

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 504

Comprehensive evaluation of metocean conditions

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1. Scope

The objective of the metocean study is to provide a comprehensive evaluation of meteorological and oceanographic environmental conditions at the offshore/onshore location. Some guidance for developing simplified metocean criteria for basic design studies is also given in section 4.7.

The metocean study shall result in best estimates of both extreme and normal/operational metocean design criteria for the project.

The analysis shall be based on available and suitable data sources, which may consist of:

- Published papers and reports
- Metocean data from specialist providers, including hindcast data, satellite observations, etc.
- Data from site surveys.

Suitable analysis methods shall be used. A general description of applicable methods is given in section 5. Alternative methods may be proposed if they result in more accurate or more reliable results: they shall be fully described by the Contractor and approved by the Company.

The design criteria that result from the metocean study shall be adequate for following design studies:

- Design of offshore/onshore installations with respect to extreme environmental conditions
- Design of offshore/onshore installations with respect to fatigue due to environmental conditions
- Design and planning of marine operations.

The metocean study comprises three phases:

1.1 Data collation

The objective of this phase is to identify and acquire the data sets required for the study.

This phase includes an investigation of all available data, following which a selection of adequate data to be acquired for the study shall be drawn up and submitted to Company for review.

Then, after Company approval, the suitable data are acquired for further analysis.

1.2 Data analysis and complementary studies

This phase covers the statistical analysis of collected data, including the extreme value analysis, and the complementary analyses that are necessary to develop the metocean design criteria. The complementary analyses may be limited, for example, to the derivation of maximum wave and crest height from extreme significant wave height and period. It may also be more complex and include, for example, wave propagation modelling or tidal and current simulations.

1.3 Preparation of metocean design criteria

This phase consists of the interpretation of the results of the metocean study and the development of metocean design criteria for the project.

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All data, all results and all information provided by Contractor in the final report and during the course of the study shall first be checked and approved internally by a recognised metocean expert and then submitted to Company's metocean expert for approval.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
API RP 2N	Recommended Practice for Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions
ISO 19901-1	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating considerations
ISO 19906	Petroleum and natural gas industries - Arctic offshore structures

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Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP GEO 507	Tsunami hazard assessment on coastal facilities
GS EP GEO 601	Seismic Hazard Assessment for Offshore Structures
GS EP GEO 602	Seismic Hazard Assessment for Onshore Structures

3. Definitions, abbreviations, conventions

3.1 General

The terms and definitions given in ISO 19901-1 and the following apply.

Special consideration shall be paid to the definition of **direction**:

- The direction (wind, wave, current, etc.) must be based on a **vector average**. An arithmetic average of direction data that included values either side of North would be in error (e.g. $(359 + 001)/2 = 180$)
- Oceanographic convention** is that winds and waves approach from the given direction, whilst currents flow towards the given direction.

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Unless otherwise specified in the Particular Technical Specification, the **directional sectors** to be considered by Contractor for the analyses are 16 sectors of 22.5° width centred on True North (N), North-Northeast (NNE), Northeast (NE), East-Northeast (ENE), East (E), East-Southeast (ESE), Southeast (SE), South-Southeast (SSE), South (S), South-Southwest (SSW), Southwest (SW), West-Southwest (WSW), West (W), West-Northwest (WNW), Northwest (NW), North-Northwest (NNW).

Calms: Periods of calm conditions, where no wind or wave or current is detected, or when the parameter value is less than the data source minimum resolution. Periods of calms shall be clearly indicated (as a percentage or number of events). When the occurrence of non-zero events in tabulated distributions are summed and added to the occurrence of calms, the result is 100% (allowing for rounding).

When not specified otherwise, the appellation “**mean wind speed**” refers to the 1-hour mean wind speed, and wind characteristics refer to its value at 10 m above ground or mean sea level.

The required **system of units** is the S.I. (Metric) system. In case other units are used, the conversion factors shall be given. All units, directional and other conventions and frames of reference for all parameters shall be clearly defined.

Time references shall be given in UTC.

All location **co-ordinates** shall be given with the system employed (geodetic datum, spheroid, grid system, origin of projection, false easting, false northing, scale factor).

3.2 Water levels

CD = Chart datum: local datum used to fix water depths on a chart or tidal heights over an area. Chart datum may be an approximation to the level of the Lowest Astronomical Tide.

Tide periodicity: Tides repeat themselves exactly with a period of approximately 18.6 years.

HAT = Highest Astronomical Tide: level of high tide when all harmonic components causing the tides are in phase.

LAT = Lowest Astronomical Tide: level of low tide when all harmonic components causing the tides are in phase.

Note: The harmonic components are in phase once per tide periodicity but these conditions are approached several times each year.

MSL = Mean Sea Level: arithmetic mean of all sea levels measured at hourly intervals over a long period, ideally the tide periodicity

Note: Seasonal changes in mean level can be expected in some regions and over many years the mean sea level can change.

In semi-diurnal waters, the following mean tide levels are applicable, averaged over a period time preferably equal to the tide periodicity:

- **MHWS = Mean High Water Spring:** mean of the high water at spring tide
- **MHWN = Mean High Water Neap:** mean of the high water at neap tide
- **MLWN = Mean Low Water Neap:** mean of the low water at neap tide
- **MLWS = Mean Low Water Spring:** mean of the low water at spring tide.

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In mixed waters, the following mean tide levels are applicable, averaged over a period time preferably equal to the tide periodicity:

- **MHHW = Mean Higher High Water:** mean of the higher of the two daily high water
- **MLHW = Mean Lower High Water:** mean of the lower of the two daily high water
- **MHLW = Mean Higher Low Water:** mean of the higher of the two daily low water
- **MLLW = Mean Lower Low Water:** mean of the lower of the two daily low water.

4. Metocean design criteria

The metocean design criteria that shall be derived from the study are listed hereunder:

4.1 Climatology

A general description of meteorological and oceanographic conditions at considered location shall be provided. This description shall include information on wind regime, wave regime, current regime and other metocean parameters with indication on seasonal variations. Probability of rare phenomena shall also be mentioned.

Rare phenomena include:

- Cyclones, squalls, tornadoes, etc.
- Internal waves
- Tsunamis.

4.2 Extreme conditions

As a minimum, the extreme values shall be specified for following return periods: 100, 10 and 1 year. In addition, a method permitting the derivation of extremes for intermediate return periods shall be given.

If requested in Particular Specification, 1,000 and 10,000 years return period values could be requested for some parameters.

4.2.1 Extreme winds

Omnidirectional and per directional sector:

- 1-hr mean wind speed (m/s)
- Range of wind speeds and gusts including but not limited to 10-min mean, 1-min mean, 3-s gust
- Wind profile applicable for each of these extreme conditions.

The most probable period of the year for extreme winds shall be indicated and the following monthly (or at least seasonal) directional extremes shall be given:

- 1-hr mean wind speed, together with 10-min mean, 1-min mean, and 3-s gust wind speeds (or if relevant, conversion factors for the calculation of the latter from the 1-hr mean wind speed).

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Additional criteria may be required for certain applications or regions. In such cases these shall be individually agreed by Company for each study. Examples include:

- Wind energy spectra
- Description of extreme events such as squalls, tropical cyclones, etc.

4.2.2 Extreme Waves

Omnidirectional and per directional sector:

- Extreme significant wave height (m), associated peak wave period (s), zero up-crossing wave period (s) and mean wave period (s)
- Extreme significant wave height and peak period contours
- Extreme significant wave height and zero up-crossing wave period contours
- Maximum wave height (m), period associated with the maximum wave (s) - most probable and range
- Maximum wave crest elevation (m)
- Frequency-direction wave energy spectrum for the extreme sea states (or one-dimensional wave energy spectrum with directional spreading), and associated parameters.

The most probable period of the year for extreme waves shall be indicated and the following monthly (or seasonal) directional extremes shall be given:

- Extreme significant wave height (m)
- Associated peak wave period (s)
- Associated zero up-crossing wave period (s).

If justified by the analysis of the data, and if possible, extreme wave conditions as described above for the total sea-state will also be computed for the swell and the local wind sea partitions.

The number of directional sectors could be reduced for determination of extreme significant wave height and peak period contours, and of extreme significant wave height and zero up-crossing period contours.

Maximum wave height and maximum crest shall be derived using recommendation from section 5.3.6.

4.2.3 Extreme Current

Omnidirectional and per directional sector:

- Tidal current
- Residual current (where appropriate including the effects of wind drift, storm surge, water density variations, oceanic currents, internal waves, river flow, etc.)

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- Combined extreme current (tidal + residual)
- Current profiles.

The most probable period of the year for extreme currents shall be indicated and the following monthly directional extremes shall be given:

- Residual current
- Combined extreme current.

4.2.4 Extreme water levels

The tidal regime shall be briefly described (diurnal, semi-diurnal, mixed, etc.). Following tidal levels shall be given, with respect to Chart Datum:

- HAT
- MHWS/MHHW
- LAT.

The extreme water levels shall be given as follows:

- Annual and monthly positive and negative storm surge and anomalies, for the above specified return periods
- Maximum wave crest elevation (see section 5.3.6)
- Total combined (usually MHWS/MHHW + storm surge + crest elevation, but preferably with adequate correlation)
- Safety margin as per international recommendations
- Minimum safe height above C.D.

4.2.5 Combined extreme parameters

As a minimum, the following combination shall be provided for the different return periods:

- Wind speed and current speed associated to extreme significant wave conditions
- Significant wave height and current speed associated to extreme wind conditions
- Significant wave height and wind speed associated to extreme current conditions.

More detailed information can be requested as specified in section 5.3.

4.3 Operational data

The data, which mainly consists in distributions useful for fatigue studies and marine operational data, shall be representative of an "Average Year".

4.3.1 Winds

- Monthly maximum, minimum, mean values, standard deviation and quantiles of mean wind speed, with associated wind direction
- Monthly histogram and percentage exceedence diagram of mean wind speed

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- Monthly wind speed/direction tabulated frequency distributions and wind roses
- Persistence statistics of wind speed above and under selected thresholds (usually 5, 10, 15, 20, 25 m/s, to be specified in the Particular Technical Specification). Guidance about persistence statistics shall be discussed with Company; Appendix 2 provides additional information on possible applicable methods.

Annual summaries of the above values.

4.3.2 Waves

- Monthly maximum, minimum, mean values, standard deviation and quantiles of significant wave height, with associated wave direction
- Monthly maximum, minimum, mean values, standard deviation and quantiles of peak wave period with associated wave direction
- Monthly maximum, minimum, mean values, standard deviation and quantiles of zero up-crossing wave period with associated wave direction
- Monthly histogram and percentage exceedence diagram of significant wave height
- Joint distribution of significant wave height and peak wave period (wave scatter diagram), omnidirectional and for directional sectors
- Joint distribution of significant wave height and zero up-crossing wave period (wave scatter diagram), omnidirectional and for directional sectors
- Monthly significant wave height/direction tabulated frequency distributions and wave roses
- Frequency-direction wave energy spectrum (or one-dimensional wave energy spectrum with directional spreading), and associated parameters.
- Persistence statistics of significant wave height above and under selected thresholds (usually 0.5, 1, 1.5, 2, 2.5, 3 m to be specified in the Particular Technical Specification). Guidance about persistence statistics shall be discussed with Company; Appendix 2 provides additional information on possible applicable methods.

Annual summaries of above values and for following data:

- Joint distribution of individual wave height and period, per class intervals of 0.5 m x 1 s, for a 1-year period
- Joint distribution of individual wave height and direction, per class intervals of 0.5 m x directional sector width, for a one year period, with the most probable associated period for each height/direction couple.

If justified by the analysis of the data, and if possible, wave conditions as described above for the total sea-state will also be computed for the swell and the local wind sea partitions.

4.3.3 Currents

- Monthly maximum, minimum, mean values, standard deviation and quantiles of current speed, with associated current direction
- Monthly frequency table, histogram and percentage exceedence diagram of current speed

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- Monthly current speed/direction tabulated frequency distributions and current roses
- Persistence statistics of current speed above and under selected thresholds (usually 0.2, 0.4, 0.6, 0.8, 1.0 m/s to be specified in the Particular Technical Specification). Guidance about persistence statistics shall be discussed with Company; Appendix 2 provides additional information on possible applicable methods.
- Variation with depth (Current profiles).

Annual Summaries of the above values.

4.3.4 Tide and water levels

Standard Tidal Levels with respect to Chart Datum:

- HAT
- MHWS/MHHW
- MHWN/MLHW
- MSL
- MLWN/MHLW
- MLWS/MLLW
- LAT
- Seasonal changes of MSL.

Harmonic constituents should be provided.

4.4 Ice

In cold regions such as the Arctic area, structures shall be designed against ice conditions, as described in [API RP 2N](#) and [ISO 19906](#). The present section lists the main parameters that shall be developed by Contractor. The database used and methods applied by Contractor for such analysis shall be fully documented.

4.4.1 Icing

- Density (kg/m^3) versus elevation above sea level
- Thickness (mm) versus elevation above sea level
- Monthly probability of occurrence.

4.4.2 Ice cover & concentration

- Dates of formation of stable ice
- Dates of ice clearance in the area
- Ice period duration in the area
- Ice-free period duration in the area
- Monthly ice coverage extent of the general area (%)