

DESIGN OF JETTY FACILITIES (AMENDMENTS/SUPPLEMENTS TO BS 6349-1/2/4)

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DESIGN AND ENGINEERING PRACTICE



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TABLE OF CONTENTS

PART I	INTRODUCTION	5
1.1	SCOPE.....	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS REFERENCES.....	9
1.5	FORMAT OF THIS DEP	9
1.6	COMMENTS ON THIS DEP	10
PART II	AMENDMENTS AND SUPPLEMENTS TO BS 6349-1	11
7	Meteorology and climatology	11
8.	Bathymetry	12
10.	Water level	12
11.	Water movement.....	13
13.	Water quality	13
14.	Sediment transport.....	13
16.	Design working life.....	14
17.	Ship data	14
18.	Navigation in approach channels.....	15
19.	Ship handling	16
20.	General	17
21.	Wave characteristics.....	17
22	Offshore wave climate	19
24.	Tsunamis.....	19
26.	Wave recording and analysis.....	19
27	Extrapolation of wave data.....	20
29.	Harbour response	20
31.	Acceptable wave conditions for moored ships.....	20
34	Winds	22
35	Snow and ice.....	23
36.	Temperature variations	23
38.	Currents	23
39.	Waves	24
40.	Earthquakes	25
42.	Mooring	25
45.	Cargo handling and transport systems	25
47.	Movements and vibrations	26
49.	Site investigations	26
50.	Properties of the ground	27
54.	Slope stability and protection	28
57.	Stone for armouring or protection works.....	29
58.	Concrete.....	29
59.	Structural steel and other methods.....	30
61.	Piles	31
66.	Protective measures	31
67.	Maintenance.....	32
PART III	AMENDMENTS AND SUPPLEMENTS TO BS 6349-2	33
2.1	General	33
2.2	Choice of structure.....	34
3.2	Loads	34
4.4	Types of sheet wall	34
6.4	Types of structures	35
6.5	Overall stability.....	35
6.8	Installation of piles	36
6.10	Design methods	36
6.11	Loading considerations	37
6.12	Design of piles	41
7.2	Types of structure	43
7.5	Design of rigid dolphins.....	43

7.6	Mooring equipment	43
9.4	Ladders	44
PART IV	AMENDMENTS AND SUPPLEMENTS TO BS 6349-4	45
4.1	Provision of fendering	45
4.6	Berthing velocities	45
4.7	Berthing energies	46
4.8	Berthing reactions and load distributions	47
4.9	Factors of safety and design stresses	47
4.11	Application of fender layout for berths	48
5.1	Fenders using elastomeric units	49
5.3	Flexible dolphins	50
5.10	Areas of applicability of fender types	50
9.2	Wind and currents	51
10.2	Vessels over 20 000 t displacement	51
11.5	Quick Release Hooks	51
11.7	Capstans	51
Annex C		52
PART V	REFERENCES	53
PART VI	BIBLIOGRAPHY	55

APPENDICES

APPENDIX 1	TYPICAL DATA OF LNG CARRIERS	57
APPENDIX 2	TYPICAL DATA OF LPG CARRIERS	58
APPENDIX 3	TYPICAL DATA OF TANKERS	59
APPENDIX 4	TYPICAL DATA OF TUGS	60

PART I INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the design, engineering and specification of fixed marine facilities for ships loading and unloading crude oil and oil products, LPG/LNG and petrochemical products.

Requirements for the design of topworks including piping, product transfer arms and other mechanical and electrical installations are not explicitly included in this DEP.

Requirements for the design of single point mooring facilities are not explicitly included in this DEP.

Parts II, III and IV of this DEP are written as amendments and supplements to BS 6349-1, BS 6349-2 and BS 6349-4, respectively; see (1.5) regarding how these amendments and supplements are constructed.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This DEP is intended for use by oil refineries, chemical plants, gas plants, exploration and production facilities and supply/distribution installations, insofar as they are involved in the engineering, construction and maintenance of jetty facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The **Contractor** is the party that carries out all or part of the (detailed) design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Marine facilities	General description encompassing all facilities required to receive ships at a marine terminal or offshore including but not limited to fixed marine facilities, single point mooring facilities, and (offshore) loading structures.
Fixed marine facilities	General description encompassing all components of the facilities required to receive ships at a marine terminal including but not limited to berths, dolphins, piles and filled approach structures.
Berth	A location at which a ship can be held in position by means of mooring lines and or chains and or fendering. The last phase of the approach of a ship (“..to berth a ship..”).
Berth monitoring systems	Equipment to monitor the velocity and position/orientation of a ship during the berthing operation.
Breakwater	A structure designed to provide shelter to the berth from waves and currents
Capital dredging	Dredging operations which are part of the construction/expansion of the harbour/jetty to create sufficiently deep water for the intended purpose.
Catwalks	A fixed structure providing pedestrian access to a dolphin/platform.
Causeway	A solid, closed coastal structure (earth or rock dam or caissons) often used to link the shoreline to the root of the trestle.
Design working life	Design working life of a structure is the assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary.
Dolphin	An isolated structure or strong point used either to • manoeuvre a vessel (turning dolphin) or to • secure a vessel and prevent it from moving away from a berth due to wind or current action (mooring dolphin) and/or to • take the impact of a berthing vessel and to hold it when being pushed against a berth by wind, waves or current (breasting or berthing dolphin).
Fender systems	A provision primarily to absorb the berthing energy exerted by a berthing ship, and secondly to be moored against using the mooring system, keeping the ship in place during loading/unloading operations.
Jetty	A fixed marine structure providing a berth or berths at some distance from the shore.
Jetty topworks	All equipment, piping and appurtenances installed on the jetty (loading platforms, trestles) required for or in support of loading/unloading of the ship (incl. personnel, stores etc.), transferring the cargo to the shore and related safety installations.

Including but not necessarily limited to:

- Gangway towers
- Loading arms and/or equipment
- Fixed cranes
- Fire pumps
- Piping
- Fire monitors
- Berth approach systems
- Mooring load monitoring systems

Loading platform	Fixed platform directly adjacent to the berthing line capable of accommodating the relevant equipment, piping and appurtenances required for loading or unloading the ship (incl. personnel and stores) including related safety installations. For smaller vessels the loading platform can also be used as berthing and mooring point.
Life cycle cost	The cumulative cost of a facility, which includes the costs of planning, construction, maintenance and interest.
Maintenance dredging	Dredging operations that are required to keep sufficiently deep water for the intended purpose.
Metoccean conditions	Meteorological and oceanographic conditions such as temperature, wind, waves, currents etc.
Mooring equipment	Bollards and hooks (including capstans, base structure, fairleads, rings and auxiliary) installed on the mooring and breasting dolphin or loading platform to secure a vessel.
Navigation	Moving a ship along a defined course.
Navigation aids	Facilities to assist in the navigation process, such as buoys, landmarks, lighthouses, radar control etc.
Operating limits	The maximum combination of environmental conditions in which marine operations can proceed (loading, unloading, berthing, arrival and departure).
Port	A place by the sea, or by a river or other waterway, where ships and boats can dock, load, and unload.
Trestle	A bridge connecting the loading platform to the shore or causeway to provide vehicular or pedestrian access and/or to support pipes or conveyors.
Weather downtime	Period during which the berth is not available for (un)loading operations as a result of adverse weather conditions (wind and visibility) and/or sea state (tide, waves, currents).

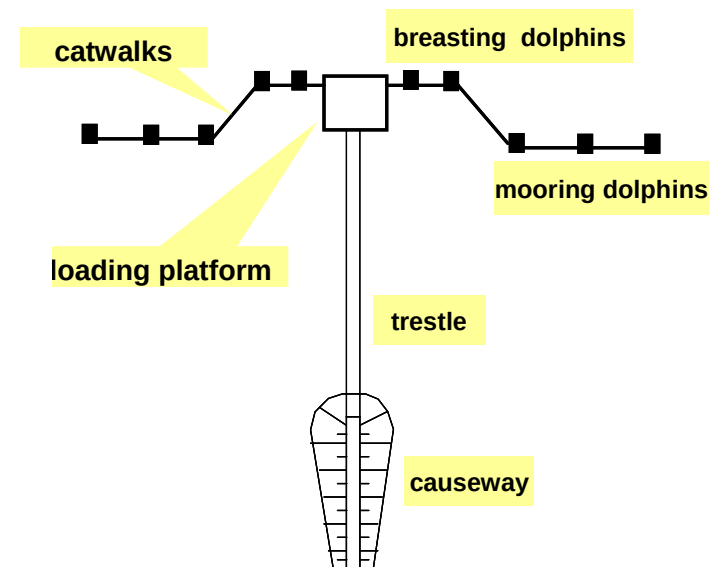


Figure 1 Nomenclature for jetty components

1.3.3 Abbreviations

The following abbreviations are used in this DEP. Other abbreviations are defined at the first place of use.

BDP	Basic Design Package
BOD	Basis of Design
CIRIA	Construction Industry Research and Information Association (UK)
CUR	Centre of Civil Engineering Research and Codes (The Netherlands);
EAU	Empfehlungen des Arbeitsausschusses "Ufereinfassungen"; (Germany) Recommendations of the Committee for Waterfront Structures, Harbours and Waterways
EPC	Engineering Procurement and Construction
FEED	Front End Engineering Design
IALA	International Association of Lighthouse Authorities
OCIMF	Oil Companies International Marine Forum
PIANC	Permanent International Association of Navigation Congresses
PS	Project Specification
ROM	Recomendaciones Obras Maritimas (Spanish Maritime Works Recommendation)
SIGTTO	Society of International Gas Tanker and Terminal Operators Ltd.

1.4 CROSS REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents directly referenced in this DEP are listed in (Part V).

Listed in Part VI-A are documents on which certain requirements in this DEP have been based. In the text of this DEP, such references are identified by [Ref. x], where x denotes the reference number included in Part VI-A.

Listed in Part VI-B are some other documents which can be useful to the reader but are neither referenced by this DEP nor used as source material.

1.5 FORMAT OF THIS DEP

Parts II, III and IV of this DEP are written as amendments and supplements to BS 6349-1, BS 6349-2 and BS 6349-4, as follows:

Part II BS 6349-1: 2000, Code of practice for general criteria

Part III BS 6439-2:1988, Design of quay walls, jetties and dolphins

Part IV BS 6349-4:1994, Code of practice for design of fendering and mooring systems

Any clauses in BS 6349-1, BS 6349-2 and BS 6349-4 that are not amended by this DEP shall remain valid as written.

This DEP is focused on the use of BS 6349 for the design of jetty structures for (large) oil ships and gas carriers. No specific attempt has been made to include amendments for other maritime structures covered in the relevant parts of BS 6349, but which are generally not used for jetties in the oil and gas industry, such as solid quay walls, container areas, roll-on / roll-off terminals etc.

The following wording is used throughout this DEP to identify any changes in the relevant parts of the BS 6349:

- Add:* This text shall be considered as additional to the referenced BS 6349 clause
- Delete:* Quoted BS 6349 text part shall be deleted.
- Replace:* Replace quoted text parts from BS 6349 by presented new text.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com. Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards folder.

PART II AMENDMENTS AND SUPPLEMENTS TO BS 6349-1

7 Meteorology and climatology

7.1 General

Add:

In the general planning of exposed jetties, a set of metocean data (i.e. wind, waves and currents) is required as a basis for the assessment of envisaged weather downtime. This dataset should be continuous and shall extend over a number of years (approximately 10 years as a minimum) to enable evaluation of seasonal and annual variations. Hindcasted data are generally available from institutes like the British Meteorological Office (UK) and NOAA (USA). These datasets shall be validated with actual site measurements during project development.

Data shall be determined at the early design stages of the project (Basis of Design) and be confirmed during detailed design (project specification), and will cover all relevant meteorological and oceanographic data (extreme and ambient conditions).

7.2 Wind

Add:

Wind roses [or wind scatter diagrams] shall be prepared considering seasonal effects to enable an assessment of the optimum berth orientation and vessel approach route relative to the wind. In the absence of detailed or local information on the relationship between mean hourly wind speeds (U_{3600}) and gust values, which shall be used for the calculation of wind loads on ships and structures, the following relationship can be assumed:

$$U(t) = U_{3600} (1.277 + 0.296 \tanh (0.9 \log_{10} (45/t)) \text{ (t in seconds) [Ref. 1]}$$

Daily variations in wind direction and wind speed can be an important aspect in the planning of ship handling operations. The berthing and departure conditions are particularly sensitive to wind loads.

7.5 Visibility

Add:

Lack of visibility can prevent the timely approach and departure of large ships. A minimum visibility of 1000 m is generally required for safe ship operations, while some ports have more than 1000 m visibility requirements (generally for departure from ports and for dangerous cargoes). Databases on visibility shall be evaluated in the design process to assess the effect on weather downtime for the marine facilities.

Note: Visibility can often be severely limited by snow storms for short periods.

8. Bathymetry

8.2 Echo sounder

8.2.3 Transmission frequency and beam width

Add:

The concept of identifying the thickness of the mud layer is important for the assessment of the required nautical depth [refer Clause 18]. The piping system of steam driven turbine ships [such as gas carriers] are sensitive to siltation processes and the intake of mud shall be avoided. The top of the fluid mud layer shall then be taken as the bottom level for navigation purposes. For other ships, however, sailing through the top soft mud layer only affects the manoeuvrability of the ship, and can in certain circumstances be accepted. This shall always be subject to approval by the Principal.

8.5 Spacing and direction of sounding profiles

Add:

For navigational channels with water depths not exceeding 1.2 times the maximum draught, survey and sounding lines should always be complemented by a full cover side scan sonar survey.

For jetty structures a spacing of 10 metres is required if an exploratory evaluation of the admiralty chart indicates that the seabed profile can vary significantly in the areas of interest. If the general bathymetry suggests a relatively flat profile a spacing of 25 m suffices. Also in this case, overlapping survey lines shall be carried out.

10. Water level

10.2 Tidal predictions

Add:

For preliminary designs tidal predictions can be derived from various sources like the Admiralty Tide Tables and websites, such as <http://www.shom.fr/> (Service Hydrographique et Océanographique de la Marine). This provides a quick tool for initial design purposes.

As general rule tidal measurements and analysis will be carried out during preliminary design of the marine facility (Basis of Design).

10.4 Tidal observations

Add:

For any green field developments in areas with tidal differences in excess of 2 m, records should be taken throughout the construction period to enable a calibration of the tidal predictions. A comprehensive tidal analysis shall be carried out from these observations to produce tide tables for the operation instructions for the facilities.

11. Water movement

11.1 General

Add:

Information on currents is relevant for a proper understanding of the morphological processes and the assessment of loads on structures. Currents also affect the manoeuvrability of ships and the mooring loads by moored vessels. In areas with strong and/or non uniform currents, geometric 2D velocity patterns shall be developed to assess the effect of obstructions, local bathymetry and potential stratification in the current profile within the draft of the ship. These velocity patterns shall be mapped and measured by means of float tracking or radar current measurements.

13. Water quality

13.5 Marine life

Add:

Marine growth can also be minimised by the use of an impressed current system on the relevant parts of the submerged structure.

If a seawater intake is integrated with the jetty structure, marine life such as fish, jellies, turtles etc. shall be kept out of the pump station of intake structures by the use of screens and by reducing the intake velocity. A passive coarse screen can be followed by a band or drum screen for the removal of smaller species.

Marine growth on supporting members such as piles can have a significant effect on current and wave forces, as it can both increase the effective width of the members and increase the roughness (influencing drag coefficients).

14. Sediment transport

14.1 General

Add:

An additional method of acquiring a general appreciation of the sediment processes is the evaluation of a sequence of (historical) satellite images of the considered site.

Special consideration shall be given to anticipated sediment transport in the selection of the location and layout of the jetty structure, and to the sedimentation of the berth and the need for maintenance dredging.

14.3.2 Littoral drift

Add:

Special attention shall be paid to the impact of the jetty/causeway structure on coastline development.

14.4 Accretion and scour

Add:

Although the rate of scour for a particular site is difficult to assess, some guidance is given in [Ref. 2]. For piled structures at an exposed site, the anticipated scour around a pile can vary from 0.5 to 1.5 times the pile diameter, which can be important for the assessment of passive resistance in the upper layers of laterally loaded piles.

For further assessment computer or physical modelling is required.

16. Design working life

Replace the first four paragraphs of this clause with the following:

The design working life of a structure is the assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary (see EN 1990).

This requires knowledge of the ambient conditions, loadings and rates of deterioration of the elements of the structure throughout its life, as well as of the anticipated future ships to be accommodated at the jetty.

Indicative categories of design working life are given in Table 1. The values given in Table 1 may also be used for determining time-dependent performance (e.g. fatigue-related calculations). The indicative design working life can vary depending on the use of the structure or on the design life of the overall facility/plant or refinery, and shall be agreed with the Principal.

Table 1: Overview of design working life categories

Design working life category	Indicative design working life (years)	Examples
1	10	Temporary structures (1)
2	25	Piled jetties and mooring and berthing structures dedicated to specific oil, gas or petrochemical operations.
3	50	Common port infrastructure including reclamation, shore protection, breakwaters, gravity quall walls.
(1) Structures or parts of structures that can be dismantled with a view to being re-used should not be considered as temporary.		

17. Ship data

17.1 General

Add:

In addition to the required information indicated in this clause, particulars on manifold positions and mooring equipment on board, such as mooring lines and winch capacities, are also relevant for the design of jetties.

17.2 Tonnage and displacement

Replace Clause 17.2 from:

For the purpose of preliminary planning the following relationships can be used.....

by:

The size of ships for transport of LNG and LPG is generally expressed as the gas carrying capacity in m³ of gas. For initial planning purposes the displacement tonnage of gas carriers can be estimated as follows:

- LNG carriers:
 - o Displacement [in tonnes] = 20,000 + 0.6*(Gas carrying capacity) [in m³]
- LPG carriers:
 - o Displacement [in tonnes] = 5,000 + 0.9*(Gas carrying capacity) [in m³]
- Oil tankers
 - o Displacement [in tonnes] = 2.1 * (DWT)^{0.95}

Delete Clause 17.3: Typical container ship and bulk carrier dimensions

Add new Clause 17.3: Typical dimensions Gas carriers, Oil tankers and tugs

Reference is made to ships' registers, such as Clarkson's database, Lloyds Register of Shipping and SIGTTO database of gas carriers for detailed information on ships for liquid cargo transport.

Typical data of ships are included as Appendices 1, 2, 3 and 4 to this DEP, and should be specified per facility in the Basis of Design.

18. Navigation in approach channels

18.2 Studies

Add:

Recent developments in simulations of vessel handling have resulted in three main types of studies:

- o Full mission real time bridge simulations with a full 360° projection of the surroundings. These simulations are powerful tools in pilot training, but are often considered too specific for design purposes, unless models of the surroundings are available.
- o PC-based real time simulations with proper modelling of the characteristics of the wind, wave and current conditions, bathymetry, port layout, ship characteristics and tug performance in various sea states. The advantage of real time simulations is that they allow proper modelling of the human element in ship handling, although the projection is often limited to bird's eye views and instrument controls.
- o PC-based fast time simulations with preset target tracks or instrument settings. This type of simulation does not include the human element in the ship's handling. However, a large number of runs can be carried out in a limited time frame, which would allow a statistical approach on variations in settings.

Selecting the most appropriate tool for navigation studies depends on local conditions. A relatively easy approach without too many variations along the track of approach can be modelled with a fast time simulation to assess stopping distances and required channel widths. More complicated approaches can be modelled with real time simulations. It is important to evaluate the actual capabilities and limitations of these tools, particularly with regard to their validation with full-scale tests.

18.3 Depth of channels

Add to the last paragraph:

The level at which the density starts to increase from the salt water value [1025 kg/m³] shall be taken as the bottom level for the assessment of the nautical depth for LNG and LPG carriers.

18.4 Width of channels

Replace the third and subsequent paragraphs by:

For preliminary design purposes the width of the approach channel shall be assessed on the basis of the recommendations included in [Ref. 3] for the section where no tugs are used or are effective. The width of the approach channel shall be confirmed with navigation studies as discussed in Clause 18.2 if the final width of the approach channel is less than the value concluded from [Ref. 3] or where it may be appropriate to reduce the width in view of the availability of tug assistance.

19. Ship handling

19.1 Manoeuvring inside harbours

Replace:

“As a general guide, a turning circle with a diameter of four times the ship's length should be allowed where no tug assistance is available. The diameter can be halved where tugs are used regularly and can be further reduced if the critical vessels are equipped with bow thrusters.”

by

“As a general guide, a turning circle with a diameter of at least four times the ship's length should be allowed where no tug assistance is available. If tug usage is available and required, the diameter of the turning circle should be at least two times the ship's length. No further reduction in the turning circle may be incorporated in the design to account for any potential beneficial effect of the use of bow thrusters.”

19.2 Berthing

Replace in second paragraph:

“Jetty-based electronic instrument systems can be provided to indicate speed and distance from the jetty during this manoeuvre.”

by

Jetty-based and hand-held electronic instrument systems shall be provided on new LNG, LPG and VLCC jetties to indicate speed and distance from the jetty during this manoeuvre. Such facilities are optional for jetties handling smaller liquid cargo ships, unless berthing operations are difficult or critical.

19.3 Mooring

Replace in second paragraph:

“Where possible, mooring loads should be established on a line by line basis by means of a suitable computer program”

by

“Mooring line loads should be established by means of a suitable computer program. For berths subject to wave action (sea and swell) and/or non-uniform current fields, due consideration shall be given to the dynamic response of moored ships. The dynamic effect of passing ships can be relevant in sheltered ports where ships are moored alongside the channel at relatively close distance. A static analysis of the mooring line forces [i.e. considering wind and current forces only] is only acceptable if wave action and passing ships are irrelevant.”

20. General

Add to second paragraph

Due attention shall be given to the local conditions at the projected maritime structures. For instance, depth-limited conditions can affect the nearshore waves so that the differences between annual and 1/100 years extremes become small. In such cases structures can be exposed to loads relatively close to their extreme values on a regular basis. This may be particularly important for designs that are based on the acceptance of a certain degree of damage or degradation (such as fatigue loads on structures or the strength and stability of breakwater armour units).

21. Wave characteristics

21.1 Wave forms

Replace in third paragraph

“For certain applications in these situations sinusoidal wave theory or solitary wave theory can give a better idealization of the wave behaviour than sinusoidal theory.”

by

In shallow waters the evaluation of wave characteristics shall be carried out on the basis of streamline function theories, such as the Rienecker-Fenton theory [Ref. 4]. For some coastline geometries, comprehensive physical or mathematical modelling may be required. Results of this modelling shall be used to assess the wave characteristics as indicated in Clause 21.2.

21.3 Sea state properties

21.3.8 Return period and design wave condition

Add at the end of the last paragraph

Maritime structures shall be designed on the basis of the following extreme values for wind, wave and surge conditions. Alternatively a probability assessment of design conditions being exceeded during the design lifetime shall be carried out. This may especially be important with shallow areas or where steep or breaking waves occur.

Table 2 Overview of return periods of extreme wind and wave conditions

Design working life category	Indicative design working life (years)	Return period extreme wind & wave conditions (2) (years)	Examples
1	10	25	Temporary structures (1)
2	25	50 (3)	Piled jetties and mooring and berthing structures dedicated to specific oil, gas or petrochemical operations.
3	50	100	Common port infrastructure including reclamation, shore protection, breakwaters, gravity quall walls.
(1) Structures or parts of structures that can be dismantled with a view to being re-used should not be considered as temporary. (2) Combinations of environmental conditions (wind, waves and surge levels) shall all be taken at the same return period as they are often correlated, and shall further be combined with mean spring tidal water levels. (3) API RP 2A recommends the use of a return period equal to several times the design working life of the facility with a minimum of 100 years for permanently manned structures for the oil and gas industry. Jetty structures are generally evacuated in the event of a storm warning and safety systems are installed to prevent product losses, thereby averting major spill and potential loss of lives. Hence the value for the return period is taken as 50 years, which is in line with the standard recommended value in BS 6349-1 [refer Clauses 37, 38 and 39].			