Rules and Regulations for the Classification of Mobile Offshore Units

Part 4
Steel Unit Structures

June 2013
# Chapter Contents

<table>
<thead>
<tr>
<th>PART</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REGULATIONS</td>
</tr>
<tr>
<td>2</td>
<td>RULES FOR THE MANUFACTURE, TESTING AND CERTIFICATION OF MATERIALS</td>
</tr>
<tr>
<td>3</td>
<td>FUNCTIONAL UNIT TYPES AND SPECIAL FEATURES</td>
</tr>
<tr>
<td>4</td>
<td>STEEL UNIT STRUCTURES</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 1</strong> General</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td><strong>Appendix A</strong> Fatigue – S-N Curves, Joint Classification and Stress Concentration Factors</td>
</tr>
<tr>
<td>5</td>
<td>MAIN AND AUXILIARY MACHINERY</td>
</tr>
<tr>
<td>6</td>
<td>CONTROL AND ELECTRICAL ENGINEERING</td>
</tr>
<tr>
<td>7</td>
<td>SAFETY SYSTEMS, HAZARDOUS AREAS AND FIRE</td>
</tr>
<tr>
<td>8</td>
<td>CORROSION CONTROL</td>
</tr>
</tbody>
</table>
## Contents

### Part 4

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>1</th>
<th>GENERAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section</td>
<td>1</td>
<td>Rule application</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Loading</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Advisory services</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Intact and damage stability</td>
</tr>
<tr>
<td>Section</td>
<td>2</td>
<td>Direct calculations</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Equivalents</td>
</tr>
<tr>
<td>Section</td>
<td>3</td>
<td>National and International Regulations</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>International Conventions</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>International Association of Classification Societies (IACS)</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>International Maritime Organization (IMO)</td>
</tr>
<tr>
<td>Section</td>
<td>4</td>
<td>Information required</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Plans and supporting information</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>Calculations and data</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
<td>Specifications</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>Plans to be supplied to the unit</td>
</tr>
<tr>
<td>Section</td>
<td>5</td>
<td>Definitions</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td>General</td>
</tr>
<tr>
<td>Section</td>
<td>6</td>
<td>Inspection, workmanship and testing</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>General</td>
</tr>
</tbody>
</table>

### CHAPTER 2 MATERIALS

<table>
<thead>
<tr>
<th>Section</th>
<th>1</th>
<th>Materials of construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Steel</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Section</td>
<td>2</td>
<td>Structural categories</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Column-stabilised units</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Self-elevating units</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Surface type units</td>
</tr>
<tr>
<td>Section</td>
<td>3</td>
<td>Design temperature</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>General</td>
</tr>
<tr>
<td>Section</td>
<td>4</td>
<td>Steel grades</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>General</td>
</tr>
</tbody>
</table>

### CHAPTER 3 STRUCTURAL DESIGN

<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>Section</td>
<td>2</td>
<td>Design concepts</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>Elastic method of design</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Limit state method of design</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Plastic method of design</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Fatigue design</td>
</tr>
</tbody>
</table>
Contents

Section 3 Structural idealisation
3.1 General
3.2 Geometric properties of section
3.3 Determination of span point
3.4 Grouped stiffeners

Section 4 Structural design loads
4.1 General
4.2 Definitions
4.3 Load combinations
4.4 Gravity and functional loads
4.5 Buoyancy loads
4.6 Wind loads
4.7 Current loads
4.8 Orientation and wave direction
4.9 Wave loads
4.10 Inertia loads
4.11 Mooring loads
4.12 Snow and ice loads
4.13 Marine growth
4.14 Hydrostatic pressures
4.15 Deck loads
4.16 Accidental loads
4.17 Fatigue design
4.18 Other loads

Section 5 Number and disposition of bulkheads
5.1 General
5.2 Self-elevating units
5.3 Column-stabilised units
5.4 Protection of tanks carrying oil fuel and lubricating oil

CHAPTER 4 STRUCTURAL UNIT TYPES

Section 1 Column-stabilised units
1.1 General
1.2 Air gap
1.3 Structural design
1.4 Upper hull structure
1.5 Columns
1.6 Lower hulls
1.7 Main primary bracings
1.8 Bracing joints
1.9 Lifeboat platforms
1.10 Topside structure

Section 2 Sea bed-stabilised units
2.1 General
2.2 Air gap
2.3 Operating conditions
2.4 Corrosion protection

Section 3 Self-elevating units
3.1 General
3.2 Air gap
3.3 Structural design
3.4 Hull structure
3.5 Deckhouses
3.6 Structure in way of jacking or elevating arrangements
3.7 Leg wells
3.8 Leg design
3.9 Unit in the elevated position
3.10 Legs in field transit conditions
3.11 Legs in ocean transit conditions
3.12 Legs during installation conditions
3.13 Stability in-place
3.14 Sea bed conditions
3.15 Foundation fixity
3.16 Bottom mat
3.17 Independent footings
3.18 Lifeboat platforms
3.19 Topside structure

Section 4 Surface type units
4.1 General

CHAPTER 5 PRIMARY HULL STRENGTH

Section 1 General requirements
1.1 General
1.2 Structural analysis
1.3 Primary structure
1.4 Connections and details
1.5 Stress concentration

Section 2 Permissible stresses
2.1 General

Section 3 Buckling strength of plates and stiffeners
3.1 Application
3.2 Symbols
3.3 Elastic critical buckling stress
3.4 Scantling criteria

Section 4 Buckling strength of primary members
4.1 Application
4.2 Symbols
4.3 Elastic critical buckling stress
4.4 Scantling criteria

Section 5 Fatigue design
5.1 General
5.2 Fatigue life assessment
5.3 Fatigue damage calculations
5.4 Joint classifications and S-N curves
5.5 Cast or forged steel
5.6 Factors of safety on fatigue life

CHAPTER 6 LOCAL STRENGTH

Section 1 General requirements
1.1 General

Section 2 Design heads
2.1 General
2.2 Symbols
2.3 Stowage rate and design heads

Section 3 Watertight shell boundaries
3.1 General
3.2 Column-stabilised units
3.3 Self-elevating units
Contents

Part 4

Section 4 Decks
4.1 General
4.2 Deck plating
4.3 Deck stiffening
4.4 Deck supporting structure
4.5 Deck openings

Section 5 Helicopter landing areas
5.1 General
5.2 Plans and data
5.3 Arrangements
5.4 Landing area plating
5.5 Deck stiffening and supporting structure
5.6 Stowed helicopters
5.7 Bimetallic connections

Section 6 Decks loaded by wheeled vehicles
6.1 General

Section 7 Bulkheads
7.1 General
7.2 Symbols
7.3 Watertight and deep tank bulkheads
7.4 Watertight flats, trunks and tunnels
7.5 Watertight void compartments
7.6 Mud tanks
7.7 Non-watertight bulkheads

Section 8 Double bottom structure
8.1 Symbols and definitions
8.2 General
8.3 Self-elevating units
8.4 Column-stabilised and sea bed-stabilised units

Section 9 Superstructures and deckhouses
9.1 General
9.2 Symbols
9.3 Definition of tiers
9.4 Design pressure head
9.5 Bulkhead plating and stiffeners
9.6 Erections on self-elevating units
9.7 Erections on other unit types
9.8 Deck plating
9.9 Deck stiffening
9.10 Deck girders and transverses
9.11 Strengthening at ends and sides of erections
9.12 Unusual designs
9.13 Aluminium erections
9.14 Fire protection

Section 10 Bulwarks and other means for the protection of crew and other personnel
10.1 General requirements
10.2 Construction of bulwarks
10.3 Guard rail construction
10.4 Helicopter landing area
10.5 Freeing arrangements
10.6 Deck drainage
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>11</th>
<th>Topside to hull structural sliding bearings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>11.2</td>
<td>Definitions, symbols and nomenclatures</td>
</tr>
<tr>
<td></td>
<td>11.3</td>
<td>References</td>
</tr>
<tr>
<td></td>
<td>11.4</td>
<td>General principle</td>
</tr>
<tr>
<td></td>
<td>11.5</td>
<td>Displacements</td>
</tr>
<tr>
<td></td>
<td>11.6</td>
<td>Serviceability, maintenance and protection requirements</td>
</tr>
<tr>
<td></td>
<td>11.7</td>
<td>Additional requirements</td>
</tr>
<tr>
<td></td>
<td>11.8</td>
<td>Components of sliding bearings</td>
</tr>
<tr>
<td></td>
<td>11.9</td>
<td>Bearing selection</td>
</tr>
<tr>
<td></td>
<td>11.10</td>
<td>Elastomer</td>
</tr>
<tr>
<td></td>
<td>11.11</td>
<td>Fatigue</td>
</tr>
<tr>
<td></td>
<td>11.12</td>
<td>Detailing</td>
</tr>
</tbody>
</table>

### CHAPTER 7 WATERTIGHT AND WEATHERTIGHT INTEGRITY AND LOAD LINES

<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>Plans to be submitted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>2</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1</td>
<td>Freeboard deck</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Freeboard</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Weathertight</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Watertight</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>Position 1 and Position 2</td>
</tr>
<tr>
<td></td>
<td>2.6</td>
<td>Damage waterline</td>
</tr>
<tr>
<td></td>
<td>2.7</td>
<td>Intact stability waterline</td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td>Down flooding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>3</th>
<th>Installation layout and stability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.1</td>
<td>Control rooms</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Damage zones</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>4</th>
<th>Watertight integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1</td>
<td>Watertight boundaries</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Tank boundaries</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>Boundary penetrations</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
<td>Internal openings related to damage stability</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>External openings related to damage stability</td>
</tr>
<tr>
<td></td>
<td>4.6</td>
<td>Strength of watertight doors and hatch covers</td>
</tr>
<tr>
<td></td>
<td>4.7</td>
<td>Weathertight integrity related to stability</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>5</th>
<th>Load lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.1</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>Column-stabilised units</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td>Self-elevating units</td>
</tr>
<tr>
<td></td>
<td>5.4</td>
<td>Surface type units</td>
</tr>
<tr>
<td></td>
<td>5.5</td>
<td>Sea bed-stabilised units</td>
</tr>
<tr>
<td></td>
<td>5.6</td>
<td>Weathertight integrity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>6</th>
<th>Miscellaneous openings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.1</td>
<td>Small hatchways on exposed decks</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>Hatchways within enclosed superstructures or ‘tween decks</td>
</tr>
<tr>
<td></td>
<td>6.3</td>
<td>Hatch coamings</td>
</tr>
<tr>
<td></td>
<td>6.4</td>
<td>Manholes and flush scuttles</td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>Companionways, doors and access arrangements on weather decks</td>
</tr>
<tr>
<td></td>
<td>6.6</td>
<td>Side scuttles, windows and skylights</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>7</th>
<th>Tank access arrangements and closing appliances in oil storage units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.1</td>
<td>General</td>
</tr>
</tbody>
</table>
### Contents

#### Section 8 Ventilators
- 8.1 General

#### Section 9 Air and sounding pipes
- 9.1 General

#### Section 10 Scuppers and sanitary discharges
- 10.1 General

#### CHAPTER 8 WELDING AND STRUCTURAL DETAILS

#### Section 1 General
- 1.1 Application
- 1.2 Symbols

#### Section 2 Welding
- 2.1 General
- 2.2 Impact test requirements
- 2.3 Workmanship and inspection
- 2.4 Fillet welds
- 2.5 Welding of tubular members

#### Section 3 Secondary member end connections
- 3.1 General

#### Section 4 Construction details for primary members
- 4.1 General
- 4.2 Geometric properties and proportions

#### Section 5 Structural details
- 5.1 General
- 5.2 Arrangements at intersections of continuous secondary and primary members
- 5.3 Openings
- 5.4 Other fittings and attachments

#### Section 6 Fabrication tolerances
- 6.1 General

#### CHAPTER 9 ANCHORING AND TOWING EQUIPMENT

#### Section 1 Anchoring equipment
- 1.1 General
- 1.2 Equipment number
- 1.3 Determination of equipment
- 1.4 Anchors
- 1.5 High holding power anchors
- 1.6 Chain cables
- 1.7 Arrangements for working and stowing anchors and cables
- 1.8 Testing of equipment

#### Section 2 Towing arrangements
- 2.1 General
- 2.2 Towing system
- 2.3 Strength
- 2.4 Retrieval system
- 2.5 Spare parts
## CHAPTER 10  STEERING AND CONTROL SYSTEMS

**Section 1  General**
- 1.1 Application
- 1.2 General symbols
- 1.3 Navigation in ice
- 1.4 Materials

**Section 2  Rudders**
- 2.1 General

**Section 3  Fixed and steering nozzles**
- 3.1 General

**Section 4  Steering gear and allied systems**
- 4.1 General

**Section 5  Tunnel thrust unit structure**
- 5.1 General

**Section 6  Stabiliser structure**
- 6.1 General

## CHAPTER 11  QUALITY ASSURANCE SCHEME (HULL)

**Section 1  General**
- 1.1 Definitions
- 1.2 Scope of the Quality Assurance Scheme

**Section 2  Application**
- 2.1 Certification of the fabrication yard

**Section 3  Particulars to be submitted**
- 3.1 Documentation and procedures

**Section 4  Requirements of Parts 1 and 2 of the Scheme**
- 4.1 General

**Section 5  Additional requirements for Part 2 of the Scheme**
- 5.1 Quality System procedures

**Section 6  Initial assessment of fabrication yard**
- 6.1 General

**Section 7  Approval of the fabrication yard**
- 7.1 General

**Section 8  Maintenance of approval**
- 8.1 General

**Section 9  Suspension or withdrawal of approval**
- 9.1 General

## APPENDIX A  FATIGUE – S-N CURVES, JOINT CLASSIFICATION AND STRESS CONCENTRATION FACTORS

**Section A1  General**
- A1.1 Application
<table>
<thead>
<tr>
<th>Section</th>
<th>A2</th>
<th>Fatigue design S-N curves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A2.1</td>
<td>Basic design S-N curves</td>
</tr>
<tr>
<td></td>
<td>A2.2</td>
<td>Modifications to basic S-N curves</td>
</tr>
<tr>
<td></td>
<td>A2.3</td>
<td>Treatment of low stress cycles</td>
</tr>
<tr>
<td></td>
<td>A2.4</td>
<td>Treatment of high stress cycles</td>
</tr>
<tr>
<td>Section</td>
<td>A3</td>
<td>Fatigue joint classification</td>
</tr>
<tr>
<td></td>
<td>A3.1</td>
<td>General</td>
</tr>
<tr>
<td>Section</td>
<td>A4</td>
<td>Stress concentration factors</td>
</tr>
<tr>
<td></td>
<td>A4.1</td>
<td>General</td>
</tr>
</tbody>
</table>
Section 1

Rule application

1.1 General

1.1.1 The Rules, in general, apply to steel units of all welded construction. The use of other materials in the structure will be specially considered. The Rules apply to the unit types defined in Parts 1 and 3. Units of unconventional design will receive individual consideration based on the general standards of the Rules.

1.2 Loading

1.2.1 The Rules are framed on the understanding that units will be properly loaded and operated. Units are to be operated in accordance with an Operations Manual which is to contain all the necessary information for the safe loading and operation of the unit, see Pt 3, Ch 1.3.

1.2.2 For surface type units, loading guidance information may be required by means of a Loading Manual, see Pt 1, Ch 2.1.9. The loading manual may be a separate document or the information can be included in the Operations Manual.

1.2.3 Where an onboard computer system having a longitudinal strength or a stability computation capability is provided, the system is to be certified in accordance with LR's Approval of Longitudinal Strength and Stability Calculation Programs.

1.3 Advisory services

1.3.1 The Rules do not cover certain technical characteristics such as stability, trim, vibration, docking arrangements, etc. The Classification Committee cannot assume responsibility for these matters, but is willing to advise upon them on request.

1.4 Intact and damage stability

1.4.1 New units will be assigned class only after it has been demonstrated that the level of intact and damage stability is adequate, see Pt 1, Ch 2.1.

1.4.2 For classification purposes, the minimum requirements for watertight and weathertight integrity are to comply with Chapter 7.

Section 2

Direct calculations

2.1 General

2.1.1 Direct calculations may be specifically required by the Rules or may be submitted in support of alternative arrangements and scantlings. LR may undertake independent calculations to check the calculations submitted by the designers.

2.2 Equivalents

2.2.1 In addition to cases where direct calculations are specifically required by the Rules, LR will consider alternative arrangements and scantlings which have been derived by direct calculations in lieu of specific Rule requirements. All direct calculations are to be submitted for examination.

2.2.2 Where direct calculation procedures are employed supporting documentation is to be submitted for appraisal and this is to include details of the following:

- Calculation methods, assumptions and references.
- Loading.
- Structural modelling.
- Design criteria and their derivation, e.g., permissible stresses, factors of safety against plate panel instability, etc.

2.2.3 LR will be ready to consider the use of Builders’ programs for direct calculations in the following cases:

(a) Where it can be established that the program has previously been satisfactorily used to perform a direct calculation similar to that now submitted.

(b) Where sufficient information and evidence of satisfactory performance is submitted to substantiate the validity of the computation performed by the program.
Section 3
National and International Regulations

3.1 International Conventions

3.1.1 The Committee, when authorised, will act on behalf of National Administrations and, if requested, LR will certify compliance in respect of National and International Statutory Safety and other requirements for offshore units.

3.1.2 In satisfying the Load Line Conventions, the general structural strength of the unit is required to be sufficient for the draught corresponding to the freeboards to be assigned. Units built and maintained in accordance with LR's Rules and Regulations possess adequate strength to satisfy the Load Line Conventions.

3.2 International Association of Classification Societies (IACS)

3.2.1 Where applicable, the Rules take into account unified requirements and interpretations established by IACS.

3.3 International Maritime Organization (IMO)

3.3.1 Attention is drawn to the fact that Codes of Practice issued by IMO contain requirements which are outside classification as defined in these Rules and Regulations.

Section 4
Information required

4.1 General

4.1.1 In general, the plans and information required to be submitted are given in 4.2.

4.1.2 Requirements for additional plans and information for functional unit types are given in Part 3.

4.1.3 Plans are generally to be submitted in triplicate, but only one copy of supporting documents and calculations will be required.

4.2 Plans and supporting information

4.2.1 Plans covering the following items are to be submitted for approval, as relevant to the type of unit:

- Erection sequence.
- Footings, pads or mats.
- Fore and aft end construction.
- Helideck.
- Ice strengthening.
- Leg structures and spuds.
- Loading manuals, preliminary and final.
- Machinery seatings.
- Main hull or pontoon structure.
- Masts and derrick posts.
- Materials and grades.
- Midship sections showing longitudinal and transverse material.
- Penetrations and attachments to primary structure.
- Profile and decks.
- Quality control and non-destructive testing procedures.
- Riser support structures.
- Rudder, stock, tiller and steering nozzles.
- Shell expansion.
- Stability columns.
- Stern frame and propeller brackets.
- Structural bulkheads and flats.
- Structure in way of jacking or elevating arrangements.
- Superstructures and deckhouses.
- Support structures for cranes, masts, derricks, flare towers and heavy equipment.
- Tank boundaries and overflows.
- Tank testing procedures and schedules.
- Temporary anchoring equipment.
- Towing arrangements and equipment.
- Transverse and longitudinal sections showing scantlings.
- Watertight sub-division.
- Watertight and oiltight bulkheads and flats.
- Watertight and weathertight doors and hatch covers.
- Welding details and procedures.

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

- General arrangements showing decks, profile and sections indicating all major items of equipment and machinery.
- Calculation of equipment number.
- Capacity plan.
- Cross curves of stability.
- Cross curves of allowable V.C.G.
- Design deck loading plan.
- Dry-docking plan.
- Operations Manual, see Pt 3, Ch 1.3.
- Tank sounding tables.
- Wind heeling moment curves.
- Lines plan or equivalent.
4.3 Calculations and data

4.3.1 The following calculations and information are to be submitted where relevant to the unit type and its design:

- Proposed class notations, operating areas and modes of operation, list of operating conditions stating proposed draughts.

- Design environmental criteria applicable to each mode, including wind speed, wave height and period, or sea state/wave energy spectra (as appropriate), water depth, tide and surge, current speed, minimum air temperature, ice and snow loads, sea bed conditions.

- A summary of weights and centres of gravity of lightship items.

- A summary of all items of deadweight, deck stores/supplies, fuel, fresh water, drill water, bulk and sack storage, crew and effects, deck loads (actual, not design allowables), riser, guideline, mooring tensions, hook or derrick loads and ballast schedules. The summary should be given for each operating condition.

- Details of distributed and concentrated gravity and live design loadings including crane overturning moments.

- Tank content data, and design pressure heads.

- Details of tank tests, model tests, etc.

- Strength and fatigue calculations.

- Calculation of hull girder still water bending moment and shear force as applicable.

- Calculation of hull girder section modulus at midships and elsewhere as required by LR.

- Stability calculations for intact and damaged cases covering a range of draughts to include all loading conditions.

- Documentation of damage cases, watertight subdivision and limits for downflooding.

- Freeboard calculation.

4.4 Specifications

4.4.1 Adequate design specifications in appropriate detail are to be submitted for information.

4.4.2 Specifications for the design and construction of the hull and structure are to include materials, grades/standards, welding construction procedures and fabrication tolerances.

4.4.3 Specifications related to the unit’s proposed operations are to include environmental criteria, modes of operation and a schedule of all model tests with reports on minimum air gap, motion predictions, mooring analysis, etc.

4.5 Plans to be supplied to the unit

4.5.1 The following plans and documents are to be placed on board the unit, see Pt 3, Ch 1,2:


- Construction Booklet.

- Main scantlings plans.

- Corrosion control system.

4.5.2 Where an OIWS (In-water Survey) notation is to be assigned, approved plans and information covering the items detailed in Pt 3, Ch 1,2 are also to be placed on board.

4.5.3 Where a ShipRight CM (Construction Monitoring) notation or descriptive note is to be assigned, the approved Construction Monitoring Plan (CMP), as detailed in the ShipRight Construction Monitoring Procedures, is to be maintained on board the unit.

Section 5

Definitions

5.1 General

5.1.1 Rule length, \( L \), in metres, for self-elevating units and semi-submersible units with twin lower hulls is to be taken as 97 per cent of the extreme length on the maximum design transit waterline measured on the centreline or on a projection of the centreline, see Fig. 1.5.1.

\[
L = 0.97L_1 \quad \text{in metres}
\]

\[
T_T = \text{maximum transit draught, in metres, measured from top of keel}
\]

Fig. 1.5.1

Rule length for self-elevating units and semi-submersible units with twin lower hulls

5.1.2 The Rule length, \( L \), for surface type units is the distance, in metres, on the summer load waterline from the forward side of the stem to the after side of the rudder post or to the centre of the rudder stock if there is no rudder post. \( L \) is to be not less than 96 per cent, and need not be greater than 97 per cent, of the extreme length on the summer load waterline. In ships with unusual stem or stern arrangements the Rule length, \( L \), will be specially considered.

5.1.3 The Rule length for units with unconventional form will be specially considered in relation to the transit or operating waterlines.

5.1.4 Breadth, \( B \), is the greatest moulded breadth, in metres.
5.1.5 **Depth**, \( D \), is measured, in metres, at the middle of the length, \( L \), from the top of keel to top of the deck beam at side on the uppermost continuous deck.

5.1.6 **Draught**, \( T_0 \), is the maximum design operating summer draught, in metres, measured from top of keel.

5.1.7 **Draught**, \( T_T \), is the maximum design transit summer draught, in metres, measured from top of keel.

5.1.8 The **block coefficient**, \( C_b \), is the moulded block coefficient corresponding to the maximum design draught \( T \) based on the Rule length \( L \) and moulded breadth \( B \) as follows:

\[
C_b = \frac{\text{Moulded displacement (m}^3\text{) at draught } T}{LB} 
\]

where

\[
T = T_0 \text{ for surface type units} \\
T = T_T \text{ for self-elevating and semi-submersible units.}
\]

5.1.9 In general, the forward perpendicular, F.P., is the perpendicular at the intersection of the waterline at the draught \( T \) with the fore end of the hull. The aft perpendicular, A.P., is the perpendicular at the intersection of the waterline at the draught \( T \) with the aft end of the hull, see also 5.1.2.

5.1.10 Amidships is to be taken as the middle of the Rule length, \( L \), measured from the forward side of the stem or hull.

5.1.11 **Lightweight** is defined as the weight of the complete unit with all its permanently installed machinery, equipment and outfit, including permanent ballast, spare parts normally retained on board, and liquids in machinery and piping to their normal working levels, but does not include liquids in storage or reserve supply tanks, items of consumable or variable loads, stores or crew and their effects.

---

**Section 6**

**Inspection, workmanship and testing**

6.1 **General**

6.1.1 Requirements regarding inspection, workmanship and testing are given in Pt 3, Ch 1.8 of the Rules for Ships and Ch 13.2 of the Rules for Materials and should be complied with.
Materials

Section 1

1. Materials of construction

2. Structural categories

3. Design temperature

4. Steel grades

Section 1

Materials of construction

1.1 General

1.1.1 The Rules relate in general to the construction of steel units, although consideration will be given to the use of other materials. For the use of aluminium alloys, see 1.3.

1.1.2 The materials used in the construction of the unit 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). Materials for which provision is not made therein may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary, see also Pt 3, Ch 1,4.

1.1.3 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, e.g., legs of self-elevating units. Generally, survey and certification are to be carried out in accordance with the requirements of the Rules for Materials.

1.2 Steel

1.2.1 Steel having a specified minimum yield stress of 235 N/mm² (24 kgf/mm²) is regarded as mild steel. Steel having a higher specified minimum yield stress is regarded as higher tensile steel.

1.2.2 When higher tensile steel is used in the construction of the unit the local scantlings determined from the Rules for steel plating, longitudinals, stiffeners and girders, etc., may be based on a \( k \) factor determined as follows:

\[
k = \frac{235}{\sigma_0} \left( k = \frac{24}{\sigma_0} \right)
\]

or 0.66, whichever is the greater

where \( \sigma_0 \) = specified minimum yield stress, of the higher tensile steel in N/mm² (kgf/mm²).

1.2.3 When higher tensile steel is used in the primary structure of ship units, the determination of the hull girder section modulus is to be based on a higher tensile steel factor \( k_L \) determined in accordance with Table 2.1.1.

1.2.4 For the application of the requirements of 1.2.2 and 1.2.3, special consideration will be given to steel where \( \sigma_0 > 355 \) N/mm² (36 kgf/mm²). Where such steel grades are used in areas which are subject to fatigue loading, the structural details are to be verified using fatigue design assessment methods.

1.2.5 Where steel castings or forgings are used for major structural components, they are to comply with Chapter 4 or Chapter 5 of the Rules for Materials, as appropriate.

1.3 Aluminium

1.3.1 The use of aluminium alloy is permitted for superstructures, deckhouses, hatch covers, helicopter platforms, or other local components on board offshore units, except where stated otherwise in Pt 3, Ch 1,4.5.

1.3.2 Except where otherwise stated, equivalent scantlings are to be derived as follows:

Plating thickness:

\[
t_a = t_s \sqrt{k_a} c
\]

Section modulus of stiffeners:

\[
Z_a = Z_s k_a c
\]

where

\[
c = \begin{cases} 0.95 & \text{for high corrosion resistant alloy} \\ 1.0 & \text{for other alloys} \end{cases}
\]

\[
k_a = \frac{235}{\sigma_a}
\]

\[
t_a = \text{thickness of aluminium plating}
\]

\[
t_s = \text{thickness of mild steel plating}
\]

\[
Z_a = \text{section modulus of aluminium stiffener}
\]

\[
Z_s = \text{section modulus of mild steel stiffener}
\]

\[
\sigma_a = 0.2 \text{ per cent proof stress or } 70 \text{ per cent of the ultimate strength of the material, whichever is the lesser.}
\]

1.3.3 In general, for welded structure, the maximum value of \( \sigma_a \) to be used in the scantlings derivation is that of the aluminium in the welded condition. However, consideration will be given to using unwelded values depending upon the weld line location, or other heat affected zones, in relation to the maximum applied stress on the member (e.g., extruded sections).

1.3.4 A comparison of the mechanical properties for selected welded and unwelded alloys is given in Table 2.1.2.

1.3.5 Where strain hardened grades (designated Hxxx) are used, adequate protection by coating is to be provided to avoid the risk of stress corrosion cracking.

1.3.6 The use of aluminium alloy for primary structure will be specially considered.
Table 2.1.2  Minimum mechanical properties for aluminium alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Condition</th>
<th>0.2% proof stress, N/mm²</th>
<th>Ultimate tensile strength, N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unwelded</td>
<td>Welded (see Note 4)</td>
</tr>
<tr>
<td>5083 O/H111</td>
<td>H112</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>5083 H112</td>
<td>H116/H321</td>
<td>215</td>
<td>125</td>
</tr>
<tr>
<td>5383 O/H111</td>
<td>H116/H321</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>5383 H116/H321</td>
<td>H112</td>
<td>220</td>
<td>145</td>
</tr>
<tr>
<td>5086 O/H111</td>
<td>H112</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>5086 H112</td>
<td>H116/H321</td>
<td>125</td>
<td>95</td>
</tr>
<tr>
<td>5086 H116/H321</td>
<td>H112</td>
<td>195</td>
<td>95</td>
</tr>
<tr>
<td>5059 O/H111</td>
<td>H116/H321</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>5059 H116/H321</td>
<td>H112</td>
<td>260</td>
<td>160</td>
</tr>
<tr>
<td>5456 O</td>
<td>H116</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>5456 H116</td>
<td>H321</td>
<td>200</td>
<td>125</td>
</tr>
<tr>
<td>5456 H321</td>
<td>H321</td>
<td>215</td>
<td>125</td>
</tr>
<tr>
<td>5754 O/H111</td>
<td>H321</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>6005A T5/T6 Extruded: Open Profile</td>
<td>215</td>
<td>215</td>
<td>260</td>
</tr>
<tr>
<td>6005A T5/T6 Extruded: Closed Profile</td>
<td>215</td>
<td>215</td>
<td>260</td>
</tr>
<tr>
<td>6061 T5/T6 Rolled Extruded: Open Profile</td>
<td>240</td>
<td>240</td>
<td>290</td>
</tr>
<tr>
<td>6061 T5/T6 Rolled Extruded: Closed Profile</td>
<td>240</td>
<td>240</td>
<td>290</td>
</tr>
<tr>
<td>6082 T5/T6 Rolled Extruded: Open Profile</td>
<td>240</td>
<td>240</td>
<td>290</td>
</tr>
<tr>
<td>6082 T5/T6 Rolled Extruded: Closed Profile</td>
<td>240</td>
<td>240</td>
<td>290</td>
</tr>
</tbody>
</table>

NOTES
1. These alloys are not normally acceptable for application in direct contact with sea-water.
2. See also Table 8.1.4 in Chapter 8 of the Rules for Materials.
3. The mechanical properties to be used to determine scantlings in other types and grades of aluminium alloy manufactured to National or proprietary standards and specifications are to be individually agreed with LR, see also Ch 8.1.1.5 of the Rules for Materials.
4. Where detail structural analysis is carried out, ‘Unwelded’ stress values may be used away from heat affected zones and weld lines, see also 1.3.3.
5. For thickness less than 12.5 mm the minimum unwelded 0.2% proof stress is to be taken as 230 N/mm² and the minimum tensile strength is to be taken as 315 N/mm².
Materials

Section 2

Structural categories

2.1 General

2.1.1 For the determination of steel grades in accordance with 4.1, all structural components of the unit may be grouped into structural categories taking into account the following aspects:
   (a) Applied loading, stress level and the associated stress pattern.
   (b) Critical load transfer points and stress concentrations.
   (c) Consequence of failure.

2.1.2 The structural categories can be summarised as follows:
   (a) Special structure:
       Primary structural elements which are in way of critical load transfer points and stress concentrations.
   (b) Primary structure:
       Structural elements essential to the overall integrity of the unit.
   (c) Secondary structure:
       Structural elements of less importance than primary structure, failure of which would be unlikely to affect the overall integrity of the unit.

2.1.3 For the structural categories of supporting structures of drilling plant and production and process plant, see Pt 3, Ch 7, 2.2 and Ch 8, 2.2 respectively.

2.2 Column-stabilised units

2.2.1 In general, the structural members of column-stabilised units are to be grouped into the following structural categories:
   (a) Special structure:
       (i) The plating of decks, heavy flanges, shell boundaries and bulkheads of the upper hull or platform which form ‘box’ or ‘I’ type supporting structure in way of critical load transfer points and which receive major concentrated loads.
       (ii) The shell plating in way of the intersections of vertical columns with platform decks and upper and lower hulls.
       (iii) End connections and major intersections of primary bracing members.
       (iv) Critical load transfer by ‘through’ material used at connections of vertical columns, upper platform decks and upper or lower hulls which are designed to provide proper alignment and adequate load transfer.
       (v) External brackets, portions of bulkheads, flats, and frames which are designed to receive concentrated loads at intersections of major structural members.
   (b) Primary structure:
       (i) The plating of decks, heavy flanges, shell boundaries and bulkheads of the upper hull or platform which form ‘box’ or ‘I’ type supporting structure except where the structure is considered as special application.
       (ii) The shell plating of vertical columns, lower and upper hulls, and diagonal and horizontal braces.
       (iii) Bulkheads, flats or decks, stiffeners and girders which provide local reinforcement or continuity of structure in way of intersections, except areas where the structure is considered as special application.
       (iv) Main support structure to cantilevered helicopter decks and lifeboat platforms.
       (v) Heavy substructures and equipment supports, e.g., drillfloor substructure, crane pedestals, anchor line fairleads and their supporting structure, see also 2.1.3.
       (vi) Riser support structure.
   (c) Secondary structure:
       (i) Upper platform decks or decks of upper hulls, except areas where the structure is considered as primary or special application.
       (ii) Bulkheads, stiffeners, flats, decks, girders and web frames in vertical columns, upper and lower hulls, diagonal and horizontal bracing, which are not considered as primary or special application.
       (iii) Helicopter platforms and deckhouses.
       (iv) Lifeboat platforms.

2.3 Self-elevating units

2.3.1 In general, the structural members of self-elevating units are to be grouped into the following categories:
   (a) Special structure:
       (i) Vertical columns in way of intersections with the mat structure.
       (ii) Intersections of lattice type leg structures which incorporate novel construction, including the use of steel castings.
   (b) Primary structure:
       (i) The plating of bulkheads, decks and shell boundaries of the main hull or platform which in combination form ‘box’ or ‘I’ type main supporting structure.
       (ii) External plating of cylindrical legs.
       (iii) Plating of all components of lattice type legs.
       (iv) Jack-house supporting structure.
       (v) External shell plating of footings and mats and structural components which receive initial transfer of loads from the leg structures.
       (vi) Internal bulkheads and girders of supporting structure of footings and mats which are designed to distribute major concentrated or uniform loads into the structure.
       (vii) Main support structure to cantilevered helicopter decks and lifeboat platforms.
       (viii) Heavy substructures and equipment supports, e.g., drillfloor substructure, drilling cantilevers and crane pedestals, see also 2.1.3.
   (c) Secondary structure:
       (i) Deck and shell boundaries of the main hull or platform, except where the structure is considered as primary application.
       (ii) Internal bulkheads, decks stiffeners and girders of the main hull structure, except where the structure is considered as primary structure.
       (iii) Internal diaphragms, girders or stiffeners in cylindrical legs.


2.4 Surface type units

2.4.1 Material classes and steel grades for individual areas of the hull structure of ship and barge type units are to comply with Pt 3, Ch 2.2 of the Rules for Ships.

2.4.2 Where the minimum design temperature, see 3.1, for exposed structure is -5°C or below, or for structural components not addressed by 2.4.1, the requirement of 2.4.3 should be complied with and the steel grades should be assigned in accordance with Table 2.4.1.

2.4.3 In general, the structure of ship type units is to be grouped into the following structural categories:

(a) Special structure:

(i) Structure in way of critical load transfer points which are designed to receive major concentrated loads in way of mooring systems, including yokes and similar structures, and supports to hawser to mooring installations including external hinges, complex padeyes, brackets and supporting structures.

(ii) Sheerstrake or rounded gunwale.

(iii) Stringer plate at strength deck.

(iv) Deck strake at longitudinal bulkheads.

(v) Bilge strake.

(vi) Continuous longitudinal hatch coamings.

(b) Primary structure:

(i) Strength deck and raised quarter deck plating except where categorised 'special'.

(ii) Bottom shell plating of the main hull except where categorised 'special'.

(iii) Bulkhead plating in way of moonpools, drilling wells and circumturret.

(iv) Upper strake in longitudinal bulkheads.

(v) Continuous longitudinal members above strength deck except where categorised 'special'.

(vi) Vertical strake (hatch side girder) and upper sloped strake in top wing tanks.

(vii) Main support structure to cantilevered helicopter decks and lifeboat platforms.

(viii) Heavy substructures and equipment supports, e.g., integrated support stools to process plant, drill floor substructure, crane pedestals, anchor line fairleads and chain stoppers for positional mooring systems and their supporting structures, see also 2.1.3.

(ix) Riser support structures.

(c) Secondary structure:

(i) Bulkhead plating, side shell, longitudinals, stiffeners, deck plating including poop deck and forecastle deck, flats, girders and web frames, etc., except where the structure is categorised as special or primary structure. For topside plant supporting structures, see also 2.1.3.

(ii) Helicopter platforms and deckhouses.

(iii) Lifeboat platforms, walkways, guard rails, minor fittings and attachments, etc.
4.1.4 Steel grades for units required to operate in severe ice conditions will be specially considered. Temperature gradient calculations may be required to assess the design temperature of the structure, see also Pt 3, Ch 6.

4.1.5 Minor structural components such as guard rails, walkways and ladders, etc., are, in general, to be constructed of Grade A steel, unless agreed otherwise by LR, see also 4.1.4.

4.1.6 For components listed in Table 2.4.2, special consideration may be given to material grades with other impact properties than those required by Table 2.4.1. In such cases, written agreement is required prior to manufacture. This evaluation is to be based on critical engineering assessment involving fracture mechanics testing on welded material from the intended supplier and proposals are to be submitted which include full details of the application, minimum temperature, design, design stresses, fatigue loads and cycles, welding procedures that will be applied and inspection procedures.

**Table 2.4.1 Thickness limitations for hull structural steels for various application categories and design temperatures for use in welded construction**

<table>
<thead>
<tr>
<th>Structural category</th>
<th>Required steel grade</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Maximum thickness permitted (mm) for various minimum design temperatures, see Note 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0°C</td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>60</td>
</tr>
<tr>
<td>D</td>
<td>100</td>
</tr>
<tr>
<td>E</td>
<td>150</td>
</tr>
<tr>
<td>AH</td>
<td>50</td>
</tr>
<tr>
<td>DH</td>
<td>100</td>
</tr>
<tr>
<td>EH</td>
<td>150</td>
</tr>
<tr>
<td>FH</td>
<td>150</td>
</tr>
<tr>
<td>AQ</td>
<td>50</td>
</tr>
<tr>
<td>DQ</td>
<td>100</td>
</tr>
<tr>
<td>EQ</td>
<td>150</td>
</tr>
<tr>
<td>FQ</td>
<td>150</td>
</tr>
<tr>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>50</td>
</tr>
<tr>
<td>E</td>
<td>100</td>
</tr>
<tr>
<td>AH</td>
<td>25</td>
</tr>
<tr>
<td>DH</td>
<td>50</td>
</tr>
<tr>
<td>EH</td>
<td>120</td>
</tr>
<tr>
<td>FH</td>
<td>150</td>
</tr>
<tr>
<td>AQ</td>
<td>25</td>
</tr>
<tr>
<td>DQ</td>
<td>50</td>
</tr>
<tr>
<td>EQ</td>
<td>120</td>
</tr>
<tr>
<td>FQ</td>
<td>150</td>
</tr>
<tr>
<td>Special</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>12,5</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
</tr>
<tr>
<td>D</td>
<td>30</td>
</tr>
<tr>
<td>E</td>
<td>100</td>
</tr>
<tr>
<td>AH</td>
<td>20</td>
</tr>
<tr>
<td>DH</td>
<td>30</td>
</tr>
<tr>
<td>EH</td>
<td>100</td>
</tr>
<tr>
<td>FH</td>
<td>150</td>
</tr>
<tr>
<td>AQ</td>
<td>15</td>
</tr>
<tr>
<td>DQ</td>
<td>30</td>
</tr>
<tr>
<td>EQ</td>
<td>100</td>
</tr>
<tr>
<td>FQ</td>
<td>150</td>
</tr>
</tbody>
</table>

**NOTES**

1. X indicates that the material is not permitted for that design temperature and structural category.
2. Materials are to comply with the requirements of Chapter 3 of the Rules for Materials.
3. Q grades refer to quenched and tempered grades (Ch 3.10 of the Rules for Materials).
4. The thicknesses refer to as constructed thicknesses (e.g., design thickness plus any allowances such as corrosion allowance).
5. Requirements for minimum design temperature lower than –30°C will require special consideration which may include the use of fracture mechanics assessments.
6. Thicknesses greater than those shown in this Table may be used subject to special consideration by LR and may include fracture mechanics assessment.
7. The interpolation of thicknesses for intermediate temperatures may be considered.
8. For LNG installations where the minimum hull shell plating temperature used in the design is the result of heat conduction from the cargo rather than environmental conditions, the material thicknesses shall be in accordance with Table 6.5 in Pt 11, Ch 6 of the Rules and Regulations for the Classification of a Floating Offshore Installation at a Fixed Location.
### Table 2.4.2 Applications where fracture mechanics may be considered to permit alternative grades of steel

<table>
<thead>
<tr>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lattice type leg structures</td>
</tr>
<tr>
<td>Cylindrical legs</td>
</tr>
<tr>
<td>Footing and mats</td>
</tr>
</tbody>
</table>

---
Section 1

General

1.1 Application

1.1.1 This Chapter indicates the general design concepts and loading and the general principles adopted in applying the Rule structural requirements given in this Part.

1.1.2 General definitions of span point, derivation of geometric properties of section and associated effective area of attached plating are given in this Chapter.

1.1.3 Additional requirements relating to functional unit types are also dealt with under the relevant unit type given in Part 3.

1.1.4 General principles of subdivision and requirements for cofferdams are given in this Chapter.

1.1.5 For surface type units, Sections 2, 3 and 5 are not applicable.

1.1.6 Structural idealisation aspects of surface type units are to comply with Pt 3, Ch 3.3 of the Rules for Ships.

1.1.7 The number and arrangement of bulkheads on surface type units are given in Pt 3, Ch 3.4 of the Rules for Ships, which are to be complied with, as applicable.

1.1.8 For all unit types, structural design loads as given in Section 4 should be considered as applicable.

Section 2

Design concepts

2.1 Elastic method of design

2.1.1 In general, the approval of the primary structure of the unit will be based on the elastic method of design and the permissible stresses in the structure are to be based on the minimum factors of safety defined in Chapter 5. When specifically requested, LR will consider other design methods.

2.2 Limit state method of design

2.2.1 When the limit state method of design is proposed for the structure, the design methods, load combinations and partial factors are to be agreed with LR.

2.3 Plastic method of design

2.3.1 When the plastic method of design based on the ultimate strength is proposed for the structure, the load factors are to be in accordance with an acceptable Code of Practice, see Pt 3, Appendix A.

2.4 Fatigue design

2.4.1 All units are to be capable of withstanding the fatigue loading to which they are subjected. The fatigue design requirements are given in Ch 5.5.

Section 3

Structural idealisation

3.1 General

3.1.1 In general, the primary structure of a unit is to be analysed by a three-dimensional finite plate element method. Only if it can be demonstrated that other methods are adequate will they be considered.

3.1.2 The complexity of the mathematical model together with the associated computer element types used must be sufficiently representative of all the parts of the primary structure to enable accurate internal stress distributions to be obtained.

3.1.3 When requested, LR can perform an independent structural analysis of the unit.

3.1.4 For derivation of local scantlings of stiffeners, beams, girders, etc., the formulae in the Rules are normally based on elastic or plastic theory using simple beam models supported at one or more points and with varying degrees of fixity at the ends, associated with an appropriate concentrated or distributed load.

3.1.5 Apart from local requirement for web thickness or flange thicknesses, the stiffener, beam or girder strength is defined by a section modulus and moment of inertia requirement.
3.2 Geometric properties of section

3.2.1 The symbols used in this sub-Section are defined as follows:

- $b$ = actual width, in metres, of the load-bearing plating, i.e. one-half of the sum of spacings between parallel adjacent members or equivalent supports
- $f = 0.3 \left( \frac{l}{b} \right)^{2/3}$ but is not to exceed 1.0. Values of this factor are given in Table 3.3.1
- $l$ = overall length, in metres, of the primary support member, see Fig. 3.3.3
- $t_p$ = thickness, in mm, of the attached plating. Where this varies, the mean thickness over the appropriate span is to be used.

Table 3.3.1 Effective width factor

<table>
<thead>
<tr>
<th>$\frac{l}{b}$</th>
<th>$f$</th>
<th>$\frac{l}{b}$</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.19</td>
<td>3.5</td>
<td>0.69</td>
</tr>
<tr>
<td>1.0</td>
<td>0.30</td>
<td>4.0</td>
<td>0.76</td>
</tr>
<tr>
<td>1.5</td>
<td>0.39</td>
<td>4.5</td>
<td>0.82</td>
</tr>
<tr>
<td>2.0</td>
<td>0.48</td>
<td>5.0</td>
<td>0.88</td>
</tr>
<tr>
<td>2.5</td>
<td>0.55</td>
<td>5.5</td>
<td>0.94</td>
</tr>
<tr>
<td>3.0</td>
<td>0.62</td>
<td>6 and above</td>
<td>1.00</td>
</tr>
</tbody>
</table>

NOTE: Intermediate values to be obtained by linear interpolation.

3.2.2 The effective geometric properties of rolled or built sections may be calculated directly from the dimensions of the section and associated effective area of attached plating. Where the web of the section is not normal to the attached plating, and the angle exceeds 20°, the properties of the section are to be determined about an axis parallel to the attached plating.

3.2.3 The geometric properties of rolled or built stiffener sections and of swedges are to be calculated in association with effective area of attached load bearing plating of thickness $t_p$, mm and of width 600 mm or 40$t_p$, mm, whichever is the greater. In no case, however, is the width of plating to be taken as greater than either the spacing of the stiffeners or the width of the flat plating between swedges, whichever is appropriate. The thickness, $t_w$, is the actual thickness of the attached plating. Where this varies, the mean thickness over the appropriate span is to be used.

3.2.4 The effective section modulus of a corrugation over a spacing $p$ is to be calculated from the dimensions and, for symmetrical corrugations, may be taken as:

$$Z = \frac{d_w}{6000} \left( 3bt_p + ct_w \right) \text{ cm}^3$$

where $d_w$, $b$, $t_p$, $c$ and $t_w$ are measured, in mm, and are as shown in Fig. 3.3.1. The value of $b$ is to be taken not greater than:

- $50t_p \sqrt{k}$ for welded corrugations
- $60t_p \sqrt{k}$ for cold formed corrugations

3.2.5 The section modulus of a double plate bulkhead over a spacing $b$ may be calculated as:

$$z = \frac{d_w}{6000} \left( 6f b t_p + d_w t_w \right) \text{ cm}^3$$

where $d_w$, $b$, $t_p$ and $t_w$ are measured, in mm, and are as shown in Fig. 3.3.2.

3.2.6 The effective section modulus of a built section may be taken as:

$$z = \frac{a d_w}{10} + \frac{t_w d_w^2}{6000} \left( 1 + \frac{200(A - a)}{200A + t_w d_w} \right) \text{ cm}^3$$

where

- $a$ = area of the face plate of the member, in cm²
- $d_w$ = depth, in mm, of the web between the inside of the face plate and the attached plating. Where the member is at right angles to a line of corrugations, the minimum depth is to be taken
- $t_w$ = thickness of the web of the section, in mm
- $A$ = area, in cm², of the attached plating, see 3.2.7. If the calculated value of $A$ is less than the face area $a$, then $A$ is to be taken as equal to $a$. 

The value of $\theta$ is to be taken not less than 40°. The moment of inertia is to be calculated from:

$$I = \frac{Z}{10} \left( \frac{d_w}{2} \right) \text{ cm}^4$$

### Table 3.3.1 Effective width factor

<table>
<thead>
<tr>
<th>$\frac{l}{b}$</th>
<th>$f$</th>
<th>$\frac{l}{b}$</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.19</td>
<td>3.5</td>
<td>0.69</td>
</tr>
<tr>
<td>1.0</td>
<td>0.30</td>
<td>4.0</td>
<td>0.76</td>
</tr>
<tr>
<td>1.5</td>
<td>0.39</td>
<td>4.5</td>
<td>0.82</td>
</tr>
<tr>
<td>2.0</td>
<td>0.48</td>
<td>5.0</td>
<td>0.88</td>
</tr>
<tr>
<td>2.5</td>
<td>0.55</td>
<td>5.5</td>
<td>0.94</td>
</tr>
<tr>
<td>3.0</td>
<td>0.62</td>
<td>6 and above</td>
<td>1.00</td>
</tr>
</tbody>
</table>

NOTE: Intermediate values to be obtained by linear interpolation.

### Fig. 3.3.1 Corrugation geometry

### Fig. 3.3.2 Double plate bulkhead geometry
3.2.7 The geometric properties of primary support members (i.e., girders, transverses, webs, stringers, etc.) are to be calculated in association with an effective area of attached load bearing plating, \( A \), determined as follows:
(a) For a member attached to plane plating:
\[
A = 10 f b t_p \text{ cm}^2
\]
(b) For a member attached to corrugated plating and parallel to the corrugations:
\[
A = 10 b t_p \text{ cm}^2
\]
See Fig. 3.3.1.
(c) For a member attached to corrugated plating and at right angles to the corrugations, \( A \) is to be taken as equivalent to the area of the face plate of the member.

3.3 Determination of span point

3.3.1 The effective length, \( l_e \), of a stiffening member is generally less than the overall length, \( l \), by an amount which depends on the design of the end connections. The span points, between which the value of \( l_e \) is measured, are to be determined as follows:
(a) For rolled or built secondary stiffening members, the span point is to be taken at the point where the depth of the end bracket, measured from the face of the secondary stiffening member, is equal to the depth of the member. Where there is no end bracket, the span point is to be measured between primary member webs. For double skin construction the span may be reduced by the depth of primary member web stiffener, see Fig. 3.3.3.
4.1.4 The design environmental criteria determining the loads on the unit and its individual elements are to be based upon appropriate statistical information and have a return period (period of recurrence) of at least 50 years for the most severe anticipated environment. If a unit is restricted to seasonal operations in order to avoid extremes of wind and wave, such seasonal limitations must also be specified.

4.1.5 Model tests are to be carried out as necessary and the tests are to include means of establishing the effects of green water loading and/or slamming on the structure through video recordings of the model testing and by measurement of the following:

- Relative motions.
- Forces on local panels mounted at various locations on exposed areas including bow areas of surface type units and accommodation areas, see also Chapter 4 and Pt 3, Ch 10.5.

4.1.6 When carrying out model tests, account is to be taken of the following:

- The test programme and the model test facilities are to be to LR's satisfaction.
- 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.
- The tests are to be of sufficient duration to establish low frequency motion behaviour.

4.1.7 The unit's limiting design criteria are to be included in the Operations Manual, see Pt 3, Ch 1.3.

4.2 Definitions

4.2.1 Still water condition is defined as an ideal condition when no environmental loads are imposed on the structure, e.g., no wind, wave or current, etc.

4.2.2 Gravity and functional loads are loads which exist due to the unit's weight, use and treatment in still water conditions for each design case. All external forces which are responses to functional loads are to be regarded as functional loads, e.g., support reactions and still water buoyancy forces.

4.2.3 Environmental loads are loads which are due directly or indirectly to environmental actions. All external forces which are responses to environmental loads are to be regarded as environmental loads, e.g., mooring forces and inertia forces.

4.2.4 Accidental loads are loads which occur as a direct result of an accident or exceptional circumstances, e.g., loads due to collisions, dropped objects and explosions, etc. See also 4.16.

4.3 Grouped stiffeners

4.3.1 Where stiffeners are equally spaced and are arranged in groups of the same scantling, the section modulus requirement of each group is to be based on the greater of:

- the mean value of the section modulus required for individual stiffeners within the group; and
- 90 per cent of the maximum section modulus required for individual stiffeners within the group.

### Section 4

#### Structural design loads

4.1 General

4.1.1 The requirements in this Section define the loads and load combinations to be considered in the overall strength analysis of the unit and the design pressure heads to be used in the Rules for local scantlings.

4.1.2 A unit's modes of operation are to be investigated using realistic loading conditions, including buoyancy, gravity and functional loadings together with relevant environmental loadings. Due account is to be taken of the effects of wind, waves, currents, motions (inertia), moorings, ice, and, where necessary, the effects of earthquake, sea bed-supporting capabilities, temperature, fouling, etc. Where applicable, the design loadings indicated herein are to be adhered to for all types of offshore units.

4.1.3 The Owner/designer is to specify the modes of operation and the environmental conditions for which the unit is to be approved, see also Pt 1, Ch 2.2.
4.3 Load combinations

4.3.1 The structure is to be designed for the most unfavourable of the following combined loading conditions (as relevant to the unit):
(a) Maximum gravity and functional loads.
(b) Design environmental loads and associated gravity and functional loads.
(c) Accidental loads and associated gravity and functional loads.
(d) Environmental loads and associated gravity and functional loads after credible failures or accidents.

NOTE
Load combination (c) relates to the loading and condition of the unit at the time of the accidental event. Load combination (d) relates to the loading and condition of the unit following the accidental event and allowing for agreed documented mitigation measures to be put in place. See also 4.16 and Chapter 4 for applicability to unit types.

4.3.2 Special requirements applicable to column-stabilised and self-elevating units are also defined in Chapter 4.

4.3.3 Permissible stresses relevant to the combined loading conditions are given in Chapter 5.

4.4 Gravity and functional loads

4.4.1 All gravity loads, including static loads such as weight, outfit, stores, machinery, ballast, etc., and live functional loads from operating derricks, cranes, winches and other equipment are to be considered. All practical combinations of gravity and functional loads are to be included in the design cases.

4.5 Buoyancy loads

4.5.1 Buoyancy loads on all underwater parts of the structure, taking account of heel and trim when appropriate, are to be considered.

4.6 Wind loads

4.6.1 Account is to be taken of the wind forces acting on that part of the unit which is above the still water level in all operating conditions and of the following:
(a) Consideration is to be given to wind gust velocities which are of brief duration and sustained wind velocities which act over intervals of time equal to or greater than one minute. Different wind velocity averaging time intervals applicable to different structural categories to be used in design calculations are shown in Table 3.4.1.
(b) Wind velocities are to be specified relative to a standard reference height of 10 m above still water level for each operating condition.

\[ V_H = V_R \left( \frac{H}{H_R} \right)^n \]

where
- \( V_H \) = wind velocity at specified height, in m/s
- \( V_R \) = wind velocity at specified reference height \( H_R \), in m/s
- \( H \) = specified height above sea level, in metres
- \( H_R \) = reference height, in metres
- \( n \) = power law exponent
  - for 3 second gust \( n = 0.077 \)
  - for 5 second mean \( n = 0.08 \)
  - for 15 second mean \( n = 0.09 \)
  - for 1 minute mean \( n = 0.125 \)
  - for 10 minute mean \( n = 0.13 \).

4.6.2 The wind force is to be calculated for each part of the structure and is not to be taken less than:
\[ F = K_w A V^2 C_s \text{N (kgf)} \]

where
- \( F \) = net force acting on any member or part of the unit. This includes the effect of any suction on back surfaces
- \( K_w = 0.613 (0.0625) \)
- \( A \) = projected area of all exposed surfaces in upright or heeled position, in \( m^2 \)
- \( V \) = wind velocity, in m/s, see 4.6.1
- \( C_s \) = shape coefficient as given in Table 3.4.2.
Table 3.4.2 Values of coefficient $C_s$

<table>
<thead>
<tr>
<th>Shape</th>
<th>$C_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical</td>
<td>0.40</td>
</tr>
<tr>
<td>Cylindrical</td>
<td>0.50</td>
</tr>
<tr>
<td>Large flat surface (hull, deckhouse, smooth underdeck areas)</td>
<td>1.00</td>
</tr>
<tr>
<td>Drilling derrick</td>
<td>1.25</td>
</tr>
<tr>
<td>Wires</td>
<td>1.20</td>
</tr>
<tr>
<td>Exposed beams and girders under deck</td>
<td>1.30</td>
</tr>
<tr>
<td>Small parts</td>
<td>1.40</td>
</tr>
<tr>
<td>Isolated shapes (cranes, booms, etc.)</td>
<td>1.50</td>
</tr>
<tr>
<td>Clustered deckhouses or similar structures</td>
<td>1.10</td>
</tr>
</tbody>
</table>

NOTE
Shapes or combinations of shapes which do not readily fall into the specified categories will be subject to special consideration.

4.6.3 When calculating wind forces the following procedures should be considered:
(a) Shielding may be taken into account when a member or structure lies closely enough behind another to have a significant effect. Procedures for determining the shielding effect and loading are to be acceptable to LR.
(b) Areas exposed due to heel, such as underdecks, etc., are to be included using the appropriate shape coefficients.
(c) If several deckhouses or structural members, etc., are located close together in a plane normal to the wind direction, the solidification effect is to be taken into account. The shape coefficient may be assumed to be 1.1.
(d) Isolated houses, structural shapes, cranes, etc., are to be calculated individually, using the appropriate shape coefficient.
(e) Open truss work commonly used for derrick towers, booms and certain types of masts may be approximated by taking 30 per cent of the projected block area of each side, e.g., 60 per cent of the projected block area of one side for double-sided truss work. An appropriate shape coefficient is to be taken from Table 3.4.2.

4.6.4 For slender structures and components, the effects of wind-induced cross-flow vortex vibrations are to be included in the design loading.

4.6.5 For slender structures sensitive to dynamic loads, the static gust wind force is to be multiplied by an appropriate dynamic amplification factor.

4.7 Current loads

4.7.1 In storm conditions, the current has two main components: the tidal and wind driven components. Submitted information on currents is to include tidal and wind induced components and the variation of their profiles with water depth, see 4.9.6 and 4.9.7. In addition, the effects of general circulation and loop currents are to be included where appropriate.

4.8 Orientation and wave direction

4.8.1 Loadings are to be assessed using sufficient wave headings and crest positions to determine the most severe loading on the unit. In addition to the maximum limiting wave height and associated periods, the unit is to be designed to withstand shorter period waves of less height when these can induce more severe loading on parts or the whole unit due to dynamic effects, etc.

4.8.2 Where a unit is required to operate at locations exposed to wind waves and swell waves acting simultaneously then this is to be taken into account when determining the wave loads.

4.9 Wave loads

4.9.1 Design wave criteria specified by the Owner/designer may be described either by means of design wave energy spectra or deterministic design waves having appropriate shape, size and period. The following should be taken into account:
(a) The maximum design wave heights specified for each operating condition should be used to determine the maximum loads on the structure and principal elements. Consideration is to be given to waves of less than maximum height, where due to their period, the effects on various structural elements may be greater.
(b) Wave lengths are to be selected as the most critical ones for the response of the structure or element to be investigated.
(c) An estimate is to be made of the probable wave encounters that the unit is likely to experience during its service life in order to assess fatigue effects on its structural elements.
(d) When units are to operate in intermediate or shallow water, the effect of the water depth on wave heights and periods of refraction due to sea bed topography is to be taken into account.

4.9.2 The forces produced by the action of waves on the unit are to be taken into account in the structural design, with regard to forces produced directly on the immersed elements of the unit and forces resulting from heeled positions or accelerations due to its motion. Theories used for the calculation of wave forces and selection of relevant coefficients are to be acceptable to LR.

4.9.3 The wave forces may be assessed from tests on a representative model of the unit by a recognised laboratory, see 4.1.5 and 4.1.6.

4.9.4 Wave theories used for the calculation of water particle motions are to be acceptable to LR and when using acceptable wave theories for wave force determination, reliable values of $C_D$ and $C_M$ which have been obtained experimentally for use in conjunction with the specific wave theory are to be used. Otherwise published data are to be used.
4.9.5 Consideration is to be given to the possibility of wave impact and wave induced vibration in the structure.

4.9.6 Where sea current acts simultaneously with waves, the effect of the current is to be included in the load estimation.

4.9.7 The following methods may be used for load estimation:
(a) The forces on structural elements with dimensions less than 0.2 of the wave length subject to drag/inertia loading due to wave and current motions can be calculated from the Morison’s equation:
\[ F = 0.5 C_D \rho A u \sqrt{u^2 + a^2} + C_M \rho V a \]
where
- \( F \) = force per unit length of member
- \( C_D \) = drag coefficient
- \( \rho \) = density of water
- \( A \) = projected area of member per unit length
- \( u \) = component of the water particle velocity at the axis of the member and normal to it (calculated as if the member were not there)
- \( l_u \) = modulus of \( u \)
- \( C_M \) = inertia coefficient
- \( V \) = volume of water per unit length
- \( a \) = component of the water particle acceleration at the axis of the member and normal to it (calculated as if the member were not there)
(b) Overall loading on an offshore structure is determined from the summation of loads on individual members at a particular time. The proper values of \( C_D \) and \( C_M \) for individual members to use with Morison’s equation will depend on a number of variables, for example: Reynolds number, Keulegan-Carpenter number, inclination of the member to local flow and effective roughness of marine growth. Therefore, fixed values for all conditions cannot be given. Typical values for circular cylindrical members, will range from 0.6 to 1.4 for \( C_D \) and 1.3 to 2.0 for \( C_M \). The values selected are not to be smaller than the lower limits of these ranges. For inclined members, the drag forces in Morison’s equation are to be calculated using the normal component of the resultant velocity vector.
(c) General values of hydrodynamic coefficients may be used in the Morison’s equation for the calculation of overall loading on the structure, namely:
- For circular cylinders covered by hard marine growth, \( C_D \) is to be not less than 0.7.
- For circular cylinders not covered by hard marine growth, \( C_D \) is to be not less than 0.6.
- For circular cylinders, \( C_M \) is to be not less than 1.7.
- If joint probability predictions of wave and current are included in the design procedure or if the conservatism is reduced in any part, consideration is to be given to increasing the drag coefficient associated with marine growth.
(d) Diffraction theory is normally appropriate to determine wave loads where the member is large enough to modify the flow field.

4.9.8 Account is to be taken of the increase of overall size and roughness of submerged members due to marine growth when calculating loads due to wave and current, see 4.13.
4.13 Marine growth

4.13.1 Marine growth will increase the weight and the overall dimensions of submerged members and alter their surface characteristics. These effects will increase the loads applied to the structure. The thickness of marine growth taken into account in the design is to be stated in the Operations Manual and the design limit is not to be exceeded in service.

4.14 Hydrostatic pressures

4.14.1 The pressure head to be used as the basis for the design of internal spaces is to be the greatest of the following:
   (a) For tanks, the maximum head during normal operation.
   (b) For shell boundaries, the hydrostatic head due to external pressure arising from the sea, taking maximum wave crest elevation in both operating and survival conditions with a minimum head of 6 m on semi-submersible units.
   (c) For watertight boundaries, the head measured to the worst damage waterline, see Chapter 7.
   (d) The minimum design pressure heads for local strength are to be in accordance with Chapter 6.

4.14.2 Where testing the tank involves pressure heads in excess of those derived in 4.14.1, the excess may be taken into account by the use of a load factor applied to the design head. Where this is done, it is to be clearly stated in the calculations.

4.15 Deck loads

4.15.1 The maximum design uniform and concentrated deck loads for all areas of the unit in each mode of operation are to be taken into account in the design. The minimum design deck loads for local strength are to be in accordance with Chapter 6.

4.16 Accidental loads

4.16.1 The following credible failures and accidents are to be considered in the design as applicable to the function of the unit.
   - Collision.
   - Dropped object.
   - Blast.
   - Accidental flooding.
   - Loss of primary bracing (column-stabilised unit).

4.16.2 Collision loads imposed by attending vessels which may be approaching, mooring or lying alongside the unit are to be considered in the design. The unit is to be designed to withstand accidental impacts between attending vessels and the unit and be capable of absorbing the impact energy.

4.16.3 The kinetic energy to be considered is normally not to be less than:
   - 14 MJ for sideway collision;
   - 11 MJ for bow or stern collision;
   - corresponding to an attending vessel of 5000 tonnes displacement with impact velocity 2 m/s.

4.16.4 A reduced impact energy may be accepted upon special consideration, taking into account the environmental design criteria.

4.16.5 The energy absorbed by the unit during a collision impact will be less than or equal to the total impact kinetic energy, depending on the relative stiffnesses of the relevant parts of the unit and the impacting ship/unit and also on the mode of collision and ship/unit operation. These factors may be taken into account when considering the energy absorbed by the unit, see also Ch 4.1 and Ch 4.3 for column-stabilised and self-elevating units respectively.

4.16.6 Collision is to be considered for all elements of the unit which may be hit by sideway, bow or stern collision. The vertical extent of the collision zone is to be based on the depth and draught of attending ships/units and the relative motion between the attending ships/units and the unit.

4.16.7 The accidental impact loads caused by dropped objects from cranes are to be considered in the design of the unit when the arrangements of the unit are such that the failure of a vital structure member could result in the collapse of the structure.

4.16.8 Critical areas for dropped objects are to be determined on the basis of the actual movement of crane loads over the unit.

4.16.9 The structural bulkheads protecting accommodation areas, and other structures that may be subject to blast pressures, are to be designed for accidental blast loading, where applicable. The design blast pressures are to be defined by the Owners/designers, see Pt 7, Ch 3.2.4.2 and are to comply with National requirements. Blast loads are to be combined with the still water loads. Environmental loads need not be considered. Design calculations are to be submitted which may be based on elastic analysis or elastoplastic design methods, see also 4.16.11.
4.16.10 Accidental flooding of a single hull compartment is to be considered in the design of the unit. As a minimum, the compartments to be addressed are to include those set out in Chapter 3 of the 2009 IMO MODU Code as applicable to the unit type. Special consideration will be given to unit types not addressed by the 2009 IMO MODU Code.

4.16.11 Units with slender members where the failure of a single member could result in the overall collapse of the unit’s structure are to be considered for credible failure of such members, see Chapter 4.

4.16.12 Requirements for helicopter landing areas are given in Ch 6,5.

4.16.13 Permissible stresses for accidental load conditions are given in Ch 5,2.

4.16.14 When a National Administration in the country in which the unit is registered and/or in which it is to operate has additional requirements for accidental loads these are to be taken into account in the design loadings.

4.17 Fatigue design

4.17.1 Fatigue damage due to cyclic loading must be considered in the design of all unit types.

4.17.2 Fatigue design calculations are to be carried out in accordance with the analysis procedures and general principles given in Ch 5,5 or other acceptable method.

4.17.3 The factors of safety on calculated fatigue life are to comply with Ch 5,5, but for the hull structure of surface type units, see Ch 4,4.

4.18 Other loads

4.18.1 If attending ships/units are to be moored to the unit, the forces imposed by the moorings on the structure are to be taken into account in the design.

4.18.2 Other local loads imposed on the structure by equipment and mooring and towing systems are to be considered in the design of the structure.

4.18.3 When partial filling of tanks is contemplated in operating conditions, the risk of significant loads due to sloshing induced by any of the vessel motions is to be considered. An initial assessment is to be made to determine whether or not a higher level of sloshing investigation is required, using the procedure given in Pt 3, Ch 3,5 of the Rules for Ships.

Section 5

Number and disposition of bulkheads

5.1 General

5.1.1 The number and disposition of watertight bulkheads are to be arranged to ensure adequate strength and the arrangements are to suit the requirements for subdivision, floodability and damage stability. They are also to be in accordance with the requirements of the National Administration in the country in which the unit is registered and/or in which it is to operate, see Pt 1, Ch 5,1 and Chapter 7.

5.1.2 Bulkheads are to be spaced at reasonable uniform intervals. Where, due to the design of a unit, the spacing of bulkheads is unusually great, the transverse strength of the unit is to be maintained by fitting suitable web frames between the bulkheads. Details of bulkheads and intermediate web frames are to be submitted for approval.

5.1.3 The requirements of 5.3.3 are to be complied with as applicable.

5.2 Self-elevating units

5.2.1 The arrangement of longitudinal and transverse bulkheads are to satisfy the overall strength requirements given in Chapters 4 and 5 when the unit is in the elevated position and when afloat.

5.2.2 The number and arrangement of watertight bulkheads are to meet the requirements of damage stability.

5.2.3 Watertight bulkheads are to extend to the uppermost continuous deck.

5.3 Column-stabilised units

5.3.1 The arrangement of watertight bulkheads and flats are to be made effective to that point necessary to meet the requirements of damage stability.

5.3.2 The arrangement of longitudinal and transverse bulkheads in the upper and lower hulls and in columns are to satisfy the overall strength requirements given in Chapters 4 and 5.

5.3.3 The subdivision and arrangement of bulkheads and cofferdams on production and oil storage units are also to comply with Pt 3, Ch 3.

5.4 Protection of tanks carrying oil fuel and lubricating oil

5.4.1 The requirements for the protection of tanks carrying oil fuel and lubricating oil, which are given in Pt 3, Ch 3,4,7 of the Rules for Ships, are to be complied with, as applicable.
1.3.2 The structure is to be designed to withstand the static and dynamic loads imposed on the unit in transit and semi-submerged conditions. All relevant loads as defined in Chapter 3 are to be considered and the permissible stresses due to the overall and local load effects are to be in accordance with Chapter 5. The minimum local scantlings of the unit are to comply with Chapter 6.

1.3.3 All modes of operation are to be investigated and the relevant design load combinations defined in Ch 5.1.2 are to be complied with. The loading conditions applicable to a column-stabilised unit are shown in Table 4.1.1.

1.3.4 The overall strength of the unit is to be analysed by a three-dimensional finite element method in accordance with Ch 3.3.

1.3.5 In order to ensure adequate structural redundancy after credible failure or accidents, the structure is to be investigated for loading condition (d) in Table 4.1.1. The environmental loads for this load case are to be taken as the same as determined for loading condition (b). The structure is to be able to withstand the following failures without causing the overall collapse of the unit’s structure:
- The failure of any main primary bracing member.
- When the upper hull structure consists of heavy or box girder construction, the failure of any primary slender member.

1.3.6 The general requirements for investigating accidental loads are defined in Ch 3.4.16, but in the case of a column-stabilised unit, collision loads against a column or pontoon will normally only cause local damage to the structure and consequently loading condition (c) in Table 4.1.1 need not be investigated from the overall strength aspects. The requirements for very slender columns will be specially considered.

1.3.7 The permissible stress levels after credible failures or accidents are to be in accordance with Chapter 5.
1.4 Upper hull structure

1.4.1 Decks and supporting grillage structures forming part of the primary structure are to be designed to resist both the overall and local loadings.

1.4.2 Openings in primary bulkheads and decks are normally to be represented in the structural model. Bulkhead openings in ‘tween decks are not, in general, to be fitted in the same vertical line. When large bulkhead openings are cut in the structure which were not included in the structural model, the bulkhead thickness is to be increased in way of the opening to compensate for the loss of shear area and stiffness.

1.4.3 When the primary deck structure consists of heavy or box girder construction and the infill deck plating is considered to be secondary structure, only the main deck girders and the secondary deck plating stiffeners need satisfy the buckling strength requirements given in Chapter 5. The infill deck plating thickness and its contribution to the overall strength of the structure will be specially considered, see also Ch 6,4.

1.4.4 When the upper hull structure is designed to be waterborne for operational purposes the upper hull scantlings are not to be less than those specified for shell boundaries of self-elevating units as defined in Ch 6,3.

1.4.5 Columns should be aligned and integrated with the bulkheads in the upper hull structure. Particular attention should be given to the detail design at the intersection of columns with the upper hull structure to minimise stress concentrations.

1.5 Columns

1.5.1 Columns are to be designed to withstand the forces and moments resulting from the overall loadings, together with forces and moments due to wave loadings and internal tank pressures.

1.5.2 In general, internal spaces within the columns are to be designed for the pressure heads defined in Ch 3,4.14.

1.5.3 High local loads are also to be taken into account in the overall design strength of the columns.

1.5.4 Internal column structure supporting main bracings is in general not to be of a lesser strength than the bracing itself.

1.5.5 When bracing forces are designed to be transmitted to the column shell, the resulting column shell stresses are to be combined with the stresses due to the hydrostatic pressure and overall forces.

1.6 Lower hulls

1.6.1 Lower hulls or pontoons are to be designed for overall bending, shear forces, and axial forces due to end pressure when combined with the local hydrostatic pressure as defined in Ch 3,4.14.

1.6.2 Irrespective of the tank loading arrangement, the scantlings of tanks are to be verified in both full and empty conditions.

1.6.3 Columns are, as far as practicable, to be continuous through the plating of the lower hull deck structure and be aligned and integrated with the internal bulkheads and/or side shell.

1.6.4 Where the column shell plating is intercostal with the lower hull deck, the deck plating below the columns is to be suitably increased and is to have steel grades with suitable through-thickness properties, see Ch 2,4.1.3.

1.6.5 Particular attention should be given to the design of the local structure at the intersection of columns with lower hulls and due account should be given to penetrations and stress concentrations.

1.7 Main primary bracings

1.7.1 Bracing members are to be designed to withstand the stresses imposed by the overall loading, together with local stresses due to wave, current and buoyancy forces and, when applicable, hydrostatic pressure.

1.7.2 Bracings are in general to be made watertight and provided with adequate means of access to enable internal inspection to be carried out when the unit is afloat.

1.7.3 Watertight bracings are to be designed for the hydrostatic pressure loads defined in Ch 3,4.14, and the scantlings are to be verified against buckling due to combined axial stresses and hoop stresses caused by external hydrostatic pressure. Ring stiffeners are to be fitted where necessary.

1.7.4 Attachments and penetrations to the shell of bracings are to be avoided as far as practicable. If attachments are unavoidable they are generally to be welded to suitable doubler plates having well rounded corners. Special consideration will be given to alternative proposals. In all cases the attachment is to be designed to minimise the resulting stress concentration in the brace and the fatigue life is to be checked.

1.7.5 Leak detection and drainage arrangements of watertight bracings are to be in accordance with Pt 5, Ch 13,3.

1.7.6 The scantlings and arrangements of free-flooding bracings will be specially considered.
1.8 Bracing joints

1.8.1 Joints at the intersection of bracings or between bracings and columns are to be designed to transmit the bending, direct and shear forces involved in such a manner as to reduce, so far as possible, the risk of fatigue failure. Stress concentrations are to be minimised by good detail design and, in general, nominal stress levels are to be made lower than in the adjacent structure by increasing plate thickness or suitably flaring the member ends, or both. Ring stiffeners or other welded attachments across the principal stress direction are to be avoided wherever possible in all regions of high stress. It this is not possible (e.g. where required to support bracket ends on otherwise unstiffened plating), the weld is to have a smooth profile without undercutting. Continuity of strength is to be maintained through the joint, and shear web plates and other axial stiffening members are to be made continuous.

1.8.2 Special attention is also to be given to the qualities of bracing details, e.g., openings, penetrations, stiffener ends, brackets and other attachments. The welding procedure is to be such as to minimise the risk of cracks, lack of penetration and lamellar tearing of the parent steel.

1.8.3 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. Plate steel used in such locations shall have suitable through-thickness properties.

1.9 Lifeboat platforms

1.9.1 The strength of lifeboat platforms is to be verified with the unit in the upright condition and in the inclined condition at an angle corresponding to the worst damage waterline, and at an inclined angle of 15° in any direction.

1.9.2 For calculation purposes, the weight of the lifeboat is to be taken as the weight when fully manned and equipped. The platform weight is to be taken as the steel weight plus the weight of davits and equipment. Symmetrical and unsymmetrical load cases are to be considered as appropriate, e.g. one lifeboat launched and the other lowering. The design calculations are to be submitted for information.

1.9.3 The following dynamic load factors are to be included in the calculations:

<table>
<thead>
<tr>
<th>Item:</th>
<th>Factor:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform weight</td>
<td>0.3 g</td>
</tr>
<tr>
<td>Lifeboat weight when stowed</td>
<td>0.3 g</td>
</tr>
<tr>
<td>Lifeboat weight when lowering</td>
<td>0.5 g</td>
</tr>
</tbody>
</table>

1.9.4 In the upright condition and in the inclined condition the permissible stresses are to comply with Ch 5.2.1.1, loadcase (a) and (b) respectively.

1.9.5 After installation of the lifeboats, testing is to be carried out to the satisfaction of LR’s Surveyors.

1.10 Topside structure

1.10.1 The minimum scantlings of superstructures and deckhouses are to comply with the requirements of Ch 6.9. Bulwarks and guard rails are to comply with Ch 6.10.

1.10.2 For units fitted with a process plant facility and/or drilling equipment, the support stools and integrated hull support structure to the process plant and other equipment supporting structures including derricks and flare structures are considered to be classification items, regardless of whether or not the process/drilling plant facility is classed, and the loadings are to be determined in accordance with Pt 3, Ch 8.2. Permissible stress levels are to comply with Chapter 5.

1.10.3 The boundary bulkheads of accommodation spaces which may be subjected to blast loading are to be designed in accordance with Ch 3.4 and permissible stress levels are to satisfy the factors of safety given in Ch 6.2.1.1(c).

1.10.4 Units with a process plant facility which comply with the requirements of Pt 3, Ch 8 will be eligible for the assignment of the special features class notation PPF.

1.10.5 Units with a drilling plant facility which comply with the requirements of Pt 3, Ch 7 will be eligible for the assignment of the special features class notation DRILL.

---

Section 2

Sea bed-stabilised units

2.1 General

2.1.1 This Section outlines the structural design requirements of sea bed-stabilised units as defined in Pt 1, Ch 2.2. Additional requirements for particular unit types related to the design function of the unit are given in Part 3. Self-elevating units are to comply with Section 3.

2.1.2 Units of this type are generally designed to operate under normal operating environmental conditions and severe storm conditions whilst resting on the sea bed. The design transit condition and design limitations are to be specified by the Owner/designer.

2.1.3 The structural analysis and determination of scantlings is to be on the basis of distribution of loadings and ballast required to satisfy 2.1.2 and all units are to have adequate reserve of bearing pressure on the support footings, pontoons or mats.

2.1.4 The requirements of Sections 1 and 3 are to be complied with as applicable to the design of the unit.

2.1.5 The permissible stress levels in all operating modes are to comply with Chapter 5.
### Structural Unit Types

#### 2.1.6

The minimum local scantlings are to comply with the requirements of Chapter 6, for column-stabilised units as applicable, but the bottom structure should not be less than required for tank bulkheads in Chapter 6 using the load head $h_4$ equivalent to the maximum design bearing pressure. In general, bottom primary members supporting shell stiffeners are to be spaced not more than 1.85 m apart and side girders or equivalent are to be spaced 2.2 m apart. The buckling strength of the primary member webs is to be in accordance with Chapter 5, see also 2.4.

#### 2.2 Air gap

2.2.1 For on-bottom modes of operation, the clearance air gap between the underside of the deck structure and the highest predicted design wave crest is to be in accordance with 3.2.1. In transit conditions, the air gap is to be in accordance with 1.2. Calculations, model test results or prototype reports are to be submitted for consideration.

#### 2.3 Operating conditions

2.3.1 Classification will be based upon the Owner's/designer's assumptions in operating the unit and the sea bed conditions. These assumptions are to be recorded in the Operations Manual. It is the responsibility of the Operator to ensure that actual conditions do not impose more severe loadings on the unit.

2.3.2 Procedures and limitations for ballasting and re-floating the unit in order to avoid overstressing the structure by static or dynamic loads are to be clearly defined in the Operations Manual, see Pt 3, Ch 1.3.

#### 2.4 Corrosion protection

2.4.1 The corrosion allowance for wastage and the means of protection are to be to the satisfaction of LR and are to be agreed at the design stage.

2.4.2 The general requirements for corrosion protection are to comply with Part 8.

### Section 3

#### Self-elevating units

#### 3.1 General

3.1.1 This Section outlines the structural design requirements of self-elevating units. Additional requirements for particular unit types related to the design function of the unit are given in Part 3.

3.1.2 A self-elevating unit is a floating unit which is designed to operate as a sea bed-stabilised unit in an elevated mode, see Pt 1, Ch 2.2.

#### 3.3 Structural design

3.3.1 The structure is to be designed to withstand the static and dynamic loads imposed upon it in transit, installation and elevated conditions. All relevant distributions of gravity and variable loads are to be considered, as are stresses due to the overall and local effects, see Ch 3.4.

3.3.2 The permissible stresses are to be in accordance with Chapter 5 and the minimum local scantlings of the unit are to comply with Chapter 6.

3.3.3 All modes of operation are to be investigated and the relevant design load combinations defined in Ch 5.1.2 are to be complied with. The loading conditions applicable to a self-elevating unit are shown in Table 4.3.1.

#### Table 4.3.1 Design loading conditions

<table>
<thead>
<tr>
<th>Mode</th>
<th>(a)</th>
<th>(b)</th>
<th>(c) See Note 2</th>
<th>(d) See Note 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site installation and re-floating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Survival</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

**NOTES**

1. For definition of loading conditions (a) to (d), see Ch 3.4.3.
2. For loading conditions (c) and (d) as applicable to a self-elevating unit, see 3.3.4 to 3.3.6.
3.3.4 The general requirements for investigating accidental loads are defined in Ch 3.4.16. In transit conditions, collision loads against the hull structure will normally only cause local damage to the hull structure and consequently loading condition (c) in Table 4.3.1 need not be investigated from the overall strength aspects. When in the elevated position, accidental damage to the legs is to be considered in the design and the unit is to be capable of absorbing the energy of impact in association with environmental loads corresponding to the appropriate one year storm condition.

3.3.5 In general, for loading condition (c) in Table 4.3.1, the level of impact energy absorbed by the local leg structure is not to be taken less than 2 MJ. If the unit is only to operate in protected waters, as defined in Pt 1, Ch 2.2.4, the level of impact energy absorbed by the local leg structure may be reduced but should not be less than 0.5 MJ. Collision loads will, in general, only cause local damage to one leg, but the possibility of progressive collapse and overturning should be considered in the design calculations which should be submitted for consideration.

3.3.6 The permissible stress levels after credible failures or accidents are to be in accordance with Chapter 5.

3.3.7 Fatigue damage due to cyclic loading is to be considered in the design of the legs of the unit for transit and elevated conditions. Fatigue damage is considered accumulative throughout the unit's design life. The extent of the fatigue analysis will be dependent on the mode and area of operations, see Ch 5.5.

3.4 Hull structure

3.4.1 The hull is to be considered as a complete structure having sufficient strength to resist all induced stresses while in the elevated position and supported by its legs. All fixed and variable loads are to be distributed, by an accepted method of rational analysis, from the various points of application to the supporting legs. The scantlings of the hull are then to be determined consistent with this load distribution.

3.4.2 Due account must be taken of loadings induced in the transit condition from external sea heads, variable deck loads and legs.

3.5 Deckhouses

3.5.1 Deckhouses are to have sufficient strength for their size, function and location. Requirements for scantlings are given in Ch 6.9.

3.5.2 Special consideration is to be given to the scantlings of deckhouses and deck modules which will not be subjected to wave loading in any operating condition such as units which are ‘dry-towed’ to the operating location.

3.6 Structure in way of jacking or elevating arrangements

3.6.1 Load carrying members in the jackhouses and frames which transmit loads between the legs and the hull are to be designed for the maximum design loads and are to be so arranged that loads transmitted from the legs are properly diffused into the hull structure. The scantlings of jackhouses are not to be less than required for deckhouses in accordance with Ch 6.9.

3.7 Leg wells

3.7.1 The scantlings and arrangements of the boundaries of leg wells are to be specially considered and the structure is to be suitably reinforced in way of leg guides, taking into account the maximum forces imposed on the structure. The minimum scantlings of leg wells are to comply with Ch 6.3.3.

3.8 Leg design

3.8.1 Legs may be either shell type or lattice type. Independent footings may be fitted to the legs or legs may be permanently attached to a bottom mat. Shell type legs may be designed as either stiffened or unstiffened shells.

3.8.2 Where legs are fitted with independent footings, proper consideration is to be given to the leg penetration of the sea bed and the end fixity of the leg.

3.8.3 Leg scantlings are to be determined in accordance with a method of rational analysis and calculations submitted for consideration, see Ch 3.3.

3.8.4 For lattice legs, the slenderness ratio of the main chord members between joints is not to exceed 40, or two thirds of the slenderness ratio of the leg column as a whole, whichever is the lesser, unless it can be shown that a calculation taking into account beam-column effect, joint rigidity and joint eccentricity justifies a higher figure.

3.9 Unit in the elevated position

3.9.1 When computing leg stresses with the unit in the elevated position, the maximum overturning load and maximum shear load on the unit, using the most adverse combination of applicable variable loadings together with the environmental design loadings, are to be considered with the following criteria:

(a) Wave forces: Values of drag coefficient, CD, and inertia coefficient, CM, vary considerably with Reynolds number, Re, and Keulegan-Carpenter number, NC, and are to be carefully chosen to suit the individual circumstances. In calculating the wave forces using acceptable wave theories, values as given in (i) to (iii) for the hydrodynamic coefficients CD and CM for non-tubular members of the leg chords may be used essentially in the drag dominated regime with post-critical Re and high NC. Otherwise more detailed information based on tests or published data is to be used.
3.10 Legs in field transit conditions

3.10.1 In field transit conditions within the same geographical area, legs are to be designed for acceleration forces caused by a 6° single amplitude of roll or pitch at the natural period of the unit, plus, 120 per cent of the gravity forces caused by the legs’ angle of inclination, unless otherwise verified by appropriate model tests or calculations. The legs are to be investigated for any proposed leg arrangement with respect to vertical position during field transit moves, and the approved positions are to be specified in the Operations Manual. Such investigation is to include strength and stability aspects. Field transit moves may only be undertaken when the predicted weather is such that the anticipated motions of the unit will not exceed the design condition.

3.10.2 The duration of a field transit move may be for a considerable period of time and should be related to the accuracy of weather forecasting in the area concerned. It is recommended that such a move should not normally exceed a twelve hour voyage between protected locations or locations where the unit may be safely elevated. However, during any portion of the move, the unit should not normally to be more than a six hour voyage to a protected location or a location where the unit may be safely elevated. Suitable instructions are to be included in the Operations Manual. Where a special leg position is required for field moves, this position is to be specified in the Operations Manual.

3.11 Legs in ocean transit conditions

3.11.1 In ocean transit conditions involving a move to a new geographical area, legs are to be designed for acceleration and gravity loadings resulting from the motions in the most severe anticipated environmental transit conditions, together with corresponding wind moments. Calculation or model test methods may be used to determine the motions. Alternatively, legs may be designed for the acceleration and gravity forces caused by a design criterion of 20° single amplitude of roll or pitch at a 10 second period. For ocean transit conditions, it may be necessary to reinforce or support the legs, or to remove sections of them. The approved condition is to be included in the Operations Manual.

3.12 Legs during installation conditions

3.12.1 When lowering the legs to the sea bed, the legs are to be designed to withstand the dynamic loads which may be encountered by their unsupported length just prior to touching the sea bed and also to withstand the shock of touching bottom while the unit is afloat and subject to wave motions.

3.12.2 Instructions for lowering the legs are to be clearly indicated in the Operations Manual. The maximum design motions, bottom conditions and sea state while lowering the legs are to be clearly stated. The legs are not to be lowered in conditions which may exceed the design criteria.
3.12.3 For units without bottom mats, all legs are to have the capability of being preloaded to the maximum applicable combined gravity plus overturning load. The approved preload procedure should be included in the Operations Manual.

3.12.4 Consideration is to be given to the loads caused by a sudden penetration of one or more legs during preloading.

3.13 Stability in-place

3.13.1 When the legs are resting on the sea bed, the unit is to have sufficient positive downward gravity loadings on the support footings or mat to withstand the overturning moment of the combined environmental forces from any direction, with a reserve against the loss of positive bearing of any footing or segment of the area, for each design loading condition. The most critical minimum variable load condition is to be considered for each loading direction and in no case is the variable load to be taken greater than 50 per cent of the maximum and using the least favourable location of the centre of gravity.

3.13.2 The safety factor against overturning is to be at least 1.25 with respect to the rotational axis through the centres of the independent footings at the sea bed. For a unit with a mat type footing, the rotational axis is to be taken at the maximum stressed edge of the mat.

3.13.3 For independent footings, the safety factor against sliding at the sea bed is to be related to the soil condition, but in no case is the safety factor to be taken as less than 1.0.

3.14 Sea bed conditions

3.14.1 Classification will be based upon the designer’s assumptions regarding the sea bed conditions. These assumptions are to be recorded in the Operations Manual.

3.14.2 Full details of the sea bed at the operating location are to be submitted to LR for review at the design stage. The effects of scouring on bottom mat bearing surfaces and footings is to be considered, see 3.16.3.

3.15 Foundation fixity

3.15.1 For units with independent legs, foundation fixity should not normally be considered for in-place strength analysis of the upper parts of the leg in way of the lower guides unless justified by proper investigation of the footing and soil conditions.

3.15.2 For in-place analysis, the lower parts of the leg with independent footings are to be designed for a leg moment no less than 50 per cent of the maximum leg moment at the lower guides, together with the associated horizontal and vertical loads.

3.16 Bottom mat

3.16.1 When the legs are attached to a bottom mat, the scantlings of the mat are to be specially considered, but the permissible stress levels are to be in accordance with Chapter 5. Particular attention is to be given to the attachment, framing and bracing of the mat in order that the loads from the legs are effectively distributed into the mat structure.

3.16.2 Mats and their attachments to the bottom ends of the legs are to be of robust construction to withstand the shock load on touching the sea bed while the unit is afloat and subject to wave motions.

3.16.3 The effects of scouring on the bottom bearing surfaces should be considered by the designer, with a stated design figure for loss of bearing area. The effects of skirt plates, where provided, may be taken into account, see also 3.14.1.

3.16.4 The minimum local scantlings of the mat structures are to comply with 3.17.5 and 3.17.6.

3.17 Independent footings

3.17.1 Independent footings are to be designed to withstand the most severe combination of overall and local loadings to which they may be subjected, see also 3.16.3. In general, the primary structure is to be analysed by a three-dimensional finite element method.

3.17.2 The complexity of the mathematical model together with the associated element types is to be sufficiently representative of all parts of the primary structure to enable internal stress distributions to be established.

3.17.3 The loading combinations considered are to represent all modes of operation so that the critical design cases are established, and are to include, but not be limited to, the following:

(a) The maximum preload concentrated or distributed over the area of initial contact.
(b) The maximum preload uniformly distributed over the entire bottom area.
(c) The relevant preload distributed over contact areas corresponding to intermediate levels of penetration, as required.
(d) The greatest leg load due to the specified environmental maxima applied over the entire bottom area, with the pressure varying linearly from zero at one end to twice the mean value at the other end.
(e) The distribution in (d) applied in different directions, depending on structural symmetry, to cover all possible wave headings.
(f) Where it is intended to move the unit without the footings being fully retracted, a special analysis of the leg to spudcan connections may be required.

3.17.4 In any case, the maximum preload shall be applied as an initial condition, for the purposes of stability in-place analysis, see 3.13.

3.17.5 The minimum local scantlings of the mat structures are to comply with 3.17.6 and 3.17.7.

3.17.6 The design of the primary structure is to be considered in its entirety, and the effects of footings or local stiffnesses are to be included in 3.17.5 and 3.17.7.

3.17.7 The minimum local scantlings of the mat structures are to comply with 3.17.5 and 3.17.6.
3.17.4 The permissible stresses are to be based on the safety factors for yield and buckling as defined in Ch 5,2. The preload cases may be considered as load case (a) in Ch 5,2 while the loadings associated with the maximum storm cases may be taken as load case (b) in Ch 5,2.

3.17.5 The minimum local scantlings of the bottom shell and stiffening and other areas subjected to pressure loading are to be determined from the formulae for tank bulkheads given in Ch 6,7. The loadhead \( h_4 \) should be consistent with the maximum bearing pressure, determined in accordance with 3.17.3, and the wastage allowance of the plating should be not less than 3,5 mm, see also 3.17.6.

3.17.6 Where it is intended to operate at a fixed location for the design life of the unit, the footing/leg structure which is below the mud line or internal areas of the footings which cannot be inspected are to have their structure designed with adequate corrosion margins and protection. The corrosion allowance for wastage and the means of protection are to be to the satisfaction of LR and are to be agreed at the design stage.

3.17.7 When the structure consists of compartments which are not vented freely to the sea, the scantlings of the shell boundaries and stiffening are not to be less than required for tank boundaries in Ch 6,7 using the load head \( h_4 \) not less than 1,4\( T_0 \) m, where \( T_0 \) is defined in Ch 1,5.

3.17.8 Where the legs of the unit are made from steel with extra high tensile strength, special consideration is to be given to the weld procedures for the leg to footing connections. Adequate preheat should be used and the cooling rate should be controlled. Any non-destructive examination of the welds should be carried out after a minimum of 48 hours have elapsed after the completion of welding.

3.18 Lifeboat platforms

3.18.1 When self-elevating units are fitted with cantilevered lifeboat platforms, the strength of the platforms is to comply with 1.9. If the lifeboat platform can be subjected to wave impact forces in transit conditions, the scantlings are to be specially considered and details are to be submitted for consideration by LR.

3.19 Topside structure

3.19.1 General requirements for topside structure are given in 1.10.
## Section 1

### General requirements

1.1 General

1.1.1 This Section defines the overall strength requirements of the unit and the permissible stresses in all operating modes.

1.1.2 The design loads are to be in accordance with Ch 3,4 and the design conditions are to be based on the most unfavourable combinations of gravity loads, functional loads, environmental loads and accidental loads.

1.1.3 Specific requirements for structural unit types are also defined in Chapter 4.

1.1.4 The local strength of the unit is to comply with the requirements of Chapter 6.

1.1.5 The limiting design environmental and operational conditions for each mode of operation is to be defined by the Owner/designer and included in the Operations Manual, see Pt 3, Ch 1,3.

### Structural analysis

1.2.1 A structural analysis of the primary structure of the unit is to be carried out in accordance with the requirements of Chapter 3 and the resultant stresses determined.

1.2.2 The loading conditions are to represent all modes of operation and the critical design cases obtained.

1.2.3 The structure is to be analysed for the relevant load combinations given in Ch 3,4,3.

1.2.4 For the combined load cases applicable to all unit types, see also Chapter 4.

1.2.5 The permissible stress levels relevant to the combined load cases defined in 1.2.3 are to be in accordance with Section 2.

1.2.6 Special consideration is to be given to structures subjected to large deformations.

### Primary structure

1.3.1 Local stresses, including those due to circumferential loading on tubular members, are to be added to the primary stresses to determine total stress levels.

1.3.2 The scantlings are to be determined on the basis of criteria which combine, in a rational manner, the individual stress components acting on the various structural elements of the unit. The stresses are to be determined using net scantlings, i.e., no corrosion allowance included, see also Pt 3, Ch 1,5.

1.3.3 The critical buckling stress of structural elements is to be considered in relation to the computed stresses, see Sections 3 and 4.

1.3.4 Fatigue damage due to cyclic loading is to be considered in the design of the unit in accordance with Section 5.

1.3.5 When computing bending stresses, the effective flange areas are to be determined in accordance with ‘effective width’, concepts derived from accepted shear lag theories and plate buckling considerations.

1.3.6 Where appropriate, elastic deflections are to be taken into account when determining the effects of eccentricity of axial loading, and the resulting bending moments superimposed on the bending moments computed for other types of loadings.

1.3.7 When computing shear stresses in bulkheads, plate girder webs or hull side plating, only the effective shear area of the plate or web is to be considered. For girders, the total depth of the girder may be considered as the web depth.

1.3.8 Members of lattice type structures may be designed in accordance with a recognised Code as defined in Part 3, Appendix A.

### Connections and details

1.4.1 Special consideration is to be given to structural continuity and connections of critical components of the primary and special structure, such as the following:

- Bracing intersections and end connections.
- Columns to lower and upper hulls.
- Jackhouses to deck.
- Legs to mat or footings.
- Mooring line attachments.

1.4.2 Critical joints depending upon the 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, see Ch 2,4,1,3.

1.4.3 Welding and structural details are to be in accordance with Chapter 8.
Primary Hull Strength

2.1.4 Non-linear and plastic design methods may be used for verifying the local structure in load cases (c) and (d), as defined in Ch 3, 4.3. Local yielding and permanent deformation can be accepted; however, the structural arrangements must prevent progressive collapse.

2.1.5 The buckling strengths of plates and stiffeners are to comply with Section 3.

2.1.6 The buckling strength for individual primary members subjected to axial compression and combined axial compression and bending is to be in accordance with Section 4.

2.1.7 Permissible stress levels for lattice type structures are to be determined as required by 1.3.8.

2.1.8 Permissible stresses in materials other than steel are to be specially considered.

Section 3
Buckling strength of plates and stiffeners

3.1 Application

3.1.1 The requirements of this Section apply to plate panels, and attached stiffeners subject to overall hull structure compression and shear stresses. The maximum design values computed are to be determined in accordance with 1.2.

3.1.2 For states of stress which cannot be defined by one single reference stress, the buckling characteristics are to be based on recognised interaction formulae.

3.1.3 LR’s ShipRight program no. 10206 may be used for the buckling assessment of flat rectangular plate panels by direct calculation.

3.2 Symbols

3.2.1 The symbols used in this Section are defined as follows:

\[ E = \text{modulus of elasticity, in N/mm}^2 \ (\text{kgf/mm}^2) \]

\[ \sigma_o = \text{specifed minimum yield stress, in N/mm}^2 \ (\text{kgf/mm}^2) \]

\[ \sigma_{CRB} = \text{critical buckling stress in compression, in N/mm}^2 \ (\text{kgf/mm}^2), \text{corrected for yielding effects} \]

\[ \sigma_E = \text{elastic critical buckling stress in compression, in N/mm}^2 \ (\text{kgf/mm}^2) \]

\[ \tau_{CRB} = \text{critical buckling stress in shear, in N/mm}^2 \ (\text{kgf/mm}^2), \text{corrected for yielding effects} \]

\[ \tau_E = \text{elastic critical buckling stress in shear, in N/mm}^2 \ (\text{kgf/mm}^2) \]

\[ \tau_o = \frac{\sigma_o}{3} \]
3.3 Elastic critical buckling stress

3.3.1 The elastic critical buckling stress of plating and stiffeners is to be determined in accordance with an agreed Code or Standard or according to Table 4.7.2 and Table 4.7.3 in Pt 3, Ch 4.7, of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

3.4 Scantling criteria

3.4.1 The critical buckling stress in compression, corrected for yielding effects, \( \sigma_{CRB} \), of plate panels and stiffeners, as derived from Table 4.7.2 and Table 4.7.3 in Pt 3, Ch 4.7 of the Rules for Ships, is to satisfy the following:

\[
\sigma_{CRB} \geq F_{SC} \sigma_A
\]

where \( F_{SC} \) = factor of safety for compression in accordance with 2.1.1 for the appropriate load case.

3.4.2 The critical buckling stress in shear, corrected for yielding effects, \( \tau_{CRB} \), of plate panels as derived from Table 4.7.2(c), in Pt 3, Ch 4.7 of the Rules for Ships, is to satisfy the following:

\[
\tau_{CRB} \geq F_{SS} \tau_A
\]

where \( F_{SS} \) = factor of safety for shear buckling in accordance with 2.1.1 for the appropriate load case.

3.4.3 Buckling criteria are to be determined for plating and plate and stiffener combinations, including (but not limited to):
- Flat bar stiffeners.
- Bulb plate stiffeners.
- Rolled angles.
- Built-up profiles.
- Floors or deep girders.

3.4.4 All appropriate buckling modes are to be investigated, including:
- Column buckling.
- Torsional buckling.
- Web and flange buckling.

3.4.5 In general, stresses are to be determined using net scantlings, i.e., no corrosion allowance included.

4.2 Symbols

4.2.1 The symbols used in this Section are defined as follows:
- \( \sigma_o \), \( E \) as defined in 3.2.1
- \( \sigma_A \) = computed axial compressive stress, in N/mm\(^2\) (kgf/mm\(^2\))
- \( \sigma_B \) = computed compressive stress due to bending, in N/mm\(^2\) (kgf/mm\(^2\))
- \( F_A \) = factor of safety for compression, in accordance with 2.1.1
- \( F_B \) = factor of safety for bending, in accordance with 2.1.1
- \( \sigma_{CRB} \) = critical overall member buckling stress, in N/mm\(^2\) (kgf/mm\(^2\)), as determined from Table 5.4.1
- \( \sigma_C \) = local member critical buckling stress, in N/mm\(^2\) (kgf/mm\(^2\))
- \( \sigma_{PA} \) = permissible axial compressive stress, in N/mm\(^2\) (kgf/mm\(^2\))
- \( \sigma_{PB} \) = permissible compressive stress due to bending, in N/mm\(^2\) (kgf/mm\(^2\))
- \( \sigma_o \) or \( \sigma_C \) or \( \sigma_{CRB} \) whichever is the lesser
- \( \sigma_o \) or \( \sigma_C \) whichever is the lesser
- \( \sigma_{PA} \) or \( \sigma_{PB} \) whichever is the lesser
- \( D \) = mean diameter of cylindrical shell, in mm
- \( t \) = thickness of cylindrical shell, in mm.

4.3 Elastic critical buckling stress

4.3.1 Where the elastic critical buckling stress exceeds 50 per cent of the specified minimum yield stress of the material, the calculated critical buckling stresses are to be corrected for yielding effects and are given by:

\[
\sigma_C = \sigma_o \left(1 - \frac{\sigma_o}{4 \sigma_E}\right) \text{N/mm}^2 \text{ (kgf/mm}^2\text{)}\text{ in compression.}
\]

4.4 Scantling criteria

4.4.1 Individual members are to be investigated for overall critical buckling in accordance with an agreed Code or Standard or Table 5.4.1 and Table 5.4.2 and also for local buckling.

4.4.2 The local buckling of cylindrical shells, either unstiffened or ring-stiffened, is to be investigated if the proportions of the shell conform to the following:

\[
\frac{D}{t} > \frac{4}{9 \sigma_o}
\]

4.4.3 When individual primary structural members are subjected to axial compression or combined axial compression and bending, the computed design stresses are to satisfy the following requirement:

\[
\frac{\sigma_A}{\sigma_{PA}} + \frac{\sigma_B}{\sigma_{PB}} \leq 1.0
\]
Section 5
Fatigue design

5.1 General

5.1.1 Fatigue damage due to cyclic loading is to be considered in the design of all unit types. The extent of the fatigue analysis will be dependent on the mode and area of operation.

5.1.2 Where any unit is intended to operate at one location for an extended period of time, a rigorous fatigue analysis is to be performed using the long-term prediction of environment for that area of operation with the unit at the intended orientation. Due allowance is to be made of any previous operational history of the unit.

5.1.3 The two basic methods of fatigue analysis available are Deterministic Fatigue Analysis and Spectral Fatigue Analysis. Both are acceptable to LR.

5.1.4 Factors which influence fatigue endurance and should be accounted for in the design calculations include:
- Loading spectrum.
- Detail structural design.
- Fabrication and tolerances.
- Corrosion.
- Dynamic amplification.

5.1.5 The following important sources of cyclic loading should be considered in the design:
- Waves (including those which cause slamming and variable-buoyancy effects).
- Wind (especially when vortex shedding is induced, e.g., on slender members).
- Currents (where these influence the forces generated by waves and/or induced vortex shedding).
- Mechanical vibration (e.g., caused by operation of machinery).

5.1.6 Where a fine mesh finite element analysis is carried out to determine local geometric stress concentration factors, selection of associated S-N curves will be specially considered. Account is to be taken of fatigue stress direction relative to the weld. In general, the element mesh size adjacent to the weld detail under consideration is to be of the order of the local plate thickness. Mesh arrangement and analysis methodology are to be agreed with LR.

5.1.7 In general, stresses are to be determined using net scantlings, i.e., no corrosion allowance included, see also Pt 3, Ch 1.5. For surface type units:
Where an approved corrosion control system is fitted, stresses can be determined using gross scantlings reduced by 25 per cent of corrosion addition.

Table 5.4.1 Overall member critical buckling stress

<table>
<thead>
<tr>
<th>Condition</th>
<th>Member critical buckling stress $\sigma_{CRB}$, N/mm$^2$ (kgf/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) When $\lambda &lt; \sqrt{\eta}$</td>
<td>$\sigma_o - \frac{\sigma_o^2}{4\eta E}$</td>
</tr>
<tr>
<td>(b) When $\lambda \geq \sqrt{\eta}$</td>
<td>$\frac{\pi^2 E}{\lambda^2}$</td>
</tr>
</tbody>
</table>

Symbols and parameters

$\sigma_o$, $E$ as defined in 3.2.1
$l$ = unsupported length of member, in metres
$K$ = effective length factor to be generally taken as unity but will be specially considered in association with end conditions
$l_e = Kl = $ unsupported effective length of member, in metres
$r$ = least radius of gyration of member cross-section, in mm, and may be taken as:

$r = 10 \frac{I}{A}$ mm

$A$ = cross-sectional area of member, in cm$^2$
$I$ = least moment of inertia of member cross-section, in cm$^4$
$\lambda$ = slenderness ratio and may be taken as:

$\lambda = \frac{l_e}{r}$

$\eta = \frac{2\pi^2 E}{\sigma_o^2 \lambda}$

Table 5.4.2 Factors of safety for overall member buckling

<table>
<thead>
<tr>
<th>Condition</th>
<th>Factor of safety, $F_C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) For case (a) as defined in 2.1.1:</td>
<td></td>
</tr>
<tr>
<td>(a) When $\lambda &lt; \sqrt{\eta}$</td>
<td>$1.67 + \frac{0.25\lambda}{\sqrt{\eta}}$</td>
</tr>
<tr>
<td>(b) When $\lambda \geq \sqrt{\eta}$</td>
<td>$1.92$</td>
</tr>
<tr>
<td>(2) For cases (b) and (c) as defined in 2.1.1:</td>
<td></td>
</tr>
<tr>
<td>(a) When $\lambda &lt; \sqrt{\eta}$</td>
<td>$1.25 + \frac{0.19\lambda}{\sqrt{\eta}}$</td>
</tr>
<tr>
<td>(b) When $\lambda \geq \sqrt{\eta}$</td>
<td>$1.44$</td>
</tr>
<tr>
<td>(3) For case (d) as defined in 2.1.1:</td>
<td></td>
</tr>
<tr>
<td>(a) When $\lambda &lt; \sqrt{\eta}$</td>
<td>$1.0 + \frac{0.15\lambda}{\sqrt{\eta}}$</td>
</tr>
<tr>
<td>(b) When $\lambda \geq \sqrt{\eta}$</td>
<td>$1.15$</td>
</tr>
</tbody>
</table>

Symbols and parameters

$F_C$ as defined in 4.2.1
$\lambda$ and $\eta$ as defined in Table 5.4.1
5.2 Fatigue life assessment

5.2.1 Fatigue life assessment of all relevant structural elements is required to demonstrate that structural connections have a fatigue endurance consistent with the planned life of the unit and compliance with the minimum requirements. The following structural elements are to be included:

(a) Column-stabilised units:
   - Bracing structure.
   - Bracing connections to lower hulls, columns and decks.
   - Column connections to lower hulls.
   - Column connections to deck.
   - Mooring structure and associated hull structure integration.
   - General structural discontinuities.

(b) Surface type units:
   - Hull longitudinal stiffener connections to transverse frames and bulkheads.
   - Toe area of main structural brackets.
   - Hopper knuckle connections.
   - Main openings in the hull envelope.
   - Mooring structure and associated hull structure integration.
   - General structural discontinuities in the primary hull structure.

(c) Self-elevating units:
   - Lattice legs and connections to footings.
   - Leg support structure.
   - Raw water towers.

(d) Other unit types:
   - Special consideration will be given to the hull structure of other unit types on the basis of this Section.

(e) General: Hull, deck and supporting structure in way of topside facilities, e.g:
   - Module support.
   - Process plant support stools.
   - Crane pedestal.
   - Flare structures.
   - Offloading station.
   - Drilling derrick and substructures.

(f) General: Other structures subjected to significant cyclic loading.

5.3 Fatigue damage calculations

5.3.1 The fatigue damage calculations are to be based on the long-term distribution of the applied stress ranges. A sufficient number of draughts and directions are to be included.

5.3.2 An appropriate wave spectrum is to be used and representative percentages of the total cumulative spectrum included for each direction under consideration. When using a limited number of directions, account is to be taken of symmetry within the structure.

5.3.3 Cumulative damage may be calculated by Miner’s summation:

\[ \sum_{j=1}^{s} \frac{n_i}{N_i} \leq \frac{1.0}{F_s} \]

where
- \( s \) = number of stress range blocks
- \( n_i \) = actual number of cycles for stress range block number ‘i’
- \( N_i \) = corresponding number of cycles obtained from the relevant S-N curve for the detail under consideration
- \( F_s \) = fatigue factor of safety from Table 5.5.1 or Table 5.5.2.

5.3.4 Cumulative damage for individual components is to take into account the degree of redundancy, accessibility of the structure and also the consequence of failure.

5.3.5 Fatigue life estimation is normally to be based on the Miner’s summation method given in 5.3.3, but consideration will be given to the use of an appropriate fracture mechanics assessment.

5.4 Joint classifications and S-N curves

5.4.1 Acceptable joint classification and S-N curves for structural details are contained in Appendix A.

5.4.2 Consideration will be given to the use of alternative methods; detailed proposals are to be submitted and agreed with LR.

5.4.3 Full penetration welds are normally to be used for all nodal joints (i.e., tubular brace to chord connections). For full penetration welded joints, fatigue cracking would usually be located at the weld toe. However, if partial penetration welds have to be used where weld throat failure is a possibility, fatigue should be assessed using the ‘W’ curve and a shear stress estimated at the weld root.

5.4.4 For nodal joints, the stress range to be used in the fatigue analysis is the hot spot stress range at the weld toe. For any particular type of loading (e.g., axial loading) this stress range is the product of the nominal stress range in the brace and the appropriate stress concentration factor (SCF).
5.4.5 The hot spot stress is defined as the greatest value around the brace/chord intersection of the extrapolation to the weld toe of the geometric stress distribution near the weld toe. This hot spot stress incorporates the effects of overall joint geometry (i.e., the relative sizes of brace and chord) but omits the stress-concentrating influence of the weld itself which results in a local stress distribution. Hence, the hot spot stress is considerably lower than the peak stress but provides a consistent definition of stress range for the design S-N curve (curve ‘T’ shown in Appendix A). Stress ranges both for the brace and chord sides are to be considered in any fatigue assessment.

5.4.6 For all other types of joint (e.g., welded stiffeners or attachments, including those at nodal joints) the joint classifications and corresponding S-N curves are to take into account the local stress concentrations created by the joints themselves and by the weld profile. The relevant stress range is then the nominal stress range which is to include any local bending adjacent to the weld under consideration. However, if the joint is also situated in a region of stress concentration resulting from the gross shape of the structure, this is to be taken into account.

5.4.7 In load-carrying partial penetration or fillet-welded joints, where cracking could occur in the weld throat, the relevant stress range is the maximum range of shear stress in the weld metal. For details which are particularly fatigue-sensitive, where failure could occur through the weld, full penetration welding is normally to be used.

5.4.8 Geometric stress concentrations may be determined from experimental tests, appropriate references, semi-empirical or parametric formulae or analytical methods (e.g., finite elements analysis). See also Appendix A.

5.4.9 Normal fabrication tolerances according to good workmanship standards as given by the Rules are considered to be implicitly accounted for in the S-N curves.

5.5 Cast or forged steel

5.5.1 Fatigue life calculations for cast or forged steel structural components are to include details of the fatigue endurance curve for the material, taking account of the particular environment, mean stress and the existence of casting defects, and the derivation of any stress concentration factors.

5.6 Factors of safety on fatigue life

5.6.1 The minimum factors of safety on the calculated fatigue life of structural components are to be in accordance with Table 5.5.1. For mooring systems, see 5.6.2.

5.6.2 The minimum factors of safety on the calculated fatigue life of anchor lines and tether components of mooring systems are to be in accordance with Table 5.5.2.

---

**Table 5.5.1 Fatigue life factors of safety for structural components**

<table>
<thead>
<tr>
<th>Inspectable/repairable</th>
<th>Fatigue life factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-substantial</td>
<td>Substantial</td>
</tr>
<tr>
<td>Yes, dry</td>
<td>1</td>
</tr>
<tr>
<td>See Note 2</td>
<td>2</td>
</tr>
<tr>
<td>Yes, wet</td>
<td>2</td>
</tr>
<tr>
<td>See Note 3</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
</tr>
</tbody>
</table>

**Notes**

1. Substantial consequences of failure include, *inter alia*, loss of life, uncontrolled outflow of hazardous or polluting products, collision, sinking. In assessing consequences, account should be taken of the potential for progressive failure. This factor will be applicable for bottom structure of oil storage tanks of single bottomed units and side structures of oil storage tanks of single sided units.

2. Includes internal and external structural elements and connections which can be subjected to dry inspection and repair.

3. Includes external structural elements and connections situated below the minimum operating draught of the unit or structure which can only be inspected during in-water surveys but dry repairs could be carried out subject to special arrangements being provided.

**Table 5.5.2 Fatigue life factors of safety for anchor line and tether components**

<table>
<thead>
<tr>
<th>Inspectable/replaceable</th>
<th>Fatigue life factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, dry</td>
<td>3</td>
</tr>
<tr>
<td>Yes, wet</td>
<td>5</td>
</tr>
<tr>
<td>No</td>
<td>10</td>
</tr>
</tbody>
</table>

**NOTE**

Anchor line or tether components include chains, steel wire ropes, and associated fittings such as shackles, connecting links, rope sockets and terminations.
Local Strength

Section
1. General requirements
2. Design heads
3. Watertight shell boundaries
4. Decks
5. Helicopter landing areas
6. Decks loaded by wheeled vehicles
7. Bulkheads
8. Double bottom structure
9. Superstructures and deckhouses
10. Bulwarks and other means for the protection of crew and other personnel
11. Topside to hull structural sliding bearings

Section 1
General requirements

1.1 General
1.1.1 All parts of the structure are to be designed to withstand the most severe combination of overall and local loadings to which they may be subjected. Permissible stresses for direct calculation methods are to comply with the requirements of Chapter 5.

1.1.2 The local effects of the loadings listed in Ch 3, 4 are to be considered and all parts of the structure are to be examined individually as necessary, and the calculations submitted. The minimum Rule scantlings of all structures are also to comply with the requirements of this Chapter, as applicable.

1.1.3 The design heads for local strength of column-stabilised, sea-bed stabilised and self-elevating units are to be in accordance with Section 2.

1.1.4 The design heads for local strength of surface type units are to be in accordance with Pt 3, Ch 3.5 of the Rules for Ships.

1.1.5 The scantlings of machinery seatings are to be specially considered. On self-propelled units, full details of power, and RPM, etc., are to be submitted.

1.1.6 The structure in way of fairleads, chainstoppers, winches, etc., forming part of anchoring or positional mooring systems is to be designed for a working load equal to the breaking strength of the mooring or anchoring lines as applicable, see also Pt 3, Ch 10, 11. Permissible stresses are to be in accordance with Ch 5.2.1.1(c). Supply boat moorings and support structures are to be designed on a similar basis.

1.1.7 Towing brackets and supporting structure are to be designed for a working load equal to the breaking strength of the topline in accordance with the requirements of Chapter 9.

1.1.8 The supporting structure in way of lifeboat davits is to be designed for the dynamic factors defined in Ch 4.1.9 and the permissible stress levels are to comply with load case (a) in Ch 5.2.1.1.

1.1.9 When a DRILL notation is to be assigned, the scantlings of the drilling derrick are to be determined in accordance with Pt 3, Ch 7. The supporting sub-structure is a classification item and calculations are to be submitted in accordance with Pt 3, Ch 7. The sub-structure is to be integrated into the unit’s hull structure and the local permissible stresses are to comply with Chapter 5.

1.1.10 The supporting structures to production and process plant are to comply with Pt 3, Ch 8.

Section 2
Design heads

2.1 General

2.1.1 This Section contains the local design heads and pressures to be used in the derivation of scantlings for decks, and bulkheads. Where scantlings in excess of Rule requirements are fitted the procedure to be adopted to determine the permissible head/pressure is also given.

2.2 Symbols

2.2.1 The symbols used in this Section are defined as follows:

\[ L \text{ and } D \text{ as defined in Ch 1.5} \]
\[ h_i = \text{appropriate design head, in metres} \]
\[ \rho = \text{design loading, in kN/m}^2 \text{ (tonne-f/m}^2\text{)} \]
\[ \rho_a = \text{applied loading, in kN/m}^2 \text{ (tonne-f/m}^2\text{)} \]
\[ C = \text{stowage rate, in m}^3/\text{tonne, see 2.3} \]
\[ E = \frac{h_i}{\rho} \]
\[ T = \frac{0.0914 + 0.003L}{D - T} = 0.15, \text{ but not less than zero} \]
\[ T = \frac{0.0914 + 0.003L}{D - T} \]
\[ \text{nor more than 0.147} \]
\[ T = T_0 \text{ or } T_1 \text{ as defined in Ch 1.5 as appropriate.} \]
2.3 Stowage rate and design heads

2.3.1 The following standard stowage rates are to be used:
(a) 1,39 m³/tonne for weather or general loading on decks.
(b) 0,975 m³/tonne for tanks with liquid of density 1,025 tonne/m³ or less on tank bulkheads and for watertight bulkheads. For liquid of density greater than 1,025 tonne/m³, the corresponding stowage rates are to be adopted.

2.3.2 The design heads and permissible deck loading are shown in Table 6.2.1. For helicopter landing areas, see Section 5.
### Table 6.2.1  Design heads and permissible deck loadings (SI units) *(see continuation)*

<table>
<thead>
<tr>
<th>Structural item and position</th>
<th>Component</th>
<th>Standard stowage rate ( C ), in ( \text{m}^3/\text{tonne} )</th>
<th>Design loading ( p ), in ( \text{kN/m}^2 )</th>
<th>Equivalent design head ( h_1 ) in metres</th>
<th>Permissible deck loading in ( \text{kN/m}^2 )</th>
<th>Equivalent permissible head, in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. All units except surface type units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Weather decks</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>( h_1 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(b) Loading for minimum scantlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Exposed deck</td>
<td>All structure</td>
<td>1.39</td>
<td>( 9.0 + 14.4 E )</td>
<td>1.2 + 2.04E</td>
<td>9.0</td>
<td>1.2</td>
</tr>
<tr>
<td>(c) Specified deck loading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Exposed deck</td>
<td>All structure</td>
<td>1.39</td>
<td>( p_a + 14.41E )</td>
<td>0.14( p_a ) + 2.04E</td>
<td>( p_a )</td>
<td>0.14( p_a )</td>
</tr>
<tr>
<td><strong>2. Other decks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Loading for minimum scantlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Work areas</td>
<td>All structure</td>
<td>1.39</td>
<td>9.0</td>
<td>( h_2 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(ii) Storage areas</td>
<td>All structure</td>
<td>1.39</td>
<td>14.13</td>
<td>( h_3 )</td>
<td>2.0</td>
<td>—</td>
</tr>
<tr>
<td>(iii) Decks forming crown of deep tanks</td>
<td>All structure</td>
<td>( C )</td>
<td>9.82( h ) ( c )</td>
<td>( h_4 ) (see Note 2)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(iv) Accommodation decks</td>
<td>All structure</td>
<td>1.39</td>
<td>8.5</td>
<td>( h_5 )</td>
<td>1.2</td>
<td>—</td>
</tr>
<tr>
<td>(b) Specified deck loading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) All areas</td>
<td>All structure</td>
<td>1.39</td>
<td>( p_a + 14.41E )</td>
<td>( h_2, h_3, h_5 )</td>
<td>0.14( p_a )</td>
<td>—</td>
</tr>
<tr>
<td>(c) Superstructure decks</td>
<td>(see Note 3)</td>
<td></td>
<td></td>
<td>( h_6 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) 1st tier</td>
<td>All structure</td>
<td>—</td>
<td>—</td>
<td>( 0.9 )</td>
<td>( 0.6 )</td>
<td>—</td>
</tr>
<tr>
<td>(ii) 2nd tier</td>
<td>(see Note 4)</td>
<td>—</td>
<td>—</td>
<td>( 0.45 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(iii) 3rd tier and above</td>
<td>All structure</td>
<td>—</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Walkways and access areas</td>
<td>All structure</td>
<td>1.39</td>
<td>4.5</td>
<td>( h_7 )</td>
<td>0.64</td>
<td>—</td>
</tr>
</tbody>
</table>
### Table 6.2.1 Design heads and permissible deck loadings (SI units) (conclusion)

<table>
<thead>
<tr>
<th>Component</th>
<th>Design loading ( P ), in kN-m/( m^2 )</th>
<th>Standard stowage rate ( C ), in m(^3)/tonne</th>
<th>Equivalent design head ( h ), in metres</th>
<th>Equivalent permissible head, ( h_{\text{p}} ), in metres</th>
<th>Permissible deck loading in kN-m/( m^2 )</th>
<th>Notes</th>
</tr>
</thead>
</table>
| All structure | 10.07 \( A \) | 0.975 | | | | **Note 1**. The equivalent design head is to be used in conjunction with the appropriate formulae in the Rules. **Note 2**. Where \( h \) equals half the distance from the top of the overflow above the crown of tank. **Note 3**. Where the deck is exposed to the weather add 2.04 \( E \) to the design head. **Note 4**. Where the forecastle is forward of 0.12 \( L \) from F.P., see weather decks.

| 3. Watertight bulkheads | 9.29 \( A \) | C but ≤ 0.975 | | | | **Note 1**. The equivalent design head is to be used in conjunction with the appropriate formulae in the Rules. **Note 2**. Where \( h \) equals half the distance from the top of the overflow above the crown of tank. **Note 3**. Where the deck is exposed to the weather add 2.04 \( E \) to the design head. **Note 4**. Where the forecastle is forward of 0.12 \( L \) from F.P., see weather decks.

| 4. Deep tank bulkheads | | | | | | **Note 1**. The equivalent design head is to be used in conjunction with the appropriate formulae in the Rules. **Note 2**. Where \( h \) equals half the distance from the top of the overflow above the crown of tank. **Note 3**. Where the deck is exposed to the weather add 2.04 \( E \) to the design head. **Note 4**. Where the forecastle is forward of 0.12 \( L \) from F.P., see weather decks.
## Table 6.2.1 Design heads and permissible deck loadings (metric units) *(see continuation)*

<table>
<thead>
<tr>
<th>Structural item and position</th>
<th>Component</th>
<th>Standard stowage rate $C$, in m³/tonne</th>
<th>Design loading $p_a$, in tonne-f/m²</th>
<th>Equivalent design head $h_1$ in metres</th>
<th>Permissible deck loading in tonne-f/m²</th>
<th>Equivalent permissible head, in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All units except surface type units</td>
<td>All structure</td>
<td>1,39</td>
<td>$0,92 + 1,467E$</td>
<td>$1,28 + 2,04E$</td>
<td>$0,92$</td>
<td>$1,28$</td>
</tr>
<tr>
<td>(b) Loading for minimum scantlings</td>
<td>All structure</td>
<td>1,39</td>
<td>$1,44$</td>
<td>$2,0$</td>
<td>$1,44$</td>
<td>$2,0$</td>
</tr>
<tr>
<td>(c) Specified deck loading</td>
<td>All structure</td>
<td>1,39</td>
<td>$p_a + 1,467E$ but not less than (a) above</td>
<td>$1,39p_a + 2,04E$</td>
<td>$p_a$</td>
<td>$1,39p_a$</td>
</tr>
<tr>
<td>2. Other decks</td>
<td>All structure</td>
<td>1,39</td>
<td>$0,92$</td>
<td>$1,28$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(a) Loading for minimum scantlings</td>
<td>All structure</td>
<td>1,39</td>
<td>$1,44$</td>
<td>$2,0$</td>
<td>$1,44$</td>
<td>$2,0$</td>
</tr>
<tr>
<td>(b) Specified deck loading</td>
<td>All structure</td>
<td>1,39</td>
<td>$0,865$</td>
<td>$1,2$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(c) Superstructure decks (see Note 3)</td>
<td>All structure</td>
<td>1,39</td>
<td>$0,9$</td>
<td>$0,6$</td>
<td>$0,45$</td>
<td>—</td>
</tr>
<tr>
<td>(d) Walkways and access areas</td>
<td>All structure</td>
<td>1,39</td>
<td>$0,46$</td>
<td>$0,84$</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Notes:
1. See continuation for more details.
2. See Note 2 for specific conditions.
3. See Note 3 for further requirements.
4. See Note 4 for additional information.
### Section 3

**Watertight shell boundaries**

#### 3.1 General

3.1.1 The requirements of Chapter 7 regarding watertight integrity are to be complied with.

3.1.2 The minimum requirements for watertight shell plating and framing of column-stabilised units and self-elevating units are given in this Section.

3.1.3 The minimum requirements for watertight shell plating and framing of surface type units are to comply with Ch 4.4.

3.1.4 The Rules are, in general, applicable to shell plating with stiffeners fitted parallel to the hull bending compressive stress. When other stiffening arrangements are proposed, the scantlings are to be specially considered and the minimum shell thickness is to satisfy the buckling strength requirements given in Chapter 5, but the minimum requirements of this Section are to be complied with.

3.1.5 The shell plating thickness is to satisfy the requirements for the overall strength of the unit in accordance with Chapters 4 and 5.

3.1.6 The scantlings of moonpool bulkheads will be specially considered with regard to the maximum forces imposed on the structure and the permissible stress levels are to comply with Chapter 5.

3.1.7 The minimum scantlings of moonpools and drilling well bulkheads on column-stabilised units are to comply with 3.2.5, but plating thickness is to be not less than 9.0 mm, see also Pt 3, Ch 2.2.

3.1.8 The scantlings of moonpools and drilling well bulkheads on surface type units and self-elevating units are to comply with Pt 3, Ch 2.2.

3.1.9 Where column structures or superstructures extend over the side shell of the unit, the side shell/sheerstrake is to be suitably increased locally at the ends of the structure.

3.1.10 On units fitted with two chines each side the bilge plating should not be less than required for bottom plating. When units are fitted with hard chines the shell plating is not to be flanged, but where the chine is formed by knuckling the shell plating, the radius of curvature, measured on the inside of the plate, is not to be less than 10 times the plate thickness. Where a solid round chine bar is fitted, the bar diameter is to be not less than three times the thickness of the thickest abutting plate. When welded chines are used, the welding is to be built up as necessary to ensure that the shell plating thickness is maintained across the weld, see also Table 6.3.3.

3.1.11 The plating of swim ends is to have a thickness not less than that required for bottom shell plating.

---

<table>
<thead>
<tr>
<th>Equivalent permissible head, in metres</th>
<th>I</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permissible deck loading, in tonne-m²</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Equivalent design head, h₀, in metres</td>
<td>0.975</td>
<td></td>
</tr>
<tr>
<td>Design loading, P, in tonne-m²</td>
<td>0.975</td>
<td></td>
</tr>
<tr>
<td>Standard stowage rate, C, in m³/tonne</td>
<td>0.975</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6.2.1 Design heads and permissible deck loadings (metric units) (conclusion)

<table>
<thead>
<tr>
<th>Component</th>
<th>Design heads and permissible deck loadings (metric units) (conclusion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Watertight bulkheads</td>
<td>Equivalent design head, h₀, in metres: 0.975</td>
</tr>
<tr>
<td>4. Deep tank bulkheads</td>
<td>Equivalent design head, h₀, in metres: 0.975</td>
</tr>
</tbody>
</table>

**NOTES**

1. The equivalent design head is to be used in conjunction with the appropriate formulae in the Rules.
2. Where h₀ equals half the distance to the top of the overflow above crown of tank.
3. Where the dock is exposed to the weather and 2.04 E to the design head.
4. Where the dock is exposed to the weather and 2.04 E to the design head.

For forecastle decks forward of 0.12 L from F.P., see weather decks.
Local Strength

3.1.12 Where a rounded sheerstrake is adopted, the radius should, in general, be not less than 15 times the plate thickness.

3.1.13 Sea inlets, or other openings, are to have well rounded corners and, so far as possible, are to be kept clear of the bilge radius. Openings on, or near to, the bilge radius are to be elliptical. The thickness of sea inlet box plating is to be the same as the adjacent shell, but not less than 12.5 mm. The ends of stiffeners should in general be bracketed and alternative proposals may be considered.

3.1.14 In general, secondary hull framing is to be continuous and the end connections of stiffeners to watertight bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of strength.

3.1.15 The end connections of secondary hull framing and primary members are also to comply with Chapter 8.

3.1.16 The lateral and torsional stability of stiffeners together with web and flange buckling criteria are to be verified in accordance with Ch 5,3.

3.1.17 Web frames supporting secondary hull framing are, in general, to be spaced not more than 3.8 m apart when the length, L, is less than 100 m and (0.006L + 3.2) m apart where L is greater than 100 m. For units which are also required to operate aground, see Ch 4,2.

3.2 Column-stabilised units

3.2.1 When the external watertight boundaries of columns, lower hulls and footings are designed with stiffened plating, the minimum scantlings for shell plating, hull framing and web frames, etc., are to comply with Table 6.3.1, see also 3.2.3.

3.2.2 The scantlings determined from Table 6.3.1 are the minimum requirements for hydrostatic pressure loads only and the overall strength is to comply with Chapter 4.

3.2.3 Where cross ties are fitted in columns or lower hulls, the scantlings are to comply with 3.3.5 and 3.3.6 taking the head $h_c$ as the pressure head $h_o$ in accordance with Table 6.3.1 as appropriate. Where cross ties are fitted inside tanks, the requirements of 3.3.4 are also to be complied with.

### Table 6.3.1 Watertight shell boundaries for lower hulls and columns of column-stabilised units and tension-leg units

<table>
<thead>
<tr>
<th>Items and requirement</th>
<th>Boundaries of lower hull or columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Shell plating thickness</td>
<td>$t = 0,004s / \sqrt{h_o k} + 2,5$ mm but not less than 9,0 mm</td>
</tr>
<tr>
<td>(2) Hull framing:</td>
<td></td>
</tr>
<tr>
<td>(a) Modulus</td>
<td>$Z = 8,5s k h_o l_e^2 \times 10^{-3}$ cm$^3$</td>
</tr>
<tr>
<td>(b) Inertia</td>
<td>$I = \frac{2,3}{k} l_e Z$ cm$^4$</td>
</tr>
<tr>
<td>(3) Primary members: Web frames supporting framing:</td>
<td></td>
</tr>
<tr>
<td>(a) Modulus</td>
<td>$Z = 8,5k h_o S l_e^2$ cm$^3$</td>
</tr>
<tr>
<td>(b) Inertia</td>
<td>$I = \frac{2,3}{k} l_e Z$ cm$^4$</td>
</tr>
</tbody>
</table>

**Symbols**

- $f = 1,1 - \frac{s}{2500S}$ but not to be taken greater than 1,0
- $h_o$ = load head in metres measured vertically as follows:
  - (a) For shell plating the distance from a point one-third of the height of the plate above its lower edge to a point $1,4T_0$ above the keel or to the bottom of the upper hull structure whichever is the lesser with a minimum of 6,0 m.
  - (b) For hull framing and primary members, the distance from the middle of the effective length to a point $1,4T_0$ above the keel or to the bottom of the upper hull structure whichever is the lesser with a minimum of 6,0 m.
- $k$ = steel factor as defined in Ch 2,1
- $l_e$ = effective length of member, in metres, as defined in Ch 3,3,3
- $s$ = spacing of frames, in mm
- $S$ = spacing or mean spacing of primary members, in metres
- $T_0$ = maximum operating draught, in metres, as defined in Ch 1,5

**NOTES**

1. In no case are the scantlings in way of tanks to be less than the requirements given in Table 6.7.1 for tank bulkheads using the load head $h_d$.
2. In no case are the scantlings to be less than the requirements given in Table 6.7.1 for watertight bulkheads using the load head $h_d$.
3. Where frames are not continuous they are to be fitted with end brackets in accordance with Section 7 or equivalent arrangements provided.
3.2.4 When the scantlings of primary web frames or girders are determined by a frame analysis or where the boundaries of columns, lower hulls and footings are designed as shells either unstiffened or ring stiffened, the scantlings may be determined on the basis of an agreed analysis, see Ch 1.2. The minimum design loads are to be in accordance with Chapter 3 and the permissible stresses are to comply with Chapter 5. The scantlings are not to be less than required by 3.2.1.

3.2.5 The minimum scantlings of the external watertight boundaries of the upper hull structure are to comply with Table 6.3.2.

3.2.6 The shell plating and structure are to be reinforced in way of mooring fairleads, supply boat moorings, towing brackets and other attachments, see also Section 1.

3.2.7 Columns, lower hulls, footings and other areas likely to be damaged by anchors, chain cables and wire ropes, etc., are to be protected or suitably strengthened.

3.2.8 Openings are not permitted in the shell boundaries of columns, lower hulls and footings except when they are closed with watertight covers fitted with closely spaced bolts, see Chapter 7.

3.3 Self-elevating units

3.3.1 The minimum scantlings of shell plating are to comply with Table 6.3.3 and the secondary hull framing and primary members are to comply with Table 6.3.4, see also 3.3.4.

3.3.2 The shell plating thickness is to be suitably increased in way of high shear forces in way of drilling cantilevers and other concentrated loads.

3.3.3 The scantlings and arrangements of the boundary bulkheads of leg wells will be specially considered with regard to the maximum forces imposed on the structure, and the permissible stress levels are to comply with Chapter 5. The minimum scantlings are to comply with Table 6.7.1 as a tank bulkhead with the load head \( h_4 \) measured to the upper deck at side. In no case is the minimum plating thickness to be less than 9 mm.

3.3.4 When cross ties are fitted inside pre-load tanks, the tensile stress in the cross ties and its end connections is not to exceed 108 N/mm² (11,0 kgf/mm²) at the test head, but the scantlings are also to comply with the requirements of 3.3.5 and 3.3.6.

Table 6.3.2 Watertight shell boundaries of the upper hull of column-stabilised units and tension-leg units

<table>
<thead>
<tr>
<th>Items and requirement</th>
<th>Boundaries of upper hull</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Shell plating thickness general</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td>See also 3.1.5</td>
<td>(a) ( t = 0,004 s f h_4 k ) mm</td>
</tr>
<tr>
<td></td>
<td>(b) ( t = 0,012 s f k ) mm but not less than 7,5 mm</td>
</tr>
<tr>
<td>(2) Bottom plating thickness between columns within ( \frac{W}{2} ) outside of</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td>column shell but not less than two web frame spaces</td>
<td>(a) ( t = 0,004 s f h_4 k ) mm + 2,5 mm</td>
</tr>
<tr>
<td>See also 3.1.5</td>
<td>(b) ( t = 0,012 s f k ) mm but not less than 7,5 mm</td>
</tr>
<tr>
<td>(3) Shell stiffeners and primary webs, general</td>
<td>To comply with Table 6.7.1 using the load head ( h_4 )</td>
</tr>
<tr>
<td>(4) Shell stiffeners adjacent to columns as defined in (2):</td>
<td></td>
</tr>
<tr>
<td>(a) Modulus</td>
<td>( Z = 8,5 s k h_4 l_e^2 \times 10^{-3} ) cm³</td>
</tr>
<tr>
<td>(b) Inertia</td>
<td>( I = \frac{2,3}{k} l_e Z ) cm⁴</td>
</tr>
</tbody>
</table>

Symbols

Symbols as defined in Table 6.7.1, except as follows:

\( h_4 \) = load head, in metres, as defined in Table 6.7.1 for watertight bulkheads but not less than 6,0 m

\( s_b = 470 + \frac{L}{0,6} \) mm or 700, whichever is the smaller

\( s_f = s \) but is not to be taken less than \( s_b \)

\( W = \) greatest width or diameter of stability column, in metres

NOTE

In no case are the scantlings in way of tanks to be less than the requirements given in Table 6.7.1 for tank bulkheads using the load head \( h_4 \).
3.3.5 When cross ties are fitted to support shell web frames the scantlings of the web frames are to be determined from Tables 6.3.4 and 6.7.1 and the area and least moment of inertia of the cross tie are to satisfy the following, see also 3.3.6 and 3.3.7:

\[ A_c \geq \frac{0.82d_c h_c S k}{1 - 0.42 \left( \frac{l_c}{\sqrt{r k}} \right)} \]

where:

- \( d_c \) = one-half the vertical distance in metres between the centres of the bottom or deck webs adjacent to the cross tie, see Fig. 6.3.1
- \( h_c \) = vertical distance from the centre of the cross tie to deck, in metres, see Fig. 6.3.1
- \( l_c \) = length of cross tie between the toes of the horizontal brackets on the web frames at the cross tie, in metres
- \( S \) = spacing of web frames, in metres
- \( l_p \) = span of web frames, see Fig. 6.3.1
- \( I_c \) = least inertia of cross tie cross-section, in cm\(^4\)
- \( A_c \) = area of cross tie, in cm\(^2\)
- \( r \) = least radius of gyration of cross tie cross-section, in cm

### Table 6.3.3 Shell plating self-elevating units

<table>
<thead>
<tr>
<th>Location</th>
<th>Thickness, in mm, see also 3.1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Bottom shell plating</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td>See Notes 1, 2 and 4</td>
<td>(a) ( t = 0.001s_1 \left( 0.043L + 10 \right) \sqrt{\frac{1}{k}} )</td>
</tr>
<tr>
<td></td>
<td>(b) ( t = 0.0052s_1 \sqrt{1.5T_T k} )</td>
</tr>
<tr>
<td>(2) Bilge plating (framed)</td>
<td>( t ) as for (1)</td>
</tr>
<tr>
<td>See Note 2</td>
<td></td>
</tr>
<tr>
<td>(3) Side shell plating</td>
<td>(a) Above ( \frac{D}{2} ) from base:</td>
</tr>
<tr>
<td>See Notes 1, 2, 3 and 4</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>(i) ( t = 0.001s_1 \left( 0.059L + 7 \right) \sqrt{\frac{1}{k}} )</td>
</tr>
<tr>
<td></td>
<td>(ii) ( t = 0.0042s_1 \sqrt{1.4T_T k} )</td>
</tr>
<tr>
<td>(b) At upper turn of bilge (see Note 2):</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>(i) ( t = 0.001s_1 \left( 0.059L + 7 \right) \sqrt{\frac{1}{k}} )</td>
</tr>
<tr>
<td></td>
<td>(ii) ( t = 0.0054s_1 \sqrt{1.2T_T k} )</td>
</tr>
<tr>
<td>(c) Between upper turn of bilge and ( \frac{D}{2} ) from base:</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>(i) ( t ) from (b)(i)</td>
</tr>
<tr>
<td></td>
<td>(ii) ( t ) from interpolation between (a)(ii) and (b)(ii)</td>
</tr>
<tr>
<td>(4) Minimum plating</td>
<td>( t_m = (6.5 + 0.033L) \sqrt{\frac{k s_1}{s_b}} )</td>
</tr>
</tbody>
</table>

### Symbols

- \( L, D, T_T \) as defined in Ch 1.5
- \( k \) = steel factor as defined in Ch 2.1
- \( s \) = spacing of secondary stiffeners, in mm
- \( s_b \) = 470 + \( \frac{L}{0.6} \) mm or 700 mm, whichever is the smaller
- \( s_1 \) = \( s \), but is not to be taken less than \( s_b \)

### Notes

1. In no case is the shell plating to be less than \( t_m \).
2. When no bilge radius is fitted and the unit is fitted with hard chines, the bottom shell thickness required by (1) is, in general, to be extended up to \( \frac{D}{2} \) from base, see 3.1.10.
3. The thickness of side shell need not exceed that determined from (1) for bottom shell when using the spacing of side shell stiffeners.
4. In no case are the scantlings of tanks to be less than the requirements given in Table 6.7.1 for tank bulkheads using load head \( h_4 \).
Local Strength

Table 6.3.4 Shell framing self-elevating units

<table>
<thead>
<tr>
<th>Items and location</th>
<th>Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Hull framing, see Note 1</td>
<td></td>
</tr>
<tr>
<td>(a) Bottom frames</td>
<td></td>
</tr>
<tr>
<td>(b) Side frames</td>
<td></td>
</tr>
<tr>
<td>(2) Primary members, see Note 1</td>
<td></td>
</tr>
<tr>
<td>(a) Bottom web frames supporting framing</td>
<td></td>
</tr>
<tr>
<td>(b) Side web frames supporting framing</td>
<td></td>
</tr>
</tbody>
</table>

\[ Z = 11.0 s k h_T l_e^2 \times 10^{-3} \text{ cm}^3 \]

\[ Z = 8.0 s k h_T l_e^2 \times 10^{-3} \text{ cm}^3 \]

Symbols

\[ D \text{ and } T_T \text{ as defined in Ch 1,5} \]

\[ h_T = \text{ load head, in metres, and is to be taken as the distance from the middle of the effective length to a point } 1.6T_T \text{ above the keel or to the upper deck at side whichever is the lesser but not less than } 0.01L + 0.7 \]

\[ k = \text{ steel factor as defined in Ch 2,1} \]

\[ l_e = \text{ effective length of member, in metres, as defined in Ch 3,3.3} \]

\[ s = \text{ spacing of frames, in mm} \]

\[ S = \text{ spacing or mean spacing of primary members, in metres} \]

NOTES

1. In no case are the scantlings in way of tanks to be less than the requirements given in Table 6.7.1 for tank bulkheads using the load head \( h_T \).
2. In no case are the scantlings to be less than the requirements given in Table 6.7.1 for watertight bulkheads using the load head \( h_T \).
3. Where frames are not continuous they are to be fitted with end brackets in accordance with Section 7 or equivalent arrangements provided.

---

Section 4

Decks

4.1 General

4.1.1 The design deck loadings for all unit types are not to be less than those defined in Sections 1 and 2.

4.1.2 The scantlings of deck structures for surface type units are to comply with Ch 4,4. The requirements of 4.1.5 and 4.1.6 are also to be complied with as applicable.

4.1.3 The minimum scantlings of deck structures on column-stabilised units and self-elevating units are to comply with this Section.

4.1.4 The scantlings of deck structures are also to satisfy the overall strength requirements in Chapter 4 and be sufficient to withstand the actual local loadings plus any additional loadings superimposed due to overall frame action. The permissible stress levels are to comply with Chapter 5.

4.1.5 Where decks form watertight boundaries in damage stability conditions, the minimum scantlings are not to be less than required for watertight bulkheads given in Section 7.
Local Strength

4.1.6 For units fitted with a process plant facility and/or drilling equipment, the support stools and integrated hull support structure to the process plant and other equipment supporting structures to drilling derricks and flare structures, etc., are considered to be classification items regardless of whether or not the process/drilling plant facility is classed and the loadings are to be determined in accordance with Pt 3, Ch 8.2. Permissible stress levels are to comply with Chapter 5.

4.2 Deck plating

4.2.1 The requirements are in general applicable to strength/weather deck plating with stiffeners fitted parallel to the hull bending compressive stress. When other stiffening arrangements are proposed, the scantlings will be specially considered, but the minimum requirements of Table 6.4.1 are to be complied with.

4.2.2 The minimum thickness of deck plating is to comply with the requirements of Table 6.4.1, except for decks in way of erections above the upper deck. For erection decks, see Section 6.

4.2.3 The thickness of strength/weather deck plating is also to be that necessary to satisfy the overall strength requirements of Chapters 4 and 5.

4.2.4 The deck plating thickness and supporting structure in way of towing brackets, winches, masts, crane pedestals, davits and machinery items, etc., is to be suitably reinforced, see also Section 1.

4.2.5 Where plated decks are sheathed with wood or approved compositions, consideration will be given to allowing a reduction in the minimum plating thickness given in Table 6.4.1.

4.3 Deck stiffening

4.3.1 The scantlings of deck stiffeners are to comply with the requirements of Table 6.4.2. Stiffeners fitted in way of concentrated loads and heavy machinery items, etc., will be specially considered.

4.3.2 The lateral and torsional stability of stiffeners together with web and flange buckling criteria are to be verified in accordance with Ch 5.3.

4.3.3 End connection of stiffeners to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of primary strength. In general deck stiffeners are to be continuous through primary support structure, including bulkheads but alternative arrangements will be considered. The end connections of stiffeners are in general to be in accordance with the requirements of Chapter 8.

Table 6.4.1 Deck plating

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Location</th>
<th>Thickness, in mm, see also 4.2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$ = breadth of increased plating, in mm</td>
<td>Strength/weather deck</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td>$f$ = 1.1 – $\frac{s}{2500S}$ but not to be taken greater than 1.0</td>
<td></td>
<td>(a) $t = 0.001s_1(0.059L + 7)\sqrt{\frac{K}{K}}$</td>
</tr>
<tr>
<td>$k$ = steel factor as defined in 2.1.2</td>
<td></td>
<td>(b) $t = 0.00083s_1\sqrt{Lk} + 2.5$ but not less than (2)</td>
</tr>
<tr>
<td>$s$ = spacing of deck stiffeners, in mm</td>
<td>Lower decks</td>
<td>(2) $t = 0.012s_1\sqrt{k}$ but not less than 7.0 mm</td>
</tr>
<tr>
<td>$s_1$ = $s$ but is to be taken not less than the smaller of:</td>
<td>Platform decks</td>
<td>(3) $t = 0.015s_1\sqrt{k}$ but not less than 6.5 mm</td>
</tr>
<tr>
<td>470 + $\frac{L}{0.6}$, mm or 700 mm</td>
<td>In way of the crown or bottom of tanks</td>
<td>(4) $t = 0.004sf\frac{bkh_4}{1.025}$ or as (1), (2) or (3) whichever is the greater but not less than 7.5 mm</td>
</tr>
<tr>
<td>$A_f$ = girder face area, in cm²</td>
<td>Plating forming the upper flange of underdeck girders</td>
<td>(5) $t = \frac{A_f}{1.8k}$ but not less than required by (1), (2), (3) or (4) as appropriate</td>
</tr>
<tr>
<td>$K_1$ = 2.5 mm at bottom of tank</td>
<td></td>
<td>Minimum breadth, $b = 760$ mm</td>
</tr>
<tr>
<td>$L$ = length of unit, in metres, as defined in Ch 1,5.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S$ = spacing of primary members, in metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$, $h_4$ as defined in Table 6.7.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES
1. The thickness derived in accordance with (1) is also to satisfy the buckling requirements of Chapter 5.
2. On column-stabilised units when the primary deck structure consists of box girders or equivalent structure and the deck plating is considered as secondary structure only the thickness of the plating will be specially considered but in no case is the thickness to be less than 6.5 mm.
3. Where the local deck loading exceeds 43.2 kN/m² (4.4 tonne-f/m²) the thickness of plating will be specially considered.
Local Strength

RULES AND REGULATIONS FOR THE CLASSIFICATION OF MOBILE OFFSHORE UNITS, June 2013

Part 4, Chapter 6

Section 4

Table 6.4.2 Deck stiffeners

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Location</th>
<th>Modulus, in cm³</th>
<th>Inertia, in cm⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>d&lt;sub&gt;w&lt;/sub&gt;</td>
<td>depth of stiffener, in mm, see Note 2</td>
<td>( Z = 5.5s k h_1 t_k^2 10^{-3} )</td>
<td>—</td>
</tr>
<tr>
<td>h&lt;sub&gt;1&lt;/sub&gt;</td>
<td>weather head, in metres</td>
<td>( Z = 5.5s k h_2 t_k^2 10^{-3} )</td>
<td>—</td>
</tr>
<tr>
<td>h&lt;sub&gt;2&lt;/sub&gt;</td>
<td>work area head, in metres</td>
<td>( Z = 5.5s k h_3 t_k^2 10^{-3} )</td>
<td>—</td>
</tr>
<tr>
<td>h&lt;sub&gt;3&lt;/sub&gt;</td>
<td>storage head, in metres</td>
<td>( Z = 4.5s k h_5 t_k^2 10^{-3} )</td>
<td>—</td>
</tr>
<tr>
<td>h&lt;sub&gt;4&lt;/sub&gt;</td>
<td>tank head, in metres, as defined in Table 6.7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h&lt;sub&gt;5&lt;/sub&gt;</td>
<td>accommodation head, in metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>steel factor defined in Ch 2.1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l&lt;sub&gt;0&lt;/sub&gt;</td>
<td>span point, in metres as defined in Ch 3.3.3 but not less than 1.5 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s</td>
<td>spacing of stiffeners, in mm</td>
<td>( I = \frac{2.3}{k} t_k^2 Z )</td>
<td></td>
</tr>
<tr>
<td>γ</td>
<td>= 1.4 for rolled or built sections</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 1.6 for flat bars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ</td>
<td>as defined in Table 6.7.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES
1. The load heads \( h_1, h_2, h_3, \) and \( h_5 \) are to be determined from the maximum design uniform loadings and are not to be less than the minimum design load heads given in Table 6.2.1.
2. The web depth, \( d_{ww} \), of stiffeners is to be not less than 60 mm.

4.4 Deck supporting structure

4.4.1 The minimum scantlings of girders and transverses supporting deck stiffeners are to comply with the requirements of Table 6.4.3.

4.4.2 Transverses supporting deck longitudinals are, in general, to be spaced not more than 3.8 m apart when the length, \( L \), is 100 m or less, and (0.006L + 3.2) m apart where \( L \) is greater than 100 m.

4.4.4 Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased. Also, where concentrations of loading on one side of the girder may occur, the girder is to be adequately stiffened against torsion.

4.4.5 Pillars are to comply with the requirements of Table 6.4.4.

4.4.6 Pillars are to be fitted in the same vertical line wherever possible, and effective arrangements are to be made to distribute the load at the heads and heels of all pillars. Where pillars support eccentric loads, they are to be strengthened for the additional bending moment imposed upon them.

4.4.7 Tubular and hollow square pillars are to be attached at their heads to plates supported by efficient brackets, in order to transmit the load effectively. Doubling or insert plates are to be fitted to decks under the heels of tubular or hollow square pillars. The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding. At the heads and heels of pillars built of rolled sections, the load is to be well distributed by means of longitudinal and transverse brackets.

4.4.8 Where pillars are not fitted directly above the intersection of bulkheads, equivalent arrangements are to be provided.

4.4.9 In double bottoms where pillars are not directly above the intersection of the plate floors and girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in floors and girders below the heels of pillars.

4.4.10 Where pillars are fitted inside tanks or under watertight flats, the tensile stress in the pillar and its end connections is not to exceed 108 N/mm² (11,0 kgf/mm²) at the test heads. In general, such pillars should be of built sections, and end brackets may be required.

4.4.11 Pillars or equivalent structures are to be fitted below deckhouses, machinery items, winches, etc., and elsewhere where considered necessary.

4.4.12 The thickness of primary longitudinal and transverse bulkheads supporting decks is to satisfy the requirements for the overall strength of the unit in accordance with Chapters 4 and 5. When the bulkheads are to be watertight the scantlings are also to comply with the requirements of Section 7.

4.4.13 The lateral and torsional stability of primary bulkhead stiffeners together with web and flange buckling criteria are to be verified in accordance with Ch 5.3.

4.4.14 When openings are cut in the primary longitudinal and transverse bulkheads the openings are to have well rounded corners and full compensation is to be provided. All openings are to be adequately framed.

4.4.15 The minimum scantlings of non-watertight pillar bulkheads are to comply with the requirements of Table 6.4.5.
Local Strength

4.5 Deck openings

4.5.1 The corners of all deck openings are to be elliptical, parabolic or well rounded and the free edges are to be smooth. Large openings are to comply with 4.5.4 and 4.5.5.

4.5.2 All openings are to be adequately framed. Attention is to be paid to structural continuity, and abrupt changes of shape, section or plate thickness are to be avoided.

4.5.3 Arrangements in way of corners and openings are to be such as to minimise the creation of stress concentrations. Openings in highly stressed areas of decks, having a stress concentration factor in excess of 2.4, will require edge reinforcements in the form of a spigot of adequate dimensions, but alternative arrangements will be considered. The area of any edge reinforcement which may be required is not to be taken into account in determining the required sectional area of compensation for the opening.

4.5.4 When large openings are cut in highly stressed areas of decks, the corners of the openings are to be elliptical, parabolic or rounded, with a radius generally not less than 1/24 of the breadth of the opening. The minimum radius for large openings is to be 150 mm, provided the inner edge of the plating is stiffened by means of a coaming or spigot. Where the inner edge is unstiffened, the minimum radius is to be 300 mm.

4.5.5 Where the corners of large openings are rounded, the deck plating thickness is to be increased at the corners of the openings.

4.5.6 Compensation will be required for deck openings cut in highly stressed areas.

4.5.7 All openings which are required to be made watertight or weather tight are to have closing appliances in accordance with the requirements of Chapter 7.
### Table 6.4.4 Pillars

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>( b ) = breadth of side of a hollow rectangular pillar or breadth of flange or web of a built or rolled section, in mm</td>
<td>(1) Cross-sectional area of all types of pillar</td>
<td>[ A_p = \frac{kP}{12.36 - 51.5 \frac{l_e}{r\sqrt{k}}} \text{ cm}^2 ] [ A_p = \frac{kP}{1.26 - 5.25 \frac{l_e}{r\sqrt{k}}} \text{ cm}^2 ] See Note</td>
</tr>
<tr>
<td>( d_p ) = mean diameter of tubular pillars, in mm</td>
<td>(2) Minimum wall thickness of tubular pillars</td>
<td>The greatest of the following:</td>
</tr>
<tr>
<td>( k ) = local scantling higher tensile steel factor, see Ch 2, 1.2.1, but not less than 0.72</td>
<td></td>
<td>(a) ( t = \frac{P}{0.392d_p - 4.9l_e} \text{ mm} )</td>
</tr>
<tr>
<td>( l ) = overall length of pillar, in metres</td>
<td></td>
<td>(b) ( t = \frac{d_p}{40} \text{ mm} )</td>
</tr>
<tr>
<td>( l_e ) = effective length of pillar, in metres, and is taken as 0.80/ ( r ) = least radius of gyration of pillar cross-section, in mm, and may be taken as: [ r = 10 \sqrt{\frac{l}{A_p}} \text{ mm} ]</td>
<td>(c) ( t = 5.5 \text{ mm} \text{ where } L &lt; 90 \text{ m}, \text{ or } 7.5 \text{ mm} \text{ where } L \geq 90 \text{ m} )</td>
<td></td>
</tr>
<tr>
<td>( A_p ) = cross-sectional area of pillar, in cm(^2)</td>
<td>(3) Minimum wall thickness of hollow rectangular pillars or web plate thickness of ( I ) or channel sections</td>
<td>The lesser of the following:</td>
</tr>
<tr>
<td>( H_g ) as defined in Table 7.4.3</td>
<td></td>
<td>(a) ( t = \frac{br}{600l_p} \text{ mm} )</td>
</tr>
<tr>
<td>( I ) = least moment of inertia of cross-section, in cm(^4)</td>
<td></td>
<td>(b) ( t = \frac{br}{55} \text{ mm} ) but to be not less than ( t = 5.5 \text{ mm} \text{ where } L &lt; 90 \text{ m}, \text{ or } 7.5 \text{ mm} \text{ where } L \geq 90 \text{ m} )</td>
</tr>
<tr>
<td>( P ) = load, in kN (tonne-f), supported by the pillar and is to be taken as: ( P = P_o + P_a ) but not less than 19.62 kN (2 tonne-f)</td>
<td>(4) Minimum thickness of flanges of angle or channel sections</td>
<td>The lesser of the following:</td>
</tr>
<tr>
<td>( P_a ) = load, in kN (tonne-f), from pillar or pillars above (zero if no pillars over)</td>
<td></td>
<td>(a) ( t_1 = \frac{br}{200l_p} \text{ mm} )</td>
</tr>
<tr>
<td>( P_o ) = load, in kN (tonne-f), supported by pillar based on ( H_g )</td>
<td></td>
<td>(b) ( t_1 = \frac{b}{18} \text{ mm} )</td>
</tr>
<tr>
<td>( b ) = breadth of side of a hollow rectangular pillar or breadth of flange or web of a built or rolled section, in mm</td>
<td>(5) Minimum thickness of flanges of built or rolled ( I ) sections</td>
<td>The lesser of the following:</td>
</tr>
<tr>
<td>( \sqrt{k} ) = ( \frac{\sqrt{k}P}{9.32} \left( \frac{\sqrt{k}P}{0.95} \right) ) and the radius of gyration estimated for a suitable section having this area.</td>
<td></td>
<td>(a) ( t_1 = \frac{br}{400l_p} \text{ mm} )</td>
</tr>
<tr>
<td>NOTE</td>
<td></td>
<td>(b) ( t_1 = \frac{b}{36} \text{ mm} )</td>
</tr>
</tbody>
</table>

As a first approximation, \( A_p \) may be taken as \( \sqrt{k}P \left( \frac{\sqrt{k}P}{9.32} \right) \) and the radius of gyration estimated for a suitable section having this area. If the area calculated using this radius of gyration differs by more than 10 per cent from the first approximation, a further calculation using the radius of gyration corresponding to the mean area of the first and second approximation is to be made.
Local Strength

5.1.2 Attention is drawn to the requirements of National and other Authorities concerning the construction of helicopter landing platforms and the operation of helicopters as they affect the unit. These include the 2009 IMO MODU Code and SOLAS Chapter II-2 Regulation 18 and Chapter III Regulation 28, as applicable. Guidance on the provision and operation of helicopter landing or winching facilities may be drawn from international Standards such as the International Chamber of Shipping (ICS) Guide to Helicopter/Ship Operations and the International Aeronautical Search and Rescue Manual (IAMSAR).

5.1.3 Where helicopter decks are positioned so that they may be subjected to wave impacts, the scantlings are to be considered in a realistic manner and increased to the satisfaction of LR.
5.1.4 Where the landing area forms part of a weather or erection deck, the scantlings are to be not less than those required for decks in the same position.

5.2 Plans and data

5.2.1 Plans and data are to be submitted giving the arrangements, scantlings and details of the helicopter deck. The type, size and weight of helicopters to be used are also to be indicated.

5.2.2 Relevant details of the largest helicopters, for which the deck is designed, are to be stated in the Operations Manual.

5.3 Arrangements

5.3.1 The landing area is to comply with applicable Regulations, International Standards or to the satisfaction of the National Authority, with respect to size, landing and take-off sectors of the helicopter, freedom from height obstructions, deck markings, safety nets and lighting, etc.

5.3.2 The landing area is to have an overall coating of non-slip material or other arrangements are to be provided to minimise the risk of personnel or helicopters sliding off the landing area.

5.3.3 A drainage system is to be provided in association with a perimeter guttering system or slightly raised kerb to prevent spilled fuel falling on to other parts of the unit. The drains are to be led to a safe area.

5.3.4 A sufficient number of tie-down points are to be provided to secure the helicopter.

5.3.5 Engine and boiler uptake arrangements are to be sited such that exhaust gases cannot be drawn into helicopter engine intakes during helicopter take-off or landing operations.

5.4 Landing area plating

5.4.1 The deck gross plate thickness, \( t \), within the landing area is to be not less than:

\[
t = t_1 + 1.5 \text{ mm}
\]

where

\[
t_1 = \frac{\alpha s}{1000} \text{ mm}
\]

\[
\alpha = \text{thickness coefficient obtained from Fig. 6.5.1}
\]

\[
\beta = \text{tyre print coefficient used in Fig. 6.5.1}
\]

\[
= \log_{10} \left( \frac{P_s k^2}{s^2} \times 10^7 \right)
\]

5.4.2 The deck gross plate thickness, \( t \), shall be determined by the following formula:

\[
t = t_1 + 1.5 \text{ mm}
\]

where

\[
t_1 = \frac{\alpha s}{1000} \text{ mm}
\]

\[
\alpha = \text{thickness coefficient obtained from Fig. 6.5.1}
\]

\[
\beta = \text{tyre print coefficient used in Fig. 6.5.1}
\]

\[
= \log_{10} \left( \frac{P_s k^2}{s^2} \times 10^7 \right)
\]

Fig. 6.5.1 Tyre print chart
The plating is to be designed for the emergency landing case taking:

\[ P_1 = 2.5 \varphi_1 \varphi_2 \varphi_3 f \gamma P_w \text{ tonnes} \]

where \( \varphi_1, \varphi_2, \varphi_3 \) are to be determined from Table 6.5.3

\( f = 1.15 \) for landing decks over manned spaces, e.g., deckhouses, bridges, control rooms, etc.

\( f = 1.0 \) elsewhere

\( P_h = \) the maximum all up weight of the helicopter, in tonnes

\( P_w = \) landing load on the tyre print, in tonnes;

For helicopters with a single main rotor, \( P_w \), is to be taken as \( P_h \) divided equally between the two main undercarriage wheels.

For helicopters with tandem main rotors, \( P_w \), is to be taken as \( P_h \) distributed between all main undercarriage wheels in proportion to the static loads they carry.

For helicopters fitted with landing gear consisting of skids, \( P_w \), is to be taken as \( P_h \) distributed in accordance with the actual load distribution given by the airframe manufacturer. If this is unknown, \( P_w \) is to be taken as \( 1/6 P_h \) for each of the two forward contact points and \( 1/3 P_h \) for each of the two aft contact points. The load may be assumed to act as a 300 mm x 10 mm line load at each end of each skid when applying Fig. 6.5.1.

\( \gamma = 0.6 \) generally. Factor to be specially considered where the helicopter deck contributed to the overall strength of the unit.

Other symbols used in this Section are defined in Section 6 and in the appropriate sub-Section.

For wheeled undercarriages, the tyre print dimensions specified by the manufacturer are to be used for the calculation. Where these are unknown, it may be assumed that the print area is 300 x 300 mm and this assumption is to be indicated on the submitted plans.

For skids and tyres with an asymmetric print, the print is to be considered oriented both parallel and perpendicular to the longest edge of the plate panel and the greatest corresponding value of \( \alpha \) taken from Fig. 6.5.1.

5.4.2 The plate thickness for aluminium decks is to be not less than:

\[ t = 1.4 t_1 + 1.5 \text{ mm} \]

where \( t_1 \) is the mild steel thickness as determined from 5.4.1.

Where the deck is fabricated using extruded sections with closely spaced stiffeners the plate thickness may be determined by direct calculations but the minimum deck thickness is to include 1.5 mm wear allowance. If the deck is protected by closely spaced grip/wear treads the wear allowance may be omitted.

### Table 6.5.1 Design load cases for deck stiffening and supporting structure

<table>
<thead>
<tr>
<th>Load cases</th>
<th>Load</th>
<th>Supporting structure</th>
<th>See Note 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UDL, in kN/m²</td>
<td>Helicopter patch load</td>
<td>Self-weight</td>
</tr>
<tr>
<td></td>
<td>See Note 2</td>
<td>See Note 2</td>
<td></td>
</tr>
<tr>
<td>(1) Overall distributed loading</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(2) Helicopter emergency landing</td>
<td>0.5</td>
<td>2.5P_w f</td>
<td>W_h</td>
</tr>
<tr>
<td>(3) Normal usage</td>
<td>0.5</td>
<td>1.5P_w</td>
<td>W_h</td>
</tr>
</tbody>
</table>

**Symbols**

\( P_h, P_w \) and \( f \) as defined in 5.4.1

**UDL** = uniformly distributed vertical load over entire landing area

**W_h** = structural self-weight of helicopter platform

**NOTES**

1. For the design of the supporting structure for helicopter platforms applicable self-weight and horizontal loads are to be added to the landing area loads.
2. The helicopter is to be so positioned as to produce the most severe loading condition for each structural member under consideration.
### Table 6.5.2  Permissible stresses for deck stiffening and supporting structure

<table>
<thead>
<tr>
<th>Load case See Table 6.5.1</th>
<th>Deck secondary structure (beams, longitudinals, See Notes 1 and 2)</th>
<th>Primary structure (transverses, girders, pillars, trusses)</th>
<th>All structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permissible stresses, in N/mm²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bending</td>
<td>Combined bending and axial</td>
<td>Shear</td>
</tr>
<tr>
<td>(1) Overall distributed loading</td>
<td>$\frac{147}{k}$</td>
<td>$\frac{147}{k}$</td>
<td>$0.6\sigma_c$</td>
</tr>
<tr>
<td>(2) Helicopter emergency landing</td>
<td>$\frac{245}{k}$</td>
<td>$\frac{220.5}{k}$</td>
<td>$0.9\sigma_c$</td>
</tr>
<tr>
<td>(3) Normal usage</td>
<td>$\frac{176}{k}$</td>
<td>$\frac{147}{k}$</td>
<td>$0.6\sigma_c$</td>
</tr>
</tbody>
</table>

**Symbols**

$k = a$ material factor:

- $k$ as defined in Ch 2,1.2 for steel members
- $k_a$ as defined in Ch 2,1.3 for aluminium alloy members

$\sigma_c = yield$ stress, 0.2% proof stress or critical compressive buckling stress, in N/mm², whichever is the lesser

**NOTES**

1. Lower permissible stress levels may be required where helideck girders and stiffening contribute to the overall strength of the unit. Special consideration will be given to such cases.

2. When determining bending stresses in secondary structure, for compliance with the above permissible stresses, 100% end fixity may be assumed.

### Table 6.5.3  Deck plate thickness calculation

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a, s, u$ and $v$ as defined in Fig. 6.5.1</td>
<td></td>
</tr>
<tr>
<td>$P_w$ = load, in tonnes, on the tyre print. For closely spaced wheels the shaded area shown in Fig. 6.5.1 may be taken as the combined print</td>
<td></td>
</tr>
<tr>
<td>$\phi_1$ = patch aspect ratio correction factor</td>
<td></td>
</tr>
<tr>
<td>$\phi_2$ = panel aspect ratio correction factor</td>
<td></td>
</tr>
<tr>
<td>$\phi_3$ = wide patch load factor</td>
<td></td>
</tr>
</tbody>
</table>

$\phi_1 = \frac{2v_1 + 1.1s}{u_1 + 1.1s} \quad v_1 = v, but \frac{a}{s} \quad u_1 = u, but \frac{a}{s}$

$\phi_2 = 1.0 \quad \text{for } u \leq (a-s)$

$= \frac{1}{1.3 - \frac{0.3}{s}(a-u)} \quad \text{for } a \geq u > (a-s)$

$= 0.77 \frac{a}{u} \quad \text{for } u > a$

$\phi_3 = 1.0 \quad \text{for } v < s$

$= 0.6 \frac{s}{v} + 0.4 \quad \text{for } 1.5 > \frac{v}{s} > 1.0$

$= 1.2 \frac{s}{v} \quad \text{for } \frac{v}{s} \geq 1.5$
Local Strength

5.5.2 In addition to the requirements of 5.5.1, the structure supporting helicopter decks is to be designed to withstand the loads imposed on the structure due to the motions of the unit. For self-elevating units, the motions are not to be less than those defined for transit conditions in Ch 4.3.10 and 3.11. The stress levels are to comply with load case 3 in Table 6.5.2, see also 5.1.3.

5.5.3 For load cases (1) and (2) in Table 6.5.1 the minimum moment of inertia, $I$, of aluminium alloy secondary structure stiffening is to be not less than:

$$I = \frac{5.25}{k_a} Z l_e \text{ cm}^4$$

where $Z$ is the required section modulus of the aluminium alloy stiffener and attached plating and $k_a$ as defined in Ch 2.1.3.

5.5.4 Where a grillage arrangement is adopted for the platform stiffening, it is recommended that direct calculation procedures be used.

5.5.5 When the deck is constructed of extruded aluminium alloy sections, the scantlings will be specially considered on the basis of this Section.

5.6 Stowed helicopters

5.6.1 In addition to the requirements of 5.4 and 5.5, when arrangements are made to stow helicopters secured to the deck in predetermined positions, the structure is to be designed for the local loadings which can occur during normal operations.

5.6.2 Local loads on the structure are to be based on the maximum design undercarriage loadings specified by the helicopter manufacturer multiplied by a dynamic amplification factor based on the predicted motions of the unit as applicable. The self weight of the helicopter deck is to be included in the loadings imposed on the primary support structure. The permissible stress levels are to be in accordance with load case 3 in Table 6.5.2.

5.6.3 When the minimum design air temperature of the unit is 0°C or below, and considering the loadings in 5.6.2, the helicopter deck is to be assumed loaded with a uniformly distributed load of 0,5 kN/m² (0,05 tonne-f/m²) to represent wet snow or ice.

5.7 Bimetalic connections

5.7.1 Where aluminium alloy platforms are connected to steel structures, details of the arrangements in way of the bimetalic connections are to be submitted.
### Table 6.7.1 Watertight and deep tank bulkhead scantlings

<table>
<thead>
<tr>
<th>Item and requirement</th>
<th>Watertight bulkheads</th>
<th>Deep tank bulkheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Plating thickness for plane, symmetrically corrugated and double plate bulkheads</td>
<td>( t = 0.004sf \sqrt{h_{d}k} ) mm but not less than 5.5 mm</td>
<td>( t = 0.004sf \frac{\rho h_{d}k}{1.025} + 2.5 \text{ mm} ) nor less than 7.5 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the case of symmetrical corrugations, ( s ) is to be taken as ( b ) or ( c ) in Fig. 3.3.1 in Chapter 3, whichever is the greater</td>
</tr>
<tr>
<td>(2) Modulus of rolled and built stiffeners, swedges, double plate bulkheads and symmetrical corrugations</td>
<td>( Z = \frac{s k h_{d}l_{e}^{2}}{71\gamma (\omega_{1} + \omega_{2} + 2)} ) cm(^3)</td>
<td>( Z = \frac{\rho s k h_{d}l_{e}^{2}}{22\gamma (\omega_{1} + \omega_{2} + 2)} ) cm(^3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the case of symmetrical corrugations, ( s ) is to be taken as ( p ), see also Note 2</td>
</tr>
<tr>
<td>(3) Inertia of rolled and built stiffeners and swedges</td>
<td>( I = 2.26l_{e}Z ) cm(^3)</td>
<td></td>
</tr>
<tr>
<td>(4) Symmetrical corrugations and double plate bulkheads</td>
<td>Additional requirements to be complied with as detailed in Table 6.7.2</td>
<td></td>
</tr>
<tr>
<td>(5) Stringers or webs supporting vertical or horizontal stiffening (a) Modulus</td>
<td>( Z = 5.5k h_{d}S l_{e}^{2} ) cm(^3)</td>
<td>( Z = 11.7\rho k h_{d}S l_{e}^{2} ) cm(^3)</td>
</tr>
<tr>
<td>(b) Inertia</td>
<td>( I = 2.2l_{e}Z ) cm(^3)</td>
<td></td>
</tr>
</tbody>
</table>

#### Symbols

- \( s, S, f, k, \rho, p \) as defined in 7.2.1
- \( d_{w} \) = web depth of stiffening member, in mm
- \( t = 1.1 - \frac{s}{2500s} \) but not to be taken greater than 1.0
- \( h_{d} \) = load head, in metres measured vertically as follows:
  - (a) For watertight bulkhead plating, the distance from a point one-third of the height of the plate above its lower edge to a point 0.91 m above the bulkhead deck at side or to the worst damage waterline, whichever is the greater
  - (b) For tank bulkhead plating, the distance from a point one-third of the height of the plate above its lower edge to the top of the tank, or half the distance to the top of the overflow, whichever is the greater
- \( l_{e} \) = effective length of stiffening member, in metres, and for bulkhead stiffeners, to be taken as \( l - e_{1} - e_{2} \), see also Fig. 6.7.1
- \( \gamma = 1.4 \) for rolled or built sections and double plate bulkheads
- \( \gamma = 1.0 \) for symmetrical corrugations of watertight bulkheads
- \( \gamma = 1.1 \) for symmetrical corrugations of deep tank bulkheads
- \( \omega, e \) = as defined in Table 6.7.3, see also Fig. 6.7.1

#### NOTES

1. In no case are the scantlings of deep tank bulkheads to be less than the requirements for watertight bulkheads where the boundary bulkheads of the tanks form part of the watertight sub-division of the unit to meet damage stability requirements, see Ch 3.5.
2. For self-elevating units, the bulkhead deck is to be taken as the freeboard deck.
3. For column-stabilised units, the bulkhead deck is, in general, to be taken as the uppermost continuous strength deck unless agreed otherwise with LR.
4. The scantlings of all void compartments adjacent to the sea are also to comply with 7.5.1.
5. In calculating the actual modulus of symmetrical corrugations the panel width \( b \) is not to be taken greater than that given by Ch 3.3.2.
6. For rolled or built stiffeners with flanges or face plates, the web thickness is to be not less than \( \frac{d_{w}}{60 \sqrt{k}} \) whilst for flat bars

\[
\text{stiffeners the web thickness is to be not less than } \frac{d_{w}}{18 \sqrt{k}}
\]
Local Strength

RULES AND REGULATIONS FOR THE CLASSIFICATION OF MOBILE OFFSHORE UNITS, June 2013

Part 4, Chapter 6

Section 7

End of stiffer unattached permitted in upper tween decks only

End connections of this type not permitted at tank boundaries

(a)

(b)

(c)

Bracket with full line
Bracket with dotted line
Floor

(d)

(e)

Fig. 6.7.1 Effective length and end constraint definitions for bulkheads
### Local Strength

#### 7.2 Symbols

| k | higher tensile steel factor, see Ch 2,1 |
| s | spacing of secondary stiffeners, in mm |
| I | inertia of stiffening member, in cm4, see Ch 3,3 |
| S | spacing or mean spacing of primary members, in metres |
| Z | section modulus of stiffening member, in cm³, see Pt 3, Ch 3,3 |
| ρ | relative density (specific gravity) of liquid carried in a tank, but is not to be taken less than 1,025. |

#### 7.3 Watertight and deep tank bulkheads

7.3.1 The scantlings of watertight and deep tank bulkheads are to comply with the requirements of Tables 6.7.1 to 6.7.3. Where tanks cannot be inspected at normal periodic surveys, the scantlings derived from this Section are to be suitably increased.

7.3.2 Where bulkhead stiffeners support deck girders, transverses or pillars over, the scantlings are to satisfy the requirements of Section 4.

7.3.3 The strength of bulkheads and flats which support the ends of bracings or columns will be specially considered.

#### 7.3.4 In way of partially filled tanks, the scantlings and structural arrangements of the boundary bulkheads are to be capable of withstanding the loads imposed by the movement of the liquid in those tanks. The magnitude of the predicted loadings, together with the scantling calculations, may require to be submitted, see also Ch 3,4.18.

#### 7.3.5 In deep tanks, oil fuel or other liquids are to have a flash point of 60°C or above (closed-cup test). Where tanks are intended for liquids of a special nature, the scantlings and arrangements will be specially considered in relation to the properties of the liquid, see 7.3.6. For the scantlings of mud tanks, see 7.6.

#### 7.3.6 Where tanks are intended for the storage of oil with a flash point less than 60°C (closed-cup test) the scantlings of bulkheads on surface-type units are to comply with Ch 4,4, but other unit types are to comply with this Section. The minimum scantlings and arrangements on all units are also to comply with Pt 3, Ch 3.

#### 7.3.7 For cofferdams on units with oil storage tanks, as defined in 7.3.6, the separation of tanks and spaces are to comply with Pt 3, Ch 3. Cofferdams are to be fitted between tanks as necessary, depending on the liquids stored. In general, cofferdams are to be fitted between tanks in accordance with the requirements of Ch 3,5.

---

### Table 6.7.2 Symmetrical corrugations and double plate bulkheads (additional requirements)

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Type of bulkhead</th>
<th>Parameter</th>
<th>Watertight bulkheads</th>
<th>Deep tank bulkheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>s, k as defined in 6.2.1</td>
<td>Symmetrically corrugated, see also Notes 1 and 2</td>
<td>$b/t$</td>
<td>Not to exceed: 85√k at top, and 70√k at bottom</td>
<td>Not to exceed: 70√k at top and bottom</td>
</tr>
<tr>
<td>$d$</td>
<td>—</td>
<td>To be not less than: 39lₑ mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$θ$</td>
<td>To be not less than 40°</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Double plate**, see also Note 3

| s/√lₑ | Not to exceed: 75√k at top, and 65√k at bottom |
| — | Not to exceed: 85√k at top, and 75√k at bottom |
| $d$/tₑ | — | To be not less than: 39lₑ mm |
| $A_w$ | To be not less than: 0.1Z lₑ cm² at top, and 0.07Z lₑ cm² at top, and 0.18Z lₑ cm² at bottom |

NOTES

1. The plating thickness at the middle of span $lₑ$ of corrugated or double plate bulkheads is to extend not less than 0.2lₑ m above mid-span.

2. Where the span of corrugations exceeds 15 m, a diaphragm plate is to be arranged at about mid-span.

3. See also Chapter 8.

4. In calculating the actual modulus of symmetrical corrugations, the panel width $b$ is not to be taken greater than that given by Ch 3,3.2.

---

RULES AND REGULATIONS FOR THE CLASSIFICATION OF MOBILE OFFSHORE UNITS, June 2013

LLOYD’S REGISTER
### Table 6.7.3 Bulkhead end constraint factors (see continuation)

<table>
<thead>
<tr>
<th>Type</th>
<th>End connection, see Fig. 6.7.1</th>
<th>( \omega )</th>
<th>( \epsilon )</th>
<th>( \mu )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled or built stiffeners and swedges</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>End of stiffeners unattached or attached to plating only</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Members with webs and flanges (or bulbs) in line and attached at deck or horizontal girder See also Note 1</td>
<td>Adjacent member of B of smaller modulus</td>
<td>( \frac{4 \delta t_B}{M_2} ) or 1.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Adjacent member B of same or larger modulus</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Bracketless connection to longitudinal member</td>
<td>Member A within length ( l )</td>
<td>1.0</td>
<td>( \frac{d_A}{1000} )</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Member A outside length ( l )</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Bracketed connection</td>
<td>To transverse member</td>
<td>Bracket extends to floor</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Otherwise</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>To longitudinal member</td>
<td>1.0</td>
<td>The lesser of ( \beta a ) or 0.1f</td>
</tr>
</tbody>
</table>

Symmetrical corrugations or double plate bulkheads

<table>
<thead>
<tr>
<th>Type</th>
<th>End connection, see Fig. 6.7.1</th>
<th>( \omega )</th>
<th>( \epsilon )</th>
<th>( \mu )</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>No longitudinal brackets</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>Welded directly to deck – no bulk-head in line</td>
<td>With longitudinal brackets and transverse stiffeners supporting corrugated bulkhead</td>
<td>The lesser of ( \frac{\delta t_B}{t_m} ) or 1.0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Welded directly to deck or girder</td>
<td>Bulkhead B, having same section, in line</td>
<td>The least of ( \frac{\delta t_B}{t_m} ) or ( \frac{\delta t_A}{t_m} ) or 1.0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Welded directly to tank top and effectively supported by floors in line with each bulkhead flange, see also Note 2</td>
<td>Thickness at bottom same as that at mid-span</td>
<td>The least of ( \frac{\delta t_A}{t_m} ) or ( \frac{\delta t_B}{t_m} ) or 1.0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Thickness at bottom greater than that at mid-span</td>
<td>The least of ( \frac{\delta t_A}{t_m} ) or ( \frac{\delta t_B}{t_m} ) or 1.0</td>
<td>The lesser of ( \alpha f ) or ( a )</td>
</tr>
<tr>
<td>14</td>
<td>Welded to stool efficiently supported by the unit's structure</td>
<td>For deep tank bulkheads 1.0</td>
<td>For watertight bulkheads the least of ( \frac{\delta t_A}{t_m} ) or ( \frac{\delta t_B}{t_m} ) or 1.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 6.7.3 Bulkhead end constraint factors (conclusion)

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>s, l, p, k</td>
<td>as defined in 7.2.1</td>
</tr>
<tr>
<td>a</td>
<td>height, in metres, of bracket or end stool or lowest strake of plating of symmetrically corrugated or double plate bulkheads, see Fig. 6.7.1</td>
</tr>
<tr>
<td>d_A</td>
<td>web overall depth, in mm, of adjacent member A</td>
</tr>
<tr>
<td>e</td>
<td>effective length, in metres, of bracket or end stool, see Fig. 6.7.1</td>
</tr>
<tr>
<td>h_0</td>
<td>h_4 but measured from the middle of the overall length l</td>
</tr>
<tr>
<td>I_e, p, h_4</td>
<td>as defined in Table 6.7.1</td>
</tr>
<tr>
<td>t_{f_s}, t_{f_B}</td>
<td>thickness of supporting floor, in mm</td>
</tr>
<tr>
<td>t_s</td>
<td>thickness, in mm, of flange plating of corrugation or double plate bulkhead at mid-span or end, respectively</td>
</tr>
<tr>
<td>t_{s_p}</td>
<td>thickness, in mm, of flange plating of member B</td>
</tr>
<tr>
<td>M</td>
<td>for watertight bulkheads</td>
</tr>
<tr>
<td>M_2</td>
<td>for deep tank bulkheads</td>
</tr>
<tr>
<td>Z_s</td>
<td>section modulus, in cm^3, of adjacent member B</td>
</tr>
</tbody>
</table>

### Notes
1. Where the end connection is similar to type 2 or 3, but member flanges (or bulbs) are not aligned and brackets are not fitted, ω = 0.
2. Where the end connection is similar to type 12 or 13, but a transverse girder is arranged in place of one of the supporting floors, special consideration will be required.

### 7.3.9 Wash bulkheads or divisions to be fitted to deep tanks as required by Ch 7.4. The division bulkhead may be intact or perforated as desired. If intact, the scantlings are to be as required for boundary bulkheads. If perforated, the plating thickness is not to be less than 7.5 mm and the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads, using h_4 measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforation is to be not less than five per cent nor more than 10 per cent of the total area of the bulkhead. Where brackets from horizontal girders on the boundary bulkheads terminate at the centreline bulkhead, adequate support and continuity are to be maintained.

### 7.4 Watertight flats, trunks and tunnels

#### 7.4.1 The scantlings and arrangements of watertight flats, trunks and tunnels are to be equivalent to the requirements for watertight bulkheads or tanks as defined in 7.3 as appropriate. The scantlings of shaft tunnels will be specially considered. The scantlings at the crown or bottom of tanks are to comply with the requirements of Table 6.4.1.

#### 7.4.2 Additional strengthening is to be fitted to tunnels under the heels of pillars, as necessary.
Local Strength

7.5 Watertight void compartments

7.5.1 In all units where watertight void compartments are adjacent to the sea, the scantlings of the boundary bulkheads are to be determined from Table 6.7.1 for watertight bulkheads but the scantlings are not to be less than required for tank bulkheads using the load head $h_4$, measured to the maximum operating draught of the unit.

7.6 Mud tanks

7.6.1 The scantlings of mud tanks are to be not less than those required for tanks using the design density of mud. However, in no case is the relative density of wet mud to be taken as less than 2.2 unless agreed otherwise with LR.

7.7 Non-watertight bulkheads

7.7.1 The scantlings of non-watertight bulkheads supporting decks are to be in accordance with Table 6.4.5.

Section 8

Double bottom structure

8.1 Symbols and definitions

8.1.1 The symbols used in this Section are defined as follows:
- $L$, $T_0$ and $T_T$ as defined in Ch 1.5
- $B$ as defined in Ch 1.5 but need not exceed $B_1$
- $B_1 =$ maximum distance between longitudinal bulkheads, in metres
- $d_{DB} =$ Rule depth of centre girder, in mm
- $d_{DBA} =$ actual depth of centre girder, in mm
- $h_{DB} =$ head from top of inner bottom to top of overflow pipe, in metres
- $h_4 =$ load head as defined in Table 6.7.1
- $s =$ spacing of stiffeners, in mm.

8.2 General

8.2.1 In general, double bottoms need not be fitted in non-propelled units and column-stabilised units, except where required by a National Administration.

8.2.2 Where double bottoms are fitted on self-elevating units or column-stabilised units, the scantlings are to comply with this Section. For surface-type units, see Ch 4.4.

8.2.3 The requirements in this Section are, in general, applicable to double bottoms with stiffeners fitted parallel to the hull bending compressive stress. When other stiffening arrangements are proposed the scantlings will be specially considered, but the minimum requirements of this Section are to be complied with.

8.2.4 The arrangements of drainage wells, recesses and dump valves in the double bottom will be specially considered.

8.2.5 If it is intended to dry-dock the unit, girders and the side walls of duct keels are to be continuous and the structure is to have adequate strength to withstand the forces imposed by dry-docking the unit.

8.2.6 Adequate access is to be provided to all parts of the double bottom. The edges of all holes are to be smooth. The size of the opening should not, in general, exceed 50 per cent of the double bottom depth, unless edge reinforcement is provided. In way of ends of floors and fore and aft girders at transverse bulkheads, the number and size of holes are to be kept to a minimum, and the openings are to be circular or elliptical. Edge stiffening may be required in these positions.

8.2.7 Provision is to be made for the free passage of air and water from all parts of tank spaces to the air pipes and suctions, account being taken of the pumping rates required. To ensure this, sufficient air holes and drain holes are to be provided in all longitudinal and transverse non-watertight primary and secondary members. The drain holes are to be located as close to the bottom as is practicable, and air holes are to be located as close to the inner bottom as is practicable, see also Pt 3, Ch 8.

8.3 Self-elevating units

8.3.1 When a double bottom is fitted to a self-elevating unit, the scantlings of the double bottom will be specially considered in accordance with Ch 4.3 but the general requirements of this Section are to be complied with.

8.3.2 The longitudinal extent of the double bottom will be specially considered in respect of the design and safety of the unit but it should extend as far forward and aft as is practicable. A double bottom need not be fitted in pre-load deep tanks or other wing deep tanks.

8.3.3 The depth of the double bottom at the centreline, $d_{DB}$, is to be in accordance with 8.3.4 and the inner bottom is, in general, to be continued out to the unit’s side in such a manner as to protect the bottom to the turn of bilge. When pre-load wing deep tanks are fitted port and starboard, the inner bottom may be terminated at the deep tank longitudinal bulkheads.

8.3.4 The centre girder is to have a depth of not less than that given by:

$$d_{DB} = 28B + 205 \sqrt{T_T} \text{ mm}$$

nor less than 760 mm. The centre girder thickness is to be not less than:

$$t = (0.008d_{DB} + 4) \sqrt{K} \text{ mm}$$

nor less than 6.0 mm. The thickness may be determined using the value for $d_{DB}$ without applying the minimum depth of 760 mm.
8.3.5 **Side girders** are to be fitted below longitudinal bulkheads. In general, one side girder is to be fitted where the breadth, \(B\), exceeds 14 m and two side girders are to be fitted on each side of the centreline where \(B\) exceeds 21 m. Equivalent arrangements are to be provided where longitudinal bulkheads are fitted. The side girders are to extend as far forward and aft as practicable and are to have a thickness not less than:

\[
t = (0.0075d_{DB} + 1) \sqrt{k} \text{ mm}
\]

nor less than 6.0 mm. In general, a vertical stiffener, having a depth not less than 100 mm and a thickness equal to the girder thickness, is to be arranged midway between floors.

8.3.6 **Watertight side girders** are to have a plating thickness corresponding to the greater of the following:

(a) \(t = (0.0075d_{DB} + 2) \sqrt{k}\) mm, or

(b) Thickness, \(t\), as for deep tanks, see 7.3, using the load head \(h_4\) which, in the case of double bottom tanks which are interconnected to side tanks or cofferdams, is not to be less than the head measured to the highest point of the side tank or cofferdam.

8.3.7 If the depth of the watertight side girders exceeds 915 mm but does not exceed 2000 mm, the girders are to be fitted with vertical stiffeners spaced not more than 915 mm apart and having a section modulus not less than:

\[
Z = 5.41d_{DB} h_{DB} s k \times 10^{-9} \text{ cm}^3
\]

The ends of the stiffeners are to be snipped. Where the double bottom tanks are interconnected with side tanks or cofferdams, or where the depth of the girder exceeds 2000 mm, the scantlings of watertight girders are to be not less than those required for deep tanks, see 7.3, and the ends of the stiffeners are to be bracketed top and bottom.

8.3.8 **Duct keels**, where arranged, are to have a thickness of side plates corresponding to the greater of the following:

(a) \(t = (0.008d_{DB} + 2) \sqrt{k}\) mm, or

(b) Thickness, \(t\), as for deep tanks, see 7.3, using the load head \(h_4\) which, in the case of double bottom tanks which are interconnected to side tanks or cofferdams, is not to be less than the head measured to the highest point of the side tank or cofferdam.

8.3.9 The sides of the duct keels are, in general, to be spaced not more than 2.0 m apart. Where the sides of the ducts keels are arranged on either side of the centreline or side girder, each side is, in general, to be spaced not more than 2.0 m from the centreline or side girder. The inner bottom and bottom shell within the duct keel are to be suitably stiffened. The primary stiffening in the transverse direction is to be suitably aligned with the floors in the adjacent double bottom tanks. Where the duct keels are adjacent to double bottom tanks which are interconnected with side tanks or cofferdams, the stiffening is to be in accordance with the requirements for deep tanks, see 7.3. Access to the duct keel is to be by watertight manholes or trunks.

8.3.10 **Inner bottom plating** is, in general, to have a thickness not less than:

\[
t = 0.00136 (s + 660) \sqrt{\frac{kL}{T_f}} \text{ mm}
\]

nor less than 6.5 mm.

8.3.11 The thickness of the inner bottom plating as determined in 8.3.10 is to be increased by 10 per cent in machinery spaces but in no case is the thickness to be less than 7.0 mm.

8.3.12 A margin plate, if fitted, is to have a thickness throughout 20 per cent greater than that required for inner bottom plating.

8.3.13 Where the double bottom tanks are common with side tanks or cofferdams, the thickness of the inner bottom plating is to be not less than that required for deep tanks, see 7.3, and the load head \(h_3\) is to be measured to the highest point of the side tank or cofferdam.

8.3.14 **Inner bottom stiffeners** are in general to have a section modulus not less than 85 per cent of the Rule value for bottom shell stiffeners, see 3.3.1. When the inner bottom design loading is considerably less than \(9.82T_f kn/m^2\) \((T_f \text{ tonne-f/m}^2)\) the scantlings of the inner bottom stiffeners will be specially considered. Where the double bottom tanks are interconnected with side tanks or cofferdams, the scantlings are to be not less than those required for deep tanks, see 7.3.

8.3.15 **Plate floors** are to be fitted under heavy machinery items and under bulkheads and elsewhere at a spacing not exceeding 3.8 m. The thickness of non-watertight plate floors is to be not less than:

\[
t = (0.009d_{DB} + 1) \sqrt{k} \text{ mm}
\]

nor less than 6.0 mm. The thickness need not be greater than 15 mm, but the ratio between the depth of the double bottom and the thickness of the floor is not to exceed 130:\(k\). This ratio may, however, be exceeded if suitable additional stiffening is fitted. Vertical stiffeners are to be fitted at each bottom shell stiffener, having a depth not less than 150 mm and a thickness equal to the thickness of the floors. For units of length, \(L\), less than 90 m, the depth is to be not less than 1.65\(L\), with a minimum of 50 mm.

8.3.16 **Watertight floors** are to have thickness not less than:

(a) \(t = (0.008d_{DB} + 3) \sqrt{k}\) mm, or

(b) \(t = (0.009d_{DB} + 1) \sqrt{k}\) mm, whichever is the greater, but not to exceed 15 mm on floors of normal depth. The thickness is also to satisfy the requirements for deep tanks, see 7.3, with the load head \(h_2\) measured to the highest point of the side tank or cofferdam if the double bottom tank is interconnected with these tanks. The scantlings of the stiffeners are to be in accordance with the requirements of 7.3 for deep tanks, but in no case is the modulus to be less than:

\[
Z = 5.41d_{DB} h_{DB} s k \times 10^{-9} \text{ cm}^3
\]

Vertical stiffeners are to be connected to the inner bottom and shell stiffeners.
8.3.17 Between plate floors, transverse brackets having a thickness not less than 0.009$d_b$ mm are to be fitted, extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be suitably stiffened at the edge, are to be fitted at every frame at the margin plate, and those at the centre girder are to be spaced not more than 1,25 m.

8.3.18 Where floors form the boundary of a sea inlet box, the thickness of the plating is to be the same as the adjacent shell, but not less than 12,5 mm. The scantlings of stiffeners, where required are, in general, to comply with 7.3 for deep tanks. Snipped ends for stiffeners on the boundaries of these spaces are to be avoided wherever practicable. The stiffeners should be bracketed or the free end suitably supported to provide alignment with backing structure.

8.4 Column-stabilised and sea bed-stabilised units

8.4.1 Where a double bottom is fitted in the lower hull of column-stabilised units or sea bed-stabilised units, the scantlings of the double bottom structure will be specially considered but the general requirements of 8.3 are to be complied with where applicable. The minimum scantlings of the double bottom structure are to be in accordance with 8.4.2.

8.4.2 The scantlings of tank boundaries are to comply with the requirements for tank bulkheads in Section 7 but the load head $h_4$ is not to be taken less than the distance measured to $T_B$. When the internal double bottom compartment is a void space the scantlings of watertight boundaries are to comply with 7.5.1 and Table 6.7.1.

8.4.3 The boundaries of a sea inlet box are to comply with the requirements of 8.3.18.

8.4.4 The strength of the bottom structures in sea bed-stabilised units is also to comply with Ch 4,2.1.6.

Section 9 Superstructures and deckhouses

9.1 General

9.1.1 The term ‘erection’ is used in this Section to include both superstructures and deckhouses.

9.1.2 This Section applies to erections on all types of units defined in Pt 3, Ch 2,2 except for erections on surface type units which are to be in accordance with Ch 4,4. Units with a Rule length, $L$, greater than 150 m will be specially considered.

9.1.3 The scantlings of exposed bulkheads and decks of deckhouses are generally to comply with the requirements of this Section, but increased scantlings may be required where the structure is subjected to local loadings greater than those defined in the Rules, see also 9.1.6. Where there is no access from inside the house to below the freeboard deck or into buoyant spaces included in stability calculations, or where a bulkhead is in a particularly sheltered location, the scantlings may be specially considered.

9.1.4 The scantlings of superstructures which form an extension of the side shell or which form an integral part of the unit’s hull and contribute to the overall strength of the unit will be specially considered. The upper hull structure of column-stabilised units are to comply with Section 3.

9.1.5 Any exposed part of an erection which may be subject to immersion in damage stability conditions and which could result in down flooding is to have scantlings not less than required for watertight bulkheads given in Section 7.

9.1.6 The boundary bulkheads of accommodation spaces which may be subjected to blast loading are to comply with Ch 3,4 and permissible stress levels are to satisfy the factors of safety given in Ch 5,2.1.1(c).

9.1.7 The scantlings of erections used for helicopter landing areas are also to comply with Section 5.

9.1.8 For requirements relating to companionways, doors and hatches, see Chapter 7.

9.2 Symbols

9.2.1 The following symbols and definitions are applicable to this Chapter, unless otherwise stated:

- $L$, $B$, $T_T$ and $C_0$ as defined in Ch 1,5.1.
- $b = \text{breadth of deckhouse, at the positions under consideration, in metres}$
- $k = \text{higher tensile steel factor, see Ch 2,1.2}$
- $l_e = \text{effective length, in metres, of the stiffening member, deck beam or longitudinal measured between span points, see Ch 3,3.3}$
- $l_s = \text{span, in metres, of erection stiffeners and is to be taken as the ‘tween deck or house height but in no case less than 2,0 m}$
- $s = \text{spacing of stiffeners, beams or longitudinals, in mm}$
- $S_0 = \text{standard spacing, in mm, of stiffeners, beams or longitudinals, and is to be taken as:}$
  - (a) for $0,05L$ from the ends: $S_0 = 610 \text{ mm or that required by (b), whichever is the lesser}$
  - (b) elsewhere: $S_0 = 470 + 1,67L_2 \text{ mm}$ but forward of 0,2$L$ from the forward perpendicular $S_0$ is not to exceed 700 mm
- $B_1 = \text{actual breadth of unit at the section under consideration, measured at the weather deck, in metres}$
- $L_2 = \text{length of unit in metres, but need not be taken greater than 250 m}$
- $L_3 = \text{length of unit in metres, but need not be taken greater than 300 m}$

9.2.2 $d = \text{breadth of deckhouse, at the positions under consideration, in metres}$

9.2.3 $t = \text{thickness of plating, in mm}$

9.2.4 $S = \text{spacing of stiffeners, beams or longitudinals, in mm}$

9.2.5 $b = \text{standard spacing, in mm, of stiffeners, beams or longitudinals}$

9.2.6 $k = \text{higher tensile steel factor}$

9.2.7 $l_e = \text{effective length, in metres, of the stiffening member, deck beam or longitudinal measured between span points}$

9.2.8 $l_s = \text{span, in metres, of erection stiffeners and is to be taken as the ‘tween deck or house height but in no case less than 2,0 m}$

9.2.9 $s = \text{spacing of stiffeners, beams or longitudinals, in mm}$

9.2.10 $S_0 = \text{standard spacing, in mm, of stiffeners, beams or longitudinals and is to be taken as:}$
  - (a) for $0,05L$ from the ends: $S_0 = 610 \text{ mm or that required by (b), whichever is the lesser}$
  - (b) elsewhere: $S_0 = 470 + 1,67L_2 \text{ mm}$ but forward of 0,2$L$ from the forward perpendicular $S_0$ is not to exceed 700 mm

9.2.11 $B_1 = \text{actual breadth of unit at the section under consideration, measured at the weather deck, in metres}$

9.2.12 $L_2 = \text{length of unit in metres, but need not be taken greater than 250 m}$

9.2.13 $L_3 = \text{length of unit in metres, but need not be taken greater than 300 m}$
Local Strength

\[ D = \text{moulded depth of unit, in metres, to the uppermost continuous deck} \]

\[ X = \text{distance, in metres, between the after perpendicular and the bulkhead under consideration.} \]

When determining the scantlings of deckhouse sides, the deckhouse is to be subdivided into parts of approximately equal length not exceeding 0.15 \( L \) each, and \( X \) is to be measured to the mid-length of each part.

\[ \alpha = \text{a coefficient given in Table 6.9.1} \]

\[ \beta = 1.0 + \left( \frac{X - 0.45}{C_b + 0.2} \right)^2 \text{ for } X \leq 0.45 \]

\[ = 1.0 + 1.5 \left( \frac{X - 0.45}{C_b + 0.2} \right)^2 \text{ for } X > 0.45 \]

\( C_b \) is to be taken not less than 0.6 nor greater than 0.8. Where the aft end of an erection is forward of amidships, the value of \( C_b \) used for determining \( \beta \) for the aft end bulkhead is to be taken as 0.8.

\[ \gamma = \text{vertical distance, in metres, from the maximum transit waterline to the mid-point of span of the bulkhead stiffener, or the mid-point of the plate panel, as appropriate} \]

\[ \delta = 1.0 \text{ for exposed machinery casings and } \left( 0.3 + 0.7 \frac{h}{B} \right) \text{ elsewhere, but in no case to be taken less than 0.475} \]

\[ \lambda = \text{a coefficient given in Table 6.9.2.} \]

### Table 6.9.1 Values of \( \alpha \)

<table>
<thead>
<tr>
<th>Position</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest tier – unprotected front</td>
<td>2.0 + 0.0083L (_3)</td>
</tr>
<tr>
<td>Second tier – unprotected front</td>
<td>1.0 + 0.0083L (_3)</td>
</tr>
<tr>
<td>Third tier and above – unprotected front</td>
<td>0.5 + 0.0067L (_3)</td>
</tr>
<tr>
<td>All tiers – protected fronts – sides</td>
<td>0.7 + 0.001L (_3) – 0.8 ( \frac{X}{L} )</td>
</tr>
<tr>
<td>All tiers – aft end where aft of amidships</td>
<td>0.5 + 0.001L (_3) – 0.4 ( \frac{X}{L} )</td>
</tr>
</tbody>
</table>

### Table 6.9.2 Values of \( \lambda \)

<table>
<thead>
<tr>
<th>Length ( L ) in metres</th>
<th>( \lambda )</th>
<th>Expression for ( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.89</td>
<td>( L \leq 150 \text{ m} )</td>
</tr>
<tr>
<td>30</td>
<td>1.76</td>
<td>( \lambda = \left( \frac{L}{10} \text{ e}^{\frac{150}{L}} \right) - \left( 1 - \left( \frac{L}{150} \right)^2 \right) )</td>
</tr>
<tr>
<td>40</td>
<td>2.57</td>
<td>( L \geq 150 \text{ m} )</td>
</tr>
<tr>
<td>50</td>
<td>3.34</td>
<td>( \lambda = \left( \frac{L}{10} \text{ e}^{\frac{150}{L}} \right) - \left( 1 - \left( \frac{L}{150} \right)^2 \right) )</td>
</tr>
<tr>
<td>60</td>
<td>4.07</td>
<td>( 150 \text{ m} \leq L \leq 300 \text{ m} )</td>
</tr>
<tr>
<td>70</td>
<td>4.76</td>
<td>( \lambda = \left( \frac{L}{10} \text{ e}^{\frac{150}{L}} \right) - \left( 1 - \left( \frac{L}{150} \right)^2 \right) )</td>
</tr>
<tr>
<td>80</td>
<td>5.41</td>
<td>( L \geq 300 \text{ m} )</td>
</tr>
<tr>
<td>90</td>
<td>6.03</td>
<td>( \lambda = 11.03 )</td>
</tr>
<tr>
<td>110</td>
<td>7.16</td>
<td>( 300 \text{ m} \leq L \leq 1100 \text{ m} )</td>
</tr>
<tr>
<td>130</td>
<td>8.18</td>
<td>( \lambda = 11.03 )</td>
</tr>
<tr>
<td>150</td>
<td>9.10</td>
<td>( L \geq 300 \text{ m} )</td>
</tr>
</tbody>
</table>

9.3.2 For self-elevating units where the freeboard corresponding to the required summer moulded draught for the unit can be obtained by considering the unit to have a virtual moulded depth of at least one standard superstructure height less than the Rule depth, \( D \), measured to the uppermost continuous deck, proposals to treat the first tier erection as a second tier, and so on, will be specially considered. The standard height of superstructure is the height defined in the International Convention on Load Lines, 1966.

### 9.4 Design pressure head

9.4.1 The design pressure head, \( h \), to be used in the determination of erection scantlings is to be taken as:

\[ h = \alpha \delta (\beta \lambda - \gamma) \text{ m} \]

9.4.2 In no case is the design pressure head to be taken as less than the following:

(a) Lowest tier of unprotected fronts:

minimum \( h = 2.5 + 0.01L \(_2\) \text{ m} \)

(b) All other locations:

minimum \( h = 1.25 + 0.005L \(_2\) \text{ m} \)
Local Strength

9.5 Bulkhead plating and stiffeners

9.5.1 The plating thickness, \( t \), of fronts, sides and aft ends of all erections other than the sides of the superstructures where these are an extension of the side shell, is to be less than:

\[
t = 0.003s \sqrt{kh} \text{ mm},
\]

but in no case is the thickness to be less than:

(a) for the lowest tier:

\[
t = (5.0 + 0.01L_3) \sqrt{kh} \text{ mm},
\]

but not less than 5.0 mm.

(b) for the upper tiers:

\[
t = (4.0 + 0.01L_3) \sqrt{kh} \text{ mm},
\]

but not less than 5.0 mm.

9.5.2 The thickness of sides of forecastles, bridges and poop is to be as required by Ch 4.4.

9.5.3 The modulus of stiffeners, \( Z \), on fronts, sides and end bulkheads of all erections, other than the sides of superstructures where these are an extension of the side shell, is to be not less than:

\[
Z = 0.0035hs l_3^2k \text{ cm}^3
\]

9.5.4 The end connections of stiffeners are to be as given in Table 6.9.3.

9.5.5 The section modulus of side frames of forecastles, bridges and poop is to be as required by Ch 4.4.

9.6 Erections on self-elevating units

9.6.1 The scantlings of exposed ends and sides of erections are to comply with 9.5, but the additional requirements of this sub-Section are to be complied with.

9.6.2 The plating thickness, \( t \), of exposed lower tier fronts is to be not less than:

\[
t = 0.0036s \sqrt{kh} \text{ mm},
\]

but in no case is the thickness to be less than 7.0 mm.

9.6.3 The modulus of stiffeners, \( Z \), on exposed lowest tier fronts is to be not less than:

\[
Z = 0.0044hs l_3^2k \text{ cm}^3
\]

9.6.4 Where the exposed side of an erection is close to the side shell of the unit, the scantlings may be required to conform to the requirements for exposed bulkheads of unprotected house fronts.

9.6.5 The scantlings of jackhouses will be specially considered, but are not to be less than the scantlings that would be required for an erection at the same location.

9.6.6 The end connections of stiffeners are to be as given in Table 6.9.3.

9.7 Erections on other unit types

9.7.1 Where the erection can be subjected to wave forces, the scantlings of exposed ends and sides of erections are to comply with 9.5.

9.7.2 When the erection is not subjected to wave forces in any condition then the structure is to be suitable for the maximum design loadings but the minimum scantlings of exposed sides and ends of all erections is to be not less than:

(a) for the lowest tier:

\[
t = (5.0 + 0.01L_3) \sqrt{kh} \text{ mm},
\]

but not less than 5.0 mm.

(b) for the upper tiers:

\[
t = (5.0 + 0.01L_3) \sqrt{kh} \text{ mm},
\]

but not less than 5.0 mm.

9.7.3 The modulus of stiffeners, \( Z \), of exposed sides and ends of all erections is to be not less than:

\[
Z = 0.0035hs l_3^2k \text{ cm}^3
\]

where

\[
h = 1.25 + 0.005L \text{ m.}
\]

---

### Table 6.9.3 Stiffener end connections

<table>
<thead>
<tr>
<th>Position</th>
<th>Attachment at top and bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Front stiffeners of lower tiers and of upper tiers when ( L ) is 160 m or greater</td>
<td>See Chapter 8, See Note</td>
</tr>
<tr>
<td>2. Front stiffeners of upper tiers when ( L ) is less than 160 m</td>
<td>May be unattached</td>
</tr>
<tr>
<td>3. Side stiffeners of lower tiers where two or more tiers are fitted</td>
<td>Bracketed, unless stiffener modulus is increased by 20 per cent and ends are welded to the deck all round</td>
</tr>
<tr>
<td>4. Side stiffeners if only one tier is fitted, and aft end stiffeners of after deck-houses on deck to which ( D ) is measured</td>
<td>See Chapter 8</td>
</tr>
<tr>
<td>5. Side stiffeners of upper tiers where ( L ) is 160 m or greater</td>
<td>See Chapter 8</td>
</tr>
<tr>
<td>6. Side stiffeners of upper tiers when ( L ) is less than 160 m</td>
<td>May be unattached</td>
</tr>
<tr>
<td>7. Aft end stiffeners except as covered by item 4</td>
<td>May be unattached</td>
</tr>
<tr>
<td>8. Exposed machinery and pump-room casings. Front stiffeners on amidship casings and all stiffeners on aft end casings which are situated on the deck to which ( D ) is measured</td>
<td>Bracketed</td>
</tr>
<tr>
<td>9. All other stiffeners on exposed machinery and pump-room casings</td>
<td>6.5 cm² of weld</td>
</tr>
</tbody>
</table>

**NOTE**

Front stiffeners of lower tiers on self-elevating units are to be bracketed.
Local Strength

9.7.4 The end connections of stiffeners not subjected to wave loadings are to be as given in Table 6.9.4.

<table>
<thead>
<tr>
<th>Position</th>
<th>Attachment at top and bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Side stiffeners of lower tiers where two or more tiers are fitted</td>
<td>Bracketed unless stiffener modulus is increased by 20 per cent and ends are welded to the deck all around</td>
</tr>
<tr>
<td>2. Side stiffeners if only one tier is fitted</td>
<td>See Chapter 8</td>
</tr>
<tr>
<td>3. All other stiffeners</td>
<td>May be unattached</td>
</tr>
</tbody>
</table>

9.8 Deck plating

9.8.1 In general, the thickness of erection deck plating is to be not less than that required by Table 6.9.5.

<table>
<thead>
<tr>
<th>Position</th>
<th>Thickness of deck plating, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of first tier erection</td>
<td>((5,5 + 0,02L) \sqrt{\frac{ks}{s_d}}) , mm</td>
</tr>
<tr>
<td>Top of second tier erection</td>
<td>((5,0 + 0,02L) \sqrt{\frac{ks}{s_d}}) , mm, but not less than 5,0 mm</td>
</tr>
<tr>
<td>Top of third tier and above</td>
<td>((4,5 + 0,02L) \sqrt{\frac{ks}{s_d}}) , mm</td>
</tr>
</tbody>
</table>

**NOTE**
For units not subjected to wave loading, see 9.8.2.

9.9 Deck stiffening

9.9.1 The requirements for deck stiffeners in this sub-Section are applicable to both beams and longitudinals.

9.9.2 Deck stiffeners on deckhouses are to have a section modulus, \(Z\), not less than:
\[Z = 0,0048h_g s k^2 \text{ cm}^3\]
but in no case less than:
\[Z = 0,025s \text{ cm}^3\]
where the load head, \(h_g\), is to be taken as not less than:
- on first tier decks \(0,9\) m
- on second tier \(0,6\) m
- on third tier decks and above \(0,45\) m
but where the deck can be subjected to weather loading, the load, \(h_g\), is to be increased in accordance with the requirements given in Table 6.2.1.

9.9.3 When deckhouses are subjected to specified deck loadings greater than the heads defined in 9.9.2 or are subjected to concentrated loads, equivalent load heads are to be used, see Table 6.2.1.

9.9.4 The section modulus of deck stiffeners on forecastles, bridges and poops is to be as required by Ch 4.4.

9.10 Deck girders and transverses

9.10.1 The scantlings of deck girders and transverses on erection decks are to be in accordance with the requirements of Table 6.4.3, using the appropriate load head, \(H_g\), determined from Table 6.2.1.

9.11 Strengthening at ends and sides of erections

9.11.1 Web frames or equivalent strengthening are to be arranged to support the sides and ends of large erections.

9.11.2 These web frames should be spaced about 9 m apart and are to be arranged, where practicable, in line with watertight bulkheads below. Webs are also to be arranged in way of large openings, boats davits and other points of high loading.

9.11.3 Arrangements are to be made to minimise the effect of discontinuities in erections. All openings cut in the sides are to be substantially framed and have well rounded corners. Continuous coamings or girders are to be fitted below and above doors and similar openings. Erections are to be strengthened in way of davits.

9.11.4 Adequate support under the ends of erections is to be provided in the form of webs, pillars, diaphragms or bulkheads in conjunction with reinforced deck beams.
9.11.5 At the corners of deckhouses and in way of supporting structures, attention is to be given to the connection to the deck, and doublers or equivalent arrangements should generally be fitted.

9.12 Unusual designs

9.12.1 Where superstructures or deckhouses are of unusual design, the strength is to be not less than that required by this Section for a conventional design.

9.13 Aluminium erections

9.13.1 Where an aluminium alloy complying with Chapter 8 of the Rules for Materials is used in the construction of erections, the scantlings of these erections are to be increased (relative to those required for steel construction) by the percentages given in Table 6.9.6.

9.13.2 The thickness, \( t \), of aluminium alloy members is to be not less than:

\[
t = 2.5 + 0.022d_w \text{ mm but need not exceed 10 mm}
\]

where \( d_w \) = depth of the section, in mm.

9.13.3 The minimum moment of inertia, \( I \), of aluminium alloy stiffening members is to be not less than:

\[
I = 5.25Zl \text{ cm}^4
\]

where \( l \) is the effective length of the member \( l_b \) or \( l_s \), in metres, as defined in 9.2 and \( Z \) is the section modulus of the stiffener and attached plating in accordance with 9.4 and 9.9, taking \( k \) as 1.

9.13.4 Where aluminium erections are arranged above a steel hull, details of the arrangements in way of the bimetallic connections are to be submitted.

9.13.5 For aluminium alloy helicopter decks, see Section 6.

9.14 Fire protection

9.14.1 Fire protection of aluminium alloy erections is to be in accordance with the fire safety Regulations of the appropriate National Administration, see Pt 7, Ch 3.

9.14.2 Where it is proposed to use aluminium alloy for items or equipment in hazardous areas, incendive sparking may constitute a risk and full details are to be submitted for consideration.

## Section 10

Bulwarks and other means for the protection of crew and other personnel

10.1 General requirements

10.1.1 Bulwarks or guard rails are to be provided at the boundaries of weather decks and exposed freeboard and superstructure decks and deckhouses.

10.1.2 Bulwarks or guard rails are to be not less than 1.0 m in height measured above sheathing, and are to be constructed as required by 10.2 and 10.3. Consideration will be given to cases where this height would interfere with the normal operation of the unit.

10.1.3 The freeing arrangements in bulwarks are to be in accordance with 10.5.

10.1.4 Guard rails, as required by 10.1.1, are to consist of at least three courses and the opening below the lowest course is not to exceed 230 mm. The other courses are to be spaced not more than 380 mm apart. Where practicable, a toe plate 150 mm high is to be fitted below the lowest course. In the case of units with rounded gunwales, the guard rail supports are to be placed on the flat of the deck.

10.1.5 Satisfactory means, in the form of guard rails, lifelines, handrails, gangways, under-deck passageways or other equivalent arrangements, are to be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the unit. For units with production and process plant, see also Pt 7, Ch 3.

10.1.6 Where access openings are required in bulwarks or guard rails, they are to be fitted with suitable gates and, in general, chains are not permitted where a person could fall into the sea.

---

**Table 6.9.6** Percentage increase of scantlings

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fronts, sides, aft ends, unsheathed deck plating</td>
<td>20</td>
</tr>
<tr>
<td>Decks sheathed in accordance with 9.8.3</td>
<td>10</td>
</tr>
<tr>
<td>Deck sheathed with wood, and on which the plating is fixed to the wood sheathing at the centre of each beam space</td>
<td>Nil</td>
</tr>
<tr>
<td>Stiffeners and beams</td>
<td>70</td>
</tr>
<tr>
<td>Scantlings of small isolated houses</td>
<td>Nil</td>
</tr>
</tbody>
</table>
Local Strength

10.1.7 Where gangways on a trunk are provided by means of a stringer plate fitted outboard of the trunk side bulkheads (port and starboard), each gangway is to be a solid plate, effectively stayed and supported, with a clear walkway at least 450 mm wide, at or near the top of the coaming, with guard rails complying with 10.1.4.

10.1.8 Where a National Administration has additional requirements for the protection of the crew or personnel on board, it is the Owners’ responsibility to comply with all necessary Regulations.

10.2 Construction of bulwarks

10.2.1 Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck. The spacing of these stays forward of 0.07\*L from the forward perpendicular is to be not more than 1.2 m on surface type units and not more than 1.83 m on other unit types. Elsewhere, bulwark stays are to be not more than 1.83 m apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. Bulwarks are to be adequately strengthened where required to support additional loads or attachments and in way of mooring pipes the plating is to be doubled or increased in thickness and adequately stiffened.

10.2.2 Bulwarks should not be cut for gangway or other openings near the breaks of superstructures, and are also to be arranged to ensure their freedom from main structural stresses.

10.2.3 The section modulus, Z, at the bottom of the bulwark stay is to be not less than:

\[ Z = (33.0 + 0.44L) h^2 s \text{ cm}^3 \]

where
\[ h = \text{height of bulwark from the top of the deck plating to the top of the rail, in metres} \]
\[ s = \text{spacing of the stays, in metres, see 10.2.1} \]
\[ L = \text{length of unit, in metres, but to be not greater than 100 m.} \]

10.2.4 In the calculation of the section modulus, only the material connected to the deck is to be included. The bulb or flange of the stay may be taken into account where connected to the deck, and where, at the ends of the unit, the bulwark plating is connected to the sheerstrake, a width of plating not exceeding 600 mm may also be included. The free edge of the stay is to be stiffened.

10.2.5 Bulwark stays are to be supported by, or to be in line with, suitable underdeck stiffening, which is to be connected by double continuous fillet welds in way of the bulwark stay connection.

10.2.6 When the bulwarks are required to support attachments or equipment for local operational or functional loads they are to be suitably strengthened.

10.3 Guard rail construction

10.3.1 Guard rails are, in general, to be constructed in accordance with a recognised Standard and the arrangement and spacing of guard rails are to comply with 10.1.4.

10.3.2 Stanchions are to be spaced not more than 1.5 m apart and the guard rails and their supports are to be designed to withstand a horizontal loading of 0.74 kN/m applied at the top rail. The permissible stresses in association with this loading are to be in accordance with Ch 5.2.1.1(a).

10.3.3 The stanchions and stays are to be supported by suitable under-deck stiffening.

10.3.4 When guard rails are required to support attachments for local operational or functional loads they are to be suitably strengthened.

10.4 Helicopter landing area

10.4.1 Safety nets are to be installed around the deck landing area, extending at least 1500 mm out from the perimeter. The netting is to be of approved material and of a flexible nature.

10.4.2 The safety net is to be supported at its outer edge and intermediate supports are to be spaced about 1.9 m apart. The supports are to be designed to withstand a concentrated load of 1.3 kN applied at any point on the supports. The permissible stresses are to satisfy the factors of safety given in Ch 5.2.1.1(a).

10.5 Freeing arrangements

10.5.1 In general, surface type oil storage units are to have open rails for at least half the length of the exposed part of the weather deck. Alternatively, if a continuous bulwark is fitted, the minimum freeing area is to be at least 33 per cent of the total area of the bulwark. The freeing area is to be placed in the lower part of the bulwark.

10.5.2 For self-elevating units and on surface type units, except where the additional requirements of 10.5.1 apply, the requirements of 10.5.3 to 10.5.18 are applicable.

10.5.3 Where bulwarks on the weather portions of freeboard or superstructure decks form wells, ample provision is to be made for rapidly freeing the decks of large quantities of water by means of freeing ports, and also for draining them.
10.5.4 The minimum freeing area on each side of the unit, for each well on the freeboard deck or raised quarter deck, where the sheer in the well is not less than the standard sheer required by the International Convention on Load Lines, 1966, is to be derived from the following formulae:

(a) where the length, \( l \), of the bulwark in the well is 20 m or less: area required = \( 0.7 + 0.035l \) \( m^2 \)

(b) where the length, \( l \), exceeds 20 m: area required = \( 0.07l \) \( m^2 \)

NOTE \( l \) need not be taken greater than \( 0.7L \), where \( L \) is the load line length of the unit in accordance with the International Convention on Load Lines, 1966.

10.5.5 If the average height of the bulwark exceeds 1.2 m or is less than 0.9 m, the freeing area is to be increased or decreased, respectively, by 0.004 \( m^2 \) per metre of length of well for each 0.1 m increase or decrease in height respectively.

10.5.6 The minimum freeing area for each well on a first tier superstructure is to be half the area calculated from 10.5.4.

10.5.7 Two-thirds of the freeing port area required is to be provided in the half of the well nearest to the lowest point of the sheer curve.

10.5.8 When the deck has little or no sheer, the freeing area is to be spread along the length of the well.

10.5.9 In units with no sheer, the freeing area as calculated from 10.5.4 is to be increased by 50 per cent. Where the sheer is less than the standard, the percentage is to be obtained by linear interpolation.

10.5.10 Where the length of the well is less than 10 m, or where a deckhouse occupies most of the length, the freeing port area will be specially considered, but in general need not exceed 10 per cent of the bulwark area.

10.5.11 Where it is not practical to provide sufficient freeing port area in the bulwark, credit can be given for bollard and fairlead openings where these extend to the deck.

10.5.12 Where a unit fitted with bulwarks has a continuous trunk or coamings, the requirements of 10.5.1 are to be complied with.

10.5.13 Where a deckhouse has a breadth less than 80 per cent of the beam of the unit, or the width of the side passageways exceeds 1.5 m, the arrangement is considered as one well. Where a deckhouse has a breadth equal to or more than 80 per cent of the beam of the unit, or the width of the side passageways does not exceed 1.5 m, or when a screen bulkhead is fitted across the full breadth of the unit, this arrangement is considered as two wells, before and abaft the deckhouse.

10.5.14 Adequate provision is to be made for freeing water from superstructures which are open at either or both ends and from all other decks within open or partially open spaces in which water may be shipped and contained.

10.5.15 Suitable provision is also to be made for the rapid freeing of water from recesses formed by superstructures, deckhouses and deck plant, etc., in which water may be shipped and trapped. Deck equipment is not to be stowed in such a manner as to obstruct unduly the flow of water to freeing ports.

10.5.16 The lower edges of freeing ports are to be as near to the deck as practicable, and should not be more than 100 mm above the deck.

10.5.17 Where freeing ports are more than 230 mm high, vertical bars spaced 230 mm apart may be accepted as an alternative to a horizontal rail to limit the height of the freeing port.

10.5.18 Where shutters are fitted, the pins or bearings are to be of a non-corrodible material, with ample clearance to prevent jamming. The hinges are to be within the upper third of the port.

10.6 Deck drainage

10.6.1 Adequate drainage arrangements by means of scuppers are to be fitted as required by Ch 7,10.
Local Strength

11.3 References
EN 1337-8, Structural bearings – Part 8: Guide bearings and restrain bearings.
EN 1337-10; Structural bearings – Part 10: Inspection and maintenance.
EN 1337-11; Structural bearings – Part 11: Transport, storage and installation.
BS 5400 1984: Steel, concrete and composite bridges – Part 9: Bridge bearing.

11.4 General principle
11.4.1 Function and types. The bearings are located at the interface between the topside modules and the hull, their function being to minimise the structural interactions of the two bodies. Particularly, they shall reduce the bending moments in the hull module support frames as well as the tension, compression and torsion in the module primary girders. Additionally, fatigue effects will be significantly reduced on both module support frames and modules.

11.4.2 The focus of this Section is on elastomeric bearing pads which are extensively used in floating offshore installations. The bearings covered in this Section are shown in cases 1.1 to 1.8 of Table 1 of EN 1337-1.

11.5 Displacements
11.5.1 Hull deformations and deflections. The hull is subject to deformations and deflections resulting from:
- Longitudinal and transverse hull expansion and contraction.
- Longitudinal bending producing hogging and/or sagging.
- Axial torsion.

Hull hogging and sagging result in relative movement between the topside module, at the support nodes, and the module support frames. These relative movements may be caused by a combination of the following factors:
- Temperature variation between hull construction and hull operational conditions.
- Waves/environmental conditions.
- Variations to the distribution of topside and cargo loads along the vessel.

11.5.2 The effect of displacement on bearings. Horizontal displacements will induce rubber strain in elastomeric bearings, and will induce sliding upon PTFE/steel surfaces for pot bearings, while vertical displacements will induce compression or tension in both types. These effects must be considered in line with the bearing material's shear, tension and compression properties.

11.5.3 Rotations for bearing design. In the absence of detailed analysis, the bearings are to be designed for a minimum rotation of +/-0.5 degrees about both horizontal axes to ensure topside members satisfy the allowable deflection criterion of 1:300.

11.6 Serviceability, maintenance and protection requirements
11.6.1 Bearings under topside structures may be exposed to dirt, debris, oil and moisture that promote corrosion and deterioration. As a result, these bearings should be designed and installed to minimise environmental damage and to allow easy access for inspection. The service demands on bearings are very severe and result in a service life that is typically shorter than that of other structural elements. Therefore, allowance for bearing replacement should be given consideration in the design process and, where possible, lifting locations should be provided to facilitate removal and re-installation of bearings without damaging the structure. See EN 1337-9, 10 and 11 for specifications.

11.7 Additional requirements
11.7.1 Design life. The module bearings are required to be designed for the same service life as the module structures. The supplier of bearing material is to provide adequate evidence to support the design life of the bearings under the specified project's conditions.

11.7.2 Environmental conditions. The module bearings shall withstand the following environmental conditions:
- Air temperature.
- Humidity.
- Solar radiation.
- Flare radiation.
- Hydrocarbon/cryogenic spills.
- Salt-water spray.

The bearings could come into contact with miscellaneous hydrocarbons due to leakages occurring on the process equipments located on the modules. The supplier shall consider this potential event and ensure the proposed solution and supplied products do not jeopardise structural integrity or satisfactory system performance over the design life, in the event that this potential condition occurs. However, bearing pads are not designed for blast, fire or cryogenic spills events. If necessary, a protection of bearing pads will be designed to ensure their integrity. Passive fire protection of the bearings may be considered to protect pads against fire events.
Local Strength

11.7.3 Modules are to be constrained against excessive movement with lateral restraints, for example, horizontal stoppers for sliding bearings. Modules are also to be constrained against uplift unless it can be confirmed that uplift cannot occur. Consideration should be given to restricting the number of longitudinal supports to two to prevent transfer of vertical displacement of the hull to the module.

11.8 Bearing selection

11.8.1 Bearing selection is influenced by many factors, including loads, geometry, maintenance, available clearance, displacement, rotation, deflection, availability, policy, designer preference, construction tolerances and cost. In general, vertical displacements are restrained, rotations are allowed to occur as freely as possible, see 11.5.3, and horizontal displacements may be either accommodated or restrained. The reaction loads on each bearing are to be in accordance with the topside structural analysis and are to account for the worst scenario loading condition, taking the relative stiffness between the topsides and hull structure into account in the analysis, as appropriate.

11.8.2 Typically, steel stoppers are used with elastomeric bearings to transfer horizontal forces from topside to the substructure. The load transfer system between bearing plates and stoppers shall be carefully designed in order to minimise impact effects.

11.9 Elastomer

11.9.1 The shear stiffness of the bearing is its most important property because it affects the forces transmitted between the superstructure and substructure. Elastomers are flexible under shear and uniaxial deformation, but they are very stiff against volume changes. This feature makes possible the design of a bearing that is flexible in shear but stiff in compression.

11.9.2 Only neoprene for plain elastomeric bearing pads and steel-reinforced elastomeric bearings is recommended. All elastomers are visco-elastic, non-linear materials and, therefore, their properties vary with strain level, rate of loading and temperature. Bearing manufacturers evaluate the materials on the basis of international rubber hardness degrees (IRHD). However, this parameter is not considered to be a good indicator of the shear modulus \( G \). The shear modulus \( G \) should not be taken less than 0.7 MPa (an IRHD not less than 50 or 55).

11.10 Fatigue

11.10.1 EN 1337 provides only test and design methods for repeated compression loadings. These should be followed in detail.

11.11 Detailing

11.11.1 Care should be taken for design of load transfer in fixed and sliding bearings. Sliding bearings should be designed according to EN1337-2. Maximum deflections under each loading case should be calculated considering non-linear behaviour. No gaps between bearing plates and stoppers are allowed. For common details, see Steel Bridge Bearing Design and Detailing Guidelines, AASHTO/NSBA G9.1 – 2004.
Section 1

1.1 Application

1.1.1 This Chapter gives the minimum classification requirements for watertight and weathertight integrity and load line application.

1.1.2 The requirements for intact and damage stability and the assignment of load lines are to be in accordance with Pt 1, Ch 2.1.

1.1.3 The requirements in this Chapter may be modified where necessary to take into account the requirements of the appropriate National Administration responsible for the intact and damage stability of the unit.

1.1.4 For the purpose of this Chapter, the basic types of units are those defined in the International Convention on Load Lines, 1966, see also Pt 3 Ch 11.1.1 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

1.2 Plans to be submitted

1.2.1 The following plans are to be submitted for approval:

- Schematic diagrams of local and remote control of watertight and weathertight doors and hatch covers and other closing appliances.
- Location of control rooms.
- Freeing arrangements.

1.2.2 The following plans are to be submitted for information:

- General arrangement.
- Arrangement plan indicating the defined watertight boundaries of spaces included in the buoyancy.
- Arrangement plans of watertight doors and hatches.
- Details of intact and worst damage stability waterlines shown in elevations and plan views.
- Freeboard plan showing the maximum design operating draughts in accordance with Load Line Regulations and indicating the position of all external openings and their closing appliances.
- Location of down flooding openings.
- Trim and stability booklet, see Pt 1, Ch 2.

Section 2

Definitions

2.1 Freeboard deck

2.1.1 The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part, and below which all openings in the sides of the unit are fitted with permanent means of watertight closing. For semi-submersible units, see also 5.2.4.

2.2 Freeboard

2.2.1 Freeboard is the distance measured vertically downwards amidships from the upper edge of the deck line to the upper edge of the related load line.

2.3 Weathertight

2.3.1 A closing appliance is considered weathertight if it is designed to prevent the passage of water into the unit in any sea conditions.

2.3.2 Generally, all openings in the freeboard deck and in enclosed superstructures are to be provided with weathertight closing appliances.

2.4 Watertight

2.4.1 A closing appliance is considered watertight if it is designed to prevent the passage of water in either direction under a head of water for which the surrounding structure is designed.


### Section 3

#### Installation layout and stability

**3.1 Control rooms**

3.1.1 Control rooms essential for the safe operation of the unit in an emergency are to be situated above zones of immersion after damage, as high as possible and as near a central position on the unit as is practicable. The requirements for the central ballast control station on column-stabilised units are to be in accordance with Pt 6, Ch 1.2.8.

**3.2 Damage zones**

3.2.1 The extent of defined damage is to be in accordance with the applicable damage stability Regulations.

3.2.2 All piping, ventilation ducts and trunks, etc., should, where practicable, be situated clear of the defined damage zones. When piping, ventilation ducts and trunks, etc., are situated within the defined extent of damage, they are to be assumed damaged and positive means of closure are to be provided at watertight subdivisions to preclude progressive flooding of other intact spaces, see also Pt 5, Ch 13.2.

3.2.3 In addition to the defined damages referred to in 3.2.1, compartments with a boundary formed by the bottom shell of the unit are to be considered flooded individually unless agreed otherwise with LR.

---

### Section 4

#### Watertight integrity

**4.1 Watertight boundaries**

4.1.1 All units are to be provided with watertight bulkheads, decks and flats to give adequate strength and the arrangements are to suit the requirements for subdivision, floodability and damage stability. In all cases, the plans submitted are to clearly indicate the location and extent of the bulkheads. In the case of column-stabilised drilling units, the scantling of the watertight flats and bulkheads are to be made effective to that point necessary to meet the requirements of damage stability and are to be indicated on the appropriate plans.

4.1.2 The number and disposition of watertight bulkheads are to comply with Ch 3.5.

4.1.3 The strength of watertight subdivisions are to comply with Ch 6.7.

4.1.4 Surface type units are to be fitted with a collision bulkhead in accordance with Pt 3, Ch 3.4.2 of the Rules for Ships.
4.2 Tank boundaries

4.2.1 Deep tanks for fresh water, fuel oil or any other tanks which are not normally kept filled in service are, in general, to have wash bulkheads or divisions.

4.2.2 Tank bulkheads and watertight divisions are to have adequate strength for the maximum design pressure head in normal operating and damage conditions and the scantlings are to comply with Ch 6,7.

4.3 Boundary penetrations

4.3.1 Where internal boundaries are required to be watertight to meet damage stability requirements, the number of openings in such boundaries is to be reduced to the minimum compatible with the design and proper working of the unit.

4.3.2 Where piping, including air and overflow pipes, ventilation ducts, shafting, electric cable runs, etc., penetrate watertight boundaries, arrangements are to be made to ensure the watertight integrity of the boundary. Details of the arrangements are to be submitted for approval.

4.3.3 No openings such as manholes, watertight doors, pipelines or other penetrations are to be cut in the collision bulkhead of surface type units, except as permitted by Pt 5, Ch 13,3 and 4.

4.3.4 Where pipelines or ducts serve more than one compartment, satisfactory arrangements are to be provided to preclude the possibility of progressive flooding through the system to other spaces in the event of damage, see also 3.2.

4.3.5 Where piping systems and ventilation ducts are designed to watertight standards and are suitable for the maximum design pressure head in damage conditions, they are to be provided with valves at the boundaries of each watertight compartment served.

4.3.6 Ventilation ducts which are of non-watertight construction are to be provided with valves where they penetrate watertight subdivision boundaries.

4.3.7 Where valves are provided at watertight boundaries to maintain watertight integrity in accordance with 4.3.5 and 4.3.6, these valves are to be capable of being operated from a pump-room or other normally manned space, a weather deck, or a deck which is above the final waterline after flooding. In the case of a column-stabilised unit, this would be the central ballast control station. Valve position indicators should be provided at the remote control station, weather deck or a normally manned space.

4.3.8 For self-elevating units, the ventilation system valves required to maintain watertight integrity should be kept closed when the unit is afloat. Necessary ventilation in this case should be arranged by alternative approved methods.

4.4 Internal openings related to damage stability

4.4.1 The requirements for the operation, alarm displays and controls of watertight doors and hatch covers and other closing appliances are given in Pt 7, Ch 1,9.

4.4.2 Internal access openings fitted with appliances to ensure watertight integrity, are to comply with the following:

(a) Watertight doors and hatch covers which are used during the operation of the unit while afloat may normally be open, provided the closing appliances are capable of being remotely controlled from a damage central control room on a deck which is above any final waterline after flooding and are also to be operable locally from each side of the bulkhead. Open/shut indicators are to be provided in the control room showing whether the doors are open or closed. In addition, remotely operated doors provided to ensure the watertight integrity of internal openings which are used while at sea are to be sliding watertight doors with audible alarm. The power, control and indicators are to be operable in the event of main power failure. Particular attention is to be paid to minimising the effect of control system failure. Each power-operated sliding watertight door is to be provided with an individual hand-operated mechanism. It shall be possible to open/close the door by hand at the door itself from both sides.

(b) Doors or hatch covers in self-elevating units or doors placed above the deepest load line draft in column-stabilised and surface units, which are normally closed while the unit is afloat may be of the quick acting type and should be provided with an alarm system (e.g., light signals) showing personnel both locally and at the central ballast control station whether the doors or hatch covers in question are open or closed. A notice should be affixed to each such door or hatch cover stating that it is not to be left open while the unit is afloat.

(c) The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the maximum design water pressure head of the watertight boundary under consideration.

4.4.3 Internal openings fitted with appliances to ensure watertight integrity, which are to be kept permanently closed while afloat, are to comply with the following:

(a) A notice to the effect that the opening is always to be kept closed while afloat is to be attached to the closing appliances in question.

(b) Opening and closing of such closing appliances are to be noted in the unit’s logbook, or equivalent.

(c) Manholes fitted with gaskets and closely bolted covers need not be dealt with as under (a).

(d) The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the maximum water pressure head of the watertight boundary under consideration.
4.5 External openings related to damage stability

4.5.1 Where watertight integrity is dependent on external openings which are used during the operation of the unit while afloat, they are to comply with the following:

(a) The lower edge of openings of air pipes (regardless of their closing appliances) is to be above the final equilibrium damage waterline including wind heel effects.

(b) The lower edge of ventilator openings, doors and hatches with manually operated means of watertight closures is to be above the final equilibrium damage waterline including wind heel effects.

(c) Openings such as manholes, fitted with gaskets and closely bolted covers, and side scuttles and windows of the non-opening type with inside hinged deadlights which are fitted with appliances to ensure watertight integrity, may be submerged. Such openings are not allowed to be fitted in the column of stabilised units.

(d) Scuppers and discharges are to be fitted with closing appliances, see 10.1.

(e) Where flooding of chain lockers or other buoyant volumes may occur, the openings to these spaces should be considered as downflooding points.

4.5.2 Where watertight integrity is dependent upon external openings which are permanently closed during the operation of the unit while afloat, such openings are to comply with the requirements of 4.4.3.

4.5.3 External watertight doors and hatch covers of limited size which are used while afloat may be accepted below the worst damage waterline, including wind heel effects, provided they are on or above the freeboard deck and the closing appliances comply with the requirements of 4.4.2(a) and (b).

4.6 Strength of watertight doors and hatch covers

4.6.1 The symbols used in this sub-Section are as follows:

\[ d = \text{distance between securing devices, in metres} \]

\[ f_1 = 1.1 - \frac{s}{2500t_s} \text{ but not greater than 1} \]

\[ h_D = \text{design pressure head, in metres, measured vertically from the bottom of the door to the worst damage waterline plus 5 m} \]

\[ k = \text{higher tensile steel factor as defined in Ch 2.1.2} \]

\[ l_s = \text{span of stiffener between support points, in metres} \]

\[ s = \text{spacing of stiffeners, in mm} \]

\[ P_1 = \text{packing line pressure along edges, in N/cm} \] (kgf/cm), but not less than 50 (5.1).

4.6.2 Closing appliances for internal and external openings are to have scantlings in accordance with this sub-Section and are to satisfy the requirements of 4.4 and 4.5 respectively.

4.6.3 In general, watertight closing appliances are to be designed to withstand the design pressure head from both sides of the appliance unless the mode of failure based on the damage stability criteria can only result in one-sided pressure loading.

4.6.4 The thickness of plating, \( t \), subjected to lateral pressure in damage conditions is to be not less than:

\[ t = 0.0048s \sqrt{h_D k} \text{ mm but not less than 8 mm.} \]

4.6.5 The section modulus, \( z \), of panel stiffeners fitted in one direction and edge stiffeners is not to be less than:

\[ z = 0.0065s k h_D l_s^2 \text{ cm}^3 \text{ but not less than 15 cm}^3 \]

The section modulus of secondary panel stiffeners may also be determined from the above formula, but doors with stiffeners designed as grillages will be specially considered.

4.6.6 The moment of inertia, \( I \), of edge stiffeners is in general not to be less than:

\[ I = 0.8P_1 d^4 \text{ cm}^4 \] (8Pd cm^4)

4.6.7 Securing devices for closing appliances are to be designed for water pressure acting on the opposite side of the appliance to which they are positioned, see also 4.6.3.

4.6.8 The strength of the bulkhead and deck framing in way of watertight closing appliances is to comply with the requirements of Ch 6.7.

4.6.9 Watertight closing appliances are to be hydraulically tested in accordance with the requirements of Table 1.8.1 in Pt 3, Ch 1.8 of the Rules for Ships. In general, the test is to be carried out before the appliance is fitted to the unit. The test pressure is to be applied separately to both sides of the appliance, see also 4.6.3.

4.6.10 After installation in the unit, watertight closing appliances are to be hose tested in accordance with the requirements of Table 1.8.1 in Pt 3, Ch 1.8 of the Rules for Ships, and functional tests are to be carried out to verify the satisfactory operation of the appliance, its control and alarm functions, as required by Pt 7, Ch 1.9.

4.7 Weathertight integrity related to stability

4.7.1 Any opening, such as an air pipe, ventilator, ventilation intake or outlet, non-watertight sidescuttle, small hatch, door, etc., having its lower edge submerged below a waterline associated with the zones indicated in (a) or (b), is to be fitted with a weathertight closing appliance to ensure the weathertight integrity, when:

(a) A unit is inclined to the range between the first intercept of the right moment curve and the wind heeling moment curve and the angle necessary to comply with the requirements of 3.3 of the 2009 IMO MODU Code during the intact condition of the unit while afloat; and

(b) A column-stabilised unit is inclined to the range:

(i) Necessary to comply with the requirements of 4.7.1(a) and 5.2.6 and with a zone measured 4.0 m perpendicularly above the final damaged waterline per 3.4.3 of the 2009 IMO MODU Code referred to Fig. 7.4.1, and
(ii) Necessary to comply with the requirements of 3.4.4 of the 2009 IMO MODU Code.

4.7.2 External openings fitted with appliances to ensure weathertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of 4.4.3(i) and (ii).

4.7.3 External openings fitted with appliances to ensure weathertight integrity, which are secured while afloat are to comply with the requirements of 4.4.2(i) and (ii).

5.1 General

5.1.1 Any unit to which a load line is required to be assigned under the applicable terms of the Load Line Convention is to be subject to compliance with the Convention, see 1.1.2. For semi-submersible and self-elevating units, see also 5.2 and 5.3 respectively.

5.1.2 The requirements of the Load Line Convention, with respect to weathertightness and watertightness of decks, superstructures, deckhouses, doors, hatchway covers, other openings, ventilators, air pipes, scuppers, inlets and discharges, etc., are taken as a basis for all units in the afloat conditions.

5.1.3 The requirements for hatchways, doors and ventilators are dependent upon the position on the unit as defined in 2.5.

5.1.4 Units which cannot have freeboard computed by normal methods laid down by the Load Line Convention will have the permissible draughts determined on the basis of meeting the applicable intact stability, damage stability and structural requirements for transit and operating conditions while afloat. In no case is the draught to exceed that permitted by the Load Line Convention, where applicable.

5.1.5 All units are to have load line marks which designate the maximum permissible draught when the unit is in the afloat condition. Such markings are to be placed at suitable visible locations on the structure, to the satisfaction of LR. These marks, where practicable, are to be visible to the person in charge of mooring, lowering or otherwise operating the unit.

5.2 Column-stabilised units

5.2.1 Load lines for column-stabilised units are to be based on the following:
- The strength of the structure.
- The air gap between the maximum operating waterline and the bottom of the upper hull structure.
- The intact and damage stability requirements.

5.2.2 The conditions of assignment are to be based on the requirements of the Load Line Convention. The Regulations of the relevant National Administration are also to be complied with, see 1.1.2.

5.2.3 In general, the heights of hatch and ventilator coamings, air pipes, door sills, etc., in exposed positions and all closing appliances are to be determined by consideration of both intact and damage stability requirements.

5.2.4 The freeboard deck and reference deck from which the air gap is measured, is normally taken as the lowest continuous deck exposed to weather and sea, and which has permanent means of closing and below which all openings are watertight and permanently closed at sea.

5.2.5 Side scuttles and windows, including those of non-opening type, or other similar openings, are not to be fitted below the freeboard deck, as defined in 5.2.4.

5.2.6 In addition to the stability requirements in 4.7, the upper deck and the boundaries of the enclosed upper hull structure between the upper deck and the freeboard deck are to be made weathertight.

5.2.7 Special consideration will be given to the position of openings which cannot be closed in emergencies, such as air intakes for emergency generators.
5.3 Self-elevating units

5.3.1 Load lines and conditions of assignment for self-elevating units when afloat in transit conditions will be subject to the applicable terms of the Load Line Convention. A load line, where assigned, is not applicable to self-elevating units when resting on the sea bed, or when lowering to or raising from such position. The Regulations of the relevant National Administration are also to be complied with, see 1.1.2.

5.3.2 Special consideration is to be given to the freeboard of units with moonpools or drilling wells extending through the main hull structure.

5.3.3 In general, the heights of hatch and ventilator coamings, air pipes, door sills, etc., in exposed positions and all closing appliances are also to be determined by consideration of both intact and damage stability requirements.

5.4 Surface type units

5.4.1 Surface type units are to comply with the requirements of 5.1.1. Special consideration is to be given to the freeboard of units with moonpools or drilling wells extending through the main hull structure.

5.5 Sea bed-stabilised units

5.5.1 When afloat in transit conditions, sea bed-stabilised units are to comply with the requirements of 5.2 and 5.3 as applicable.

5.6 Weathertight integrity

5.6.1 Closing arrangements for shell, deck and bulkhead openings and the requirements for ventilators, air pipes and overboard discharges, etc., are to comply with Sections 6 to 10.

5.6.2 The requirements of this Chapter conform, where relevant, with those of the Load Line Convention. Reference should also be made to any additional requirements of the National Authority of the country in which the unit is to be registered and to the appropriate Regulations of the Coastal State Authority in the area where the unit is to operate.

5.6.3 The closing appliances are, in general, to have a strength at least corresponding to the required strength of that part of the hull in which they are fitted.

5.6.4 The requirements for closing appliances of hatches, doors, ventilators, air pipes, etc., and their associated coamings, situated at such a height as will not constitute a danger to the weathertightness of the unit, will be specially considered.

5.6.5 In all areas where mechanical damage is likely, all air and sounding pipes, scuppers and discharges, including their valves, controls and indicators, are to be well protected. This protection is to be of steel or other equivalent material.

Section 6
Miscellaneous openings

6.1 Small hatchways on exposed decks

6.1.1 The requirements of Pt 3, Ch 11.6.1 of the Rules for Ships are to be complied with, as applicable.

6.1.2 In general, small hatch cover scantlings and securing devices are to be in accordance with Table 7.6.1 or with an acceptable standard.

Table 7.6.1 Hatch cover scantlings

<table>
<thead>
<tr>
<th>Size of hatch (mm)</th>
<th>Plate (mm)</th>
<th>Stiffeners</th>
<th>Toggles</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 x 600</td>
<td>8,0</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>760 x 760</td>
<td>8,0</td>
<td>–</td>
<td>6</td>
</tr>
<tr>
<td>925 x 925</td>
<td>8,0</td>
<td>75 x 7.5 mm flat bar</td>
<td>7</td>
</tr>
<tr>
<td>1220 x 1220</td>
<td>10,0</td>
<td>75 x 7.5 mm flat bar</td>
<td>8</td>
</tr>
</tbody>
</table>

6.1.3 Hatch covers of a greater size than those defined in Table 7.6.1 will have their scantlings and closing arrangements specially considered.

6.1.4 When applicable, large hatch covers are to comply with the requirements of Pt 3, Ch 11 of the Rules for Ships.

6.1.5 Small hatches, including escape hatches, are to be situated clear of any obstructions.

6.1.6 The height and scantlings of coamings are to be in accordance with 6.3.

6.2 Hatchways within enclosed superstructures or ‘tween decks

6.2.1 The requirements of 6.1 are to be complied with, where applicable.

6.2.2 Access hatches within a superstructure or deckhouse in Position 1 or 2 need not be provided with means for closing if all openings in the surrounding bulkheads have weathertight closing appliances.

6.3 Hatch coamings

6.3.1 The height of coamings of hatchways situated in Positions 1 and 2 closed by steel covers fitted with gaskets and clamping devices are to be not less than:

- 600 mm at Position 1;
- 450 mm at Position 2.

6.3.2 Lower heights than those defined in 6.3.1 may be considered in relation to operational requirements and the nature of the spaces to which access is given.
6.3.3 Coamings with height less than given in 6.3.1 may normally be accepted for column-stabilised units after special consideration, see also 6.3.4.

6.3.4 Coamings heights on all units are also to satisfy the requirements for intact and damage stability, see 4.5 and 4.7.

6.3.5 The thickness of the coamings is to be not less than the minimum thickness of the structures to which they are attached, or 11 mm, whichever is the lesser. Stiffening of the coaming is to be appropriate to its length and height. Scantlings of coamings more than 900 mm in height will be specially considered.

6.4 Manholes and flush scuttles

6.4.1 Manholes and flush scuttles fitted in Positions 1 and 2, or within superstructures other than enclosed superstructures, are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

6.5 Companionways, doors and access arrangements on weather decks

6.5.1 The requirements of Pt 3, Ch 11,6.4 of the Rules for Ships are to be complied with, as applicable.

6.5.2 For access to spaces in the oil storage area on units with tanks for the storage of oil in bulk, see Pt 3, Ch 3.2.11.

6.5.3 The height of doorway sills above deck sheathing, if fitted, is to be not less than 600 mm in Position 1, and not less than 380 mm in Position 2. For semi-submersible units, see 5.2.3.

6.5.4 Doorway sill heights on all units are also to satisfy the requirements for intact and damage stability, see 4.5 and 4.7.

6.5.5 On surface type oil storage units, direct access from the freeboard deck to the machinery space through exposed casings is not permitted, except when 6.5.6 applies. A door complying with 6.5.3 may, however, be fitted in an exposed machinery casing on these units, provided that it leads to a space or passageway which is of equivalent strength to the casing and is separated from the machinery space by a second weathertight door complying with 6.5.3. The outer and inner weathertight doors are to have sill heights of not less than 600 mm and 230 mm respectively and the space between is to be adequately drained by means of a screw plug or equivalent.

6.5.6 For surface type oil storage units with freeboards greater than, or equal to, a Type B ship (as defined in the Load Line Convention), inner doors are not required for direct access to the engine room.

6.6 Side scuttles, windows and skylights

6.6.1 For surface type and self-elevating units, when afloat, the requirements of Pt 3, Ch 11,6.5 of the Rules for Ships are to be complied with, as applicable.

6.6.2 A plan showing the location of side scuttles and windows is to be submitted. Attention is to be given to any relevant Statutory Requirements of the Coastal State Authority where the unit is to operate and/or the National Authority of the country in which the unit is to be registered.

6.6.3 The location of windows and side scuttles and the provision of deadlights or storm covers on semi-submersible units will be specially considered in each case, see also 4.5.1(c) and 5.2.5.

6.6.4 Windows and side scuttles are to be of the non-opening type where damage stability calculations indicate that they would become immersed as a result of specified damage.

7 Tank access arrangements and closing appliances in oil storage units

7.1 General

7.1.1 The requirements of Pt 3, Ch 11,7 of the Rules for Ships are to be complied with, as applicable.

7.1.2 The height of coamings may be required to be increased if this is shown to be necessary by damage stability regulations.

7.1.3 Access openings are to have smooth edges and edge stiffening is also to be arranged in regions of high stress.

7.1.4 Small openings are to be kept clear of other access openings.

7.1.5 The general requirements for access to spaces within the oil storage area are to comply with Pt 3, Ch 3.2.11.

8 Ventilators

8.1 General

8.1.1 The requirements of Pt 3, Ch 12,2 of the Rules for Ships are to be complied with, as applicable.
8.1.5 Pressure/vacuum valves as required by Pt 5, Ch 15 may be accepted as closing appliances for oil storage tanks.

---

**Section 10**

Scuppers and sanitary discharges

10.1 General

10.1.1 The requirements of Pt 3, Ch 12.4 of the Rules for Ships are to be complied with, as applicable.

10.1.2 The additional requirements contained within this Section are applicable to semi-submersible and self-elevating units only.

10.1.3 Normally, each separate overboard discharge from an enclosed space is to be fitted with an automatic non-return valve at the shell boundary. Where the inboard end of a discharge is situated below the worst damage water line, the non-return valve is to be of a type which is effective at the worst expected inclination after damage, whatever the orientation, and is to have a positive means of closing, operable from a readily accessible position above the damage water line. An indicator is to be fitted at the control position showing whether the valve is open or closed.

10.1.4 The requirements for non-return valves are applicable only to those discharges which remain open while the unit is afloat during normal operation. For discharges which are closed while the unit is afloat, such as gravity drains from tanks, a single screw-down valve operated from the freeboard deck is considered to provide sufficient protection. An indicator is to be fitted at the control position showing whether the valve is open or closed.

10.1.5 The non-return valve required by 10.1.3 is to be mounted directly on the shell and secured in accordance with Pt 5, Ch 13.2.4. If this is impracticable, a short distance piece of rigid construction may be introduced between the valve and the shell.

10.1.6 Discharge piping, situated between the sea level and the bottom of the upper hull of semi-submersible units and below the bottom shell of the self-elevating units when in the elevated position, is to be of substantial construction, well secured and protected.
Welding and Structural Details

Part 4, Chapter 8
Sections 1 & 2

Section

1 General
2 Welding
3 Secondary member end connections
4 Construction details for primary members
5 Structural details
6 Fabrication tolerances

Section 1
General

1.1 Application
1.1.1 This Chapter is applicable to all unit types and components.
1.1.2 Requirements are given in this Chapter for the following:
   (a) Welding connection details, defined practices and sequence, consumables and equipment, procedures, workmanship and inspection.
   (b) End connection scantlings and constructional details for longitudinals, beams, frames and bulkhead stiffeners.
   (c) Primary member proportions, stiffening and construction details.
1.1.3 All units are to comply with the requirements of Pt 3, Ch 10 of the Rules for the Classification of Ships (hereinafter referred to as the Rules for Ships), as applicable to the type of unit. Additional requirements as indicated in the following Sections should also be complied with, as applicable.

1.2 Symbols
1.2.1 Symbols are defined as necessary in each Section.

Section 2
Welding

2.1 General
2.1.1 Requirements for welding are given in Chapter 12 and Chapter 13 of the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials) and general requirements for hull construction are also given in Pt 3, Ch 10.2 of the Rules for Ships.
2.1.2 Additional requirements with respect to unit types as indicated in this Section should also be complied with, as applicable.

2.2 Impact test requirements
2.2.1 Charpy V-notch impact tests are to be carried out in the weld metal, fusion line and heat affected zone in accordance with 2.2.2 to 2.2.4.
2.2.2 For special structure, the impact test temperature and minimum absorbed energy for the weld and heat affected zone are to be the same as that specified for the base materials being welded.
2.2.3 For primary and secondary structure, the impact test temperature and the minimum absorbed energy for the weld metal and heat affected zone are to be in accordance with the requirements of the material grade being welded, as specified in Table 12.2.2 in Chapter 12 of the Rules for Materials.
2.2.4 Fabrications whose thickness exceeds 65 mm are, in general, to be subjected to a post weld heat treatment. Impact tests are required to be made on specimens heat treated in the same manner as the actual construction. The absorbed energy is to be in accordance with 2.2.2 and 2.2.3; however, the test temperatures may be 10°C higher.

2.3 Workmanship and inspection
2.3.1 Checkpoints examined at the construction stage are generally to be selected from those welds intended to be examined as part of the agreed quality control programme to be applied by the Builder. The locations and numbers of checkpoints are to be agreed between the Builder and the Surveyor. Special attention is to be paid to the welded connections of primary bracings and their end connections and other structure defined as special in Ch 2.2.
2.3.2 Additional locations for NDE for surface type units are shown in Table 8.2.1.
2.3.3 Typical locations for NDE and the recommended number of checkpoints to be taken in column-stabilised and self-elevating units are shown in Table 8.2.2. For other unit types, the extent of NDE will be specially considered in each case. Critical locations as identified by LR’s ShipRight Fatigue Design Assessment and other relevant fatigue calculations are also to be considered, where applicable. A document detailing the proposed items to be examined is to be submitted by the Builder for approval.
2.3.4 For the hull structure of units designed to operate in low air/sea temperatures, the recommended extent of non-destructive examination will be specially considered.
2.3.5 All NDE is to be performed in accordance with the requirements specified in Ch 13.2 of the Rules for Materials.
2.3.6 In general, fabrication tolerances are to comply with Section 6. It is important to ensure that compatibility exists between design calculations and construction standards, particularly in fatigue sensitive areas.
### Table 8.2.1 Additional non-destructive examination of welds on surface type units (as applicable)

<table>
<thead>
<tr>
<th>Structural item</th>
<th>Location</th>
<th>Checkpoints, see Note 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrations and attachments to hull, e.g., sea inlets, piping, anode supports</td>
<td>Throughout</td>
<td>100%</td>
</tr>
<tr>
<td>Moonpool integration structure</td>
<td>Throughout</td>
<td>See Notes 2 and 4</td>
</tr>
<tr>
<td>Topside support structure connections to hull and hull structure in way</td>
<td>Throughout</td>
<td>25%, see Notes 4 and 5</td>
</tr>
<tr>
<td>Flare stack and crane pedestal structure</td>
<td>Throughout</td>
<td>50%, see Notes 4 and 5</td>
</tr>
<tr>
<td>Connections to deck</td>
<td>Local</td>
<td>100%</td>
</tr>
<tr>
<td>Other structural items</td>
<td>Throughout</td>
<td>See Notes 3 and 4</td>
</tr>
<tr>
<td>Side shell butts, seams and intersection welds where vessel is strengthened</td>
<td>Forward end, Remainder</td>
<td>See Note 6, See Note 7</td>
</tr>
<tr>
<td>Exposed shell butts, seams and intersection welds where vessel is designed</td>
<td>Throughout</td>
<td>See Note 7</td>
</tr>
<tr>
<td>Local areas identified as fatigue sensitive, e.g.:</td>
<td>Local</td>
<td>See Note 3</td>
</tr>
<tr>
<td>- Identified bracket connections at intersections of side shell longitudinal</td>
<td>Local</td>
<td>100%</td>
</tr>
<tr>
<td>and transverse frames and bulkheads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Key locations identified on moonpool integration structure</td>
<td>Local</td>
<td>100%</td>
</tr>
<tr>
<td>- Topside support stool welds to upper deck and underdeck welds in way</td>
<td>Local</td>
<td>100%</td>
</tr>
<tr>
<td>- Flare stack support welds to upper deck and underdeck welds in way</td>
<td>Local</td>
<td>100%</td>
</tr>
</tbody>
</table>

**NOTES**

1. The diameter of each checkpoint is to be between 0.3 and 0.5 m, and volumetric and magnetic particle checks are to be carried out unless indicated otherwise.
2. 10% selection of butts and seams and 20% at intersections. Particular attention is to be given in way of stops and starts of automatic and semi-automatic welding during fabrication.
4. Particular attention is also given to ends of bracket connections where fitted.
5. Particular attention to be given in way of weld intersections and discontinuities at stop and start positions.
6. 10% of butts and seams and 30% at intersections. Particular attention to be taken in way of stops and starts of automatic and semi-automatic welding during fabrication.
7. 10% selection of butts and seams and 25% at intersections. Particular attention to be given in way of stops and starts of automatic and semi-automatic welding during fabrication.
8. Agreed locations are not to be indicated on blocks prior to the welding taking place, nor is any special treatment to be given at these locations.
9. Particular attention is to be given to repair rates. Additional welds are to be tested in the event that defects such as lack of fusion or incomplete penetration are repeatedly observed.
### Table 8.2.2  Non-destructive examination of welds on column-stabilised and self-elevating units

<table>
<thead>
<tr>
<th>Structural item</th>
<th>Volumetric checkpoints</th>
<th>Magnetic particle checkpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracing butt and seam welds</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Bracing weld connections to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* columns</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* pontoons</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* upper hull</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* lower nodes</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Attachments to legs and bracings</td>
<td>—</td>
<td>100%</td>
</tr>
<tr>
<td>Penetrations through legs and bracings</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Bracing shell attachment of diaphragms, gussets, stiffeners</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Column shell butts and seams</td>
<td>See Note 4</td>
<td>20%</td>
</tr>
<tr>
<td>Column weld connections to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* pontoons</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* upper hull</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* in way of anchor fairleads and sheaves</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Internal column structure connections</td>
<td>5%, see Note 5</td>
<td>See Note 3</td>
</tr>
<tr>
<td>Pontoon, hull, shell and bulkhead butts/seams</td>
<td>See Note 4</td>
<td>20%</td>
</tr>
<tr>
<td>Leg footings or mats</td>
<td>See Note 4</td>
<td>20%</td>
</tr>
<tr>
<td>Internal pontoon structure</td>
<td>5%, see Note 5</td>
<td>See Note 3</td>
</tr>
<tr>
<td>Hull penetrations, subsea inlets, anode and attachments, piping connection supports, etc.</td>
<td>100%</td>
<td>—</td>
</tr>
<tr>
<td>Bilge keel butts</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Self-elevating unit leg connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* leg chords</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* leg trusses</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>* leg attachments to footings or mats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* butts and seams in chords and trusses</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Upper hull: Main bulkheads/deck girders</td>
<td>See Notes 2 &amp; 4</td>
<td>See Note 6</td>
</tr>
<tr>
<td>Strength decks and drill floor</td>
<td>See Notes 2 and 4</td>
<td>See Note 7</td>
</tr>
<tr>
<td>In way of windlasses and mooring winches</td>
<td>—</td>
<td>100%</td>
</tr>
<tr>
<td>Topside support structure connections to deck</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Flare stack, crane pedestals and gusset connections to deck</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Drill floor, derrick substructure and moonpool structure</td>
<td>See Notes 4 and 7</td>
<td>See Note 7</td>
</tr>
<tr>
<td>Helideck primary support, cantilevered lifeboat platform primary support</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Helideck and lifeboat platform remainder</td>
<td>See Note 8</td>
<td>—</td>
</tr>
<tr>
<td>Other items</td>
<td>See Note 8</td>
<td>See Note 8</td>
</tr>
</tbody>
</table>

**NOTES**

1. Back-up structure of the items in question is also to be included, where applicable.
2. 100% in way of full penetration welding at end of diaphragm plates, gussets, stiffeners, etc.
3. 50% in way of fillet welds around stiffener ends, notches, cut-outs, drain hole openings, etc.
4. 10% selection of butts and seams and 20% at intersections. Particular attention to be taken in way of stops and starts of automatic and semi-automatic welding during fabrication.
5. 10% random selection of butt welds, of pontoon and column shell longitudinal stiffeners and transverse and longitudinal bulkheads stiffeners.
6. 10% random selection of fillet welds in way of stiffener ends, drain hole openings, cut-outs, notches, etc.
7. Girder and sub-structure butt welds 100% UT; principal connections to deck and main structure 100% UT and 100% MPI.
8. Random spot checks to the Surveyor’s satisfaction.
9. The diameter of each checkpoint is to be between 0.3 and 0.5 m.
2.4 Fillet welds

2.4.1 Additional weld factors for structure not specifically covered by the Rules for Ships are given in Table 8.2.3.

2.4.2 Continuous welding is to be adopted in the following locations:
(a) All weldings inside tanks and peak compartments.
(b) Primary and secondary members to shell in lower hulls and stability columns.
(c) Primary and secondary members to main bracings, trusses or ‘K’ joints.

Table 8.2.3 Additional weld factors

<table>
<thead>
<tr>
<th>Item</th>
<th>Weld factor</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) General application:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Shell boundaries of columns to lower and upper hulls</td>
<td>full penetration</td>
<td>except as required below</td>
</tr>
<tr>
<td>(b) Internal watertight or oiltight plate boundaries</td>
<td>0.34</td>
<td>generally, but alternative proposals will be considered in specific areas</td>
</tr>
<tr>
<td>(2) (a) Upper hull framing and hull framing on self-elevating units:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Webs of web frames and stringers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to shell</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>to face plate</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>(ii) Tank side brackets to shell and inner bottom</td>
<td>0.34</td>
<td>to be in accordance with the Rules for Ships</td>
</tr>
<tr>
<td>(b) Primary hull framing and girders on lower hulls, columns and caissons of column-stabilised units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Decks and supporting structure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary deck girders and connections between primary members on column-stabilised units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Self-elevating units:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Leg construction, general</td>
<td>full penetration</td>
<td></td>
</tr>
<tr>
<td>(b) Leg connections to footings or mats</td>
<td>full penetration</td>
<td></td>
</tr>
<tr>
<td>(c) Internal webs, girders and bulkheads in footings and mats</td>
<td>0.44</td>
<td>full penetration may be required</td>
</tr>
<tr>
<td>(d) Internal stiffeners in footings and mats</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(e) Jackhouses, general</td>
<td>0.44</td>
<td>full penetration may be required</td>
</tr>
<tr>
<td>(f) Bulkheads and primary structures in way of leg wells</td>
<td>0.44</td>
<td>full penetration may be required</td>
</tr>
<tr>
<td>(5) Main bracings and ‘K’ joints, etc.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Ring frames, girders and stiffeners</td>
<td>full penetration</td>
<td>generally, but alternative proposals may be considered</td>
</tr>
<tr>
<td>(b) Shell boundaries and end connections including brackets, gussets and cruciform plates</td>
<td>full penetration</td>
<td></td>
</tr>
<tr>
<td>(6) Miscellaneous structures, fittings and equipment:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Rings and coamings for manhole type covers to shell on stability columns and lower hulls</td>
<td>full penetration</td>
<td>generally, but alternative proposals may be considered</td>
</tr>
<tr>
<td>(b) Rings for manhole type covers, to deck or bulk head</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(c) Frames of watertight and weathertight bulk head doors</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(d) Stiffening of doors</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>(e) Ventilator, air pipes, etc., coamings to deck Load line positions 1 and 2 elsewhere</td>
<td>0.34</td>
<td>0.21</td>
</tr>
<tr>
<td>(f) Ventilator, etc., fittings</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>(g) Scuppers and discharges, to deck</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>(h) Masts, demick posts, crane pedestals, etc., to deck</td>
<td>0.44</td>
<td>full penetration welding may be required generally</td>
</tr>
<tr>
<td>(i) Deck machinery seats to deck</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>(k) Mooring equipment seats and fairleads</td>
<td>0.44</td>
<td>full penetration welding may be required</td>
</tr>
<tr>
<td>(l) Bulwark stays to deck</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>(m) Bulwark attachment to deck</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(n) Guard rails, stanchions, etc., to deck</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(o) Bilge keel ground bars to shell</td>
<td>0.34</td>
<td>continuous fillet weld, minimum throat thickness 4 mm</td>
</tr>
<tr>
<td>(p) Bilge keels to ground bars</td>
<td>0.21</td>
<td>light continuous or staggered intermittent fillet weld, minimum throat thickness 3 mm</td>
</tr>
<tr>
<td>(q) Fabricated anchors</td>
<td>full penetration</td>
<td></td>
</tr>
</tbody>
</table>
2.5 Welding of tubular members

2.5.1 Welding is to comply with agreed Internationally or Nationally accepted Codes such as AWS or API and all welding generally is to conform to the following:

(a) All steel is to be joined by complete penetration groove welds.

(b) Unless single sided welding has been agreed for the particular weld configuration, double sided welds are to be used, wherever practicable.

(c) In lattice type structures, a minimum weld attachment length at the cord of 1.5 times the brace wall thickness is required at all locations. This is based on fatigue considerations.

(d) Care is to be taken to ensure the weld surface profile is smooth and blends with the parent material.

(e) Backing strips are not to be used unless specially agreed with LR.

(f) Root gaps are to be generally in the range of 3 to 6 mm.

(g) Bevels are to be such that the included angle is in the range 45° to 60°. However, when the dihedral angle is less than 45°, the included angle may be reduced as indicated for locations 4 and 5, see Fig. 8.2.2.

(h) Where saddle weld toe grinding has been agreed as a method of improving fatigue life, at the locations agreed, the grinding of the weld toe is to produce a smooth transition between the weld and the parent plate. The grinding should remove all defects, slag inclusions and any undercut. Overgrinding into the parent plate is not to exceed 2 mm or 0.05 times the plate thickness, whichever is less. The grinding tool should preferably have a spherical head (e.g., a tungsten carbide burr) and, in general, disc-grinders are to be avoided except for initial heavy grinding. Any marks made by rotation of the grinding tool are to be aligned with the direction of stress. The surface of the main body of the weld may be dressed to produce a better concave profile if the as-welded profile is poor, see Fig. 8.2.1 and Fig. 8.2.8. Care must be exercised in order that overgrinding does not excessively reduce the size of the attachment weld and in no case less than that required by the Rules.
Welding and Structural Details

Fig. 8.2.3  Welding at location 1

From both sides

\[ L = \frac{T}{\sin \psi} \]
\[ L_{\text{min}} = 1.5T \]
\[ L_{\text{max}} \text{ need not exceed } 1.75T \]

From one side

\[ L = \frac{T}{\sin \psi} \]
\[ L_{\text{min}} = 1.5T \]
\[ L_{\text{max}} \text{ need not exceed } 1.75T \]

Fig. 8.2.4  Welding at location 2

From one side

\[ \psi = 150^\circ - 90^\circ \]

From both sides

\[ \psi = 150^\circ - 90^\circ \]
Welding and Structural Details

Part 4, Chapter 8

Section 2

Fig. 8.2.5   Welding at location 3

Fig. 8.2.6   Welding at location 4
Welding and Structural Details

Fig. 8.2.7 Welding at location 5

Back-up weld made from outside. Completed initial passes are discounted until the width of groove, \( w \), is sufficient to assure sound welding. (for \( w \), see Fig. 8.2.6)

Fig. 8.2.8 Weld grinding

Radius to be as shown above or 12 mm whichever is greater

Detail A

Grind to smooth transition

Brace stub wall

\[ R = \frac{t}{2} \]
Welding and Structural Details

Section 3
Secondary member end connections

3.1 General

3.1.1 Requirements relating to secondary member end connections are given in Pt 3, Ch 10,3 of the Rules for Ships which should be complied with.

Section 4
Construction details for primary members

4.1 General

4.1.1 Requirements relating to construction details for primary members are given in Pt 3, Ch 10,4 of the Rules for Ships, which should be complied with.

4.1.2 Additional requirements with respect to unit types as indicated in this Section should also be complied with, as applicable.

4.2 Geometric properties and proportions

4.2.1 The minimum web thickness of primary shell members in the lower hulls of column-stabilised units is to be not less than 0,017 \( S_w \), where \( S_w \) is spacing of stiffeners on member web, or depth of unstiffened web, in mm.

Section 5
Structural details

5.1 General

5.1.1 Requirements relating to structural details are given in Pt 3, Ch 10,5 of the Rules for Ships, which should be complied with.

5.1.2 Additional requirements with respect to unit types as indicated in this Section should also be complied with, as applicable.

5.2 Arrangements at intersections of continuous secondary and primary members

5.2.1 In the lower hulls of column-stabilised units, where primary member webs are slotted for the passage of secondary members, web stiffeners are generally to be fitted normal to the face plate of the member to provide adequate support for the loads transmitted. The ends of web stiffeners are to be attached to the secondary members.

5.2.2 Web stiffeners may be flat bars of thickness, \( t_w \), with a minimum depth of 0,08\( d_w \) or 75 mm, whichever is the greater. Alternative sections of equivalent moment of inertia may be adopted. The direct stress in the web stiffeners is to be determined in accordance with the Rules for Ships.

5.2.3 For units other than surface type, direct stress in the vertical web stiffener and the shear stresses in the lug, collar plate and weld connections are to satisfy the factors of safety given in Ch 5,2.1.1(a).

5.2.4 For units other than surface type, the head \( h_1 \) used to calculate load transmitted to connections of secondary members is to be obtained from the following, as applicable:

(a) \( h_o \) from Table 6.3.1 in Chapter 6.
(b) \( h_T \) from Table 6.3.4 in Chapter 6.
(c) \( h_4 \) from Table 6.7.1 in Chapter 6.

5.3 Openings

5.3.1 Penetrations in main bracing members are to be avoided as far as possible. Details of essential penetrations or openings in main bracing members are to be submitted for consideration.

5.4 Other fittings and attachments

5.4.1 Gutterway bars at the upper deck are to be so arranged that the effect of main hull stresses on them is minimised and the material grade and quality of the bar are to be the same standard as the deck plate to which it is attached.

5.4.2 Where attachments are made to rounded gunwale plates, special consideration will be given to the required grade of steel, taking into account the intended structural arrangement and attachment details. In general, the material grade and the quality of the attachment are to be to the same standard as the gunwale plates.

5.4.3 Fittings and attachments to main bracing members are to be avoided as far as possible. Where they are necessary, full details are to be submitted for consideration.

Section 6
Fabrication tolerances

6.1 General

6.1.1 All fabrication tolerances are to be in accordance with good shipbuilding practice and be agreed with LR before fabrication is commenced. Where appropriate, tolerances are to comply with a National Standard. In general, the tolerances for the fabrication of structural members for fatigue sensitive areas are to comply with the requirements of this Section.
6.1.2 For cylindrical members, the out of roundness is not to exceed 0.5 per cent of the true mean radius or 25 mm of the true mean internal diameter, whichever is the lesser.

6.1.3 When measuring cylindrical members, the out of roundness is to be measured always as a deviation from the true mean radius in order to avoid errors.

6.1.4 Cylindrical members are not to deviate from straightness by 3 mm or \( l \) mm, whichever is the greater, where \( l \) is the length of the member, in metres.

6.1.5 The misalignment of plate edges in butt welds is not to exceed the lesser of the following values:
- Special structure 0.1\( t \) or 3 mm
- Primary structure 0.15\( t \) or 3 mm
- Secondary structure 0.2\( t \) or 4 mm
where \( t = \) thickness of the thinnest plate, in mm.

6.1.6 Misalignment of non-continuous plates such as cruciform joints is not to exceed the lesser of the following values:
- Special structure 0.2\( t \) or 4 mm
- Primary structure 0.3\( t \) or 4 mm
- Secondary structure 0.5\( t \) or 5 mm
where \( t = \) thickness of the thinnest plate, in mm.

6.1.7 Plate deformation measured at the mid point between stiffeners or support points is not to exceed the lesser of the following values:
- Special structure \( \frac{s}{200} \) mm
- Primary structure \( \frac{s}{130} \) or \( t \) mm
- Secondary structure \( \frac{s}{80} \) or \( t \) mm
where \( s = \) stiffener spacing or unsupported panel width, in mm
\( t = \) plate thickness, in mm.
Section 1

Anchoring equipment

1.1 General

1.1.1 To be assigned the figure (1) in the character of Classification, the anchoring equipment, i.e., anchors, cables, windlass and winches, etc., necessary for the unit during ocean voyages or location moves, is to be as required by this Section. The Regulations governing the assignment of the figure (1) for equipment are given in Pt 1, Ch 2.2.

1.1.2 When the equipment fitted to the unit is designed primarily as positional mooring equipment, consideration will be given to accepting the proposed equipment as equivalent to the Rule requirements but only if the arrangements are such that it can be efficiently used as anchoring equipment. See also Pt 1, Ch 2.2.3.3 and Pt 3, Ch 10.

1.1.3 Where the Classification Committee has agreed that anchoring and mooring equipment need not be fitted in view of the particular service of the unit, the character letter N will be assigned, see also Pt 1, Ch 2.2.2.2.

1.2 Equipment number

1.2.1 The requirement for anchors, cables, wires and ropes is to be based on an Equipment Number calculated as follows:

\[
\text{Equipment Number} = \Delta^{\frac{1}{3}} + 2.0A_1 + \frac{A_2}{10}
\]

where

- \(\Delta\) = moulded displacement in transit condition, in tonnes
- \(A_1\) = projected area perpendicular to wind direction when at anchor, in \(m^2\)
- \(A_2\) = projected area parallel to wind direction when at anchor, in \(m^2\)

In calculating the areas \(A_1\) and \(A_2\):

- Masking effect can be taken into account for columns;
- Open trusswork of derricks, booms and towers, etc., may be approximated by taking 30 per cent of the block area of each side, i.e., 60 per cent of the projected area of one side for double sided trusswork.
- When calculating projected areas, account is to be taken of topside process facilities. Special consideration will be given to structure extending outside of the Rule length, \(L\).

1.3 Determination of equipment

1.3.1 The basic equipment of anchors and cables is to be determined from Table 9.1.1 and associated notes. Table 9.1.1 is based on the following assumptions:

(a) The anchors will be high holding power anchors of an approved design, see 1.5.
(b) The chain cable will be in accordance with the requirements of 1.6.

1.3.2 Where the equipment is based on 1.1.2, the sizes of individual anchors are not to exceed the values given in Table 9.1.1 by more than seven per cent unless the cable sizes are increased as appropriate.

1.3.3 Where the equipment is based on 1.1.2, the minimum cable strength is to be maintained and 1.7.6 is also to be complied with.

1.4 Anchors

1.4.1 Two anchors are to be fitted and arranged so that they may be readily dropped should an emergency occur.

1.4.2 The mass of each anchor is to be as given in Table 9.1.1 except that one anchor may weigh seven per cent less than the Table weight so long as the total weight of the two anchors attached to the cables is not less than twice the tabular weight for one anchor.

1.4.3 Anchors are to be of approved design. The design of all anchor heads is to be such as to minimise stress concentrations, and in particular, the radii on all parts of cast anchor heads are to be as large as possible, especially where there is a considerable change of section.

1.4.4 Positional mooring anchors of the type which are generally similar to conventional marine anchors but which must be specially laid the right way up, or which require the fluke angle or profile to be adjusted for varying types of sea bed, will not normally be accepted as anchoring equipment in accordance with these Rules.

1.4.5 If ordinary ship type stockless bower anchors, not approved as high holding power anchors, are to be used as Rule equipment, the mass of each anchor is to be not less than 1.33 times that listed in Table 9.1.1 for the unit’s Equipment Number.

1.4.6 The requirements for manufacture, proof testing and identification of anchors are to be in accordance with Chapter 10 of the Rules for Materials.
Table 9.1.1  Equipment – Anchors and chain cables

<table>
<thead>
<tr>
<th>Equipment number</th>
<th>Equipment Letter</th>
<th>High holding power anchor mass, in kg</th>
<th>Stud link chain cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeding</td>
<td>Not exceeding</td>
<td>Length per anchor, in metres</td>
<td>Diameter, in mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grade U1</td>
</tr>
<tr>
<td>50</td>
<td>70</td>
<td>A</td>
<td>140</td>
</tr>
<tr>
<td>70</td>
<td>90</td>
<td>B</td>
<td>180</td>
</tr>
<tr>
<td>90</td>
<td>110</td>
<td>C</td>
<td>230</td>
</tr>
<tr>
<td>110</td>
<td>130</td>
<td>D</td>
<td>270</td>
</tr>
<tr>
<td>130</td>
<td>150</td>
<td>E</td>
<td>310</td>
</tr>
<tr>
<td>150</td>
<td>175</td>
<td>F</td>
<td>360</td>
</tr>
<tr>
<td>175</td>
<td>205</td>
<td>G</td>
<td>430</td>
</tr>
<tr>
<td>205</td>
<td>240</td>
<td>H</td>
<td>500</td>
</tr>
<tr>
<td>240</td>
<td>280</td>
<td>I</td>
<td>590</td>
</tr>
<tr>
<td>280</td>
<td>320</td>
<td>J</td>
<td>680</td>
</tr>
<tr>
<td>320</td>
<td>360</td>
<td>K</td>
<td>770</td>
</tr>
<tr>
<td>360</td>
<td>400</td>
<td>L</td>
<td>860</td>
</tr>
<tr>
<td>400</td>
<td>450</td>
<td>M</td>
<td>970</td>
</tr>
<tr>
<td>450</td>
<td>500</td>
<td>N</td>
<td>1080</td>
</tr>
<tr>
<td>500</td>
<td>550</td>
<td>O</td>
<td>1190</td>
</tr>
<tr>
<td>550</td>
<td>600</td>
<td>P</td>
<td>1300</td>
</tr>
<tr>
<td>600</td>
<td>660</td>
<td>Q</td>
<td>1440</td>
</tr>
<tr>
<td>660</td>
<td>720</td>
<td>R</td>
<td>1580</td>
</tr>
<tr>
<td>720</td>
<td>780</td>
<td>S</td>
<td>1710</td>
</tr>
<tr>
<td>780</td>
<td>840</td>
<td>T</td>
<td>1850</td>
</tr>
<tr>
<td>840</td>
<td>910</td>
<td>U</td>
<td>1990</td>
</tr>
<tr>
<td>910</td>
<td>980</td>
<td>V</td>
<td>2140</td>
</tr>
<tr>
<td>980</td>
<td>1060</td>
<td>W</td>
<td>2290</td>
</tr>
<tr>
<td>1060</td>
<td>1140</td>
<td>X</td>
<td>2470</td>
</tr>
<tr>
<td>1140</td>
<td>1220</td>
<td>Y</td>
<td>2660</td>
</tr>
<tr>
<td>1220</td>
<td>1300</td>
<td>Z</td>
<td>2840</td>
</tr>
<tr>
<td>1300</td>
<td>1390</td>
<td>A†</td>
<td>3040</td>
</tr>
<tr>
<td>1390</td>
<td>1480</td>
<td>B†</td>
<td>3240</td>
</tr>
<tr>
<td>1480</td>
<td>1570</td>
<td>C†</td>
<td>3440</td>
</tr>
<tr>
<td>1570</td>
<td>1670</td>
<td>D†</td>
<td>3670</td>
</tr>
<tr>
<td>1670</td>
<td>1790</td>
<td>E†</td>
<td>3940</td>
</tr>
<tr>
<td>1790</td>
<td>1930</td>
<td>F†</td>
<td>4210</td>
</tr>
<tr>
<td>1930</td>
<td>2080</td>
<td>G†</td>
<td>4500</td>
</tr>
<tr>
<td>2080</td>
<td>2280</td>
<td>H†</td>
<td>4840</td>
</tr>
<tr>
<td>2280</td>
<td>2380</td>
<td>I†</td>
<td>5180</td>
</tr>
<tr>
<td>2380</td>
<td>2530</td>
<td>J†</td>
<td>5510</td>
</tr>
<tr>
<td>2530</td>
<td>2700</td>
<td>K†</td>
<td>5850</td>
</tr>
<tr>
<td>2700</td>
<td>2870</td>
<td>L†</td>
<td>6230</td>
</tr>
<tr>
<td>2870</td>
<td>3040</td>
<td>M†</td>
<td>6530</td>
</tr>
<tr>
<td>3040</td>
<td>3210</td>
<td>N†</td>
<td>6980</td>
</tr>
<tr>
<td>3210</td>
<td>3400</td>
<td>O†</td>
<td>7430</td>
</tr>
<tr>
<td>3400</td>
<td>3600</td>
<td>P†</td>
<td>7880</td>
</tr>
<tr>
<td>3600</td>
<td>3800</td>
<td>Q†</td>
<td>8330</td>
</tr>
<tr>
<td>3800</td>
<td>4000</td>
<td>R†</td>
<td>8780</td>
</tr>
<tr>
<td>4000</td>
<td>4200</td>
<td>S†</td>
<td>9250</td>
</tr>
<tr>
<td>4200</td>
<td>4400</td>
<td>T†</td>
<td>9700</td>
</tr>
<tr>
<td>4400</td>
<td>4600</td>
<td>U†</td>
<td>10100</td>
</tr>
<tr>
<td>4600</td>
<td>4800</td>
<td>V†</td>
<td>10600</td>
</tr>
<tr>
<td>4800</td>
<td>5000</td>
<td>W†</td>
<td>11000</td>
</tr>
<tr>
<td>5000</td>
<td>5200</td>
<td>X†</td>
<td>11600</td>
</tr>
<tr>
<td>5200</td>
<td>5500</td>
<td>Y†</td>
<td>12100</td>
</tr>
<tr>
<td>5500</td>
<td>5800</td>
<td>Z†</td>
<td>12700</td>
</tr>
<tr>
<td>5800</td>
<td>6100</td>
<td>A*</td>
<td>13400</td>
</tr>
<tr>
<td>6100</td>
<td>6500</td>
<td>B*</td>
<td>14100</td>
</tr>
<tr>
<td>6500</td>
<td>6900</td>
<td>C*</td>
<td>15000</td>
</tr>
<tr>
<td>6900</td>
<td>7400</td>
<td>D*</td>
<td>16000</td>
</tr>
<tr>
<td>7400</td>
<td>7900</td>
<td>E*</td>
<td>17500</td>
</tr>
<tr>
<td>7900</td>
<td>8400</td>
<td>F*</td>
<td>18500</td>
</tr>
<tr>
<td>8400</td>
<td>8900</td>
<td>G*</td>
<td>19500</td>
</tr>
<tr>
<td>8900</td>
<td>9400</td>
<td>H*</td>
<td>20500</td>
</tr>
<tr>
<td>9400</td>
<td>10000</td>
<td>I*</td>
<td>22000</td>
</tr>
<tr>
<td>10000</td>
<td>10700</td>
<td>J*</td>
<td>23500</td>
</tr>
<tr>
<td>10700</td>
<td>11500</td>
<td>K*</td>
<td>25000</td>
</tr>
<tr>
<td>11500</td>
<td>12400</td>
<td>L*</td>
<td>26500</td>
</tr>
<tr>
<td>12400</td>
<td>13400</td>
<td>M*</td>
<td>29000</td>
</tr>
<tr>
<td>13400</td>
<td>14600</td>
<td>N*</td>
<td>31500</td>
</tr>
<tr>
<td>14600</td>
<td>16000</td>
<td>O*</td>
<td>34500</td>
</tr>
</tbody>
</table>

Note 1. Consideration will be given to the acceptance of equipment differing from these requirements on units which are classed for restricted service (generally those with geographical limitations ensuring service in sheltered or shallow waters only).

Note 2. Special consideration will be given to units which are unmanned during towed voyages and transfer moves.
1.5 High holding power anchors

1.5.1 Anchors of designs for which approval is sought as high holding power anchors are to be tested at sea to show that they have holding powers of at least twice those of approved standard stockless anchors of the same mass.

1.5.2 If approval is sought for a range of sizes, then at least two sizes are to be tested. The smaller of the two anchors is to have a mass not less than one tenth of that of the larger anchor, and the larger of the two anchors tested is to have a mass not less than one tenth of that of the largest anchor for which approval is sought.

1.5.3 The tests are to be conducted on not less than three different types of bottom, which should normally be soft mud or silt, sand or gravel, and hard clay or similarly compacted material.

1.5.4 The test should normally be carried out from a tug, and the pull measured by dynamometer or derived from recently verified curves of tug rev/min against bollard pull. A scope of 10 is recommended for the anchor cable, which may be wire rope for this test, but in no case should a scope of less than six be used. The same scope is to be used for the anchor for which approval is sought and the anchor that is being used for comparison purposes.

1.5.5 High holding power anchors are to be of a design that will ensure that the anchors will take effective hold of the sea bed without undue delay and will remain stable, for holding forces up to those required by 1.5.1, irrespective of the angle or position at which they first settle on the sea bed when dropped from a normal type of hawse pipe. In case of doubt, a demonstration of these abilities may be required.

1.6 Chain cables

1.6.1 The minimum sizes and lengths of chain cables are to be as required by Table 9.1.1.

1.6.2 Chain cables may be of mild steel, special quality steel or extra quality steel in accordance with the requirements of Chapter 10 of the Rules for Materials and are to be graded in accordance with Table 9.1.2.

1.6.3 Grade U1 material having a tensile stress of less than 400 N/mm² (41 kgf/cm²) is not to be used in association with high holding power anchors. Grade U3 material is to be used only for chain 20.5 mm or more in diameter.

1.6.4 The form and proportion of links and shackles are to be in accordance with Chapter 10 of the Rules for Materials.

1.6.5 As an alternative to the chains listed in Table 9.1.1, consideration will be given to the use of the following:
- Chain cables of Grades R3, R3S and R4 in accordance with Ch 10.3 of the Rules for Materials.
- Wire rope meeting the requirements of the Rules for Materials.
In this case, the length and breaking strength of the wire rope will be specially considered.

1.7 Arrangements for working and stowing anchors and cables

1.7.1 A windlass or winch of sufficient power and suitable for the type of cable is to be provided for each of the anchor cables. Where Owners require equipment significantly in excess of Rule requirements, it is their responsibility to specify increased windlass or winch power.

1.7.2 The windlasses or winches are to be securely fitted and efficiently bedded to suitable positions on the unit. The structural design integrity of the bedplate is the responsibility of the Builder and windlass manufacturer.

1.7.3 The following performance criteria are to be used as a design basis for the windlass:

(a) The windlass is to have sufficient power to exert a continuous duty pull over a period of 30 minutes of:

$$36,79 \times d_{c}^{2} \text{ N (3,75} \times d_{c}^{2} \text{ kgf)}$$ for Grade U1 chain,

$$41,68 \times d_{c}^{2} \text{ N (4,25} \times d_{c}^{2} \text{ kgf)}$$ for Grade U2 chain,

$$46,6 \times d_{c}^{2} \text{ N (4,75} \times d_{c}^{2} \text{ kgf)}$$ for Grade U3 chain,

where $d_{c}$ is the chain diameter, in mm.

(b) The windlass is to have sufficient power to exert, over a period of at least two minutes, a pull equal to the greater of:

(i) short-term pull:

$$1,5 \times \text{continuous duty pull as defined in 1.7.3(a).}$$

(ii) anchor breakout pull:

$$16,24W_{a} + \left(1,65W_{a} + 14,0l_{c}d_{c}^{2}\right) \times \frac{d_{c}^{2}}{1000} \text{ N}$$

where

- $l_{c}$ is length of chain cable per anchor, in metres, as given by Table 9.1.1
- $W_{a}$ is the mass of high holding power anchor, in kg, as given in Table 9.1.1

Table 9.1.2 Anchoring equipment chain grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Material</th>
<th>Tensile strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>Mild steel</td>
<td>300–490 (31–50)</td>
</tr>
<tr>
<td>U2(a)</td>
<td>Special quality steel (wrought)</td>
<td>490–690 (50–70)</td>
</tr>
<tr>
<td>U2(b)</td>
<td>Special quality steel (cast)</td>
<td>490–690 (50–70)</td>
</tr>
<tr>
<td>U3</td>
<td>Extra special quality steel</td>
<td>690 min. (70 min.)</td>
</tr>
</tbody>
</table>
(c) The windlass, with its braking system in action and in conditions simulating those likely to occur in service, is to be able to withstand, without permanent deformation or brake slip, a load, applied to the cable, given by:

\[ K_b d^2 (44 - 0.08d) \text{ N} \]

\[ (K_b d^2) (44 - 0.08d) \text{ kgf} \]

where

\[ K_b \text{ is given in Table 9.1.3.} \]

**NOTE**

The performance criteria are to be verified by means of shop tests in the case of windlasses manufactured on an individual basis. Windlasses manufactured under LR’s Type Approval Scheme will not require shop testing on an individual basis.

**Table 9.1.3 Windlass braking factors**

<table>
<thead>
<tr>
<th>Cable grade</th>
<th>Windlass used in conjunction with chain stopper</th>
<th>Chain stopper not fitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>4.41 (0.45)</td>
<td>7.85 (0.8)</td>
</tr>
<tr>
<td>U2</td>
<td>6.18 (0.63)</td>
<td>11.0 (1.12)</td>
</tr>
<tr>
<td>U3</td>
<td>8.83 (0.9)</td>
<td>15.7 (1.6)</td>
</tr>
</tbody>
</table>

1.7.4 Where shop testing is not possible and Type Approval has not been obtained, calculations demonstrating compliance with 1.7.3 are to be submitted, together with detailed plans and an arrangement plan showing the following components:

- Shafting.
- Gearing.
- Brakes.
- Clutches.

1.7.5 During trials on board the unit, the windlass should be shown to be capable of raising the anchor from a depth of 82.5 m to a depth of 27.5 m at a mean speed of not less than 9 m/min. Where the depth of water in the trial area is inadequate, suitable equivalent simulating conditions will be considered as an alternative.

1.7.6 The cable is to be capable of being paid out in the event of a power failure.

1.7.7 Windlass performance characteristics specified in 1.7.3 and 1.7.5 are based on the following assumptions:

- One cable lifter only is connected to the drive shaft.
- Continuous duty and short-term pulls are measured at the cable lifter.
- Brake tests are carried out with the brakes fully applied and the cable lifter declutched.
- The probability of declutching a cable lifter from the motor with its brake in the off position is minimised.
- Hawse pipe efficiency assumed to be 70 per cent.

1.7.8 An easy lead of the cables from the windlass or winch to the anchors and chain lockers or wire storage drum is to be arranged. Where cables pass over or through stoppers, these stoppers are to be manufactured from ductile material and be designed to minimise the probability of damage to, or snagging of, the cable. They are to be capable of withstanding without permanent deformation a load equal to 80 per cent of the Rule breaking load of the cable passing over them.

1.7.9 The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain or spurling pipes are to be of suitable size and provided with chafing lips. If more than one chain is to be stowed in one locker then the individual cables are to be separated by substantial divisions in the locker.

1.7.10 Provision is to be made for securing the inboard ends of the cables to the structure. This attachment should have a working strength of not less than 63.7 kN (6.5 tonne-f) or 10 per cent of the breaking strength of the chain cable, whichever is the greater, and the structure to which it is attached is to be adequate for this load. Attention is drawn to the advantages of arranging that the cable may be slipped in an emergency from an accessible position outside the chain locker.

1.7.11 Where wire rope cables are used, these are to be stored on suitable drums. The lead to the drums is to be such that the cables will reel onto the drums reasonably evenly. If the drums are designed to apply the full winch hauling load to the cables then the arrangements, using spooling gear or otherwise, are to ensure even reeling of the cables onto the drums.

1.7.12 Fairleads, hawse pipes, anchor racks and associated structure and components are to be of ample thickness and of a suitable size and form to house the anchors efficiently, preventing, as much as practicable, slackening of the cable or movements of the anchor being caused by wave action. The plating and framing in way of these components are to be reinforced as necessary. Columns, lower hulls, footings and other areas likely to be damaged by anchors, chain cables and wire ropes, etc., are to be suitably strengthened.

1.7.13 The design of the windlass is to be such that the following requirements or equivalent arrangements will minimise the probability of the chain locker or forecastle being flooded in bad weather:

- a weathertight connection can be made between the windlass bedplate, or its equivalent, and the upper end of the chain pipe;
- access to the chain pipe is adequate to permit the fitting of a cover or seal, of sufficient strength and proper design, over the chain pipe if the sea is liable to break over the windlass; and
- for column-stabilised units, see Ch 7.4.7.2.
1.8 Testing of equipment

1.8.1 All anchors and chain cables are to be tested at establishments and on machines recognised by LR and under the supervision of LR’s Surveyors or other Officers recognised by LR, and in accordance with the Rules for Materials.

1.8.2 Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the unit.

1.8.3 Steel wire ropes are to be tested as required by the Rules for Materials.

Section 2
Towing arrangements

2.1 General

2.1.1 All non-self-propelled units and other units not designed for unassisted sea passages are to be provided with adequate arrangements for towing.

2.1.2 Plans and full particulars of the unit’s towing facilities are to be submitted for approval, together with calculations or model test data supporting the assigned system design load. The maximum permitted static bollard pull for each towing arrangement is to be stated on the plans.

2.1.3 Particulars of the towing system, its design load and the operational instructions are to be incorporated in the Operations Manual.

2.2 Towing system

2.2.1 Units are to be provided with a main towing system suitable for towing with one or two towing vessels and in addition it is recommended that an emergency towing system is provided.

2.2.2 The emergency towing system may be arranged by using the unit’s anchor line or similar system.

2.2.3 The main towing system is to be suitable for the design load in accordance with 2.1.2 but is not to be taken less than 75 tonne-f.

2.2.4 The components of the towing system are to be manufactured and tested in accordance with Chapter 10 of the Rules for Materials.

2.2.5 The main towing system is to consist of not less than the following parts:
- Two attachments to the unit (e.g. towing brackets).
- Two chain/wire rope pendants connected to the unit.
- One triangular plate or equivalent.
- Two wire rope towlines as ‘weak links’.
- Shackles for connections.

2.2.6 Wire ropes are to have ‘hard eyes’ fitted at their ends.

2.2.7 Where towing bridles can be subjected to heavy wear due to chafing, chains are to be used.

2.2.8 The attachments to the unit are to be as far apart as practicable and on column-stabilised units the attachments are to be fitted to the lower hulls.

2.2.9 The length of the towing pendants attached to the unit is not to be less than the distance between the attachments.

2.2.10 The position and arrangement of the towing attachments are to be such that it is possible to change the chain/wire towing pendant connections quickly in calm water.

2.2.11 When towing with two towing vessels, each towline (weak link) is to be fitted between the unit’s towing pendants and the towlines of the towing vessels. When towing with one towing vessel, the towline (weak link) is to be connected between the triangular plate or equivalent and the towline of the towing vessel.

2.2.12 The length of each towline (weak link) is, in general, not to be less than 50 m so that the connection to the towline of the towing vessel is at a safe distance from the unit.

2.3 Strength

2.3.1 Each towing pendant connected to the unit is to have a minimum breaking strength of three times the design load, see 2.2.3.

2.3.2 The towline (weak link) is to have a breaking strength of approximately 85 per cent of the breaking strength of the towing pendant connected to the unit.

2.3.3 The towing pendant connections to the unit, triangular plate and shackles are to have a breaking strength greater than the strongest part of the towing system.

2.3.4 The attachments to the unit are to be designed for a towing direction of 0° to 90° off centreline port and starboard. Account is to be taken of the specified range of inclination angles.

2.3.5 Towing brackets or pad-eyes and their support structure are to be designed to the breaking strength of the attached towing pendant. The permissible stresses are to be in accordance with Ch 5,2.1.1(c).
2.4 Retrieval system

2.4.1 Means are to be provided to retrieve the unit’s towing pendants or bridle in the event that the towing vessel’s towline or the towline (weak link) should break.

2.5 Spare parts

2.5.1 It is recommended that an adequate number of spare parts for the towing system be provided on board during towing operations.
Section

1 General

2 Rudders

3 Fixed and steering nozzles

4 Steering gear and allied systems

5 Tunnel thrust unit structure

6 Stabiliser structure

Section 1

1.1 Application

1.1.1 This Chapter applies to all the unit types detailed in Part 3, and requirements are given for rudders, nozzles, steering gear, tunnel thrust unit structure and stabiliser structure.

1.1.2 Where units are fitted with conventional rudders, the scantlings and arrangements are to comply with the requirements of this Chapter.

1.1.3 Where a self-propelled unit is fitted with a non-conventional rudder or the rudder is omitted, special consideration will be given to the steering system so as to ensure that an acceptable degree of reliability and effectiveness is provided in order to achieve equivalence to the normal Rule requirements.

1.2 General symbols

1.2.1 The following symbols and definitions are applicable to this Chapter, unless otherwise stated:

\[ L, B, C_b \] as defined in Ch 1.5.1

\[ \sigma_0 = \text{minimum yield stress or 0.5 per cent proof stress of the material, in N/mm}^2 (\text{kgf/mm}^2) \]

\[ k = \text{higher tensile steel factor, see Ch 2.1.2.} \]

1.3 Navigation in ice

1.3.1 Where an ice class notation is included in the class of a unit, additional requirements are applicable as detailed in Pt 3, Ch 6.

1.4 Materials

1.4.1 The requirements for materials are contained in the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).

Section 2

Rudders

2.1 General

2.1.1 Requirements for rudders are given in Pt 3, Ch 13.2 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships), which should be complied with.

2.1.2 Where an OIWS (In-water Survey) notation is to be assigned, see also Pt 1, Ch 2.2.4.9, means are to be provided for ascertaining the rudder pintles and bush clearances and for verifying the security of the pintles in their sockets with the unit afloat.

Section 3

Fixed and steering nozzles

3.1 General

3.1.1 Requirements for fixed and steering nozzles are given in Pt 3, Ch 13.3 of the Rules for Ships, which should be complied with.

Section 4

Steering gear and allied systems

4.1 General

4.1.1 Requirements for steering gear are given in Pt 5, Ch 19.

4.1.2 When units are fitted with steering arrangements consisting of Azimuth thrusters, see Pt 5, Ch 20.

Section 5

Tunnel thrust unit structure

5.1 General

5.1.1 Requirements for tunnel thrust unit structure are given in Pt 3, Ch 13.5 of the Rules for Ships, which should be complied with.

5.1.2 Thrust units are to be enclosed in suitable watertight spaces to prevent flooding in the case of leakage or damage to the thrust unit.
Section 6
Stabiliser structure

6.1 General

6.1.1 Requirements for stabiliser structure are given in Pt 3, Ch 13.6 of the Rules for Ships, which should be complied with.
Quality Assurance Scheme (Hull)

Part 4, Chapter 11

Sections 1 & 2

1 Section 1

1.1 Definitions

1.1.1 Quality Assurance Scheme. LR’s Quality Assurance requirements for the hull construction of mobile offshore units are defined as follows:

(a) Quality Assurance. All activities and functions concerned with the attainment of quality including documentary evidence to confirm that such attainment is met.

(b) Quality system. The organisation structure, responsibilities, activities, resources and events laid down by Management that together provide organised procedures (from which data and other records are generated) and methods of implementation to ensure the capability of the fabrication yard to meet quality requirements.

(c) Quality programme. A documented set of activities, resources and events serving to implement the quality system of an organisation.

(d) Quality plan. A document derived from the quality programme setting out the specific quality practices, special processes, resources and activities relevant to a particular unit or series of similar units. This document will also indicate the stages at which, as a minimum, direct survey and/or system monitoring will be carried out by the Classification Surveyor.

(e) Quality control. The operational techniques and activities used to measure and regulate the quality of construction to the required level.

(f) Inspection. The process of measuring, examining, testing, gauging or otherwise comparing the item with the approved drawings and the fabrication yard’s written standards, including those which have been agreed by LR for the purposes of classification of the specific type of unit concerned.

1.2 Scope of the Quality Assurance Scheme

1.2.1 This Chapter specifies the minimum Quality system requirements for a fabrication yard to construct mobile offshore units under LR’s Quality Assurance Scheme.

1.2.2 For the purposes of this Chapter of the Rules, ‘construction (hull)’ comprises the primary bracings, columns, legs, footings, hull structure, appendages, superstructure, deckhouses and closing appliances, all as required by the Rules.

1.2.3 Although the requirements of this scheme are, in general, for steel structures of all welded construction, other materials for use in hull construction will be considered.

2 Section 2

2.1 Certification of the fabrication yard

2.1.1 Requirements for application are given in Pt 3, Ch 15,2 of the Rules for Ships, which should be complied with.
Quality Assurance Scheme (Hull)

Section 3
Particulars to be submitted

3.1 Documentation and procedures

3.1.1 Requirements for particulars to be submitted are given in Pt 3, Ch 15,3 of the Rules for Ships, which should be complied with.

Section 4
Requirements of Parts 1 and 2 of the Scheme

4.1 General

4.1.1 Requirements for Parts 1 and 2 of the scheme are given in Pt 3, Ch 15,4 of the Rules for Ships, which should be complied with.

Section 5
Additional requirements for Part 2 of the Scheme

5.1 Quality System procedures

5.1.1 Additional requirements for Part 2 of the scheme are given in Pt 3, Ch 15,5 of the Rules for Ships, which should be complied with.

Section 6
Initial assessment of fabrication yard

6.1 General

6.1.1 Requirements for the initial assessment of the Shipyard are given in Pt 3, Ch 15,6 of the Rules for Ships, which should be complied with.

Section 7
Approval of the fabrication yard

7.1 General

7.1.1 Requirements for approval of the shipyard are given in Pt 3, Ch 15,7 of the Rules for Ships, which should be complied with.

Section 8
Maintenance of approval

8.1 General

8.1.1 Requirements for maintenance of approval are given in Pt 3, Ch 15,8 of the Rules for Ships, which should be complied with.

Section 9
Suspension or withdrawal of approval

9.1 General

9.1.1 Requirements for suspension or withdrawal of approval are given in Pt 3, Ch 15,9 of the Rules for Ships, which should be complied with.
Section A1  General

A1.1  Application


A1.1.2  All tubular joints are assigned Class T. Other types of joints are assigned Class B, C, D, E, F, F2, G or W depending upon:

- geometric arrangements;
- direction of applied stress; and
- method of fabrication and inspection.

A1.1.3  Details of the design S-N curves are given in Section A2, joint classifications are given in Section A3.

A1.1.4  Guidance on the determination of global stress concentration factors is given in Section A4.

A1.1.5  Other methods may be used after special consideration and agreement with LR. Detailed proposals are to be submitted.

Section A2  Fatigue design S-N curves

A2.1  Basic design S-N curves

A2.1.1  The basic design curves consist of linear relationships between \( \log(S_B) \) and \( \log(N) \). They are based upon a statistical analysis of appropriate experimental data and may be taken to represent two standard deviations below the mean line. Thus the basic S-N curves are of the form:

\[
\log(N) = \log(K_1) - d \sigma - m \log(S_B)
\]

where

- \( N \) = the predicted number of cycles to failure under stress range \( S_B \)
- \( K_1 \) = a constant relating to the mean S-N curve
- \( d \) = the number of standard deviations below the mean
- \( \sigma \) = the standard deviation of \( \log N \)
- \( m \) = the inverse slope of the S-N curve.

The relevant values of these terms are shown in Table A2.1. Table A2.1 also shows the value of \( K_2 \)

\[
\log(K_2) = \log(K_1) - 2\sigma
\]

which is relevant to the basic design curves (i.e. for \( d = 2 \)).

A2.2  Modifications to basic S-N curves

A2.2.1  The factors listed in this sub-Section are to be considered when using the basic S-N curve.

A2.2.2  Unprotected joints in sea-water. For joints without adequate corrosion protection which are exposed to sea water the basic S-N curve is reduced by a factor of two on life for all joint classes.

Note

For high strength steels, i.e. \( \sigma_y > 400 \text{ N/mm}^2 \), a penalty factor of two may not be adequate. In addition the correction relating to the numbers of small stress cycles is not applicable.

A2.2.3  Effect of plate thickness. The fatigue strength of welded joints is to some extent dependent on plate thickness, strength decreasing with increasing thickness. The basic S-N curves shown in Figs. A2.2 and A2.3 relate to thicknesses as follows:

- Nodal joints (Class T) up to 32 mm
- Non-nodal joints (Classes B-G) up to 22 mm.

For joints of other thicknesses, correction factors on life or stress have to be applied to produce a relevant S-N curve. The correction on stress range is of the form:

\[
S = S_B \left( \frac{t_B}{t} \right)^{1/4}
\]

where

- \( S \) = the fatigue strength of the joint under consideration
- \( S_B \) = the fatigue strength of the joint using the basic S-N curve
- \( t \) = the actual thickness of the member under consideration
- \( t_B \) = the thickness relevant to the basic S-N curve

Substituting the above relationship in the basic S-N curve equation in A2.1.1 and using the equation for \( \log(K_2) \) in A2.1.1 yields the following equation of the S-N for a joint member thickness \( t \):

\[
\log(N) = \log(K_2) - m \log \left( \frac{S}{S_B} \left( \frac{t_B}{t} \right)^{1/4} \right)
\]

A value of \( t = 22 \text{ mm} \) should be used for calculating endurance \( N \) when the actual thickness is less than 22 mm.

Note

This gives a benefit for nodal joints with wall thicknesses in the range of 22 to 32 mm.
A2.2.4 Weld improvement. For welded joints involving potential fatigue cracking from the weld toe, an improvement in strength by at least 30 per cent, equivalent to a factor of 2.2 on life, can be obtained by controlled local machining or grinding of the weld toe. This is to be carried out either with a rotary burr or by disc grinding. The treatment should produce a smooth concave profile at the weld toe with the depth of the depression penetrating into the plate surface to at least 0.5 mm below the bottom of any visible undercut, see Fig. A2.1, and ensuring that no exposed defects remain. The maximum depth of local machining or grinding is not to exceed 2 mm or five per cent of the plate thickness. In the case of a multi-pass weld more than one weld toe may need to be dressed. Where toe grinding is used to improve the fatigue life of fillet welded connections, care should be taken to ensure that the required throat size is maintained. The benefit of grinding is only applicable for welded joints which are adequately protected from sea-water corrosion. Any credit for other beneficial treatments should be justified. It is recommended that no advantage for toe grinding should be taken at the initial design stage. Overall weld profiling is preferred but no improvement in fatigue strength can be allowed unless accompanied by toe grinding. In the case of partial penetration welds, where failure may occur from the weld root, grinding of the weld toe cannot be relied upon to give an increase in strength.

A2.2.5 Special consideration will be given to alternative techniques intended to improve weld quality. Detailed proposals are to be submitted.

### Table A2.1 Details of basic S-N curves

<table>
<thead>
<tr>
<th>Class</th>
<th>(K_1) (\log_{10})</th>
<th>(K_1) (\log_e)</th>
<th>(m)</th>
<th>Standard deviation (\log_{10})</th>
<th>(\log_e)</th>
<th>(K_2) (N/mm^2)</th>
<th>(S_o)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>(2.343 \times 10^{15})</td>
<td>15,3697</td>
<td>35,3900</td>
<td>4.0</td>
<td>0.1821</td>
<td>0.4194</td>
<td>1.01 (\times 10^{15})</td>
</tr>
<tr>
<td>C</td>
<td>(1.082 \times 10^{14})</td>
<td>14.0342</td>
<td>32.3153</td>
<td>3.5</td>
<td>0.2041</td>
<td>0.4700</td>
<td>4.23 (\times 10^{13})</td>
</tr>
<tr>
<td>D</td>
<td>(3.988 \times 10^{12})</td>
<td>12.6007</td>
<td>29.0144</td>
<td>3.0</td>
<td>0.2065</td>
<td>0.4824</td>
<td>1.52 (\times 10^{12})</td>
</tr>
<tr>
<td>E</td>
<td>(3.289 \times 10^{12})</td>
<td>12.5169</td>
<td>28.8216</td>
<td>3.0</td>
<td>0.2509</td>
<td>0.5777</td>
<td>1.04 (\times 10^{12})</td>
</tr>
<tr>
<td>F</td>
<td>(1.289 \times 10^{12})</td>
<td>12.2370</td>
<td>28.1770</td>
<td>3.0</td>
<td>0.2183</td>
<td>0.5027</td>
<td>0.63 (\times 10^{12})</td>
</tr>
<tr>
<td>F2</td>
<td>(1.231 \times 10^{12})</td>
<td>12.0900</td>
<td>27.8387</td>
<td>3.0</td>
<td>0.2279</td>
<td>0.5248</td>
<td>0.43 (\times 10^{12})</td>
</tr>
<tr>
<td>G</td>
<td>(0.566 \times 10^{12})</td>
<td>11.7525</td>
<td>27.0614</td>
<td>3.0</td>
<td>0.1793</td>
<td>0.4129</td>
<td>0.25 (\times 10^{12})</td>
</tr>
<tr>
<td>W</td>
<td>(0.368 \times 10^{12})</td>
<td>11.5662</td>
<td>26.6324</td>
<td>3.0</td>
<td>0.1846</td>
<td>0.4251</td>
<td>0.16 (\times 10^{12})</td>
</tr>
<tr>
<td>T</td>
<td>(4.577 \times 10^{12})</td>
<td>12.6606</td>
<td>29.1520</td>
<td>3.0</td>
<td>0.2484</td>
<td>0.5720</td>
<td>1.46 (\times 10^{12})</td>
</tr>
</tbody>
</table>

NOTES
1. Idealised hot spot stress
2. For example, the T curve expressed in terms of \(\log_{10}\) is:
   \[
   \log_{10}(N) = 12.6606 - 0.2484d - 3\log_{10}(S_B)
   \]

---

**Fig. A2.1** Weld improvements
Fig. A2.2 Basic design S-N curve for non-nodal joints
Fig. A2.3  Basic design S-N curves for nodal joints.
A2.3 Treatment of low stress cycles

A2.3.1 Under constant amplitude stresses there is a certain stress range, which varies both with the environment and with the size of any initial defects, below which an indefinitely large number of cycles can be sustained. In air and sea-water with adequate protection against corrosion, and with details fabricated in accordance with this Appendix, it is assumed that this non-propagating stress range, $S_o$, is the stress corresponding to $N = 10^7$ cycles; relevant values of $S_o$ are shown in Table A2.1.

A2.3.2 When the applied fluctuating stress has varying amplitude, so that some of the stress ranges are greater and some less than $S_o$, the larger stress ranges will cause growth of the defect, thereby reducing the value of the non-propagating stress range below $S_o$. In time, an increasing number of stress ranges, below $S_o$ can themselves contribute to crack growth. The final result is an earlier fatigue failure than could be predicted by assuming that all stress ranges below $S_o$ are ineffective.

A2.3.3 An adequate estimate of this behaviour can be made by assuming that the S-N curve has a change of inverse slope from $m$ to $m + 2$ at $N = 10^7$ cycles. This correction does not apply in the case of unprotected joints in sea-water.

A2.4 Treatment of high stress cycles

A2.4.1 For high stress cycles the design S-N curve for nodal joints (the T curve) may be extrapolated back linearly to a stress range equal to twice the material yield stress $2\sigma_y$.

A2.4.2 An example of the high stress cycle limit for the T curve is given in Fig. A2.4.

A2.4.3 A similar procedure can be adopted for non-nodal joints (Classes B-G) where local bending or other structural stress concentrating features are involved and the relevant stress range includes the stress concentration.

A2.4.4 If the joint is in a region of simple membrane stress then the design S-N curves may be extrapolated back linearly to a stress range given by twice the tensile stress limitations given in these Rules.

A2.4.5 For the Class W curve, extrapolation may be made back as for the non-nodal joints but to a stress range defined by half the values given above (i.e. with reference to shear instead of tensile stress).
Fig. A2.4 Treatment of high cyclic stresses for the T-curve and a material with yield stress = 350 N/mm²
Section A3

Fatigue joint classification

A3.1 General

Fatigue joint classification details including notes on mode of failure and typical examples are given in Table A3.1.

Table A3.1  Fatigue joint classification (see continuation)

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE 1  MATERIAL FREE FROM WELDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notes on potential modes of failure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In plain steel, fatigue cracks initiate at the surface, usually either at surface irregularities or at corners of the cross-section. In welded construction, fatigue failure will rarely occur in a region of plain material since the fatigue strength of the welded joints will usually be much lower. In steel with rivet or bolt holes or other stress concentrations arising from the shape of the member, failure will usually initiate at the stress concentration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Plain steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) In the as-rolled condition, or with cleaned surfaces but with no flame-cut edges of re-entrant corners.</td>
<td>B Beware of using Class B for a member which may acquire stress concentration during its life, e.g. as a result of rust pitting. In such an event Class C would be more appropriate.</td>
<td></td>
</tr>
<tr>
<td>(b) As (a) but with any flame-cut edges subsequently ground or machined to remove all visible sign of the drag lines.</td>
<td>B Any re-entrant corners in flame-cut edges should have a radius greater than the plate thickness.</td>
<td></td>
</tr>
<tr>
<td>(c) As (a) but with the edges machine flame-cut by a controlled procedure to ensure that the cut surface is free from cracks.</td>
<td>C Note, however, that the presence of a re-entrant corner implies the existence of a stress concentration so that the design stress should be taken as the net stress multiplied by the relevant stress concentration factor.</td>
<td></td>
</tr>
<tr>
<td><strong>TYPE 2  CONTINUOUS WELDS ESSENTIALLY PARALLEL TO THE DIRECTION OF APPLIED STRESS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notes on potential modes of failure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With the excess weld metal dressed flush, fatigue cracks would be expected to initiate at weld defect locations. In the as-welded condition, cracks might initiate at stop-start positions or, if these are not present, at weld surface ripples. General comments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Backing strips:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If backing strips are used in making these joints: (i) they must be continuous; and (ii) if they are attached by welding those welds must also comply with the relevant Class requirements (note particularly that tack welds, unless subsequently ground out or covered by a continuous weld, would reduce the joint to Class F, see joint 6.5).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Edge distance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An edge distance criterion exists to limit the possibility of local stress concentrations occurring at unwelded edges as a result for example, of undercut, weld spatter or accidental overweave in manual fillet welding (see also notes on joint Type 4). Although an edge distance can be specified only for the ‘width’ direction of an element, it is equally important to ensure that no accidental undercutting occurs on the unwelded corners of, for example, cover plates or box girder flanges. If it does occur it should subsequently be ground smooth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Full or partial penetration butt welds, or fillet welds. Parent or weld metal in members, without attachments built up of plates or sections, and joined by continuous welds.</td>
<td>B The significance of defects should be determined with the aid of specialist advice and/or by the use of fracture mechanics analysis. The NDT technique must be selected with a view to ensuring the detection of such significant defects.</td>
<td></td>
</tr>
<tr>
<td>(a) Full penetration butt welds with the weld overfill dressed flush with the surface and finish-machined in the direction of stress, and with the weld proved free from significant defects by non-destructive examination.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Butt or fillet welds with the welds made by an automatic submerged or open arc process and with no stop-start positions within the length.</td>
<td>C If an accidental stop-start occurs in a region where Class C is required remedial action should be taken so that the finished weld has a similar surface and root profile to that intended.</td>
<td></td>
</tr>
<tr>
<td>(c) As (b) but with the weld containing stop-start positions within the length.</td>
<td>D For situation at the ends of flange cover plates see joint Type 6.4.</td>
<td></td>
</tr>
</tbody>
</table>
Fatigue – S-N Curves, Joint Classification and Stress Concentration Factors

Part 4, Appendix A
Section A3

Table A3.1 Fatigue joint classification (continued)

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE 3 TRANSVERSE BUTT WELDS IN PLATES (i.e. essentially perpendicular to the direction of applied stress)</td>
<td>Note that this includes butt welds which do not completely traverse the member, such as circular welds used for inserting infilling plates into temporary holes.</td>
<td></td>
</tr>
<tr>
<td>Notes on potential modes of failure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With the weld ends machined flush with the plate edges, fatigue cracks in the as-welded condition normally initiate at the weld toe, so that the fatigue strength depends largely upon the shape of the weld overfill. If this is dressed flush the stress concentration caused by it is removed and failure is then associated with weld defects. In welds made on a permanent backing strip, fatigue cracks initiate at the weld metal/strip junction and in partial penetration welds (which should not be used under fatigue conditions), at the weld root.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welds made entirely from one side, without a permanent backing, require care to be taken in the making of the root bead in order to ensure a satisfactory profile.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design stresses:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the design of butt welds of Types 3.1 or 3.2 which are not aligned, the stresses must include the effect of any eccentricity. An approximate method of allowing for eccentricity in the thickness direction is to multiply the normal stress by ( (1 + 3 \frac{e}{t}) ), where ( e ) is the distance between centres of thickness of the two abutting members; if one of the members is tapered, the centre of the untapered thickness must be used; and ( t ) is the thickness of the thinner member.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With connections which are supported laterally, e.g. flanges of a beam which are supported by the web, eccentricity may be neglected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Parent metal adjacent to or weld metal in full penetration butt joints welded from both sides between plates of equal width and thickness or where differences in width and thickness are machined to a smooth transition not steeper than 1 in 4.</td>
<td>Note that this includes butt welds which do not completely traverse the member, such as circular welds used for inserting infilling plates into temporary holes.</td>
<td></td>
</tr>
<tr>
<td>(a) With the weld overfill dressed flush with the surface and with the weld proved free from significant defects by non-destructive examination.</td>
<td>C The significance of defects should be determined with the aid of specialist advice and/or by the use of fracture mechanic analysis. The NDT technique must be selected with a view to ensuring the detection of such significant defects.</td>
<td></td>
</tr>
<tr>
<td>(b) With the welds made, either manually or by an automatic process, other than submerged arc, provided all runs are made in the downhand position.</td>
<td>D In general, welds made by the submerged arc process, or in positions other than downhand, tend to have a poor reinforcement shape, from the point of view of fatigue strength. Hence such welds are downgraded from D to E.</td>
<td></td>
</tr>
<tr>
<td>(c) Welds made other than in (a) or (b).</td>
<td>E In both (b) and (c) of the corners of the cross-section of the stressed element at the weld toes should be dressed to a smooth profile. Note that step changes in thickness are in general, not permitted under fatigue conditions, but that where the thickness of the thicker member is not greater than 1.15 x the thickness of the thinner member, the change can be accommodated in the weld profile without any machining. Step changes in width lead to large reductions in strength (see joint Type 3.3).</td>
<td></td>
</tr>
<tr>
<td>3.2 Parent metal adjacent to, or weld metal in, full penetration butt joints made on a permanent backing strip between plates of equal width and thickness or with differences in width and thickness machined to a smooth transition not steeper than 1 in 4.</td>
<td>F Note that if the backing strip is fillet welded or tack welded to the member the joint could be reduced to Class G (joint Type 4.2).</td>
<td></td>
</tr>
</tbody>
</table>
Table A3.1  Fatigue joint classification (continued)

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 Parent metal adjacent to, or weld metal in, full penetration butt welded joints made from both sides between plates of unequal width, with the weld ends ground to a radius not less than 1.25 times the thickness ( t ).</td>
<td>F2</td>
<td>Step changes in width can often be avoided by the use of shaped transition plates, arranged so as to enable butt welds to be made between plates of equal width. Note that for this detail the stress concentration has been taken into account in the joint classification.</td>
</tr>
<tr>
<td>4.1 Parent metal (of the stressed member) adjacent to toes or ends of bevel-butt or fillet welded attachments, regardless of the orientation of the weld to the direction of applied stress and whether or not the welds are continuous round the attachment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) With attachment length (parallel to the direction of the applied stress) ( \leq 150 \text{ mm} ) and with edge distance ( \geq 10 \text{ mm} ).</td>
<td>F</td>
<td>The decrease in fatigue strength with increasing attachment length is because more load is transferred into the longer gusset giving an increase in stress concentration.</td>
</tr>
<tr>
<td>(b) With attachment length (parallel to the direction of the applied stress) ( &gt; 150 \text{ mm} ) and with edge distance ( \leq 10 \text{ mm} ).</td>
<td>F2</td>
<td></td>
</tr>
<tr>
<td>4.2 Parent metal (of the stressed member) at the toes or the ends of butt or fillet welded attachments on or within 10 mm of the edge or corners of a stressed member and regardless of the shape of the attachment.</td>
<td>G</td>
<td>Note that the classification applies to all sizes of attachment. It would therefore include, for example, the junction of two flanges at right angles. In such situations a low fatigue classification can often be avoided by the use of a transition plate (see also joint Type 3.3).</td>
</tr>
<tr>
<td>4.3 Parent metal (of the stressed member) at the toe of a butt weld connecting the stressed member to another member slotted through it.</td>
<td></td>
<td>Note that this classification does not apply to fillet welded joints (see joint Type 5.1b). However it does apply to loading in either direction (L or T in the sketch).</td>
</tr>
<tr>
<td>(a) With the length of the slotted-through member, parallel to the direction of the applied stress, ( \leq 150 \text{ mm} ) and with edge distance ( \geq 10 \text{ mm} ).</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>(b) With the length of the slotted-through member, parallel to the direction of the applied stress, ( &gt; 150 \text{ mm} ) and with edge distance ( \geq 10 \text{ mm} ).</td>
<td>F2</td>
<td></td>
</tr>
<tr>
<td>(c) With edge distance ( &lt; 10 \text{ mm} ).</td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>
### TYPE 5  LOAD-CARRYING FILLET AND T BUTT WELDS

Notes on potential modes of failure:

Failure in cruciform or T joints with full penetration welds will normally initiate at the weld toe, but in joints made with load-carrying fillet or partial penetration butt welds cracking may initiate either at the weld toe and propagate into the plate or at the weld root and propagate through the weld. In welds parallel to the direction of the applied stress, however, weld failure is uncommon, cracks normally initiate at the weld end and propagate into the plate perpendicular to the direction of applied stress. The stress concentration is increased, and the fatigue strength is therefore reduced, if the weld end is located on or adjacent to the edge of a stressed member rather than on its surface.

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
</table>
| 5.1 Joint description
  Parent metal adjacent to cruciform joints or T joints (member marked X in sketches).

(a) Joint made with full penetration welds and with any undercutting at the corners of the member dressed out by local grinding. | Member Y can be regarded as one with a non-load-carrying weld (see joint Type 4.1). Note that in this instance the edge distance limitation applies. |
| (b) Joint made with partial penetration or fillet welds with any undercutting at the corners of the member dressed out by local grinding. | F2 In this type of joint, failure is likely to occur in the weld throat unless the weld is made sufficiently large (see joint Type 5.4). |
| 5.2 Parent metal adjacent to the toe of load-carrying fillet welds which are essentially transverse to the direction of applied stress (member X in sketch).

(a) Edge distance ≥10 mm. | F2 These classifications also apply to joints with longitudinal weld only. |
| (b) Edge distance <10 mm. | G |
| 5.3 Parent metal at the ends of load-carrying fillet welds which are essentially parallel to the direction of applied stress, with the weld end on plate edge (member Y in sketch). | G |
| 5.4 Weld metal in load-carrying joints made with fillet or partial penetration welds, with the welds either transverse or parallel to the direction of applied stress (based on nominal shear stress on the minimum weld throat area). | W This includes joints in which a pulsating load may be carried in bearing, such as the connection of bearing stiffeners to flanges. In such examples the welds should be designed on the assumption that none of the load is carried in bearing. |
### Type number, description and notes on mode of failure

**6.1 Parent metal at the toe of a weld connecting a stiffener, diaphragm, etc., to a girder flange.**

(a) Edge distance $\geq 10$ mm (see joint Type 4.2).

(b) Edge distance $<10$ mm.

**6.2 Parent metal at the end of a weld connecting a stiffener, diaphragm, etc., to a girder web in a region of combined bending and shear.**

E This classification includes all attachments to girder webs.

**6.3 Parent metal adjacent to welded shear connectors.**

(a) Edge distance $\geq 10$ mm.

(b) Edge distance $<10$ mm (see Type 4.2).

**6.4 Parent metal at the end of a partial length welded cover plate, regardless of whether the plate has square or tapered ends and whether or not there are welds across the ends.**

G This Class includes cover plates which are wider than the flange. However, such a detail is not recommended because it will almost inevitably result in undercutting of the flange edge where the transverse weld crosses it, as well as involving a longitudinal weld terminating on the flange edge and causing a high stress concentration.

**6.5 Parent metal adjacent to the ends of discontinuous welds, e.g. intermittent web/flange welds, tack welds unless subsequently buried in continuous runs.**

E This also includes tack welds which are not subsequently buried in a continuous weld. This may be particularly relevant in tack welded backing strips. Note that the existence of the cope hole is allowed for in the joint classification, it should not be regarded as an additional stress concentration.

**Ditto, adjacent to cope holes.**

F

### Class explanatory comments

Edge distance refers to distance from a free, i.e. unwelded edge. In this example, therefore, it is not relevant as far as the (welded) edge of the web plate is concerned. For reason for edge distance see note on joint Type 2.

This classification includes all attachments to girder webs.

This also includes tack welds which are not subsequently buried in a continuous weld.

Note that the existence of the cope hole is allowed for in the joint classification, it should not be regarded as an additional stress concentration.

### Examples, including failure modes

**TYPE 7 DETAILS RELATING TO TUBULAR MEMBERS**

**7.1 Parent material adjacent to the toes of full penetration welded nodal joints.**

T In this situation design should be based on the hot spot stress as defined in Ch 5.5 (see also this Section for guidance on partial penetration welds).
### Type number, description and notes on mode of failure

#### 7.2 Parent metal at the toes of welds associated with small (≤150 mm in the direction parallel to the applied stress) attachments to the tubular member.
- As above, but with attachment length >150 mm.

#### 7.3 Gusseted connections made with full penetration or fillet welds. (But note that full penetration welds are normally required).
- Note that the design stress must include any local bending stress adjacent to the weld end.
- For failure in the weld throat of fillet welded joints.

#### 7.4 Parent material at the toe of a weld attaching a diaphragm or stiffener to a tubular member.
- Stress should include the stress concentration factor due to overall shape of adjoining structure.

#### 7.5 Parent material adjacent to the toes of circumferential butt welds between tubes.
- In this type of joint the stress should include the stress concentration factor to allow for any thickness change and for fabrication tolerances.

#### Notes:
- **C** The significance of defects should be determined with the aid of specialist advice and/or by the use of fracture mechanics analysis. The NDT technique should be selected with a view to ensuring the detection of such significant defects.
- **E** Note that step changes in thickness are, in general, not permitted under fatigue conditions, but that where the thickness of the thicker member is not greater than 1.15 x the thickness of the thinner member, the change can be accommodated in the weld profile without any machining.

### Table A3.1 Fatigue joint classification (continued)

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2 Parent metal at the toes of welds associated with small (≤150 mm in the direction parallel to the applied stress) attachments to the tubular member. As above, but with attachment length &gt;150 mm.</td>
<td>F</td>
<td><img src="440726" alt="Image" /></td>
</tr>
<tr>
<td>7.3 Gusseted connections made with full penetration or fillet welds. (But note that full penetration welds are normally required).</td>
<td>F</td>
<td><img src="440737" alt="Image" /></td>
</tr>
<tr>
<td>7.4 Parent material at the toe of a weld attaching a diaphragm or stiffener to a tubular member.</td>
<td>F</td>
<td><img src="440727" alt="Image" /></td>
</tr>
<tr>
<td>7.5 Parent material adjacent to the toes of circumferential butt welds between tubes.</td>
<td>In this type of joint the stress should include the stress concentration factor to allow for any thickness change and for fabrication tolerances.</td>
<td><img src="440728" alt="Image" /></td>
</tr>
<tr>
<td>(a) Welds made from both sides with the weld overfill dressed flush with the surface and with the weld proved free from significant defects by non-destructive examination.</td>
<td>C</td>
<td><img src="440729" alt="Image" /></td>
</tr>
<tr>
<td>(b) Weld made from both sides.</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>(c) Weld made from one side on a permanent backing strip.</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>(d) Weld made from one side without a backing strip provided that full penetration is achieved.</td>
<td>F2</td>
<td><img src="440729" alt="Image" /></td>
</tr>
</tbody>
</table>
### Table A3.1  Fatigue joint classification (conclusion)

<table>
<thead>
<tr>
<th>Type number, description and notes on mode of failure</th>
<th>Class explanatory comments</th>
<th>Examples, including failure modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6 Parent material at the toes of circumferential butt welds between tubular and conical section.</td>
<td>C Class and stress should be those corresponding to the joint type as indicated in 7.5, but the stress must also include the stress concentration factor due to overall form of the joint.</td>
<td><img src="4407/30" alt="Example" /></td>
</tr>
<tr>
<td>7.7 Parent material of the stressed member adjacent to the toes of bevel butt or fillet welded attachments in a region of stress concentration.</td>
<td>F or F2 Class depends on attachment length (see Type 4.1) but stress should include the stress concentration factor due to overall shape of adjoining structure.</td>
<td><img src="4407/31" alt="Example" /></td>
</tr>
<tr>
<td>7.8 Parent metal adjacent to, or weld metal in, welds around a penetration through the wall of a member (on a plane essentially perpendicular to the direction of stress). Note that full penetration welds are normally required in this situation.</td>
<td>D In this situation the relevant stress should include the stress concentration factor due to the overall geometry of the detail.</td>
<td><img src="4407/32" alt="Example" /></td>
</tr>
<tr>
<td>7.9 Weld metal in partial penetration or fillet welded joints around a penetration through the wall of a member (on a plane essentially parallel to the direction of stress).</td>
<td>W The stress in the weld should include an appropriate stress concentration factor to allow for the overall joint geometry.</td>
<td><img src="4407/33" alt="Example" /></td>
</tr>
</tbody>
</table>
Section A4

Stress concentration factors

A4.1 General

A4.1.1 In general, any discontinuity in a stressed structure results in a local increase in stress at the discontinuity. The ratio of the peak stress at the discontinuity to the nominal average stress that would prevail in the absence of the discontinuity is commonly referred to as the stress concentration factor (SCF). The peak stress (i.e. nominal stress x SCF) is normally used in conjunction with an appropriate S-N curve to derive the estimated fatigue life.

A4.1.2 The design weld S-N curves are given in Section A2 for the particular joint arrangements given in Section A3.

A4.1.3 Stress concentration factors may be derived using a number of different methods, such as finite element techniques, closed form analytical formula or from model tests. For complex arrangements, a detailed finite element based analysis will most likely be required.

A4.1.4 For semi-submersible units, experience has shown that the areas of minimum fatigue life are usually found at the joints, stiffener terminations, penetrations in primary bracings and also at their junctions with hull, columns and decks. For jack-up structures locations of minimum fatigue life are usually found on the lattice legs and support structure. Other structures subjected to significant cyclic loading also require assessment.

A4.1.5 Stress concentration factors for tubular brace to chord connections may be determined from LR’s technical report Recommended Parametric Stress Concentration Factors or an equivalent standard.

A4.1.6 Where finite element methods are used to determine local stress distributions for fatigue assessment, the geometric hot spot stress should account for the effect of structural discontinuities, excluding the presence of the weld. Misalignment of structural members should be accounted for where applicable.

A4.1.7 Linear extrapolation over reference points at 0.5 and 1.5 x plate thickness away from the point of interest (normally the weld toe) may be made to determine the geometric hot spot stress.

A4.1.8 In general, the geometric hot spot stress can be used in conjunction with the D class S-N curve given in Fig. A2.2.

A4.1.9 The maximum fabrication axial misalignment for fatigue prone locations would normally be limited to the smaller of 0.1 x t or 3 mm.

\[
t = \text{thickness of thinner plate}
\]

The maximum angular misalignment would be limited to the smaller of 0.001 x length of member or 3 mm. For this guidance, it may be assumed that the effects of these maximum fabrication misalignments are included within the S-N classification.