
**Petroleum and natural gas
industries — Specific requirements
for offshore structures —**

**Part 5:
Weight management**

*Industries du pétrole et du gaz naturel — Exigences spécifiques
relatives aux structures en mer —*

Partie 5: Gestion des poids

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Contents

Page

Foreword.....	vi
Introduction.....	viii
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	2
4 Abbreviations.....	6
5 Principles of weight management.....	7
5.1 General.....	7
5.2 Weight management during project lifecycle phases.....	7
5.3 Weight management objectives.....	7
5.3.1 Objectives during conceptual design phase.....	7
5.3.2 Objectives during FEED, detail engineering and construction phases.....	8
5.3.3 Objectives during operations and decommissioning phases.....	8
5.4 Illustration of weight versus time.....	8
5.5 Loading conditions.....	9
5.5.1 General.....	9
5.5.2 Typical loading conditions.....	9
6 Control Weights.....	10
6.1 General.....	10
6.2 Purpose.....	11
6.3 Budget weights and NTE weights.....	11
6.3.1 Budget Weights.....	11
6.3.2 Reserves.....	11
6.3.3 NTE weights.....	12
6.4 Loading conditions and parameters.....	12
6.5 Control weights during operations phase.....	12
7 Weight management during project execution phases.....	12
7.1 Conceptual design.....	12
7.1.1 General.....	12
7.1.2 Predicted weight.....	13
7.1.3 Conceptual design weight.....	13
7.1.4 Upper bound weight constraint.....	13
7.1.5 Weight estimating.....	14
7.1.6 Key documentation.....	14
7.1.7 Estimating principles.....	15
7.1.8 Deliverables.....	17
7.2 FEED.....	18
7.2.1 General.....	18
7.2.2 Weight management plan.....	18
7.2.3 Weight management procedure.....	19
7.2.4 Weight reporting.....	19
7.2.5 Weight checking and verification.....	20
7.3 Detail engineering.....	21
7.3.1 General.....	21
7.3.2 Weight management plan.....	21
7.3.3 Weight management procedure.....	21
7.3.4 Weight reporting.....	21
7.3.5 Weight checking and verification.....	23
7.4 Construction.....	23
7.4.1 General.....	23
7.4.2 Weight database.....	23
7.4.3 Weight reporting.....	24

7.4.4	Weighing of assemblies	24
7.5	Installation and HUC	24
7.6	Operations	24
7.6.1	General	24
7.6.2	Weight management procedure	24
7.6.3	Weight database	25
7.6.4	Legacy weight databases	25
7.6.5	Laydown and storage drawings	25
7.6.6	Decommissioning	26
8	Requirements for suppliers' weight data and weighing of tagged equipment and assembled discipline bulks	26
8.1	General	26
8.2	Submission of weight data	26
8.3	Weighing requirements	27
8.3.1	Equipment	27
8.3.2	Discipline bulks	27
8.4	Weighing procedure	27
8.5	Weighing devices	28
8.5.1	Type of weighing device	28
8.5.2	Calibration of weighing devices	28
8.5.3	Maximum relative uncertainty for weighing devices	28
8.5.4	Capacity of weighing device	29
8.5.5	Spare weighing devices and ancillaries	29
8.6	Witnessing of weighing	29
8.7	Scheduling of weighings	29
8.8	Environmental conditions during a weighing	29
8.9	Weighing operation	29
8.10	Temporary items present during a weighing	30
8.11	Permanent items not installed during a weighing	30
8.12	Weighing certificate	30
9	Requirements for weighing of major assemblies	31
9.1	General	31
9.2	Weighing procedure	31
9.3	Weighing system	32
9.3.1	Load cells	32
9.3.2	Read-out devices	32
9.3.3	Uncertainty of weighing system	32
9.3.4	Calibration of load cells	33
9.3.5	Capacity of weighing system components	33
9.3.6	Spare load cells and ancillaries	33
9.3.7	Hydraulic jacking system	33
9.3.8	Levelness of the assembly during the weighing	34
9.4	Preparations prior to the weighing	34
9.4.1	Notification and witnessing of weighings	34
9.4.2	Environmental conditions during a weighing	34
9.4.3	Weighing prediction report	34
9.4.4	Temporary items during the weighing	35
9.5	Weighing operation	35
9.5.1	Number of results recorded	35
9.5.2	Readings of load cells and level criteria	36
9.5.3	Consistency of results	36
9.5.4	CoG calculations	36
9.5.5	Weighing report	36
9.5.6	Weighing certificate	37
	Annex A (informative) Commentary	38
	Annex B (informative) Weighing certificates	42

Annex C (informative) Example control weight summary	46
Annex D (informative) Variable weight	47
Annex E (informative) Example decision-making RAPID matrix	51
Annex F (informative) Weighing result uncertainty	53
Annex G (informative) Weight database structure	56
Annex H (informative) Weight management guidelines for concrete structures	57
Annex I (informative) Coordinate systems	60
Annex J (informative) Weight allowances and reserves	62
Annex K (informative) Weight management competencies	64
Bibliography	65

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 19901-5:2016), which has been technically revised.

The main changes are as follows:

- part title changed to "Weight Management";
- document restructured and columnization removed;
- weight control classes removed;
- requirements for weight management for all project phases implemented;
- annexes deleted or relocated to body of document:
 - previous Annex A "Weight data sheets – tagged equipment" combined with previous Annex B "Weighing certificates" to create new joined into a new [Annex B](#) "Weighing certificates";
 - previous Annex C "Weight and load budget (WLB) formats and levels" replaced with new [Annex C](#) "Control weights";
 - deleted previous Annex D "Major elements of the weight displacement";
 - information in previous Annex E "Supplier weighing procedure" relocated to [Clause 8](#);
 - deleted previous Annex F "Guidelines for displacement measurement of floating facilities";

- information in previous Annex G “Requirements for weight control during operations” relocated to [Clause 7](#);
 - information in previous Annex H “Requirements for topsides weight estimation — New builds/ green field” relocated to [Clause 7](#);
 - information in previous Annex I “Executive summary description” relocated to [Clause 7](#);
 - replaced previous Annex J “Weighing result uncertainty” with [Annex F](#) “Weighing result uncertainty”;
 - previous Annex K “Weight control database structure” replaced with new [Annex G](#) “Weight database structure”.
- Annexes added:
- [Annex A](#) “Commentary”;
 - [Annex D](#) “Variable weight”;
 - [Annex E](#) “Example decision-making RAPID matrix”;
 - [Annex H](#) “Weight of concrete structures”;
 - [Annex I](#) “Coordinate systems”;
 - [Annex J](#) “Weight allowances and reserves”;
 - [Annex K](#) “Weight management competencies”.

A list of all parts in the ISO 19901 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The International Standards on offshore structures prepared by TC 67/SC 7 (ISO 19900, the ISO 19901 series, ISO 19902, ISO 19903, ISO 19904-1, the ISO 19905 series, and ISO 19906) constitute a common basis covering those aspects that address design requirements and assessments of all offshore facilities used by the petroleum and natural gas industries worldwide. Through their application the intention is to achieve reliability levels appropriate for manned and unmanned offshore facilities, whatever the type of structure and the nature of the materials used.

It is important to recognize that structural integrity is an overall concept comprising models for describing actions, structural analyses, design rules, safety elements, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one aspect of design in isolation can disturb the balance of reliability inherent in the overall concept or structural system. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

The International Standards on offshore structures prepared by TC 67/SC 7 are intended to provide a wide latitude in the choice of structural configurations, materials and techniques without hindering innovation. Sound engineering judgement is therefore necessary in the use of these International Standards.

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Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 5: Weight management

1 Scope

This document specifies requirements for managing and controlling the weight and centre of gravity (CoG) of offshore facilities by means of mass management during all lifecycle phases including; conceptual design, front end engineering design (FEED), detail engineering, construction and operations. These can be new facilities (greenfield) or modifications to existing facilities (brownfield).

Weight management is necessary throughout operations, decommissioning and removal to facilitate structural integrity management (SIM). The provisions of this document are applicable to fixed and floating facilities of all types.

Weight management only includes items with static mass.

Snow and ice loads are excluded as they are not considered to be part of the facility. Dynamic loads are addressed in ISO 19904-1, ISO 19901-6 and ISO 19901-7.

This document specifies:

- a) requirements for managing and controlling weights and CoGs of assemblies and entire facilities;
- b) requirements for managing weight and CoG interfaces;
- c) standardized terminology for weight and CoG estimating and reporting;
- d) requirements for determining not-to-exceed (NTE) weights and budget weights;
- e) requirements for weighing and determination of weight and centre of gravity (CoG) of tagged equipment, assemblies, modules and facilities;

This document can be used:

- f) as a basis for costing, scheduling or determining suitable construction method(s) or location(s) and installation strategy;
- g) as a basis for planning, evaluating and preparing a weight management plan and reporting system;
- h) as a contract reference;
- i) as a means of refining the structural analysis or model.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 approved variation

approved scope change affecting the *predicted weights* (3.32) and changing the *control weights* (3.11)

3.2 assembly

designed and fabricated group of *discipline bulks* (3.12) and *tagged equipment* (3.34) that form one unit

EXAMPLE Deck, module, living quarters, bridge, flare, substructure.

3.3 brownfield

modifications made to an existing *facility* (3.16)

3.4 budget weight

weight and *centre of gravity* (3.5) reference values as part of the *control weights* (3.11)

3.5 centre of gravity CoG

point in a body or system of bodies at which the entire weight is considered to act

Note 1 to entry: For assemblies, the aggregate CoG is the mathematical weighted mean of the CoGs of the individual items (comprising the completed assembly) measured from a common reference point.

3.6 centre of gravity envelope CoG envelope

defined volume within which the *centre of gravity* (3.5) of an *assembly* (3.2) is constrained for a specified *loading condition* (3.23)

3.7 conceptual design

phase of design during which several concepts are evaluated, and preferred concepts are selected

3.8 conceptual design weight

sum of the *predicted weight* (3.32) and the *conceptual design weight reserve* (3.9)

Note 1 to entry: This weight is used for engineering purposes and for checking fabrication/installation strategies during conceptual design.

3.9 conceptual design weight reserve

provision during conceptual design to allow for reserves when control weights are determined

EXAMPLE Management reserve, planned future reserve and unplanned future reserve.

3.10**consumable**

material used and replenished during normal operation of a *facility* (3.16)

EXAMPLE Potable/service water, diesel fuel, crew provisions, drilling powders for creation of mud and/or cement.

3.11**control weights**

budget weight (3.4) [and associated *centre of gravity envelope* (3.6)], *not-to-exceed weight* (3.28) [and associated *centre of gravity envelope* (3.6)] and reserves [e.g. *management reserve* (3.24), *planned future reserve* (3.31), *unplanned future reserve* (3.38)] for each *loading condition* (3.23)

3.12**discipline bulks**

all *dry weight items* (3.43) excluding *tagged equipment* (3.34)

EXAMPLE Piping, manual valves, structural, cable and trays, etc.

3.13**dry weight**

weight of a component, *weight item* (3.43) or an *assembly* (3.2) in its dry installed condition including permanent contents in closed systems in *tagged equipment* (3.34)

Note 1 to entry: Examples of permanent contents are gearbox oil, hydraulic oil, filter sand, coolant, etc.

Note 2 to entry: Excludes variable weights.

Note 3 to entry: Dry weight results in permanent actions, defined as G1 and G2 in ISO 19902 and ISO 19901-3.

3.14**estimate to complete****ETC**

estimated weight (3.15) of *discipline bulks* (3.12) and/or *tagged equipment* (3.34) with insufficient definition measured by weight take-off

3.15**estimated weight**

weight derived by using norm-based calculations or previous experience

3.16**facility**

topsides (3.36) and substructure that is built and installed to serve a particular purpose

3.17**front end engineering design****FEED**

phase following *conceptual design* (3.7) phase, during which the selected concept is matured, and design parameters normally are fixed

3.18**greenfield**

new facilities that are fabricated onshore and installed offshore

3.19**gross weight take-off****gross WTO**

net weight take-off (3.27) plus *net weight allowance* (3.26)

3.20

hook-up and commissioning

HUC

installation of components or *assemblies* (3.2) after the *topsides* (3.36) have been installed to complete a functioning *facility* (3.16)

3.21

lift weight

weight of a component or *assembly* (3.2) at its lift points, including permanent items and *temporary items* (3.35), but excluding the lift rigging

3.22

lightship weight

displacement of the complete floating *facility* (3.16) (i.e. ready for service) with all its machinery, equipment and outfitting, including permanent ballast, required spare parts, constant process fluids and liquids in *tagged equipment* (3.34) and piping at their working levels but without liquids in storage or reserve supply tanks, items of consumable or variable loads, stores or crews and their effects

3.23

loading condition

condition for which the weight and *centre of gravity* (3.5) of an *assembly* (3.2) is required to be managed

Note 1 to entry: See 5.5.

3.24

management reserve

reserve to take account for scope changes after setting the *control weights* (3.11)

3.25

master equipment list

MEL

project specific list for compiling and managing technical data for *tagged equipment* (3.34)

3.26

net weight allowance

addition applied to *net weight take-off* (3.27) to account for weight growth due to item weight uncertainty, design development and construction

Note 1 to entry: Guidance on net weight allowances is given in Annex J.

3.27

net weight take-off

net WTO

weight take-off based on the actual designed data from 3D model, engineering drawings or supplier data

3.28

not-to-exceed weight

NTE weight

maximum acceptable weight and *centre of gravity envelope* (3.6) for the respective *loading condition* (3.23)

3.29

operating reserve

weight difference between the *predicted weight* (3.32) and the *not-to-exceed weight* (3.28) during the operations phase

3.30

operating weight

dry installed weight plus *variable weight* (3.40)

3.31**planned future reserve**

reserve to account for planned modifications (e.g. additions, removals or relocations) during the operations phase of the *facility* (3.16)

3.32**predicted weight**

expected (median) weight, the sum of *gross weight take-off* (3.19) and *estimate to complete* (3.14) through all project phases

Note 1 to entry: The median (P50) weight estimate has a 50-50 chance of being lesser or greater than the out-turn weight.

Note 2 to entry: During the conceptual design phase, the net and gross WTO's can be zero.

3.33**reconciled weighed weight**

actual weight at the time of the weighing, including any weighing correction(s)

3.34**tagged equipment**

equipment identified and tracked in the *master equipment list* (3.25)

3.35**temporary items**

items temporarily installed during a *loading condition* (3.23) and removed afterwards

Note 1 to entry: Temporary items do not form part of a structure's permanent dry or operating weight.

3.36**topsides**

assemblies placed on a substructure (fixed or floating) to provide some or all of a *facility's* (3.16) functions

Note 1 to entry: For floating facilities and jack-ups, the hull deck is not typically part of the topsides, however, some of the equipment and discipline bulks mounted in or on the hull can be defined as part of the topsides.

Note 2 to entry: A separate fabricated deck or module support frame is part of the topsides.

3.37**uncertainty allowance**

allowance, based on risk analysis or experience, to account for the immaturity of the conceptual design scope

3.38**unplanned future reserve**

reserve to account for the addition of unplanned modifications during the operations phase of the *facility* (3.16)

EXAMPLE Equipment upgrades, process and non-process system modifications (including new flowlines), additional supporting structures, etc.

3.39**upper bound weight constraint**

maximum weight during *conceptual design* (3.7) phase

3.40

variable weight

weights of fluid and powders in *tagged equipment* (3.34) and piping, including process and non-process fluids (e.g. brine, potable water and diesel storage), drill pipe, drill casing, drilling *consumables* (3.10) (e.g. fluids and powders), scaffolding, laydown areas and storage areas, that occur coincidentally

Note 1 to entry: A more comprehensive list of variable weight is given in [Table D.1](#).

Note 2 to entry: Variable weight results in variable actions, defined as Q1 in ISO 19902 and ISO 19901-3.

3.41

weight database

database containing the *net weight take-off* (3.27), *gross weight take-off* (3.19) and/or *estimate to complete* (3.14) for each *weight item* (3.43) that sums to the *predicted weight* (3.32) and *centre of gravity* (3.5) for each *loading condition* (3.23)

Note 1 to entry: See [Annex G](#).

3.42

weight database custodian

WDC

organization tasked with the responsibility for maintaining the *weight database* (3.41) during operations phase

Note 1 to entry: The weight database custodian should be appointed at the start of operations.

3.43

weight item

individual or group of *discipline bulks* (3.12) and/or *tagged equipment* (3.34), *variable weights* (3.40) or *assembly* (3.2) identified for weight reporting purposes

3.44

weight management objective

set of engineering goals necessary to fulfil weight and *centre of gravity* (3.5) requirements

3.45

weight sensitive

predicted weight is 95 % or more of the capacity of the transport and installation (T&I) marine equipment or the predicted weight is 95 % or more of the *not-to-exceed weight* (3.28)

4 Abbreviations

CAD	computer assisted design
MoC	management of change
NTE	not-to-exceed
PoB	personnel on board
RAPID	recommend, agree, perform, input and decide
SIM	structural integrity management
T&I	transport and installation
3D	three dimensional

5 Principles of weight management

5.1 General

Weight management is the set of processes and activities performed by all disciplines and project groups to achieve the weight management objectives set out during the life cycle phases of the facility.

5.2 Weight management during project lifecycle phases

Weight management shall apply at all phases of a facility:

- a) conceptual design;
- b) FEED;
- c) detail engineering;
- d) construction;
- e) installation and HUC;
- f) operation;
- g) decommissioning.

Different weight estimating techniques are typically used at different phases of the facility lifecycle:

- h) analogue-based or norm-based estimates (conceptual design and FEED);
- i) WTO-based estimates (FEED and detail engineering);
- j) weighed weights of equipment/ assembly (detail engineering and construction);
- k) as-built weights (operations and decommissioning).

Weight items that form part of the 3D CAD model should include the 3D CAD model reference of the item in the weight database.

Weight items that do not form part of the 3D CAD model shall be stored as individual items in the weight database. Example attributes are shown in [Annex G](#).

5.3 Weight management objectives

5.3.1 Objectives during conceptual design phase

Weight management objectives during the concept design phase of a facility should:

- a) set an upper bound weight constraint and associated CoG of the facility;

NOTE The upper bound weight is typically set early in the conceptual design phase, so the concept options for the facility and the installation options (that depend on operating limits for marine equipment) can be developed in accordance with the project strategy.

- b) develop facilities weight data for T&I marine equipment capacity;
- c) prepare weight data that is suitable for cost estimation and procurement processes;
- d) prepare facilities loads for in-place topsides structural and substructure studies;
- e) prepare facilities weights and centres of gravity (CoG) for transport and installation studies;

- f) confirm feasibility of project design weight assumptions to determine sensitivity of concept to future weight growth and associated CoG shifts;
- g) identify major mitigation options available to combat future weight growth and CoG shifts that could impact the feasibility of a concept option;
- h) protect the concept option in accordance with the design basis;
- i) identify weight risks and opportunities;
- j) track, monitor and review all weight changes before they are incorporated into the weight database.

Additional guidelines on weight management for concrete structures is provided in [Annex H](#).

5.3.2 Objectives during FEED, detail engineering and construction phases

The weight management objectives during the FEED, detail engineering and construction phases of a facility should:

- a) set the NTE weight and associated CoG of the facility for the in-service operating conditions;

NOTE 1 NTE weight and CoG envelope for the in-service operating condition is typically set in the FEED phase so that the design of the topsides and substructure can progress with confidence.

- b) set NTE weights and CoG envelopes of the facility and its assemblies for the pre-service load-out, transport and installation loading conditions;

NOTE 2 This allows T&I marine equipment to be identified and reserved at an early stage of the project.

- c) prepare a weight report at the end of construction together with supporting data, including explanations of weight changes, weighing reports and weight certificates;
- d) prepare a facility weight database containing weight data available at the end of the installation phase that is documented, summarized, auditable and traceable.

Additional guidelines on weight management for concrete structures is provided in [Annex H](#).

Monte Carlo simulations may be used to calculate weight risks and opportunities based on their perceived probability of occurrence and consequence (if they were to occur).

5.3.3 Objectives during operations and decommissioning phases

The weight management objectives during the operations and decommissioning phases of a facility should:

- a) maintain a facility weight database;

NOTE 1 This is typically performed by recording weight and CoG changes in the weight database due to brownfield projects.

- b) track weight and associated CoG changes against the NTE weight and associated CoG.

NOTE 2 This is typically performed to confirm NTE weight and associated CoG envelope are not exceeded or to initiate an assessment to confirm structural capacity or strengthening requirements.

5.4 Illustration of weight versus time

[Figure 1](#) illustrates the weight terms used and their relationship versus the life of the facility.

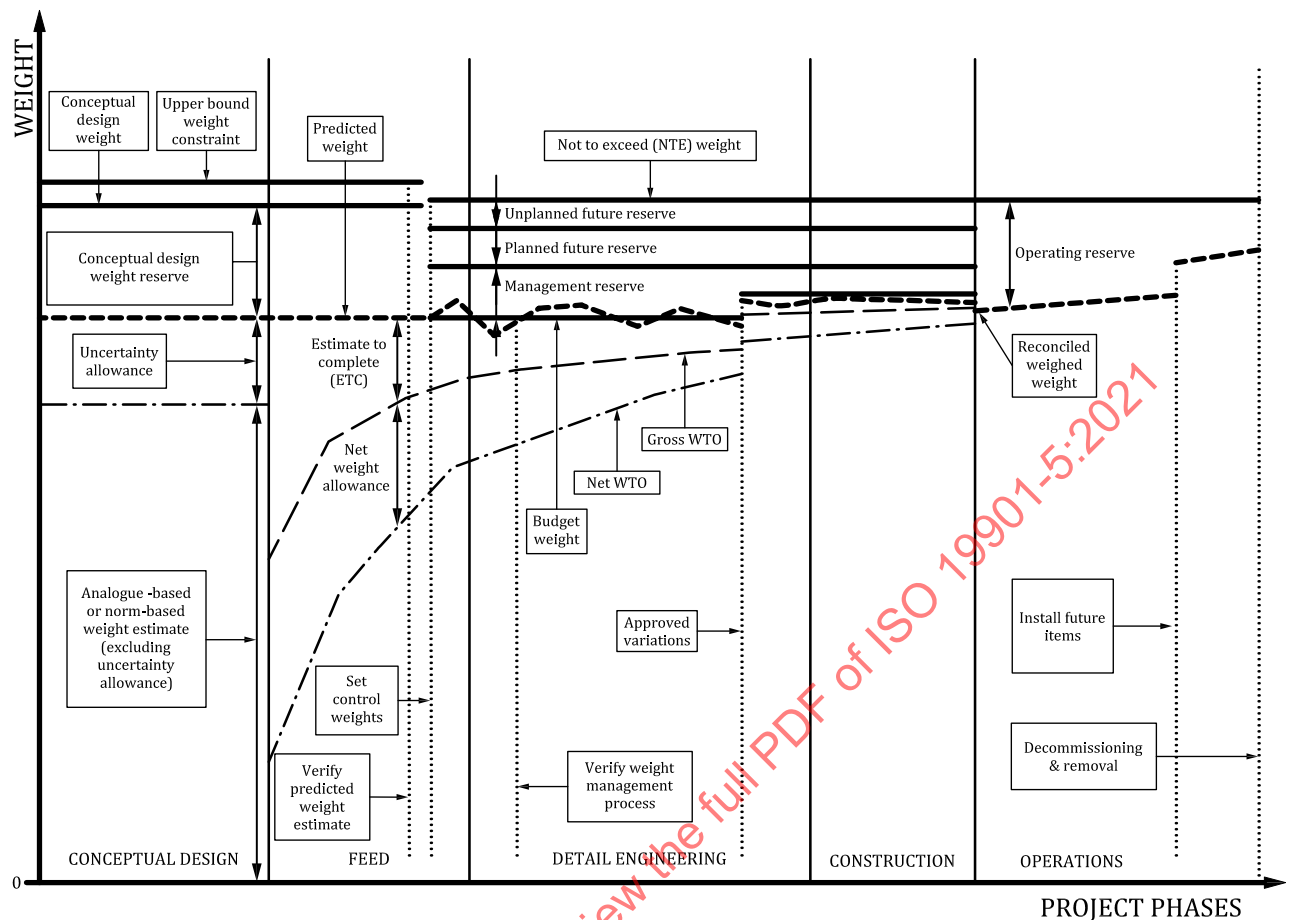


Figure 1 — Weight terms and activities vs life of the facility (weight development graph)

5.5 Loading conditions

5.5.1 General

Loading conditions are used during FEED, detail engineering and construction to distinguish between the facility/ assembly weight at each phase of its life.

Each loading condition shall:

- identify and quantify the weight and CoG;
- have corresponding control weight (including CoG envelope), see [Clause 6](#).

5.5.2 Typical loading conditions

Loading conditions should include:

- dry installed condition;

NOTE 1 This is the weight and CoG of the facility after HUC, complete and ready for service but excluding variable weight (except for pre-commissioning variable weight).

NOTE 2 For floating facilities, the lightship weight is typically used for the dry conditions. The lightship weight can vary between project phases (e.g. bare hull, hull with topsides installed).

- operating condition;

NOTE 3 This is the dry installed weight plus variable weight. The locations and fill-level of the variable weight represent maximum weight conditions typically experienced during the operations phase.

NOTE 4 The location and fill-level of the variable weight is documented in the weight management procedure. See [D.1](#) and [D.3](#) for examples.

NOTE 5 Drilling weights are typically included in combination B in [Table D.2](#).

NOTE 6 The weight database does not reflect the worst topsides loading condition, as this requires the application of variable and environmental loads used for structural design. [D.3](#) shows examples of variable loads.

NOTE 7 For floating facilities, the hull tank loading conditions and associated displacements are not part of the weight management as per this document but are covered in class rules and International Standards. These rules and standards include the intact and damaged stability requirements for various types of facilities, their loading conditions, operating modes and project phases.

c) pre-service conditions:

- 1) fabrication (including assembly during fabrication);
- 2) load out (including float-on);
- 3) transport;
- 4) installation (including launching, float-off, upending, float-over, lifting).

NOTE 8 Fabrication weight typically includes the weight of any frames and temporary items (including pre-installed lift rigging if applicable) that are attached to the facility / assembly during the main steps of construction of the facility / assembly.

NOTE 9 Load-out weight typically includes the weight of any load-out frames and temporary items (including pre-installed lift rigging if applicable) that are attached to the facility / assembly during the movement and set-down with the facility / assembly on the transport vessel.

NOTE 10 Transport weight typically includes the weight of temporary items (including pre-installed lift rigging), internal sea fastenings and voyage protection added for transport, plus any variable weights for equipment or discipline bulk items that are required for subsequent installation operations.

NOTE 11 Installation conditions typically include the weight and CoG of the facility / assembly when transferred from its transport condition to its permanent installed position.

NOTE 12 Lift weight of the facility / assembly typically includes the weight of the sea fastening and temporary items remaining after freeing of the facility / assembly from the transport grillage.

NOTE 13 Lift weight typically excludes the weight of the lift rigging (e.g. slings, shackles and spreader bars).

d) future operations.

NOTE 14 Future operations include management reserve, planned future reserve and unplanned future reserve.

6 Control Weights

6.1 General

Control weights (see [Annex C](#)) shall:

- a) consist of budget and NTE weights (including reserves and associated CoG envelopes);
- b) be used to manage weight growth and CoG shifts for each loading condition from FEED to the end of construction;

- c) be set after verification of the predicted weight (see 7.2.5 and 7.3.5);
- d) be managed under a MoC process.

A decision-making process shall be established for weight management decisions. An example RAPID decision matrix is shown in [Annex E](#).

The control weights should be set during FEED at the transition from norm-based estimates (or analogue-based estimates) to WTO-based estimates.

Organizations that are contracted to supply sub-components of the facility may be allocated respective budget weights.

6.2 Purpose

Control weights should be used for:

- a) weight and CoG control;
- b) control of costs and schedule;
- c) confirming loading conditions are within load-out, transport and installation capacities;
- d) confirming loading conditions are within the structural capacities for topsides assemblies and substructures;
- e) confirming loading conditions are within the bearing capacity and stability of the facility (temporary or permanent).

6.3 Budget weights and NTE weights

6.3.1 Budget Weights

Budget weights, including CoG envelopes, shall be established for each loading condition (see 5.5).

The CoG envelopes may be two-dimensional or three-dimensional depending on the facility or assembly.

Budget weights are typically used as a target that predicted weights are unlikely to exceed throughout FEED, detail engineering and construction phases.

$$\text{Budget weight} \geq \text{Net WTO} + \text{Net weight allowance} + \text{ETC} + \text{variable weight (for applicable loading conditions)}$$

6.3.2 Reserves

Reserves shall include:

- a) management reserve;
- b) planned future reserve;
- c) unplanned future reserve.

Management reserve shall apply for each loading condition.

NOTE 1 Management reserve is typically used to manage weight increases due to change in scope.

Planned future reserve and unplanned future reserve shall only apply to the future operations loading condition.

NOTE 2 Planned future reserve and unplanned future reserve are typically used to design the facility for future operations.

6.3.3 NTE weights

NTE weights, including CoG envelopes shall be established for each loading condition (see 5.5).

CoG envelopes may be two-dimensional or three-dimensional depending on the facility or assembly.

NTE weights are typically based on budget weight, management reserve, planned future reserve and unplanned future reserve as applicable.

$$\begin{array}{ccccccc} \text{NTE} & \geq & \text{budget} & + & \text{management} & + & \text{planned} & + & \text{unplanned} \\ \text{weight} & & \text{weight} & & \text{reserve} & & \text{futures reserve} & & \text{futures reserve} \end{array}$$

NTE weights for pre-service loading conditions (construction, loadout, transport, installation, HUC) should only include management reserves.

6.4 Loading conditions and parameters

Revisions to the control weights shall take place under MoC procedures.

Weight increases due to scope changes that have been approved by MoC procedure may be drawn down from the management reserve.

Weight increases that exceed the control weights (including excursions outside the CoG envelopes) and have been rejected by MoC procedure shall be subject to corrective action.

Corrective action shall be applied to reduce weight or amend CoG shifts (e.g. revision to layout of equipment or discipline bulks, weight shedding, reassessment of allowances) to stay within the limits of the control weights.

A decision-making process is typically established for weight management decisions that are controlled by MoC. An example RAPID decision matrix is shown in Annex E.

6.5 Control weights during operations phase

Weight and CoG changes, due to brownfield projects, should be managed by keeping within the NTE weight and CoG envelope during the operations phase.

The NTE weight and CoG envelope (i.e. the control weights for the operating loading condition) may be revised in the operations phase by structural assessment of the topsides or substructure.

NOTE Structural assessment of the facility is typically used for brownfield projects with significant weight increases.

7 Weight management during project execution phases

7.1 Conceptual design

7.1.1 General

Weight management during conceptual design shall:

- a) develop weight estimates for each facility option;

- b) prepare the weight estimates for the following preferred configuration(s):
 - 1) predicted weights for dry and operating (i.e. dry weight + variable weight) loading conditions;
 - 2) conceptual design weights for dry, operating, load-out, transport and installation loading conditions;
 - 3) upper bound weight constraints for design, construction and installation;
- c) carry weight estimates for the preferred configuration(s) forward into FEED.

A predicted weight and conceptual design weight should exist for each loading condition.

The upper bound weight constraint typically depends on the planned installation method.

Weight estimating in the conceptual design phase is norm-based but is typically also reliant on experience-based judgement. See [Annex K](#) for example weight management competencies.

7.1.2 Predicted weight

The predicted weight shall:

- a) include specific equipment weights, discipline weights (based on historical norms) and items known to exist;

NOTE There is a possibility that available historical norms include or exclude items such as flares, cranes, stair-towers, cantilevers, roof equipment, hose handling, etc.
- b) include an uncertainty allowance (see guidance in [Annex J](#));
- c) be equally likely to overestimate or underestimate the out-turn weight, i.e. is a median (P50) weight.

Predicted weights should be used for cost estimation and benchmarking purposes.

7.1.3 Conceptual design weight

Conceptual design weight shall include the predicted weight and the conceptual design weight reserve.

Conceptual design weights shall be used for conceptual design engineering and to determine technical feasibility (e.g. analysis of topsides and substructures and checking construction, transport and installation strategies).

Conceptual design weight reserve shall be based on degree of confidence in the predicted weight and is the provision for weight reserves used in FEED, detail engineering and construction.

7.1.4 Upper bound weight constraint

Upper bound weight constraints are typically the weight limitations due to:

- a) construction methods capability;
- b) transport route;
- c) transport barge capacity and stability;
- d) installation methods capability;
- e) load carrying capacity of supporting structures.

Upper bound weight constraints are typically used to avoid the risk of above limitations being exceeded.

7.1.5 Weight estimating

Weight estimating during conceptual design should be based on:

- a) defined facility geometry
- b) definition of major tagged equipment and MEL;
- c) equipment layouts;
- d) itemized weight and CoG of assemblies (i.e. by equipment, structural and discipline bulks);
- e) estimate of the variable weights;
- f) itemized structural weights by type (i.e. primary, secondary and tertiary/outfitting);
- g) itemized discipline bulks weights (e.g. piping, electrical, instrumentation);
- h) provision of separate topsides and substructure weights;
- i) defined coordinate systems;
- j) specified uncertainty allowances;
- k) conceptual design weight reserve;
- l) defined upper bound weight constraints.

7.1.6 Key documentation

7.1.6.1 General

The following documentation shall be used as input:

- a) MEL;
- b) facility layout.

The following documentation shall be prepared:

- c) weight management procedure;
- d) potential weight variation register.

7.1.6.2 MEL

MEL should include the dry weight and variable weight for each item of equipment.

7.1.6.3 Facility layout

Facility layout should include:

- a) topsides geometry;
- b) size and location of tagged equipment listed in the MEL;
- c) equipment position, orientation and elevation to meet production and process safety requirements;
- d) space allocation for maintenance, operations and mechanical handling;
- e) routing for piping, electrical, instrumentation and HVAC;
- f) main accessways and escape routes;

- g) stair-towers and cantilevers;
- h) structural framing (e.g. main columns, girders, bracing);
- i) appurtenances (e.g. flares, booms, cranes);
- j) buildings and enclosures;
- k) laydown and storage areas;
- l) drilling facilities and requirements;
- m) interfaces with seabed infrastructure and other facilities (e.g. bridge landings);
- n) requirements for construction and T&I (e.g. loadout frames, lift points, lifting sling clearance envelopes).

7.1.6.4 Weight management procedure

The weight management procedure should include:

- a) weight management objectives;
- b) weight management methodology;
- c) weight deliverable requirements.

7.1.6.5 Potential weight variation register

Potential weight variation register should include:

- a) evaluation of the weight and CoG impacts for each weight risk or opportunity throughout conceptual design;
- b) status of each weight risk or opportunity (e.g. closed out during conceptual design or carried forward into FEED).

7.1.7 Estimating principles

7.1.7.1 Estimating methods

During the conceptual design phase, the dry weights should be estimated using a minimum of two of the following methods:

- a) analogue;
- b) MEL norms;
- c) area and/or volumetric norms.

Choice of estimating methods should be based on availability of weight data from previous projects having similar facility characteristics. Typical matching characteristics are listed in [Table 1](#).

Table 1 — Facility characteristics for norm based weight estimation

Environmental conditions during operation	Operating pressure	Secondary separation system
Environmental conditions during transport	Operating temperatures	Produced water system
Installation method	Production flow rates	Compression system
Geotechnical condition	Export flow rates	Number of people on board
	Primary separation system	Number of cranes
	Electric power demand	

In accordance with [7.1.7.2](#), [7.1.7.3](#) and [7.1.7.4](#), additional weight estimating uncertainty allowances shall be included in predicted weights to account for weight uncertainties due to immaturity of the conceptual design.

Historical topsides operating to dry weight ratios from existing facilities with similar characteristics (see [Table 1](#)) should be used to develop operating weights for the conceptual design (see [Annex J](#) for example conceptual operating to dry weight ratios).

Weight estimates during conceptual design should be checked against historical benchmark data.

7.1.7.2 Analogue method

Analogues from previous projects or facilities with similar characteristics may be used to estimate the weight.

Suitable analogues should be selected from existing facilities that match the characteristics of the facility basis of design with characteristics of existing projects or facilities. Typical matching characteristics are listed in [Table 1](#).

NOTE Analogue methods typically provide accurate weight estimates if the conceptual design is a close copy of the analogue facility.

An analogue uncertainty allowance should be added to account for differences between the characteristics (e.g. production rates, power requirements, range of analogue weights) of the analogue and the facility being designed. Guidance on analogue uncertainty allowance is provided in [Annex J](#).

Predicted weight based on the analogue method is determined as:

$$\text{Predicted weight} = \text{analogue weight} + \text{uncertainty allowance} + \text{variable weight (for applicable loading conditions)}$$

7.1.7.3 MEL norms method

MEL norms may be used to estimate the predicted weight of discipline bulks relative to the weight of tagged equipment in the MEL.

Predicted weights of discipline bulks may be itemized by assembly or system dependent on the size of the facility.

MEL norms should be developed from existing facilities that match the characteristics of the facility basis of design. Typical matching characteristics are listed in [Table 1](#).

MEL norms may be either a single set of norms for the best matched facility or the mean set of norms from several like facilities.

A MEL uncertainty allowance should be added to account for the immaturity of the MEL weight. Guidance on MEL uncertainty allowance is provided in [Annex J](#).

An uncertainty allowance should be added to account for the concept phase immaturity.

Predicted weight based on the MEL norms method is determined as:

$$\text{Predicted weight} = \text{MEL weight} + \sum_{\text{for all discipline bulks}} \left[\text{MEL weight} \times \text{norm for discipline bulks} \right] + \text{uncertainty allowance} + \text{variable weight (for applicable loading conditions)}$$

MEL norms are typically itemized by facility type and by discipline.

NOTE The P50 estimate of predicted weight can be improved if the norms are also itemized by type of equipment [e.g. hydrocarbon system (mechanical packages, pumps and vessels), utility system (mechanical packages, pumps and vessels), power generation, mechanical handling etc.].

7.1.7.4 Area and/or volumetric norms method

Area and/or volumetric norms may be used to estimate the predicted weight once layouts have been prepared.

Area and volumetric norms should be developed from existing facilities that match the characteristics of the facility basis of design. Typical matching characteristics are listed in [Table 1](#).

Area and volumetric norms may be either a single set of norms for the best matched facility or the mean set of norms from several like facilities.

Area and volumetric norms should be consistent with the application of the norms (i.e. effective areas may or may not include walkways, cantilevers, etc).

Layout area/volume uncertainty allowance should be added to account for immaturity of the current layout area/volume (i.e. underestimate of area/volume due to design development). Guidance on layout area and volume allowances is provided in [Annex J](#).

Predicted weight based on the area and/or volume norms method is determined as:

$$\text{Predicted weight} = \sum_{\text{for all disciplines}} \left[\text{layout area/volume} \times \text{norm for discipline} \right] + \text{uncertainty allowance} + \text{variable weight (for applicable loading conditions)}$$

Weights and locations for systems based on area and/or volumetric norms can be used to determine CoGs of assemblies and the overall CoG of the facility.

7.1.8 Deliverables

At the completion of the conceptual design phase, the following shall be available for handover to FEED:

- predicted weights and CoGs for facility and major assemblies for pre-service (e.g. transport, lift) and for in-service (dry, operating and future) loading conditions;
- conceptual design weights and CoGs for facility and major assemblies for pre-service and in-service loading conditions;
- upper bound weight constraints;
- weights itemized by equipment, structural (by primary, secondary and tertiary/outfitting) and discipline bulks;
- variable weights;
- temporary weights (if applicable);

- g) itemized list of the allowances in predicted weights;
- h) data source and basis for input data;
- i) method(s) of estimating;
- j) benchmarking analysis report using historical data (if applicable);
- k) weight database (if available);
- l) global and local co-ordinate system origins;
- m) potential weight variation register.

7.2 FEED

7.2.1 General

FEED is the project phase where principal design variables are resolved and sizes, volumes and variable weights are optimized.

The norm-based estimate of predicted weight initiated in conceptual design shall transition to a WTO/datasheet-based estimate of predicted weight.

NOTE 1 The transition to a WTO/datasheet-based estimate of predicted weight is due to the refinement in design data during FEED.

Predicted weight based on WTO and datasheets is determined as:

$$\text{Predicted weight} = \text{Net weight} + \frac{\text{Net weight}}{\text{allowance}} + \text{ETC} + \text{variable weight (for applicable loading conditions)}$$

Guidance on allowances for WTOs and weight datasheets is provided in [Annex J](#).

NOTE 2 Net weight allowance applies to assemblies or items that have been developed from a WTO or vendor supplied weights, and ETC applies to assemblies or items that have not been developed from a WTO or vendor supplied weight estimate.

Weight management during FEED shall include:

- a) weight management plan;
- b) weight management procedure;
- c) weight reporting;
- d) weight data checking and verification.

Weight estimating in the FEED phase is norm-based or initial WTO but is typically also reliant on experience-based judgement. See [Annex K](#) for example weight management competencies.

7.2.2 Weight management plan

The weight management plan should be prepared at the start of FEED and should be developed through detail engineering, construction and operations. The plan defines the weight management required for the project.

The weight management plan during FEED should include:

- a) weight stakeholders (e.g. project leader, construction manager);
- b) assumptions and boundary conditions (e.g. maximum lift weight);
- c) required level of uncertainty for weight estimates per project phase to support inputs to project cost estimates;
- d) expected level of engineering scope to deliver the required confidence in the weight estimate;
- e) management reserve, planned future reserve and unplanned future reserve;
- f) key deliverables for each discipline to support weight estimates;
- g) key performance indicators (e.g. benchmarking, RAPID decision matrix);
- h) frequency (e.g. monthly) for issuing weight reports per phase, and accountability and responsibility for providing them;
- i) frequency, timing and reference sources for benchmarking and verification;
- j) weight management organigram and resourcing requirements;
- k) process for weight management decisions that are controlled by MoC (see [Annex E](#));
- l) handover activities to detail engineering and operations to enable future active weight management.

7.2.3 Weight management procedure

The weight management procedure during FEED should include:

- a) weight management objectives;
- b) weight estimating methodology;
- c) global and local coordinate systems and origins, with reference to topsides geometry;
- d) area designation system;
- e) weight input requirements;
- f) net weight allowances together with progress measures that define when reduction in net weight allowances can occur;
- g) governing loading conditions;
- h) weight reporting boundaries between various components of the facility (e.g. topside, substructure or hull);
- i) weight reporting codes (e.g. project phase, status, net weight allowance);
- j) discipline item checklists;
- k) MoC actions if predicted weights exceeds budget weights or CoGs shift outside of their CoG envelopes;
- l) transfer of weight management responsibility through the various project phases.

7.2.4 Weight reporting

Weight reports, during FEED should include:

- a) predicted weight and CoG summary for the overall facility;

- b) predicted weights and CoGs itemized for each assembly and loading condition;
- c) detailed WTOs itemized by assembly, area, discipline, location, and weight reporting codes;
- d) net weight allowances itemized by assembly, area and discipline;
- e) ETCs;
- f) variable weight (for operating loading conditions);
- g) management reserve, planned future reserve and unplanned future reserve;
- h) reference to laydown and storage drawings (for operating loading conditions);
- i) global and local coordinate systems and origins, with reference to topsides geometry;
- j) demarcations between topsides and substructures;
- k) comparative assessment of predicted weights and CoGs with the control weights;
- l) weight versus time trend graphs and CoG envelope plots;
- m) weight versus time trend graphs for the MEL equipment, and for the facility deck area (in m²);
- n) potential weight variation register;
- o) weight checking results and conclusions.

For floating facilities, equipment and discipline bulks that form part of the topsides process and utility systems but are located on, or in, the hull shall be reported separately (e.g. topsides equipment and discipline bulks located on the hull deck or in the deck box).

NOTE These particular items are typically part of the topsides engineering scope but are located on, or in, the hull for convenience.

The typical format of a weight report is shown in [Table 2](#) (see [7.3.4](#)).

7.2.5 Weight checking and verification

Weight estimates shall be checked by a continuous process during FEED.

NOTE Checking identifies weight trends and CoG movements. Adverse weight trends and CoG excursions outside of the control weights are addressed in [Clause 6](#).

Verification of weight estimates shall:

- a) be conducted prior to setting the control weights;
- b) evaluate methodology and completeness of dry and operating weight estimates;
- c) identify and quantify weight risks and uncertainties;
- d) provide assurance evidence for setting the control weights.
- e) be scheduled by the project team;
- f) be performed by parties outside of the project team.

7.3 Detail engineering

7.3.1 General

Detail engineering is the project phase where the design is typically developed and refined to allow commencement of construction activities.

Weights in this phase should be based on WTOs (including net weight allowances), ETCs and supplier weight estimates or weighed weights.

Predicted weight based on WTO and datasheets is determined as:

$$\text{Predicted weight} = \text{Net WTO} + \text{Net weight allowance} + \text{ETC} + \text{variable weight (for applicable loading conditions)}$$

Guidance on net weight allowances is provided in [Annex J](#).

Weight management during detail engineering shall include:

- a) weight management plan;
- b) weight management procedure;
- c) weight reporting;
- d) weight checking and verification.

Weight estimating and control in the detail engineering phase typically relies on multi-discipline experience and organizational skills to manage the flow of weight data. See [Annex K](#) for example weight management competencies.

7.3.2 Weight management plan

The weight management plan (see [7.2.2](#)) should be developed in line with the detail engineering execution plan and organizations involved in the project.

7.3.3 Weight management procedure

The weight management procedure (see [7.2.3](#)) should be developed to account for weight data from the 3D CAD model and suppliers.

7.3.4 Weight reporting

Weight reporting (see [7.2.4](#)) should be developed by reducing the ETCs, increasing WTOs and reducing net weight allowances using progress measures that define when reductions in net weight allowances can occur.

Weight reports in detail engineering:

- a) should be issued monthly;
- b) shall be issued monthly for weight sensitive assemblies.

The typical content of a weight report is shown in [Table 2](#).

Table 2 — Weight report content

EXECUTIVE SUMMARY	— a short summary of project focus areas; — a brief description of changes in predicted weights, CoGs and control weights (for all loading conditions) since the previous weight report.
1 Introduction	
1.1 Purpose	— a description of the purpose of the weight report.
1.2 Scope	— a brief description of the scope of work for the project and the corresponding scope/content of the weight report; — a list of the specific loading conditions that are reported.
1.3 Loading conditions	— a description of the loading conditions presented in the report.
2 Report basis	
2.1 Sources of information	— a list of reference material used (e.g. layout drawings, weight take-offs from a 3D model, plot plans, MEL, discipline input) and the respective issue dates used to create the weight report; — the cut-off date used for submission of the discipline weight data.
2.2 Report assumptions	— a list of the assumptions used to create the report.
2.3 Estimates	— a table showing the ETCs in the current report.
2.4 Reserves	— a table showing the magnitude of the reserves (management, planned future and unplanned future) in the current report.
3 Loading condition summaries	General loading condition reporting requirements: — tables showing weight and CoG summaries for assemblies, modules and entire facilities; — comparison of weight and CoG data between the current and previous weight report; — comparison of weight and CoG data between current weight report and the budget weight and CoG; — description of weight variations to the previous weight report; — any drawdowns from the reserves and any changes in control weights.
3.1 Dry installed loading condition	— see requirements above.
3.2 Operating loading condition	— see requirements above.
3.3/4/5... Other loading conditions summaries	— see requirements above.
4 Weight and CoG trend graphs	— weight and CoG trend graphs for all agreed loading conditions showing the weight development and CoG shift over time; — weight trend graph for MEL weight data and facility deck area.
5 Potential weight variation register	— listing of possible weight risks (increases) and opportunities (reductions). List includes possible changes to scope and design that are to be controlled through a MoC process before inclusion in the weight report.
6 Attachments	
6.1 Definitions	— table showing the definition of expressions used in the report.
6.2 Abbreviations	— table to explain the abbreviations used in the report.
6.3 Coordinate systems	— sketch showing CoG coordinate system origin and platform geometry.
6.4 Laydown/ storage	— sketches showing location and weight capacity for laydown and storage areas.
6.5 Weight phase codes	— table showing the relevant weight phase codes used in the weight database.

Table 2 (continued)

6.6	References	— table showing the reference documents, standards, procedures and specifications etc. for the report.
6.7	Report schedule	— schedule indicating the planned cut-off and issued dates for the report.
6.8	Design data	— principal design data for the project.
6.9	Other	— other useful information.

7.3.5 Weight checking and verification

Weight estimates shall be checked by a continuous process during detail engineering to track weight trends and CoG movements.

NOTE Checking identifies weight trends and CoG movements. Adverse weight trends and CoG excursions outside of the control weights are addressed in [Clause 6](#).

Verification of the weight management process during detail engineering shall:

- be conducted after the process has been implemented (i.e. after 2 to 3 issues of the weight report);
- provide assurance evidence that the process has been implemented and applied by the project;
- identify risk of process being ineffective or insufficient for the project weight management objectives;
- be scheduled by the project team;
- be performed by parties outside of the project team.

7.4 Construction

7.4.1 General

Weight management shall be maintained during the construction phase and shall include:

- updates to the weight management plan and the weight management procedure to reflect construction activities;
- weight reporting;
- weighing of assemblies.

7.4.2 Weight database

During the construction phase the weight database should be updated to include:

- WTOs and adjustments to net weight allowances due to improved design maturity;
- weighed weights of tagged equipment and assemblies;
- material substitutions during construction;
- field corrections;
- field run items;
- fabricator designed materials;
- temporary construction or installation items that are onboard during reported loading conditions (e.g. loadout, transport).

7.4.3 Weight reporting

Weight reports shall be prepared as per [7.3.4](#).

7.4.4 Weighing of assemblies

Weighing of supplier items and assemblies is addressed in [Clause 8](#) and [9](#) respectively.

Weighing results (weights and CoGs) that have been reconciled to take account of temporary construction items shall supersede predicted weights for the subsequent project phases (e.g. installation, HUC, operations, decommissioning).

Assemblies not weighed shall retain their weight in the weight database, based on the WTOs and net weight allowances.

7.5 Installation and HUC

Weight management shall be maintained during installation and HUC and shall include:

- a) updates to the weight database;
- b) checks that assembly weights and CoGs are within installation capacities (e.g. cranes, rigging);
- c) records of weights and locations of items added to, or removed, from the facility during HUC (e.g. installation aids and equipment, HUC materials, equipment, containers and consumables).

Installation and HUC items left on the facility (e.g. scaffolding, containers, spares, surplus materials) after HUC shall be included in the weight database.

The weight management responsibility shall be transferred to the WDC at the completion of HUC activities.

7.6 Operations

7.6.1 General

Weight management shall be maintained by the WDC throughout operations and shall include:

- a) weight management procedure;
- b) weight database;
- c) laydown and storage drawings;
- d) managing the dry and operating weights and CoG's.

Weight and CoG monitoring for a floating facility during the operations phase should be in conformance with DNVGL-OTG-12.

7.6.2 Weight management procedure

A weight management procedure shall be prepared at the start of the operations phase.

The weight management procedure should include:

- a) roles and responsibilities of parties;
- b) methodology for recording weight and CoG changes due to planned and unplanned brownfield projects and decommissioning;
- c) weight reporting intervals and initiators (e.g. brownfield projects) for interim weight reports.

NOTE The facility weight and CoG is typically summarized and reported annually, provided no major brownfield projects occur during that timeframe.

Weight management for significant brownfield projects (e.g. those adding 3 % or more to the total operating weight) shall conform to 7.1 to 7.5.

Minor brownfield projects undertaken during operations should conform to 7.1 to 7.5.

7.6.3 Weight database

Regardless of weight, the weight database shall be maintained and updated with a record of all brownfield projects on the facility.

The weight database for the operations phase should include:

- a) dry installed weight using reconciled weighed weights for weighed assemblies, or a WTO including net weight allowances for weight items or assemblies not weighed;
- b) variable weight determined using a WTO including net weight allowance for weight items or assemblies.

NOTE 1 The locations and fill-level of the variable weight represent maximum weight conditions typically experienced during the operations phase.

NOTE 2 The location and fill-level of the variable weight is documented in the weight management procedure. See D.1 and D.3 for examples.

The weight database should be subject to ongoing review, with in-depth reviews every 5 years or when major changes to weight or CoG of the facility occur (e.g. those adding 3 % or more to the total operating weight).

The review should confirm the weight database represents accurate dry installed weight and CoG and operating weight and CoG for the facility.

7.6.4 Legacy weight databases

Where there is insufficient documentation to demonstrate the requirements of 7.1 to 7.5 have been followed, existing weight databases shall be verified to ensure the accuracy and completeness of dry weights, variable weights and CoG data.

The verification of the legacy database shall take place either at change of facility ownership, at the next in-depth weight database review (see 7.6.3), prior to major changes to topsides weight or CoG (e.g. those adding 3 % or more to the total operating weight), or prior to commencing the decommissioning phase.

The verification of the weight database shall include the following:

- a) the weight database reflects up to date layout drawings and MEL;
- b) the location and fill-level of the variable weights, including laydown, storage and scaffolding. Table D.1 shows examples;
- c) drilling weights in accordance with Table D.2 load combination B;
- d) where practical, summarized discipline bulks weight estimates (e.g. main steelwork = 800 t) are replaced with WTO data (e.g. weight per drawing, CAD model);
- e) all operations phase facility brownfield projects.

7.6.5 Laydown and storage drawings

Laydown and storage drawings shall be updated to reflect their current status.

Laydown and storage drawings form the basis of platform signage that can be displayed at laydown and storage areas on the facility. [Clause D.2](#) shows an example laydown and storage drawing.

7.6.6 Decommissioning

A site survey at the facility should be performed to confirm the level of confidence of the weight database.

Weight management deliverables for removals should include:

- a) as-built weight database including all discipline bulks and tagged equipment;
- b) dry and residual variable weights and CoGs of each assembly or component that forms part of the removal operation;
- c) weight survey results and conclusions.

NOTE A complete and up-to-date detailed weight database for a facility is an essential document to assist with safe and controlled removals.

8 Requirements for suppliers' weight data and weighing of tagged equipment and assembled discipline bulks

8.1 General

Purchase orders shall include provisions for suppliers to make submissions of weight and CoG data at milestones as noted in [8.2](#).

Items provided under discipline bulks purchase orders (e.g. structural steel, piping components, electrical cables) are not typically considered as individual items – as in the case of tagged equipment. However, due the uniqueness of assemblies of discipline bulk items (e.g. valves complete with controlled actuators, architectural wall panels complete with in-fill steel), supplier submission of weight and CoG data may be specified – following the same requirements as tagged equipment.

The supplier shall calculate the weight and CoG as accurately as possible – based on available design documents and/or results from weighings.

Upon completion of manufacturing, tagged equipment and assembled discipline bulks shall be weighed as noted in [8.3](#).

NOTE See [Annex B](#) for an example weighing certificate for tagged equipment and discipline bulks.

8.2 Submission of weight data

The supplier shall prepare weight data:

- a) as a part of the bid documents;
- b) within a timeframe specified after awarding the purchase order;
- c) prior to start of fabrication (e.g. documents are approved for construction);
- d) if a design change results in a weight change exceeding an agreed magnitude value;
- e) at completion of fabrication and prior to weighing;
- f) after completion of a weighing (included in the weighing certificate).

The weight data shall contain:

- g) as-installed dry weight and CoG – inclusive of any permanent fluids (e.g. lubricants, hydraulic oils, coolants);
- h) weight and CoG of normal operating content (i.e. content being stored within or flowing through the item);
- i) total weight of the item in normal operating condition (this is the combination of weight and CoG values for items g and h noted above);
- j) hydro-test weight and CoG (where applicable);
- k) transport weight and CoG.

8.3 Weighing requirements

8.3.1 Equipment

At completion of fabrication of tagged equipment, suppliers shall weigh all items with estimated weights more than 10 kN (1 t). If multiple identical items are supplied, only a representative sample shall be weighed. Published catalogue weight data, or supplier's detailed weight calculations, shall be acceptable for items with estimated weights less than 10 kN (1 t) at completion of fabrication.

8.3.2 Discipline bulks

Individual discipline bulk items (e.g. structural steel, piping, cable tray) are not expected to be weighed. However, when it is not possible to accurately determine the weight of an assembly created from multiple discipline bulks components, a weighing should be performed to confirm the weight of the assembly.

8.4 Weighing procedure

As part of their scope of work, the supplier shall, within a defined time frame (e.g. three months after purchase-order issue), prepare a written weighing procedure.

The weighing procedure shall include:

- a) a list of all items (tagged equipment or discipline bulks) to be weighed using the proposed method and weighing devices;
- b) identification of the tagged equipment and purchase order under which the tagged equipment is being supplied - using project defined identification nomenclature;
- c) a description of the weighing devices and weighing method to be used (e.g. strain-gauge compression load cells and hydraulic jacks, a load-link mounted on an overhead lifting device, a floor mounted weighing scale);
- d) structural details and weight of supporting frames beneath, or lifting spreader bars above (if required) used to distribute the weight of the item being weighed to the measuring device(s) to be used;
- e) calculations demonstrating that supports, jacking points, foundations or spreader bars will not be over stressed during weighing operations;
- f) a description of the measuring, recording and lifting devices to be used, giving rated capacity, expected uncertainty and environmental operating range (temperature and humidity);
- g) example calibration certificates for all weight measuring devices (including spares) to be used during the weighing;

- h) identification of the calibration standard used and the organization responsible (name and address) for performing the calibration of the weight measuring devices;
- i) an example calculation illustrating how the overall weight and CoG of the item will be determined from the data collected using the proposed weighing method;
- j) a dimensioned layout drawing showing the proposed location of the weight measuring device(s) relative to a reference point on the item;
- k) an example calculation showing how permanent items not present for the weighing are to be mathematically added (weight and CoG) to the weighing results, and how temporary items (packaging, tools, etc.) not forming part of the permanent items are to be mathematically removed (weight and CoG) from the weighing results;
- l) the expected schedule (month and year) for weighing the item;
- m) the geographic location (address) for the weighing;
- n) if used, the name and contact information of specialist weighing subcontractor to be employed for the weighing.

8.5 Weighing devices

8.5.1 Type of weighing device

Weighing of tagged equipment or assembled discipline bulks with a predicted weight greater than or equal to 100 kN (10 t), shall be performed using electronic compression load cells. Electronic compression load cells are defined as a load cell where the load cell is supported from the ground and the object to be weighed is loaded on top of the load cell. This method shall be used to establish the CoG in the plane parallel to the top of the load cells. A mix of different types of devices during a weighing operation is not permitted.

Weighing devices shall have a digital display or similar that is easily accessible and displays the results with the same level of uncertainty as that of the load cell. If more than one weighing device is used, the display shall show the actual load for each of the load cells simultaneously. The precision of the display shall be in accordance with the precision of the weight measuring device. Dial gauges are not permitted.

8.5.2 Calibration of weighing devices

Weighing devices shall be calibrated over their entire operating capacity – as defined by the manufacturer. The calibration shall be performed by a laboratory or testing agency that meets the requirements of ISO/IEC 17025 or is accredited for the relevant scope by an accreditation body.

For items with expected weights equal to or greater than 100 kN (10 t), weighing devices shall have been calibrated within the previous 6 months. For items with expected weights less than 100 kN (10 t), weighing devices shall have been calibrated within the previous 12 months.

The calibration certificate(s) shall be available a minimum of 48 hours prior to start of weighing.

8.5.3 Maximum relative uncertainty for weighing devices

Weighing devices shall have maximum relative measurement uncertainties in conformance with the appropriate national standard for the country in which the weighing is being performed.

For items with an estimated weight greater than or equal to 10 kN (1 t) at completion of fabrication, the maximum relative measurement uncertainty shall not exceed $\pm 1\%$.

8.5.4 Capacity of weighing device

To account for weight underestimation and provide a level of safety against potential overloading the calibrated device, the weighing shall be planned in such a way that the individual weighing device(s) operate within a range between 20 % and 80 % of its calibrated capacity.

8.5.5 Spare weighing devices and ancillaries

To minimize delays due to failures of weighing devices or their ancillary components, spares parts (e.g. weighing device, display, cables) shall be present during a weighing.

8.6 Witnessing of weighing

Weighing operations should be independently witnessed (e.g. by purchaser, third party verification authority).

8.7 Scheduling of weighings

Weighings of tagged equipment and assembled discipline bulks shall be scheduled once fabrication is completed and prior to the item being prepared (e.g. crated or wrapped) for shipment from the location of manufacture.

8.8 Environmental conditions during a weighing

A weighing performed in an outdoor location shall only proceed under the following environmental conditions:

- a) the ambient temperature and relative humidity are within the limits of the weighing device(s) manufacturer's recommended operating environmental range;
- b) the measured wind speed (10 minute average) does not exceed 5 m/s, or gusts do not exceed more than 2,5 m/s more than the measured wind speed (wind measurements are to be taken at a height of 2 m above ground level);
- c) there is no risk of precipitation (e.g. rain or snow) immediately prior to or during the weighing operation;
- d) there is sufficient natural or artificial lighting available to permit a safe weighing operation.

8.9 Weighing operation

Weighing of tagged equipment and assembled discipline bulks shall consist of recording a minimum of three consecutive and consistent results. Weighing results are consistent when the difference between the highest and lowest result, and the mathematical mean of the three consecutive results, is less than the uncertainty of the weighing device(s) being used. Additional results shall be gathered until three consecutive and consistent results are obtained.

Results are recorded after the item being weighed has been totally raised from its supports and sufficient time has elapsed to permit stabilization of the weights presented on the weighing device displays. Once the result has been recorded, the item is returned (lowered onto the supports) and the weighing device display is permitted to return to a 'zero' or no-load reading. Any residual load (i.e. a load value present on the weighing device display after the weighing device(s) has been removed from contact with the item being weighed) shall be recorded.

Weighings shall be delayed if one of the following problems has arisen:

- a) inconsistent weighing results;
- b) mechanical/electrical fault or breakdown;

- c) overloading of the weighing devices;
- d) adverse environmental conditions.

The cause of the problem shall be determined before the weighing is permitted to continue. Provisions shall be made to repair or replace the suspect weighing device(s). Weighing devices may be interchanged in an attempt to isolate the problem to the weighing device or other weighing devices. The weighing system shall not be demobilized until the results are deemed to be satisfactory by those witnessing the weighing.

8.10 Temporary items present during a weighing

The weight of temporary items present during the weighing shall be kept to a minimum. If at all possible, the weighing should be performed prior to packing the item for shipment from the supplier's manufacturing facility.

Unless weights and locations for temporary items have been determined – either by calculation or measured by weighing – prior to a weighing operation, items no longer required shall be removed.

Individual temporary items with estimated weights greater than 10 kN (1 t) shall have their weights confirmed by a separate weighing – either prior to or immediately after completion of a weighing. Individual temporary items with estimated weights less than 10 kN (1 t) may have their weights confirmed by either a calculation or by a separate weighing – either prior to or immediately after completion of a weighing.

A complete list of temporary items remaining for the weighing (including a brief description, estimated and/or measured weights, and CoG) shall be included in the weighing certificate. The impact of the temporary items on the overall weight and CoG of the item being weighed shall be mathematically considered (i.e. deducted) in the weighing result.

8.11 Permanent items not installed during a weighing

The weight of permanent items not installed at the time of the weighing shall be kept to a minimum. Non-installed permanent items with estimated weights greater than 10 kN (1 t) shall have their weights confirmed by a separate weighing – either prior to or immediately after completion of a weighing. Non-installed permanent items with estimated weights less than 10 kN (1 t) may have their weights confirmed by either a calculation, or by a separate weighing – either prior to or immediately after completion of a weighing.

A complete list of permanent items missing from the weighing (including a brief description, estimated and/or measured weights, and CoG) shall be included in the weighing certificate. The impact of the missing permanent items on the overall weight and CoG of the item being weighed shall be mathematically considered (i.e. added) in the weighing result.

8.12 Weighing certificate

A weighing certificate shall be prepared and include:

- a) the actual weighed weight, read out from the weighing device;
- b) a detailed list and summary weight and CoG of temporary items (if any) present during the weighing;
- c) a detailed list and summary weight and CoG of permanent items (if any) not installed at the time of the weighing;
- d) calculations showing determination of the as-weighed weight and CoG;
- e) the resulting total dry weight and CoG;

- f) the content weight and COG for normal operating condition;
- g) the resulting total operating weight and CoG.

NOTE Photographs of the weighing provide a record of permanent and temporary items included during weighing and permanent items excluded from the weighing.

See [Annex B](#) for an example weighing certificate.

9 Requirements for weighing of major assemblies

9.1 General

All topsides assemblies shall be weighed at, or near, the end of the construction to verify the overall weight and CoG in the plane parallel to the locations of the load cells.

Substructures and subsea facilities shall be weighed at, or near, the end of construction if the design is weight sensitive and/or the CoG position needs to be verified.

Weighings shall be performed using strain-gauge compression load cells and a system of hydraulic jacks to raise and lower the assembly.

For a floating facility, confirmation of lightship weight and CoG is specified in IMO, The International Code on Intact Stability^[12].

9.2 Weighing procedure

The weighing procedure shall include:

- a) a description of the assembly or assemblies to be weighed, including project name, client, and assembly designation (name, identification code, etc.);
- b) a description of the weighing method to be used (e.g. using strain-gauge compression load cells and hydraulic jacks) (see [9.3.1](#) and [9.3.7](#));
- c) structural details of supporting foundations at the locations of the load cells;
- d) structural details of load spreader frames to be placed beneath the assembly in order to distribute the weight of the assembly onto the load cells;
- e) calculations demonstrating that supports, jacking points, foundations or spreader bars will not be over stressed during weighing operations;
- f) a schematic diagram showing the arrangement of hydraulic jacks, pumps and interconnecting pipework to be used during the weighing operation to raise and lower the assembly onto the load cells;
- g) a description of the load cells, data recording system (measured weights, level of assembly, etc.) and lifting devices;
- h) a description of the measuring, recording and lifting devices to be used, giving rated capacity, expected uncertainty and environmental operating range (temperature and humidity);
- i) the rated capacity, expected uncertainty and environmental operating range (temperature and humidity) of the load cells;
- j) the rated capacity of the individual hydraulic jacks and the complete hydraulic system;
- k) a description, including all safety measures, of the method to be used to control the vertical movement of the assembly during the weighing operations;

- l) example calibration certificates for all load cells (including spares) to be used during the weighing;
- m) identification of the calibration standard used and the organization responsible (name and address) for performing the calibration of the load cells;
- n) an example calculation illustrating how the overall weight and CoG of the assembly will be determined from the data collected using the proposed weighing method;
- o) example calculations illustrating how the overall uncertainty will be calculated from the data gathered during the weighing (see [9.3.3](#));
- p) a dimensioned layout drawing showing the proposed location of the load-cells relative to project reference system for the assembly;
- q) example calculations showing how permanent items not present for the weighing are to be mathematically added (weight and CoG) to the weighing results, and how temporary items not forming part of the permanent works are to be mathematically removed (weight and CoG) from the weighing results;
- r) the expected schedule (month and year) for weighing the assembly;
- s) the geographic location (address) for the weighing;
- t) if used, the name and contact information of specialist weighing subcontractor employed for the weighing.

9.3 Weighing system

9.3.1 Load cells

The weighing system shall consist of strain-gauge compression load cells. Other types of load cell may be used if it can be demonstrated they have levels of uncertainty comparable to strain-gauge compression load cells and meet the requirements of [9.3.3](#).

Load cells shall be equipped with a spherical seating (or equivalent) head assembly to minimize horizontal forces and bending moments and to reduce the uncertainty of the coordinates for the reaction forces.

Load cells should only be used for the project for which they have been calibrated.

9.3.2 Read-out devices

The weight measured by individual load cells shall be indicated on a digital display at a central location. All weight measuring devices shall incorporate a digital read-out that gives a continuous reading of the weight measured by each load cell. Dial gauges shall not be permitted. The precision of the display shall be in accordance with the precision of the load cell. A method for producing a hard copy (print-out) and electronically storing the results should be provided.

Weights shall be displayed and recorded with a resolution of one third (or better) of the measurement uncertainty (e.g. a resolution of 1 kN (0,1 t) or better for a 600 kN (60 t) load cell reading with 0,5 % uncertainty).

9.3.3 Uncertainty of weighing system

Individual load cells shall have a maximum measurement uncertainty within $\pm 0,5\%$, $k = 2$ (the coverage factor for a level of confidence (or confidence interval) of 95,45 %) of rated calibrated capacity. The measurement uncertainty shall be calculated and presented by the calibration authority in accordance with ISO/IEC Guide 98-3 (GUM) or a document for determination of uncertainty in force measurements based on the GUM.

The maximum measurement uncertainty of the weighing system shall be within $\pm 1,0$ %, $k = 2$ (the coverage factor for a level of confidence (or confidence interval) of 95,45 %) of actual weighed weight. The measurement uncertainty of the weighing result shall be calculated after principles given in the GUM.

See [Annex F](#) for further information.

9.3.4 Calibration of load cells

Load cell calibration shall be performed by a laboratory that meets the requirements of ISO/IEC 17025, or is accredited for the relevant scope by an accreditation body. Calibrations shall be carried out over the full range of the capacity of the load cells and be documented with calibration certificates.

The calibration shall be completed a maximum of six months prior to the expected date of the weighing operation.

Depending on the output of the read-out device, the calibration shall be completed using either of the following methods:

- a) If the output on the read-out unit is dependent on the length of the cable connecting it to the load cell, the calibration shall be performed with the read-out unit connected.
- b) If the output on the read-out unit is independent of the length of the cable connecting it to the load cell, the load cell shall be calibrated mechanically, separately from the amplifiers. Amplifiers shall be calibrated electrically using a precision strain-gauge calibrator. Both the calibrator and its read-out unit shall have valid calibration certificates. Type, serial number, uncertainty of measurement, and reference to the master load cell shall be included on the calibration certificates.

9.3.5 Capacity of weighing system components

The weighing operation shall be planned in such a way that the load cells and jacking (lifting) devices operate within a range between 20 % to 80 % of the calibrated capacity of the load cells. If the weighing system load cells are installed for purposes other than weighing the assembly (e.g. raising the assembly for placement of taller supports), the loads applied shall not exceed 80 % of the load cells calibrated capacity.

9.3.6 Spare load cells and ancillaries

To minimize delays due to failures of load cells or their ancillary components, spares parts (e.g. load cells, display, cables) shall be present during a weighing.

9.3.7 Hydraulic jacking system

The weighing system shall be comprised of either separate jacks and load cells or jacks with integral load cells attached to the top of the piston of the jack. The assembly weight shall be applied directly to the load cells, either by jacking up and lowering onto the load cells (where separate load cells and jacks are used) or by jacking the load cells up to the assembly and then lifting (where the load cells are integral to the jacks). Systems using separate load cells and jacks shall have the load cells positioned adjacent to the jacks.

The hydraulic system shall operate so that the assembly can be raised and lowered smoothly to apply loads uniformly and simultaneously onto the load cells. It is essential that the jacking system employed for the weighing operation be able to produce simultaneous uniform vertical movement at all weighing points.

Hydraulic systems shall be controlled by a single device to prevent differential rising (i.e. twisting or racking) of the assembly. The hydraulic system shall have an emergency stop button capable of signalling the hydraulic system to hold the assembly in-place at any point in the jack stroke.

9.3.8 Levelness of the assembly during the weighing

During the weighing operation, particularly at the time of recording the weighing results, the levelness of the assembly (in the plane defined by the tops of the load cells) shall be monitored to ensure the difference in elevation between adjacent jacking points is kept to the lesser of 2 mm or 1/1 000 of the distance between the jacking points.

9.4 Preparations prior to the weighing

9.4.1 Notification and witnessing of weighings

Weighing operations should be independently witnessed (e.g. facility owner, third party verification authority).

9.4.2 Environmental conditions during a weighing

A weighing performed in an outdoor location, shall only proceed under the following environmental conditions:

- a) the ambient temperature or relative humidity are within the limits of the load cell manufacturer's recommended operating environmental range;
- b) the measured wind speed (10-minute average) does not exceed 5 m/s, or gusts do not exceed more than 2,5 m/s more than the measured wind speed. Wind measurements shall be taken at a height of 2 m above ground level;
- c) there is no risk of precipitation (e.g. rain, snow) immediately prior to or during the weighing operation;
- d) there is sufficient natural or artificial lighting to permit a safe weighing operation.

9.4.3 Weighing prediction report

A weighing prediction report shall be prepared prior to the commencement of a weighing operation. The report shall provide details (weights and CoGs) used to determine the expected weight and CoG of the assembly at the time of weighing.

The weighing prediction report shall contain:

- a) the total theoretical weight and CoG for the assembly to be weighed;
- b) a list or database (item description, weight and CoG) and summaries for all permanent items present for the weighing;
- c) a list or database (item description, weight and CoG) and summaries for all permanent items not present for the weighing;
- d) a list or database (item description, weight and CoG) and summaries for all temporary items present for the weighing.

Upon completion of a weighing, the weight and CoG from the weighing shall be compared to the weight and CoG from the weighing prediction report.

If the mathematical difference between the weighed weight and the weight from the weighing prediction report is greater than $\pm 1,0$ %, a weight reconciliation shall be performed. This reconciliation will look for errors (e.g. missed or double-counted items) in the weighing prediction report, and errors (e.g. incorrect recording of weighing results) in the weighing data that have caused the difference to be greater than $\pm 1,0$ %. The weighing prediction report shall be updated accordingly and included in the weighing report [see 9.5.6 h)].

If the mathematical difference between the CoG from the weighing and the CoG from the weighing prediction report is greater than $\pm 0,5$ % of the distance between the extreme East-West and North-South primary steel supports or trusses, a post-weighing CoG reconciliation shall be performed. This reconciliation will look for errors (e.g. errors in data entry, coordinates transposed) in the CoGs of items in the weighing prediction report and errors in the weighing data (e.g. incorrect location coordinates assigned to a load cell) that have caused the difference to be greater than $\pm 0,5$ %. The weighing prediction report shall be updated accordingly and included in the weighing report, see [9.5.6 h](#)).

Once the reconciliation has reduced the differences in weight and CoG to within the noted limits, reconciliation efforts may cease.

9.4.4 Temporary items during the weighing

When possible, unnecessary temporary items (i.e. those no longer required to be in-place during the weighing) shall be removed from the assembly before the start of the weighing.

The total weight of temporary items present during the final weighing shall not exceed 1 % of the weight of the permanent items present.

Temporary items weighed separately prior to assembly weighing (e.g. designed temporary items that form part of the assembly's structural integrity and foundations such as load-out frames, grillage etc. and materials and inventory related to testing/commissioning activities) shall be excluded from the total weight of temporary items present for the weighing (i.e. 1 % of the weight of permanent items present).

Attachment points between the assembly and external access (e.g. scaffolding and stair towers supported from the ground) shall be released so that raising the assembly will not raise a portion of the access for which a weight has not been included.

9.5 Weighing operation

9.5.1 Number of results recorded

Before commencing the weighing operation, a test weighing shall be performed to check operation of the hydraulic lifting system, and load cells.

For each weighing operation, a sufficient number of weighing cycles shall be performed to obtain a series of three consecutive and consistent results, see [9.5.3](#).

A weighing cycle is the process of starting at a 'no weight' condition (assembly is not in contact with the load cells), to the full weight being placed on the load cells, recording the load cell values, removing the weight from the load cells, and recording any residual values on the load cells ('no weight' condition) when the assembly is fully raised.

If possible while the load cells are completely unloaded, the reading and display shall be reset to zero for the next weighing cycle. If a reset is not possible, all residual readings shall be recorded, and the weighing result corrected accordingly.

Provision shall be made to replace load cells or interchange their positions if any of the following problems has arisen during the weighing cycle:

- a) inconsistent weighing results;
- b) excessive residual readings when the assembly is not in contact with the load cells;
- c) mechanical/electrical fault or breakdown;
- d) overloading of a load cell;
- e) adverse change in environmental conditions.

Resolution of any issues by replacing load cells or load recording device shall cause a restart of the weighing. All previously recorded values shall be discarded.

9.5.2 Readings of load cells and level criteria

At the time of recording the load cell readings, the assembly shall be lifted clear of all supports, with a minimum air gap of 3 mm. This shall be visually confirmed at each support point.

An acceptable load distribution shall be maintained during the weighing operation. The load cell readings shall be taken simultaneously after the readings have stabilized, assembly level checked (see [9.3.8](#)) and recorded, and wind speed and direction recorded.

9.5.3 Consistency of results

Discounting clearly inconsistent or erroneous results, individual weighing results as measured for each of the weighing cycles shall not vary from the mean of the three accepted weighing results by more than the levels of weighing system uncertainty defined in [9.3.3](#).

9.5.4 CoG calculations

The final CoG shall be calculated using the mean of the three accepted results.

9.5.5 Weighing report

The weighing report shall be prepared and include:

- a) name and contact information of the organization that performed the weighing;
- b) a list of names and contact information for key personnel;
- c) a copy of all data (load cell readings, environmental conditions, level survey results, etc.) recorded during the weighing (see [B.2](#));
- d) calibration certificates of all load cells – including spares;
- e) a plan view drawing of the assembly showing the locations of the load cells (dimensioned in the project coordinate system) and load cell identification information (e.g. serial numbers);
- f) a detailed list and summary weight and CoG of temporary items present during the weighing;
- g) a detailed list and summary weight and CoG of permanent items not installed at the time of the weighing;
- h) a copy of final weighing prediction report including any modifications made up to immediately before the weighing plus changes made during a post-weighing reconciliation;
- i) a log showing chronological order of weighing operation activities (e.g. start time, time of recording readings, discovery of device faults and resolution);
- j) any deviation from the approved weighing procedure;
- k) calculations showing determination of the as-weighed weight and CoG;
- l) calculations showing the resulting CoG of the item in the project reference system;
- m) calculations showing determination of the weighing correction factor – the weight and associated CoG that when combined with the final weighing prediction (complete with post weighing reconciliations) equals the reconciled weighed weight;
- n) reconciliation studies (if necessary);
- o) a copy of weighing certificate (if issued).

NOTE Photographs of the weighing provide a record of permanent and temporary items included during weighing and permanent items excluded from the weighing.

9.5.6 Weighing certificate

A weighing certificate shall include:

- a) project identification;
- b) time, date and location of weighing;
- c) as-weighed weight and CoG;
- d) reference to the global coordinate system for the weighed assembly;
- e) identification of weighing devices and calibration;
- f) estimated weight and weighing uncertainty.

See [B.2](#) for an example weighing certificate.

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Annex A (informative)

Commentary

A.1 Commentary to 7.1 – Conceptual design

The focus of conceptual design is to select a safe, cost effective and competitive concept to progress into the FEED phase.

Within the conceptual design phase there are typically three stages:

- a) concept identification;
- b) concept screening;
- c) concept selection.

The first two stages of conceptual design confirm project viability and develop a shortlist of technically and commercially viable development options. The third stage evaluates this shortlist to select a concept that is robust to technical and commercial risks and uncertainties. Independent technical benchmarking at defined intervals is used to verify concept weights.

In conceptual design, analogues and norms are used to derive predicted dry weights. Predicted operating weights are typically derived using historical operating to dry weight ratios (see [Annex J](#)).

Successful weight management during conceptual design is achieved by a comprehensive understanding of the function of the facility, application of analogues or norms to estimate weights and experience-based judgement to determine net weight allowances and weight reserves (see [Annex K](#)).

Concept identification and screening

Given the immature level of definition during these stages, concept types are identified and screened using simple high-level techniques to provide a concept shortlist. Weights are typically estimated using suitable analogues and boundary constraints with due care to avoid discounting options that can offer value. While these weight estimates are indicative, they provide sufficient support for cost estimating and screening for feasibility of installation, transportation and other execution-related aspects. Weight uncertainty will likely exist at this early stage and can be accounted for by applying an analogue weight allowance when determining the predicted weight. Upper bound weight constraints can be used for initial construction and installation strategies.

Appropriate analogues are selected and factors that drive the concept weight are evaluated. These factors can differ between concepts, and include environmental conditions, installation method, power demand, gas-oil ratio (GOR), pressure, water depth, etc. Simply identifying an analogue facility without identifying critical parameters carries a risk of over or under-estimating the predicted weight.

Increasing the number of analogue facilities to develop comparison weights can help to improve the level of confidence in a weight estimate and help ensure that one or two unique analogues are not creating a bias.

Understanding each of the analogues is important. For example, a selected analogue facility with a reservoir containing high-pressure dry gas can have a reduced requirement for compression and separation systems when compared to a new facility with significantly different reservoir characteristics (e.g. low-pressure gas with a higher moisture content, which would require more compression and separation). In this example, a high-pressure dry gas facility is not an appropriate analogue for a new facility with different reservoir characteristics. As another example, the majority

of FPSO analogues are oil processing facilities. Care is needed when conducting weight estimation for facilities that are not oil producing or not within the analogue throughput ranges.

When developing the predicted weight using analogues, it is preferable to interpolate between analogue facilities, rather than use metrics and extrapolation. If analogue facilities do not exist and extrapolation is used, then the relative uncertainty in the weight estimate is evaluated.

Analogue-derived weight estimates can be supplemented by basic engineering (e.g. MEL and deck layouts to validate the predicted weight of a topsides or supporting jacket). MEL and area/volume norms can be used to provide a better understanding of the sensitivity to layout and functionality. To allow comparison of screening options, a fully populated MEL using best weight estimates, is used. Assumptions made during these phases are documented and can be used for technical and commercial screening to establish a concept shortlist. The agreed shortlist is benchmarked to confirm certainty of the predicted weight. This shortlist will be the basis upon which a refined technical definition can be built to improve the weight estimating level of confidence and transition to concept selection.

Concept Selection

The level of confidence in a weight estimate improves with increasing definition during the concept selection phase to the extent that system risks can be understood, albeit at the MEL level. The typical approach for concept selection is to use MEL norms and area/volume norms. At this stage, individual systems can be assessed to determine the level of confidence in the tagged equipment selection parameters and provide refinement in predicted weights based on MEL norms.

Weight uncertainty at this stage can be accounted for by applying weight allowances (i.e. MEL weight allowances, layout area allowances or layout volume allowances as appropriate) when determining predicted weights. Conceptual weight reserve is also applied as a provision for reserves used in FEED and Detail engineering (i.e. management reserve, planned future reserve and unplanned future reserve) when determining the conceptual design weight.

Before a concept can be recommended for selection it is benchmarked to validate its predicted weight.

The predicted weight for the preferred concept(s) forms the basis for inputs to the cost estimates and schedules used in the concept selection decision and the handover pack that forms the weight data for progress into the FEED phase.

A.2 Commentary to 7.1.7 – Estimating principles

A number of weight estimation techniques are used in the development of the predicted weight. Choosing which to use and when depend on where the project is in the conceptual design phase and the availability of suitable analogues and norms. Key to the successful application of these techniques is having a robust MEL and layout for each concept option.

Typically, a combination of weight estimation techniques is used to establish the predicted weight and identify specific attributes that can lead to a high level of uncertainty in the estimate. These techniques are explained in 7.1.7.2 to 7.1.7.4.

A.3 Commentary to 7.1.7.2 – Analogue method

The throughput-based approach is a common method used in the initial stage of the conceptual design phase. This method utilises benchmarking data from analogue facilities to determine the relative delta in weight due to differences in hydrocarbon and fluids handling between the analogues and the facility being designed.

A database of facilities including weight, throughput and other environmental factors (e.g. metocean, region, reservoir characteristics) is necessary to produce a relationship between the analogues and the facility being designed.

This method has a higher level of confidence if existing analogue data is plentiful. The range of the level of confidence can drop off quickly if this method is used to extrapolate weight estimates outside of the existing historical data that is used to develop the benchmarking data. Care is necessary to understand both the inputs and availability of data used to produce the predicted weight. Variability in throughput data can result in greater uncertainty in the weight estimate when factors like H₂S and CO₂ content result in the need for additional equipment.

A.4 Commentary to 7.1.7.3 – MEL norms method

The MEL norms method utilises discipline bulks norms derived from analogue facilities and applies them to the MEL weight to develop the predicted weight for the concept under consideration. MEL norms are typically expressed as tonne/tonne, as they are a ratio of the discipline bulks weights to the MEL equipment weights.

MEL norms can be applied to the overall facility or can be system based. A significant advantage of using a system-based approach is that the MEL net weight allowances can be better apportioned to items in the MEL to produce a refined predicted weight estimate.

For those components outside the intent of the MEL norms method (e.g. flares, bridges, living quarters) separate parameter norms are developed using suitable analogues.

A.5 Commentary to 7.1.7.4 – Area and/or volumetric norms method

The area or volumetric norms method utilizes equipment and discipline bulks norms derived from analogue facilities and applies them to facility layouts to develop the predicted weight for the concept under consideration. Area norms are typically expressed in t/m² units and applied to the layout plan area. Volumetric norms are typically expressed in t/m³ units and applied to the layout volume (i.e. layout plan area x height). Area and volumetric norms are typically produced for each discipline.

Area or volumetric norms can be applied to the overall facility or can be system based. A significant advantage of using a system-based approach is that area or volumetric norms are applied to specific parts of the facility (e.g. designated process or utilities areas), which can result in a refined predicted weight estimate.

For those components outside the intent of the area or volumetric norms method (e.g. flares, bridges, living quarters), separate parameter norms are developed using suitable analogues.

A.6 Commentary to 7.2.1 – General

Estimate to complete (ETC) is a portion of the predicted weight that is typically used in FEED, detail engineering and construction phases. It accounts for weight of items that exist but have not been subject to WTO (e.g. known items within the project scope that have not been designed or CAD-modelled due to insufficient design data).

ETC for weight items is estimated on a discipline basis. Discipline check sheets are typically used to avoid omission or overlap of weight items. This is a continuous weight management process performed during the FEED, detail engineering and construction phases. As the design progresses and more detailed WTO is performed, then discipline ETC is superseded and replaced by the gross WTO.

A structural secondary steel example is presented to illustrate the use of ETC. Three snapshot WTO intervals are considered at:

- a) late FEED;
- b) early detail engineering;
- c) late detail engineering.

By late FEED, input from the CAD model allows the structural discipline to determine the gross WTO as 650 tonnes (made up from 565 tonnes net WTO and 85 tonnes net weight allowance). ETC best estimate secondary steel weights are calculated as 850 tonnes to account for items not designed or modelled (e.g. equipment supports, crane boom rest, mechanical handling steelwork, piperack and installation aids).

By early detail engineering, the CAD structural secondary steel model is more defined, and the gross WTO is estimated as 1 085 tonnes. ETC best estimate weights are 410 tonnes to account for items not designed or modelled.

By late detail engineering, the CAD structural secondary steel model is near complete and the gross WTO is estimated as 1 420 tonnes. ETC best estimate weights are 55 tonnes to account for items not designed or modelled.

The three snapshots can be represented in [Table A.1](#).

Table A.1 — Example ETC for Structural Secondary Steel

Design Stage	Secondary Steel Gross WTO (t)	Secondary Steel ETC (t)	Secondary Steel Predicted Weight (t)
WTO during late FEED	650	850	1 500
WTO during early detail engineering	1 085	410	1 495
WTO during late detail engineering	1 420	55	1 475

A.7 Commentary to 7.6.4 – Legacy Weight Databases

Errors in weight or CoG of facilities can lead to uncertainties in global strength and stability, and can underestimate internal forces and moments in load carrying elements in both topsides structures and substructures.

Since the topside operating weight comprises both dry weight and variable weight, and the variable weight can be a significant part of the predicted weight, both dry weight and variable weight (including associated CoGs) are verified or corrected where necessary.

Weight errors and uncertainties can arise due to the following:

- weight data has been summarized (leading to lack of detail) or lost, particularly when ownership of the facility has changed;
- modifications on the facility have not been recorded in the weight database;

NOTE 1 Most facilities are likely to have had modifications during the operations phase (an older facility of 10 000 t topsides or more can typically have over 1,000 modifications).

- material loaded or offloaded during normal operations has not been recorded in the weight database;
- laydown and storage areas are full simultaneously but are not reflected in the weight database;
- weight database does not contain scaffolding used or stored on the facility.

NOTE 2 During the operations phase, a 10 000 t topsides can typically have 250 t to 350 t of scaffold on board, split between deployed areas for maintenance and scaffold stores.

Annex B (informative)

Weighing certificates

B.1 Example tagged equipment and discipline bulks weighing certificate

Tagged equipment and discipline bulks weighing certificate			
			Page 1 of 2
Project:		Client:	
Item/tag No.:		Bid package No.:	
Description:			
Purchase Order No.:			
Supplier:			
Weighed components or other items	Date	Dry weight (Unit:)	
		Calculated (purchase order)	Recorded
Total dry weight this item/tag No.:			
Weighing device(s)		NOTE Show CoG on sheet 2.	
Make:			
Type:			
Range:		Approved:	Date: Signature:
Serial number(s):			
Calibration date(s):		Supplier:	
Calibration authority:		Purchaser:	
Document number:			

Tagged equipment and discipline bulks weighing certificate — CoG status				
				Page 2 of 2
Project:		Client:		
Item/tag No.:		Bid package No.:		
Description:				
Purchase order No.:				
Supplier:				
Weighed components or other items	Date	Dry weight recorded (Unit:)	CoG	
			East (X)	North (Y)
				Elevation (Z)
Total dry weight and CoG, including permanent items excluded during weighing and excluding temporary items included during weighing:				

Side view

Top view

Overall dimensions (mm):
 $L =$ $W =$ $H =$

Local Dry weight CoG (mm):
East (X) =
North (Y) =
Elevation (Z) =

Content weight for operating condition:
..... kg

Operating weight (dry + content):
..... kg

Local operating weight CoG (mm):
East (X) =
North (Y) =
Elevation (Z) =

When measurement of CoG is necessary, please fill in this sheet and include a sketch showing overall dimensions, CoG data, key features and orientation. CoG refers to datum point which is indicated on the equipment's GA drawing, shown in plan and elevation.

B.2 Example assembly weighing certificate

Assembly weighing certificate						Page 1 of 2
Project:			Client:			
Assembly:			Location of weighing:			
Wind speed & direction:			Temperature (°C)			
Weighing operation time start/end:			Weighing operation date:			
Load cell reference	Load cell reading at weighing (Unit:)					Mean
	1 st	2 nd	3 rd	4 th (if req.)		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
Weighing results						
	Weight (Unit:)	CoG East (X) (m)	CoG North (Y) (m)			
Estimated						
1 st						
2 nd						
3 rd						
4 th						
Average of weighing results						

Assembly weighing certificate						
						Page 2 of 2
Project:				Client:		
Assembly:				Location of weighing:		
Load cell reference	Load cell reading and location coordinates					
	1 st	2 nd	3 rd	4 th (if req.)	X	Y
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
Witnessed:				Signature		Date:
Weighing contractor:						
Contractor:						
Project:						

A dimensional sketch showing the load cell positions, reference to the global coordinate system and wind direction should be attached to this certificate.

Annex C (informative)

Example control weight summary

Table C.1 shows the control weights for one loading condition. See 5.5 for typical loading conditions.

Table C.1 — Example topsides operating control weight summary

Loading condition: Operating												
Area code		Budget weight and corresponding CoG envelope				Reserves (t)			NTE weight and corresponding CoG envelope			
		W	E	N	El	Management	Planned future	Unplanned future	W	E	N	El
A	Utilities											
B	Mud											
C	Drilling											
D	Flare boom											
E	Living quarters											
F	Process deck 1 & 2											
G	Process deck 3,4,5 & piperack											
H	Wellbay											
I	Hook-up											
	TOTAL											
W: Weight (t)												
E: Easting (m) min, max												
N: Northing (m) min, max												
El: Elevation (m) min, max												

Annex D (informative)

Variable weight

D.1 Example variable weights and fill-levels

[Table D.1](#) lists example variable weights and fill-level, including movable items. This represents a coincident loading condition that results in the maximum total variable weight for a manned facility with a single drilling derrick.

Table D.1 — Summary of typical variable weights

Variable weight (including moveable items)	Fill-level (full = normal operating level)
DRILLING	
Setback weight (for longest hole including bottom hole assembly +5 % rejects)	full
Piperack weight (9 5/8" casing string for longest hole, +5 % rejects) with piperack casing posts deployed	full
Catwalk (pipe bridge) on piperack	full length
Service containers on drill deck laydown (normally 100 t to 200 t)	laydown full
Drilling line reel	reel full
Drill floor tools (typically 10 t)	full
P-tank storage for cement, bentonite, and baryte (aerated)	full
Sack store	full
Mud in tankage (active and reserve tanks typically 1,6 to 2,0 t/m ³)	tanks full
Drill water in brine tanks	tanks full
Completions fluid storage	storage full
Mud in cuttings cleaning system	system full
Cutting slurry in cuttings reinjection system	system full
Mud in shakers and mud cleaning system	system full
Mud in degasser will be empty if mud tanks are full	zero
Mud in trip tank will be empty if mud tanks are full	zero
Wireline unit and tool house	full
Coiled tubing unit	reel full
Radioactive store and explosive store	full
In-line BOP stack (weight carried by surface casing string)	zero
Off-line BOP stack (on test stump)	full
LAYDOWN and STORAGE	
Laydown and storage areas (all areas full - single stacked containers)	laydown full
Scaffold stores and deployed maintenance scaffold (15,000 t operating topsides typically has 250 t to 350 t of scaffold)	full
Platform stores and spares	stores full
Tote tanks and intermediate bulk containers areas	tanks full

Table D.1 (continued)

Variable weight (including moveable items)	Fill-level (full = normal operating level)
PROCESS & non-PROCESS contents	
Diesel in storage tanks and day tanks	full
Potable water in storage tanks	full
Fluids in process equipment including process separators, test separator and KO drum (with allowance for sand accumulation)	normal operating
Water in Coolers and Radiators	normal
Fluids in degassers	normal
Water in fire pumps	full
Chemicals in injection package	full
AFFF in storage tanks	full
Methanol in methanol system	full
Fluids in deluge system	full
Hydraulic fluids in power packs and accumulators	full
Water in seawater system	full
Water in firewater system	full
Fluids in process piping and valves	full
Water in potable water system	full
Water in produced water system	full
Equipment including gearbox fluids, lube oil, etc.	full
CRANES	
Platform cranes assumed un-laden in parked position as laydown areas are full	zero
LIVING QUARTERS	
PoB and luggage located in quarters module(s) 0,2 t/person	full
Refrigerators and galley stores	full
Helicopter(s) on helideck	full
Lifeboats empty of personnel (PoB in quarters module)	zero
LIVE LOADS	
Live loads on walkways, laydown and maintenance areas are accounted for elsewhere (e.g. PoB and luggage in quarters, containers on laydown areas).	zero
BRIDGE REACTIONS	
Bridge reaction from operating contents in bridge pipework	full
NOTE Bridge dry weight reacted by the supporting deck is typically included in the variable weight (as the bridge itself is treated as a separate assembly).	

D.2 Example laydown and storage drawing

Figure D.1 shows a typical laydown / storage drawing, with details of deck levels, laydown area sizes and weights.

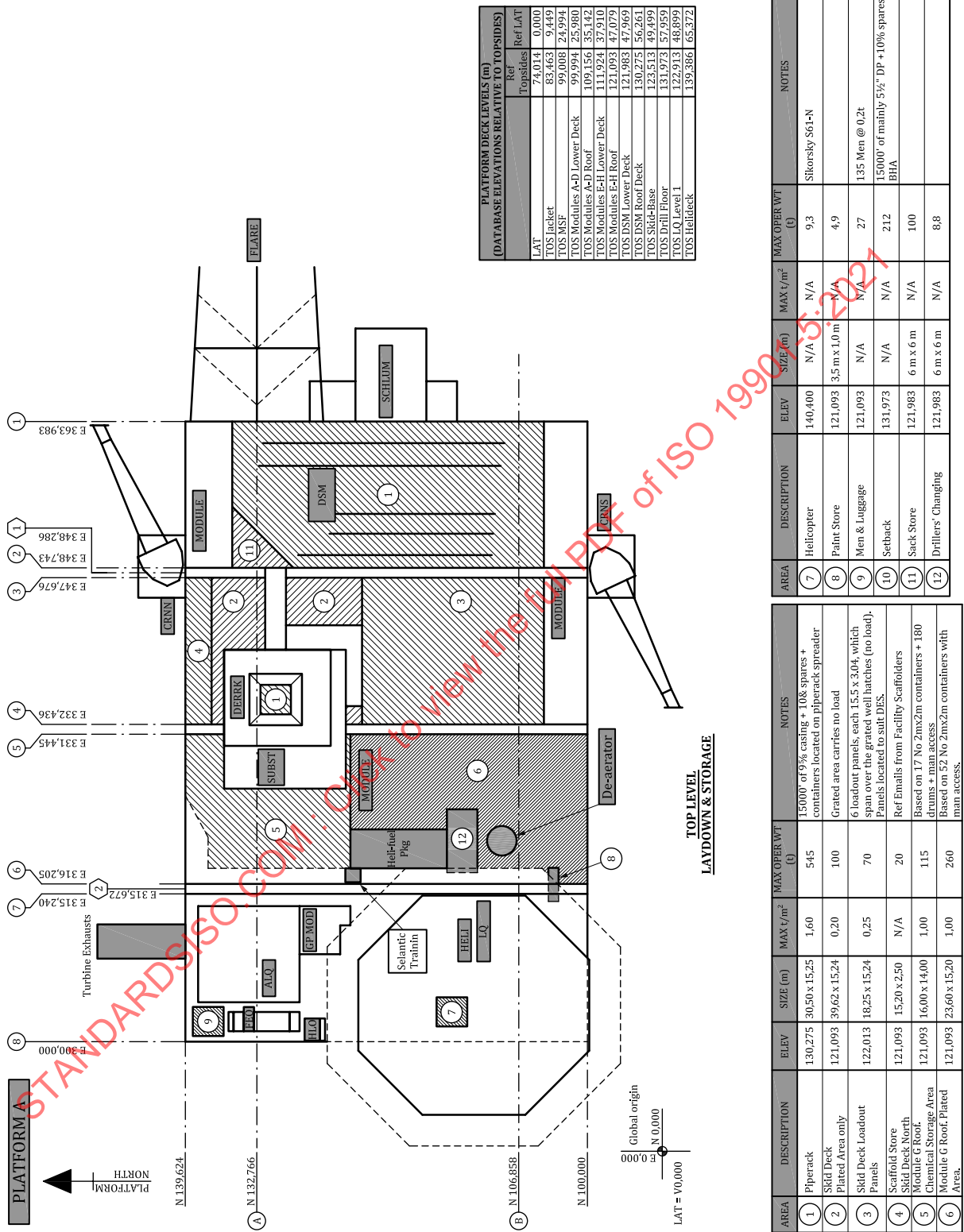


Figure D.1 — Typical Laydown / Storage Drawing

D.3 Example drilling load combinations

Table D.2 shows examples of drilling load combinations.

Table D.2 — Example drilling load combinations

Example load combinations A to D	A	B	C	D
	Drilling paused (Storm)	Drilling in progress (Operating)	Stuck casing (Operating)	stuck drill string (Operating)
Drill string location	in setback ^b	in setback ^b	in setback ^b	downhole ^c
Casing location	9 5/8 inch on piperack ^d	9 5/8 inch on piperack ^d	downhole ^e	9 5/8 inch on piperack ^d
Drilling derrick location	over corner slot furthest from wind and wave direction	over corner slot furthest from wind and wave direction	over corner slot furthest from wind and wave direction	over corner slot furthest from wind and wave direction
Hook load ^a	zero	zero	derrick rating ^a	derrick rating ^a
^a Hook load for a typical derrick rating is 1,000,000 lbs = 454 t. ^b Drill string is stored in setback - stacked vertically in 90 ft stands (triples) for longest hole - plus 5 % rejects and bottom hole assembly. ^c Drill pipe is downhole rather than in setback. ^d Weight for 9 5/8 inch casing (approx. 80 % of longest well) - plus 5 % rejects. (Realistic distribution is 50 % of casing, plus supply and fixed containers on the piperack, with remainder of the casing hanging on the hook.). ^e Casing is downhole rather than on piperack. ^f Drill string in setback can be run downhole to reduce wind load in an extreme storm.				

Annex E (informative)

Example decision-making RAPID matrix

An example of RAPID decision-making matrix for weight management is shown in [Table E.1](#) below.

Table E.1 — Rapid matrix – example

Phase	Description	Within principal contractor organization				Within facility owner / operator organization			
		DL	WM	SE	EM/PM	WM	SE	EM	PM
Decisions during Conceptual Design	Set upper bound weight constraint (based on criteria in 7.1)	I	A	I	R	A	A	D	
	Set values for conceptual design weight and predicted weight	I	I	I	R	I	I	D	
Decisions during FEED	Implement findings of FEED weight verification	I	P	A	R	A	A	D	
	Set control weights (inc. CoGs)		I	I	R	I	I	D	
Monthly decisions during FEED, Detailed Engineering & Construction (cont'd)	Input to monthly weight management meeting	I	P	I	R	A	I	D	
	Review latest values of predicted weight vs control weights		P	I	P	P	P	P	
	Implement findings of detail engineering weight verification	I	P	A	R	A	A	D	
	Approve/reject monthly changes if predicted weights < budget weights CoGs inside envelopes		I		D	A		A	
	Approve/Reject monthly changes if predicted weights < budget weights plus management reserves, and CoGs are inside envelopes		I		A	A		D	
	Approve/Reject monthly changes if predicted weights > budget weights plus management reserves, and CoGs are inside envelopes		I		A	A		A	D
Monthly decisions during FEED, Detailed Engineering & Construction	Approve/Reject monthly changes if predicted weights > NTE, and CoGs are outside envelopes		I		A	A		A	D
	Record and complete MoC process for agreed decisions. Implement changes to control weights (after MoC process is approved)		P		A	A		A	
Decisions during Hook-up & Project hand-over	Reconcile weighed weights	I	P		A	A		A	
	Finalize weight database & weight report	I	P	I	A	A	A	A	