INDIAN REGISTER OF SHIPPING

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF FIXED OFFSHORE STEEL STRUCTURES

July 2023



General Information

This consolidated version of the 'Rules and Regulations for the Construction and Classification of Fixed Offshore Steel Structures' (July 2023) supersedes the July 2022 edition of the Rules.

This edition of the Rules consists of amendments carried out subsequent to the publication of July 2022 edition of the Rules. Such amendments are indicated in **Table 1.**

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF FIXED OFFSHORE STEEL STRUCTURES – July 2023

TABLE 1 – AMENDMENTS INCORPORATED IN THIS EDITION *These amendments will come into force as indicated in the Table*

 Section / Clause
 Subject/ Amendments

 Chapter 1: General
 The amendments are applicable from 1 July 2023

 1/ 1.3.1
 Editorial amendments are made for better clarity.

Indian Register of Shipping

Rules and Regulations for the Construction and Classification of Fixed Offshore Steel Structures

July 2023

Contents

- Chapter 1 General
- Chapter 2 Surveys
- Chapter 3 Materials and Welding
- Chapter 4 Environmental Conditions
- Chapter 5 Design Loads
- Chapter 6 Structural Design
- Chapter 7 Soil Foundation
- Chapter 8 Marine Operations

Rules and Regulations for the Construction and Classification of Fixed Offshore Steel Structures - 2023 Page 1 of 5

Contents

Chapter 1 : General

Section 1 : General Information

1.1 Indian Register of Shipping

1.2 Fees

1.3 Survey reports

1.4 Register of Ships

1.5 Liability

1.6 Access of Surveyor to structure, shipyards or works

1.7 Compliance with statutory requirements

Section 2 : Classification Regulations

2.1 General

- 2.2 Application of Rules
- 2.3 Interpretations of the Rules

2.4 Character of classification and Class Notations

2.5 Materials, components, equipment and machinery

2.6 Request for surveys

2.7 Repairs

2.8 Alterations

2.9 Date of build

2.10 Appeal from Surveyors' recommendations

2.11 Certificates

2.12 Suspension, withdrawal and deletion of class

2.13 Reclassification of offshore structure

Section 3 : Classification of Fixed Offshore Steel Structures Built under the Survey of Indian Register of Shipping

- 3.1 Classification of new constructions
- 3.2 Plans and design data
- 3.3 Information manual
- 3.4 Records

Section 4 : Classification of Existing Fixed Offshore Steel Structures not built under the Survey of Indian Register of Shipping

4.1 General procedure for classification of fixed offshore structure not built under survey of IRS

4.2 Plans and data to be furnished as required in 4.1.1 $\,$

Chapter 2 : Surveys

| Section 1 : General Requirements | Section 2 : Annual Surveys |
|----------------------------------|--------------------------------|
| 1.1 General | 2.1 General |
| 1.2 Provision for surveys | 2.2 Survey requirements |
| 1.3 Survey Planning | Section 3 : Special Surveys |
| 1.4 Thickness measurement | 3.1 General |
| 1.5 Reactivation surveys | 3.2 Special continuous surveys |
| 1.6 Surveys after damage | 3.3 Special survey |

| Section 4 : Underwater Surveys | 5.5 Structural analysis | |
|---|---|--|
| 4.1 General | 5.6 Implementation of repairs | |
| 4.2 Survey requirements | 5.7 Reuse of offshore structures | |
| Section 5 : Extension of Use and Reuse | Section 6 : Surveys during Construction | |
| 5.1 General | 6.1 General | |
| 5.2 General requirements for extension of use | 6.2 Quality assurance | |
| 5.3 Review of design documentation | 6.3 Tightness and hydrostatic testing | |
| 5.4 Survey of offshore structure | procedures | |

Chapter 3 : Materials and Welding

Section 1 : Materials for Construction

- 1.1 General
- 1.2 Structural steel
- 1.3 Steel tubes and pipes
- 1.4 Steel for tubular joints
- 1.5 Cement grouting

Section 2 : Corrosion Protection

- 2.1 General
- 2.2 Corrosion control methods
- 2.3 Coating systems
- 2.4 Cathodic protection
- 2.5 Types of cathodic protection systems

2.6 Selection of the type of cathodic protection system2.7 Special mechanical and electrical considerations

Section 3 : Welding

- 3.1 General
- 3.2 Information to be submitted
- 3.3 Welding and supervision
- 3.4 Welding procedures
- 3.5 Fabrication
- 3.6 Production welding
- 3.7 Inspection

| Section 1 : General | Section 5 : Tide |
|-------------------------------------|--|
| 1.1 Scope | 5.1 Tides |
| 1.2 Determination of design data | Section C. Climate Temperature and Marine |
| 1.3 Environmental factors | Growth |
| 1.4 Environmental design conditions | 6.1 Temperature |
| Section 2 - Wayse | 6.2 Marine growth |
| Section 2 : waves | 6.3 Other environmental factors |
| 2.1 Wave data | |
| 2.2 Design application | Section 7 : Earthquake |
| Section 3 · Wind | 7.1 General |
| | 7.2 Evaluation of effects on structure |
| 3.1 General | 7.3 Earthquake criteria |
| 3.2 Extreme value prediction | |
| Section 4 · Currents | Section 8 : Conditions Due to Snow and Ice |
| | 8.1 Accumulation of ice or snow |
| 4.1 General | 8.2 Sea ice and icebergs |

Chapter 4 : Environmental Conditions

Chapter 5 : Design Loads

| Section 1 : General | Section 3 : Environmental loads |
|-----------------------------------|--|
| 1.1 Scope | 3.1 General |
| Soction 2 : Typos of Loads | 3.2 Wave loads |
| | 3.3 Current loads |
| 2.1 Load types | 3.4 Wind loads |
| 2.2 Permanent loads (dead loads) | 3.5 Loads due to snow and ice accumulation |
| 2.3 Live loads / functional loads | 2.6 Defermetion loads |
| 2.4 Deformation loads | 5.0 Delotination loads |
| 2.5 Environmental loads | 3.7 Marine growth |
| | 3.8 Sea ice loads |

5.2 Loads

| Section 4 : Loads due to Accidents | Section 6 : Earthquake Loads |
|---|--------------------------------|
| 4.1 General | 6.1 General |
| Section 5 . Transportation and Installation | 6.2 Strength level earthquake |
| Loads | 6.3 Ductility level earthquake |
| 5.1 General | 6.4 Seismic response |
| | |

Chapter 6 : Structural Design

| Section 1 : General | 4.1 General |
|---|---------------------------------|
| 1.1 General information | 4.2 Factors of safety |
| Section 2 : Design Methods and Criteria | 4.3 Design parameters |
| 2.1 Design method selection | Section 5 : Dynamic Analysis |
| 2.2 Plastic design | 5.1 General |
| 2.3 Modeling of the structure | 5.2 Dynamic loads |
| 2.4 Model test | 5.3 Structural design |
| 2.5 Superposition of stress components | 5.4 Structural analysis |
| Section 3 : Loading Conditions | Section 6 : Earthquake Analysis |
| 3.1 Definition of loading conditions | 6.1 Strength of structure |
| Section 4 : Allowable Stress Design | 6.2 Dynamic response |

Chapter 7 : Soil Foundation

| Section 1 : General | 2.2 Soil investigation and testing |
|----------------------------|------------------------------------|
| 1.1 Scope | 2.3 Reports |
| 1.2 Foundation design | Saction 3 · Design Considerations |
| 1.3 Soil | Section 5. Design Considerations |
| 1.4 Miscellaneous | 3.1 General |
| | 3.2 Soil characteristics |
| Section 2 : Investigations | 3.3 Cyclic loads |
| 2.1 Site investigation | 3.4 Scouring |

| Section 4 : Pile Foundation | 4.6 Load transfer to pile |
|----------------------------------|----------------------------|
| | 4.5 Pile groups |
| 3.8 Local deformation behavior | 4.4 Laterally loaded piles |
| 3.7 Settlements and displacement | 4.3 Axially loaded piles |
| 3.6 Soil strength and stability | 4.2 File design |
| 3.5 Hydraulic stability | 4.2 Dilo dopign |

4.1 General

Chapter 8 : Marine Operations

| Section 1 : General | Section 2 : Analysis |
|---------------------|-----------------------------|
| 1.1 General | 2.1 Loads |
| 1.2 Documentation | 2.2 Strength of attachments |
| | 2.3 Stability |

End of Contents

Chapter 1

General

| Contents | |
|----------|--|
| Section | |
| 1 | General Information |
| 2 | Classification Regulations |
| 3 | Classification of Fixed Offshore Steel Structures Built under the Survey of Indian Register of Shipping |
| 4 | Classification of Fixed Offshore Steel Structures not Built under the Survey of Indian Register of Shipping |
| | |

Section 1

General Information

1.1 Indian Register of Shipping

1.1.1 Indian Register of Shipping (hereinafter referred to as "IRS") was incorporated in 1975 as a Public Limited Company under Section 25 of the Indian Companies Act, 1956 for the purpose of providing amongst other things a faithful and accurate classification of mercantile shipping classed with it, to approve designs of, to survey and to issue reports on mercantile and non mercantile ships, hovercrafts, hydrofoils etc. all within the scope of classification described in the Rules. This Section contains General Regulations which have been adopted by IRS for its governance.

1.1.2 Information regarding the Board of Directors and Technical Committee of IRS is given in Part 1, Chapter 1 of the IRS Rules and Regulations for the Construction and Classification of Steel Ships (Main Rules).

1.2 Fees

1.2.1 Fees will be charged for all surveys and for other services rendered by IRS or any of its publications in accordance with established scales. Traveling expenses incurred by the Surveyors in connection with such services are also chargeable.

1.3 Survey reports

1.3.1 All reports of survey are to be made by the Surveyors according to the form prescribed and submitted for consideration of the Board or the Sub-Committee of Classification, but the character and notations assigned by the latter is to be reported to the Board. The Board may, in specified instances, vest in the Managing Director discretionary powers to act on its behalf, and all such actions being reported to the Board at its subsequent meeting.

1.3.2 The reports of the Surveyors shall, subject to the approval of the Managing Director, be open to inspection of the Owner and any other person authorised in writing by the Owner. Copies of the reports will, subject to the approval of the Managing Director, be supplied to Owners or their representatives

1.4 Register of Ships

1.4.1 A Register of Ships is available on-line on IRCLASS Website which contains the names of ships, character of class and notations assigned together with other relevant useful information for ships classed with IRS. This register also includes the names of fixed offshore structures, the character of class notation assigned together with other relevant useful information for fixed offshore structures classed with IRS.

1.5 Liability

1.5.1 Whilst Indian Register of Shipping, a Classification Society, along with its subsidiaries and associates (hereinafter referred to as the Society) and its Board/Committees use their best endeavours to ensure that the functions of the Society are properly carried out, in providing services, information or advice, neither the Society nor any of its servants or agents warrants the accuracy of any information or advice supplied. Except as set out herein, neither the Society nor any of its servants or agents (on behalf of each of whom the Society has agreed this clause) shall be liable for any loss damage or expense whatever sustained by any person due to any act or omission or error of whatsoever nature and howsoever caused of the Society, its servants or agents or due to any inaccuracy of whatsoever nature and howsoever caused in any information or advice given in any way whatsoever by or on behalf of the Society, even if held to amount to a breach of warranty. Nevertheless, if any person uses services of the Society, or relies on any information or advice given by or on behalf of the Society and suffers loss damage or expenses thereby which is proved to have been due to any negligent act omission or error of the Society its servants or

agents or any negligent inaccuracy in information or advice given by or on behalf of the society then the Society will pay compensation to such person for his proved loss up to but not exceeding the amount of the fee charged by the Society for that particular service, information or advice.

1.5.2 Any notice of claim for loss, damage or expense as referred to in 1.5.1 shall be made in writing to Head Office within six months of the date when the service, information or advice was first provided, failing which all the rights to any such claim shall be forfeited and the Society shall be relieved and discharged from all liabilities.

1.6 Access of Surveyor to structure, shipyards or works

1.6.1 The Surveyors are to be given free access to offshore structure classed with IRS as well as to shipyards/fabrication facility, works, etc. so as to perform their duties, and are to receive adequate assistance for this purpose.

1.7 Compliance with statutory requirements

1.7.1 Consideration should be given to any relevant requirements of the National Authority of the country in which the offshore structure is to be installed.

Section 2

Classification Regulations

2.1 General

2.1.1 When an offshore structure is assigned a specific Character of Class by Indian Register of Shipping, it implies that IRS has been satisfied that the said offshore structure meets, for this particular class, with these Rules and Regulations or requirements equivalent thereto. The offshore structure will continue to be classed with IRS so long as it is found, upon examination at the prescribed annual and periodical surveys, to be maintained in a fit and efficient condition and in accordance with the Periodical Survey requirements of these Rules.

2.1.2 The classification of an offshore structure with IRS does not exempt the owners from compliance with any additional and/or more stringent requirements issued by the Administration and/or local port authority.

2.2 Application of Rules

2.2.1 These rules apply to pile supported fixed offshore steel structures. Classification is valid only for operation in the specified area which will be mentioned in the certificate. The design of the structure and pile foundation are to be suitable for the water depth in the area of operation.

2.2.2 The rules are applicable to those features of the system that are permanent in nature and can be verified by plan review, calculation, physical survey and other appropriate means. Any statement in the rules regarding other features is to be considered as guidance to designer, builder or owner.

2.2.3 Unless directed otherwise by IRS, no new Regulations or amendments to the Rules

relating to the character of classification or class notation is to be applied to the existing fixed offshore steel structures.

2.2.4 Unless directed otherwise by IRS, no new Rules and Regulations or amendments to the existing Rules & Regulations become applicable within 6 months after the date of issue nor after the approval of main structural plans. Where it is proposed to use existing previously approved plans for a new contract, written application is to be made to IRS.

2.3 Interpretations of the Rules

2.3.1 The correct interpretation of the requirements contained in the Rules and other Regulations is the sole responsibility and at the sole discretion of IRS.

2.4 Character of Classification and Class Notations

2.4.1 Character **SUL** is assigned to indicate that, the offshore structure meets the Rule requirements for assignment of this Character of Class.

2.4.2 The distinguishing mark \mathbf{H} inserted before Characters of Class or Class Notation(s) is assigned to new offshore structure constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS.

2.4.3 The Class Notation **FIXED OFFSHORE STRUCTURE (PILE FOUNDATION)** will be assigned to fixed offshore installations with topsides supported by a space frame structure (jacket) reaching into the seabed and founded by different types of piles.

Additional notations would be assigned where the topside facilities have been built to the requirements of IRS.

2.4.4 **Operating area Notation:** An appropriate notation will be appended to the class notation to specify the operating area of the offshore structure.

2.4.5 The distinguishing mark \square inserted before a Character of Class (SUL, SU (-), SU, IY as appropriate), is assigned to fixed offshore structures admitted into IRS Class during the course of construction and surveyed by an IACS Society.

2.4.6 The distinguishing mark inserted before a Character of Class (SUL, SU (-), SU, IY as appropriate), is assigned to fixed offshore structures admitted into IRS Class at the time of delivery of the structure and constructed under the survey of an IACS Society.

2.4.7 **Description**: A 'description' may be assigned to indicate the purpose or role of a structure. In general, there would be no specific rule requirements to be complied with for assignment of a description.

2.5 Materials, components, equipment and machinery

2.5.1 The materials used in the construction of offshore structure, or in the repair of offshore structure already classed, are to be of good quality and free from defects and are to be tested in accordance with the relevant Rules. The steel is to be manufactured by an approved process at works recognized by IRS. Alternatively, tests to the satisfaction of IRS will be required to demonstrate the suitability of the steel.

Consideration may be given by IRS to accept the works approved by IACS member societies with whom IRS currently has co-operation agreements for this purpose.

2.5.2 Certification of materials, components, equipment and machinery is carried out on the basis of the following, considering IRS and /or IMO requirements, as applicable:

> a) Type approval carried out by IRS b) Unit certification by IRS

Mutual recognition of certificates, if type approved by an IACS member society or European Union recognized organization based on commonly agreed design requirements between IRS and the recognized organization.

2.6 Request for surveys

2.6.1 It is the responsibility of the Builders or Owners, as applicable, to inform the Surveyors of IRS in the port at which the surveys for supervision during new construction or offshore structure in service are to be undertaken and to ensure that all surveys for issue of class certificate for new construction, and maintenance of class for offshore structure in service are carried out.

2.7 Repairs

2.7.1 Any repairs to the offshore structure either as a result of damage or wear and tear which are required for the maintenance of offshore structure's class are to be carried out under the inspection of and to the satisfaction of the Surveyors.

2.8 Alterations

2.8.1 Any alterations proposed to be carried out to approved scantlings and arrangements of the offshore structure are to meet with the approval of IRS and for this purpose plans and technical particulars are to be submitted for approval in advance. Such approved alterations are to be carried out under the inspection of, and to the satisfaction of, the Surveyors.

2.9 Date of build

2.9.1 The date of completion of the special survey inspection will normally be taken as the date of build to be entered in the Register of ships and offshore units.

Where there is a substantial delay between completion of construction survey and the offshore structure commencing service, the date of commissioning may be specified on the classification certificate.

When modifications are carried out on an offshore structure, the initial date of build remains assigned to the offshore structure.

2.10 Appeal from Surveyors' recommenddations

2.10.1 If the recommendations of the Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to IRS, who may direct a special examination to be held.

2.11 Certificates

2.11.1 Certificates of Class will be issued to Builders or Owners when the required reports on completion of Special Surveys of new offshore structure or of existing offshore structure submitted for classification have been received from the Surveyors and approved by IRS.

2.11.2 Certificates of class maintenance in respect of completed periodical special surveys will also be issued to Owners.

2.11.3 The Surveyors are permitted to issue Interim Certificates to enable an offshore structure, classed with IRS, to proceed with its operation provided that, in their opinion, it is in a fit and efficient condition. Such Certificates will contain Surveyors' recommendations for continuance of Class, but in all cases are subject to confirmation by IRS. 2.11.4 Individual Certificates can also be issued for, equipment and fittings which have been manufactured under IRS Survey and in accordance with these Regulations.

2.12 Suspension, withdrawal and deletion of class

2.12.1 The class of an offshore structure may be suspended if the annual or special survey has not been completed by the due date and an extension has not been agreed to or the structure is not under attendance by the surveyor with a view to complete the surveys.

The class of an offshore structure may be subject to a suspension procedure if an item of continuous survey is overdue at the time of annual survey unless the item is dealt with or postponed by agreement.

The class of an offshore structure is liable to be suspended if the owner fails to notify IRS of any damage which may adversely affect classification or subsequently fails to arrange for the survey as may be advised by IRS.

2.12.2 When the class of an offshore structure holding IRS class, is withdrawn by IRS in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the Register of Ships and Offshore Units. After one year, the notation will be altered to "Classed IRS until" (with date).

2.12.3 When the Regulations as regards surveys of the offshore structure have not been complied with and the offshore structure thereby is not entitled to retain her class, the class will be withdrawn and the notation "IRS Class withdrawn" (with date) will be made in the Register of Ships and Offshore Units. After one year, the notation will be altered to "Classed IRS until" (with date).

2.12.4 The class of an offshore structure is liable to be withheld or, if already granted may be withdrawn in case of any non-payment of fees or expenses chargeable for the service rendered.

2.12.5 When it is found that an offshore structure is being operated in a manner contrary to that agreed at the time of classification, or is being operated in conditions onerous than those agreed, the class is liable to be suspended or withdrawn.

2.12.6 The class of an offshore structure which has maintained class would be deleted on

receipt of information that it has been scrapped or ceases to exist, and an appropriate entry would be made in the Register of Ships and Offshore Units.

2.12.7 In cases where the class has been suspended by IRS and it becomes apparent that the owners are not interested in maintaining IRS class, the notation will be amended to withdrawn status.

2.13 Reclassification of Offshore Structure

2.13.1 When Owners request for reclassification of an offshore structure for which the class previously assigned has been withdrawn, IRS

will require a Special Survey for Reclassification to be held by the IRS Surveyors. The extent of the survey will depend upon the age of the offshore structure and the circumstances of each case.

2.13.2 If the offshore structure is found or placed in good and efficient condition in accordance with the requirements of the Rules and Regulations at the Special Survey for Reclassification, IRS may decide to reinstate her original class or assign such other class as considered appropriate.

2.13.3 The date of reclassification will appear in the Register of Ships and Offshore Units.

Section 3

Classification of Fixed Offshore Steel Structures Built under the Survey of Indian Register of Shipping

3.1 Classification of new constructions

3.1.1 The request for classification of new constructions is to be submitted to IRS by the shipyard or owner in the form provided by IRS. The request is to include complete details regarding class notation and statutory requirements, where applicable.

3.1.2 Plans and particulars as specified in the Rules will have to be submitted to IRS sufficiently in advance of commencement of construction. On satisfactory examination of compliance with the Rules, IRS would affix its stamp of approval on the plans. Any deviation from approved drawings will require to be approved by IRS prior to execution of work.

IRS reserves the right to request for additional plans, information or particulars to be submitted.

Approval of plans and calculations by IRS does not relieve the Builders of their responsibility for the design, construction and installation of the various parts, nor does it absolve the Builders from their duty of carrying out any alterations or additions to the various parts on board deemed necessary by IRS during construction or installation on board or trials.

3.1.3 IRS will assess the production facilities and procedures of the shipyard and other manufacturers as to whether they meet the requirements of the construction Rules. 3.1.4 During construction of an offshore structure, IRS will ensure by surveys that parts of offshore structure requiring approval have been constructed in compliance with approved drawings, all required tests and trials are performed satisfactorily, workmanship is in compliance with current engineering practices and welded parts are produced by qualified welders.

3.1.5 The offshore structure will be subjected to operational trials in the presence of IRS Surveyor.

3.1.6 On completion of the offshore structure, copies of as fitted plans showing the offshore structure as built, essential certificates and records, operating manual etc. are to be submitted by the Builder generally prior to issuance of the Interim Certificate of Class.

3.2 Plans and design data

3.2.1 Plans showing the scantlings, arrangements and details of the principal parts of the structure of each unit to be built under IRS Class are to be submitted for approval before construction commences. These plans are to clearly indicate the scantlings, types and grades of materials, joint details and welding, or other methods of connection. These plans are to include the following, where applicable:

- General arrangement plans clearly showing in sufficient detail the overall configuration, dimensions and layout of the structure, facilities and foundation
- A layout plan indicating the locations of equipment and locations of the equipment loads and other design deck loads, fender loads, etc, which are imposed on the structure.
- Structural plans indicating the complete main structural arrangement, dimensions, member sizes, plating and framing, material properties and details of connections and attachments.
- Pile plans indicating arrangements, nominal sizes, thickness and penetration.
- Welding details and procedures
- Methods and locations for nondestructive testing (NDT)
- Corrosion control arrangements
- Structural plans indicating the complete arrangement of structures such as helidecks, crane pedestals, equipment foundations and manner of reinforcement, fendering and other structures which are not normally considered vital to the overall structural integrity of the offshore structure.

3.2.2 Site condition report

3.2.2.1 As required in subsequent parts of these rules, site condition report is to be submitted. The purpose of these reports is to demonstrate that site conditions have been evaluated in establishing design criteria.

3.2.2.2 The following environmental data are to be submitted:

- Environmental conditions of wind, waves, currents, seiche, tide, water depth, sea and air temperature and ice
- Seabed topography, stability and pertinent geotechnical data, seismic conditions

3.2.3 Design Reports

3.2.3.1 Information is to be submitted for the offshore structure which describes the methods of design and analysis which were employed to

establish its design. The estimated design life of an offshore structure is also to be stated.

3.2.3.2 Model tests may be used to determine the design loads or to verify the calculated design loads. The applicability of the test results will depend on the demonstration of the adequacy of the methods employed, including enumeration of possible sources of error, limits of applicability and methods of extrapolation to full scale data. The description of model test facilities and procedures, analysis and a summary of the results are to be submitted. It is recommended that IRS is consulted regarding model testing.

3.2.3.3 A report on environmental conditions is to be submitted covering description of all environmental phenomena appropriate to the areas of construction, transportation, and installation. This should cover wind, waves, current, temperature, tide, marine growth, chemical components of air and water, snow and ice, earthquake and other relevant phenomena as appropriate to the type and location of the structure. The following are to be included:

- a) Parameters necessary to define the Extreme Environmental Condition and Operating Environmental Conditions, as defined in Ch. 4, 1.4;
- b) Environmental conditions likely to be experienced during the transportation of the structure to its final site;
- c) Strength and Ductility Level Earthquakes, as defined in Ch. 4, Sec 7.

3.2.3.4 A report on foundation data in accordance with the requirements in Ch. 7, Sec 2.

The report is to include the following:

- a) References for the investigation, sampling, testing, and interpretive techniques employed during and after the site investigation.
- b) Predicted soil-structure interaction, such as p-y data, to be used in design.
- c) Axial and lateral pile capacities and response characteristics, the capacity of pile groups
- d) The effects of cyclic loading on soil strength, scour, settlements and lateral displacements, slope stability, bearing and lateral stability

e) Dynamic interaction between soil and structure, soil reactions on the structure, and penetration resistance.

3.2.3.5 Recommendations relative to any special anticipated problem regarding installation are to be included in the report on foundations. Items such as the following are to be included, as appropriate: hammer sizes, soil erosion during installation, bottom preparation, and procedures to be followed should pile installation procedures significantly deviate from those anticipated.

3.2.4 Design Calculations

3.2.4.1 Calculations are to be submitted to demonstrate the sufficiency of the proposed design as required in subsequent chapters. Computer software used for calculations are to be validated.

3.2.4.2 Design and analysis calculations are to be submitted for items relating to loadings, structural stresses and deflections for in-place and marine operations. (Also see 1.2 of Chapter 8).

3.2.4.3 Calculations for loadings are to be submitted in accordance with Ch. 5.

3.2.4.4. The submitted calculations should include the following:

a) Stresses in localized areas and structural joints

b) Calculations for the dynamic response of the structure

c) Fatigue life of critical members and joints

d) Calculations for the stresses in piles and the load capacity of the connection between the structure and the pile.

e) Adequacy of the structural elements, members or local structure for loads from marine operations (see Ch 8)

f) The calculations are to demonstrate, that the deflections resulting from the operational loadings and overall structural displacement and settlement do not impair the structural performance of the platform.

3.3 Information Manual

3.3.1 The information manual is to be submitted for review by IRS to verify consistency with the design information and limitations considered in the classification. Any additional information required by coastal or flag Administrations are to be included in the operations and maintenance manual.

3.4 Records

3.4.1 A data book of the record of construction is to be developed and maintained including the following:

- a) material traceability records including mill certificates,
- b) welding procedure specification and qualification records,
- c) shop welding practices,
- d) welding inspection records,
- e) construction specifications,
- f) structural dimension check records,
- g) nondestructive testing records,
- h) records of completion of items identified in the quality control program
- i) towing and pile driving records,
- j) position and orientation records,
- k) leveling and elevation records, etc.

3.4.2 The compilation of these records is a condition of classing the structure. After fabrication and installation, these records are to be retained by the Operator or Fabricator for future references. The minimum time for record retention is not to be less than the greatest of the following:

- a) the warranty period,
- b) the time specified in construction agreements, or
- c) the time required by statute or governmental regulations.

3.4.3 Apart from 3.4.1 following records are to be maintained on board:

- a) Records of surveys as mentioned in Ch.2.
- b) Inspection, maintenance and testing records
- c) Structure alteration log

Section 4

Classification of Existing Fixed Offshore Steel Structures not built under the Survey of Indian Register of Shipping

4.1 General procedure for classification of fixed offshore structure not built under survey of IRS

4.1.1 Plans and design documentation of the fixed offshore structure are to be submitted for approval. It is preferable to have the plans approved before the classification survey is commenced.

4.1.2 Full special classification surveys would require to be carried out by IRS Surveyors in order to satisfy themselves regarding the workmanship and to verify the approved scantlings and arrangements. The scope of these surveys may, however, be modified in the case of offshore structure built under the Special Survey and holding valid certificates of class of established classification societies, if prior to commencement of survey by IRS, documentary evidence of all classification surveys held by the other society subsequent to last special survey carried out by them could be produced. In such cases, a special survey notation will not be assigned in conjunction with the classification survey. The next special survey therefore would become due five years from the special survey held by the other society and not five years from classification with IRS.

In cases of transfer of class from another society to single class of IRS, the interim certificate of

class or any other documents enabling the offshore structure to operate can be issued only after all overdue surveys and recommendations or conditions of class issued by the previous society are satisfactorily completed.

4.1.3 For offshore structure not built under survey of IRS but subsequently taken in class with the above procedure, the mark signifying the survey during construction will be omitted.

4.1.4 Once an offshore structure has been taken into IRS class, periodical surveys are subsequently to be held as per these rules.

4.1.5 In cases where it is found that the Offshore structure has reached or is about to reach its design life, an evaluation of the structure for extension of use will need to be carried out according to the requirements of Chapter 2, Section 5.

4.2 Plans and data to be furnished as required in 4.1.1

4.2.1 Plans of hull and equipment showing the main scantlings and arrangements of the actual offshore structure and any proposed alterations are to be submitted for approval. These are to normally comprise of the plans listed in Cl. 3.2.

End of Chapter

Chapter 2

Surveys

| | Contents | |
|---------|-----------------------------|--|
| Section | | |
| 1 | General Requirements | |
| 2 | Annual Surveys | |
| 3 | Special Surveys | |
| 4 | Underwater Surveys | |
| 5 | Extension of Use and Reuse | |
| 6 | Surveys During Construction | |
| | | |

Section 1

General Requirements

1.1 General

1.1.1 All offshore structures are to be subjected to periodical surveys for the purpose of maintenance of class. Survey notations and Survey intervals are given in Table 1.1.1. 1.1.2 Requirements for extension of use and reuse are provided in Sec 5.

1.1.3 Survey requirements during construction are provided in Sec 6.

| (Any specific requirements of the local authority are also to be complied with) | | |
|---|----------------------------|--------------------------|
| Survey | Main class survey notation | Survey interval in years |
| Special Survey | SS | 5 |
| Continuous Survey | CS | 5 |
| Annual Survey | AS | 1 ¹ |

1.2 Provision for surveys

1.2.1 The Surveyors are to be provided with necessary facilities for a safe execution of survey.

1.2.2 Means are to be provided to enable the Surveyor to examine the structure in a safe and practical way.

1.2.3 Thickness measurement is normally to be carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven to the Surveyor as required.

1.2.4 One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

- radiographic equipment
- ultrasonic equipment
- magnetic particle equipment
- dye penetrant.

1.3 Survey Planning

1.3.2 For underwater inspection, plans and procedures are to be submitted for review in advance of the survey and made available on board. These should include drawings or forms for identifying the areas to be surveyed, the extent of structure cleaning, nondestructive testing locations, including NDT methods, nomenclature, and for the recording of any damage or deterioration found. Submitted data, after review by IRS, will be subject to revision if found to be necessary in light of experience.

1.4 Thickness Measurement

1.4.1 Thickness measurements shall be carried out in accordance with recognized methods, by authorized personnel or companies. Rust and contamination are to be removed from the components to be examined. The Surveyor is entitled to require check measurements or more detailed measurements to be performed in his presence. 1.4.2 The scope of thickness measurements as well as the reporting depends upon the particular installation and shall be documented by IRS Head Office in advance of measurements and prior to commencing the survey.

1.5 Reactivation surveys

1.5.1 In the case of offshore structures which have been out of service for an extended period, the requirements for reactivation surveys will be specially considered in each case with due regard given to the status of surveys at the time of the commencement of the de-activation period, the length of the period, and conditions under which the unit had been maintained during that period.

1.6 Surveys after damage

1.6.1 It is the responsibility of the owner/ operator of the offshore structure to report to IRS without delay any damage, defect or failure, which could affect classification so that it may be examined at the earliest opportunity by IRS Surveyor(s). All repairs found necessary by the Surveyor are to be carried out to his satisfaction.

Section 2

Annual Surveys

2.1 General

2.1.1 Annual Class Surveys are to be held within three months either way of each annual anniversary date of the crediting of the previous Special Survey or of the original installation date.

2.1.2 If the end of design life of the offshore structure has been reached or will be reached before the next survey, an evaluation as per the requirements of Section 5 is to be carried out for extension of use of the structure.

2.2 Survey requirements

2.2.1 At each Annual Survey, the offshore structure is to be generally examined so far as can be seen to ensure its satisfactory condition. The examination is to include a review of the maintenance records of the offshore structure.

2.2.2 The annual survey will generally cover visual examination of all important structural elements readily accessible, with regard to deformations, cracks, corrosion, etc. Where a special inspection plan has been prepared, the corresponding indications have to be considered, e.g. for critical areas with stress concentrations, locations with previous repairs, etc.

2.2.3 Any repairs or renewals carried out to coatings and cathodic protection systems since last survey as well as their effectiveness are to be reported at each survey.

2.2.4 The structure within the splash zone is to be inspected visually with regard to corrosion, marine growth and damages, e.g. from collisions. Where damages are found which could extend further downwards, diver inspections may be called for. Where it appears that significant deterioration or damage has occurred to the installation since the last survey, a diver examination of underwater structure, the sea floor and corrosion control system is to be carried out.

2.2.5 The exposed parts of the main structure, deck, deck house and structures attached to the deck, derrick substructure including supporting structure, accessible internal spaces and the applicable parts described in this Section are to be generally examined and placed in satisfactory condition as found necessary.

2.2.6 Jackets, diagonal and horizontal braces together with any other parts of the upper supporting structure as accessible above the waterline are to be checked.

2.2.7 The Surveyor is to be satisfied that no material alterations have been made to the installation and its structural arrangements.

2.2.8 The scope for any thickness measurements is to be defined in the survey schedule/special inspection plan.

Section 3

Special Surveys

3.1 General

3.1.1 For offshore structures, the first Special Survey becomes due five years after the date of installation. Subsequent Special Surveys become due five years after the assigned date of the previous Special Survey.

However, an extension of class of 3 months maximum beyond the 5th year can be granted in exceptional circumstances. In this case the next period of class will start from the expiry date of the Special Survey before the extension was granted.

3.1.2 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date.

3.1.3 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

3.1.4 The special survey is to ensure that the offshore structure is in satisfactory condition and that the unit is fit for its intended purpose for the new period of class of 5 years to be assigned subject to proper maintenance and operation and surveys carried out at the due dates.

3.1.5 If the end of design life of the offshore structure has been reached or will be reached before the next annual survey, an evaluation as per the requirements of Section 5 is to be carried out for extension of use of the structure.

3.2 Special continuous surveys

3.2.1 At the request of the Owner, a system of Continuous Survey may be accepted whereby the Special Survey requirements are carried out in regular rotation in accordance with the Rules to complete all the requirements of the particular Special Survey within a five year period. Any defects that may affect classification found during the survey, are to be reported upon and dealt with to the satisfaction of the Surveyor.

Thickness gauging of the structure for special survey is to be undertaken after the fourth annual survey.

3.3 Special Survey

3.3.1 Special Survey of offshore structures is to include compliance with the foregoing Annual Survey requirements. In addition, the following requirements as listed below are to be carried out as applicable, the parts examined, placed in satisfactory condition, and reported upon.

3.3.2 One or more of the following crack detection test methods may be undertaken if deemed necessary by the Surveyor:

- a) radiography test (X or gamma rays)
- b) ultrasonic test

- c) magnetic particle test
- d) dye penetrant test, etc.

3.3.3 In addition to the annual survey, a comprehensive survey of the underwater and above water structure is to be carried out covering the following aspects:

- a) Overall condition and integrity.
- b) The structure including tanks, void spaces, helicopter deck and its supporting structure, machinery spaces, and all other internal spaces are to be examined externally and internally for damage, fractures, or excessive wastage. Thickness measurements of plating and framing may be required where wastage is evident or suspected.
- c) Suspect areas may be required to be tested for tightness, non-destructive tested or thickness gauged.
- d) Tanks and other normally closed compartments are to be ventilated, gas freed and cleaned as necessary to expose damages and allow meaningful examination and thickness gauged in case of excessive wastage.
- e) All tanks, compartments and freeflooding spaces throughout the installation are to be examined externally and internally for excess wastage or damage.
- f) Internal examination and testing of void spaces, compartments filled with foam or corrosion inhibitors, and tanks used only for lube oil, light fuel oil, diesel oil, or other non-corrosive products may be waived, provided that upon a general examination the Surveyor considers their condition to be satisfactory.

External thickness measurements may be required to confirm corrosion control.

- g) Structures such as derrick substructure and supporting structures, jack-houses, deck houses, superstructures, helicopter landing areas, raw water (sea water intake) towers and their respective attachments to the deck.
- h) Structure/plate thickness measurements and non-destructive testing according to an approved inspection plan and/or onthe-spot decision where damages are suspected.
- i) Foundations and supporting headers, brackets, and stiffeners for drilling related apparatus, where attached to structure, deck, superstructure or deck house.
- Effectiveness of the corrosion protection system (potential measurements, condition of anodes etc.)
- k) Marine growth.
- I) Condition of foundations (changes in topography/ scouring, settlement).

3.3.4 Account may be taken of data recorded by instruments installed to monitor structural and foundation behavior. Special attention shall be given to areas of stress concentration and of suspected or proven damage, and to areas where repairs have been carried out previously.

3.3.5 Cleaning and/or uncovering of areas selected for close-up inspection and non-destructive testing may be necessary.

3.3.6 An underwater survey (Refer Section 4) is to be part of special survey.

Section 4

Underwater Surveys

4.1 General

4.1.1 The outside structure and related items of are to be examined at special surveys.

Consideration may be given at the discretion of IRS, to any special circumstances justifying an extension of the interval. In such circumstances an extension of examination of the fixed offshore installation's structure of 3 months can be granted by IRS.

4.1.2 Plans and procedures for underwater surveys to be in accordance with Sec 3, 3.3.

4.2 Survey Requirements

4.2.1 The diving firm assisting in underwater surveys must be approved by IRS for this purpose. Validity of an approval granted shall depend on the continued qualification for satisfactorily carrying out the work required.

4.2.2 Underwater internal thickness measurements of suspect areas may be required in conjunction with the underwater inspection. Means for underwater nondestructive testing may also be required for fracture detection.

4.2.3 The areas to be surveyed are to be sufficiently clean and the seawater clear and calm enough to permit meaningful examination and photography, if necessary, by the diver. The structures below the waterline must be free from fouling and overall or spot cleaning may be required. Where marine growth is found to be higher than that has been accounted for in the calculation of design loads (Refer Chapter 5, Sub-section 3.7), cleaning of marine growth may be required.

4.2.4 An examination of the outside of the structure above the waterline is to be carried out by the IRS Surveyor. Means and access are to be provided to enable the Surveyor to accomplish visual inspection and nondestructive testing as necessary.

4.2.5 Underwater areas are to be surveyed and/or relevant maintenance work is to be carried out with assistance by a diver of an approved firm whose performance is controlled by a Surveyor, using an underwater camera with monitor, communication and recording systems. The underwater pictures on the surface monitor screen must offer reliable technical information such as to enable the Surveyor to judge the parts and/or the areas surveyed. If applicable, the effectiveness of the corrosion protection system (potential measurements, conditions of anodes, etc.), the marine growth and the condition of foundations (changes in topography / scouring, settlement) are to be inspected. In cases where turbidity of the water is found to affect reliable examination, alternative methods may be used as acceptable to the Surveyor.

4.2.6 Damage areas are to be photographed. Examination, marking and thickness measurements of such locations may be necessary as determined by the attending Surveyor. Means are to be provided for location, orienting and identifying underwater surfaces in photographs or on video. The records are to be made available to IRS.

Section 5

Extension of Use and Reuse

5.1 General

5.1.1 This Section covers requirements for the following:

a) Continuance of classification of an existing offshore structure for extension of service beyond initially estimated design life;

b) Removal and re-use of an offshore structure at a different location.

5.1.2 This section also applies to existing offshore structures newly offered for classification to IRS. For structures already

classed with IRS, some of the evaluations and surveys may not be necessary.

5.2 General requirements for Extension of Use

5.2.1 The procedure for the extension of use of an existing fixed offshore structure is given in Fig.5.2.1.

5.2.2 An initial assessment for feasibility of continued use of the offshore structure is to be made using the results of I and II in Figure 5.2.1. Further steps will be carried out only if the initial assessment shows possibility of re-use.

5.2.3 The requirements of Chapter 6 are to be applied for in-place analysis of the structure.

5.2.4 An assessment of fatigue life is to be carried out in accordance with Chapter 6. A spectral fatigue analysis method is recommended for this purpose. Environmental data for past service and future are to be taken into account.

In order to consider the uncertainties in evaluation of remaining fatigue life, it is to be ensured that the estimated remaining fatigue life of all the structural members and joints is not to be less than twice the extended service life.



Fig.5.2.1

5.2.5 The following methods may be employed to improve the fatigue life where necessary:

a) Strengthening of structural members;
b) Periodical monitoring and nondestructive evaluation of critical areas;
c) grinding weld toes for joints with full penetration welds.

5.2.6 Where the original fatigue life calculation of joints shows that it already covers the extension period, re-calculation of fatigue life may not be required. In such case, the following are to be confirmed from surveys:

a) the environmental data used in the original calculations remain valid;

b) cracks are not found during survey of joints and any damaged members are replaced or repaired;

c) Marine growth and corrosion are within allowable limits.

5.2.7 Periodical surveys are to be carried out for monitoring and ensuring the satisfactory condition of the structure.

5.3 Review of design documentation

5.3.1 The following original design information is to be submitted (if not already available with IRS) for evaluation of structural integrity:

- a) Design calculation reports
- b) Design and as-fitted plans
- c) Build Specifications
- d) Construction Survey records
- e) Periodical survey and maintenance records

5.3.2 Where some of the above information is not available, conservative assumptions may be made and actual measurements and testing carried out as necessary.

5.4 Survey of offshore structure

5.4.1 Condition Assessment Surveys are to be carried out to determine the actual condition of the platform which would be witnessed and monitored by IRS surveyor.

5.4.2 IRS will review and verify maintenance manual, logs and records. Any alterations, repairs or installation of equipment since installation are to be included in the records.

5.4.3 The special survey requirements in Section 3 are to be included in the survey for

extension of use. The surveys generally cover examination of splash zone, inspection of above water and underwater structural members and welds for damages and deteriorations, examination and measurements of corrosion protection systems and marine growth, sea floor condition survey, examination of secondary structural attachments, risers and riser clamps. Special attention is to be given to the following critical areas:

- a) Areas of high stress;
- b) Areas of low fatigue life;

c) Damage incurred during installation or while in service;

d) Repairs or modifications made while in service;

e) Abnormalities found during previous surveys.

The need for more frequent future periodical surveys will be determined based on the calculated remaining fatigue life described in 5.2.4 and past inspection results.

5.4.4 The corrosion protection system is to be reevaluated to ensure that existing anodes are capable of serving the extended design life of the platform. If found necessary by the reevaluation, replacement of the existing anodes or addition of new anodes may have to be carried out. Necessary maintenance is to be carried out to protective coatings in the splash zone.

5.5 Structural analysis

5.5.1 The results of the condition assessment survey are to be considered in the structural analyses of an existing structure. Specifically, deck loads, wastage, marine growth, scour, and any platform modifications and damage are to be considered in the analysis model.

5.5.2 The original fabrication materials and fit-up details are to be established such that proper material characteristics are used in the analysis and any stress concentrations are accounted for.

5.5.3 The pile driving records are to be made available so that the foundation can be accurately modeled.

5.5.4 For areas where the design is controlled by earthquake or ice conditions, the analyses for such conditions are also to be carried out.

5.5.5 Areas requiring careful inspection will be identified based on the results of the analysis.

5.5.6 Possible alterations of platforms to allow their continued use will be identified and evaluated by analysis.

5.5.7 Reduction of deck load and other loads on the structure may be considered to improve fatigue life or reduction of stresses. The results of these load reduction on the structure are to be evaluated to determine whether the repairs/ alterations is needed.

5.5.8 An ultimate strength analysis with appropriate safety factors may also be considered for evaluation of the structure.

5.6 Implementation of repairs

5.6.1 The extent of repairs or modifications which will be necessary to certify the platform for continued operation will be decided based on the condition assessment survey and structural analysis.

5.6.2 A second survey may be necessary to inspect areas where the analysis results indicate high stresses.

5.6.3 Members and joints found overstressed are to be strengthened.

5.6.4 Joints with low fatigue life may be improved by the methods indicated in 5.2.5.

5.6.5 The residual fatigue life of the joints is to be considered as basis for determining the periodic survey intervals for the future.

5.7 Reuse of offshore structures

5.7.1 General

5.7.1.1 Re-use of an offshore platform involves removal and re-installation at a different location. The requirements in 5.2 to 5.5 are to be applied in general with regard to condition assessment and structural analysis.

5.7.1.2 The analysis should take into account the environmental and geotechnical data for the new site. Any modifications made to the structure to enable the removal operation and to suit the new site are to be considered in the analysis.

5.7.2 Survey

5.7.2.1 The Owner is to advise IRS of the proposal to change locations addressing removal, transportation and re-installation aspects of the change. Survey requirements described in sections above and 5.4, wherever applicable, are to be complied with in addition to an engineering analysis required to justify the integrity of the installation for the design life at the new location.

5.7.3 Removal and Reinstallation Operation

5.7.3.1 Removal procedure is to be planned and analyzed to verify that the integrity of the structure will not be affected by the operation.

5.7.3.2 Plans/ details of removal, sea fastenings, transportation analysis and calculations are to be submitted for review. The requirements given in Chapter 8 are to be applied in general for the re-installation of offshore platforms.

Section 6

Surveys during Construction

6.1 General

6.1.1 Requirements for surveys during construction and installation are generally addressed in this section.

6.1.2 The specific survey requirements during construction and installation are elaborated in Chapter 3 "Materials and Welding" and Chapter 8 "Marine Operations" respectively.

6.2 Quality Assurance

6.2.1 The fabricating yard is to have a quality assurance program compatible with the type, size and intended function of the structure. A quality assurance plan is to be developed and submitted to IRS for review.

6.2.2 Various inspection stages during construction are to be addressed in the quality assurance plan.

6.2.3 Surveyors will be assigned to monitor the fabrication of structures and assure that all tests and inspections specified in the quality assurance plan are being carried out by competent personnel.

6.2.4 It is to be noted that the monitoring provided by IRS is a supplement to and not a replacement for inspections to be carried out by the Fabricator or Operator.

6.2.5 The quality assurance plan is to address the following items, as appropriate:

- i) Material quality and traceability
- ii) Steel Forming
- iii) Welder qualification and records
- iv) Welding procedure specifications and qualifications
- v) Weld inspection
- vi) Tolerances alignments and compartment testing
- vii) Corrosion control systems
- viii) Tightness and hydrostatic testing procedures
- ix) Nondestructive testing
- x) Installation of main structure.

6.3 Tightness and Hydrostatic Testing Procedures

6.3.1 A testing procedure for watertight compartments is to be submitted by the fabricating yard for approval by IRS. Compartments which are to be maintained watertight during installation are also to be tested. The testing is to be carried out to the satisfaction of the attending Surveyor.

End of Chapter

Chapter 3

Materials and Welding

| Contents | | | |
|----------------------------|--|--|--|
| | | | |
| Materials for Construction | | | |
| Corrosion Protection | | | |
| Welding | | | |
| | | | |

Section 1

Materials for Construction

1.1 General

1.1.1 The materials used for the construction or repair of the hull and machinery of fixed offshore structures, which are classed or intended to be classed with IRS, are to be manufactured, tested and inspected in accordance with the requirements of Part 2 of the IRS *Rules and Regulations for the Construction and Classification of Steel Ships.*

1.1.2 Materials complying with recognized national or international standards like API RP-2A may also be accepted by IRS. If other materials are intended to be used, the relevant specifications with all details required for appraisal are to be submitted to IRS for approval.

1.1.3 The materials selection process is to reflect the overall philosophy regarding design life, inspection and maintenance, safety and environmental profile, failure risk evaluations and other specific project requirements.

1.1.4 In the choice of materials for the different members of the steel structure the following criteria are to be considered:

- importance of the member within the structure (consequence of failure, redundancy);
- Character of load and stress level (static or dynamic loads, residual stresses, stress concentrations, direction of stresses in relation to the rolling direction of the material, etc.);

- design temperature;
- chemical composition (suitability for welding);
- yield and tensile strength of the material (dimensioning criteria);
- ductility of the material (resistance to brittle fracture at given design temperature);
- through-thickness properties (resistance to lamellar tearing).

1.1.5 The requirements for materials and corrosion protection in this chapter consider the following zones of a fixed offshore installation depending on the location of the structural members:

1.1.5.1 *Splash Zone.* The part of the installation containing the areas above and below the still water level which are regularly subjected to wetting due to wave action.

1.1.5.2 *Atmospheric Zone*. That part of the installation above the splash zone being exposed to sea spray, atmospheric precipitation.

1.1.5.3 *Submerged Zone.* That part of the installation below the splash zone.

1.1.6 The minimum service temperature of the material is to be taken as the lowest average daily temperature based on meteorological data over a period of at least 10 years. This

temperature is to be used for determining the requirements for structural members as specified in 1.1.6.1 to 1.1.6.3.

1.1.6.1 *Material below the Splash Zone*. For material below the splash zone, the service temperature is in general to be taken as 0 [°C]. However, higher service temperatures may be used based on available data for the lowest average daily water temperature applicable to the depths involved.

1.1.6.2 Material within or above the Splash Zone. For material within or above the splash zone, the service temperature is the same as the lowest average daily atmospheric temperature. A higher service temperature may be used if the material above the waterline is warmed by adjacent sea water temperature or by auxiliary heating.

1.1.6.3 *Conditions for Local structure.* Where the local structural members are subject to lower temperature by cryogenic storage or other cooling conditions, appropriate reduced minimum service temperatures may be used.

1.2 Structural Steel

1.2.1 Steel Selection

1.2.1.1 Materials used are required to exhibit satisfactory formability and weldability characteristics. Steel is to conform to a definite specification with the minimum strength level and impact properties according to its usage.

1.2.1.2 Requisite documentation is to be submitted to substantiate the applicability of proposed steel. Reference can also be made to API RP 2A (WSD), 'Material'.

1.2.2 Steel Groups

1.2.2.1 Steels may be grouped according to strength levels and welding characteristics as follows :

.1 **Group I Steels**. Mild Steels with specified minimum yield strengths of 280 [MPa] or less.

.2 **Group II Steels**. Intermediate strength steels with specified minimum yield strengths of 280 to 360 [MPa]. Low hydrogen welding processes would be required for these steels.

.3 **Group III Steels**. High strength steels with specified minimum yield strengths in excess of 360 [MPa]. Such steels may be used provided

that each application is investigated with regard to:

a) Weldability and special welding procedures which may be required;b) Fatigue problems which may result from the use of higher working stresses; and

c) Notch toughness in relation to other elements of fracture control, such as fabrication, inspection procedures, service stress, and temperature environment.

1.2.3 Material Toughness

1.2.3.1 The fracture toughness of materials is to be satisfactory for the intended application.

1.2.3.2 Appropriate supporting information or test data are to indicate that the toughness of the steels will be adequate for their intended application and minimum service temperature.

1.2.3.3 When members are subjected to significant tensile stress, fracture toughness is to be considered in the selection of materials.

1.2.3.4 Satisfactory toughness characteristics can be demonstrated by any one of the following:

i. Demonstration of past successful application, under comparable conditions, of a steel, produced to a recognized standard (such as those of the ASTM, API or other recognized standard); or

ii. Charpy impact testing.

1.2.3.5 Where the structure is located in areas prone to sea ice loads; special consideration is to be given to the suitability of material.

1.2.4 Steel with through thickness properties

1.2.4.1 Where the strains in the structural member due to welding or in service loads are perpendicular to the surface, use of steel with improved through thickness (Z-direction) properties may be required.

1.2.5 Bolts and Nuts

1.2.5.1 Bolts and nuts are to have mechanical properties and corrosion characteristics compatible with the structural element being joined. They are to be manufactured and tested in accordance with recognized material standards.

1.3 Steel Tubes and Pipes

1.3.1 Steel tubes and pipes intended for welded structures, parts of machinery and equipment are to meet the requirements of Part 2 of the IRS *Rules and Regulations for the Construction and Classification of Steel Ships*.

1.3.2 Seamless or welded structural pipes are to conform to the specifications listed in Table 11.3 of the API RP2A WSD as amended or other equivalent international standard acceptable to IRS.

1.3.3 Consideration is to be given for the selection of steels with toughness characteristics suitable for the conditions of service. For tubes cold-formed to D/t less than 30, and not subsequently heat-treated, due allowance is to be made for possible degradation of notch toughness, e.g. by specifying notch toughness tests run at reduced temperature.

1.4 Steel for Tubular Joints

1.4.1 Tubular joints are subject to local stress concentrations which may lead to local yielding and plastic strains at the design load. During the service life, cyclic loading may initiate fatigue cracks, making additional demands on the ductility of the steel, particularly under dynamic load. Heavy wall joint-cans designed for punching shear are specifically subject to such effects.

1.4.2 Underwater Joints

1.4.2.1 For underwater portions of redundant template-type platforms, steel for joint cans (such as jacket leg joint cans, chords in major X and K joints, and through-members in joints designed as overlapping) are to meet one of the following notch toughness criteria at the temperature given in Table 1.4.2.1

.1 NRL Drop-Weight Test no-break performance.

.2 Charpy V-notch energy: 20 [J] for Group I steels, 34 [J] for Group II steels, and 47 [J] for Group III steels (transverse test).

Table 1.4.2.1 : Input Testing Conditions

| | • | 5 | | |
|--|----------------------------|----------------|--|--|
| D/t | Test Temperature | Test Condition | | |
| Over 30 | 20°C below T _{as} | Flat Plate | | |
| 20-30 | 30°C below T _{as} | Flat Plate | | |
| Under 20 | 10°C below T _{as} | As Fabricated | | |
| Tas Lowest Anticipated Service Temperature | | | | |

1.4.3 Above Water Joints

1.4.3.1 For above water joints exposed to lower temperatures and possible impact from boats, or for critical connections at any location, steels with higher notch toughness are to be considered. e.g., API Spec. 2H, Grade 42 or Grade 50. For steels of yields strength of 345 [MPa] and higher, special attention is to be given to welding procedures.

1.4.4 Through thickness properties

1.4.4.1 For critical connections involving high restraint (including adverse geometry, high yield strength and/or thick sections), throughthickness shrinkage strains, and subsequent through thickness tensile loads in service, use of steel having improved through-thickness (Zdirection) properties is to be considered, e.g., API Spec 2H, Supplements S4 and S5.

1.4.5 Brace Ends

1.4.5.1 Although the brace ends at tubular connections are also subject to stress concentration, the conditions of service are not quite as severe as for joint-cans. For critical braces, for which brittle fracture would be catastrophic, consideration is to be given to the use of stub-ends in the braces having the same impact properties as the joint-can. This need not be applied to the body of braces (between joints).

1.5 Cement Grouting

1.5.1 If required by design, the space between the piles and the surrounding structure is to be carefully filled with grout. The requirements for grouting strength are to be in accordance with API RP 2A or other international standard acceptable to IRS. 1.5.2 Prior to installation, the compressive strength of the grout mix design is to be confirmed on a representative number of laboratory specimens cured under conditions which simulate the field conditions.

1.5.3 A representative number of specimens taken from random batches during grouting operations are to be tested to confirm that the design grout strength has been achieved.

Section 2

Corrosion Protection

2.1 General

2.1.1 Materials are to be protected from the effects of corrosion by the use of a corrosion protection system including the use of coatings. The intensity of corrosion of an unprotected steel structure in seawater varies markedly with its position relative to the sea levels. The splash zone above the mean tide level is the most severely attacked region due to continuous contact with highly aerated sea water and the erosive effects of spray, waves and tidal actions.

2.1.2 Three generally accepted methods of corrosion protection are

- painting or coating
- cathodic protection
- sheathing

2.1.3 The type of fouling likely to occur and their possible effects on corrosion protection coatings are also to be considered whilst designing such systems.

2.1.4 The National Association of Corrosion Engineers (NACE) publication SP 0176-2007, as amended or, ISO 12495 or, other appropriate recognized standards may be referred for design of corrosion protection systems.

2.1.5 Details of corrosion control systems (such as coatings, sacrificial anodes or impressed current systems) are to be submitted with adequate supporting data to show their suitability.

2.1.6 The design of the cathodic protection systems is to take into account the following:

.1 Structure construction specifications and practices

.2 Offshore site conditions

.3 Field survey data, corrosion test data and operating experience

2.1.7 The structural design in Chapter 6 considers an implicit general corrosion margin for the structures with the assumption that an effective corrosion protection system is provided including coatings.

2.2 Corrosion Control methods

2.2.1 Atmospheric Zone

2.2.1.1 Steel surfaces in the atmospheric zone are to be protected by a coating system proven for marine atmospheres by practical experience or relevant testing.

2.2.2 Splash Zone

2.2.2.1 Steel surfaces in the splash zone are to be protected by a coating system proven for splash zone applications by practical experience or relevant testing. A corrosion allowance is also to be considered in combination with a coating system for especially critical structural items.

2.2.2.2 Steel surfaces in the splash zone, below the mean sea level are to be designed with cathodic protection in addition to coating.

2.2.3 Submerged Zone

2.2.3.1 Steel surfaces in the submerged zone are to have a cathodic protection system. The cathodic protection design is to include current drain to any electrically connected items for which cathodic protection is not considered necessary (e.g. piles). The cathodic protection is also to include the splash zone beneath Mean Sea Level.

2.2.3.2 For certain applications, cathodic protection is only practical in combination with a

coating system. Any coating system is to be proven for use in the submerged zone by practical experience or relevant testing demonstrating compatibility with cathodic protection.

2.2.4 Internal Zones

2.2.4.1 Internal zones (i.e. tanks, voids and internal spaces) exposed to seawater for a long period of time (e.g. ballast tanks) are to be protected by a coating system proven for such applications by practical experience or relevant testing. Cathodic protection is to be considered for use in combination with coating.

2.2.4.2 A coating system and/or corrosion allowance is to be provided for internal zones that are empty (including those occasionally exposed to seawater for a short duration of time). No further corrosion control is required for internal zones with continuous control of humidity. Further, no coating is required for zones that do not contain water and that are permanently sealed.

2.2.4.3 Tanks for fresh water are to have a suitable coating system. Coating systems to be used for potable water tanks are to be specially considered.

2.2.4.4 To facilitate inspection, light coloured and hard coatings are to be used for components of internal zones subject to major fatigue forces requiring visual inspection for cracks.

2.2.4.5 Only anodes on aluminium or zinc basis are to be used. Due to the risk of hydrogen gas accumulation, anodes of magnesium or impressed current cathodic protection are not to be used in tanks.

2.2.4.6 For cathodic protection of ballast tanks that may become affected by hazardous gas from adjacent tanks for storage of oil or other liquids with flash point less than 60 [°C], anodes on zinc basis are preferred.

2.2.4.7 Due to the risk of thermite ignition, no aluminium base anodes are to be installed such that a detached anode could generate an energy of 275 [J] or higher (i.e. as calculated from anode weight and height above tank top). Coatings containing more than 10% aluminium on dry weight basis are not to be used for such tanks.

2.2.4.8 A corrosion allowance is to be implemented for internal compartments without

any corrosion protection (coating and/or cathodic protection) but subject to a potentially corrosive environment such as occasional exposure to seawater, humid atmosphere or produced/ cargo oil. Any corrosion allowance for individual components (e.g. plates, stiffeners and girders) is to be defined taking into account:

- a) design life
- b) maintenance philosophy
- c) steel temperature
- d) single or double side exposure.

2.2.4.9 Minimum corrosion allowance to be applied as alternative to coating is as follows:

- a) one side unprotected: 1.0 [mm]
- b) two sides unprotected: 2.0 [mm]

2.3 Coating Systems

2.3.1 Specifications for coatings are to be defined during design. At least the following aspects are to be covered in the specification:

a) type of coating;
b)surface preparation (surface roughness and cleanliness);
c) thickness of individual layers;
d) inspection and testing.

For use of aluminium containing coatings in tanks that may become subject to explosive gas, the aluminium content is limited to maximum 10% on dry film basis.

2.3.2 Corrosion in the atmospheric zone is typically controlled by the application of a protective coating system.

2.3.3 Diverse coating schemes are recommended in NACE SP 0108-2008, as amended, for corrosion protection of offshore structures. The corrosion rate in the extended tidal zone is typically 100 times higher than in the atmospheric zone and therefore the systems need to be designed accordingly.

2.3.4 The application of coatings may not be suitable for parts of submerged structures requiring frequent inspection for fatigue cracks, e.g. critical welded nodes of jacket structures.

2.4 Cathodic Protection

2.4.1 The electrical current demand on each part of the structure is to be considered in the design of the system. The current density required is not the same for all parts of the structure as the environmental conditions are variable. The following areas and parts are to be considered :

- a) areas located in the tidal and transition zone
- b) areas located in the buried zone
- c) areas located in the immersed zone
- d) wells to be drilled (electrical current allowance per well)
- e) Neighbouring structures and pipelines in electrical contact with the fixed steel offshore structure to be protected.

2.4.2 Cathodic protection can be achieved using:

- a) the galvanic (or sacrificial) anodes system
- b) the impressed current system
- c) a combination of both cathodic protection systems (Hybrid Systems)

2.4.3 For permanently installed offshore structures, galvanic anodes are usually preferred. When using hybrid systems, the galvanic anodes should provide cathodic protection during float out, initial installation and subsequently during the impressed current systems shutdowns.

2.4.4 Galvanic anodes are also to be installed in areas where it may be difficult to achieve adequate level of polarization by the impressed current system due to shielding effects.

2.4.5 As the electrical current demand is not constant with time, the cathodic protection system is to be able to deliver the repolarization current density required for short periods throughout the life of the structure.

2.5 Types of Cathodic Protection Systems

2.5.1 Galvanic Anode Systems

2.5.1.1 Galvanic anodes may be alloys of active metals such as magnesium, zinc or aluminium. The method used to attach the anodes to the structure is to ensure that low resistance electrical contact is maintained throughout the operating life of the anodes. The choice of materials for anodes should take into account any local statutory regulations.

2.5.1.2 The composition of aluminium or zinc alloys are to be suitable to ensure satisfactory performance in sea water.

2.5.1.3 The design of the galvanic anode systems is to be based on the consideration of the current densities such as

- a) *initial electrical current density*, used to determine the anode dimensions, to verify that the output current capacity of new anodes, is adequate to obtain a complete initial polarization of the structure within a few weeks.
- b) average electrical current density, used to determine the weight of the anodes. This current density is required to maintain an adequate polarization level of the structure during its design life.
- c) *final electrical current density*, used to verify that the output current capacity of the anodes when they are consumed to an extent commensurate with their utilization factor, is adequate to re-polarize the structure after severe storms or after marine growth cleaning operations.

2.5.1.4 The electrochemical properties of the anode materials are to be documented or determined by appropriate tests including information such as susceptibility to passivation, susceptibility to inter-granular corrosion and the practical electrical current capacity or consumption rate per annum.

2.5.1.5 For coated structures, the galvanic anode material is to be capable of supplying current even after many years of very low anodic current density. As a minimum, recordings of the general protection level are to be performed by lowering a reference electrode from a location above the water level.

2.5.1.6 The following documentation with respect to galvanic anode systems is to be provided :-

- a) referred design code and design premises;
- b) calculations of surface areas and cathodic current demand (mean and initial/final) for individual sections of the structure;
- c) calculations of required net anode mass for the applicable sections based on the mean current demands;
- calculations of required anode current output per anode and number of anodes for individual sections based on initial/ final current demands;
- e) drawings of individual anodes and their location.

2.5.1.7 Magnesium Alloy Anodes are not recommended for long life designs.

2.5.1.8 Aluminium Alloy Anodes may be be used in sea water or in marine sediments. However, they are not preferred in areas prone to mud coverage particularly at low current output.

2.5.1.9 Zinc Alloy Anodes can also be used in sea water or in marine sediments. Zinc alloy anodes are not to be used at temperatures exceeding 50[°C] unless supported by appropriate tests.

2.5.10 For jackets equipped with mud mats, the part of the mats facing downwards are only to be protected by zinc alloy anodes.

2.5.2 Impressed Current Anode Systems

2.5.2.1 Impressed current anode systems may include lead silver alloy, platinum over various substrates, mixed metal oxides, lead-platinum, graphite or silicon-iron. These anodes are to be connected with an electrically insulated conductor, either singly or in groups, to the positive terminal of a DC source such as a rectifier or generator. The structure to be protected is to be connected to the negative terminal of the DC source.

2.5.2.2 The following documentation is to be provided for impressed current anode systems:

- a) referred design code and design assumptions;
- b) calculations of surface areas and cathodic current demand (mean and initial/final) for individual sections of the structure;
- c) calculations of required net anode mass for the applicable sections based on the mean current demands;
- d) general arrangement drawings showing locations of anodes, anode shields, reference electrodes, cables and rectifiers;
- e) detailed drawings of anodes, reference electrodes and other major components of the system;
- evaluation of anode and reference electrode performance to justify the specified design life;
- g) documentation of rectifiers and current control system;
- h) specification of sizing of anode shields;
- i) specification of anode shield materials and application;
- j) commissioning procedure, incl. verification of proper protection range by independent potential measurements;

k) operational manual, including procedures for replacement of anodes and reference electrodes.

2.5.3 Combination of galvanic anode and impressed current systems

2.5.3.1 A combination cathodic protection system may be used to provide protection during structure construction and during times when the impressed current system is inoperative.

2.5.3.2 If the galvanic portion of the system is smaller than a conventional long-term system, it requires careful design to ensure adequate amount and distribution of current.

2.6 Selection of the type of Cathodic Protection System

2.6.1 The type of cathodic protection system is to be decided based on the following considerations:

2.6.1.1 Availability of electrical power

2.6.1.2 Dependability of the overall system

a) Galvanic anode systems are dependable for long term protection

b) Impressed current systems are capable of providing long term protection but are less tolerant of shortcoming in design, installations and maintenance than galvanic anode systems. Proper attention is to be paid to mechanical strength, connections, cable protection, choice of anode type and integrity of power source. Adequate monitoring systems are to be provided.

c) Built-in redundancy, the use of appropriate design margins and adequate maintenance provisions can increase the dependability of the impressed current system.

2.6.1.3 Total protective current required

2.6.1.4 Once the current requirement is established, the feasibility of protection with galvanic anodes and selection of anode material (apart from cost considerations) can be based on the following:

a) Resistivity of the electrolyte,

b) Anode-to-structure potential (when structure is at protected level),

c) Freedom from mechanical damage in installation, launching and operation,

d) Useful life expectancy of anode material, and

e) Structure weight and structural limitations.

2.6.1.5 The physical space available for impressed current anodes placed on the ocean floor is to be determined by the proximity of other structures and pipelines and by future construction and maintenance considerations.

2.7 Special Mechanical and Electrical Considerations

2.7.1 The performance of the cathodic protection system is dependent on the ability of the various components to withstand the physical stresses to which they are subjected.

2.7.2 The following aspects are to be considered for galvanic anode systems :

2.7.2.1 Anodes are to be located on the structure to ensure polarization of node welds as early as possible. Node welds are critical for the structural strength of the structures. Weld consumables that can cause welds to be anodic to the steel are not to be used. Tests are to be carried out as part of the welding prequalification tests.

2.7.2.2 Anode cores are to be structurally suitable for the anode weight and the forces to which the anode is subjected, both during structure setting and pile-driving operations and during storms and hurricanes. The core is to be able to withstand the anticipated wave forces in the later stages of anode consumption, when the body of the anode is no longer adding its strength to the anode core.

2.7.2.3 The core is to be designed to maintain the electrical integrity with the anode body for the full design life of the anode.

2.7.2.4 Reinforcement to the structural members to support larger size galvanic anodes may be provided by gussets or doubler plates.

2.7.2.5 When galvanic anodes are mounted flush with the steel surface, either the steel surface of the back face of the anode is to be coated or fitted with a dielectric shield to prevent premature consumption of the anode material from the back face and possible failure of the mount because of constant pressure developed by the corrosion products of the anode.

2.7.3. The following important aspects need to be considered for impressed current systems:

2.7.3.1 The electrical connection between the anode lead cable and the anode body must be made watertight and mechanically sound.

2.7.3.2 Cable and connection insulating materials are to be resistant to chlorine, seawater, hydrocarbons and other harmful chemicals.

2.7.3.3 Suitable mechanical protection is to be provided to both the anode and its connecting cable. On suspended systems, the individual anodes or anode strings are to be equipped with winches or other retrieval means as a damage preventing measure during severe storms or for routines inspection and maintenance. The loss of protection during these periods is to be considered.

2.7.3.4 All precautions are to be taken to avoid any leakage of water through the hull penetration. A cofferdam is to be provided. Typical anode mountings with cofferdam arrangement are given in Annex D of ISO 13173.

2.7.3.5 Acceptable installation methods for fixed type impressed current anodes include, but are not limited to, the following:

.1 Anodes may be installed at lower ends of protective vertical steel pipe casings or conduits. Casings are to be attached to above-water structure members and supported at repeating members below water. The anodes are to be lowered through the casings (which protect the anode lead wires) and are to be allowed to extend below a termination fitting at the bottom of each casing. The anode retrieval or replacement can be then accomplished without diver assistance. Marine growth or corrosion scale may make anode retrieval difficult.

.2 Anodes can be installed on submerged structural members using offset steel structural supports attached to the structure members.

.3 Anodes with essentially flat configurationmounted, insulating-type holders can be attached directly to submerged structure members or to auxiliary structural members, such as vertical pipes which can be removed for anode replacement. .4 Anodes may also be bottom installed (on specially designed concrete sleds; to minimize the possibility of them getting covered with mud/ silt) on the ocean floor.

2.7.3.6 Impressed current anodes are to be located as far as practical from any structural member (usually a minimum distance of 1.5 [m]). If a spacing of 1.5 [m] is not feasible, a dielectric shield is to be used. 2.7.3.7 The impressed current equipment is to be simple, rugged and easily maintainable. Manually adjustable oil cooled rectifiers with both DC and AC overload protection are preferred.

2.7.3.8 Arrangements for temporary power or early energizing of the impressed current system or a short term galvanic anode system may be provided to cater for time delay until permanent electrical power becomes available.

Section 3

Welding

3.1 General

3.1.1 Welding for steel structures is to comply with the requirements of a recognized specification, such as the Structural Welding Code - Steel of the American Welding Society (AWS), D 1.1.

3.1.2 The requirements for inspection and approval of weld consumables such as electrodes, wires, fluxes, etc are provided in Part 2, Chapter 11 of the IRS *Rules and Regulations for the Construction and Classification of Steel Ships*.

3.1.3 This section gives additional requirements to be complied with, as applicable, for classification.

3.2 Information to be submitted

3.2.1 The following details are to be covered in the plans and specifications submitted for review/ approval:

- a) The extent of welding for the main parts of the structure;
- b) The extent of nondestructive inspection of the weld;
- c) The welding process, filler metal and joint design;
- d) The welding sequence and procedures to be followed for the erection and welding of the main structural members.

3.3 Welding and Supervision

3.3.1 Welders are to be adequately qualified and experienced in the type of work proposed and in the proper use of the welding processes and procedures to be followed. The records of their test and qualifications are to be available at the yard. A sufficient number of skilled supervisors are to be employed to ensure effective control of welding and fabrication activity.

3.4 Welding Procedures

3.4.1 Welding and Weld procedure qualifications may be carried out in accordance with provisions of a recognized standard like AWS D1.1/D1.1 M : 2010.

Procedures are to be developed for welding of all joints prior to construction. The types of electrodes, edge preparations, welding techniques and welding positions are to be addressed in the procedures.

3.4.2 In the case of thick sections, careful consideration is to be given to joint preparation, preheat, welding sequence, heat input and inter pass temperature.

3.4.3 Fitting and Temporary Attachments

3.4.3.1 The edge preparation and fitting of members to be welded are to be carried out as per the joint detail which has been approved. Edge preparations are to be accurate and uniform.

3.4.3.2 Temporary attachments to the structure, such as scaffolding, fabrication and erection aids etc are to be limited, as much as practicable. The following requirements are to be met for provision of temporary attachments:

.1 Temporary attachments are not to be removed by hammering or by arc-air gouging. Attachments to leg joint cans, skirt sleeve joint cans, brace joint can, brace stub ends and joint stiffening rings are to be flame cut to 3 [mm] above parent metal and mechanically ground to a smooth flush finish with the parent metal.

.2 Attachments on all areas that are to be painted are to be removed in the same manner, as in .1 above prior to any painting.

.3 Attachments to all other areas not covered in .1 and .2 above are to be removed by flame cutting just above the attachment weld (maximum 6 [mm] above the weld). The remaining attachment steel is to be completely seal welded.

.4 Attachments to aid in splicing of legs, braces, sleeves, piling, conductors, etc are to be removed to a smooth flush finish.

.5 The removal of such items is to be carried out to the satisfaction of the attending Surveyor.

3.4.5 Cleanliness

3.4.5.1 All surfaces to be welded are to be clean, dry and free from rust, scale and grease. Primer coatings of ordinary thicknesses, or equivalent coatings may be used, provided it is demonstrated that their use has no adverse effect on the production of satisfactory welds.

3.4.5.2 The surface and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag before next run is applied.

3.4.5.3 Weld joints prepared by arc-air gouging may require additional preparation by grinding or chipping and wire brushing prior to welding, to minimize the possibility of excessive carbon on the surfaces.

3.4.6 Tack Welds

3.4.6.1 Tack welding is to be kept to a minimum, and where used, should be equal in quality and grade of filler metal to that of the finished welds. Any defective tack weld is to be cut out before completing the finished welds. Care is to be taken while removing tack welds to ensure that the structure is not damaged while doing so.

3.4.6.2 Preheat may be necessary prior to tack welding when the materials to be joined are highly restrained.

3.4.6.3 The above precautions are to be followed also when making any permanent welded markings.

3.4.7 Run-on and Run-off Tabs

3.4.7.1 When used, run-on and run-off tabs are to be designed to minimize the possibility of high stress concentrations and base-metal and weld-metal cracking.

3.4.8 Welding Procedure Limitations

3.4.8.1 Low hydrogen electrodes and processes are to be used for all welding of steel with nominal yield strength of 280 [MPa] or more, or when a weld throat thickness is in excess of 13 [mm], (i.e., hydrogen contents less than 15 [ml/100g]).

3.4.8.2 All welding by processes employing an external gas shield of the arc area is to be undertaken with wind protection.

3.5 Fabrication

3.5.1 Splices

3.5.1.1 Pipe splices are to be in accordance with the requirements of API Spec 2B or any other equivalent recognized standard. Pipes used as beams are also to be subject to the requirements of Cl 3.5.1.2.

3.5.1.2 Segments of beams with the same cross-sections may be spliced. Splices are to be full penetration in accordance with AWS D1.1-2002 or equivalent. The use of the beam is to determine the location and frequency of splicing.

3.5.2 Welded Tubular Connections

3.5.2.1 The intersection of two or more tubular members forms a connection with stress concentrations at and near the joining weld. The welds are to achieve as full a joint penetration as is practicable, and the external weld profile is to merge smoothly with the base metal on either side.

3.5.2.2 Any member framing into or overlapping onto any other member is to be beveled for a complete joint penetration groove weld.

3.5.3 Plate Girder Fabrication and Welding

3.5.3.1 Fabrication tolerances are to be governed by AWS D1.1/ D1.1M:2010 except where specific service requirements dictate the use of more severe control over the deviations from the theoretical dimensions assumed in the design.

3.6 Production Welding

3.6.1 Protection against Environmental effects

3.6.1.1 Proper precautions are to be taken to ensure that all welding is done under conditions where the welding site is protected against the harmful effects of moisture, wind, and severe cold.

3.6.2 Welding Sequence

3.6.2.1 Welding is to be carried out symmetrically such that shrinkage on both sides of the structure will be equalized.

3.6.2.2 The ends of frames and stiffeners are to be left unattached to the plating at the subassembly stage until connecting welds are made in the intersecting systems of plating, framing and stiffeners at the erection stage.

3.6.2.3 Welds are not to be carried across an un-welded joint or beyond an un-welded joint which terminates at the joint being welded, unless specially approved.

3.6.3 Preheating and Post weld Heat Treatment

3.6.3.1 The use of preheating is to be considered when welding higher-strength steels, materials of thick cross section, materials subject to high restraint, and when welding is performed under high humidity conditions or low temperature. The control of inter pass temperature is to be specially considered when welding quenched and tempered higher-strength steels.

3.6.3.2 Post weld heat treatment, when specified, is to be carried out using an approved method.

3.6.4 Low-hydrogen Electrodes or Welding Processes

3.6.4.1 Unless otherwise approved, the use of low-hydrogen electrodes or welding processes is required for welding all higher-strength steels, and may also be considered for ordinarystrength steel weldments subject to high restraint.

3.6.4.2 When using low-hydrogen electrodes or processes, proper precautions are to be taken to ensure that the electrodes, fluxes and gases used for welding are clean and dry.

3.6.5 Back Gouging

3.6.5.1 Chipping, grinding, arc-air gouging or other suitable methods are to be employed at the root or underside of the weld to obtain sound metal before applying subsequent beads for all full-penetration welds.

3.6.5.2 When arc-air gouging is employed, the selected technique is to minimize carbon buildup and burning of the weld or base metal.

3.6.5.3 Quenched and tempered steels are not to be flame gouged using oxy-fuel gas.

3.6.6 Peening

3.6.6.1 The use of peening is not recommended for single-pass welds and the root or cover passes on multi-pass welds. Peening, when used to correct distortion or to reduce residual stresses, is to be effected immediately after depositing and cleaning each weld pass.

3.6.7 Fairing and Flame Shrinking

3.6.7.1 Fairing by heating or flame shrinking, and other methods of correcting distortion or defective workmanship in fabrication of main strength members and other members which may be subject to high stresses, are to be carried out only with the approval of the Surveyor.

3.6.7.2 These corrective measures are to be kept to an absolute minimum when higher strength quenched and tempered steels are involved, due to high local stresses and the possible degradation of the mechanical properties of the base material.

3.6.8 Weld Soundness and Surface Appearance

3.6.8.1 Production welds are to be sound, crackfree and reasonably free from lack of fusion or penetration, slag inclusions and porosity.

3.6.8.2 The surfaces of welds are to be visually inspected and are to be regular and uniform with a minimum amount of reinforcement and reasonably free from undercut and overlap and free from injurious arc strikes.

3.6.8.3 Contour grinding when required by an approved plan or specification or where deemed necessary by the Surveyor is to be carried out to the satisfaction of the Surveyor.

3.7 Inspection

3.7.1 Inspection of Welds

3.7.1.1 The following methods may be used for non-destructive examination of welds:

a) radiographic testing (RT)
b) ultrasonic testing (UT)
c) magnetic-particle inspection (MPI)
d) dye-penetrant inspection (DPI)

The standards used for the above are to be acceptable to IRS.

3.7.1.2 All weld fit-ups (joint preparation prior to welding) are to be visually inspected before welding.

3.7.1.3 When the weld cross section is to be evaluated for overall soundness, RT or UT, or both, may be used.

3.7.1.4 MPI or DPI may be used when investigating the outer surface of welds, as a check of intermediate weld passes such as root passes, and to check back chipped, ground or gouged joints prior to depositing subsequent passes.

3.7.1.5 In the case of steels such as higherstrength steels which may be susceptible to delayed cracking the final nondestructive testing is to be delayed for a suitable period to permit detection of such defects.

3.7.1.6 Weld run-on or run-off tabs may be used where practicable and these may be sectioned for examination.

3.7.2 Extent of Inspection of Welds

3.7.2.1 A plan for nondestructive testing of the structure is to be submitted for review. The extent and method of inspection is to be indicated on the plan

3.7.2.2 Nondestructive testing is generally to be carried out after all forming and post weld heat treatment, and procedures are to be adequate to detect delayed cracking.

3.7.2.3 Welds which are inaccessible or difficult to inspect in service are to be subjected to increased levels of nondestructive inspection.

3.7.2.4 Nondestructive examination of full penetration butt welds is generally to be carried out by radiographic or ultrasonic methods.

3.7.2.5 To assess the extent of surface imperfections in welds made in steels used in critical structural locations, representative inspection by the MPI or DPI is also to be undertaken.

3.7.2.6 The recommended minimum extent of nondestructive testing to be conducted is indicated in Table 3.7.2.6.

| Table 3.7.2.6 : Recommended Minimum Extent of NDE Inspection | | | | | |
|--|-----------------|--------------------------|--|--|--|
| Case | Extent (%) | Method | | | |
| Structural Tubular | | | | | |
| Longitudinal Weld Seam (L) | 10 ¹ | UT or RT | | | |
| Circumferential Weld Seam (C) | 100 | UT or RT | | | |
| Intersection of L&C | 100 | UT or RT | | | |
| Tubular Joints | | | | | |
| Major brace-to-chord welds | 100 | UT | | | |
| Major brace-to-brace welds | 100 | UT | | | |
| Miscellaneous Bracing | | | | | |
| Conductor guides | 10 ¹ | UT (or MPI) ² | | | |
| Secondary bracing and subassemblies, i.e., splash zone, and/ or mudline secondary bracing, | 10 ¹ | UT (or MPI) ² | | | |
| boat landings, etc. | | | | | |
| Attachment weld connecting secondary | 100 | UT or MPI | | | |
| Deck Members | | | | | |
| All primary full penetration welds | 100 | UT or RT | | | |
| All partial penetration welds | 100 | Visual ³ | | | |
| All fillet welds | 100 | Visual ³ | | | |

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Table 3.7.2.6 (Contd.)

1. Partial inspection is to be conducted as 10 percent of each piece, not 100 percent of 10 percent of the number of pieces. Partial inspection is to include a minimum of three segments randomly selected unless specific problems are known or suspected to exist. All suspect areas (e.g., areas of tack welds) are to be included in the areas to be inspected. If rejectable flaws are found from such 10% inspection, additional inspection is to be performed until the extent of rejects has been determined and the cause corrected.

2. Depending upon design requirements and if specified in the plans and specifications MPI may be an acceptable inspection method.

3. May include MPI and/or DPI.

3.7.2.7 If UT is used as the primary inspection method, such testing is to be supplemented by a reasonable amount of radiographic inspection to determine that adequate quality control is being achieved.

3.7.2.8 Classification of Application

3.7.2.8.1 Welds are to be designated as being special, primary or secondary depending on the function and severity of service of the structure in which the welds are located. The designation of welds are to be indicated in the plan for nondestructive testing mentioned in 3.7.2.1.

3.7.2.8.2 Special welds are those occurring in structural locations of critical importance to the integrity of the structure or its safe operation.

3.7.2.8.3 Secondary welds are those occurring in locations of least importance to the overall integrity of the structure.

3.7.2.8.4 Primary welds are those occurring in locations whose importance is intermediate between the special and secondary classifications.

3.7.2.9 Extent of Nondestructive Inspection

.1 In general, the number of penetration type welds (i. e., butt, T, K and Y joints) to be inspected in each classification is to be based on the percentages stated below.

.2 Alternatively, the extent of RT and UT may be based on other methods, provided the alternative will not result in a lesser degree of inspection.

.3 All welds considered special are to be inspected 100% by UT or RT.

.4 Twenty percent of all welds considered primary are to be inspected by UT or RT.

.5 Welds considered to be secondary are to be inspected on a random basis using an appropriate method.

.6 In locations where ultrasonic test results are not considered reliable, the use of MPI or DPI as a supplement to ultrasonic inspection is to be conducted. For T, K, or Y joints, approval may be given to substituting MPI or DPI for UT if this will achieve a sufficient inspection quality.

.7 MPI or DPI of fillet welds is to be undertaken for all permanent fillet welds used in jacket construction, all jacket-to-pile shim connections, and all fillet welds in special application areas of the deck structure.

.8 The random inspection of other deck fillet welds is to be carried out as decided by the Surveyor.

End of Chapter

Chapter 4

Environmental Conditions

| Contents | | |
|----------|--|--|
| Section | | |
| 1 | General | |
| 2 | Waves | |
| 3 | Wind | |
| 4 | Currents | |
| 5 | Tide | |
| 6 | Climate, Temperature and Marine Growth | |
| 7 | Earthquake | |
| 8 | Conditions Due to Snow and Ice | |

Section 1

General

1.1 Scope

1.1.1 This chapter describes various environmental conditions to which an offshore structure may be subjected to during fabrication, transportation, installation and operation.

1.2 Determination of design data

1.2.1 An offshore installation will be exposed to various environmental conditions during its life time. These environmental conditions are to be described using relevant data of the area in which the installation is to be situated with due consideration for the seasonal period in which the structure is to be transported and installed.

1.2.2 Probabilistic methods for prediction are to be based on statistical distributions of the environmental phenomenon being considered. Methods and mathematical models used for hindcasting and their validation are to be well documented.

1.2.3 Where published data is available for the area concerned, such data may be referred.

1.2.4 The effect of climate change on the environmental conditions is to be taken into account by using methods acceptable to IRS.

1.3 Environmental factors

1.3.1 The design of an offshore structure will require investigation of the following environmental factors:

- Waves
- Wind
- Currents
- Tides and Storm Surges
- Air and Sea Temperatures
- Ice and Snow
- Marine Growth
- Seismicity
- Sea Ice

1.3.2 Following phenomena may require investigation depending upon specific installation site:

- Tsunamis
- Submarine slides
- Seiche
- Abnormal composition of air and water
- Air humidity
- Salinity
- Ice drift
- Icebergs
- Ice Scouring
- Internal waves.

1.3.3 The required investigation for seabed and soil conditions is described in Ch 7.

1.4 Environmental Design Conditions

1.4.1. The joint probability of occurrence of wind, waves and current and other environmental factors is to be considered while determining the environmental design conditions.

1.4.2 In the absence of site-specific data, it is to be assumed that environmental phenomena may approach the installation from any direction.

1.4.3 The worst possible combination of directions of environmental phenomena, from the point of view of effects on the installation, is to be considered for the design.

1.4.4 Operating Environmental Condition

1.4.4.1 Limiting environmental factors for each operating condition are to be determined. This is to be based on safe operation of the installation under the operating environmental conditions. These operating conditions are to include transportation, offloading and installation of structure, drilling or production operations, evacuation etc.

1.4.5 Extreme Environmental Condition

1.4.5.1 This condition consists of the combination of environmental factors producing the most unfavorable effects on the structure, as a whole and as defined by the parameters given below. This condition is to be described by a set of parameters representing an environmental condition which has a high probability of not being exceeded during the life of the structure and will normally be composed of

- i. The maximum wave height corresponding to the selected recurrence period along with the associated wind, current and limits of water depth and appropriate ice and snow effect.
- ii. The extreme air and sea temperature.
- iii. The maximum and minimum water level due to tide and storm surge.

1.4.5.2 Depending on the site-specific condition, consideration should be given to the combination of event contained in item i above.

1.4.5.3 The recurrence period chosen for events i, ii, and iii above is normally not to be less than 100 years, unless justification for a reduction can be provided and agreed upon by IRS.

1.4.5.4 A recurrence interval less than 100 years may be used in the case of events i, ii, and iii above, for the following:

a) Unmanned structures; or

b) Structures which can be easily evacuated during the designed event; orc) Structures with shorter life span than typical 20 years

In any case the recurrence interval is not to be less than 50 years.

1.4.5.5 For sites located in seismically active areas, an earthquake of magnitude which has a reasonable likelihood of not being exceeded during the structure life to determine the risk of damage (Strength Level Earthquake) and a rare intense earthquake (Ductility Level Earthquake) to evaluate the risk of structural collapse are to be considered in the design.

1.4.5.6 The magnitude of the parameters characterizing these earthquake having recurrence period appropriate to the design life of the structure are to be determined The effects of the earthquakes are to be accounted for in design but, generally, need not be taken in combination with other environmental factors.

1.4.5.7 For installations located in areas susceptible to tsunami waves, submarine slides, seiche or other phenomena, the effects of such phenomena are to be based on the most reliable estimates available and, as practicable, the expected effects are to be accounted for in design. Generally, for such phenomena, suitable data and recommendations submitted by consultants may be accepted as a basis for design. Rules and Regulations for the Construction and Classification of Fixed Offshore Steel Structures - 2023 Page 3 of 6

Section 2

Waves

2.1 Wave data

2.1.1 Wave parameters for design of structure may be based on wave statistics at the location which is normally available as Published data. Hindcasting techniques may also be employed for prediction of waves.

2.1.2 A deterministic or probabilistic method may be used to specify the design wave depending on the topic being considered.

2.1.3 In simple deterministic design analysis, the wave may be described by the wave height, wave period, direction and water depth.

2.1.4 In stochastic method, the wave data is normally characterized by significant wave height, average zero-up-crossing period or spectral peak period. Appropriate wave spectra suitable to the wave climate in the area are to be used.

2.2 Design application

2.2.1 Design waves or sea states are to be those resulting in the most unfavourable effects on the structure or local member considered. Waves which cause the most unfavorable effects on the overall structure may differ from the waves having most severe effect on individual structural components.

2.2.2 Recognized methods are to be employed for determining long term and extreme values of wave parameters to be used for design.

2.2.3 The wave data to be used in required analysis is to reflect conditions at the site and the type of structure.

2.2.4 Breaking wave criteria are to be appropriate to the installation site and based on recognized techniques.

2.2.5 More frequent waves of lesser heights, in addition to the most severe wave conditions are to be investigated when fatigue and dynamic analysis are required.

Section 3

Wind

3.1 General

3.1.1 Statistical wind data is normally to include information on the frequency of occurrence, duration and direction of various wind speeds.

3.1.2 If on-site measurements are taken, the duration of individual measurements and the height above sea-level of measuring devices is to be stated.

3.1.3 Sustained winds are to be considered those having durations equal to or greater than one minute, while gust winds are winds of less than one minute duration.

3.2 Extreme value prediction

3.2.1 Wind speed statistics are to be used as the basis for the description of the long term wind conditions.

3.2.2 Long term distributions are to be preferably based on statistical data for the same averaging periods of wind speed which are used for the determination of loads. Data for other averaging periods may be converted by applying appropriate scaling methods.

3.2.3 In general, a 3 second wind speed averaging time interval is to be used for individual members and equipment. Where wind load is to be applied to the whole topside structure, a 1 minute time interval is to be used.

3.2.4 Vertical profiles of horizontal wind are to be determined as given in Chapter 5, Table 3.4.7(b).

Section 4

Currents

4.1 General

4.1.1 Current speed, direction of current and variation with depth are to be considered for the design.

4.1.2 The information on the joint probability of the phase and directionality of the current components with respect to other environmental phenomena are to be taken into account when deciding the design values.

4.1.3 The following types of current are to be considered, as appropriate to the installation site:

- tidal,
- wind-generated,
- density,
- Coastal and ocean currents
- river-outflow.

4.1.4 The variation in current profile with water depth due to wave action is to be accounted for by suitable method. Unusual profiles due to bottom currents and stratified effects due to river outflow currents are to be accounted for.

Section 5

Tide

5.1 Tides

5.1.1. Tides may be classified as the following types:

- lunar or astronomical tides,
- wind tides, and
- pressure differential tides.

5.1.2 The combination of wind tides and pressure differential tides is termed as storm surge.

5.1.3 The water depth at any location consists of the mean depth, defined as the vertical distance between the sea bed and an appropriate nearsurface datum, and a fluctuating component due to astronomical tides and storm surges.

5.1.4 The astronomical tidal range is defined as the range between the highest astronomical tide, HAT, and lowest astronomical tide, LAT.

5.1.5 The highest still water level to be used for design is defined by the water depth at the highest astronomical tide plus the water level elevations due to storm surge.

5.1.6 The smallest still water level to be used for design is defined by the smaller value of either the water depth due to the lowest astronomical tide minus the water level decline due to storm surge or the chart datum, whichever is applicable.

5.1.7 Storm surge is to be estimated from available statistics or by mathematical storm surge modeling.

5.1.8 For design purposes, the design environmental wave crest elevation is to be superimposed on the still water level.

5.1.9 Variations in the elevation of the daily tide may be used in determining the elevations of boat landings, barge fenders and the corrosion prevention treatment of structure in the splash zone. Water depths assumed for various topics of analysis are to be clearly stated.

5.1.10 Water depth and statistical tidal data shall be provided by a competent Authority. The application of the data is subject to approval by IRS.

Section 6

Climate, Temperature and Marine Growth

6.1 Temperature

6.1.1 Maximum and Minimum temperatures are to be defined in terms of highest and lowest daily mean temperatures and their corresponding recurrence periods. Estimates of design temperatures of air and water are to be based on relevant data that are provided by competent institutions.

6.1.2 If design air temperatures are less than 0 °C, the amount of snow and rain turning to ice on exposed surfaces is to be specified.

6.1.3 If design air temperatures are less than – 2°C, the amount of ice accretion on free surfaces, e.g., lattice structures, as result of seawater spray is to be specified.

6.1.4 Temperature data is to be used to for selection of structural materials, ambient ranges and conditions for machinery and equipment design. Thermal stresses, where relevant are to be evaluated based on temperature data.

6.2 Marine Growth

6.2.1 Marine growth is to be considered in the design of an offshore structure taking into account biological and environmental factors relevant to the site considered. The rate and extent of marine growth may be based on past experience and available field data.

6.2.2 Marine fouling effect on the member resulting in increased sectional area and surface roughness and consequent increase in hydrodynamic loads and added weight are to be taken into account.

6.2.3 Effect of marine fouling on the coatings for corrosion protection is to be considered.

6.2.4 Structural components can be considered hydrodynamically smooth if they are either above the highest still-water level or sufficiently deep, such that marine growth is sparse enough to ignore the effect of roughness. Site-specific data should be used to establish the extent of the rough zones.

6.3 Other environmental factors

6.3.1 Depending on circumstances, other environmental factors can effect operations and can consequently influence the design of structures. Appropriate data shall be compiled as applicable including, records and or predictions of,

- precipitation
- humidity
- fog
- wind chill
- salinity of sea water
- oxygen content of sea water
- turbidity
- hail storms

Section 7

Earthquake

7.1 General

7.1.1 In areas of seismic activity, the following two different earthquake levels are to be considered:

• A strength level earthquake (SLE) represents a level not unlikely to happen in the region of the planned installation. For this level the strength of the structure is used up to the minimum nominal upper yield stress but the main functions of the offshore

installation can still be fulfilled and, can be continued after sufficient checking.

• A ductility level earthquake (DLE) represents an extreme level that normally puts the offshore installation out of operation, but still allows the main elements of the installation to keep their position, and the structure is thus able to survive. This should make it possible for the crew to save themselves or to be evacuated and should avoid extreme damage of the installation and to the environment.

7.1.2 The characteristics of these two earthquake levels (acceleration intensity, duration) are to be established by a competent Authority and agreed upon with IRS.

7.2 Evaluation of effects on structure

7.2.1 The effects of earthquakes are to be considered for structures located in areas known to be seismically active.

7.2.2 The following factors are to be taken into account for determining the effect of earthquakes:

a) Seismicity of the area on the basis of historical, seismological data and records

b) Location and characteristics of active faults in the region

c) Attenuation of ground motion between the faults and the site

d) Subsurface soil conditions

7.3 Earthquake criteria

7.3.1 Appropriate criteria for Strength level and ductility level earthquake are to be established based on seismic data. The criteria should cover response spectra, peak ground accelerations and duration of earthquake.

7.3.2 In addition to the above criteria for ground motion, other earthquake related phenomena are to be taken into account as relevant, such as Liquefaction of subsurface soils, Submarine slides, Tsunamis etc.

Section 8

Conditions Due to Snow and Ice

8.1 Accumulation of Ice or Snow

8.1.1 Where structures are to be installed in areas with possibility of accumulation of ice and snow effect of these on the structure are to be evaluated.

8.2 Sea ice and Icebergs

8.2.1 The probability of occurrence of sea ice and icebergs in the operating area is to be established.

8.2.2 If seasonal sea ice is probable in the operating area, the modes of occurrence and the mechanical properties of the ice is to be determined by a competent Authority.

8.2.3 If permanent sea ice is probable in the operating area, thickness and extension as well as mechanical properties and drifting

characteristics are to be determined by a competent Authority.

8.2.4 This data is to be used to determine design characteristics of the installation as well as possible evacuation procedures.

8.2.5 The effects of sea ice on structures must consider the frozen-in condition (winter), breakout in the spring, and summer pack ice invasion as applicable.

8.2.6 Impact, both centric and eccentric, must be considered where moving ice may impact a structure. The force exerted by the broken or crushed ice in moving past the structure must also be considered. Impact should consider both that of large masses (multi-year floes and icebergs) moving under the action of current, wind, and Coriolis effect, and that of smaller ice masses which are accelerated by storm waves

End of Chapter

Chapter 5

Design Loads

| Contents | | | |
|----------|---------------------------------------|--|--|
| Section | | | |
| 1 | General | | |
| 2 | Types of Loads | | |
| 3 | Environmental Loads | | |
| 4 | Loads due to Accidents | | |
| 5 | Transportation and Installation Loads | | |
| 6 | Earthquake Loads | | |

Section 1

General

1.1 Scope

1.1.1 This chapter specifies the types of loads acting on offshore structures and the methods of determination of these loads. The loads include those acting during transportation and installation and in service after installation.

1.1.2 The types of loads described in this chapter are to be considered in the design of the structure, as applicable.

Section 2

Types of Loads

2.1 Load Types

2.1.1 Loads on offshore structures may be divided into the following types for evaluation purposes:

- Permanent Loads
- Functional Loads
- Deformation Loads
- Environmental Loads
- Loads due to Accidents
- Transportation and Installation Loads
- Earthquake Loads

2.2 Permanent Loads (Dead Loads)

2.2.1 Permanent loads are those loads due to gravity which remains same during the considered mode of operation.

2.2.2 Permanent loads include the following:

- Weight of all structure and piping in air in air
- Weight of permanent ballast and fixed machinery.
- External hydrostatic pressure considered at the still water level.
- Static earth pressure

2.2.3 The above loads are to be specified in the in the design documents and taken into account in design calculations.

2.3 Live Loads/Functional Loads

2.3.1 Live loads are loads associated with the normal operation and use of the structure is

Page 2 of 8

loads which may change during the mode of operation considered.

2.3.2 Live loads include the following.

- a. Weight of drilling or production equipments which are removable: e.g: derrick, draw works, mud pumps, mud tanks, rotating equipment. .
- b. Weight of consumables such as mud, chemicals, water, fuel, pipe, cable, stores, drill stem, casing, etc
- c. Liquids in pipes during operation
- d. Liquids in pipes during testing
- e. Liquids in tanks
- f. Forces due to operation, e.g derrick reaction, crane and vehicle forces.
- g. Vessel mooring forces including accidental impact.
- h. Forces due to helicopter landing/ take off and parking.

2.3.3 Where the live loads are dynamic in nature, response of the structure is to be evaluated for such loads. e.g sloshing in tanks, vehicle, vessel impact and helicopter loads etc.

2.3.4 Static and dynamic live loads acting on the structure at the time of transportation and

installation are to be evaluated and considered in the design.

2.4 Deformation Loads

2.4.1 Deformation of the structure due to the following can result in deformation loads:

- a) Temperature variations resulting in thermal stresses
- b) Soil displacements
- c) Deformations of adjacent structures.

2.5 Environmental Loads

2.5.1 Loads due to environmental phenomena such as wind, waves, current, ice, snow, and earthquake are categorized as environmental loads.

2.5.2 Environmental Loads in the operating condition and extreme condition are to be considered as specified in Chapter 4.

2.5.3 Earthquake loads and accidental loads may be considered separately and combinations with other environmental loads are normally not required.

Section 3

Environmental Loads

3.1 General

3.1.1 Environmental loads are to be evaluated using the data on environmental phenomena described in Chapter 4. This section covers all environmental loads other than earthquake loads. Earthquake loads are covered separately in section 6. The loads may be determined using one or more of the following methods, as appropriate:

a) Model tests

- b) field tests
- c) Analysis and calculations

3.1.2 The load calculation method is to be appropriate to the structure's characteristics and site conditions.

3.2 Wave Loads

3.2.1 General

3.2.1.1 The design wave criteria are to be specified by the Owner / Designer considering the environmental data. A design value of wave load on a structural element (local wave load) or on the entire structure (global wave load) may be estimated by using the methods given in 3.2.2 or 3.2.3.

3.2.1.2 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.

3.2.1.3 Forces caused by the action of waves on the installation/unit are to be taken into account in the structural design. Theories used to calculate wave forces and to select relevant force coefficients are to be acceptable to IRS.

3.2.1.4 Hydrodynamic characteristics of the structure are to be considered in selecting the method to estimate design wave loads.

3.2.1.5 Forces on appurtenances such as boat landings, fenders or bumpers, walkways, stairways, grout lines, and anodes shall be considered for inclusion in the hydrodynamic model of the structure. Forces on some appurtenances may be important for local member design. Appurtenances are generally modeled by non-structural members that contribute equivalent wave forces.

3.2.2 Wave loads on small structural members with respect to the wave length.

3.2.2.1 The method in 3.2.2 is applicable to small structures, which does not significantly modify the incident wave. This condition is satisfied if D/L < 0.2, where D is a characteristic dimension of the structure (e.g., diameter of structural members, such as platform legs) in the direction of wave propagation, and L is the wave length.

3.2.2.2 Following steps are to be used to evaluate the wave loads:

- Establish design wave height and wave period for the given location. (refer Ch 4,Sec 2)
- Establish the wave theory to be used for above established wave height, wave period and the water depth at the location.
- Estimate water particle kinematics based on wave theory chosen.
- Establish values of Drag coefficient and Mass Coefficient
- Establish marine growth
- Apply Morrison's Formula

3.2.2.3 The Morison formula may be used to calculate the force exerted by waves on a cylindrical object, such as a structural member.

The wave force can be considered as the sum of a drag force and an inertia force, as follows: $F_w = F_D + F_I$

Where,

 F_w = hydrodynamic force vector per unit length along the member, acting normal to the axis of the member

 F_D = drag force vector per unit length F_D = (ρ /2) D C_D u_n | u_n| [kN/m] ρ = mass density of sea water [tonne/m³]

D = projected width [m] of the member in the direction of the cross-flow component of velocity (in the case of a circular cylinder, D denotes the diameter)

C_D = drag coefficient (dimensionless)

 u_n = component of the velocity vector, normal to the axis of the member [m/s],

 $|u_n|$ = absolute value of u_n [m/s];

 $F_1 = \rho (\pi D^2 / 4) C_M a_n [kN/m]$

 a_n = component of the water particle acceleration normal to the axis of the member $[m/s^2]$

D = effective diameter of circular cylindrical member, including marine growth

 C_M = inertia coefficient based on the displaced mass of fluid per unit length (dimensionless),

For structural shapes other than circular cylinders, the term (π D²/4) above is to be replaced by the actual cross-sectional area of the shape.

3.2.2.4 Values of u_n and a_n for use in Morison's equation are to be determined using wave theories appropriate to the wave heights, wave periods and water depths being considered. Drag and inertia coefficients vary considerably with section shape, Reynold's number, Keulegan-Carpenter number and surface roughness. They are to be based on reliable data obtained from literature, model or full scale tests.

Drag coefficient and Inertia coefficient are to be estimated in accordance with procedure given API RP 2A (WSD). Values for more complicated structural elements can be accepted from competent institution, with the approval from IRS In the case of pile supported template type structures, the normal ranges of values of C_D and C_M are 0.6 to 1.2 and 1.5 to 2.0 respectively.

3.2.2.5 Morison equation, as stated above, ignores the convective acceleration component in the inertia force calculation as well as lift forces, impact related slam forces, and axial Froude-Krylov forces.

3.2.2.6 The total loads on the structure is to be determined by superposition of local wave loads

Page 4 of 8

and their phases. Total base shear and overturning moment are calculated by a vector summation of local drag and inertia forces due to waves and currents, dynamic amplification of wave and current forces, and wind forces on the exposed portions of the structure.

3.2.2.7 Slam forces can be neglected because they are nearly vertical. Lift forces can be neglected for jacket-type structures because they are not correlated from member to member. Axial Froude-Krylov forces can also be neglected.

3.2.2.8 The wave crest shall be positioned relative to the structure so that the total base shear and overturning moment have their maximum values. The following aspects need to be considered:

- The maximum base shear may not occur at the same wave position as the maximum overturning moment.
- In special cases of waves with low steepness and an opposing current, maximum global structure force may occur near the wave trough rather than near the wave crest.
- Maximum local member stresses may occur for a wave position other than that causing the maximum global structure force. For example, some members of conductor guide frames may experience their greatest stresses due to vertical drag and inertia forces, which generally peak when the wave crest is far away from the structure centerline.

3.2.2.9 When Morison equation is used to calculate hydrodynamic loads on a structure, the variation of C_D as a function of Reynolds number (R_n), Keulegan-Carpenter number (K_c), and roughness shall be taken into account in addition to the variation of the cross-sectional geometry:

$$R_n = \frac{U_{max}D}{\vartheta}$$
$$K_c = \frac{U_{max}T}{D}$$

Relative Roughness = k/ D

D = Diameter [m]

T= Wave period [sec]

U_{max} = maximum velocity [m/sec]

 ϑ = kinematic viscosity of water [m²/ sec]

k = roughness height [m] See Table 3.2.2

| Table 3.2.2 | : Surface roughness | |
|-------------|---------------------|--|

| Surface type | k |
|---------------------|---------------------|
| Steel, uncoated new | 5 .10 ⁻⁶ |
| Steel, painted | 5. 10 ⁻⁶ |
| Steel highly rusted | 0.003 |
| Marine Growth | 0.005 to 0.05 |

3.2.3 Diffraction Theories

3.2.3.1 The method given below is applicable for Rigidly positioned structure, for which scattering of sea waves cannot be neglected. This condition is satisfied if $D/L \ge 0.2$, where D is a characteristic dimension of the structure (e.g., diameter of structural members, such as platform legs) in the direction of wave propagation, and L is the wave length.

3.2.3.2 Diffraction theories may be based on sink-source methods or finite fluid volume methods. For simple geometric shapes, analytical solutions may be used. For surface piercing bodies, results from sink-source methods are to be checked to avoid unreliable predictions in the neighborhood of irregular frequencies. Appropriate computer codes or a compatible procedure acceptable to IRS may be applied.

3.2.3.3 Model tests may be used for if the loads cannot be adequately predicted by analytical or computational methods due to the configuration of the structure.

3.2.3.4 In the case of structures consisting of a combination of large and slender parts, diffraction theory and Morrison equation may be respectively used for the appropriate part of the structure. However, modification of the wave particle velocities and accelerations due to the large parts of the structure are to be taken into account in the Morrison equation.

3.2.3.5 Hydrodynamic interaction between large structures are to be taken into account.

3.2.3.6 Increase of wave height near large structures is to be taken into account in the

wave load calculations and for the under deck clearance.

3.2.3.7 For installation sites where the ratio of water depth to wave length is less than 0.25, nonlinear effects of wave action are to be taken into account. This may be done by modifying linear diffraction theory to account for nonlinear effects or by model tests.

3.3 Current Loads

3.3.1 Where current is acting alone (i.e., no waves), a design value of sea current pressure on structural elements at depth z below the still-water level is defined as follows:

$$P_C(z) = \frac{1}{2} \rho U_C^2(z) \quad for \ 0 \ge z \ge -d$$

 $P_{C}(z)$ = Sea current pressure [kN/m²]

 $U_{C}(z)$ = Design sea current speed [m/s]

 ρ = density of seawater [t/m³]

z = coordinate of height above sea level [m]

d = depth from still water to bottom [m]

3.3.2 Using $P_C(z)$ as defined above, design sea current loads F(z) may be calculated according to the following formula:

$$F = P_C(z) \times A$$

F = Current force [kN]

 $P_{C}(z)$ = current pressure [KPa]

A = current projected area [m²]

3.3.3 Values of the current projected area to be corrected for effects of marine growth.

3.3.4 In cases where superposition of current and wave is deemed necessary, the current velocity shall be added vectorially to the wave particle velocity. The resultant velocity is to be used to compute the total force using methods given in 3.2. Apparent wave parameters are to be estimated based on superposition of waves and currents, and used to estimate forces.

3.4 Wind Loads

3.4.1 Wind pressures and loads may be calculated using the method described in this sub-section. Alternatively, model testing using wind tunnels may also be used for determination of wind loads.

3.4.2 In general, the loads due to various environmental factors are to be combined to determine the load on the overall structure. The wind load in this case is to be determined using a one-minute sustained wind speed.

For individual structures, the wind loads are to be separately considered without combining with other loads, using the wind speeds indicated in 3.4.2 and 3.4.3.

3.4.3 Wind pressures on individual structural members, equipment on open decks, etc. are to be determined using a three second gust wind speed.

3.4.4 For wind loads on large structures forming part of the platform such as living quarters, walls, enclosures, etc, wind gust speeds of higher than three seconds duration may be used, e.g fifteen second gust wind speed.

3.4.5 For wind loads normal to flat surfaces or normal to the axis of members not having flat surfaces, the following relation may be used.

$$F = 6.11 \ C_h C_s V^2 A \times 10^{-4}$$

F = wind force [kN]

 C_s = shape coefficient, See Table 3.4.7 (a)

 C_h = height coefficient, See Table 3.4.7 (b)

V = wind velocity [m/s]

A = projected area of member on a plane normal to the direction of the considered force $[m^2]$

3.4.6 For any direction of wind approach to the structure, the wind force on flat surfaces should be considered to act normal to the surface. The wind force on cylindrical objects should be assumed to act in the direction of the wind.

3.4.7 In the absence of experimental data, values for the shape coefficient (*Cs*) may be assumed as follows.

| Table 3.4.7(a) : Values of wind coefficient | | | |
|---|------|--|--|
| Shape | Cs | | |
| Spherical | 0.4 | | |
| Cylindrical | 0.5 | | |
| Major flat surfaces and overall | 1.0 | | |
| projected area of platform | | | |
| Isolated structural shapes (cranes, | 1.5 | | |
| angles, beams, channels, etc.) | | | |
| Under-deck areas (exposed beams | 1.3 | | |
| and girders) | | | |
| Derricks or truss cranes (each face) | 1.25 | | |

Table 3.4.7(b) : Values Height Coefficient

| Height in | Ch | | | |
|---|---------------|------|--|--|
| Over | Not Exceeding | - | | |
| 0 | 15.3 | 1.0 | | |
| 15.3 | 30.5 | 1.10 | | |
| 30.5 | 46.0 | 1.20 | | |
| 46.0 | 61.0 | 1.30 | | |
| 61.0 | 76.0 | 1.37 | | |
| 76.0 | 91.5 | 1.43 | | |
| 91.5 | 106.5 | 1.48 | | |
| 106.5 | 122.0 | 1.52 | | |
| 122.0 | 137.0 | 1.56 | | |
| 137.0 | 152.5 | 1.60 | | |
| 152.5 | 167.5 | 1.63 | | |
| 167.5 | 183.0 | 1.67 | | |
| 183.0 | 198.0 | 1.70 | | |
| 198.0 | 213.5 | 1.72 | | |
| 213.5 | 228.5 | 1.75 | | |
| 228.5 | 244.0 | 1.77 | | |
| 244.0 | 259.0 | 1.79 | | |
| Above | 1.80 | | | |
| *The height of the centre of the wind exposed area from sea level | | | | |

3.4.8 The area of open truss commonly used for derricks and crane booms may be approximated by taking 60% of the projected area of one side with the shape coefficient taken in accordance with Table 3.4.7.

3.4.9 Shielding effect may be considered when a structural member is shielded from direct exposure to the wind by being close enough behind another member. Generally, the two structural components are to be separated by not more than seven times the width of the windward component for a reduction to be taken in the wind load on the leeward member.

3.4.10 Dynamic effects due to the cyclic nature of gust wind and cyclic loads due to vortex induced vibration are to be taken into account where relevant. Consideration is to be given to wind loads on members during transportation phase.

3.5 Loads due to snow and ice accumulation

3.5.1 Where there is possibility of icing and parts of the structure may get covered with ice or snow, the weight of ice or snow is to be added to the permanent load under all loading conditions.

3.5.2 Snow can settle on both, horizontal surfaces and, if the snow is sufficiently wet, on non-horizontal windward parts of installations or units.

3.5.3 Ice on the topsides of installations or units can accumulate due to freezing of snow, spray or rain.

3.5.4 The weight of snow and ice assumed for calculation of loads will be reviewed by IRS.

3.6 Deformation loads

3.6.1 The effect of temperature gradients resulting in deformation and stresses in the structure are to be considered. These stresses are to be added to the permanent load induced stresses and deformations under operating conditions, where relevant.

3.7 Marine growth

3.7.1 The following effects of anticipated marine growth are to be accounted for in design.

• Increase in hydrodynamic diameter

- Increase in surface roughness in connection with the determination of hydrodynamic coefficients (e.g., lift, drag and inertia coefficients)
- Increase in dead load and inertial mass

Relevant information shall be submitted to IRS for verification.

3.7.2 Thickness of marine growth shall be assessed according to local experience. If no relevant data are available, a thickness of 50 mm may be chosen for normal climatic conditions.

3.8 Sea Ice Loads

3.8.1 The ice loads on the structure due to ice structure interactions are to be taken into account. The local and global effects are to be considered.

3.8.2 Ice-structure interactions to be considered for evaluation of loads are to be based on the expected ice environment. The aspects to be included in the evaluation would include ice pressure loads and impact loads from drifting ice and ice bergs.

3.8.3 The following aspects of the ice are to be considered in the valuation of ice loads:

- a) Ice sheet thickness
- b) Ice crystal orientation
- c) bulk salinity
- d) porosity and density
- e) ice strength
- f) loading rate
- g) temperature
- h) Size of structure relative to the ice thickness

Section 4

Loads due to Accidents

4.1 General

4.1.1 Accidental loads are loads not normally occurring during the installation and operating phases, but which shall be taken into account, depending on location, type of operations, and possible consequences of failure. Causes for accidental loads within this context may be the following:

a) collisions (other than normal mooring impacts)

- b) falling or dropped objects
- c) Accidental impact from helicopter
- d) failing or inadequate crane operations
- e) explosions, fire
- f) strength level earthquakes

4.1.2 The design of the installation is to be such that the consequences of damage are within acceptable limits and that an adequate margin of safety against collapse is available.

Section 5

Transportation and Installation Loads

5.1 General

5.1.1 The loads of short duration resulting from marine operations for transportation and installation are to be considered. Examples of such operations are the following:

- a) load-out from shore to barge or vessel
- b) float-out from drydock
- c) construction and outfitting afloat
- d) wet or dry towage and other marine transportation
- e) installation
- f) jacket launching
- g) float-over of topsides
- h) piling, grouting
- i) modifications to an existing structure
- j) total or partial decommissioning and removal of the structure

5.2 Loads

5.2.1 The loads for these phases are to be evaluated according to the type of installation and the situation at site. In determining these loads, the following aspects shall be considered:

- a) The required equipment, vessels, and other means involved are designed and verified for adequate performance
- b) Operating weather conditions are forecasted for a period long enough to complete the required marine operations.
- c) The marine operations are planned to minimize the probability of accidental situations, breakdowns, or delays and are covered by detailed contingency actions.

Section 6

Earthquake Loads

6.1 General

6.1.1 The characteristics of earthquake levels (acceleration intensity, duration, etc.) are to be estimated as specified in Chapter 4.

6.2 Strength Level Earthquake

6.2.1 The effect of Strength level earthquakes (SLE) are to be evaluated considering the ultimate strength of the structure. In zones with low to moderate seismic activity, a linear elastic analysis of the structure may be sufficient to determine the reinforcements required.

6.3 Ductility Level Earthquake

6.3.1 In the case of ductility level earthquakes (DLE), the structure may be evaluated allowing plastic deformation, provided there is no global collapse of the structure

6.3.2 Where inelastic response of specific components of the structure is considered in the analysis, details of such components are to be taken into account to ensure appropriate ductility characteristics and structural constraints. Other modes of failure such as shear failure are also to be considered.

6.4 Seismic Response

6.4.1 Seismic events may be represented by input response spectra or by time histories of significant ground motion. Where the global response of the structure is essentially linear, a dynamic spectral analysis is generally appropriate. Where nonlinear response of the structure is significant, a transient dynamic analysis is to be carried out.

End of Chapter

Chapter 6

Structural Design

| | Contents | | |
|---------|-----------------------------|--|--|
| Section | | | |
| 1 | General | | |
| 2 | Design Methods and Criteria | | |
| 3 | Loading Conditions | | |
| 4 | Allowable Stress Design | | |
| 5 | Dynamic Analysis | | |
| 6 | Earthquake Analysis | | |
| | | | |

Section 1

General

1.1 General Information

1.1.1 This chapter describes the principles of design and analysis of steel structures of fixed offshore installations

1.1.2 Structural strength and integrity of a fixed offshore structure depends on the structural safety against failure modes, quality of materials, quality of fabrication, in-service inspection and maintenance. This chapter deals with the required level of design analysis.

1.1.3 Loads and loading conditions should generally be considered in accordance with Ch4 (environmental conditions) and Ch5 (Design Loads). Other specific loading criteria/values may be applied if they are well documented and agreed upon. The load cases and combinations considered are to be the most unfavorable conditions likely to occur.

1.1.4 The dynamic natures of loads acting on the structure are to be taken into account by suitable methods where the frequencies of the loads are in the range of natural frequencies of the structure. In some cases it may be accounted for quasi-statically. 1.1.5 Strength/stress analysis may be carried out in accordance with different, recognized methods and standards. See section 2. It is to be ascertained in every case that design fundamentals and standards used are consistent and compatible for the structure under consideration.

1.1.6 Structural redundancy is to be considered in the design. Slender main bearing structural elements are normally demonstrated to be redundant

1.1.7 Where the top side structure is not designed to resist wave impact, a sufficient distance between the probable highest wave elevation and the lower edge of the structure is to be provided. An air gap of 1.5 m is recommended.

1.1.8 An effective corrosion protection system is to be provided including coatings for the structure, see Ch 3(materials and welding).

1.1.9 Loading conditions occurring during construction, transport or sea installation are to be considered in the design, see Ch 8 (marine operations) and Section 3 (loading conditions).

Section 2

Design Methods and Criteria

2.1 Design method selection

2.1.1 Structural strength analysis may be based on linear elastic theory. However, where nonlinear relations between loads and its effects are found to be important, they are also to be accounted for. It is also to be verified that structural instability (buckling) is prevented. Where plastic design is used, the limitations described in 2.4 are to be considered.

2.1.2 Where deterministic method ("allowable stress design") is used for analysis it is to be in compliance with the requirements of Sec. 4.

2.1.3 Semi-probabilistic design method, in association with limit states and partial safety factor design may be applied using adequate and relevant codes. (For example ISO 19900). Relevant data and safety factors used for design are to be acceptable to IRS.

2.2 Plastic design

2.2.1 Plastic design which allows part of structure to exceed elastic limits may be accepted provided the following conditions are satisfied:

- It is possible to establish failure mechanisms with well-defined "hinges". At plastic hinge locations, the crosssection of the members shall have sufficient rotation capacity to enable the required plastic hinge to develop without local buckling.
- The material employed at the points of possible plastic deformations are to be sufficiently ductile.
- The detail construction and/or the nature of the loads shall be such that fatigue is prevented.

2.2.2 Plastic design may be suitable e.g. for structures intended for collision protection, and for earthquake design.

2.3 Modeling of the structure

2.3.1 Main load bearing and stiffening components and supporting and constraining effects are to be considered in the structural model.

2.3.2 The degree of detailing should take account of the geometry of the structure and its influence on load distribution, external loads and of expected stress pattern.

2.3.3 Where modeling is made by means of beam elements, the actual rigidities are to be accounted for as precisely as practicable, particularly in way of connections (joints). The effective width of associated plating may be chosen according to accepted standards.

2.3.4 Stress concentration effects are to be carefully investigated, either by using adequate calculation methods (e.g. finite elements), or based on experience data.

2.3.5 The soil stiffness is to be represented as precisely as practicable

2.3.6 For calculations analyzing the dynamic behavior of the whole structure (global behavior), the mass distribution may generally be simulated in a simplified form, using equivalent or lumped masses. Also see Sec 5.

2.4 Model Test

2.4.1 Model investigations (tests) may be accepted as a supplement to structural analysis subject to acceptance of IRS. In special cases model tests may be required.

2.5 Superposition of stress components

2.5.1 Stresses or other load effects resulting from relevant global and local effects are to be combined according to their simultaneous occurrence. (See Sec 3). Stresses of different type (e.g. tension, shear) and different direction are to be combined according to recognized criteria (equivalent stress, von Mises). In the case of tubular members, combination of stresses using the method given in API RP2A may be accepted by IRS. Rules and Regulations for the Construction and Classification of Fixed Offshore Steel Structures - 2023 Page 3 of 6

Section 3

Loading Conditions

3.1 Definition of loading conditions

3.1.1 LC – A (Operating Condition)

3.1.1.1 The following loads are to be taken into account in this condition:

a) Gravity loads which are permanent in natureb) Hydrostatic loads;

c) Variable gravity loads which are applied for a long period of time such as ballast and equipment weights;

d) Variable functional loads such as from crane or drilling operations;

e) Environmental loads during normal operation (If not specified individually, a 10 year recurrence period is considered to be acceptable for the environmental loads);

f) Impact loads during normal operations, e.g. mooring of attending vessels.

3.1.2 LC – B (Extreme Environmental Condition)

3.1.2.1 The following loads are to be taken into account in this condition:

a) Loads specified in 3.1.1.1 a), b) and c);

b) The most unfavorable extreme environmental loads;

c) Functional loads which are assumed to be acting in extreme environment.

3.1.2.2 Several possible load combinations may have to be considered.

3.1.3 LC – C (Accident Scenario)

3.1.3.1 The following loads are to be considered in this condition:

a) Loads specified in 3.1.1.1 a), b) and c);

b) Accidental loads, such as impact from collisions, impact from dropped objects, fire or explosions as defined in individual case (see 3.1.3.2);

c) Environmental loads (a recurrence period of one year may be considered in this case).

3.1.3.2 Risk analyses are to be carried out to identify and assess accidental events that may occur and the consequences of such events. If the risk analysis identifies a significant risk from this type of loading, the effect on structural integrity of the platform is to be assessed.

3.1.3.3 In earthquake prone regions, a "strength level earthquake" is to be considered under this loading condition as an alternative to an impact or collision. The associated environmental and functional loads are to be agreed upon in the individual case.

3.1.4 LC – D (Ductility Level Earthquake)

3.1.4.1 This loading condition covers an extreme level of earthquake, defined in Ch 4 Sec 7. The structure is to be evaluated for the dynamic loads resulting from the earthquake according to Sec 6.

3.1.5 LC – E (Marine Operations)

3.1.5.1 This loading condition covers operations associated with moving or transporting an offshore structure or part thereof during the construction, installation or abandonment process (See Ch 8).

3.1.5.2 The maximum permissible environmental condition and the recurrence period of environmental loads being considered during operations are to be defined.

3.1.5.3 Dynamic amplification of the loads during lifting operation is to be considered in the evaluation.

3.1.5.4 For the construction and installation phase, safety factors or allowable stresses will be agreed upon according to the probability of occurrence of the relevant loads, the importance of the structural element and the possible consequences of failure.

3.1.5.5 The limiting environmental conditions for specific operations and the limited operations that can be performed during extreme environmental conditions are to be defined. Appropriate instructions are to be provided in the operating manual.

| Table 3.1 : Loads to be considered in each loading condition | | | | | | |
|--|--------|--------|--------|--------|-------|--|
| LOAD TYPES | LC - A | LC - B | LC - C | LC - D | LC –E | |
| Dead load | YES | YES | YES | YES | YES | |
| Equipment Load | YES | YES | YES | YES | YES | |
| Variable/Functional Loads | YES | YES | NO | NO | YES | |
| Buoyancy | YES | YES | YES | YES | YES | |
| Environmental Loads | YES | NO | NO | NO | YES | |
| Extreme Environmental Loads | NO | YES | NO | NO | NO | |
| Impact/Collision Loads | YES | NO | YES | NO | NO | |
| Strength level Earthquake | NO | NO | YES | NO | NO | |
| Ductility level Earthquake | NO | NO | NO | YES | NO | |
| Dynamic Loads | YES | YES | NO | YES | YES | |

Section 4

Allowable Stress Design

4.1 General

4.1.1 The allowable stress approach is method generally, based on linear elastic theory and global safety factors. The allowable stresses are function of minimum specified yield strength of the material.

4.1.2 This method is not applicable for loading condition LC-D, which is to be verified as given in Section 6.

4.1.3 The allowable stresses method is based on the following:

$$\sigma \leq \frac{\sigma_y}{FOS_G}$$
$$\tau \leq \frac{\tau_y}{FOS_G}$$

 σ, τ = Resulting stresses σ_y, τ_y = Minimum specified yield strength. FOS_G = Global factor of safety

4.2 Factors of safety

4.2.1 In the case of tubular members, girders, frames and other structural components, the safety factors may be chosen according to Table 4.2.1.

4.2.2 In the case of local plate bending under lateral pressure, the scantlings will be evaluated using plate theory based formulations instead of the safety factors mentioned above.

4.3 Design Parameters

4.3.1 Areas with high compressive or shear stresses due to bending or torsion are to be checked for overall and /or local buckling failure. Detailed buckling analysis may be carried out according to recognized codes and standards acceptable to IRS (e.g. API RP-2A, WSD).

4.3.2 The allowable stresses may require to be reduced in the case of the following:

- a) areas not easily in accessible for inspection;
- b) uncertainty in the loads;
- c) lack of structural redundancy (see 1.1.6).

4.3.3 Specific structural details such as joints of tubes or rolled sections may be designed according to proven standards and codes (e.g.

API-RP 2A WSD). In addition, consideration is to be given to fatigue, in accordance with the above or other standards or codes acceptable to IRS.

4.3.4 Fatigue life assessment is to be carried out for structural members and joints which may be prone to fatigue failure. The members in the splash zone and those that are difficult to inspect in service are to be considered for the fatigue life evaluation. A spectral fatigue analysis is recommended for evaluation.

| Table 4.2.1 : Global Factor of Safety | | | | | | |
|---------------------------------------|--------------------|--------|--------|--------|-------|--|
| STRESS | LOADING CONDITIONS | | | | | |
| | LC - A | LC - B | LC - C | LC - D | LC –E | |
| Axial and Bending Stress | 1.45 | 1.25 | 1.15 | NA | 1.45 | |
| Shear Stress | 2.16 | 1.90 | 1.82 | NA | 2.16 | |
| Equivalent Stress | 1.25 | 1.10 | 1.05 | NA | 1.25 | |

Section 5

Dynamic Analysis

5.1 General

5.1.1 A dynamic analysis of structure will be required to be carried out when the design sea state contains significant wave energy at frequencies close to the natural frequency of vibrations of the platform.

5.2 Dynamic loads

5.2.1 The following dynamic loads are to be considered, as relevant:

a) Environmental loads such as waves, wind, currents, earthquake;

b) Variable functional loads from drilling or process equipment.

5.3 Structural Design

5.3.1 The global dynamic behavior of the structure will generally be required to be

evaluated if the eigen periods are larger than 3 seconds.

5.3.2 Structural components

5.3.2.1 Large structural components such as flare boom, helicopter deck etc. and local structural members are to be evaluated for dynamic loads due to wind, wave, current, iceflow or wave slamming.

5.3.2.2 Wind induced vortex shedding and variable wind speeds (gusts) and resulting dynamic stress amplifications are to be considered for exposed slender structures such as radio towers and flare booms.

5.3.2.3 Structural components supporting rotating equipment are to be checked for resonance from induced excitation forces and moments by such equipment. Where, resonance cannot be avoided, the dynamic stress level is to be evaluated by a forced vibration analysis.

5.3.2.4 For structures which are subject to earthquake loading the eigen-frequencies of appurtenances or equipment supports should be substantially larger than the frequencies of the basic structure modes.

5.4 Structural Analysis

5.4.1 The structural model is to be prepared taking into account the requirements outlined in 2.5.

5.4.2 Special regard is to be paid to the interaction between structure and foundation.

5.4.3 The effect of marine growth is to be taken into account by considering an increase in member thickness and in hydrodynamic masses.

5.4.4 Equivalent viscous damping may be used for dynamic investigations of fixed steel

structures. As an estimate two to three percent of critical damping may be considered.

5.4.5 Method of analysis

5.4.5.1 The analysis method to be used is to be decided depending on the type of loading and the structural response.

5.4.5.2 A spectral analysis may be used for structures with a linear elastic response to random loading, provided a linearization of the non-linear load effects is possible. This method may be used to determine dynamic response of fixed jacket structures due to extreme wave loads and for fatigue damage evaluation.

5.4.5.3 Where the non-linearity of wave loads and the structural response cannot be simplified for linear analysis, a time domain based nonlinear analysis is to be carried out.

Section 6

Earthquake Analysis

6.1 Strength of structure

6.1.1 The strength and stiffness of offshore structures is to be adequate to prevent any significant damage in the event of a probable earthquake. API RP 2A (WSD) may be used for guidance for the design of a platform for earthquake ground motion.

6.1.2 Where the design horizontal ground acceleration is less than 0.05 g, earthquake analysis is not required to be carried out.

6.2 Dynamic response

6.2.1 The dynamic response analysis of the structure may be carried out in the frequency

domain by spectral method or in the time domain. Generally a three-dimensional structure model shall be used for the analysis.

6.2.2 When the spectral analysis is applied, the "Complete Quadratic Combination" (CQC) method may be used for combining modal responses.

6.2.3 The earthquake induced structural responses are to be combined with other load components acting permanently on the structure. The stress levels in members are not to be more than the values for loading condition C in Sec 4.

End of Chapter

Chapter 7

Soil Foundation

| Contents | | | | | |
|----------|-----------------------|--|--|--|--|
| Section | | | | | |
| 1 | General | | | | |
| 2 | Investigations | | | | |
| 3 | Design Considerations | | | | |
| 4 | Pile Foundation | | | | |

Section 1

General

1.1 Scope

1.1.1 This chapter covers design methodologies and other requirements for pile foundation of fixed offshore structure.

1.2 Foundation Design

1.2.1 The foundation design of fixed offshore structures is to consider all types of loads which may occur during installation and operation of the structure.

1.2.2 The design factor of safety is to be decided based on prior experience under similar conditions, method and extent of data collection,

scatter of design data and consequences of failure.

1.3 Soil

1.3.1 The soil behavior and its interaction with the foundation is to be investigated with special regard to static, dynamic and transient loading.

1.4 Miscellaneous

1.4.1 Design practices which are not explicitly covered in these rules for foundations will be subject to approval by IRS on case to case basis.

Section 2

Investigations

2.1 Site Investigation

2.1.1 The site investigation is to be carried out at the actual site, defined as the area within which the structure may be installed, including accepted tolerance limits from theoretical centre.

2.1.2 The actual extent, depth and choice of investigation method are to take into account the type, size and intended use of the structure, uniformity of soil and seabed conditions and type of soil deposits.

The site investigation program is to comprise but not necessarily be limited to the following:

- Sea Floor Survey
- Site Geological Survey
- Soil investigation and testing

The results of these investigations are to be the basis for additional site related studies.

2.1.3 The actual extent of a geotechnical site investigation has to be agreed upon by IRS individually for each site.

2.1.4 Topography and other geophysical data for the conditions existing at and near the surface of the sea floor are to be obtained.

2.1.5 The regional geological characteristics are to be taken into account for planning the subsurface investigation.

2.1.6 An assessment of the seismic activity at the site is to be carried out. In this case, attention is to be paid to identification of fault zones, extent and geometry of faulting and possible attenuation effects due to conditions in the region of the field.

2.1.7 For structures located in a production area, the possibility of sea floor subsidence due to a drop in reservoir pressure is to be considered.

2.2 Soil Investigation and Testing

2.2.1 The objectives of the soil investigation and testing program are the following:

- a) to obtain data concerning the stratigraphy and engineering properties of the soil;
- b) to assess whether the desired level of structural safety and performance can be obtained;
- c) to assess the feasibility of the proposed method of installations.

2.2.2. In general, the testing program is to provide the following:

- a) Strength classification and deformation properties of the soil;
- b) The dynamic characteristics of the soil;
- c) The static and cyclic soil-structure interaction.

2.2.3 The soil testing program is to consist of adequate number of in-situ tests, borings and samplings to examine all important soil and rock strata.

2.2.4 The length of at least one bore hole for a pile or cluster of piles is to be sufficient to cover the length of piles and a zone of influence further down. The zone of influence is to be at

least 15 [m] or 1.5 times the diameter of the cluster, whichever is greater, unless it can be shown by analytical methods that a lesser depth is justified. Additional bore holes of lesser depth are required if discontinuities in the soil are likely to exist within the area of the structure. A reasonably continuous profile is to be obtained during recovery of the boring samples.

2.2.5 The desired extent of sample recovery and field testing is to be as follows.

- a) the recovery of the materials to a depth of 12 [m] below the mudline is to be as complete as possible. Thereafter, samples at significant changes in strata are to be obtained;
- at least one undrained strength test on selected recovered cohesive samples is to be performed in the field;
- c) where practicable, a standard penetration test or equivalent on each significant sand stratum is to be performed, recovering samples where possible.

2.2.6 Field samples for laboratory work are to be retained and packaged to minimize changes in moisture content and disturbance. These are to be tested at a recognized laboratory.

2.2.7 The testing in the laboratory is to include the following tests and evaluation:

- a) unconfined compression tests on clay strata where needed to supplement field data;
- b) water content and Atterberg limits on selected cohesive samples;
- c) density of selected samples;
- estimation of constitutive parameters of stress-strain relationships. Results of unconfirmed compression tests, unconsolidated undrained triaxial compression tests, or consolidated undrained triaxial compression tests may be used for this purpose;
- e) grain size sieve analysis, on each significant sand and silt stratum.

2.2.8 Additional tests may be required to evaluate the dynamic characteristics of the soil and the static and cyclic lateral soil-pile interaction.

2.3 Reports

2.3.1 In addition to the foundation design documentation mentioned in Ch. 1 Sec. 4, the results of studies to assess the following effects considering the presence of the structure in the field are to be submitted:

- a) Scouring potential of the sea floor;
- b) Hydraulic instability and the occurrence of sand waves;

Section 3

Design Considerations

3.1 General

3.1.1 The design of foundations is to take account of all effects which may influence bearing capacity and functionality of the foundation system, including the effect of displacements.

3.2 Soil Characteristics

3.2.1 For each soil layer the physical properties are to be thoroughly evaluated with the help of in-situ and laboratory testing as specified in 2.2.

3.3 Cyclic Loads

3.3.1 For structures installed in seismically active areas, the proneness of the soil to partial liquefaction, which may result in reduction of soil strength and stiffness, has to be considered.

3.3.2 Other possible cyclic load effects, such as changes in load-deflection characteristics, liquefaction potential and slope stability are also to be considered and these effects are to be accounted for.

3.4 Scouring

3.4.1 The possibility of scour around the foundation is always to be investigated.

In case that scouring may occur the foundation has to be protected by suitable means or alternatively, the foundation has to be considered as partly unsupported

3.4.2 If no other data is available for the specific site conditions, the scour depth at pile

foundations may be estimated as 2.5 times the pile diameter for design purposes.

c) Instability of slopes in area where the

d) Liquefaction and other soil instabilities;

e) Effects of volcanic sands, organic

matter, carbonate soil, calcareous sands and other substances which

degrade the strength of the soil

structure is to be placed;

foundation.

3.4.3 The design criteria are to be verified by regular surveys. In case the limits established in the design are not matching the actual situation, countermeasures are to be taken.

3.5 Hydraulic Stability

3.5.1 For foundations which may exhibit significant hydraulic gradient within the supporting soils, an investigation is to be done to ensure the hydraulic stability.

3.6 Soil Strength and Stability

3.6.1 The ultimate strength or stability of soil is to be determined using test results which are compatible with the method selected.

3.6.2 Total or effective stress analysis is to be used for soil stability investigations.

3.6.3 In a total stress approach the total shear strength of the soil obtained from test data is used. A total stress approach largely ignores changes in the soil's pore water pressure under varying loads and the drainage conditions at the site.

3.6.4 When an effective stress approach is used effective soil strength parameters and pore water pressures are determined from tests which attempt to predict in-situ total stresses and pore pressures.

3.6.5 If necessary, due to existing slope or due to installation effects, the risk of slope failure or the possibility of a deep slip is to be considered.

Page 4 of 5

3.6.6 For soft, normally consolidated clays or loose sand deposits, consideration of seafloor instability is required.

3.6.7 Seabed movements due to action of waves, earthquake or operational effects, e.g. drilling, dredging, may cause reduced resistance or increased loading and are to be considered.

3.7 Settlements and Displacement

3.7.1 Long term settlements and displacements of the structure as well as the surrounding soil are to be analyzed.

3.8 Local Deformation Behavior

3.8.1 The load deformation behavior of a piled foundation is to be analyzed with special regard to possible structure-pile interaction.

3.8.2 Changes in soil conditions due to temporarily situated platform such as self elevating drilling units, workover rigs or tender rigs placed near the structure are to be assessed and analyzed. These changes and their influence on the structure are to be incorporated in the foundation design to ensure that structure's function and safety are not impaired.

Section 4

Pile Foundation

4.1 General

4.1.1 Among several existing types of pile foundations the following are most frequently used offshore:

- a) Open Ended and Driven Piles
- b) Driven and Under reamed Piles
- c) Drilled and Grouted Piles

Many other designs are used to suit the needs of the individual soil conditions.

4.1.2 For each type of pile foundation the soilpile interaction and pile capacity are to be evaluated with due regard to field specific soil conditions.

4.1.3 Methods of pile installation are to be consistent with the type of soil at the site, and with the installation equipment available. Pile driving is to be carried out and supervised by qualified and experienced personal and pile driving records are to be obtained and submitted for review.

4.1.4 Where the pile does not achieve the desired penetration during installation, a reevaluation of the pile's capacity is to be carried out considering the parameters resulting from the actual installation.

4.1.5 Where necessary the effects of bottom instability in the vicinity of the structure are to be assessed.

4.2 Pile Design

4.2.1 The design of piled foundations (individual and group piles) is to fulfill requirements for axial and lateral load capacity and stiffness.

4.2.2 Among others the following factors will affect the design:

- a) diameter
- b) penetration
- c) spacing
- d) mudline restraint
- e) material
- f) pile footing
- g) installation method

4.2.3 The design method is to incorporate the pile geometry, properties and arrangement. It is to be capable of simulating the non-linear properties of the soil and be compatible with the load deflection behavior of the structure and pile foundation system.

4.2.4 Deflections and rotations are to be checked for individual piles and pile groups.

4.3 Axially Loaded Piles

4.3.1 For piles in compression, the axial capacity is to be evaluated based on the skin friction developed along the length of the pile and the end bearing reaction at the tip of the pile. The axial capacity of a pile subjected to tension is to be based on the skin friction only.

4.3.2 Various parameters needed to evaluate skin friction and end bearing is to be based on recognized analytical methods such as that given in API RP 2A (WSD) or any other method agreed by IRS. Acceptance of alternative methods may be also subject to proof of satisfactory experience in service.

4.3.3 The result of dynamic pile driving analysis alone is not to be used to predict the axial load capacity of a pile.

4.3.4 Following loading conditions are to be investigated:

| Loading Condition | Factor Of Safety |
|---|---------------------|
| LC-A (Operating Condition) | 2 |
| LC-B (Extreme Environment Condition) with specified Operating Loads | 1.5 |
| LC-B (Extreme Environment Condition) with minimum weights. | 1.5 |

4.4 Laterally Loaded Piles

4.4.1 The lateral load bearing capacity of the pile is to be evaluated considering the combined effects of load-deflection (p-y) characteristics of the soil and pile, and that of the pile and the structure. The reduction in lateral bearing capacity due to cycling loading is also to be taken into account.

4.4.2 Reference is to be made to the API RP 2A (WSD) for a procedure to evaluate the loaddeflection (p-y) characteristics of laterally loaded piles. Alternative methods may be accepted by IRS based on the conditions at the location of installation.

4.5 Pile Groups

4.5.1. In the case of pile groups, the effects of close spacing on the load and deflection characteristics are to be determined.

4.6 Load transfer to pile

4.6.1 The following methods may be used for load transfer from the structure to the piles:

- a) connecting the jacket or pile sleeves to the piles by welding, or
- b) grouting the annulus between the jacket leg or pile sleeve and the pile, or
- c) using mechanical devices such as pile grippers.

4.6.2 The design of the grouted pile to structure connection is to consider the use of mechanical shear connectors as their presence increase the strength of the connection, and eliminates the effect of long term grouting shrinkage.

4.6.3 Adequate clearance between the pile and the jacket leg is to be provided for proper placement of the grout.

4.6.4 Reliable means for the introduction of the grout to the annulus are to be provided to ensure complete filling of the annulus and to minimize the possibility of dilution of the grout and the formation of void in the grout. Wiper or similar devices should be used to minimize intrusion of mud into the annulus during installation. For design of grouted connection, reference may be made to API RP 2A (WSD) or other international standards.

4.6.5 If mechanical devices are used their strength and fatigue characteristics are to be adequately demonstrated by analysis, testing and experience.

End of Chapter

Chapter 8

Marine Operations

| Contents | | | | | |
|----------|----------|--|--|--|--|
| Section | | | | | |
| 1 | General | | | | |
| 2 | Analysis | | | | |

Section 1

General

1.1 General

1.1.1 Marine operations, i.e. operations associated with moving or transporting an offshore structure or parts thereof during the construction, installation or abandonment process, may have decisive influence on the overall design and on the dimensioning of scantlings

1.1.2 The following activities are considered as marine operations for the purpose of these Rules:

- a) Lifting and mooring operations
- b) Load-out
- c) Construction afloat
- d) Towing
- e) Launching and upending
- f) Submergence
- g) Mating
- h) Pile installation
- i) Final field erection
- j) Removal operations

1.1.3 The review and survey by IRS will cover, as far as applicable, the following:

a) Location Survey and review of environmental conditions

- b) Load-out Analyses
- c) Transportation Analyses including motion response
- d) Lifting/Launching/Upending Analyses including on-bottom stability
- e) Lifting/float-over, Lowering and Touchdown Analyses including dynamic influences

1.1.4 In addition to the above investigations, Marine Warranty Survey (MWS) document review and on-site surveillance will cover as far as applicable the following:

- a) Condition Survey of vessels and equipment involved;
- b) Load-out Procedure including quay condition, mooring and retrieval system;
- c) Transportation Arrangement including sea-fastening, stability, towing;
- d) Lifting/Launching/Upending Procedure (rigging, mooring, clearances);
- e) Installation Procedures including anchor handling, positioning, piling, grouting, mating.

1.1.5 The Surveyor will verify that operations are being carried out satisfactorily and expert supervision is available. In the case of towing, it is expected the tug master follows appropriate procedures. The Operator may opt for the presence of a surveyor during the towing operation. Page 2 of 2

1.2.1 The marine operations planned to transport and install the structure are to be indicated in a report which is to be submitted for review.

1.2.2 The report is to contain following information:

- a) Description of the marine operations to be performed and the procedures to be employed
- b) For operations which do not govern design of the structure, a description of the

engineering logic, experience or preliminary calculations supporting this conclusion

- c) For operations which govern design of the structure, the assumptions, calculations and results of the analyses required in Sec. 2.
- d) For structures to be upended or submerged by selective ballasting, a detailed description of the mechanical, electrical and control systems to be employed, the ballasting schedule and supporting calculations.

Section 2

Analysis

2.1 Loads

2.1.1 The loads and combinations of loads acting on the structure during marine operations are to be evaluated by appropriate analysis.

2.1.2 Inertial, impact, and local loads which are likely to occur during marine operations are to be considered

2.1.3 The effect on fatigue life of the structure due to cyclic loads occurring during marine operations is to be taken into account

2.2 Strength of attachments

2.2.1 Analysis is to be carried out for evaluating the strength of attachments used for the operation and their supporting structure (tie downs, skid beams, etc.) to withstand the loads. The strength criteria of Ch. 6 are to be used.

2.3 Stability

2.3.1 Stability and reserve buoyancy of the structure are to be evaluated for the safety of the structure during the operation.

2.3.2 The centre of gravity of the structure may require to be determined by experimental methods, where necessary, for large structures.

End of Chapter