A2.1 in Appendix A.

5.3.3 Hoisting and pipe handling equipment are to comply with Section 6.

5.3.4 Associated equipment such as oil engines, electric motors, generators, turbines, etc., are to comply with the applicable Sections of the Rules.

5.4 Materials

5.4.1 Materials are to comply with Ch 1,4 except where modified by this Section.

5.4.2 The selected materials are to be suitable for the purpose intended and must have adequate properties of strength and ductility. Materials used in welded construction are to be of known and documented weldable quality.

5.4.3 Materials for structural and mechanical components are to have minimum Charpy V-Notch energy values of 34 J at the minimum design temperature.

5.4.4 For selection of acceptable materials suitable for hydrogen sulphide-contaminated products (sour service), reference is made to ISO 15156: Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production, see Appendix A.

5.4.5 Grey iron castings are not to be used for critical components.

5.4.6 Proposals to use spheroidal graphite iron castings for critical components operating below 0°C will be specially considered by LR in each case.

5.4.7 In general, bolts and nuts are to comply with the standards listed in Appendix A, A1.2.

5.4.8 Bolts and nuts for major structural and mechanical components are to have a tensile strength of not less than 600 N/mm².

5.4.9 For general service, the specified tensile strength of bolting material should not exceed 1000 N/mm².

5.4.10 Where required, materials of high heat resistance are to be used and the ratings are to be verified.

5.5 Design and construction

5.5.1 The design strength of drilling equipment is to comply generally with Part 5, as applicable, and with LR agreed Codes and Standards.

5.5.2 Drilling equipment and systems are to be protected from excessive loads and pressures.

5.5.3 All drilling equipment is to be located such as to ensure safe operation, and must be suitably protected if for location in a hazardous area. Protection is to limit surface temperature to a maximum of 80 per cent of auto-ignition temperature. This temperature, if unknown, may be taken to be a maximum of 200°C.

5.5.4 The equipment is to be suitable for the design environmental conditions for the unit and the submitted design data for drilling equipment is to include all loading conditions, for each item, including the most unfavourable combination of loads, and any external loading conditions.

6.1 General

6.1.1 The requirements of this section are applicable to the following equipment:
- Drawworks.
- Air and hydraulic winches (utility or man-riding).
- Pipe handling equipment.

6.1.2 Hoisting and pipe handling equipment are to be designed in accordance with internationally recognised and agreed Codes and Standards and in accordance with the requirements of Section 1.

6.1.3 The list in Appendix A, A.1.2 gives reference to some generally recognised Codes and Standards frequently specified for hoisting and pipe handling equipment. These Codes and Standards may be used for certification, but the additional requirements given in these Rules apply and will take precedence over the Codes and Standards wherever conflict occurs.

6.1.4 Hoisting and pipe handling equipment is to be suitable for the service intended and for the maximum loads, pressures, temperatures and environmental conditions to which the system may be subjected.

6.1.5 Hoisting appliances are to be fitted with a permanent nameplate, clearly indicating the safe working load (SWL), hoisting/lowering speeds, test loads and also the wire rope size and grade.
6.1.6 Individual components such as blocks, sheaves, hooks, shackles, wire slings and the like are to be permanently marked with their safe working load (SWL). The maximum SWL of an interdependent equipment system is to be based on the weakest component of the system.

6.1.7 Wire clamps are to be of an approved number and type. The number of clamps are to be not less than three.

6.1.8 Wire ropes are to comply with a suitable Code or Standard, or with the requirements of LR's LAME Code.

6.1.9 Suitable means are to be provided to secure all drill pipes and collars, etc., when stowed in the drilling derrick area.

6.1.10 Pipe storage racks are to be in accordance with Ch 2,2.7 and means are to be provided to restrain pipes and other loose drilling equipment from being accidentally released from storage racks during any operating condition.

6.1.11 Lifting tongs are to be securely attached to the derrick, or an equivalent support structure, and anchored by a wire rope or rigid support having a minimum breaking strength greater than the strength of the pulling cable.

6.1.12 Hydraulic actuators are to be of an approved type and construction.

6.1.13 Cranes used for pipe handling are to comply with LR's LAME Code, see also Chapter 11.

6.2 Plans and data submission

6.2.1 Design documentation for mechanical equipment is to be submitted in accordance with the equipment categories and certification requirements defined in Section 1.

6.2.2 The submitted information should include the following, as applicable, to the equipment categories:

- Design specification, including data of working medium and pressures.
- Minimum/maximum temperatures, corrosion allowance, environmental and external loads.
- Plans, including sufficient detail and dimensions to evaluate the design.
- Strength calculations as applicable.
- Material specifications and welding.

6.2.3 Plans and calculations submitted in respect of hoisting equipment should include all torque transmitting components such as rope drum, gearing, shafting, brake components and base frame.

6.3 Equipment certification

6.3.1 Equipment categories and certification of hoisting and pipe handling equipment are to be in accordance with the requirements of Section 1.

6.3.2 A general guide to specific equipment categories are given in Table A2.1 in Appendix A.

6.3.3 Associated equipment such as oil engines, electric motors, generators, turbines, etc., are to comply with the applicable Sections of the Rules.

6.4 Materials

6.4.1 Materials including bolts are to comply with 5.4.

6.5 Drawworks

6.5.1 Drawworks which rely on an auxiliary brake (retarder) to supplement the mechanical friction brake for safe operation of the hoisting system are to comply with the following requirements:

(a) The mechanical coupling or clutch between the auxiliary brake and the drawworks drum is to be provided with a system to ensure against inadvertent disengagement of the auxiliary brake.

(b) Hydrodynamic braking retarders are to be fitted with equipment to monitor adequately fluid temperature and fluid level or fluid flow, as appropriate, within the hydrodynamic braking retarder system.

(c) For hoisting systems employing electromagnetic brakes, the cooling water supply for the brake oil is to be adequately monitored as to flow and temperature.

(d) Where electromagnetic braking systems are used which can fail to danger, an emergency stop system is to be provided. Such a system is to monitor the electromagnetic braking system to detect potentially dangerous faults within the system or alternatively monitor the kinetic energy of the travelling block and hook-load to determine if the limiting energy is exceeded. Whichever monitor system is employed, it is to bring into operation an emergency stop system if the above conditions are encountered.

(e) The emergency stop system is to be automatically activated and be capable of applying full braking torque, with a minimum time delay by either:

- the application of the drawwork’s mechanical friction brake by pneumatic, hydraulic or other means; or
- the connection of an adequate electrical supply directly to the electromagnetic brake coils. The security of this supply is to be of high integrity.

(f) The emergency stop system is to be capable of providing one stop under full load conditions and be capable of lowering the load over the full height of the drawwork’s lift. For this requirement the mechanical brake may be employed.

(g) The design of an emergency stop system should reflect the requirement for a low probability of failure under normal or emergency use.

(h) Monitor systems of the type provided under (d) are to:

- monitor the current being delivered to the brake coil;
- utilise a ‘proportional’ or a ‘threshold’ system; and
- incorporate an earth leakage monitor on the brake coil circuit.

Note that the following definitions of a proportional and threshold system apply:
10

**RULES AND REGULATIONS FOR THE CLASSIFICATION OF A FLOATING OFFSHORE INSTALLATION AT A FIXED LOCATION, June 2013**

**Drilling Plant Facility Part 3, Chapter 7**

Sections 6 & 7

- A ‘threshold system’ is defined as a system in which a comparison is made between the brake coil current and a preset threshold value which does not vary once it is set and is independent of the driller’s control lever when moved from the off position.
- A ‘proportional system’ is defined as a system which compares the brake coil current of a variable threshold value which is proportional to the position of the driller’s control lever when moved from the off position.

(j) Audible and visual alarms are to be provided at the driller’s control position to indicate when limiting parameters of the auxiliary brake have been reached or the emergency stop system has been brought into operation, as appropriate.

6.6 Casing stabbing boards

6.6.1 Casing stabbing boards are to comply with the following requirements:

(a) The platform is to be equipped with a latch lock mechanism which secures it when not in motion.
(b) Adequate safety gear of the progressive type is to be provided, designed to engage within freefall conditions.
(c) It should not be possible to lower the platform by brake alone. Therefore, two locking devices are to be provided, such that one locking device operates when the lifting handle is at neutral and the other one operates if the hoist mechanism fails. Each device is to be independent.
(d) A speed controlling device is to prevent the raising and lowering speed of the platform exceeding tripping speed.
(e) A rack and pinion system is to be designed such that a single or common mode failure cannot occur.
(f) All equipment associated with the lifting or lowering is to be secured to the derrick structure.

6.7 Winches

6.7.1 Man-riding winches are to comply with the following requirements:

(a) Two fail-safe brakes are to be provided, one automatic and the other manual.
(b) Hydraulic winches may be provided with a regenerative brake system with breaking valve, in place of a secondary manual brake.
(c) The operating lever is to be returned to neutral upon release in any position.
(d) Declutching devices are not to be fitted, unless otherwise agreed by LR, see (e).
(e) ‘Sprag’ type unidirectional bearings (freewheels) are acceptable subject to regular satisfactory in-service inspection.
(f) Lowering under normal operating conditions is to be through control of the motor.
(g) Means for prevention of overriding and underriding of the winch is to be provided, where reasonably practicable.

6.7.2 Winches for use with casing stabbing boards should have one automatic/manual fail safe brake.

6.7.3 The ratio of winch drum diameter to rope diameter should be at least 20.

6.7.4 A minimum of three turns of rope is to remain on the winch drum after maximum payout of the load.

6.7.5 The external diameter of rope drum flanges is to be such that the equivalent projection of at least two rope diameters is available above the top rope layer.

6.8 Design and construction

6.8.1 The design strength of hoisting appliances is to comply with the general requirements of Part 5, as applicable, and with LR’s agreed Codes and Standards.

6.8.2 Drawworks are to comply with the requirements of 6.5.

6.8.3 Casing stabbing boards are to comply with the requirements of 6.6.

6.8.4 Hoisting appliances are to be protected from excessive loads.

6.8.5 Hoisting appliances are to be located such as to ensure safe operation, and must be suitably protected if for location in a hazardous area. Protection is to limit surface temperature to a maximum of 80 per cent of auto-ignition temperature. This temperature, if unknown, may be taken to be a maximum of 200°C.

6.8.6 Submitted design data for hoisting appliances is to include all load and hoisting/lowering speed combinations at the rope drum.

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**Section 7**

**Electrical installations**

7.1 General

7.1.1 In general, electrical installations are to comply with the requirements of Pt 6, Ch 2. On installations handling liquefied gas, the requirements of Pt 11, Ch 10 are also to be adhered to.

7.1.2 Electrical equipment installed in areas where an explosive gas atmosphere may be present is to be in accordance with Pt 7, Ch 2. On installations handling liquefied gas, the requirements of Pt 11, Ch 10 are also to be adhered to.
Section 8

Control systems

8.1 General

8.1.1 In general, control engineering systems are to comply with the requirements of Pt 6, Ch 1 and/or with the appropriate Codes or Standards defined in Appendix A, as applicable.

8.1.2 The control aspects of the BOP stack are to be in accordance with the requirements of 3.5.

8.1.3 Emergency shut-down systems and other safety and communication systems are to comply with the requirements of Pt 7, Ch 1.

Section 9

Fire, hazardous areas and ventilation

9.1 General

9.1.1 Hazardous areas and ventilation are to comply with Ch 3,3 and Pt 7, Ch 2.

9.1.2 The general requirements for fire safety are to comply with Pt 7, Ch 3.
Process Plant Facility

Section 1, Chapter 8

1. General

1.1 Application

1.1.1 The requirements of this Chapter apply to the process plant facility on board production and oil storage units as defined in Chapter 3. The process plant facility includes the equipment and supporting structure and systems used for oil and gas production including separation, treating and processing systems and equipment and systems used in support of production operations. The requirements of this Chapter are considered to be supplementary to the requirements in the relevant Parts of the Rules.

1.1.2 The Rules cover the design strength and safety aspects of the process plant facility installed on board production and oil storage units.

1.1.3 The operational aspects and reliability of the production and process plant facility are not covered by class except when they have an effect on the overall safety of the production unit, the personnel on board or the environment.

1.1.4 The Rules are framed on the understanding that a unit with an installed production and process plant facility will not be operated in environmental conditions more severe than those for the design basis and class approval.

1.1.5 It is the responsibility of the Owners/Operators to ensure that the production and process plant facility is properly maintained and operated by qualified personnel and that the test and operational procedures are clearly defined and complied with.

1.1.6 The limiting design criteria on which approval is based are to be stated in the unit’s Operations Manual.

1.2 Class notations

1.2.1 The Regulations for classification and the assignment of class notations are given in Pt 1, Ch 2, to which reference should be made.

1.2.2 Production units with an installed process plant facility which comply with the requirements of this Chapter, or recognised Codes and Standards agreed with Lloyd’s Register (hereinafter referred to as ‘LR’), will be eligible for the assignment of the special features class notation PPF.

1.2.3 When a production unit is to be verified in accordance with the Regulations of a Coastal State Authority an additional descriptive note may be assigned in accordance with Pt 1, Ch 2.

1.3 Scope

1.3.1 The following additional topics applicable to the special features class notation are covered by this Chapter:

- Major equipment and structures of the production and process plant.
- Oil or gas processing system, including flowlines from the riser termination flanges, manifolds, production swivels, separators, heaters and coolers, relief and blowdown systems and water treatment systems.
- Production plant safety systems.
- Production plant utility systems.
- Riser compensating and tensioning system.
- Relief and flare system.
- Well control system.

1.3.2 Unless agreed otherwise with LR, the Rules consider the following as the main boundaries of the production and process plant facility:

- Any part of the production and process system located on the unit including the riser connector valves or christmas tree but excluding the risers is considered part of the facility.
- The shut-down valve at the export outlet from the production or process plant to the storage or offloading facility.
- The outlet from hydrocarbon flare and vent system.

1.4 Plant design characteristics

1.4.1 The design and arrangements of the process plant are to comply with the requirements of this Chapter and/or recognised Codes and Standards, see 1.5.

1.4.2 Attention is to be given to the relevant Statutory Regulations of the National Administrations in the area of operation and also the country of registration, as applicable.
1.4.3 The plant and supporting structures above the deck are to be designed for all operating and transit conditions in accordance with recognised and agreed Codes and Standards, suitably modified to take into account the unit’s motions and marine environmental aspects. Except for the emergency condition, as detailed in 1.4.4, the total stress in any component of the plant is not to exceed the Code or Standard value at the temperature concerned, unless expressly agreed otherwise by LR, whether the plant is operative or non-operative, when subjected to any of the following loads, as applicable:

(a) Static and dynamic loads due to wave-induced unit motions.
(b) Loads resulting from hull flexural effects at the plant support points, as appropriate.
(c) Direct wind loads.
(d) Normal gravity and functional loads.
(e) Thermal loads, as appropriate.
(f) Ice and snow loads, as appropriate.

1.4.4 In general, the plant and supporting structures above the deck are to be designed for an emergency static condition with the unit inclined to the following angle:

- Column-stabilised and tension leg units: 25° in any direction.
- Ship units: 22.5° heel, port and starboard, and trimmed to an angle of 10° beyond the maximum normal operating trim.
- Self-elevating units: 17° in any direction in transit conditions only.

These angles may be modified by LR in particular cases as considered necessary. The emergency static condition for other types of units will be specially considered. In no case is the inclined angle for the emergency static condition to be taken less than the maximum calculated angle in the worst damage condition in accordance with the appropriate damage stability criteria.

1.4.5 In the emergency condition defined in 1.4.4, the plant is to be assumed to have maximum operating weights, temperatures and pressures, unless agreed otherwise with LR. When applicable, the plant is also to be subjected to ice and snow loads. Wind loads need not be considered to be acting during this emergency condition. The total stress in any component of the plant or support structure above the deck is not to exceed the minimum yield stress of the material.

1.4.6 The permissible stresses in the primary hull structure below plant and equipment supports are to be in accordance with Pt 4, Ch 6.

1.5 Recognised Codes and Standards

1.5.1 Installed process plant facility designed and constructed to standards other than the Rule requirements will be considered for classification subject to the alternative standards being agreed by LR to give an equivalent level of safety to the Rule requirements. It is essential that in such cases LR is informed of the Owner’s proposals at an early stage in order that a basis for acceptance of the standards may be agreed. Refer to Appendix A for applicable international Codes and Standards considered by LR as an equivalent level of safety to Rule requirements.

1.5.2 In general, the requirements in this Chapter are based on internationally recognised Codes and Standards for the production and process plant as defined in Appendix A. Other Codes and National Standards may be used after special consideration and prior agreement with LR. When considered necessary, additional Rule requirements are also stated in this Chapter.

1.5.3 Where necessary, the Codes and Standards are to be suitably modified and/or adapted to take into account all marine environmental aspects.

1.5.4 The agreed Codes and Standards may be used for design, construction and installation but where considered applicable by LR, compliance with the additional requirements stated in the Rules is required. Where there is any conflict the Rules will take precedence over the Codes or Standards.

1.5.5 The mixing of Codes or Standards for each equipment item or system is to be avoided. Deviation from the Code or Standard must be specially noted in the documentation and approved by LR.

1.6 Equipment categories

1.6.1 The approval and certification of production and process plant equipment are to be based on equipment categories agreed with LR.

1.6.2 Production and process plant equipment including their associated pipes and valves are to be divided into equipment Categories 1A, 1B and II depending on their complexity of manufacture and their importance with regard to the safety of personnel and the installation and their possible effect on the environment.

1.6.3 The following equipment categories are used in the Rules:

- **1A** Equipment of primary importance to safety, for which design verification and survey during fabrication are considered essential. Equipment in this category is of complicated design/manufacture and is not normally mass produced.
- **1B** Equipment of primary importance to safety, for which design verification and witnessing the product quality are considered essential. Equipment in this category is normally mass produced and not included in Category 1A.
- **II** Equipment related to safety, which is normally manufactured to recognised Codes and Standards and has proven reliability in service but excluding equipment in Category 1A and 1B.

1.6.4 A guide to equipment and categories is given in Appendix A. A full list of equipment categories for each production and process plant facility is to be agreed with LR before manufacture. Minor equipment components need not be categorised.
1.7 Equipment certification

1.7.1 Equipment is to be certified in accordance with the following requirements:

(a) **Category 1A**:
- Design verification and issue of certificate of design strength approval.
- Pre-inspection meeting at the suppliers with agreement and marking of quality plan and inspection schedule.
- Survey during fabrication and review of fabrication documentation.
- Final inspection with monitoring of function/pressure/load tests and issue of a certificate of conformity.

(b) **Category 1B**:
- Design verification and issue of certificate of design strength approval, where applicable, and review of fabrication documentation.
- Final inspection with monitoring of function/pressure/load tests and issue of certificate of conformity.

(c) **Category II**:
- Supplier's/manufacturer's works certificate giving equipment data, limitations with regard to the use of the equipment and the supplier's/manufacturer's declaration that the equipment is designed and fabricated in accordance with recognised Standards or Codes.

1.7.2 All equipment recognised as being of importance for the safety of personnel and the production and process plant facility is to be documented by a data book.

1.8 Fabrication records

1.8.1 Fabrication records are to be made available for Categories **1A** and **1B** equipment for inspection and acceptance by LR Surveyors. These records are to include the following:
- Manufacturer's Statement of Compliance.
- Reference to design specification and plans.
- Traceability of materials.
- Welding procedure tests and welders' qualifications.
- Heat treatment records.
- Records/details of non-destructive examinations.
- Load, pressure and functional test reports.

1.9 Installation of plant equipment

1.9.1 The installation of equipment on board the unit is to be controlled by LR in accordance with the following principles:
- All Category **1A** and **1B** equipment, delivered to the unit, is to be accompanied by a certificate of design strength approval and an equipment certificate of conformity and all other necessary documentation.
- All Category **II** equipment, delivered to the unit, is to be accompanied by equipment data and a works' certificate.
- Control and follow-up of non-conformities/deviations specified in design certificates and certificate of conformity.

- Ongoing survey and final inspection of the installed production and process plant.
- Monitoring of functional tests after installation on board in accordance with an approved test programme.
- Issue of a plant installation report.

1.10 Maintenance and repair

1.10.1 It is the Owner's/Operator's responsibility to ensure that installed production and process plant is maintained in a safe and efficient working condition in accordance with the manufacturer's specification.

1.10.2 When it is necessary to repair or replace installed production and process plant, any repaired or spare part is to be subject to the equivalent certification as the original.

1.11 Plans and data submissions

1.11.1 Plans, calculations and data are to be submitted as required by the relevant Parts of the Rules together with the additional plans and information listed in this Chapter. Plans are to be submitted in triplicate, but only a single copy of supporting documents and calculations are required.

### Section 2

#### Structure

2.1 Plans and data submissions

2.1.1 The following additional plans and information are to be submitted:
- General arrangement plans of the plant layout.
- Plans and design calculations as required for derricks in Ch 7.2, where appropriate.
- Structural plans of equipment skids, support stools and design calculations.
- Structural plans of equipment support frames and trusses and design calculations.
- Flare structures and design calculations.

2.2 Materials

2.2.1 Materials are to comply with Ch 1.4 and material grades are to comply with Pt 4, Ch 2 using the categories defined in this Section.

2.2.2 Support structures for the production and process plant are to be divided into the following categories:
- Primary structure.
- Secondary structure.

2.2.3 Some specific examples of structural elements which are considered as primary structure are as follows:
- Module main frame members and deck support stools.
- Main legs and chords including end connections.
- Foundation bolts.
2.3 Miscellaneous structures

2.3.1 The design loadings for all structures supporting plant including equipment skids, stools, support frames and trusses are to be defined by the designers/Builders and calculations are to be submitted in accordance with an appropriate Code or Standard, see Appendix A. The design requirements of 1.4 are to be complied with.

2.3.2 The design of process plant support structure is to integrate with the primary hull underdeck structure.

2.3.3 The permissible stresses in the hull structure below the production and process plant are to be in accordance with Ch 3,2 and Pt 4, Ch 6,2.

2.4 Flare structures

2.4.1 Flare structures are to be designed for an emergency condition and for normal operating conditions as defined in 1.4 and in accordance with an appropriate Code or Standard, see Appendix A.

2.4.2 The flare structures are also to be designed for the imposed loads due to handling the structure and when in the stowed position.

2.4.3 The designers/Builders are to specify the maximum weight of the burner and spreader and the design criteria defined in 1.4.

2.4.4 The structural design of flare structures is to include the effect of fatigue loading and the thermal loads during flaring, see Pt 4, Ch 6.

2.4.5 Where National Administrations give specific requirements with respect to fatigue design, it is the responsibility of the Owners to comply with such Regulations.

2.4.6 For slender structures and components, the effects of wind induced cross-flow vortex vibrations are to be assessed.

2.4.7 Wind loads are to be calculated in accordance with the Code for Lifting Appliances in a Marine Environment (LAME) or a recognised Code or Standard, see Appendix A.

2.4.8 Permissible stresses in the hull structure below the flare structure supports are to be in accordance with Pt 4, Ch 6.

2.5 Lifting appliances

2.5.1 Lifting appliances including those used for handling flare structures and blow out preventers are to be in accordance with LR’s LAME Code, see also Chapter 11.

2.6 Guard rails and ladders

2.6.1 It is the Owners’ responsibility to provide permanent access arrangements and protection by means of ladders and guard rails. It is recommended that such arrangements are designed in accordance with a recognised Code or Standard.

Section 3
Production, process and utility systems

3.1 Plans and particulars

3.1.1 Plans and particulars showing arrangement of production, process and utility systems and equipment listed in 1.3, and diagrammatic plans of the associated piping systems, are to be submitted for approval.

3.2 General requirements for piping systems

3.2.1 The design and construction of the piping systems, piping and fittings forming parts of such systems are to be in accordance with a recognised Code or Standard (see 1.5), and also to comply with the remainder of this Section.

3.2.2 Piping systems for the production and process plant are in general to be separate and distinct from piping systems essential to the safety of the unit. Notwithstanding this requirement, this does not exclude the use of the unit’s main, auxiliary and/or essential services for process plant operations in suitable cases. Attention is drawn to the relevant Chapters of Part 5, Main and Auxiliary Machinery, when such services are to be utilised. Substances which are known to present a hazard due to a reaction when mixed are to be kept entirely separate.

3.2.3 All piping systems are to be suitable for the service intended and for the maximum pressures and temperatures to which they are likely to be subjected.

3.2.4 The number of detachable pipe connections in hydrocarbon production and process piping is to be limited to those which are necessary for installation and dismantling. The pipe connections are to be suitable for the intended use.

3.2.5 Soft-seated valves and fittings which incorporate elastomeric sealing materials installed in systems containing hydrocarbons or other flammable fluids are to be of a fire-tested type.

3.2.6 The production and process system piping is to be protected from the effects of fire, mechanical damage, erosion and corrosion. Corrosion coupons or test spool pieces are to be designed into the system. Spool pieces are to be fitted in such a manner as to be easily removed or replaced. Sand probes and filters should be provided where necessary for extraction of sand or reservoir fracture particles.
3.2.7 The corrosion allowance for hydrocarbon production and process piping of carbon steel is not to be less than 2 mm.

3.2.8 Piping for services essential to the production and process operations, and piping containing hydrocarbon or other hazardous fluids is to be of steel or other approved metallic construction. Piping material for hydrogen sulphide-contaminated products (sour service) is to comply with ISO 15156: Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production, see Appendix A.

3.2.9 Arrangements are to be made to isolate the unit from the supply and discharge of produced oil and gas by the provision of suitable shut-down valves on the unit and at the receiving installation. The valves on board the unit are to be operable from the control stations as well as locally at the valve.

3.2.10 If a single failure in the supply from utility systems, such as compressed air or cooling water, which are essential to the operation of the production and process plant could cause an unacceptable operating condition to arise, an alternative source of supply is to be provided.

3.2.11 Process vessel washout connections are to be fitted with non-return valves in addition to the shut-off valves.

3.2.12 The locking open/closed of valves is to be by means of a suitable keyed locking device operated under a permit-to-work system.

3.2.13 For process vessels which periodically require isolation prior to gas-freeing and personnel entry, pipelines which connect the vessel to a source of pressure and/or hazardous fluid are to be provided with isolating valves, bleed arrangements and means to blank off the open end of the pipe. For systems containing significant hazards, consideration is to be given to double block and bleed valves and blanking-off arrangements.

3.2.14 For ship units, the design of piping systems should take into consideration the effects of hull girder bending.

3.3 Flexible piping

3.3.1 Flexible piping elements approved for their intended use may be installed in locations where rigid piping is unsuitable or impracticable. Such flexible elements are to be accessible for inspection and replacement, and are to be secured and protected so that personnel will not be injured in the event of failure.

3.3.2 Short lengths of flexible hose may be utilised to allow for limited misalignment or relative movement. All flexible hoses are to be manufactured to a recognised Code or Standard and a prototype hose with end fittings attached is to have been burst-tested to the minimum pressure stipulated by the appropriate standard. Protection against mechanical damage is to be provided where necessary.

3.3.3 Means are to be provided to isolate flexible hoses, if used in systems where uncontrolled outflow would be critical.

3.4 Christmas tree

3.4.1 The christmas tree is to have at least one remotely-operated, self-closing master valve and a corresponding wing valve for each penetration of the tree. In addition, there is to be a closing device for each penetration at a level higher than the wing outlets.

3.4.2 Additional wing outlets, such as injection lines, are to penetrate the christmas tree above the lowest remotely-operated master valve, and be fitted with a remotely-operated, self-closing control valve and a check valve installed as close as possible to the injection point. The injection point for hydrate inhibitor may be fitted below the lowest self-closing master valve if the christmas tree is fitted with valve(s) below this point.

3.4.3 All valves in the vertical penetrations of the christmas tree are to be capable of being opened and kept in the open position by means of an external operational facility independent of the primary actuator.

3.4.4 Valves that are important in connection with the emergency shut-down system such as the master and wing valves are to be fitted locally with visual position indicators.

3.4.5 Where exposure to H₂S-contaminated products is likely, the materials and welds are to meet the requirements of NACE MR0175/ISO 15156 – Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production.

3.5 Protective pressure relief

3.5.1 Process vessels, equipment and piping are to be provided with pressure-relieving devices to protect against system pressures exceeding the maximum allowable pressure such that the system will remain safe under all foreseeable conditions, unless the system is designed to withstand the maximum pressure which can be exerted on it under any circumstances. Where appropriate, sections of the production and process system are to be protected against underpressure resulting from a change of temperature or state of the contents, see also 4.9.

3.5.2 The pressure relieving devices are to be sized to handle the expected maximum relieving rates due to any single failure or fire incident. The rated discharge capacity of any pressure-relieving device is to take into account the back pressure in the vent system.

3.5.3 For protected items or sections of the system not in continuous service, a single pressure-relieving device is acceptable. Block valves for maintenance purposes, where fitted, in the pressure relief lines are to be interlocked with the source of pressure or spare relief valves as applicable.
3.5.4 For any particular item or section of the system in continuous service, at least two pressure relief possibilities are to be provided for operational and maintenance purposes. In this case, each pressure relief possibility is to be designed to handle 100 per cent of the maximum relieving rate expected unless alternative systems are available or short term shut-down is acceptable.

3.5.5 If more than two pressure relief possibilities are provided on any particular item or section of the system in continuous service, and any pressure relief possibility is designed to handle less than 100 per cent of the maximum relieving rate expected, the arrangements are to be such as to allow any one device to be isolated for operational and maintenance purposes without reducing the capacity of the remaining devices below 100 per cent of the maximum relieving rate.

3.5.6 Block valves fitted in pressure relief lines for isolation purposes are to be of the full-flow type, capable of being locked in the fully open position by an approved keyed method.

3.5.7 The arrangement in 3.5.4 or 3.5.5 is to ensure that all relief possibilities cannot be isolated from the system at the same time, by interlocking the block valves using an approved keyed method of interlocking operated under a permit-to-work system.

3.5.8 The set pressure for all pressure-relieving devices should generally not exceed the design pressure of the protected system or item. Pressure relief valves are to be sized such that any accumulation of pressure from any source will not exceed 110 per cent of the design pressure.

3.5.9 Bursting discs fitted in place of, or in series with, a pressure relief valve are to be rated to rupture at a pressure not exceeding the design pressure of the protected system or item. However, in the case of a bursting disc fitted in parallel with a relief valve(s), such as in vessels containing substances which may render a pressure relief valve inoperative or where rapid rates of pressure rise may be encountered, the bursting disc is to be rated to burst at a maximum pressure not exceeding 1.3 times the design pressure of the vessel at the operating temperature.

3.5.10 Pressure-relieving devices are normally to be connected to the flare and relief header to minimise the escape of hydrocarbon fluids, and to ensure their safe collection and disposal. Where appropriate, vent and discharge piping arrangements are to be such as to avoid the possibility of a hazardous reaction between any of the fluids involved.

3.5.11 In circumstances where hazardous vapours are released directly to the atmosphere, the outlets are to be arranged to vent to a safe location where personnel would not be endangered.

3.5.12 The inlet piping to a pressure relief device should be sized so that the pressure drop from the protected item to the pressure relief device inlet flange does not exceed three per cent of the device set pressure.

3.5.13 Pressure-relieving devices and all associated inlet and discharge piping are to be self-draining. Open vents are to be protected against ingress of rain or foreign bodies.

3.5.14 Relief piping supports are to be designed to ensure that reaction forces during relief are not transmitted to the vessel or system, and to ensure that relief devices are not used as pipe supports or anchors where the resultant forces could interfere with the proper operation of the device.

3.5.15 The design and material selection of the pressure-relieving devices and associated piping is to take into consideration the resulting low temperature, vibration and noise when gas expands in the system.

3.5.16 Positive displacement pumps and compressors for hydrocarbon oil/gas service are to be provided with relief valves in closed circuit, set to operate at a pressure not exceeding the maximum allowable pressure of the pump or equipment connected to it, and adequately sized to ensure that the pump output can be relieved without exceeding the system's maximum allowable pressure. Proposed alternatives to relief valves may be considered and full details are to be submitted.

3.5.17 Relief valves may also be required on the suction side of pumps and compressors when recycling from the discharge side is possible.

3.6 Flaring arrangements

3.6.1 Facilities for gas flaring and oil burning are to be adequate for the flaring requirements during well control, well testing and production operations. For well testing, at least two flare lines are to be arranged through which any flow from the well may be directed to different sides of the unit.

3.6.2 The flare system is to be designed to ensure a clean, continuous flame. Provision is to be made for the injection of make-up gas into the vent system to maintain steady flaring conditions. A means of cooling the flare burners when used for well testing is to be made available.

3.6.3 The flare burners are to be located at a safe distance from the unit. This distance, or protection zone, is to be determined by consideration of the calculated thermal radiation levels. For limiting thermal radiation levels, see 3.9.

3.6.4 For well test systems, any flare line or other line downstream of the choke manifold is to have an inside diameter not less than the inside diameter of the largest line in the choke manifold.

3.6.5 Production and process plant venting systems are to be led to a liquid separator or knock-out drum to remove any entrained liquids which cannot be safely handled by the flare. Where a liquid blowdown system is provided, adequate provision is to be made in the design for the effects of back pressure in the system, and for vapour flash-off when the pressures in the blowdown system are reduced.
3.9 Radiation levels

3.9.1 The location and designed throughput of the flare is to take into consideration the levels of thermal radiation to ensure that exposure of personnel, structure and equipment is acceptable even under unfavourable wind conditions.

3.9.2 Under normal operating circumstances, the intensity of thermal radiation, including solar radiation, in unprotected areas where personnel may be continuously exposed is not to exceed 1.9 kW/m² in calm conditions. Allowance for the cooling effect of wind in unsheltered areas may be taken into consideration in determining the radiation levels.

3.9.3 Under emergency flaring conditions, the intensity of thermal radiation at muster stations and in areas where emergency actions of short duration may be required by personnel is not to exceed 4.7 kW/m² in calm conditions.

3.9.4 Suitable radiation screens, water screening or equivalent provision should be utilised to protect personnel, structure and equipment as necessary.

3.10 Firing arrangements for steam boilers, fired pressure vessels, heaters, etc.

3.10.1 The requirements of this Section are applicable to all types of fired equipment associated with the process plant. The equipment is to be constructed, installed and tested to the Surveyor’s satisfaction.

3.10.2 Details of the design and construction of the fuel gas burning equipment for steam boilers, oil and gas heater furnaces, etc., are to be in accordance with agreed Codes, Standards and specifications normally used for similar plants in land installations, suitably modified and/or adapted for the marine environment. Ignition of the burners is to be by means of permanently installed igniters, or properly located and interlocked pilot burners and main burners arranged for sequential ignition.

3.10.3 Proposals for the furnace purging arrangements prior to ignition of the burners are to be submitted. Such arrangements are to ensure that any accidental leakage of product liquid or gas into the furnace, from a liquid or gas heating element, or from the accidental ingestion of flammable gases and/or vapours, does not result in hazardous conditions.

3.10.4 Proposals for the furnace purging arrangements prior to ignition of the burners are to be submitted. Such arrangements are to ensure that any accidental leakage of product liquid or gas into the furnace, from a liquid or gas heating element, or from the accidental ingestion of flammable gases and/or vapours, does not result in hazardous conditions.

3.10.5 Compartments containing fired pressure vessels, heaters, etc., for heating or processing hazardous substances are to be arranged so that the compartment in which the fired equipment is installed is maintained at a higher pressure than the combustion chamber of the equipment. For this purpose, induced draft fans or a closed system of forced draught may be employed. Alternatively, the fired equipment may be enclosed in a pressurised air casing.

3.6.6 The flare system is to be capable of controlling any excess gas pressures resulting from emergency depressurising conditions.

3.7 Depressurising system

3.7.1 All production and process plant in which significant volumes of hydrocarbon liquids and gases with potential for incident escalation can be blocked in during a fire is to be capable of being depressurised. The capacity of the system should be based on evaluation of:

- system response time;
- heat input from defined accident scenarios;
- material properties and material utilisation ratio;
- other protection measures, e.g., active and passive fire protection; and
- system integrity requirements.

3.7.2 The emergency depressurising system is to be designed to reduce pressures to a level to prevent rupture of the pressure containing components. As a minimum requirement, the depressurising system is to be designed to ensure that the pressure is reduced to half the equipment’s maximum allowable working pressure or 6.9 bar, whichever is lower, within approximately 15 minutes.

3.7.3 The cooling effect due to throttling of large volumes of high pressure gas in the discharge piping and valves during the depressurising period is to be evaluated for appropriate material selection. Where temperatures below minus 29°C are expected, the piping and valve material is to have specified average Charpy V-notch impact values of 27J at the calculated lowest operational temperature.

3.7.4 The vent system design should ensure that allowance has been given to the possibility of high dynamic forces at pipe bends and supports during emergency depressurisation.

3.8 Cold vents

3.8.1 A cold vent is acceptable only if it is determined that the gas release will not create any danger to the unit. Due consideration is to be given to the prevailing wind to ensure that gases do not flow down around operating areas. Where cold venting is provided, the arrangement is to minimise:

- Accumulation of toxic and flammable gases.
- Ignition of vent gases from outside sources.
- Flashback upon accidental ignition of the vent gases.

3.8.2 In order to avoid continuous burning of the vent gases in the case of accidental ignition, an extinguishing system using a suitable inert gas is to be installed.

3.8.3 The dew point of the gases is to be such that they will not condense at the minimum ambient temperature. In the case of liquid condensation in the cold vent piping, a drain or liquid collection system is to be provided to prevent accumulation of liquid in the vent line.
3.10.6 The fired equipment is to be suitably lagged. The clearance spaces between the fired equipment and any tanks containing oil are to be not less than 760 mm. The compartments in which the fired equipment is installed are to be provided with an efficient ventilating system.

3.10.7 Smoke box and header box doors of fired equipment are to be well fitted and shielded, and the uptake joints made gastight. Where it is proposed to install dampers in the uptake gas passages of fired equipment, the details are to be submitted. Dampers are to be provided with a suitable device whereby they may be securely locked in the fully open position.

3.10.8 Each item of fired equipment is to have a separate uptake to the top of the stack casing. Where it is proposed to install process fired equipment with separately fixed furnaces converging into a convection section common to two or more furnaces and/or a secondary radiant section at the confluence of the fired furnace uptake to the convection section, the proposed arrangements, together with the details of the furnace purging and combustion controls, are to be submitted.

3.11 Drain systems

3.11.1 Drainage systems are to be provided to collect and direct drained or escaped liquids to locations where they can be safely handled or stored. In general, equipment is to be provided with a hard-piped, closed drainage system for produced liquids, an open system handling drainage from hazardous areas, and an open system handling drainage from non-hazardous areas. These systems are to be entirely separate and distinct.

3.11.2 The hazardous drainage systems are to be kept separate and distinct from those of the main and auxiliary machinery systems. Consideration will be given to directing the process facilities hazardous drains to the facilities oil storage tanks. The hazardous drains fluids should not be allowed to free-fall into the tank. In units equipped with an inert gas system a U-seal of adequate height, or equivalent method, should be arranged in the piping leading to the oil storage tanks.

3.11.3 Provision is to be made for protection against over-pressurisation of a lower pressure drainage system when connected to a higher pressure system.

3.12 Bilge and effluent arrangements

3.12.1 Where, during operation, the production plant spaces contain, or are likely to contain, hazardous and/or toxic substances, they are to be kept separate and distinct from the unit’s main bilge pumping system. This does not, however, preclude the use of the unit’s main bilge system when the production plant is shut down, gas freed or otherwise made safe.

3.12.2 The bilge and effluent pumping systems handling hazardous and/or toxic substances should, wherever possible, be installed in the space associated with the particular hazard. Spaces containing pumping systems that take their suctions from a hazardous space will also be designated as hazardous spaces unless all associated pipelines are of all-welded construction without flanges, valve glands and bolted connections, and the pump is totally enclosed.

3.12.3 Bilge and effluent piping systems related to the production plant are to be constructed of materials suitable for the substances handled, including any accidental admixture of such substances.

3.12.4 Arrangements are to be provided for the control of the bilge and effluent pumping systems installed in production and process plant spaces from within the spaces and from a position outside the spaces.

Section 4
Pressure vessels and bulk storage

4.1 General

4.1.1 The Rules in this Section are applicable to fired and unfired pressure vessels associated with process plant, and drilling plant defined in Chapter 7.

4.1.2 Pressure vessels are to be designed in accordance with Pt 5, Ch 10 and Ch 11 or with internationally recognised and agreed Codes and Standards and in accordance with the requirements of Section 1.

4.1.3 The list in Appendix A, A1.2.11 gives reference to some generally recognised Codes and Standards frequently specified for drilling and production equipment. These Codes and Standards may be used for certification, but the additional requirements given in the Rules apply and the Rules will take precedence over the Codes and Standards wherever conflict occurs.

4.1.4 Portable gas cylinders and other pressure vessels used to transport liquids or gases under pressure are to comply with an acceptable National or International Code or Standard.

4.1.5 Where pressure parts are of such an irregular shape that it is impracticable to design their scantlings by the application of recognised formulae, the acceptability of their construction is to be determined by hydraulic proof testing and strain gauging or by an agreed alternative method.

4.2 Plans and data submissions

4.2.1 Design documentation is to be submitted for all pressure vessels.

4.2.2 The submitted information is to include the following:
- Design specification, including data of working medium and pressures.
- Minimum/maximum temperatures, corrosion allowance, environmental and external loads.
• Plans, including sufficient detail and dimensions to evaluate the design.
• Strength calculations for normal operating and emergency conditions.
• Bill of Materials including material specifications as necessary.
• Fabrication specifications including welding, heat treatment, type and extent of NDE.

4.3 Equipment Certification

4.3.1 Equipment certification is to be carried out in accordance with Section 1 and equipment categories are to comply with Table A2.3 in Appendix A.

4.4 Materials

4.4.1 Materials for pressure vessels are to comply with Ch 1,4 and the Rules and Regulations for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials), except where modified by this Section.

4.4.2 Welded carbon/manganese (C–Mn) steels used for major pressure containing parts should have a chemical composition limited by the carbon content and the carbon equivalent:

Carbon content

\[ C \leq 0.25 \]

When the elements in the following formula are known, this formula is to be used:

Carbon Equivalent:

\[
CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \leq 0.45 \]

Symbols are as defined in the Rules for Materials.

4.4.3 The use of material not meeting these limitations is subject to special consideration in each case. The welding of such materials normally requires more stringent fabrication procedures regarding the selection of consumables, preheating and post weld heat treatment.

4.4.4 Materials for pressure containing parts are to be tested at the temperature specified in Table 13.4.1 in Chapter 13 of the Rules for Materials and are to achieve a minimum energy of 27J for materials with specified minimum yield strength less than or equal to 360 MPa and 42J for higher strength materials.

4.4.5 Equipment and components required for hydrogen sulphide-contaminated products (sour service) are to meet the property requirements of NACE MR0175/ISO 15156 – Petroleum and natural gas industries – Materials for use in H₂S-containing environments in oil and gas production.

4.4.6 Materials employed in liquefied natural gas pressure vessels are to be impact tested in accordance with Pt 4, Ch 2.

4.5 Design pressure and temperature

4.5.1 The design pressure is the maximum permissible working pressure and is not to be less than the highest set pressure of the safety valve. If the design of the system is such that it may be possible for it to see a vacuum, the design pressure is also to consider the minimum working pressure which the system may see.

4.5.2 The calculations made to determine the scantlings of the pressure parts are to be based on the design pressure, adjusted where necessary to take account of pressure variations corresponding to the most severe operating conditions.

4.5.3 It is desirable that there should be a margin between the normal pressure at which the pressure vessel operates and the lowest pressure at which any safety valve is set to lift, to prevent unnecessary lifting of the safety valve.

4.5.4 The design temperature, \( T \), used to evaluate the allowable stress, \( \sigma \), is to be taken as the actual mean wall metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when the plans of the pressure part are being considered. For fired steam boilers, \( T \), is to be taken as not less than 250°C.

4.6 Design safety factors

4.6.1 The term ‘allowable stress’, \( \sigma \), is the stress to be used in the formulae for calculating the scantlings of pressure vessels.

4.6.2 The allowable stress used for the design of a pressure vessel is to be in accordance with the Code or Standard being used to design that vessel.

4.6.3 Pressure vessels are to be designed for the emergency conditions referred to in 1.4.

4.6.4 It is not permissible to use the allowable stress levels of one Code or Standard to determine the scantlings using the formulae from a different Code or Standard.

4.6.5 The yield strength used in the determination of allowable stress or in calculations is not to exceed 0.85 of the specified minimum tensile strength of the material in question.

4.7 Construction and testing

4.7.1 Fabrication documentation is to be compiled by the manufacturer simultaneously with the fabrication in a systematic and traceable manner so that all the information regarding the design specification, materials, fabrication processes, inspection, heat treatment etc., can be readily examined by the Surveyor.

4.7.2 Welding procedures and construction requirements for welding are to be in accordance with those specified in Chapters 12 and 13 of the Rules for Materials.

4.7.3 Procedures for performing non-destructive examination, and the acceptance criteria to be applied, are to be in accordance with Chapter 13 of the Rules for Materials.
4.8 Hydrostatic test pressure

4.8.1 Pressure vessels are to be subject to a hydrostatic test in accordance with the applied Code, Standard, or specification before being taken into service.

4.8.2 The hydrostatic test pressure is to be a minimum of 1.5 times the design pressure if not specified in the Code or Standard.

4.8.3 The pressure and holding time are to be recorded.

4.8.4 Primary general membrane stresses are in no case to exceed 90 per cent of the minimum yield strength of the material.

4.9 Protective and pressure relief devices

4.9.1 Pressure vessels are to be provided with protective devices so that they remain safe under all foreseeable conditions.

4.9.2 Where pumps and pressure surges are capable of developing pressures exceeding the design conditions of the system, effective means of protection such as pressure relief devices or equivalent are to be provided.

4.9.3 Pressure relief valves are to be sized such that any accumulation of pressure from any source will not exceed 121 per cent of the design pressure. For specific fire contingencies where accumulated pressure could exceed 121 per cent, design proposals will be specially considered.

4.9.4 Bursting discs fitted in place of, or in series with, safety valves are to be rated to burst at a maximum pressure not exceeding the design pressure of the vessel at the operating temperature. Bursting discs are only to be used for pressure vessels located in open areas or if fitted in conjunction with a relief line led to an open area.

4.9.5 Where a bursting disc is fitted downstream of a safety valve, the maximum bursting pressure is also to be compatible with the pressure rating of the discharge system.

4.9.6 In the case of bursting discs fitted in parallel with relief valves to protect a vessel against rapid increase of pressure, the bursting disc is to be rated to burst at a maximum pressure not exceeding 1.3 times the design pressure of the vessel at operating temperature.

4.9.7 Pressure relief devices are to be type tested to establish their discharge capacities at their maximum rated design pressures and temperatures in accordance with an approved Code or Standard.

4.9.8 Where pressure relief devices can be isolated from the pressure vessel whilst in service, there is to be an alternative independent pressure relief device. The system pressure relief valve set pressure and bursting disc rupture pressure should be displayed at the respective operating position.

4.9.9 Any isolating valves used in conjunction with pressure relief devices are to be the full flow type capable of being locked in the full open position. Where isolating valves are arranged downstream and upstream of a relief device they are to be interlocked with each other.

4.9.10 Where pressure relief devices are duplicated on the same vessel or system and fitted with isolating valves, these valves are to be interlocked as to ensure that before one relief device is isolated the other relief device is fully open and the required discharge capacity is maintained. The interlocking system is to be submitted for approval.

4.9.11 The design of the pressure-relieving system is to take into account the characteristics of the fluid handled and any extreme environmental condition recorded for the geographical zone of operation. The vent and pressure relieving systems are to be self draining.

4.9.12 The rated discharge capacity of any pressure relief device is to take into account the back pressure in the vent systems. Where hazardous vapours are discharged directly to the atmosphere the outlets are to be arranged to vent to a safe location.

4.10 Bulk storage vessels

4.10.1 Bulk storage vessels are to be designed in accordance with the general requirements of this Section and with one of the internationally recognised Codes or Standards for fusion welded pressure vessels quoted in Appendix A, A1.2.11, and in accordance with the design requirements given in Section 1, see also Ch 7,3.10.

4.10.2 For bulk storage vessels in enclosed areas, testable safety valves are to be used, which can be vented out of the area. Such enclosed areas are to be ventilated so that a pressure build-up will not occur in the the event of a break or a leak in the air supply system.

4.10.3 Bulk storage vessels are normally to be supported by suitable skirts in order to distribute the loads into the supporting structure.

4.10.4 Bulk storage vessels which penetrate watertight decks or flats are to be suitably reinforced, see Ch 3,2.10.

Section 5
Mechanical equipment

5.1 General

5.1.1 The Rules in this Section are applicable to all types of mechanical equipment associated with the production and process plant with the exception of pressure vessels which are dealt with in Section 4.
5.1.2 Mechanical equipment is to be designed in accordance with internationally recognised and agreed Codes or Standards and in accordance with the requirements of Section 1.

5.1.3 The list in Appendix A, A1.2 gives reference to some generally recognised Codes and Standards frequently specified for drilling and production equipment. These Codes and Standards may be used for certification, but the additional requirements given in these Rules apply and will take precedence over the Codes and Standards wherever conflict occurs.

5.1.4 Production and process plant equipment is to be suitable for the service intended and for the maximum loads, pressures, temperatures and environmental conditions to which the system may be subjected.

5.2 Plans and data submissions

5.2.1 Design documentation for mechanical equipment is to be submitted in accordance with the equipment categories and certification requirements defined in Section 1.

5.2.2 The submitted information should include the following as applicable to the equipment categories:
- Design specification, including data of working medium and pressures.
- Minimum/maximum temperatures, corrosion allowance, environmental and external loads.
- Plans, including sufficient detail and dimensions to evaluate the design.
- Strength calculations as applicable.
- Material specifications and welding details.

5.3 Equipment certification

5.3.1 Equipment categories and certification of production and process plant equipment are to be in accordance with the requirements of Section 1.

5.3.2 A general guide to specific equipment categories are given in Table A 2.3 in Appendix A.

5.3.3 Hoisting and pipe handling equipment are to comply with Ch 7.6.

5.3.4 Associated equipment such as oil engines, electric motors, generators, turbines, etc., are to comply with the applicable Sections of the Rules.

5.4 Materials

5.4.1 Materials are to comply with Ch 1.4 and the Rules for Materials, except where modified by this Section.

5.4.2 The selected materials are to be suitable for the purpose intended and must have adequate properties of strength and ductility and materials to be welded are to be of weldable quality.

5.4.3 As a minimum, Charpy impact tests are required to be carried out at the minimum design temperature (MDT) and exhibit minimum impact energies of 34J for minimum specified yield strengths of up to 360 MPa and 40J for higher yield strengths. For equipment used in LNG applications, the impact test temperature and energy requirements are to be in accordance with Pt 4, Ch 2.

5.4.4 For selection of acceptable materials suitable for hydrogen sulphide contaminated products (sour service), reference is to be made to the NACE MR0175/ISO 15156 Standard in Appendix A, A1.2.21.

5.4.5 Grey iron castings are not to be used for critical components.

5.4.6 Proposals to use spheroidal graphite iron castings for critical components operating below 0°C will be specially considered by LR in each case.

5.4.7 In general, bolts and nuts are to comply with the Standards listed in Appendix A, A1.2.

5.4.8 Bolts and nuts for major structural and mechanical components are to have a tensile strength of not less than 600 N/mm².

5.4.9 For general service, the specified tensile strength of bolting material should not exceed 1000 N/mm².

5.4.10 Where required, materials of high heat resistance are to be used and the ratings are to be verified.

5.5 Design and construction

5.5.1 The design strength of production and process plant equipment is to comply generally with Part 5, as applicable, and with LR agreed Codes and Standards.

5.5.2 All equipment included in this Section is to be suitable for the design environmental conditions for the unit.

5.5.3 Combustion equipment and combustion engines are not normally to be located in a hazardous area, unless the air space is pressurised to make the area non-hazardous in accordance with the following criteria:
- Pressurisation air is to be taken from a safe area.
- An alarm is to be fitted to indicate loss of air pressure.
- An air lock system with self-closing doors is to be fitted.
- The exhaust outlet is to be located in a non-hazardous area, and be fitted with spark arrestors, see 5.5.4.
- The combustion air inlet is to be located in a non-hazardous area.
- Automatic shut-down is to be arranged to prevent overspeeding in the event of accidental ingestion of flammable gases or vapours.

5.5.4 Efficient spark arresters, of LR approved type, are to be fitted to the exhaust from all combustion equipment, except from exhaust gas turbines. Water cooled spark arresting equipment is to be fitted with means to give a warning in the event of failing cooling water supply.
5.5.5 Exhaust gases are to be discharged so that they will not cause inconvenience to personnel or a dangerous situation during helicopter operations.

5.5.6 The equipment and systems are to be designed, installed, and protected so as to be safe with regard to the risk of fire, explosions, leakages and accidents.

5.5.7 For any equipment using magnetic bearings, a system overview of magnetic bearing systems fitted to the equipment is to be submitted to LR for information. Any equipment which uses active magnetic bearings is to be supplied with a back-up system, such that in the event of a power failure of the active magnetic system the equipment can be brought to a safe condition. Details of the back-up system are to be submitted to LR for approval. If the back-up system has a finite life then the manufacturer is to advise LR and the Owner what the life of the back-up system is. The Owner is to ensure that the life of the back-up system is monitored, so that the equipment is not operated beyond the life of the back-up system.

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Section 6

Electrical installations

6.1 General

6.1.1 In general, electrical installations are to comply with the requirements of Pt 6, Ch 2.

6.1.2 Electrical equipment installed in areas where an explosive gas atmosphere may be present is to be in accordance with Pt 7, Ch 2.

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Section 7

Control systems

7.1 General

7.1.1 In general, control engineering systems are to comply with the requirements of Pt 6, Ch 1 and/or the appropriate Codes or Standards defined in Appendix A.

7.1.2 Emergency shut-down systems and other safety and communication systems are to comply with the requirements of Pt 7, Ch 1.

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Section 8

Fire, hazardous areas and ventilation

8.1 General

8.1.1 Hazardous areas and ventilation are to comply with Ch 3,3 and Pt 7, Ch 2.

8.1.2 The general requirements for fire safety are to comply with Pt 7, Ch 3.

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Section 9

Riser systems

9.1 General

9.1.1 Production riser systems, which comply with the requirements of Chapter 5 will be eligible for the special features class notation PRS.
Section 1

1. General

1.1 Application

The requirements of this Chapter apply to units with installed dynamic positioning systems, and are additional to those applicable in other Parts of these Rules.

1.1.2 A unit provided with a dynamic positioning system in accordance with these Rules will be eligible for an appropriate class notation which will be recorded in the ClassDirect Live website.

1.1.3 Requirements, additional to these Rules, may be imposed by the National Authority with whom the unit is registered and/or by the administration within whose territorial jurisdiction it is intended to operate. Where national legislative requirements exist, compliance with such regulations is also necessary.

1.1.4 For the purpose of these Rules, dynamic positioning means the provision of a system with automatic and/or manual control capable of maintaining the heading and position of the unit during operation within specified limits and environmental conditions.

1.1.5 For the purpose of these Rules, the area of operation is the specified allowable position deviation from the desired set point, see 1.3.2.

1.2 Classification notations

1.2.1 Units complying with the requirements of this Chapter will be eligible for one of the following class notations, as defined in Pt 1, Ch 2:

- **DP(CM)** See Section 2.
- **DP(AM)** See Section 3.
- **DP(AA)** See Section 4.
- **DP(AAA)** See Section 5.

1.2.2 The notations given in 1.2.1 may be supplemented with a Performance Capability Rating (PCR). This rating indicates the calculated percentage of time that a unit is capable of maintaining heading and position under a standard set of environmental conditions (North Sea), see Section 6.

1.2.3 Additional descriptive notes may be entered in the ClassDirect Live website, indicating the type of position reference system, control system, etc.

1.2.4 Where a DP notation is not requested, dynamic positioning systems are to comply with the requirements of Section 2, as far as is practicable.

1.3 Information and plans required to be submitted

1.3.1 The following information and plans are to be submitted in triplicate. The Operation Manuals specified in 1.3.8 are to be submitted in a single set.

1.3.2 Details of the limits of the area of operation and heading deviations, together with proposals for redundancy and segregation provided in the machinery, electrical installations and control systems, are to be submitted. These proposals are to take account of the possible loss of performance capacity should a component fail or in the event of fire or flooding, see also 1.3.6 and Sections 4 and 5.

1.3.3 Where a common power source is utilised for thrusters, details of the total maximum load required for dynamic positioning are to be submitted.

1.3.4 Plans of the following, together with particulars of ratings in accordance with the relevant Parts of the Rules, are to be submitted for:

(a) Prime movers, gearing, shafting, propellers and thrust units.
(b) Machinery piping systems.
(c) Electrical installations.
(d) Pressure vessels for use with dynamic positioning system.

1.3.5 Plans of control, alarm and safety systems, including the following, are to be submitted:

(a) Functional block diagrams of the control system(s).
(b) Functional block diagrams of the position reference systems and the environmental sensors.
(c) Details of the electrical supply to the control system(s), the position reference system(s) and the environmental sensors.
(d) Details of the monitoring functions of the controllers, sensors and reference systems, together with a description of the monitoring functions.
(e) List of equipment with identification of the manufacturer, type and model.
(f) Details of the control systems, e.g., control panels and consoles, including the location of the control stations.
(g) Test schedules (for both works’ testing and sea trials) that are to include the methods of testing and the test facilities provided.
1.3.6 For assignment of a DP(AA) or DP(AAA) notation, a Failure Mode and Effects Analysis (FMEA) is to be submitted, demonstrating that adequate segregation and redundancy of the machinery, the electrical installation and the control systems have been achieved in order to maintain position in the event of equipment failure, see Section 4, or fire or flooding, see Section 5. The FMEA is to take a formal and structured approach and is to be performed in accordance with an acceptable and relevant National or International Standard, e.g., IEC 60812.

1.3.7 Where the DP notation is to be supplemented with a Performance Capability Rating (PCR), see 1.2.2, the following information is to be submitted for assignment of a PCR:
(a) Lines plan.
(b) General arrangement.
(c) Details of thruster arrangement.
(d) Thruster powers and thrusts.

1.3.8 Operation Manuals, including details of the dynamic positioning system operation, installation of equipment, maintenance and fault finding procedures, together with a section on the procedure to be adopted in an emergency, are to be submitted. A copy of the manual is to be placed and retained on board the unit.

Section 2
Class notation DP(CM)

2.1 General

2.1.1 The requirements for class notation DP(CM) are given in Pt 7, Ch 4.2 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships), which are to be complied with where applicable.

Section 3
Class notation DP(AM)

3.1 Requirements

3.1.1 The requirements for class notation DP(AM) are given in Pt 7, Ch 4.3 of the Rules for Ships, which are to be complied with where applicable.

3.1.2 Additional requirements with respect to unit types as indicated in this Section should also be complied with as applicable.

3.1.3 A manually initiated emergency alarm, clearly distinguishable from all other alarms associated with the dynamic positioning system, is to be provided at the dynamic positioning control station to warn all relevant personnel in the event of a total loss of dynamic positioning capability. In this respect consideration is to be given to additional alarms being provided at locations such as the Master’s accommodation and operational control stations.
Section 1

1. Application

1.1 This Chapter applies to positional mooring systems for floating units at a fixed location.

1.2 The requirements apply to the following categories of unit and mooring type:
   - Ship units, column-stabilised units, offshore loading buoys and other similar type moored floating structures.
   - Multi-leg mooring systems, either spread-moorings or single-point moorings.
   - Catenary systems or taut-leg systems.

1.3 Other types of application will be specially considered.

1.4 The requirements of this Chapter are not applicable to the mooring tethers on tension-leg units. For the design requirements of tension-leg units, see Pt 4, Ch 5.

1.5 Requirements additional to these Rules may be imposed by the National Authority with whom the unit is registered and/or by the Administration of the coastal state(s) with territorial jurisdiction over the waters in which it is intended to operate.
Positional Mooring Systems

(d) Fairleads/bending shoes.
(e) Chain or wire rope stoppers.
(f) Winches or windlasses.

1.3.5 Thruster-assist. The use of thrusters, inclusive of their associated equipment, to supplement the unit’s positional mooring system.

1.3.6 Catenary mooring. A mooring system which derives its compliancy mainly from the catenary action of the anchor lines. Some additional resilience is provided by the characteristic axial elasticity of the anchor lines.

1.3.7 Taut-leg mooring. A mooring system based on light-weight anchor lines pre-tensioned to a taut configuration with no significant catenary shape at any unit offset, and applying vertical and horizontal loads at the anchor points. With this type of system, compliancy is derived from the inherent axial elastic stretch properties of the anchor line.

1.3.8 Single-point mooring. An offshore mooring facility based on a single buoy or single tower, see Ch 2,1.2.6.

1.3.9 Spread mooring. A multi-line mooring system designed to maintain an offshore unit on an approximately fixed heading.

1.4 Plans and data submission

1.4.1 The positional mooring system will be subject to review and approval. The following information and plans are to be submitted in triplicate, to cover the design review and class approval of the positional mooring system:
(a) Plans of the positional mooring system and associated equipment are to be submitted including the following, as applicable:
• General arrangement of floating unit.
• Mooring layout.
• Field layout.
• Anchor lines and fittings.
• Anchor points.
• Fairleads/bending shoes.
• Cable stoppers.
• Winches, windlasses or tensioners.
(b) For thruster-assisted positional mooring systems, plans of the following together with particulars of ratings, in accordance with the relevant Parts of these Rules are to be submitted:
• Prime movers, gearing, shafting, propellers and thrust units, see also Part 5.
• Machinery piping systems.
• Electrical installations.
(c) In addition, details of proposals for the redundancy provided in machinery, electrical installations and control systems are to be submitted. These proposals are to take account of the possible loss of performance capability should a component fail. Where a common power source is utilised for thrusters, details of the total maximum load required for thruster-assist are to be submitted.
(d) Plans of control, alarm and safety systems including the following are to be submitted:
• Functional block diagrams of the control system(s).
• Functional block diagrams of the position reference systems and environmental sensors.
• Details of electrical supply to the control system(s), the position reference system(s) and the environmental sensors.
• Details of the monitoring functions of the controllers, sensors and reference system together with a description of the monitoring functions.
• List of equipment with identification of the manufacturer, type and model.
• Details of the overall alarm system linking the centralised control station, subsidiary control stations, relevant machinery spaces and operating areas.
• Details of control stations, e.g., control panels and consoles, including the location of the control stations.
• Factory and customer acceptance test schedules which are to include the methods of testing and the test facilities provided.

1.4.2 Single copies of the following supporting plans, data, calculations or documents are to be submitted:
(a) General:
• Mooring design premise.
• Moored unit details (dimensions and main particulars).
(b) Specifications:
• Materials.
• Equipment and fittings.
• Model testing.
(c) Data reports:
• Environmental criteria.
• Sea bed conditions.
• Soil and soil conditions.
(d) Design reports and calculations:
• Hydrodynamic/motion analysis.
• Mooring analysis.
• Model test results.
• Design load report.
• Anchor line components: strength and fatigue.
• Anchor point: strength and fatigue.
• Anchor point holding capacity.
• Fatigue.
• Equipment/ancillaries including the associated equipment, stoppers and fairleads: strength and fatigue.
• Corrosion protection and/or corrosion allowance.
(e) Other information:
• Installation procedures.
• Installation records for piles and anchors, see also Ch 12.5.
• In-service inspection programme.
Positional Mooring Systems

1.4.3 An Operations Manual, as required by Ch 1,3, is to be submitted and the manual is to contain all necessary information and instructions regarding positional mooring and, where relevant, thruster-assisted positional mooring. It would normally also contain descriptions of the following:

- Mooring systems.
- Laying the mooring system.
- Anchor pre-loading.
- Pre-tensioning anchor lines.
- Tension adjustment.
- Winch/windlass performance.
- Winch/windlass operation.
- Procedure in event of failure or emergency.
- Procedure for operating thrusters.
- Fault-finding procedures for thruster-assist system.
- Maintenance procedures.

Section 2
Survey

2.1 General requirements

2.1.1 Positional moorings, with or without thruster-assist, are to be inspected and tested during manufacture/construction and under working conditions on completion of the installation.

2.1.2 The scope of inspection and/or testing to be carried out at the manufacturer’s works is to be agreed with Lloyd's Register (hereinafter referred to as LR) before the work is commenced.

2.1.3 The general requirements for Periodical Surveys, contained in Pt 1, Ch 2 of the Rules, are to be complied with.

Section 3
Environmental conditions

3.1 General

3.1.1 The Owner/Operator or designer is to specify the environmental criteria for which the unit is to be considered. The extreme environmental conditions applicable to the location are to be specified, together with all operating environmental limits. Detailed specialist environmental reports are to be submitted, with sufficient supporting information to demonstrate the validity of the criteria, see 3.3.

3.1.2 A comprehensive set of operating and extreme environmental limiting conditions is to be submitted. This is to cover the following cases, as applicable, and any other conditions relevant to the system under consideration:

- Extreme environmental conditions.
- Limiting environmental conditions in which the unit and/or ship may remain moored.
- Limiting environmental conditions in which the unit and/or ship’s main operating functions may be carried out (e.g., production and/or transfer of product).
- Limiting environmental conditions in which the unit and/or ship may (re)connect.

3.2 Environmental factors

3.2.1 The following environmental factors are to be considered in the design of the positional mooring system:

- Water depth and tidal variations.
- Wind, including gust spectral characteristics.
- Significant wave height.
- Wave period.
- Wave spectral characteristics.
- Current.
- Relative angles between wind, wave and current.
- Marine growth.
- Air and sea temperatures.
- Sea bed conditions.
- Soil conditions.

3.2.2 In certain locations the following factors may need to be considered in the design of the positional mooring system:

- Ice.
- Seismic events, such as earthquakes.

3.3 Metocean data

3.3.1 As part of the environmental data, the following metocean data will normally be required to be submitted:

- 100, 10 and 1-year return period values for wind-speed, significant wave height and current.
- Directional data for extreme values of wind, waves and current.
- Wave height/period joint frequency distribution (wave scatter diagram).
- Wave spectral parameters.
- Wind/wave/current angular separation data.
- Current speed and/or directional variation over the water depth.
- Long-term wave statistics by direction.

3.4 Environmental parameters

3.4.1 Water depth. Minimum and maximum still water levels are to be determined, taking full account of the tidal range, sea bed subsidence, wind and pressure surge effects. Data is to be submitted to show the variation in water depth in way of the installation. This data is to be referenced to a consistent datum and is to include, where relevant, the water depth in way of each anchor or pile, gravity base or foundation, pipeline manifold, and in way of the radius swept by an attached ship.
3.4.2 Wind. The one-hour wind speed, plus wind gust spectrum, will normally require to be applied in design. The following wind gust spectra formulations can be adopted for the time varying component:
- API RP 2A.
- Other published spectra formulations may be accepted, see Appendix A, A1.2.17.

Estimating wind forces and moments for design input into analysis or model basin wind fields should preferably be done on the basis of wind tunnel tests using an accurate project-specific model.

3.4.3 Waves:
(a) To ensure that the most critical combinations of low frequency and wave frequency response are determined, a broad range of sea states represented by significant wave heights and peak periods will require to be investigated, preferably based on the use of a 100-year contour.
(b) For this approach, a wave contour of significant wave height and peak period combinations will require to be developed, using appropriate extrapolation techniques, to extend shorter term wave height and period joint frequency distribution data. Appropriate methods of developing the wave contour are to be used, see Appendix A, A1.2.18.
(c) The method of determining the wave contour is to be documented and included with the design submission package. Where adequate wave height/period joint distribution data is not available to enable such a contour to be produced, a conservative choice of wave period range will require to be applied in the design.
(d) As the wave spectrum is a combination of wind-driven waves and swell, consideration will need to be given for certain locations, to the joint occurrence and angular separation between these two components.

3.4.4 Current. Design current velocities are to be established, taking account of all relevant components including the following:
- Tidal currents.
- Circulation currents.
- Wind driven current.
- Storm surge generated current.

3.4.5 Marine growth. Account is to be taken in the design of build-up of marine growth on the anchor lines, riser system and/or the hull, and the resulting increase in load and damping. The thickness of marine growth taken into account is to be stated in the Operations Manual and is not to be exceeded in service.

3.4.6 Air and sea temperature. The minimum and maximum air and sea temperatures are to be specified in accordance with Chapter 1.

3.4.7 Sea bed conditions. The sea bed conditions at the proposed locations of the anchor points and along the anchor line corridors are to be determined to provide data for the design of the anchoring system. Requirements for site investigation are contained in Chapter 12.

3.4.8 Soil conditions. The soil conditions at the proposed locations of the anchor points are to be determined to provide data for the design of the anchoring system. Requirements for site investigation are contained in Chapter 12.

3.4.9 Sea ice and icebergs. The design philosophy of units intended to be moored in regions subject to sea ice or icebergs will require to be defined, including any quick-release mooring system arrangements.

3.4.10 Seismic. The requirements for units intended to be moored in regions subject to seismic events, such as earthquakes or tsunamis, will be subject to special consideration.
4.3 Design environmental conditions

4.3.1 Unless agreed otherwise with LR, the following design environmental combinations are to be considered:
(a) 100-year sea state + 100-year wind + 10-year current.
(b) 100-year sea state + 10-year wind + 100-year current.
Joint probabilities of the various environmental actions may be taken into account if such information is available and can be adequately documented.

4.3.2 For 100-year waves, a range of different wave height/period combinations will require to be considered, see 3.4.3.

4.3.3 For a unit and/or ship designed to disconnect from the mooring system, appropriate lower limiting environmental conditions can be applied for the connected cases.

4.3.4 The mooring system with the unit and/or ship disconnected is normally required to be designed for the 100-year criteria referenced above.

4.3.5 For directional combinations, see also 4.4.

4.4 Directional combinations

4.4.1 Sufficient combinations of directions of wind and current relative to wave direction are to be investigated to ensure the critical cases are found. Swell is to be superimposed from the worst case direction, see 3.4.3(d). The following combinations are envisaged as a minimum for design (unless joint directional probabilities of the various environmental actions are available and can be adequately documented):
(a) Wave, wind and current collinear.
(b) Wind and current at 30° to waves.
(c) Wind at 30° to waves, and current at 90° to waves.

4.5 Environmental directions relative to unit and mooring system

4.5.1 For spread moored units, at least head, quartering, beam and down-line directions are to be considered in mooring analysis. Dependent on response analysis and wind, wave and current force/moment calculations, other directions may require to be considered, see also 4.4.

4.5.2 For weathervaning units, the following cases must be considered as a minimum requirement:
- Wave direction along mooring line.
- Wave direction between mooring lines.

4.5.3 Where the mooring lines are grouped, additional wave directions will require to be considered at intermediate headings between the directions given above.

4.5.4 For a positional mooring system without thruster-assist, two conditions will normally need to be analysed:
- loss of highest loaded line leading to highest excursions; and
- loss of second highest loaded line leading to highest line tensions.

4.6 Other design aspects

4.6.1 Anchor lines are to have adequate clearance from subsea equipment such as templates, flowlines, etc.

4.6.2 The design of the mooring system is to take account of the offset limits required by the riser system, and the avoidance of contact between risers and anchor lines.

4.6.3 Where production, or other normal operational activity, is intended to be continued during periods where an anchor line is disconnected for inspection, etc., specific environmental limitations are to be established to ensure that safety factors are maintained even with one line out of action. A similar procedure applies when machinery and equipment cannot remain fully functional during maintenance and inspection.

4.6.4 Wherever practicable, permanent moorings are to be designed to allow removal for repair in reasonable weather of damaged components without seriously reducing the overall safety of the unit as a whole.

4.6.5 In cases where the mooring system is intended to be actively controlled by adjustment of line lengths and tensions, satisfactory evidence must be submitted to show that the adjustment procedure is practical, taking account of winch control and prevailing environmental conditions.

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**Table 10.4.1 Thruster allowance**

<table>
<thead>
<tr>
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<th>TA(1)</th>
<th>TA(2)</th>
<th>TA(3)</th>
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</thead>
<tbody>
<tr>
<td>Operating (Intact)</td>
<td>None</td>
<td>70% of all</td>
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**NOTES**

1. The conditions for assignment of supplementary notations TA(1), TA(2) and TA(3) are defined in Section 14.
2. Net thrust values can be applied in the calculations, to the extent indicated in the Table. The basis for deductions due to thruster-hull, thruster-current and thruster-thruster interference is to be documented and included in the design submission.
3. Refer to 4.1.1 for the Rule basis of failure, including thruster system failure, for damaged case.

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3. Refer to 4.1.1 for the Rule basis of failure, including thruster system failure, for damaged case.
4.6.6 Where units are moored in areas where high velocity currents occur, dynamic excitation due to vortex shedding is to be considered.

4.6.7 Hawse pipes used in the mooring system are to have adequate strength for the imposed loads and when located inside tanks are to be considered for sloshing forces.

Section 5
Design analysis

5.1 General

5.1.1 A comprehensive analysis will be required in all cases and model tests are normally to be performed for ship shape units or unique designs. Validation will be required for each part of the analysis process, by correlation with model tests or other proven method.

5.2 Model testing

5.2.1 The model test programme and test facilities are to be to LR's satisfaction.

5.2.2 The model is to be of an adequate scale and is to fully represent the moored unit. Account is to be taken of the different draughts, deck structures and large equipment appendages such as anchor racks or thrusters. In case of (ultra) deep water moorings, the scale and representation of the moorings will be subject to special consideration.

5.2.3 The tests are to be of sufficient duration to establish the low frequency behaviour, and most probable maxima with sufficient reliability.

5.2.4 The tests are to include means of establishing the effects of green water and/or slamming, through video recordings of the model testing, and by measurement of the following:
- Relative motions.
- Forces on local panels mounted at various locations such as bow area and accommodation.

5.2.5 It is recommended that an initial analysis be performed prior to the start of the model test programme, in order to understand and clarify the conceptual design, and to help focus the model testing on the most important design parameters.

5.3 Analysis aspects

5.3.1 The analysis is to take account of the following:
- The effect of current on wave drift force.
- The effect of water depth on current forces, first order responses and wave drift.

5.3.2 For response analysis, anchor line properties are to be based on the total line diameter including corrosion allowance, see Table 10.8.1.

5.3.3 Weight and elasticity properties of anchor lines are to be obtained from chain or rope manufacturers. This information is to be documented and included in the submission.

5.4 Analysis

5.4.1 The following analyses, which may be combined, are to be carried out and submitted to LR:
- Hydrodynamic analysis of the floating unit.
- Motions analysis of the moored unit.
- Mooring analysis.

5.4.2 The following data has to be derived from the analyses:
- Steady force offsets, and tensions, from wind, current and wave drift.
- Wave frequency motions/accelerations.
- Low frequency offsets and tensions from 2nd order wave drift forces, and wind gust effects.

5.4.3 Time domain or frequency domain analysis methods can be applied. The basis for linearisation of the frequency domain analysis is to be documented.

5.4.4 For low frequency response analysis, the non-linear stiffness characteristics are to be satisfactorily represented. The amplitude of low frequency motion will be highly dependent on system damping from the following:
- Current.
- Wave drift.
- Viscous effects on the hull.
- Anchor lines and risers.
- Wind effects.

Thrust damping may also be applicable in relevant cases and the basis for the damping terms used in the analysis is to be documented and submitted.

5.5 Combination of low and high frequency components

5.5.1 Maximum design values for offset and tension are preferably to be derived from combined wave frequency and low frequency response analyses. The time domain simulations are to be of sufficient length to establish reasonable confidence levels in the predictions of maximum response.

5.5.2 The most probable maximum values for tension and offset can be determined from the distribution of peak loads. The statistical basis (Weibull, etc.) being applied to derive the probability distribution is to be documented and submitted.
5.5.3 Tensions and offset values can be combined as follows, when low frequency and wave frequency analyses are conducted separately:
(a) **Offset:**
\[ X_{\text{MAX}} = X_{\text{MEAN}} + X_{\text{LF sig}} + X_{\text{WF max}} \]
or
\[ X_{\text{MAX}} = X_{\text{MEAN}} + X_{\text{LF max}} + X_{\text{WF sig}} \]
whichever is the greater
where
- \( X_{\text{MAX}} \) = maximum vessel offset
- \( X_{\text{MEAN}} \) = mean vessel offset
- \( X_{\text{LF sig}} \) = significant low frequency offset
- \( X_{\text{LF max}} \) = maximum low frequency offset
- \( X_{\text{WF sig}} \) = significant wave frequency offset
- \( X_{\text{WF max}} \) = maximum wave frequency offset.

(b) **Tension:**
\[ T_{\text{MAX}} = T_{\text{MEAN}} + T_{\text{LF sig}} + T_{\text{WF max}} \]
or
\[ T_{\text{MAX}} = T_{\text{MEAN}} + T_{\text{LF max}} + T_{\text{WF sig}} \]
whichever is the greater
where
- \( T_{\text{MAX}} \) = maximum tension
- \( T_{\text{MEAN}} \) = tension at mean vessel offset
- \( T_{\text{LF sig}} \) = significant low frequency tension
- \( T_{\text{LF max}} \) = maximum low frequency tension
- \( T_{\text{WF sig}} \) = significant wave frequency tension computed at maximum low frequency offset position, \( X_{\text{LF max}} \)
- \( T_{\text{WF max}} \) = maximum wave frequency tension computed at significant wave frequency offset position, \( X_{\text{WF sig}} \).

5.5.4 Estimates of maximum design values can be based on the following:
(a) **Low frequency:**
\[ X_{\text{LF sig}} = 2\sigma_{x_{\text{LF}}} \]
\[ X_{\text{LF max}} = \sigma_{x_{\text{LF}}} \sqrt{2(\ln N_{\text{LF}})} \]
\[ T_{\text{LF sig}} = 2\sigma_{T_{\text{LF}}} \]
\[ T_{\text{LF max}} = \sigma_{T_{\text{LF}}} \sqrt{2(\ln N_{\text{LF}})} \]
where
- \( X_{\text{LF sig}} \) = significant low frequency offset
- \( X_{\text{LF max}} \) = maximum low frequency offset
- \( T_{\text{LF sig}} \) = significant low frequency tension
- \( T_{\text{LF max}} \) = maximum low frequency tension
- \( \sigma_{x_{\text{LF}}} \) = standard deviation of low frequency offset
- \( \sigma_{T_{\text{LF}}} \) = standard deviation of low frequency tension
- \( N_{\text{LF}} \) = number of low frequency oscillations during short-term storm state (not less than three hour storm)
\[ \ln = \log_{e} \]
\[ e = \text{base of natural logarithms, 2.7183.} \]

(b) **Wave frequency:**
\[ X_{\text{WF sig}} = 2\sigma_{x_{\text{WF}}} \]
\[ X_{\text{WF max}} = \sigma_{x_{\text{WF}}} \sqrt{2(\ln N_{\text{LF}})} \]
\[ T_{\text{WF sig}} = 2\sigma_{T_{\text{WF}}} \]
\[ T_{\text{WF max}} = \sigma_{T_{\text{WF}}} \sqrt{2(\ln N_{\text{LF}})} \]
where
- \( X_{\text{WF sig}} \) = significant wave frequency offset
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- \( N_{\text{WF}} \) = number of wave frequency oscillations during short-term storm state (not less than three hour storm)
\[ \ln = \log_{e} \]
\[ e = \text{base of natural logarithms, 2.7183.} \]
6.3.4 Consideration will be given to the use of alternative methods, detailed proposals are to be submitted and agreed with LR.

6.3.5 The minimum factors of safety on the calculated fatigue lives for components of the mooring system are to comply with Table 6.5.2 in Pt 4, Ch 6.

Section 7

Wire ropes

7.1 General

7.1.1 This Section applies to steel wire ropes for offshore positional mooring systems.

7.1.2 Wire ropes and associated fittings are to be of an approved design.

7.2 Rope construction

7.2.1 When selecting a rope construction the following considerations apply:

- Required service life.
- Position in catenary.
- Axial stiffness properties of rope.
- Bending over sheaves, etc.
- Characteristic torsional properties of rope construction.

7.2.2 Various rope constructions can be accepted for long-term mooring applications. These include:

- spiral strand.
- locked coil.
- six-strand.
- Other constructions can be considered.

7.3 Design verification

7.3.1 The design of wire rope and associated fittings is to be verified. The following information will be required for appraisal and information:

- Plans of rope, socket and other fittings.
- Materials.
- Design specification.
- Purchaser’s specification.
- Codes and Standards applied.
- Calculations for the strength and fatigue of rope, socket, fittings, and their corrosion protection.
- Torsional stiffness data.

7.3.2 Data from prototype rope tests is to be made available as required.

7.3.3 Fatigue life calculations for steel wire ropes can be carried out in accordance with a recommended Code, e.g., API RP 2SK: Recommended Practice for Design and Analysis of Stationkeeping Systems for Floating Structures. Rope bending fatigue effects are to be included where relevant.

7.3.4 The minimum factors of safety on the calculated fatigue lives of wire rope and fittings are to comply with Table 6.5.2 in Pt 4, Ch 6.

7.3.5 The rope termination including the socket is to be designed to withstand a load of not less than the minimum breaking strength of the attached wire rope.
7.4 Materials

7.4.1 Steel wire used for rope manufacture is to be manufactured in accordance with a recognised National Standard:
(a) The steel is to be of homogeneous quality, consistent strength, and free from visual defects likely to impair the performance of the rope.
(b) The minimum tensile strength of the wire is to be the tensile strength ordered. The maximum tensile strength is not to exceed the specified minimum strength by more than 230 N/mm². The tensile strength should normally be within the range 1420 to 1770 N/mm².

7.4.2 The material used in the manufacture of sockets is to comply with the following requirements:
(a) Cast sockets:
   - Castings are to be manufactured and tested generally in accordance with Chapter 4 of the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).
   - As a supplement to Chapter 4 of the Rules for Materials, impact tests are to be carried out at a test temperature of minus 20°C, to satisfy a minimum average energy requirement of 40J, with no more than one individual result from each three test specimens being less than 70% of the required minimum average. Increased material toughness may be required in specific cases.
   - Alternative casting standards to Chapter 4 of the Rules for Materials complying with recognised national or proprietary specifications may be accepted, see also Ch 4.1.1.3 of the Rules for Materials.
(b) Fabricated sockets:
   - Plate material to be Grade D or DH quality in accordance with Chapter 3 of the Rules for Materials. Increased material toughness may be required in some cases.
   - Plate with through-thickness properties will generally be required, in accordance with Ch 3,8 of the Rules for Materials.
(c) Socket pins:
   - Socket pins may be cast or forged. Where cast, material requirements are to comply with (a) above. Forged socket pins are to be manufactured in accordance with Chapter 5 of the Rules for Materials.
   - As a supplement to Chapter 5 of the Rules for Materials, impact tests are to be carried out at a test temperature of minus 20°C, to satisfy a minimum average energy requirement of 40J, with no more than one individual result from each three test specimens being less than 70% of the required minimum average. Increased material toughness may be required in specific cases.
   - Alternative standards to Chapter 5 of the Rules for Materials, complying with recognised national or proprietary specifications may be accepted, see also Ch 5,1.1.3 of the Rules for Materials.

7.5 Corrosion protection

7.5.1 Wire ropes are to be protected against corrosion. The corrosion protection will normally consist of galvanising or other sacrificial coating of individual wires. Filler wires of zinc or other suitable sacrificial material can be incorporated in the outer layers of the rope, as an addition to, but not in place of, galvanising of individual wires.

7.5.2 Galvanising is to meet the following minimum standards:
(a) Zinc:
   - BS EN 1179.
(b) Zinc weight:
   - ASTM A 603 Table 5, Class A (spiral strand and locked coil).
   - ISO 2232, Quality B (six-strand ropes).
(c) Alternative recognised Codes or Standards providing acceptable equivalence will be considered.

7.5.3 Sockets are to be protected against corrosion by sacrificial anodes or acceptable equivalent.

7.5.4 Suitable arrangements are to be made to insulate the corrosion protected rope/socket assembly from adjacent non-protected elements in the system.

7.5.5 Polyethylene sheathing can also be used on appropriate rope constructions, as an addition to, but not normally as an alternative to, galvanising:
(a) Where sheathing is intended to be fitted, the specification is to be submitted. ASTM D 1248 is an acceptable specification for medium or high density polyethylene sheathing.
   - A continuous strip of contrasting colour is to be incorporated into the sheathing to aid monitoring for twist.

7.6 Manufacture and testing

7.6.1 Steel wire ropes are to be manufactured in accordance with the design standards and procedures and at a works approved by LR. Ropes and fittings will be subject to LR survey during manufacture and testing.

7.6.2 A certified ISO 9001/9002 Quality System is to be in place and a quality plan is to be produced and agreed with LR’s Surveyors.

7.6.3 Where sheathing is specified, it is to be carried out in accordance with the Quality Plan.

7.6.4 Cast sockets are to be manufactured and tested in accordance with the requirements of 7.4.2(a).
7.6.5 The following minimum requirements for the non-destructive testing of cast sockets are applicable:
(a) **Ultrasonics**: All areas of all sockets and pins.
(b) **Radiography**: Critical areas of first, last, and one intermediate socket selected by the LR Surveyor to be examined. Critical areas to be identified on design drawings, and these to be included in the design submission for verification.
(c) **Magnetic Particle Inspection (MPI)**: 100 per cent of all sockets and pins.
(d) **Visual**: 100 per cent of all sockets and pins.

7.6.6 The material of plate fabricated sockets is to comply with 7.4.2(b) and welding and NDE to be in accordance with Pt 4, Ch 9. Post-weld heat treatment to be carried out for thicknesses exceeding 65 mm.

7.6.7 Tests are to be carried out on individual wires for the following:
- Tensile strength and elongation.
- Torsion.
- Reverse bend.
- Zinc coating: mass, uniformity and adhesion.

Tests are to be carried out in accordance with recognised National Standards such as ISO 2232, and ASTM A603, as appropriate.

7.6.8 Rope production samples are to be tested for the following:
- Modulus.
- Minimum breaking strength.

7.6.9 The tests required by 7.6.8 are to be as follows:
(a) The modulus test is to be carried out on one finished rope sample taken from the first production length. Production sockets need not be fitted for this particular test. Load/extension characteristics and permanent stretch are to be determined and documented. Acceptance criteria for permanent stretch is to be as follows:
- Maximum of 0,4 per cent for spiral strand and locked coil ropes.
- Maximum of 0,8 per cent for six-strand ropes.

The modulus of elasticity is to be calculated and documented. The basis for the calculated value (cross-sectional metallic area, or area of circle enclosing the rope) is to be clearly stated.

(b) Breaking load test is to be carried out on one sample taken from each manufactured length.
- Where the rope design, the machine, and the machine settings are identical, consideration can be given to a reduction in the number of tests. As a minimum, breaking load tests are to be carried out on a sample taken from each of the first manufactured length, and one other length, selected by LR Surveyors.
- Tests are to be carried out in accordance with a recognised National Standard such as DIN 51201.

- One of the rope samples is to be fitted at one end with a socket taken from the project production batch, and socketed in accordance with approved procedures. Where more than one socket design type is involved, a further assembly is to be tested for each different type of socket.
- The rope sample and the production socket is to withstand the specified minimum breaking load. The socket pin is to be able to be removed after the test, and replaced, without the application of undue force.
- NDE to be carried out on the socket following testing (100 per cent visual and 100 per cent MPI).

7.7 **Identification**

7.7.1 Each wire rope assembly is to be marked at each end with the letters LR and the Certificate Number.

7.8 **Certification**

7.8.1 A certificate is to be issued for each rope assembly by LR. The following is to be included in the Certificate:
- Purchaser's name and order number.
- Description of order, including wire rope diameter and construction.
- Tested minimum breaking load.
- Design Appraisal Document Number.
- Socket inspection certificate references.
- Individual wire certificate references.
- Sheathing report references.

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### Section 8

**Chains**

#### 8.1 **Chain grades**

8.1.1 Chains to be offshore Grades R3, R3S, or R4 and are to comply with Ch 10,3 and Ch 10,4 of the Rules for Materials, as applicable. Acceptance of other grades will be subject to special consideration.

#### 8.2 **Corrosion and wear**

8.2.1 A size margin over and above the minimum chain size required to satisfy Rule factor of safety requirements is to be included to allow for the corrosion and wear which can occur over the intended service life of the anchor chain or associated component. The minimum margins shown in Table 10.8.1 are recommended.
Section 9
Provisional requirements for fibre ropes

9.1 General
9.1.1 This Section gives provisional requirements for fibre ropes used in positional mooring systems. The requirements apply to fibre ropes incorporated as follows:

(a) Catenary mooring system:
- Fibre rope insert lines, these being confined to the suspended part of the catenary system. Chain or wire rope will be fitted in parts of the anchor leg subject to contact with sea bed or floating unit.

(b) Taut-leg moorings:
- In this case, fibre rope will form the majority of the anchor leg's length. System compliancy will come from the inherent extensibility of the fibre rope. Chain will be fitted at upper and lower parts of the taut leg, where hard contact can occur.
- Special consideration will be given to other types of fibre rope mooring application.

9.2 Design aspects
9.2.1 Fibre ropes and associated fittings are to be of an approved design. The following information to be submitted:

(a) Specifications:
- Rope purchaser's specification.
- Rope design specification.
- Rope manufacturing and testing specification.

(b) Plans:
- Rope, spool piece and other fittings.

(c) Calculations:
- Strength and fatigue of rope and fittings.

(d) Rope particulars:
- Fibre type.
- Diameter of rope.
- Length at specified tension.
- Construction.
- Weight in air and water.
- Sheathing type.
- Terminations.
- Bend limiters.

Table 10.8.1 Chain size corrosion and wear margins

<table>
<thead>
<tr>
<th>Region of anchor chain</th>
<th>Margin (mm per year service life, on chain diameter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splash zone</td>
<td>0.3</td>
</tr>
<tr>
<td>Catenary</td>
<td>0.2</td>
</tr>
<tr>
<td>Touch down zone and sea bed</td>
<td>0.4</td>
</tr>
</tbody>
</table>

NOTE Additional margins greater than those indicated in the Table may be required where chains are subjected to high wear rates.

9.2.2 Factors of safety for fibre rope anchor line elements are to be a minimum of 20 per cent higher than the levels given in Section 6 for chain and wire rope materials.

\[
\text{Factor of Safety} = \frac{\text{Minimum breaking strength}}{\text{Maximum tension}}
\]

A reduction factor will require to be applied to the standard designated Minimum Breaking Strength, where the test database for the rope type is statistically small.

9.2.3 The fibre rope section of an anchor leg is not to touch the sea bed in any intact or damaged condition.

9.2.4 Fibre ropes are to be kept sufficiently far below the waterline, and below the connection point on the unit, to avoid any possibility of contact damage.

9.3 Manufacture
9.3.1 Fibre ropes are to be manufactured at a works approved by LR.

9.3.2 Ropes and fittings will be subject to LR survey during manufacture and testing.

9.3.3 A certified ISO 9001/9002 Quality System is to be in place and a quality plan is to be produced and agreed with LR Surveyors.

9.3.4 The ropes and fittings are to be manufactured in accordance with the approved design, standards and procedures.

9.3.5 See also requirement of Ch 10,7 of the Rules for Materials.

Section 10
Anchor points

10.1 Drag embedment anchors – Structural aspects

10.1.1 This sub-Section, and 10.2, apply to drag embedment anchors of high holding power type. Proposals for the use of other anchor types will be specially considered.
10.1.2 Anchors are to be of an approved type.

10.1.3 Material selection for drag embedment anchors are, generally, to be in accordance with Pt 4, Ch 2,4, taking the structural category as ‘Primary’.

10.1.4 Supporting calculations to verify the structural strength of the anchor for design service loads and for proof test loads are to be submitted.

10.1.5 The anchors are to be manufactured in accordance with the requirements of Chapter 10 of the Rules for Materials.

10.1.6 Anchors are to be subject to proof test loading in the manner laid down in the Rules. The level of proof test loading for positional mooring anchors is 50 per cent of the minimum rated breaking strength of the attached anchor line.

10.1.7 Proof load testing of large fabricated anchors (in excess of 15 tonnes mass) may be waived for classification, subject to the following:

(a) Structural strength of anchor type being verified by finite element analysis procedure.

(b) All main structural welds being subject to non-destructive examination as follows at manufacture:
   - 100 per cent visual.
   - 100 per cent MPI.
   - 100 per cent UT/radiographic, for full penetration welds.

10.1.8 Notwithstanding the above, attention is drawn to the separate requirement of some National Authorities for proof load testing of anchors.

10.2 Drag embedment anchors – Holding capacity

10.2.1 The requirements of 10.1 are also to be considered, in addition to this sub-Section.

10.2.2 The following information is to be submitted:
   - Soils data for the anchor locations.
   - Data, calculations and analysis supporting the selection of anchor.
   - Anchor details.
   - Proposed test loading at installation.

10.2.3 Factors of safety for anchor holding capacity are not to be less than the values given in Table 10.10.1.

10.2.4 An acceptable basis for drag anchor design is contained in Ch 12,4.

10.2.5 All anchors will require to be test loaded at installation, to the satisfaction of LR Surveyors. The installation test load is to be agreed, but is normally not to be less than 80 per cent of the maximum Intact Load. The test load is not, however, to exceed 50 per cent of the minimum breaking strength of the anchor line. The test load is to be held for a minimum of 20 minutes.

### Table 10.10.1 Factors of safety for anchor holding capacity

<table>
<thead>
<tr>
<th>Design case</th>
<th>Anchor load case</th>
<th>Factor of safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>Static load, see Note 1</td>
<td>2.0</td>
</tr>
<tr>
<td>Intact</td>
<td>Dynamic load, see Note 1</td>
<td>1.5</td>
</tr>
<tr>
<td>Damaged</td>
<td>Dynamic load</td>
<td>1.15</td>
</tr>
</tbody>
</table>

**NOTES**
1. Static load refers to steady plus low frequency load components. Dynamic load refers to static plus wave frequency components of loading.
2. Increased factors of safety will require to be applied where the data supporting the anchor selection is not considered adequate in a particular case.
3. Where the use of vertically loaded anchors (VLAs) is proposed, for soft soil areas, special consideration will be given to required factors of safety.

10.3 Anchor piles

10.3.1 This sub-Section applies to anchor piles which are either driven or drilled and grouted into the sea bed to provide resistance to axial, lateral and torsional loading. Piles installed by vibrating hammers are not recommended where axial loading is significant.

10.3.2 Anchor piles are characterised by being relatively long and slender and having a length to diameter or width ratio generally greater than 10.

10.3.3 The anchor pile design is to be approved by LR.

10.3.4 The anchor pile is to be designed to provide sufficient ultimate capacity to resist the maximum applied axial, lateral and torsional loads with appropriate factors of safety based on a working stress design approach.

10.3.5 Anchor piles designed to resist the maximum applied vertical, lateral and torsional loads with appropriate loads and resistance coefficient based on a load and resistance factor design approach are to be specially considered. In addition to performing ultimate limit state (ULS) analyses for anchor pile stability, serviceability limit state (SLS) analyses should also be performed to assess pile deflection and rotation.

10.3.6 Table 10.10.2 defines the design case and factors of safety to be used for anchor piles for a catenary mooring system. Table 10.10.2 does not apply to axial capacity of piles installed by vibrating hammers.

10.3.7 Table 10.10.3 defines the design case and factors of safety to be used for anchor piles for a taut-leg mooring system. Table 10.10.3 does not apply to axial capacity of piles installed by vibrating hammers.

10.3.8 The factors of safety given in Table 10.10.3 are applicable to anchor pile groups for taut-leg mooring systems. Individual anchor piles within a group are to achieve a minimum factor of safety of 1.5.
10.3.9 Anchor pile analysis is generally performed using a beam-column finite element analysis with the soil resistance modelled using non-linear axial and lateral load-deflection response curves. The axial and lateral pile behaviour is considered to be uncoupled except for the effect of axial load on pile bending stresses, p-y effect. For anchor pile analysis performed using a continuum finite element model of the pile and soil, sufficient load cases should be analysed to investigate the effects of axial, lateral and combined axial and lateral loading on pile stability considering the factors of safety given in Tables 10.10.2 and 10.10.3.

<table>
<thead>
<tr>
<th>Table 10.10.2</th>
<th>Minimum factors of safety for anchor piles for a catenary mooring system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design case</td>
<td>Anchor load case</td>
</tr>
<tr>
<td>Intact</td>
<td>Static load, see Note 1</td>
</tr>
<tr>
<td>Intact</td>
<td>Dynamic load, see Note 2</td>
</tr>
<tr>
<td>Damaged</td>
<td>Dynamic load</td>
</tr>
</tbody>
</table>

**NOTES**
1. Static load refers to steady plus low frequency components of loading.
2. Dynamic load refers to static plus wave frequency components of loading.

10.3.13 Consideration could be given to performing special tests, such as centrifuge model tests, to provide a better understanding of anchor pile behaviour.

10.3.14 The anchor pile response under lateral and torsional loading is to be determined to ensure that deflections and rotations remain within tolerable limits. The effect on capacity of scouring of sea bed soils around the anchor pile is to be considered, unless the pile head is to be installed below sea bed level.

10.3.15 Consideration is to be given to the possible formation of a posthole at the pile head and its effect on capacity.

10.3.16 No account is to be taken of soil suction at the pile tip or the effect of rate of loading.

10.3.17 Analysis of the anchor pile/soil interaction response is to take into account the non-linear stress/strain behaviour of the foundation soils and the stress history and cyclic loading effects on soil resistance. Allowance is to be made for the response of different soil types.

10.3.18 An acceptable basis for anchor pile design is contained in Ch 12.6.

<table>
<thead>
<tr>
<th>Table 10.10.3</th>
<th>Minimum factors of safety for anchor piles for a taut-leg mooring system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design case</td>
<td>Anchor load case</td>
</tr>
<tr>
<td>Intact</td>
<td>Static load, see Note 1</td>
</tr>
<tr>
<td>Intact</td>
<td>Dynamic load, see Note 2</td>
</tr>
<tr>
<td>Damaged</td>
<td>Dynamic load</td>
</tr>
</tbody>
</table>

**NOTES**
1. Static load refers to steady plus low frequency components of loading.
2. Dynamic load refers to static plus wave frequency components of loading.

10.3.21 A driveability study should be performed for driven anchor piles to assess the driving stresses in both the anchor pile and connection between the anchor line and pile.

10.3.22 A fatigue damage assessment should be performed for both the anchor pile and connection between the anchor line and pile, taking into account stress ranges due to environmental loading and pile driving, where appropriate. Particular attention should be given to any stiffening arrangement of the connection between the anchor line and pile. For certain soil conditions, stiffening arrangements internal to the pile can have a significant influence on the number of hammer blows required to achieve design pile penetration during driving and the fatigue damage.

10.3.23 Consideration is to be given to the anchor pile installation tolerances on verticality and orientation when designing the connection between the anchor line and pile.

10.3.24 The connection between the anchor line and anchor pile is to be designed so as to minimise disturbance to the sea bed soils during pile installation, which could reduce the axial and lateral resistance provided by the anchor pile. Reduction in anchor pile capacity is to be taken into account.
Positional Mooring Systems

10.3.25 Details of the proposed method of anchor pile and anchor line installation are to be submitted. Consideration is to be given to the tolerances associated with anchor pile verticality and orientation.

10.3.26 Requirements for anchor pile installation are contained in Ch 12.6.

10.3.27 Anchor piles are not required to be test loaded at installation. However, for catenary mooring systems, pre-loading of the anchor line is to be carried out to ensure its alignment through the sea bed soil.

10.3.28 For taut-leg mooring systems, consideration is to be given to the provision of a monitoring system for the measurement of long-term vertical movements of the anchor piles relative to the surrounding soil.

10.4 Suction anchor piles

10.4.1 This sub-Section applies to anchor piles which are installed by suction to achieve the required penetration into the sea bed to provide resistance to axial, lateral and torsional loading. Suction is applied by creating a reduced water pressure within the pile compared to the external ambient water pressure. Suction anchor piles can be retrieved from the sea bed by reversing the suction process.

10.4.2 Suction anchor piles are characterised by having a large diameter and a length to diameter ratio generally less than eight and are essentially caisson-type foundations if it is less than three.

10.4.3 The suction anchor pile design is to be approved by LR.

10.4.4 The suction anchor pile is to be designed to provide sufficient ultimate capacity to resist the maximum applied axial, lateral and torsional loads with appropriate factors of safety based on a working stress design approach.

10.4.5 Suction anchor piles designed to resist the maximum applied vertical, lateral and torsional loads with appropriate load and resistance coefficients based on a load and resistance factor design approach are to be specially considered. In addition to performing ultimate limit state (ULS) analyses for suction anchor pile stability, serviceability limit state (SLS) analyses should also be performed to assess pile deflection and rotation.

10.4.6 Table 10.10.4 defines the design case and factors of safety to be used for suction anchor piles for a catenary mooring system.

10.4.7 Table 10.10.5 defines the design case and factors of safety to be used for suction anchor piles for a taut-leg mooring system.

10.4.8 Appropriate failure modes for the soil are to be considered when evaluating the ultimate capacity of suction anchor piles. The installation tolerances are to be considered when assessing failure modes for the soil.

10.4.9 Suction anchor pile analysis is generally performed using either a continuum finite element model or a limit plasticity model of the pile and soil in order to assess appropriate failure modes. Sufficient load cases should be analysed to investigate the effects of axial, lateral and combined axial and lateral loading on suction anchor pile stability considering the factors of safety given in Tables 10.10.4 and 10.10.5.

10.4.10 The possible variation in inclination of the applied loading to the suction anchor pile is to be taken into account.

10.4.11 Consideration is to be given to the effects of cyclic loading on suction anchor pile capacity.

10.4.12 For suction anchor piles subjected to permanent tension loads, consideration is to be given to long term changes to soil stresses around the suction anchor pile and upward creep.

10.4.13 Consideration is to be given to performing special tests, such as centrifuge model tests, to provide a better understanding of suction anchor pile behaviour.
10.4.14  The suction anchor pile response under lateral and torsional loading is to be determined to ensure that deflections and rotations remain within tolerable limits. The effect on capacity of scouring of sea bed soils around the anchor piles is to be considered.

10.4.15  Consideration is to be given to the possible formation of a posthole at the pile head and its effect on capacity.

10.4.16  No account is to be taken of soil suction at the pile tip or the effect of rate of loading, unless the suction anchor pile is provided with a cap and suction can be justified based on rate of loading and soil permeability.

10.4.17  Analysis of the suction anchor pile/soil interaction response is to take into account the non-linear stress/strain behaviour of the foundation soils and the stress history and cyclic loading effects on soil resistance. Allowance is to be made for the response of different soil types.

10.4.18  An acceptable basis for suction anchor pile design is contained in Ch 12,6.

10.4.19  The suction anchor pile is to have sufficient strength to account for the stresses due to extreme operating and installation loading conditions in accordance with Chapter 12 and Part 10 (for ship units). Where necessary, a detailed finite element stress analysis is to be carried out.

10.4.20  The connection between the anchor line and suction anchor pile is to be suitably designed in accordance with Pt 4, Ch 7,1. Where necessary, a detailed finite element stress analysis is to be carried out.

10.4.21  A fatigue damage assessment should be performed for both the suction anchor pile and connection between the anchor line and suction pile taking into account stress ranges due to environmental loading. Particular attention should be given to any stiffening arrangement of the connection between the anchor line and pile.

10.4.22  Consideration is to be given to the suction anchor pile installation tolerances on verticality and orientation when designing the connection between the anchor line and suction anchor pile.

10.4.23  The connection between the anchor line and suction anchor pile is to be designed so as to minimise disturbance to the sea bed soils during pile installation, which could reduce the axial and lateral resistance provided by the suction anchor pile. Reduction in suction anchor pile capacity is to be taken into account.

10.4.24  Details of the proposed method of suction anchor pile and anchor line installation are to be submitted. Consideration is to be given to the tolerances associated with suction anchor pile verticality and orientation and also to the internal soil heave.

10.4.25  Requirements for suction anchor pile installation are contained in Ch 12,6.

10.4.26  Suction anchor piles are not required to be test loaded at installation. However, for catenary mooring systems, preloading of the anchor line is to be carried out to ensure its alignment through the sea bed soil.

10.4.27  For taut-leg mooring systems, consideration could be given to the provision of a monitoring system for the measurement of long-term vertical movements of the suction anchor piles relative to the surrounding soil.

10.5  Gravity anchors

10.5.1  This sub-Section applies to gravity frame or block anchors, which rely on their mass to provide resistance to vertical, lateral and torsional loading. Gravity anchors may be provided with skirts which penetrate the sea bed to provide increased lateral resistance.

10.5.2  The gravity anchor design is to be approved by LR.

10.5.3  The gravity anchor is to be designed to resist the maximum applied vertical, lateral and torsional loads with appropriate load and material coefficients based on a load and resistance factor design approach.

10.5.4  A material coefficient for soil of 1,25 is to be applied to the design shear strength, tangent of the angle of internal friction of the soil and tangent of the angle of interface friction between the soil and gravity anchor.

10.5.5  Appropriate load coefficients will be specially considered for particular applications for catenary and taut-leg mooring systems.

10.5.6  Appropriate failure modes for the soil are to be considered when evaluating the ultimate capacity of gravity anchors. The installation tolerances are to be taken into account when assessing failure modes for the soil.

10.5.7  The possible variation in inclination of the applied loading to the gravity anchor is to be taken into account.

10.5.8  Consideration is to be given to the effects of cyclic loading on gravity anchor capacity.

10.5.9  Consideration is to be given to performing special tests, such as centrifuge model tests, to provide a better understanding of gravity anchor behaviour.

10.5.10  The gravity anchor response under vertical, lateral and torsional loading is to be determined to ensure that deflections and rotations remain within tolerable limits.

10.5.11  Consideration is to be given to the possible scouring of sea bed soils around the gravity anchor and its effect on capacity.

10.5.12  No account is to be taken of soil suction or the effect of rate of loading.
10.5.13 Analysis of the gravity anchor/soil interaction response is to take into account the non-linear stress/strain behaviour of the foundation soils and the stress history and cyclic loading effects on soil resistance. Allowance is to be made for the response of different soil types.

10.5.14 An acceptable basis for gravity anchor design is contained in Ch 12,7.

10.5.15 The gravity anchor is to have sufficient strength to account for the stresses due to survival, operating and installation loading conditions in accordance with Ch 12,7 and Part 10 (for ship units). Where necessary, a detailed finite element stress analysis is to be carried out. Reinforced concrete gravity anchors are to be specially considered.

10.5.16 The connection between the anchor line and gravity anchor is to be suitably designed in accordance with Pt 4, Ch 7,1. Where necessary, a detailed finite element stress analysis is to be carried out.

10.5.17 A fatigue damage assessment should be performed for the connection between the anchor line and gravity anchor, taking into account stress ranges due to environmental loading. Particular attention should be given to any stiffening arrangement of the connection between the anchor line and gravity anchor.

10.5.18 Consideration is to be given to the gravity anchor installation tolerances on inclination and orientation when designing the connection between the anchor line and gravity anchor.

10.5.19 Details of the proposed method of gravity anchor and anchor line installation are to be submitted. Consideration is to be given to the tolerances associated with gravity anchor inclination and orientation and skirt penetration, if applicable.

10.5.20 Requirements for gravity anchor installation are contained in Chapter 12,7.

10.5.21 Gravity anchors are not required to be test loaded at installation. However, for catenary mooring systems, pre-loading of the anchor line is to be carried out to ensure its alignment along the sea bed.

11.1.2 The minimum operating range of the fairlead to be considered in conjunction with the design load is shown in Fig. 10.11.1.

11.1.3 Fairleads and stoppers and their supporting structures are to be designed for a load equivalent to either mooring line maximum design load when defined or the rated minimum break strength of the anchor line, but see also 11.1.8 and Pt 4, Ch 7,1.1.6.

11.1.4 The maximum permissible stresses for the design criteria given in this sub-Section are to be in accordance with Pt 4, Ch 6,2.1.1(c).

11.1.5 Materials and steel grades are generally to comply with the requirements given in Pt 4, Ch 2 for primary structures.

11.1.6 Chain cable fairleads are to have a minimum of five pockets.
Wire rope fairleads are generally to have a minimum diameter of 16 times the wire rope diameter.

Special consideration will be given to permissible stresses where the chain is of downgraded quality. There have been cases of closing plates on the fairlead shaft coming loose due to corrosion of the threads of the securing bolts, resulting in serious damage to the fairlead arrangements and the complete jamming of the fairlead and chain. Consequently, the securing bolts should also be checked to ensure that the bolt material does not corrode preferentially should the sacrificial anode system fail to function in way of the fairlead.

Section 12
Anchor winches and windlasses

12.1 General

This Section applies to winches and windlasses designed actively to control anchor line tensions in-service, or to release anchor lines in an emergency.

Special consideration will be given to requirements for winches and windlasses for passive mooring systems, or permanent mooring systems.

Machinery items are to be constructed to recognised design Codes and Standards. The relevant requirements of Part 5 may be used as guidance for small and simple equipment, but for larger and more complex designs, special analysis techniques such as finite element methods (or equivalent) are considered to be more appropriate.

Machinery items are to be installed and tested in accordance with the relevant requirements of Part 5. For electrical and control equipment, see Section 13.

12.2 Materials

Materials are to comply with the Rules for Materials. Alternatively, materials which comply with national or proprietary specifications may be accepted, provided that these specifications give reasonable equivalence to the requirements of the Rules for Materials, or are approved for a specific application. Generally, survey and certification are to be carried out in accordance with the requirements of the Rules for Materials.

For the selection of material grades, individual components of anchor winches and windlasses are to be categorised as primary or secondary.

Components where the failure would result in the loss of a primary function of the winch or windlass are to be considered to be ‘primary components’, see also 12.2.5.

All other components where the failure would not result in the loss of a primary function of the winch or windlass are to be categorised as ‘secondary components’.

Primary components which are designed with an adequate degree of redundancy in their operation will be specially considered and may be categorised as secondary.

Material grades for all components are in general related to the thickness of the material, the structural category and the minimum design air temperature and are to be selected to provide adequate notch toughness.

Material grades for welded plate components are in general to comply with Pt 4, Ch 2.4. For thicker plates and/or lower design temperature the steel grades will be specially considered.

Material grades for components which are not subject to welding will be specially considered.

Castings and forgings are to comply with Chapters 4 and 5 of the Rules for Materials respectively and the requirements for notch toughness in relation to the design air temperature will be specially considered.

Non-ductile materials are not to be used for torque transmitting items or for those elements subject to tensile/bending stresses.

Spheroid graphite iron castings are to comply with Ch 7,3 of the Rules for Materials, Grades 370/17 or 400/12, or to an equivalent National Standard.

The use of grey iron castings will be subject to special consideration. Where approved, they are to comply with the requirements of Ch 7,2 of the Rules for Materials. This material is not to be used for gear components.

Brake lining materials are to be compatible with operating environmental conditions.

12.3 Brakes

Each anchor winch or windlass is required to have one primary braking system and one secondary braking system. The two systems are to operate independently. The requirements of 12.5 are to be complied with.

The braking action of the motor unit may be used for secondary braking purposes where the design is suitable.

A residual braking force of at least 50 per cent of the maximum braking force required by 12.5.1 is to be immediately available and automatically applied in the event of a power failure.

12.4 Stoppers

If the winch motor is to be used as a secondary brake then a stopper is to be provided to take the anchor line load during maintenance of the primary brake.
Positional Mooring Systems  

Part 3, Chapter 10  

Section 12

12.4.2 The stopper may be one of two different types: a pawl stopper fitted at the cable lifter/drum shaft, or a stopper acting directly on the anchor line.

12.4.3 Where the stopper acts directly on the cable, its design is to be such that the cable will not be damaged by the stopper at a load equivalent to the rated breaking strength of the cable.

12.4.4 See also 13.4.11 and 13.4.12, for stopper control station requirements, and 13.4.6, for emergency release of stoppers.

12.5 Winch/windlass performance

12.5.1 The primary brake is required to hold a static load equal to the minimum break strength of the anchor line (at the intended outer working layer of wire rope on storage drum winches). The static load capacity of the primary brake can be reduced to 80 per cent of that value when a stopper capable of holding 100 per cent of the breaking strength of the line is fitted.

12.5.2 The secondary brake is required to hold a static load equal to 50 per cent of the minimum breaking strength of the anchor line.

12.5.3 For passive or permanent positional mooring systems the primary brake is required to hold a static load equal to 150 per cent of the winch/windlass capacity, when isolated from operational/survival mooring line loads using a stopper. A secondary brake is not required in this case.

12.5.4 The anchor winch or windlass is to have adequate dynamic braking capability. The two brake systems in joint operation are to be capable of fully controlling without overheating, the anchor lines during:
- all anchor handling operations;
- adjustment of anchor line tensions. (This is particularly relevant where the mooring system has been designed and sized on the basis of active adjustment of anchor lines in extreme conditions, to minimise line tensions.)

12.5.5 See also 13.4 for control of winches, windlasses, stoppers and paws, for brake fail-safe requirements and standby power for operation of brakes and release of stoppers in the event of a failure of normal power supply.

12.5.6 Means are to be provided to enable the anchor lines to be released from the unit after loss of main power.

12.5.7 The pulling force of the winches or windlasses is to be sufficient to carry out anchor pre-loading on location, to the necessary level. A minimum low-speed pull equal to 40 per cent of the anchor line breaking strength is recommended.

12.6 Strength

12.6.1 Design load cases for the winch or windlass assembly and the stopper, when fitted, are given in Table 10.12.1. The associated maximum allowable stresses are to be based on the factors of safety given in Table 10.12.2.

Table 10.12.1 Design load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Condition</th>
<th>Anchor line load percentage of break strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Winch braked</td>
<td>100%, see Note</td>
</tr>
<tr>
<td>2</td>
<td>Stopper engaged</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>Winch pulling</td>
<td>40% or specified duty pull if greater</td>
</tr>
</tbody>
</table>

NOTE Where a stopper is fitted, the anchor line load in Case 1 may be taken as the brake slipping load, but is not to be less than 80% of the break strength of the anchor line.

Table 10.12.2 Load case factors of safety

<table>
<thead>
<tr>
<th>Stress</th>
<th>Load case</th>
<th>1 and 2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear</td>
<td>1.89</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Tension, compression, bending</td>
<td>1.25</td>
<td>1.67</td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>1.11</td>
<td>1.43</td>
<td></td>
</tr>
</tbody>
</table>

NOTES 1. Factors of safety relate to tensile yield stress.
2. Combined stress = \(\sqrt{\sigma_X^2 + \sigma_Y^2 - \sigma_X\sigma_Y + 3\tau^2}\)
Where \(\sigma_X\) and \(\sigma_Y\) are the combined axial and bending stresses in the X and Y directions respectively and \(\tau\) is the combined shear stress due to torsion and/or bending in the X-Y plane.

12.7 Testing

12.7.1 Tests are to be carried out at the manufacturer’s works in the presence of the Surveyor, on at least one of the winches or windlasses out of the total outfit for the unit. The tests to be carried out are given in Table 10.12.3. Alternatively, where a prototype winch has been suitably tested, consideration will be given to the acceptance of these results.

12.7.2 The residual braking capability is to be verified in accordance with 12.5.4.

12.7.3 Each winch or windlass is to be tested on board the vessel in the presence of the Surveyor, to demonstrate that all main aspects including dynamic brakes function satisfactorily. The proposed test programme is to be submitted.
12.8 Type approval

12.8.1 Winches or windlasses may be Type Approved in accordance with LR’s Type Approval Scheme. Where this type approval is obtained, the requirements of 12.7.1 may not be applicable.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static brake – Primary</td>
<td>100% anchor line break strength (or 80% where stopper fitted, see 12.5.1)</td>
</tr>
<tr>
<td>Static brake – Secondary</td>
<td>50% anchor line break strength</td>
</tr>
<tr>
<td>Stopper (where fitted)</td>
<td>100% anchor line break strength</td>
</tr>
<tr>
<td>Motor stall test</td>
<td>Specified stall load</td>
</tr>
</tbody>
</table>

13.3 Control aspects – Disconnectable mooring systems

13.3.1 This sub-Section is applicable to units or ships which are disconnectable to avoid hazards or severe storm conditions.

13.3.2 Power, control and thruster systems and other systems necessary for the correct functioning of the positional system are to be provided and configured such that a fault in any active component will not result in a loss of position.

13.3.3 At least two automatic control systems are to be provided and arranged to operate independently.

13.3.4 Adequate controls are to be provided at the control station for satisfactory operation of the connect/disconnect mechanism.

13.3.5 Hydraulic and electrical systems are to be served by two means of power supply. Failure of the main supply is to activate an alarm.

13.3.6 Where the mooring system is designed on the basis of the unit or ship disconnecting at limiting environmental levels below the 100-year extreme case required by 4.3, means are to be provided to enable the rapid release of the unit or ship as applicable from the mooring system in an emergency. The quick-disconnect system is to be based on single operation at the control station, and may be independent of the normal control system.

13.3.7 Suitable fail-safe measures are to be provided to prevent inappropriate or inadvertent disconnection of the mooring system.

13.3.8 The reconnection of a disconnectable unit or ship is to be to the satisfaction of LR Surveyors.

(f) Offloading tanker status:
   • position.
   • heading.
   • hawser tension.
   • offloading hose connections status.

13.2.5 Alarms are to be provided for the following fault conditions, as applicable:
   (a) Deviation from positional limits.
   (b) Deviation from heading limits.
   (c) Deviation from anchor line tension limits (high and low).
   (d) Gyro compass fault.
   (e) Position reference system fault.
   (f) Wind speed and direction indicator fault.
   (g) Offloading tanker deviation from attached limits.
   (h) Control computer system fault.
   (i) Turret/unit relative heading limit exceedence.
### 13.4 Controls of winch and windlass systems

13.4.1 This sub-Section is applicable to mooring systems incorporating winches, windlasses, etc., which are used to actively control and adjust anchor line tensions in-service, or to release anchor lines in an emergency.

13.4.2 Adequate controls are to be provided at the local control station for satisfactory operation of the winch(es).

13.4.3 The braking system is to be arranged so that the brakes, when applied, are not released in the event of a failure of the normal power supply.

13.4.4 Standby power is to be provided to enable winch brakes to be released within 15 seconds in an emergency. The release arrangements are to be operable locally at each winch and from the central control position, and are to be such that the entire anchor line can be lowered in a controlled manner.

13.4.5 The standby power is to be such that during lowering of the anchor line it is possible to apply the brakes once and then release them again in a controlled manner.

13.4.6 Standby power is to be provided so that any anchor line stoppers or pawl mechanisms may be released from either the local or central control stations up to a line tension equal to the minimum rated break strength of the anchor line. These mechanisms are to be capable of release at the maximum angles of heel and trim under the damage stability and flooding conditions for which the unit is designed.

13.4.7 At least one position reference system and one gyrocompass or equivalent is to be provided, when applicable, to ensure the specified area of operation and heading deviation can be effectively monitored.

13.4.8 Position reference systems are to incorporate suitable position measurement techniques which may be by means of acoustic devices, radio, radar, taut wire, riser angle, gangway extension and angle or other acceptable means, depending on the service conditions for which the unit is intended.

13.4.9 A vertical reference sensor is to be provided, if applicable, to measure the pitch and roll of the unit.

13.4.10 Means are to be provided to ascertain the wind speed and direction acting on the unit.

13.4.11 The operation of winches, windlasses and associated brakes, chain stoppers and pawls is to be controlled locally from weather protected control stations which provide good visibility of the equipment and associated anchor handling operations.

13.4.12 A central control station, which may be located on the bridge or a separate manned control room, is to be provided from which brakes, chain stoppers and pawls can be remotely released.

13.4.13 For each anchor winch the respective local control station is to be provided with a means of indicating the following:

- (a) Line tension.
- (b) Length of line paid out.
- (c) Line speed.

13.4.14 The indication required by 13.4.13(a), and (b), is to be repeated to the central control station and in addition a means of indicating the following is to be provided at this position:

- (a) Mooring patterns and anchor line catenaries.
- (b) Status of winch operation.
- (c) Position and heading, see also 13.4.7.
- (d) Gangway angle and extension, when applicable.
- (e) Riser angle, when applicable.
- (f) Wind speed and direction, see also 13.4.10.

13.4.15 Means of voice communication are to be provided between the central control station, each local control station and anchor handling vessels, when applicable.

13.4.16 Alarms are to be provided at the local and central control stations for the following fault conditions:

- (a) Excessive line tension.
- (b) Loss of line tension.
- (c) Excessive gangway angle and extension, when applicable.
- (d) Excessive riser angle, when applicable.

13.4.17 Alarms are to be provided adjacent to the winches and windlasses to warn personnel prior to and during any remote operation.

13.4.18 Alarms are to be provided at the central control station for the following fault conditions:

- (a) When the unit deviates from its predetermined area of operation.
- (b) When the unit deviates from its predetermined heading limits.

These alarms are to be adjustable but should not exceed specified limits. Arrangements are to be provided to fix and identify their set points.

### Section 14

**Thruster-assisted positional mooring**

14.1 **General**

14.1.1 Where the positional mooring system is assisted by thrusters, as defined in Section 4, units complying with the requirements of this Section together with the requirements in Section 15 will be eligible for one of the following class notations as specified in 1.2:

| TA (1) | See 15.1 |
| TA (2) | See 15.2 |
| TA (3) | See 15.3 |

14.1.2 Machinery items are to be constructed, installed and tested in accordance with the relevant requirements of Part 5, together with the requirements of 14.2 and Section 15.
14.2 Thrust units

14.2.1 Thruster installations are to be designed to minimise potential interference with other thrusters, sensors, hull or other surfaces which could be encountered in the service for which the unit is intended.

14.2.2 Thruster intakes are to be located at sufficient depth to reduce the possibility of ingesting floating debris and vortex formation.

14.2.3 Steerable thrusters and thrusters having variable pitch propellers are to be provided with two independent supplies of motive power to the pitch and direction actuating mechanisms.

14.2.4 Each thruster unit is to be provided with a high power alarm. The setting of this alarm is to be adjustable and below the maximum thruster output.

14.2.5 The response and repeatability of thrusters to changes in propeller pitch or propeller speed/direction of rotation are to be suitable for maintaining the area of operation and the heading deviation specified.

14.2.6 The thrust unit housing is to be tested at a hydraulic pressure of not less than 1.5 times the maximum when the assignment of the service immersion head of water or 1.5 bar (1.5 kgf/cm²), whichever is the greater.

14.3 Electrical equipment

14.3.1 The electrical installation is to be designed, constructed and installed in accordance with the relevant requirements of Pt 6, Ch 2, together with the requirements of 14.3.3 to 14.3.8, and the relevant requirements of Section 15.

14.3.2 Where the thruster units are electrically driven, the relevant requirements, including surveys, defined in Pt 6, Ch 2,15 are to be complied with.

14.3.3 The total generating capacity is to be in accordance with 15.1.3, 15.2.8 and 15.3.8, as applicable.

14.3.4 Where the electrical power requirements are supplied by one generator set, on loss of power there is to be provision for automatic starting and connection to the switchboard of a standby set and automatic restarting of essential auxiliary services. For other requirements relevant to particular thruster-assisted class notations, see Section 15.

14.3.5 An alarm is to be initiated at the thruster-assisted positioning control station(s) when the total electrical load of all operating thruster units exceeds a preset percentage of the running generator(s) capacity. This alarm is to be adjustable between 50 and 100 per cent of the full load capacity, having regard to the number of electrical generators in service.

14.3.6 The number and ratings of power transformers are to be sufficient to ensure full load operation of the thruster-assisted positioning system even when one transformer is out of service. This does not require duplication of a transformer provided as part of a transformer/silicon controlled rectifier (SCR) drive unit.

14.3.7 Thruster auxiliaries, control computers, reference systems and environmental sensors are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practical and without the use of common feeders, transformers, converters, protective devices or control circuits.

14.3.8 Where the auxiliary services and positioning mooring thrusters are supplied from a common source, the following requirements are to be complied with:
   (a) The voltage regulation and current-sharing requirements defined in Pt 6, Ch 2,8.4 are to be maintained over the full range of power factors that may occur in service.
   (b) Where SCR converters are used to feed the thruster motors, and the instantaneous value of the line-to-line voltage wave-form on the a.c. auxiliary system busbars deviates by more than 10 per cent of \( \sqrt{2} \) times the r.m.s. voltage from the instantaneous value of the fundamental harmonic, the essential auxiliary services are to be capable of withstanding the additional temperature rise due to the harmonic distortion. Control, alarm and safety equipment is to operate satisfactorily with the maximum supply system wave-form distortion, or be provided with suitably filtered/converted supplies.
   (c) When the control system incorporates volatile memory it is to be supplied via uninterruptible power supplies provision for automatic starting and connection to the (UPS), see also Pt 6, Ch 1,2.9.

14.4 Control engineering systems – Additional requirements

14.4.1 The control engineering systems are to be designed in accordance with the relevant requirements of Section 13 together with the additional requirements of 14.4.2 to 14.4.3 and the relevant requirements of Section 15.

14.4.2 Indication of the following is to be provided at each station from which it is possible to control the thruster-assisted positioning system, as applicable:
   - The heading and location of the vessel relative to the desired reference point or course.
   - Vectorial thrust output, individual and total.
   - Operational status of position reference systems and environmental sensors.
   - Environmental conditions, e.g., wind speed and direction.
   - Availability status of standby thruster units.
Positional Mooring Systems

14.4.3 Alarms are to be provided for the following fault conditions where applicable:
- When the unit deviates from its predetermined area of operation.
- When the unit deviates from its predetermined heading limits.
- Position reference system fault (for each reference system).
- Gyrocompass fault.
- Vertical reference sensor fault.
- Wind sensor fault.
- Taut wire excursion limit.
- Automatic changeover to a standby position reference system or environmental sensor.
- Control computer system fault.
- Automatic changeover to a standby control computer system, see 15.3.3.

14.4.4 Suitable processing and comparative techniques are to be provided to validate the control system inputs from position and other sensors, to ensure the optimum performance of the thruster-assisted mooring system.

14.4.5 Abnormal signal errors revealed by the validity checks required by 14.4.4 are to operate alarms.

14.4.6 The control system for thruster-assisted positioning operation is to be stable throughout its operational range and is to meet the specified performance and accuracy criteria.

14.4.7 Automatic controls are to be provided to maintain the desired heading of the unit.

14.4.8 The deviation from the desired heading is to be adjustable, but is not to exceed the specified limits. Arrangements are to be provided to fix and identify the set point for the desired heading.

14.4.9 Sufficient instrumentation is to be fitted at the central control station to ensure effective control and indicate that the system is functioning correctly, see 14.4.2.

15.1 Notation TA(1)

15.1.1 For assignment of the notation TA(1), in accordance with Section 4, the applicable requirements of Sections 13 and 14 together with 15.1.2 to 15.1.3 are to be complied with.

15.1.2 Centralised automated manual control of the thrusters is to be provided to supplement the position mooring system. The manual control system is to provide output signals to the thrusters via the manual controller to change the speed, pitch and azimuth angle, as applicable, as indicated at the central control station, see 13.2.

15.1.3 For electrically driven thruster systems, the total generating capacity of the electrical system is to be not less than the maximum dynamic positioning load together with the maximum auxiliary load. This may be achieved by parallel operation of two or more generating sets, provided the requirements of Pt 6, Ch 2.2.2 are complied with.

15.2 Notation TA(2)

15.2.1 For assignment of the notation TA(2), in accordance with Section 4, the applicable requirements of Sections 13 and 14 together with 15.2.2 to 15.2.8 are to be complied with.

15.2.2 Automatic and manual control systems are to be provided to supplement the positional mooring systems and arranged to operate independently so that failure in one system will not render the other system inoperative, see also 15.1.2 for manual control.

15.2.3 The automatic control system is to utilise automatic inputs from the position reference system, the environmental sensors and line tensions, and automatically provide output signals to the thrusters to change the speed, pitch and azimuth angle, as applicable, such that the mooring system is not held at maximum line tension.

15.2.4 In the event of a failure of a reference or environmental sensor, the control systems are to continue to operate on signals from the remaining sensors without manual intervention.

15.2.5 In the event of line failure or failure of the most effective thruster, the unit is to be capable of maintaining its predetermined area of operation and desired heading in the environmental conditions for which the unit is designed and/or classed.

15.2.6 Control, alarm and safety systems are to incorporate a computer-based consequence analysis which may be continuous or at predetermined intervals and is to analyse the consequence of predetermined failures to verify that the anchor line tensions and position/heading deviations remain within acceptable limits. In the event of a possible hazardous condition arising as a result of the consequence analysis an alarm is to be initiated at the central control station.

15.2.7 The area of operation is to be adjustable, but is not to exceed the specified limits, which are to be based on a percentage of water depth, or if applicable a defined absolute surface movement. Arrangements are to be provided to fix and identify the set point for the area of operation.

15.2.8 For electrically driven thruster systems, the following requirements are to be complied with:
(a) Generating capacity, as defined in 15.1.3.
(b) With one generating set out of action, the capacity of maximum positioning load with the most effective thruster inoperative together with the essential services defined by Pt 6, Ch 2.1.5.
(c) Where generating sets are arranged to operate in parallel, the supplies to essential services are to be protected by the tripping of non-essential loads as required by Pt 6, Ch 2,6.9 and additionally, on loss of a running generator, a reduction in thrust demand may be accepted provided the arrangements are such that a sufficient level of dynamic position capability is retained to permit the three degrees of manoeuvrability of the unit.

(d) Indication of absorbed electrical power and available on-line generating capacity is to be provided at the main thruster-assisted positioning control station, see 14.4.1.

(e) Means are to be provided to prevent starting of thruster motors until sufficient generating capacity is available.

15.3 Notation TA(3)

15.3.1 For assignment of the notation TA(3), in accordance with Section 4, the applicable requirements of Sections 13 and 14, together with 15.2.3 to 15.2.8 and 15.3.2 to 15.3.8, are to be complied with.

15.3.2 Two automatic control systems are to be provided and arranged to operate independently so that failure in one system will not render the other system inoperative.

15.3.3 In the event of failure of the working system the standby automatic control system is to be arranged to change over automatically without manual intervention and without any adverse effect on the vessel’s station keeping capability. The automatic changeover is to initiate an alarm.

15.3.4 At least two position reference systems as defined by 13.4.8, and two gyrocompasses or equivalent, are to be provided.

15.3.5 At least two of each of the sensors as required by 13.4.9 and 13.4.10 are to be provided.

15.3.6 When two voyage recording systems are deployed, their outputs are to be compared and an alarm raised when a significant difference occurs.

15.3.7 The arrangement is to be verified by means of a Failure Mode and Effects Analysis (FMEA). Such components may include, but not be restricted to, the following:

- Mooring systems.
- Prime movers, e.g., auxiliary engines.
- Generators and the excitation equipment.
- Switchgear.
- Pumps.
- Thrusters.
- Fans.
- Valves, where power-actuated.

15.3.8 Control, alarm and safety systems are to incorporate a computer-based consequence analysis which may be continuous or at predetermined intervals and is to analyse the consequence of predetermined failures to verify that position and heading deviation remain within acceptable limits. In the event of a possible hazardous condition being indicated from the consequence analysis, an alarm is to be initiated.

Section 16

Trials

16.1 General

16.1.1 Before a new installation (or any alteration or addition to an existing installation) is put into service, trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturer’s works and are to be based on the approved test schedules list as required by 1.4.1(d).

16.1.2 The suitability of the positional mooring and/or thruster-assisted positional mooring system is to be demonstrated during sea trials, observing the following:

(a) Response of the system to simulated failures of major items of control and mechanical equipment, including loss of electrical power.

(b) Response of the system under a set of predetermined manoeuvres for changing:

- Location of area of operation;
- Heading of the unit.

(c) Automatic thruster control and line tension optimisation.

(d) Monitoring and consequence analyses.

(e) Simulation of line breakage and damping.

(f) Continuous operation of the thruster-assisted positional mooring system over a period of four to six hours.

16.1.3 Two copies of the test schedules, as required by 1.4.1(d), signed by the Surveyor and Builder are to be provided on completion of the survey. One copy is to be placed on board the unit and the other submitted to LR.
Section 1

Rule application

1.1 General

1.1.1 Masts, derrick posts, crane pedestals and similar supporting structures to equipment are classification items, and the scantlings and arrangements are to comply with the additional requirement of this Chapter.

1.1.2 Classification of lifting appliances is optional and may be assigned at the request of the Owner on compliance with the appropriate requirements.

1.1.3 Proposals to class lifting appliances on unclassed units will be specially considered.

1.2 Masts, derrick posts and crane pedestals

1.2.1 The scantlings of masts and derrick posts, intended to support derrick booms and of crane pedestals are to comply with the requirements of the Code for Lifting Appliances in a Marine Environment (LAME).

1.2.2 In addition to the information and plans requested in Lloyd’s Register’s (hereinafter referred to as ‘LR’) LAME, the following details are to be submitted:

- Details of deck-houses or other supports for the masts, derrick posts or crane pedestals, together with details of the attachments to the hull structure.
- Details of any reinforcement or additional supporting material fitted to the hull structure in way of the mast, derrick post or crane pedestal.

1.2.3 Masts, derrick posts or crane pedestals are to be efficiently supported and, in general, are to be carried through the deck and satisfactorily scarfed into transverse or longitudinal bulkheads, or equivalent structure. Alternatively, the mast, derrick posts or crane pedestals may be carried into a deck-house or equivalent structure, in which case the house is to be of substantial construction. Proposals for other support arrangements will be specially considered.

1.2.4 Deck plating and underdeck structure are to be reinforced under masts, derrick posts and crane pedestals. Where the deck is penetrated the deck plating is to be suitably increased locally.

1.2.5 The permissible stresses in the support structure are to be in accordance with Pt 4, Ch 6,2.

1.3 Lifting appliances

1.3.1 Offshore units fitted with lifting appliances built in accordance with LR’s LAME in respect of structural and machinery requirements will be eligible to be assigned special features class notations as listed in Table 11.1.1. This notation will be retained so long as the appliances are found upon examination at the prescribed surveys to be maintained in accordance with LR’s requirements.

### Table 11.1.1 Special features class notations associated with lifting appliances

<table>
<thead>
<tr>
<th>Lifting Appliances</th>
<th>PC</th>
<th>PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>optional notation.</td>
<td>indicates that the unit's main deck cranes are included in class</td>
<td>optional notation. indicates that the unit's personnel lifts are included in class</td>
</tr>
</tbody>
</table>

1.4 Crane boom rests

1.4.1 With the crane boom in the stowed position the structure of the crane boom support structure is to be designed for the maximum reaction forces in any operating condition, taking into account the maximum design environmental loadings and inertia forces due to unit motions.

1.4.2 The crane boom support structure is also to be verified in the emergency condition defined in Ch 8,1.4.

1.4.3 The permissible stresses in the crane boom support structure and the deck structure below are to be in accordance with Pt 4, Ch 6,2.

1.5 Runway beams

1.5.1 Runway beams are to be designed and tested in situ in accordance with a recognised Standard and marked with the safe working load, see also Appendix A.

1.6 Lifting padeyes

1.6.1 Padeyes attached to the main structure which are to be used with a rated lifting appliance are to be proof tested after installation and marked with the safe working load (SWL). The proof load is not to be less than 1,5 × SWL.

1.6.2 Lifting lugs are to be permanently marked with SWL, tested after installation and NDE to the Surveyor’s satisfaction. In agreement with LR, testing and NDE of lifting lugs with SWL < 1 tonne may be by sampling, provided design calculations can demonstrate a factor of safety greater than 2.
1.7 Access gangways

1.7.1 Pedestals and similar structures supporting installed gangways used for access to adjacent fixed installations are classification items and the scantlings and arrangements are to comply with the general requirements for crane pedestals and support structure in 1.2.

1.7.2 The gangway is to comply with the relevant Statutory Regulations of the National Administration of the country in which the unit is registered and/or in which it is to operate and design calculations for the supporting structure are to be submitted.
Section 1

General

1.1 Introduction

This Chapter covers the foundations aspects of drag pile, suction pile and gravity anchor points. Where alternative approaches to the recommendations given in Sections 3, 5 and 7 have been used Lloyds Register (hereinafter referred to as 'LR') may require additional consideration to be given to the foundation design.

1.1.2 Other types of anchor point foundations will be specially considered, as will those supported on permafrost or ice.

1.2 Site investigation

1.2.1 The anchor point foundations design is to be based on the geotechnical conditions found at the actual site.

1.2.2 Sufficient appropriate laboratory and in situ tests are to be performed in order to determine the strength and deformation characteristics of the strata underlying the sea bed, and a full report of all tests is to be submitted for approval, see Sections 2 and 3.

1.3 Stability of sloping sea beds

1.3.1 Where the anchor point is located on or near a slope, the influence of slope failure due to wave or possible earthquake loading on the anchor point is to be investigated. In particular, consideration is to be given to the influence of increased loading due to slope failures and flow slides.

1.3.2 The results of any calculations or tests are to be submitted.

Section 2

Site investigation

2.1 Extent of investigation

2.1.1 Site investigation data and laboratory testing results are to be submitted to LR to enable the Surveyors to satisfy themselves with regard to:

- sea bed topography;
- nature and stability of the sea bed surface; and
- geomorphology and engineering properties of the strata underlying the sea bed.

2.1.2 The extent of investigations is to be sufficient in area, depth and detail to cover adequately the foundation design. The size and complexity of the proposed anchor point arrangements and the anticipated sea bed soil conditions to be encountered at the anchor point locations are to be considered in determining the extent.

2.2 Methods of investigation

2.2.1 The site investigation is to include combinations of the following methods, where appropriate:

- Detailed bathymetric and side-scan sonar surveys.
- Shallow seismic reflection surveys.
- Shallow sea bed sampling.
- Borehole sampling.
- Shallow and deep in situ cone penetrometer testing.
- In situ testing such as remote vane, radioactive borehole logging, pressure meter and other proven methods.

Alternative methods may be considered acceptable with the agreement of LR.
2.2.2 The methods of investigation are to be adequate to give reliable information on the following:
- Sea bed topography in sufficient detail for the type of anchor point being installed.
- Presence of sand waves.
- Surface deposits, rock outcrops and debris.
- Variations in subgrade conditions at the anchor point locations.
- Stability of sloping sea beds.
- Natural eruptions and erosion of the sea bed due to emissions of gas, mud, fresh water springs, etc.
- Presence of shallow gas.

3.1 Location control
3.1.1 Detailed location and delineation of an area to be investigated is to be by a system accurate to within ±10 m relative to known markers. The subsequent positioning of the anchor point at the selected site must be properly related to the location of the site investigation.

3.2 Bathymetric survey
3.2.1 A bathymetric survey is generally to be performed over an area centred on the proposed floating installation location using an echo sounder and side-scan sonar. The number and spacing of survey lines are to be appropriate to the site characteristics and type and number of anchor points.

3.2.2 The side-scan sonar system is used to map underwater surface features such as rock outcrops, boulders, wrecks, sand waves, pipelines, etc. Where bathymetric and geophysical studies are used as a means of site selection, a wider coverage would be necessary. In such a case the spacing of survey lines may be increased.

3.3 Geophysical survey
3.3.1 Seismic reflection survey measurements should be made concurrently with the bathymetric soundings and side-scan sonar survey. The most suitable seismic profiling system for the site conditions encountered is to be adopted.

3.3.2 Other geophysical studies may be adopted in addition to the seismic reflection survey if thought to be appropriate.

3.4 Observation at the sea bed
3.4.1 The bathymetric survey can be complemented by obtaining soil samples from the sea bed surface. These samples may be obtained with a gravity drop sampler, 'vibrocore' or equivalent system.

3.4.2 Television camera surveys of the sea bed are to be performed at the proposed anchor point locations immediately prior to installation.

3.5 Preliminary geological appraisal of site
3.5.1 Detailed geological information regarding the upper layers of soil and rock may not exist in some offshore areas. In these areas this information will normally have to be gathered from the site investigation sampling programme, see 3.11.

3.5.2 In offshore areas where detailed geological data already exist, this information is to be obtained and used to aid determination of the scope and method of site study.

3.6 Scope of borehole sampling
3.6.1 A minimum of one exploration borehole is to be made at each anchor point location.

3.6.2 Where site conditions are geotechnically uniform, a lesser number of exploration boreholes may be justified at an anchor point cluster.

3.6.3 For drag anchors, borings are to extend to a depth greater than the maximum anticipated depth of penetration of the drag anchor. For anchor piles and suction anchor piles, borings are to extend to a depth greater than the maximum anticipated depth of influence of the proposed anchor pile. For gravity anchors, at least one boring is to extend to a depth greater than the maximum anticipated lateral dimension of the proposed gravity base.

3.6.4 Sufficient samples are to be taken in each boring to define adequately soil stratification and properties.

3.6.5 In general, a more detailed investigation of the upper soils immediately below the sea bed is to be carried out for gravity anchors. This may include shallow borings and/or surface cone penetration tests over the proposed location of the foundation, in addition to the boreholes referred to in 3.6.1.

3.6.6 Particular attention is to be given to identifying any thin weak strata which may be critical to the sliding stability of gravity anchors, but of relatively little significance to the design of friction piles.

3.6.7 Careful depth control is to be exercised for all in situ testing and sampling.

3.6.8 Records are to be kept of drilling parameters.

3.7 In situ testing
3.7.1 Calibrations of in situ test apparatus are to be made, and records of these are to be available to LR on request.
3.7.2 Correlation of such techniques as the cone penetration test is to be made by alternating sampling and cone penetration testing in the same borehole. Alternatively, the correlation could be made by performing the in situ testing in a borehole immediately adjacent to the sampling borehole.

3.7.3 For drag anchors, shallow cone penetration tests are to extend to a depth greater than the maximum anticipated depth of penetration of the drag anchor.

3.8 Sampling

3.8.1 All sampled material, both disturbed and undisturbed, is to be retained for inspection and testing.

3.8.2 The largest size of sample possible is to be employed, within the limitations imposed by the dimensions of the drilling equipment.

3.8.3 Samples of nominal 70 to 75 mm diameter are a preferred minimum.

3.8.4 Detailed records of each sampling process are to be made which are to include estimates of resistance to penetration (e.g., blow count of drop hammer) and comments on any problems encountered during sampling. These records, together with the preliminary sample description, are to be attached to subsequent descriptions and laboratory test reports for the sample.

3.8.5 In general, pushed samples are preferred to driven samples in cohesive soils and carbonate soils.

3.8.6 Where a wire-line hammer sampler is employed, the depth of each sample is to be checked by measuring the wire-line length.

3.9 Sample storage

3.9.1 For undisturbed samples intended for onshore laboratory testing, consideration is to be given to retaining these sealed in the sample tube under pressure representative of the computed in situ stress condition. However, in general, it is acceptable to extrude samples and seal them in wax.

3.9.2 Where suitable facilities exist, as much testing as possible is to be performed offshore.

3.9.3 Strength and deformation tests are to be performed on a proportion of the sample immediately following sample extrusion, see 3.12. However, where limited onboard testing facilities exist, samples which cannot be tested immediately are to be placed directly in storage as described above.

3.9.4 All samples are to be labelled in such a way that it is possible to establish the precise order and position of the sample in the borehole. Where a sample is sufficiently large (greater than 50 mm long) and can be distinguished as having a top and bottom, relative to its orientation in the borehole, the sample is to be stored in that orientation and marked as such.

3.10 Sample description

3.10.1 It is most important to establish an accurate and detailed description of each sample. Firstly, in the field, immediately before testing and then again in the onshore laboratory. This practice is worthwhile since significant changes in colour, structure or physical behaviour may be observed to have taken place in the period from the time of sample collection to full extrusion in the laboratory. The latter phase of description, in the onshore laboratory, is to include, where appropriate, a detailed geological description of vertically split sections of the samples. Points which are to be covered by the sample descriptions are detailed in 3.10.2 to 3.10.6.

3.10.2 Colour:
(a) The natural colour of the soil is to be recorded immediately following extraction from the borehole.
(b) A colour check of all samples is to be made in the offshore laboratory, when the samples are being prepared for testing. Standard colour charts are to be used and a record made of any observed colour changes.

3.10.3 Consistency:
(a) A written description of the hardness of the sample, based on its resistance to sampling and its cone resistance, is to be made in the field.
(b) For cohesive soils, the shear strength ranges pertaining to the terms soft, firm, stiff, hard, etc., are to be defined.
(c) Suitable aids for consistent estimation of shear strength in cohesive soils are the pocket penetrometer and miniature vane tests, which are to be employed whenever possible.
(d) More accurate determination of consistency and stress/strain characteristics will evolve from element tests. Any major difference is to be identified since there may be a real physical change due to sample ageing or other phenomena, such as the influence of natural fissuring.

3.10.4 Structure:
(a) The existence of joints, fissures, stratification change, laminations, organic fragments, erratics, or shells, together with their dimensions and frequency, are to be recorded in the sample description.
(b) Structural description of the samples is to be carried out both in the field immediately following extrusion, and in the onshore laboratory. Noticeable changes of structural description such as increased fissure size or shattering are to be recorded.
3.10.5 **Grain size and index properties:**
(a) Grain size is to be determined by standard laboratory tests (sieve and hydrometer analyses).
(b) Care is to be taken to observe (and record) fine layers and beds of different grain size which may significantly alter the grain size distribution of a laboratory specimen.
(c) Where finely laminated materials are encountered, emphasis is to be placed on the visual description of undisturbed specimens.
(d) For fine grained soils, Atterberg limits and natural moisture content are to be determined for all samples.

3.10.6 Odours due to the presence of gas or organic material are to be recorded.

3.10.7 Colour photography is to be used wherever possible to aid description. Although use may be made of photographic techniques in the onshore laboratory, photographs of samples showing their condition immediately following extraction may be made, where their existence can add to the description of the specimen. It is recognised that true colour rendering is difficult. Therefore, a colour chart is to be included in all colour photographs.

3.10.8 Photographs of samples made on board are likely to be taken under far from ideal conditions. Therefore, they are to be confined to recording sample condition immediately following extrusion and, after compression testing, to show failure mode.

3.10.9 Representative samples and parts of samples not utilised as test specimens may be split and photographed with colour film, partially dried and re-photographed.

3.10.10 Sample descriptions for all samples are to be included in the soil laboratory report.

3.11 **Geological interpretation of cores and soil samples**

3.11.1 The actions in 3.11.2 to 3.11.6 may be reduced or eliminated if they repeat work carried out, or to be carried out, in seismic survey programmes.

3.11.2 Having maintained the cores and soil samples in their correct geological sequence as recommended, see 3.9, a detailed geological interpretation of the log of the borehole may be made.

3.11.3 The geological description of the borehole is to be made by a qualified geologist.

3.11.4 The geologist is to examine the partially dried split sections of the cores and soil samples, if available, and extract appropriate specimens for laboratory testing. The testing programme assigned by the geologist, however, is to be additional to that required by the soil mechanics engineer.

3.11.5 The results of the geological test programme are to be considered only as supporting data, by means of which a better definition of the site stratigraphy and stress history can be determined. Where relatively small amounts of sampled material exist it may be necessary for the geological tests to be performed on the remains of specimens which have already undergone engineering tests.

3.11.6 The geological testing programme may generally be restricted to techniques such as:
- Comparison of grain size distributions as a means of determining deposition history.
- Detailed examination of interglacial deposits where they are found.
- Identification of erratics.
- Simple chemical tests.
- Simple mineralogy.
- Pollen analysis and micropalaeontological examination.

3.12 **Onboard testing**

3.12.1 The ability to perform engineering tests on undisturbed samples of soil immediately after they are extracted from the borehole is to be considered an ideal practice.

3.12.2 Simple onboard tests are to include the following:
(a) Hand penetrometer and vane tests on the exposed ends and sides of undisturbed samples of cohesive soils. Results of such tests are only to be considered as an approximate index of strength. Any evidence of anisotropy is to be noted. The hand vane test may also be performed on remoulded samples of cohesive soil as a means of determining sensitivity.
(b) Fall-cone test on samples of soft cohesive material as a means of estimating undrained shear strength.
(c) Natural moisture content and density determinations.

3.12.3 Where more sophisticated laboratory facilities exist on board, the following additional tests may be performed:
(a) Triaxial compression tests. A sketch, or preferably a photograph, of the failed specimen is to be made, and be attached to the test report.
(b) Consolidation (oedometer) tests, preferably at a constant rate of strain. Such tests might be carried out to determine preconsolidation pressures and consolidation characteristics of samples of cohesive soil.

3.12.4 In addition to the above onboard testing, a full programme of onshore laboratory tests as recommended in 3.13 to 3.19 are to be performed.

3.13 **Laboratory index tests**

3.13.1 The following index tests are to be performed on a representative number of specimens throughout the soil profile:
- Natural moisture content and density determination.
- Atterberg limit tests on all cohesive samples.
- Grain size distribution using both sieves and hydrometer.
3.14 Shear strength parameter determination – Cohesive soils

3.14.1 Hand penetrometer and vane tests are to be performed in the laboratory, for comparison with onboard measurements. Any significant change in strength is to be noted.

3.14.2 Laboratory penetrometers and fall cones (for soft soils) may also be employed as a means of determining undrained shear strength of small samples.

3.14.3 Quick unconsolidated undrained and quick consolidated undrained triaxial compression tests are to be performed, with cell pressures equal to or greater than the computed overburden pressure of the specimen.

3.14.4 Effective stress parameters of cohesive soil are to be determined where applicable, using either consolidated undrained triaxial compression tests with pore pressure measurement, or drained triaxial compression tests. Where only a limited number of samples are available, multi-stage consolidated undrained tests with pore pressure measurement may be adopted.

3.14.5 It is to be noted that current practice is to use unconsolidated undrained triaxial tests as the basis of shear strength parameter determination for analysis of piles in cohesive soils, and it is therefore vital that sufficient of these tests are performed to define adequately the shear strength variation with depth.

3.14.6 For gravity anchor foundations, consideration is to be given to performing a wide range of tests which take account of the shearing mechanism expected to occur at various locations within the soil beneath the foundation.

3.15 Shear strength parameter determination – Cohesionless soils

3.15.1 Drained or consolidated undrained triaxial compression tests and shear box tests may be used to determine the shear strength parameters of sands. These tests are to be performed over a range of relative densities for each sand specimen, since the sampling process will lead to significant disturbance.

3.15.2 In general, shear strength parameters for use in design of piles in cohesionless soils are to be determined on the basis of cone penetration tests and sample descriptions.

3.15.3 For gravity anchor foundations, consideration is to be given to performing a wide range of tests which take account of the shearing mechanism expected to occur at various locations within the soil beneath the foundation.

3.16 Special shear strength determination tests

3.16.1 Consideration is to be given to performing tests which will provide some estimate of the present in situ stress condition and anisotropy.

3.17 Consolidation characteristics

3.17.1 It is unlikely that large samples (150 mm diameter) will be obtained from the average offshore site investigation. Therefore, consolidation characteristics may be measured by the standard oedometer test.

3.17.2 Care is to be taken to avoid swelling on introduction of water into the cell at low stress levels.

3.17.3 Preconsolidation pressure and coefficients of compressibility may be determined directly from the test.

3.17.4 The rate of consolidation is to be estimated, having regard to the detailed sample description and the permeability of the fabric, since rates of consolidation measured in a small oedometer test are likely to be misleading.

3.18 Chemical tests

3.18.1 The chemical properties of the soil and soil pore water are to be established where appropriate. The following properties are to be determined:

- Chloride (salt) content.
- Sulphate content.
- pH.
- Carbonate content.

3.19 Permeability

3.19.1 Estimates of permeability may be based on grain size distribution for sandy soils.

Section 4
Drag anchors

4.1 Drag anchor design

4.1.1 The drag anchor design is to be approved by LR and the anchors are to be subject to test loading at installation to the satisfaction of LR Surveyors, see Chapter 10.

4.2 Ultimate holding capacity, penetration and drag

4.2.1 For drag anchors, the ultimate holding capacity, penetration and drag are to be based on empirical design data for the specific type of anchor under consideration. The soil conditions at the anchor location and previous experience in similar soil conditions with the specific type of anchor are to be considered.
SECTION 5

Anchor and suction anchor piles

5.1 Anchor and suction anchor pile design

5.1.1 The anchor and suction anchor pile designs are to be approved by LR.

5.2 Axial and lateral capacity

5.2.1 The pile penetrations are to be determined by their ability to develop sufficient axial, tensile (and compressive) and lateral capacity to resist the maximum applied loads with appropriate factors of safety.

5.2.2 The minimum factors of safety for anchor piles are to comply with Tables 10.10.2 and 10.10.3, and for suction anchor piles with Tables 10.10.4 and 10.10.5, in Chapter 10.

5.2.3 Consideration is to be given to cyclic loading effects on pile axial and lateral capacity.

5.2.4 For anchor pile clusters, the group as a whole is to have a factor of safety as required by Table 10.10.2 and Table 10.10.3 in Chapter 10. Individual anchor piles in a group may have lower factors of safety.

5.2.5 The efficiency of the group, that is its capacity compared to the sum of the capacities of individual anchor piles within the group, is to be checked.

5.3 Anchor and suction anchor pile response

5.3.1 Analysis of the anchor and suction anchor pile/soil interaction under lateral and axial loading is to take account of the non-linear stress/strain behaviour of the foundation soils and of stress history and cyclic loading effects on soil resistance. Allowance is to be made for the response of different soil types.

5.3.2 When anchor pile groups are analysed the interaction between the piles is to be considered.

5.3.3 Anchor and suction anchor pile stresses are to be checked for extreme, operating and installation loading conditions in accordance with Pt 4, Ch 3, or a recognised structural design Code.

5.4 Sea bed erosion

5.4.1 Account is to be taken of the effects of both global and local scour in calculations of pile response and axial and lateral capacity.

5.5 Installation – General

5.5.1 Details of the proposed method of installation and its associated monitoring system are to be submitted. Where possible the placing of the anchor and suction anchor piles is to be monitored using the same positioning system as was used to locate the position of the site survey area, and which is to be accurate to within ±10 m.

5.5.3 Orientation and verticality of the pile during installation are to be recorded.

5.6 Installation of driven anchor piles

5.6.1 Driving stresses and static stresses due to the weight of the hammer are to be considered in the selection of pile driving hammers and pile wall thickness. Driving stresses are also to be included in any assessment of pile fatigue.

5.6.2 Where driving shoes are employed as a means of reducing soil plug friction during pile driving, an equivalent reduction of internal skin friction is to be adopted in the determination of allowable end bearing capacity.

5.6.3 A full record of the anchor pile driving operation is to be kept, and is to be submitted to LR.

5.6.4 The record of anchor pile driving operations to be submitted to LR is to include the following details:
- Timing of the various operations.
- Hammer characteristics.
- Blowcount.
- Configuration of the top of the pile giving the cushion and anvil materials together with salient dimensions.
- State of cushion (number of blows suffered and physical appearance) at the start of driving and time(s) at which cushion is changed.
- Estimates of hammer stroke and any measurements of striking energy and energy transmitted to pile head.
- Soil plug measurement on completion of pile driving.

5.7 Installation of bored anchor piles

5.7.1 The methods for drilling and grouting and details of the plant and materials to be used are to be submitted to LR for approval.

5.7.2 The construction programme is to avoid leaving holes open for long periods in soils or rock sensitive to exposure to water or drilling fluids.
A full record of the drilling and grouting operation is to be submitted to LR.

A specimen record is to be submitted for approval prior to the installation of the first pile.

The record of installation of drilled and grouted anchor piles to be submitted to LR is to include the following details:

- Timing of various operations.
- Method of drilling.
- Density, viscosity, flow rate and pressure of drilling fluid during drilling.
- Description of returns, if any, from the borings.
- Bit pressure, torque and speed of drilling tools.
- Details of circulation loss and any remedies adopted.
- Hole survey details (the profile and linearity of all holes are to be surveyed to their full depth).
- Details of checks made to determine the existence of any material which has fallen into the hole prior to grouting.
- Final position of any reinforcement or insert piles placed.
- Fluid pressure maintained during drilling and grouting.
- Details of the density, flow rate, grout level and pressure of grout during pumping and total volume of grout pumped (means of monitoring should be specified).
- Details of grout mix design and of its constituent materials.
- Programme of grout sampling and testing, including measurements of density and grout crushing strength at 28 days.
- Grout level on completion and after at least 12 hours after completion.

The proposed installation procedures are to be submitted to LR for approval.

Appropriate records are to be submitted to LR for approval.

Soil resistance to suction anchor piles is to be determined. The potential for internal soil heave and soil plug failure during installation is to be considered.

The record of installation of piles installed by suction to be submitted to LR is to include:

- pile penetration;
- pressure differential;
- orientation; and
- verticality.

Section 6
Acceptable basis for anchor and suction anchor pile design

6.1 Axial capacity

6.1.1 This Section is for guidance and is not mandatory for classification purposes.

6.1.2 The ultimate pull-out capacity, \( Q_t \), is to be determined from the formula:

\[
Q_t = A_s f_s
\]

where

- \( A_s \) = external side surface area in contact with soil
- \( f_s \) = unit skin friction.

6.1.3 The ultimate bearing capacity, \( Q_{ult} \), may be determined for compression loads by:

\[
Q_{ult} = A_s f_s + A_p q_p
\]

where

- \( A_p \) = gross end area of pile in contact with soil
- \( q_p \) = unit end bearing capacity.

6.1.4 For driven and suction installed open ended piles, end bearing \((A_p q_p)\) is not to exceed the capacity of the internal plug, which is given by the sum of the internal skin friction \((A_{si} f_{si})\) and the end bearing on the pile wall, where

\[
A_{si} = \text{internal surface area of pile in contact with soil}
\]

\[
f_{si} = \text{internal unit skin friction, which may differ from } f_s, \text{ e.g., due to the effect of a driving shoe.}
\]

6.1.5 In cohesionless soils (sand and silts) in tension, a reduced value of \( f_s \), as compared with compression loading, is to be adopted.

6.1.6 The effective weight of the pile is also to be accounted for in the analysis. In general, this is to be added to the pile load.

6.2 Skin friction in cohesive soils

6.2.1 The unit skin friction, \( f_u \), for piles driven and suction installed through cohesive soils (clays and silts) may be based on the undrained shear strength of the soil reduced by a constant which is related to the actual undrained shear strength.

\[
f_u = \alpha S_u
\]

where

- \( S_u \) = the undrained shear strength of a soil layer
- \( \alpha \) is an empirical factor.

6.2.2 Values of \( \alpha \) are defined according to Table 12.6.1.

6.2.3 It is to be noted that the values given in Table 12.6.1 are based on limited pile load tests with respect to pile diameter, capacity and soil shear strength. In this regard, caution is to be exercised in extrapolating beyond the limits of the data set.
Table 12.6.1 Values of $\alpha$  

<table>
<thead>
<tr>
<th>$S_u$ (kPa)</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 25</td>
<td>1,0</td>
</tr>
<tr>
<td>25 – 75</td>
<td>linear decrease from unity at $S_u = 25$ kPa to 0,5 at $S_u = 75$ kPa</td>
</tr>
<tr>
<td>greater than 75</td>
<td>0,5</td>
</tr>
</tbody>
</table>

6.2.4 Other methods of determining $f_s$ may be considered, provided they are supported by sufficient evidence of their validity together with appropriate laboratory and field test results.

6.2.5 For drilled and grouted piles $\alpha$ is, in general, to be taken as 0,4, irrespective of undrained shear strength.

6.3 End bearing in cohesive soils

6.3.1 For anchor piles end bearing in cohesive soils:

$$q_p = N_q S_u$$

where $N_q$ may be taken as 9, in most circumstances, for clays with water contents within the plastic range. $N_q$ may be less than 9 in sensitive clays.

6.3.2 No end bearing is to be taken for drilled and grouted piles unless it can be demonstrated that there is no infill at the bottom of the drilled hole, or the calculations account for the compressibility of such infill.

6.4 Skin friction in cohesionless soils

6.4.1 The unit skin friction, $f_s$, for piles driven and suction installed through cohesionless soils is to be determined by:

$$f_s = K\sigma'_v \tan \delta$$

where

- $\sigma'_v = \gamma' d$
- $\gamma' = $ mean submerged density of soil to depth $d$
- $d = $ depth of soil element below the mudline
- $K = $ coefficient of lateral earth pressure
- $\delta = $ angle of soil friction on pile wall as determined, in the absence of cone data, by Table 12.6.2, wherein $\phi$ is the angle of internal friction of soil.

6.4.2 Values of $K$ may be adopted as follows:

- (a) Compressive loading, $K = 0,7$.
- (b) Tension loading, $K = 0,5$.

Alternative values of $K$ may be adopted provided their use can be justified for the particular soil conditions encountered.

6.4.3 The unit skin friction, $f_s$, is not to exceed limiting values determined for local conditions, based on cone resistances and sample descriptions. These limits are not to be greater than 100 kPa where no cone data is available, or 120 kPa where cone data is available.

6.4.4 For carbonate granular soils, reduced values of unit friction, determined for local conditions, are to be used.

Table 12.6.2 Design criteria for axial capacity of driven piles in medium dense to very dense silica sand

<table>
<thead>
<tr>
<th>$\phi$ (degrees)</th>
<th>$\delta$ (degrees)</th>
<th>$N_q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very dense clean sand</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Very dense silty sand</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Dense clean sand</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Dense silt sand</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Medium dense clean sand</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Medium dense silt</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

NOTE: The parameters for very loose to loose sand and silt should be specially considered.

6.5 End bearing in cohesionless soils

6.5.1 For piles end bearing in cohesionless soils, $q_p$, is to be determined by:

$$q_p = \sigma'_v N_q$$

where

- $N_q = $ bearing capacity factor in accordance with Table 12.6.2 in the absence of cone data
- $\sigma'_v = \gamma' d$.

6.5.2 The unit end bearing $q_p$ is not to exceed limiting values determined for local conditions, based on cone resistances and sample descriptions. These limits are not to be greater than 10 MPa, where cone data is not available, or 15 MPa where cone data is available.

6.5.3 No end bearing is to be taken for drilled and grouted piles unless it can be demonstrated that there is no infill at the bottom of the drilled hole, or the calculations account for the compressibility of such infill.

6.6 Skin friction and end bearing in rocks

6.6.1 Skin friction and end bearing in rocks are to be specially considered.

6.7 Axial capacity of pile groups

6.7.1 Consideration is to be given to the effect of close spacing of piles, since the ultimate axial capacity of a group can be less than the sum of the individual capacities.
6.7.2 The calculation of safe loading may be based on consideration of the group as an ‘equivalent pier’ such that, for compressive loads:

\[ Q_g = S A_{sg} + q A_{pg} \]

where
- \( Q_g \) = ultimate bearing capacity of the pile group
- \( S A_{sg} \) = the ultimate frictional capacity of a pile group
- \( S \) = average shearing resistance, soil to pile and soil to soil
- \( A_{sg} \) = surface area of outer perimeter of pile group if considered as an equivalent pier
- \( q \) = unit end bearing
- \( A_{pg} \) = gross end area of piles in group. In order to account for different rates of mobilisation of skin friction and end bearing, \( A_{pg} = nA_p \) where \( n \) is number of piles in group and \( A_p \) is single pile tip area.

**Note**
For tensile loads, no end bearing (or suction) component is to be considered, and the shearing resistance may be lower, as noted in 5.2.5.

6.7.3 The surface area of soil to pile shear is to be maximised, in order to give the most conservative solution. The group capacity should not exceed the sum of the individual pile capacities.

### 6.8 Pile response and lateral capacity

6.8.1 For anchor piles, the lateral capacity and pile response are to be determined using either a beam-column non-linear soil/structure interaction finite element analysis or finite difference analysis. The non-linear axial and lateral soil resistance/pile deflection behaviour is to be modelled using t-z and p-y curves, respectively.

6.8.2 For suction anchor piles, the lateral capacity and stability are to be determined using both limit equilibrium and non-linear soil/structure interaction finite element analyses. Pile response and the determination of soil reaction stresses for structural analysis of the suction anchor pile are to be analysed using non-linear soil/structure interaction finite element methods.

### 6.9 Driving stresses

6.9.1 The stresses induced in the pile during driving can be estimated using a wave equation analysis.

6.9.2 Total stresses during driving are not to exceed yield.

6.9.3 Fatigue damage due to pile driving is to be considered.
7.4 Influence of cyclic loading

7.4.1 The influence of cyclic loading on the foundation soils is to be investigated and taken into account in the foundation design for:
- Bearing capacity.
- Sliding stability.
- Displacements.
- Erosion.

7.4.2 In making this assessment, full account is to be taken of possible reduction of soil shear strength and changes in deformation properties.

7.4.3 When cohesionless soils of loose and variable density occur, the possibility of soil liquefaction under cyclic loading is to be considered for environmental loading cycles and also for seismic conditions where these may be critical.

7.5 Sea bed erosion

7.5.1 The influence of erosion of soils from around and beneath the foundation is to be taken into account in its design. Erosion due to the following causes is to be investigated:
(a) The effect of waves and currents passing over the sea bed at velocities sufficient to dislodge and transport particles of bed material (scour).
(b) The relief of hydraulic pressures and pore water pressures built up under the foundation due to environmental loading, which may cause the removal of soil from beneath the foundation (sub-surface erosion or piping).

7.5.2 The methods proposed for the prevention of, and/or protection against, erosion are to be submitted for approval. In general, primary protection is to be provided by sea bed-penetrating skirts.

7.5.3 Any erosion protection system laid on the sea bed is to be so designed that it will permit free dispersion of pore water pressures that may be generated in the surface soil under cyclic loading conditions.

7.5.4 Provision is also to be made for the relief of water pressure generated within the skirts during installation of the structure.

7.6 Foundation contact pressure

7.6.1 Calculations of local contact stresses between the foundation and the sea bed are to take into account the results of the sea bed survey.

7.6.2 Unless specifically considered in the design, any voids remaining beneath the foundation after installation are to be filled with, e.g., cementitious grout.

7.7 Sea bed penetrating elements

7.7.1 Where foundations have skirts, dowels or other sea bed-penetrating elements which transfer load to the sea bed, the effect of these components is to be taken into account when determining the efficiency of, and loads in, the foundations for bearing capacity and sliding resistance. These items are to be designed as structural members.

7.7.2 The resistance of skirts, dowels, etc., to penetration of the sea bed during installation of the foundation and their effect, if any, on water flow beneath the foundation during installation is to be taken into account in the design calculations.

7.8 Installation of gravity anchor foundations

7.8.1 The positioning of the foundation is to be properly related to the location of the site investigation.

7.8.2 Any significant obstructions identified by the sea bed survey carried out prior to installation are to be removed before emplacement.

7.8.3 Differential ballasting may be required to accommodate non-uniform soil properties or a sloping sea bed. In general, reduction of pressure beneath the foundation is not to be used to aid installation, unless it can be demonstrated that washout or flow of soil will not occur.

7.8.4 Records of settlement and tilt of the structure are to be made during installation and properly correlated to those required to be kept while the structure is in service.

---

**Section 8**

**Acceptable basis for gravity anchor design**

8.1 Bearing capacity

8.1.1 Published formulae for calculating the bearing capacity of uniform soils subjected to vertical or inclined loads may be used to assess the stability of gravity foundations assuming equivalent static loading conditions.

8.1.2 A suitable method, described in 8.1.3 to 8.1.9, is based on the following publications:
- Brinch Hansen, J (1961) *A general formula for bearing capacity*, Danish Geotechnical Institute Bulletin 11; and
8.1.3 The bearing capacity of a horizontal base founded on level ground is given, for cohesionless soils, by the equation:
\[
\frac{Q}{A'} = 0.5 \gamma' B' N_\gamma s_\gamma d_\gamma i_\gamma + (\sigma'_v N_q s_q d_q i_q)
\]
and for undrained cohesive soils by:
\[
\frac{Q}{A'} = N_c S_u + (1 + s_c + d_c - i_c)
\]
where
- \(Q\) = bearing capacity
- \(A'\) = effective foundation area
- \(\gamma'\) = submerged unit weight of soil
- \(B'\) = effective foundation width
- \(N_\gamma, N_q, N_c\) = bearing capacity factors
- \(s_\gamma, s_q, s_c\) = shape factors
- \(d_\gamma, d_q, d_c\) = depth factors
- \(i_\gamma, i_q, i_c\) = load inclination factors
- \(\sigma'_v\) = effective overburden pressure
- \(S_u\) = undrained shear strength.

8.1.4 For loose or soft soils the bearing capacity may be lower than that calculated by the equations in 8.1.3.

8.1.5 The effective foundation area, \(A'\), is a rectangular area whose geometric centre coincides with the centre of resultant vertical and horizontal loads and which follows as closely as possible the nearest outline of the actual base. The width of the equivalent rectangle is \(B'\) and the length \(L'\).

8.1.6 The bearing capacity factors are defined as follows:
\[
N_\gamma = 1.5 (N_q - 1) \tan \phi'
\]
\[
N_q = e^{\pi \tan \gamma} \tan^2 45^\circ + \left( \frac{\phi'}{2} \right)
\]
\[
N_c = \pi + 2
\]
where \(\phi'\) is the effective angle of friction of the soil, in degrees.

8.1.7 The load inclination factors are given as follows:
\[
i_\gamma = 1 - 0.7 \left( \frac{H}{V} \right)^5
\]
\[
i_q = 1 - 0.5 \left( \frac{H}{V} \right)^5
\]
\[
i_c = 0.5 - 0.5 \sqrt{1 - \frac{H}{A'S_u}}
\]
where
- \(H\) and \(V\) are horizontal and vertical loads respectively.

8.1.8 The shape factors are given as follows:
\[
s_\gamma = 1 - 0.4 i_\gamma \frac{B'}{L}
\]
\[
s_q = 1 + i_q \sin \phi' \frac{B'}{L}
\]
\[
s_c = 0.2 (1 - 2i_c) \frac{B'}{L}
\]

8.1.9 The depth factors \(d_\gamma\) and \(d_q\) may generally be taken as unity, and \(d_c\) as zero.

8.1.10 The formulations from 8.1.2 are strictly only applicable to a foundation bearing on a single, semi-infinite, stratum of isotropic, homogeneous soil. However, real sites incorporating a number of soil strata of different materials or cohesive soils with increasing strength with depth may be assessed using such formulations provided that conservative soil properties are used. Alternative methods of analysis and computer and physical models may also be used to evaluate such soil conditions.

8.2 Sliding stability

8.2.1 The analysis is to consider all possible failure modes in sliding. These may be dependent on the configuration of any sea bed-penetrating elements of the foundation. Particular consideration is to be given to the influence of weak strata or zones.

8.3 Sea bed penetrating elements

8.3.1 The penetration resistance of elements such as skirts and dowels is to be based on conservative (upper bound) estimates of soil strength. Also, by considering more typical penetration resistances, account may be taken of lateral variation of soil conditions over the extent of the foundation in formulating possible eccentric ballasting requirements.

8.4 Local soil reactions

8.4.1 Local soil reactions on gravity foundations are to be based on the highest expected values of soil strength in the upper soil layers.

8.5 Deformations

8.5.1 Deformation analyses may be made using numerical methods or hand calculations.

8.5.2 Account is to be taken of soil stratification and non-linearity, and of uncertainties in soil deformation properties.

8.5.3 Soil stiffnesses may be estimated from laboratory tests or empirical correlations.
A1.1 Abbreviations

The following abbreviations are used in this Appendix:

- **AISC**: American Institute of Steel Construction.
- **ANSI**: American National Standards Institute.
- **API**: American Petroleum Institute.
- **ASME**: American Society of Mechanical Engineers.
- **BS**: British Standard.
- **CSA**: Canadian Standards Association.
- **DIN**: Deutsches Institut für Normung.
- **FEM**: Fédération Européenne de la Manutention.
- **IP**: International Petroleum.
- **ISO**: International Organization for Standardization.
- **NACE**: National Association of Corrosion Engineers.
- **NS**: Norwegian Standard.
- **TBK**: Norwegian Pressure Vessel Committee.
- **UKOOGA**: United Kingdom Offshore Operators Association.

A1.2 Recognised Codes and Standards

A1.2.4 **Blow out prevention:**

- API Spec. 16A: Specification for Drill through Equipment.
- API RP 16E: Design of Control Systems for Drilling Well Control Equipment.

A1.2.5 **Lifting appliances for blow out preventer and burner boom, and other equipment:**

- API Spec 2C: Specification for Offshore Pedestal Mounted Cranes.
- ASME B30.20: Below the Hook Lifting Devices.
- API Spec 8C: Drilling and Production Hoisting Equipment.
- ISO 10245 (all parts): Cranes – Limiting and Indicating Devices.
- LR’s Code for Lifting Appliances in a Marine Environment.

A1.2.6 **Derrick:**

- API 4E: Drilling and Well Servicing Structures.

A1.2.7 **Drilling equipment:**

- API Spec. 7: Specification for Rotary Drilling Equipment.
- API RP 7G: Drill Stem Design and Operating Limits.
- API Spec. 8A: Drilling and Production Hoisting and 8C Equipment.
- API RP 8B: Hoisting Tool Inspection and Maintenance Procedures.
- API Spec. 9A: Wire Rope.
- API RP 9B: Application, Care and Use of Wire Rope for Oil Field Service.
- ISO 10405: Petroleum and Natural Gas Industries – Care and Use of Casing and Tubing.
- ISO 10426: Petroleum and Natural Gas Industries – Cements and Materials for Well Cementing.
- ISO 11960: Petroleum and Natural Gas Industries – Steel Pipes for Use as Casing or Tubing for Wells.
| ISO 14693 | Petroleum and Natural Gas Industries – Drilling and Well-Servicing Equipment. |
| ISO 13680 | Petroleum and Natural Gas Industries – Corrosion-Resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock – Technical Delivery Conditions. |
| FEM 1001 | Rules for the Design of Hoisting Appliances, Section 1, Booklets 3 to 8. |

**A1.2.8 Wellhead equipment:**
- API Spec. 6A Wellhead and Christmas Tree Equipment.

**A1.2.9 Piping:**
- ASME B16.47 Large Diameter Steel Flanges: NPS 26 Through NPS 60.
- API RP 17B Flexible Pipe.
- API RP 520 Design and Installation of Pressure Relieving Systems in Refineries.

**A1.2.10 Riser and flow lines:**
- API RP 2RD Riser Design.
- API Bul 2J Comparison of Marine Drilling Riser Analysis.
- BS PD 8010 Code of Practice for Pipelines, Part 2, Pipelines Subsea: Design, Construction and Installation.
- ISO 3183 Petroleum and Natural Gas Industries – Steel Pipe for Pipeline Transportation Systems.
- ISO 10414 Petroleum and Natural Gas Industries – Field Testing of Drilling Fluids.
- ISO 10426 Petroleum and Natural Gas Industries – Cements and Materials for Well Cementing.
- ISO 11960 Petroleum and Natural Gas Industries – Steel Pipes for Use as Casing or Tubing for Wells.
- ISO 15156 Petroleum and Natural Gas Industries – Materials for Use in H-2S-Containing Environments in Oil and Gas Production.
- ISO 15463 Petroleum and Natural Gas Industries – Field Inspection of New Casing, Tubing and Plain-End Drill Pipe.
ISO 18165 Petroleum and Natural Gas Industries – Performance Testing of Cementing Float Equipment.

ISO 15590 Petroleum and Natural Gas Industries – Induction Bends, Fittings and Flanges for Pipeline Transportation Systems.


A1.2.11 Pressure vessels/fired units/heat exchangers:
- TBK-1-2: General Rules for Pressure Vessels.
- ASME Section VIII, Div. 1 and 2: Rules for Construction of Pressure Vessels.
- PD 5500: Unfired Fusion Welded Pressure Vessel.
- ASME Section 1: Power Boilers.
- ASME Section IV: Heating Boilers.
- ASME BPVC Sec I: Boiler and Pressure Vessel Code, Section I, Rules For The Construction of Power Boilers.
- ASME BPVC Sec IX: Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
- ASME BPVC Sec V: Boiler and Pressure Vessel Code, Section V, Non-destructive Examination.
- ASME BPVC Sec VIII-1: Boiler and Pressure Vessel Code, Section VIII, Rules For The Construction Of Pressure Vessels, Division 1.
- ASME BPVC Sec VIII-2: Boiler and Pressure Vessel Code, Section VIII, Rules For The Construction Of Pressure Vessels, Division 2 – Alternative Rules.
- ASME BPVC Sec VIII-3: Boiler and Pressure Vessel Code, Section VIII, Rules For The Construction Of Pressure Vessels, Division 3 – Alternative Rules For Construction Of High Pressure Vessels.
- BS 2790: Shell Boiler of Welded Construction.
- TEMA: Tubular Exchangers Manufacturers Association.
- API RP 530: Calculation of Heater Tube Thickness in Petroleum Refineries.
- API 661: Air Cooled Heat Exchangers for General Refinery Service.
- BS EN 12952: Water-Tube Steam Generating Plant.

A1.2.12 Process plant equipment:
- API 610: Centrifugal Pumps for General Refinery Service.
- API 615: Sound Control of Mechanical Equipment for Refinery Service.
- API 617: Centrifugal Compressors for General Refinery Services.
- API Std 613: Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services.
- API Std 614: Lubrication, Shaft-Sealing, and Control-Oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services.
- API Std 618: Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services.
- API Std 619: Rotary Type Positive Displacement Compressors for Petroleum, Chemical and Gas Industry Services.
- API Std 620: Design and Construction of large welded, low-pressure storage tanks.
- API Std 650: Welded steel tanks for oil storage.
- API Std 670: Machinery Protection Systems.
- API Std 671: Special purpose Couplings for Petroleum, Chemical and Gas Industry Services.
- API Std 672: Packaged, Integrally Geared, Centrifugal Air Compressors for Petroleum, Chemical and Gas Industry services.
- API Std 673: Centrifugal Fans for Petroleum, Chemical and Gas Industry Services.
- API Std 674: Positive displacement pumps – Reciprocating.
- API Std 675: Positive displacement pumps – Controlled volume.
- API Std 676: Positive displacement pumps – Rotary.
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>ISO 10439</td>
<td>Petroleum, Chemical and Gas Service Industries – Centrifugal Compressors.</td>
</tr>
<tr>
<td>ISO 13631</td>
<td>Petroleum and Natural Gas Industries – Packaged Reciprocating Gas Compressors.</td>
</tr>
<tr>
<td>ISO 13691</td>
<td>Petroleum and Natural Gas Industries – High-speed Special Purpose Gear Units.</td>
</tr>
<tr>
<td>ISO 14310</td>
<td>Petroleum and Natural Gas Industries – Downhole Equipment – Packers and Bridge Plugs.</td>
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<tr>
<td>ISO 15136</td>
<td>Downhole Equipment for Petroleum and Natural Gas Industries – Progressing Cavity Pump Systems for Artificial Lift.</td>
</tr>
<tr>
<td>NFPA No. 37</td>
<td>1975 Stationary Combustion Engines and Gas Turbines.</td>
</tr>
<tr>
<td>BS 5950</td>
<td>Structural Use of Steelwork in Building.</td>
</tr>
<tr>
<td>BS 2853</td>
<td>The Design and Testing of Steel Overhead Runway Beams.</td>
</tr>
<tr>
<td>BS EN 1993</td>
<td>Eurocode 3: Design of Steel Structures.</td>
</tr>
<tr>
<td>BS 8118</td>
<td>Structural Use of Aluminium. Design of Flat Plate Structures.</td>
</tr>
<tr>
<td>BS 8100</td>
<td>Lattice Towers and Masts.</td>
</tr>
<tr>
<td>API RP 2SK</td>
<td>Recommended Practice for Design and Analysis of Stationkeeping Systems for Floating Structures.</td>
</tr>
<tr>
<td>EN 1337-8</td>
<td>Structural bearings – Part 8: Guide bearings and restrain bearings.</td>
</tr>
<tr>
<td>EN 1337</td>
<td>Structural bearings – Part 5: European Standard, Construction Standardisation: Pot Bearing.</td>
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</tbody>
</table>
A1.2.14 Hazard area classification:

- API RP 500: Classification of Locations for Electrical Installations at Petroleum Facilities.
- API RP 505: Classification of Locations for Electrical Installations at Petroleum Facilities, Classed as Class I, Zones 0, 1 & 2.

A1.2.15 Fire standards:

- ISO 13702: Petroleum and Natural Gas Industries – Control and Mitigation of Fires and Explosions on Offshore Production Installations – Requirements and guidelines.
- NFPA No. 10: Portable Extinguishers.
- NFPA No. 11: Low-Expansion Foam.
- NFPA No. 11A: Medium- and High-Expansion Foam Systems.
- NFPA No. 11C: Mobile Foam Apparatus.
- NFPA No. 12: Carbon Dioxide Systems.
- NFPA No. 12A: Halon 1301 Systems.
- NFPA No. 16: Deluge Foam-Water Systems.
- NFPA No. 16A: Closed Head Foam-Water Sprinkler Systems.
- NFPA No. 20: Centrifugal Fire Pumps.
- NFPA No. 68: Venting of Deflagrations.
- NFPA No. 69: Explosion Prevention Systems.
- NFPA No. 750: Standard for Installation of Water Mist Fire Suppression System.

A1.2.16 Bearings:

- ASME 77-DE-39: Design Criteria to Prevent Core Crushing Failure in Large Diameter Case Hardened Ball and Roller Bearings.

A1.2.17 Wind gust spectra formulations:

- Slettringen (Norwegian Petroleum Directorate): HSE OTI 95-634.

A1.2.18 Wave contour development:

- Winterstein et al, Environmental Parameters for Extreme Response: Inverse Form with Omission Factors.

A1.2.19 Codes for concrete structures:

- BS 8110: Structural Use of Concrete, Parts 1, 2 and 3.
- NS 3473: Concrete Structures – Design Rules.
- CSA S474: Concrete Structures, Offshore Structures.
- ISO 19903: Fixed Concrete Structures.

Other publications:
- Health and Safety Executive, Offshore Installations: Guidance on Design, Construction and Certification. (This guidance is no longer updated.)
- Norwegian Petroleum Directorate, Guidelines relating to concrete structures to regulations relating to load bearing structures in the petroleum activities.
## Codes, Standards and Equipment Categories

### Part 3, Appendix A

#### Sections A1 & A2

<table>
<thead>
<tr>
<th>A1.2.20</th>
<th><strong>Subsea:</strong></th>
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<tbody>
<tr>
<td>ISO 14723</td>
<td>Petroleum and Natural Gas Industries – Pipeline Transportation Systems – Subsea Pipeline valves.</td>
</tr>
<tr>
<td>ISO 15156-3</td>
<td>Petroleum and Natural Gas Industries – Materials for Use in H&lt;sub&gt;2&lt;/sub&gt;S-Containing Environments in Oil and Gas Production – Part 3: Cracking-resistant CRAs (corrosion resistant alloys) and Other Alloys. Use of Surface Valves and Underwater Safety Valves Offshore.</td>
</tr>
<tr>
<td>API RP 14H</td>
<td>Fire Test for Valves.</td>
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<tr>
<td>API Spec 6FA</td>
<td>Petroleum Valves (Gate, Plug, Ball and Check Valves).</td>
</tr>
<tr>
<td>API Spec 6D</td>
<td>Pressure Gauges and Gauge Attachments.</td>
</tr>
<tr>
<td>ASME B40.100</td>
<td>Petroleum, Petrochemical and Natural Gas Industries – Collection and Exchange of Reliability and Maintenance Data for Equipment.</td>
</tr>
<tr>
<td>ISO 13637</td>
<td>Petroleum and Natural Gas Industries – Mooring of Mobile Offshore Drilling Units (MODUS) – Design and Analysis.</td>
</tr>
<tr>
<td>WRC Bull 107</td>
<td>Welding Research Council – Local Stresses in Spherical and Cylindrical Shells Due to External Loading.</td>
</tr>
<tr>
<td>WRC Bull 297</td>
<td>Welding Research Council – Local Stresses in Spherical and Cylindrical Shells Due to External Loading on nozzles – Supplement to WRC Bull 107.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>A1.2.21</th>
<th><strong>Miscellaneous:</strong></th>
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<tr>
<td>NACE MR0175/ISO 15156</td>
<td>Petroleum and Natural Gas Industries – Materials for use in H&lt;sub&gt;2&lt;/sub&gt;S-Containing Environment in Oil and Gas Production.</td>
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<tr>
<td>ISO 19901-4 (2003), Petroleum and Natural Gas Industries – Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations.</td>
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</table>

### Section A2

#### Equipment categories

#### A2.1 Drilling equipment

A2.1.1 A list of usual drilling equipment with its categories is given in Table A2.1.
### Table A2.1 Usual drilling equipment with its categories (see continuation)

<table>
<thead>
<tr>
<th>Systems and types of equipment</th>
<th>Category</th>
<th>Description of equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Well protection valves with control systems</td>
<td>1A</td>
<td>Hydraulic connector for wellhead</td>
</tr>
<tr>
<td>1.1 Blow out prevention</td>
<td>1A</td>
<td>Ram preventers</td>
</tr>
<tr>
<td>1.1.1 Equipment</td>
<td>1A</td>
<td>Annular preventers</td>
</tr>
<tr>
<td>1.1.2 Control equipment</td>
<td>1B</td>
<td>Accumulators for subsea stack</td>
</tr>
<tr>
<td>1.2</td>
<td>Subsea fail-safe valves in choke and kill lines</td>
<td></td>
</tr>
<tr>
<td>1.2 Choke and kill equipment</td>
<td>1A</td>
<td>Clamp</td>
</tr>
<tr>
<td>1.2</td>
<td>Test stump</td>
<td></td>
</tr>
<tr>
<td>1.2.1</td>
<td>Accumulators in control system</td>
<td></td>
</tr>
<tr>
<td>1.2.2</td>
<td>Welded pipes and manifolds</td>
<td></td>
</tr>
<tr>
<td>1.2.3</td>
<td>Unwelded hydraulic piping</td>
<td></td>
</tr>
<tr>
<td>1.2.4</td>
<td>Flexible control hoses</td>
<td></td>
</tr>
<tr>
<td>1.2.5</td>
<td>Hydraulic hose reel</td>
<td></td>
</tr>
<tr>
<td>1.2.6</td>
<td>Hydraulic power unit including pumps and manifold</td>
<td></td>
</tr>
<tr>
<td>1.2.7</td>
<td>Control panels</td>
<td></td>
</tr>
<tr>
<td>1.3 Diverter unit</td>
<td>1B</td>
<td>Acoustic transportable emergency power package</td>
</tr>
<tr>
<td>1.3</td>
<td>Control panels</td>
<td></td>
</tr>
<tr>
<td>2. Marine riser with control systems</td>
<td>1A</td>
<td>Choke manifold</td>
</tr>
<tr>
<td>2.1</td>
<td>All piping to and from choke manifold</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Piping for choke, kill and booster lines</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Flexible hoses for choke, kill and booster lines</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Valves in choke, kill and booster lines</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Unions and swivel joints</td>
<td></td>
</tr>
<tr>
<td>3. Heave compensation</td>
<td>1B</td>
<td>Emergency circulation pump – pressure side</td>
</tr>
<tr>
<td>3.1 Tensioning system for riser and guidelines</td>
<td>1B</td>
<td>Diverter house with annular valve</td>
</tr>
<tr>
<td>3.2 Drill string compensator</td>
<td>1B</td>
<td>Diverter piping</td>
</tr>
<tr>
<td>3.3</td>
<td>Valves in diverter piping</td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>Control panel</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>Hydraulic power unit including pumps and manifold</td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Control panel</td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Riser tensioner</td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Guideline and podline tensioners</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>Hydro-pneumatic accumulators</td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>Pressure vessels</td>
<td></td>
</tr>
<tr>
<td>3.11</td>
<td>Piping system</td>
<td></td>
</tr>
<tr>
<td>3.12</td>
<td>Air compressors</td>
<td></td>
</tr>
<tr>
<td>3.13</td>
<td>Air dryers</td>
<td></td>
</tr>
<tr>
<td>3.14</td>
<td>Wire ropes for tensioning equipment</td>
<td></td>
</tr>
<tr>
<td>3.15</td>
<td>Sheaves for riser tension line</td>
<td></td>
</tr>
<tr>
<td>3.16</td>
<td>Sheaves for guideline and podline</td>
<td></td>
</tr>
<tr>
<td>3.17</td>
<td>Telescopic arms for tension lines</td>
<td></td>
</tr>
<tr>
<td>3.18</td>
<td>Control panels</td>
<td></td>
</tr>
<tr>
<td>3.19</td>
<td>Compensator</td>
<td></td>
</tr>
<tr>
<td>3.20</td>
<td>Hydro-pneumatic accumulators</td>
<td></td>
</tr>
<tr>
<td>3.21</td>
<td>Pressure vessels</td>
<td></td>
</tr>
<tr>
<td>3.22</td>
<td>Piping system including flexible hoses</td>
<td></td>
</tr>
<tr>
<td>3.23</td>
<td>Air compressor</td>
<td></td>
</tr>
<tr>
<td>3.24</td>
<td>Air dryer</td>
<td></td>
</tr>
<tr>
<td>3.25</td>
<td>Wire ropes</td>
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<td>3.26</td>
<td>Sheaves</td>
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</tr>
<tr>
<td>3.27</td>
<td>Control panels</td>
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### Table A2.1 Usual drilling equipment with its categories (continued)

<table>
<thead>
<tr>
<th>Systems and types of equipment</th>
<th>Category</th>
<th>Description of equipment</th>
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<td><strong>4. Hoisting rotation and pipe handling</strong></td>
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</tr>
<tr>
<td>4.1 Drilling derrick</td>
<td>1A</td>
<td>Derrick and substructure</td>
</tr>
<tr>
<td>4.2 Hoisting equipment for derrick</td>
<td>1B</td>
<td>Sheaves for crown block and travelling block</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crown block including support beams</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guide track and dolly for travelling block</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Travelling block</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Drilling hook</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Swivel</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Links</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Elevators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drilling line and sand line</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Deadline anchor</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Drawworks including foundation</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Air winches for the transport of personnel</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Cranes in derrick</td>
</tr>
<tr>
<td><strong>4.3 Rotary equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Rotary table including skid adopter and driving unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kelly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Master bushing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kelly bushing</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Top drive</td>
</tr>
<tr>
<td><strong>4.4 Pipe handling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Racking arms with or without lifting head</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finger board</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Manual tongs for pipe handling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power tongs for pipe handling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kelly spinner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power slips</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Elevators for lifting pipe</td>
</tr>
<tr>
<td><strong>5. Miscellaneous equipment for drilling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Pressurised storage vessels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piping system for pressurised bulk transport</td>
</tr>
<tr>
<td><strong>6. Bulk storage, drilling fluid circulation and cementing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1 Bulk storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Piping systems for mixing of drilling fluid and suction line to the drilling fluid pump</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centrifugal pumps for mixing drilling fluid</td>
</tr>
<tr>
<td><strong>6.2 Drilling fluid, circulation and transportation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.2.1 Suction and transport System II</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piping systems for mixing of drilling fluid and suction line to the drilling fluid pump</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centrifugal pumps for mixing drilling fluid</td>
</tr>
<tr>
<td><strong>6.2.2 Well circulation system (high pressure)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drilling fluid pump – pressure side</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Pulsation dampers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piping circulation of drilling fluid in the well</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Standpipe manifold</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Rotary hose with end connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kelly cocks</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Non-return valve in drill string (inside BCP)</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Mixing pumps</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Safety valves</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Circulation head</td>
</tr>
<tr>
<td><strong>6.2.3 Mud return system on deck</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mud return pipe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dump tank</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shale shaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drilling fluid tanks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trip tank</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Desander, desilter</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Degasser</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Piping from degasser to burners or to ventilation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemical mixers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agitators for drilling fluid</td>
</tr>
<tr>
<td><strong>6.2.4 Cementing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centrifugal pumps for mixing of cement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piping system for mixing cement and suction line to the cement pump</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Cement pump – pressure side</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Pulsation dampener</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Piping for cement pump discharge</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Safety valves</td>
</tr>
</tbody>
</table>
A2.2 Miscellaneous equipment

A2.2.1 A list of miscellaneous equipment forming part of the drilling installation is given in Table A2.2.

Table A2.2  Miscellaneous equipment forming part of the drilling installation

<table>
<thead>
<tr>
<th>Component</th>
<th>Conditions</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Piping</td>
<td>Thickness of wall &gt; 25.4 mm Design temperature &gt; 400°C</td>
<td>1B</td>
</tr>
<tr>
<td></td>
<td>All welded pipes and piping systems used in Category 1A and 1B piping systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipes other than those mentioned above and pipes in Category II systems</td>
<td>II</td>
</tr>
<tr>
<td>2. Flanges and couplings</td>
<td>Standard flanges and pipe couplings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-standard flanges and pipe couplings used in Category 1A and 1B piping systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flanges and pipe couplings other than those mentioned above, and flanges and couplings for Category II piping systems</td>
<td></td>
</tr>
<tr>
<td>3. Valves</td>
<td>Valve body welded construction with ANSI rating &gt; 600 lbs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valves designed and manufactured in accordance with recognised standards</td>
<td></td>
</tr>
<tr>
<td>4. Components of high strength material</td>
<td>Specified yield strength &gt; 345 N/mm² or tensile strength &gt; 515 N/mm²</td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. The equipment list is intended as a guide only and does not necessarily cover all the equipment items found in a drilling plant facility.
2. Equipment considered to be important for safety which is not listed in the Table will be specially considered by LR and categorised.

A2.3 Production equipment

A2.3.1 A list of usual production equipment with its categories is given in Table A2.3.
### Table A2.3 Production equipment with its categories

<table>
<thead>
<tr>
<th>Systems and types of equipment</th>
<th>Category</th>
<th>Description of equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Christmas tree and subsea production system</td>
<td>1A</td>
<td>Christmas tree, wellhead couplings, valves and control lines</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Production manifolds and piping</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Template and other floor structures</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Well safety valve</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Electrical control module</td>
</tr>
<tr>
<td>2. Riser system</td>
<td>1A</td>
<td>Riser sections</td>
</tr>
<tr>
<td>2.1 Rigid</td>
<td>1A</td>
<td>Hydraulic connector unit</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Ball and flexible joints</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Telescopic joints</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Support ring for tensioning system</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Valves and actuators</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Inflection restrictors</td>
</tr>
<tr>
<td>2.2 Flexible</td>
<td>1A</td>
<td>Flexible riser</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Connectors</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Buoyancy elements</td>
</tr>
<tr>
<td>3. Riser tensioning system</td>
<td>1B</td>
<td>Riser compensator</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Hydro-pneumatic accumulator</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Pressure vessel</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Pipe system</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Wire ropes</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Sheaves</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Telescopic arm for wire ropes</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Control panel</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Air compressor with drier</td>
</tr>
<tr>
<td>4. Hoisting and handling equipment for rigid riser</td>
<td>1A</td>
<td>Derrick</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Crown block with supporting beams</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Travelling block</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Hook</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Wire ropes</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Air tuggers for personnel</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Air tuggers</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Loose equipment for riser handling</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Crane for handling production equipment</td>
</tr>
<tr>
<td>5. Oil production/processing equipment</td>
<td>1B</td>
<td>Production manifold with valves</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Separator</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Heat exchanger</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Gas liquid separator/cleansers</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Gas compressor (pressure side)</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Dehydrators</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Crude oil loading pumps</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Crude oil and gas metering equipment</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Gas liquid separator tanks</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Glycol contactor</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Water injection pump (pressure side)</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Glycol injection pump with equipment</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Oil protection and process shut-down equipment</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Valves and pipes</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Flare system</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Pig launcher/receiver unit</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Instrumentation and control equipment</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Swivel for production</td>
</tr>
<tr>
<td>6. Pressure vessels (general)</td>
<td>1B</td>
<td>Pressure vessels</td>
</tr>
<tr>
<td>7. Miscellaneous equipment</td>
<td>1A</td>
<td>Flare booms</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Burners</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Instrumentation components in general</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Main instrumentation components and equipment in critical systems (e.g., control panels)</td>
</tr>
<tr>
<td>8. For well overhaul and maintenance equipment, see Table A2.1</td>
<td>1B</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES**

1. The equipment list is intended as a guide only and does not necessarily cover all the equipment items found in a production plant facility.
2. Equipment considered to be important for safety which is not listed in the Table will be specially considered by LR and categorised.
### Table A2.4  Mechanical and electrical equipment and its categories for units engaged in the production, storage and offloading of liquefied gases in accordance with Part 11 (see continuation)

<table>
<thead>
<tr>
<th>Systems and types of equipment</th>
<th>Category</th>
<th>Description of equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mechanical and electrical equipment certification required</td>
<td>A1A</td>
<td>Boil-off gas compressor</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Turbo Expander</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Gas heat exchanger</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Burner</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Flare</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Cold vents</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Tensioning system</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Structural bearings</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Cold vent boom</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Offloading hose</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Offloading hose end valve</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Hawser strong point</td>
</tr>
<tr>
<td></td>
<td>IIA</td>
<td>Pneumatic line thrower</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Generators and motors over 100 kW</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Uninterruptible power supplies, including battery chargers, with rating above 100 kVA</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Explosion protected equipment if not carrying a certificate from a recognised test institution</td>
</tr>
<tr>
<td></td>
<td>IIA</td>
<td>All other electrical equipment</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Main control panels</td>
</tr>
<tr>
<td></td>
<td>IIA</td>
<td>Instrumentation components</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Gas turbines &gt; 110 kW</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Fire water pump skids (Package)</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Gas compressor skid (Package)</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Power generation skid</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Steam turbines</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Gears, shafts and couplings &gt; 110 kW</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Lifting appliances: see LR’s Code for Lifting Appliances in a Marine Environment and hoisting and handling</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Subsea facilities</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Hydraulic and pneumatic power units</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Flexible risers</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Control umbilicals</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Storage tanks over 1000 L</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Fired pressure vessels</td>
</tr>
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<td></td>
<td>A1A</td>
<td>Subsea systems</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Pressure vessels over 7 bar design pressure or 200°F design temperature</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Engines over 110 kW</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Fire pumps and fire pump packages</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Switchboards</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Fixed fire-fighting system</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Fixed fire and gas detection system</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Utility pumps and air compressors</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Expansion joint</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Expansion joint in cryogenic services</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>Non standard valves</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>ESD valve and actuator</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Christmas tree block and valves</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>HPU and pneumatic panels</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Dynamic positioning system</td>
</tr>
<tr>
<td></td>
<td>B1A</td>
<td>IGS system</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Cargo loading instrument</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Piping for Class I and Class II and boiler superheaters</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Mooring winches and windlass</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Spark arrestors and vent heads, PV valves</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Mooring chain</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Hydraulic actuator</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Anchor</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>GRE piping</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Resins</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Chokes</td>
</tr>
<tr>
<td></td>
<td>A1A</td>
<td>Winches and windlasses</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Communication equipment</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Fire and gas control panel and indicator</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Master Mode switch</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Fire hoses</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>Anodes</td>
</tr>
</tbody>
</table>
## Table A2.4  Mechanical and electrical equipment and its categories for units engaged in the production, storage and offloading of liquefied gases in accordance with Part 11 (conclusion)

<table>
<thead>
<tr>
<th>Systems and types of equipment</th>
<th>Category</th>
<th>Description of equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Marine system equipment to be built under survey as per Pt 5, Ch 1.1</td>
<td>See Note 1A</td>
<td>Main propulsion engines including their associated gearing, flexible couplings, scavenging blowers and superchargers</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Machinery and equipment for lowering deck structures of self-elevating units</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Boilers supplying steam for propulsion or for services essential for the safety or the operation of the ship at sea, including superheaters, economisers, desuperheaters, steam heated steam generators and steam receivers. All other boilers having working pressures exceeding 3.4 bar (3.5 kgf/cm²), and having heating surfaces greater than 4.65 m²</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Auxiliary engines which are the source of power for services essential for safety or for the operation of the ship at sea</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Steering machinery</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Athwartship thrust units, their prime movers and control mechanisms</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>All pumps necessary for the operation of main propulsion and essential machinery, e.g., boiler feed, cooling water circulating, condensate extraction, oil fuel and lubricating oil pumps</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>All heat exchangers necessary for the operation of main propulsion and essential machinery, e.g., air, water and lubricating oil coolers, oil fuel and feed water heaters, de-aerators and condensers, evaporators and distiller units</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Air compressors, air receivers and other pressure vessels necessary for the operation of main propulsion and essential machinery. Any other unfired pressure vessels for which plans are required to be submitted as detailed in Ch 11.1.6</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Valves and other components intended for installation in pressure piping systems having working pressure exceeding 7.0 bar</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Alarms and control systems as detailed in Pt 6, Ch 1 and Pt 7, Ch 1</td>
</tr>
</tbody>
</table>

### NOTES

Items marked TA are to be type approved.

1. Category for gears, shafts and couplings is to be either 1A, 1B or II, depending on the category of the prime mover associated with the unit.

2. Fire water pump (directly driven) can be considered Category 1B. Fire water lift pump (not directly driven) of proven design may be accepted by confirmation of material, witness of testing and review of fabrication documentation (1B). Fire water pump packages are to be built under survey (1A).

3. For complex machinery and equipment packages, categorisation and approval procedure to be agreed with on a case by case basis, considering selection of materials, service and complexity of design and fabrication method.

4. The approval procedure to be agreed with on a case by case basis, depending on function and criticality. See relevant Rule requirements, AS 4343, EC directives, Regulatory requirements, specific purchaser requirement.

Additional Notes for classed pressure vessel requirements. See also Pt 5, Ch 10.1.6.

Plans of pressure vessels are to be submitted in triplicate for consideration where all the conditions in (a) or (b) are satisfied:

(a) The vessel contains vapours or gases, e.g., air receivers, hydrometers or similar vessels and gaseous CO₂ vessels for fire-fighting, and 

\[ pV > 600 \]

\[ p > 1 \]

\[ V > 100 \]

\[ V = \text{volume (litres) of gas or vapour space.} \]

(b) The vessel contains liquefied gases, for fire-fighting or flammable liquids, and 

\[ p > 7 \]

\[ V > 100 \]

\[ V = \text{volume (litres).} \]