ISO/TC 67/SC 7
Offshore structures

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N 1134 ISO-DIS 19901-5 20191212

Document type:	Other committee ballot
Date of document:	2019-12-12
Expected action:	VOTE
Action due date:	2019-01-13
No. of pages:	83
Background:	ISO 19901-5 Ed 3 "Petroleum and natural gas industries — Specific requirements for offshore structures — Part 5: Weight management" , approval to send to DIS. Please ensure your NSB votes by the due date using the ISO balloting portal.
Committee URL:	https://isotc.iso.org/livelink/livelink/open/tc67sc7

ISO 19901-5:2019(X)

ISO TC 67/SC 7/WG 6

Secretariat: BSI

Petroleum and natural gas industries — Specific requirements for offshore structures — Part 5: Weight management

DIS stage

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Published in Switzerland

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Foreword

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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*.

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

The main changes compared to the previous edition are as follows:

— Title changed to Weight Management

— Document restructured and columnisation removed.

— Weight control classes removed

— Requirements for weight management for all project phases implemented

— Annexes restructured:

  o Previous Annexes A and B joined into a new Annex A.

  o Previous Annex B deleted and replaced with new Annex B Accuracy of major assemblies weighing predictions added

  o Previous Annex D and F joined into new Annex D Guidelines for displacement measurement of floating facilities

  - Previous Annex E deleted and replaced by new revised Annex E Weight management during operations
  - Previous Annex F updated to Annex D Guidelines for displacement measurement of floating facilities
  - Previous Annex G updated to Annex E Weight management during operations
  - Previous Annex H updated to Annex F Requirements for topside weight estimation — New builds/green field
  - Previous Annex I updated to Annex G Executive summary description
  - Previous Annex J expanded and updated to Annex H Weighing result uncertainty
  - Previous Annex K updated to Annex I Weight management database structure

— New annexes added:

  - Annex J Weight management of concrete structures
  - Annex K Coordinate systems

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 ISO 19900, ISO 19901 (all parts), ISO 19902, ISO 19903, ISO 19904, ISO 19905 (all parts) and ISO 19906 relating to offshore structures constitute a common basis covering those aspects that address design requirements and assessments of all offshore structures 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 structures, 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.

ISO 19900, ISO 19901 (all parts), ISO 19902, ISO 19903, ISO 19904, ISO 19905 (all parts) and ISO 19906 relating to offshore structures 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.

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, detail engineering, onshore/inshore construction, and offshore installation. These facilities can be completely new installations (Greenfield) or the modifications to existing installations (Brownfield). It is also necessary to continue managing and controlling weight throughout operations, decommissioning and removal to facilitate Structural Integrity Management (SIM) and to assist with removal of facilities during decommissioning. The provisions are applicable to offshore facilities of all types (fixed and floating). Only items with mass shall be addressed. Loads not related to mass shall be omitted. Se ISO 19904-1, ISO 19901-6 and ISO 19901-7.

Weights from mass of snow and ice are not to be included as they are not part of a facility.

This document specifies:

a) managing and controlling weights and CoGs for components and entire facilities;

b) managing weight and CoG interfaces;

c) standardised terminology for weight and CoG estimating and reporting;

d) requirements for determining Not To Exceed (NTE) weights and budget weights;

e) weighing and determination of weight and CoG of tagged equipment, major assemblies, modules and facilities;

This document can be used as a basis for:

a) costing, scheduling or determining suitable construction method(s) or location(s);

b) planning, evaluating and presenting the client's, contractor's or fabricator's weight management and reporting system;

c) as a contract reference between client, contractor and suppliers;

d) 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)*

3 Terms and definitions

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

3.1
approved variations
approved scope changes affecting the predicted weight and changing the weight budget figures.

3.2
assembly
designed and fabricated group of bulk and equipment items which form one unit

3.3
brownfield
modifications/upgrade to an existing installation, including removing of redundant systems and equipment and adding new structures and systems

3.4
budget weight
localised budgets weights and CoG (3.9) parameters set by project for discipline(s) and/or sub-contractor(s) and identified in the weight budget document (3.57)

3.5
bulk
loose construction materials e.g. piping, valves, cable and trays, etc.

EXAMPLES Structural steel also fits the definition of 'bulks'

Note 1 to entry: Bulk items support the equipment items by providing infrastructure around and between them.

3.6
centre of gravity
CoG
the point in a body or system of bodies at which the entire weight may be considered to act

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

3.7
client
organisation for which a weight report is prepared

Note 1 to entry: This is the project owner (oil company/operator, fabricator, engineering sub-contractor, lift/transport contractor, etc.).

3.8
contractor
organisation tasked with the design of a facility or part of a facility.

3.9
CoG envelope
defined constraint volume within which the CoG of an assembly shall remain for a specified loading condition

3.10
conceptual design
the first phase of design, during which several concepts are evaluated until it is clear which concept should be carried forward.

3.11
conceptual design weight allowance
and allowance added to the conceptual predicted weight to reach the design weight

3.12
consumables
materials consumed and replenished during normal operating of an offshore installation.

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

3.13
contents
fluids or powders held within piping, equipment or structural tanks at their normal operating levels

Note 1 to entry: Typical contents are hydrocarbons, cooling and heating mediums, chemicals, fuels, condensates, seawater, fresh water, powders (drilling cement and mud additives), etc. Fluids continuously installed in an item of equipment (e.g. coolants and lubricating oils) are not to be considered as contents. See dry weight (3.18) for additional explanation.

3.14
deadweight
total carrying capacity of a floating facility

Note 1 to entry: Includes weight of crude oil, deck cargo, temporary items, water, marine growth, ballast water, consumables, crew and their effects.

Note 2 to entry: See Annex D.

3.15
design weight
the weight unlikely to be exceeded in conceptual design. This weight is used for engineering purposes

3.16
discipline
branch of engineering reflecting a single aspect in the project

EXAMPLES Architectural, drilling, electrical, HVAC, instrumentation, loss control (safety), piping, structural and telecommunications.

3.17
displacement
weight of the volume of water displaced by a floating structure

Note 1 to entry: The sum of lightweight and deadweight including mooring system load, appendences and/or appurtenances e.g. structures outside the moulded hull.

Note 2 to entry: See Annex D.

3.18
dry weight
weight of a component, weight item or an assembly in its dry installed condition including permanent utilities in closed equipment systems

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

Note 2 to entry: Any content of operating fluid flowing through a component, weight item or an assembly is excluded.

3.19
equipment
component or arrangement of components, built for specific function(s)

Note 1 to entry: The component/assembly normally has unique documentation due to its function and complexity.

Note 2 to entry: Refer to tagged equipment (3.50) for further explanation.

3.20
estimate to complete
ETC
the estimated weight of items not included in the gross WTO in order to bring it up to the predicted weight.

3.21
estimated weight
weight based on initial calculation or previous experience

3.22
fabricator
organisation contractually tasked with construction of a portion (such as assemblies, modules, topsides, hull etc.) of a facility

3.23
facility
a construction (such as a topside, hull etc.) that is built, installed, or established to serve a particular purpose

3.24
float-out
loading condition for transfer of assembly, module or topsides from a construction site to become self-floating

3.25
future weight
weight of a component or an assembly to be installed after a specified time after the start of production

3.26
front end engineering design
FEED
the phase following conceptual design phase, during which the selected concept is matured, and design parameters normally are fixed

3.27
greenfield
new facilities which are fabricated onshore and installed offshore

3.28
grillage
structure, secured to the deck of a transport barge or vessel, designed to support the cargo (e.g. module or topsides) and distribute the loads between the cargo and the internal structure of the transport barge or vessel

3.29
gross weight take off
gross WTO
the net weight take off including weight allowance (3.56)

3.30
hook-up
installation of components or assemblies after the modules have been installed to complete it into a functioning installation

3.31
lifting gear
items needed during a lifting operation to connect the lifting hook to the item being lifted

EXAMPLE Slings, spreader bars, lifting frames, shackles.

3.32
lift weight
weight of a component, assembly, or a module at its lift points, including permanent and temporary items, but excluding the lifting gear

3.33
loading condition
design condition(s) for which the weight and CoG of an assembly, module or topside is required to be controlled

EXAMPLE Dry, operating, lift, load-out, shackles.

3.34
load-out
loading condition for transfer by way of horizontal movement of an assembly, module or topsides from its land-based construction site onto a transport barge or vessel

Note 1 to entry: See 5.4

3.35
management reserves
reserves to take account for any scope changes during the detail engineering phase

3.36
master equipment list
MEL
project specific list for compiling and management of technical data for tagged equipment

3.37
mating
loading condition for transfer of an assembly, module or topsides supported on barge(s) or vessel(s) to a temporary or permanent support structure

3.38
module
assembly of items forming a major building block that forms a component part of a facility, which needs to be controlled with respect to weight and CoG

3.39
net weight take off
net WTO
the weight take off based on the actual designed data from 3-dimensional model, engineering drawings or supplier data

3.40
not-to-exceed weight
NTE weight
maximum acceptable weight and CoG envelope for any given loading condition

3.41
operating
loading condition for an operating offshore facility at the start of steady-state production

Note 1 to entry: All bulk and equipment items are present with contents at nominal operating levels.

3.42
operating reserves
weight difference between the predicted weight and the NTE weight during the operating phase

3.43
operational reserves
reserves to account for unplanned future modifications

3.44
operating weight
sum of the dry weight and the contents weight

3.45
planned futures
weight budget reserve to account for planned future installations on the facility.

3.46
predicted weight
the actual expected weight. sum of gross WTO and ETC, the actual estimated/calculated weight through all project phases

3.47
reconciled weighed weight
the actual weight at the time of the weighing including any weighing correction(s)

3.48
sea fastening
items used for temporary retention of permanent or temporary items in position during transport at sea

Note 1 to entry: sea fastening may be internal to or external of the item (module or topsides) being transported.

3.49
supplier
a party that supplies goods or services

3.50
tagged equipment
equipment identified and labelled in accordance with the project coding manual and tracked in MEL

3.51
temporary items
items temporarily installed during a loading condition and removed afterwards

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

3.52
topsides
structure and equipment placed on a supporting structure [fixed or floating] to provide some or all of a platform's functions.

Note 1 to entry: For a ship-shaped floating structure, the deck is not part of the topsides.

Note 2 to entry: For a jack-up, the hull is not part of the topsides.

Note 3 to entry: A separate fabricated deck or module support frame is part of the topsides.

[SOURCE: ISO 19900]

3.53
tow-out
loading condition for towing of a complete floating structure to the offshore installation site

3.54
transport
loading condition for transfer of an assembly or module from one inshore or at shore location to another location, or to the offshore installation site

3.55
upper bound weight constraint
the absolute maximum weight. go/no go weight during conceptual design phase

Note 1 to entry: See 8.1.1

3.56
weight allowance
additions to account for expected general growth due to immaturity of the current project

Note 1 to entry: the weight allowance will typically cover for data accuracy, design change and fabrication allowances

3.57
weight budget document
WBD
document defining the budget weights and CoG limits for each loading condition of the facility

3.58
weight database
live database containing the present predicted weights and CoGs for all loading conditions (3.33), including net and gross WTO (3.39, 3.29) and estimate to complete (ETC) (3.20) for a facility, broken down by modules and by engineering disciplines

3.59
weight database custodian
WDC
the organization tasked with the responsibility for maintaining the weight database

3.60
weight item
item or collection of bulk and/or equipment, contents or assembly identified for weight reporting purposes

3.61
weight objective
defined set of engineering goals necessary to fulfil the project contractual weight and CoG requirements and intentions in order to contribute to the correct design quality as defined by the management

3.62
weight phase code
code used in the weight database to identify the loading conditions in which a weight item is present

3.63
weight policy
a statement from project management defining how the weight objective is to be achieved

Note 1 to entry: As a minimum, the policy should include:

- the importance of the weight objective to the project aims and results;
- the priority, profile and control of weights at different levels in the project;
- a philosophy for responsibility and authority within and between project groups engaged in weight management activities

3.64
weight report
regularly issued document that – based on best available information – details the weight and CoG for specified assemblies, modules and topsides, and loading conditions

Note 1 to entry: This document provides the basic weight data per loading condition for the project

EXAMPLE Stability calculations, structural integrity.

3.65
weight reserve
a lump sum weight or percentage of a total weight (at a specified CoG) added for budgeting purposes to allow for potential design growth or changes to the original concept

3.66
weight status code
a code indicating the maturity of the weight of a weight item

Note 1 to entry: The weight status code is often used to assess the value of the weight allowance applied. As a design matures, the weight status code will change so that an item's weight allowance is reduced.

4 Abbreviated terms

CoG	Centre of Gravity
FEED	Front End Engineering Design
MEL	Master Equipment List
NTE	Not to Exceed
SIM	Structural Integrity Management
T&I	Transport & Installation
WB	Weight Budget
WDC	Weight Database Custodian
WMG	Weight Management Group
WR	Weight Report
WTO	Weight Take-Off
t	Metric tonne (1000 kg)

5 Principles of Weight Management

5.1 Weight management during project lifecycle phases

The weight of the installation shall be managed at each of the following phases of the project:

a) Conceptual Design

b) Front End Engineering Design (FEED)

c) Detail Engineering

d) Construction

e) Installation

f) Operational life

g) Decommissioning

5.2 Objectives

The objectives of weight management are to accurately predict and control the weight and CoG and keep within prescribed NTE parameters for the complete lifecycle for offshore facilities.

Different weight estimating techniques are used during the life cycle of a facility, e.g. historical volumetric dry weight calculations at conceptual design phase, estimated weights during FEED, calculated, computer aided design (CAD), and weighed weights during detail engineering, as-built weights during fabrication. The weight of modifications made during the operating and decommissioning phases may be estimate using a combination of noted techniques.

The primary aims of a project during the concept design stage should be as follows:

a) to set an upper bound weight constraint and associated CoG of the facility as early as possible 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) to set the design weight for the structural design of the facility;

c) to develop and control facilities weight data for T&I capacity and substructure design loading;

d) to provide weight data that is suitable for cost estimation and procurement processes;

e) to provide facilities loads for in-place topsides structural and substructure analyses;

f) to provide facilities weights and centres of gravity for sea transportation and installation analysis;

g) “Stress-Test” feasibility of project design weight assumptions to determine sensitivity of concept to future weight growth and associated CoG excursions;

h) to identify major mitigation options available to combat future weight growth and CoG shifts which could impact the feasibility of a concept option;

i) to protect feasibility of the concept option in accordance with the design basis;

j) to identify weight risks and opportunities;

k) to track and police all weight changes before they are incorporated into the weight database.

The more detailed objectives of weight management are:

a) to set robust NTE weight and associated CoG of the facility and its component parts for the operating condition as early as possible in the conceptual design phase, so the design of the topsides and substructure can progress with confidence;

b) to set robust NTE weight and CoG of a facility’s and its components parts for the load-out, transport and lift loading conditions, in order that the necessary transport barges and installation cranes vessels can be identified and reserved if need be, at an early stage in the project;

c) to set NTE weights for design of the structure during FEED and detailed design engineering phases;

d) to monitor and control weight and associated CoG changes of a facility during the facility’s lifecycle in order to ensure that the NTE limits are not exceeded;

e) to provide a fully updated, well-structured facility weight database at the end of the installation phase, which contains weight data that is fully documented, logically summarised and fully auditable and traceable, in order that on-going weight monitoring and control can be continued throughout the remaining lifecycle of the facility;

f) to provide a project weight report together with a full set of back-up data, explanations of changes, module weighing reports and weight certificates;

g) to provide the weight database(s) in an electronic format for on-going operating phase use.

Weight database custodian(s) and weight management engineer(s) shall be appointed for the project phases. The persons involved in weight management shall be competent for the role they perform.

NOTE 1 For concrete structures special considerations regarding weight management to be taken, see Annex J

NOTE 2 Monte Carlo simulations should be used to estimate the overall weight impact of the risks and opportunities based on their perceived probability of occurrence and the corresponding weight impact.

5.3 Weight development graph

Weight management shall be in accordance with the weight development graph presented in Figure 1 and explanations to predicted weight form Table 1.

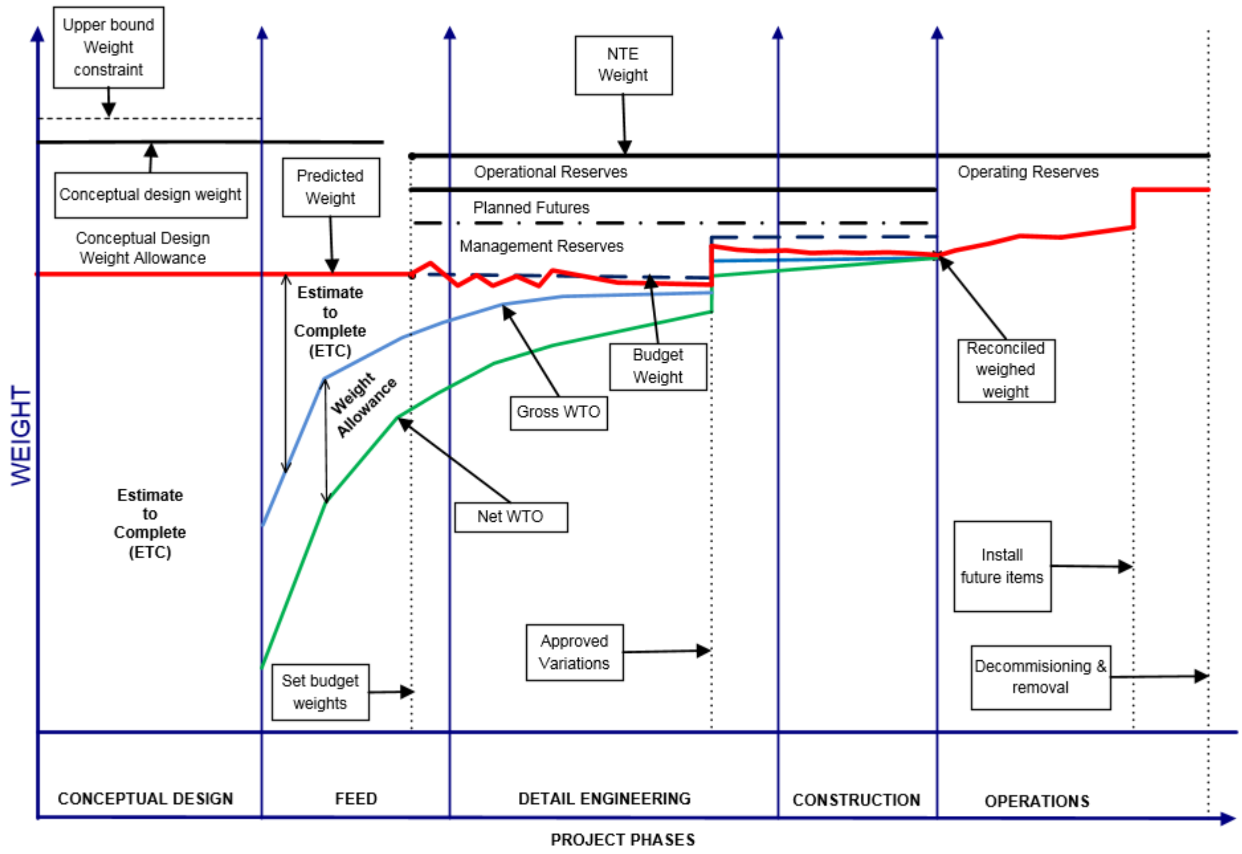


Figure 1—Weight development graph

where:	is:
Approved Variations	Approved scope changes affecting the predicted weight and changing the weight budget figures.
Conceptual Design Weight Allowance	An allowance added to the predicted weight during conceptual design to include for uncertainty and to give the conceptual design weight. Note: The conceptual design weight allowance (based on the dry weight) should be in the order of 30 % in the start of design and this uncertainty could be reduced during the course of concept.
Design weight	The design weight is the weight unlikely to be exceeded in conceptual design. This weight is used for engineering purposes and structural calculations during the conceptual design phase.

Management Reserves	Reserves to take account for any scope changes during the detail engineering phase
Operating Reserves	The weight difference between the predicted weight and the NTE weight during the operating phase.
Operational Reserves	Reserves to account for unplanned future modifications
Planned futures	Weight budget reserve to account for planned future installations on the facility.
Predicted weight	The actual expected weight. sum of gross WTO and ETC The actual estimated/calculated weight through all project phases
Reconciled weighed weight	The actual weight at the time of the weighing including any weighing correction(s)
Upper bound Weight constraint	The absolute maximum weight. Go/no go weight during conceptual design phase see 7.1.1

Note : All weight increases shall be subject to management control.

Table 1 — Formulas for predicted weight

Project Phase	Predicted Weight Formula
Conceptual Design	ETC = Predicted Weight
Feed	Net WTO + Weight Allowance = Gross WTO, Gross WTO + ETC = Predicted weight.
Detail engineering	Net WTO + Weight Allowance = Gross WTO, Gross WTO + ETC = Predicted weight.
Construction	Net WTO + Weight Allowance = Gross WTO Gross WTO + ETC = Predicted weight.
Operations	Reconciled weighed weight + Weight of installed items during/after installation – Weight of removed items during/after installation = Predicted weight.

5.4 Loading conditions

For each loading condition, all weight items that are known or predicted to occur shall be identified, quantified and located together with its corresponding CoG. Typically, each loading condition used in a given project need a corresponding weight budget.

Typical loading general conditions are, but not limited to:

a) dry installed:
a theoretical calculation of the facility's/module's final installed weight and CoG excluding the contents weight. The calculated weight shall be based on the dry weight when the facility is ready to begin operating i.e. temporary items removed.

b) operating installed:
the dry installed weight and CoG, plus the content weights.

c) operations:
the operating installed weight and CoG, including laydown area weights but not including live loads (e.g. mooring loads).

d) load-out to transport vessel/float-out
a calculation of the facility's/module's weight and CoG while it is being moved from its onshore construction location and placed onto a transport vessel. The calculated load-out weight shall include the weight of any load-out frames and temporary items that are attached to the facility/module during the movement and set-down with the facility/module on the transport vessel.

e) transportation:
a calculation of the facility's/module's weight and CoG, whilst being transported to the installation site. The calculated transport weight shall in addition to the load-out weight, include the weight of any internal sea fastenings and voyage protection added after load-out, plus any content weights for equipment or piping that will be operating during the transport phase as per pre-commissioning plan.

f) installation (including lift and float-over):
is a calculation of the facility's/module's weight and CoG when shifted from the transport vessel on to its permanent installed position. The calculated facility's/module's installation weight shall only include the weight of any items of sea-fastening and temporary items remaining after freeing of the facility/module from its transport grillage. The lift weight shall be calculated as the weight at the lifting points.

g) future operating installed
the facility's/module's operating installed weight and CoG, with addition of any planned future items or future reserves.

For floating facilities shall:

a) the baseline for weight/CoG monitoring be the "lightship" condition;

b) the loading conditions selected for monitoring include:

   1. conditions that potentially limit the weight or CoG;

   2. critical structural conditions (i.e. stress, deflection, fatigue);

   3. damage stability conditions;

   4. de-manning;

   5. offshore installation phase;

   6. temporary phases at construction yard, such as during module lifting.

c) the loading conditions selected for monohulls include a typical loading/discharge sequence and also the critical maintenance/inspection conditions.

For subsea facilities additional loading conditions will typically be (but not limited to):

a) partly submerged through splash zone:
This condition reflects the module/unit partly submerged weight and CoG, including full

buoyancy when the module/unit is in the splash zone, hollow structural sections assumed not to be filled. The weight shall be calculated as the weight at the lifting points;

b) fully submerged:
This condition reflects the module/unit submerged weight and CoG, including buoyancy and filled hollow structural sections, when the module/unit is fully submerged and being installed at the seabed. The weight shall be calculated as the weight at the lifting points;

c) operating installed subsea:
This condition reflects the module/unit fully submerged weight and CoG, including content weight.

6 Weight budget

6.1 General

For all offshore facilities, weight and CoG information for all loading conditions shall be controlled from the start of conceptual design. A weight budget document shall be compiled, detailing all key weight budget parameters. The budget weights and CoG constraints shall be determined for the modules, topsides and supporting substructures (inclusive of temporary items required for the appropriate loading conditions). This shall be done in cooperation with the relevant disciplines as well as the project management. The budget weights and CoG constraints shall be presented in the project WB as a reference point to be used during the project. The WB document containing the budget weights shall normally be established during the FEED or at the early start of the detail engineering phase.

The WB is to be reference point for:

a) weight, and CoG control and reporting during all phases of the project;

b) structural capacity requirements for assemblies, modules, topsides and supporting structures;

c) bearing capacity and stability of the facility (temporary or permanent);

d) control of overall cost and schedule

e) ensuring that all loading conditions are within the anticipated capacities.

6.2 Requirements

Each participant in a project (typically the client, contractor and sub-contractors) shall be allocated their respective budget weights.

The contractor budget weights shall be established by either the client or the contractor. If established by the client, the WB shall be included in the project contract documents.

The project management or client shall have overall responsibility for variations to margins between the various WBs. WBs for subcontractors and vendors shall be established by the contractor.

Under normal circumstances, revisions to WBs shall not take place unless concept or major changes to the design – which impact the weight, or CoG – are implemented by the project management and/or client.

All participants in the project shall be responsible for adherence to established WB values.

In the event that the project weight management detects the possibility of a significant variation from the established WBs, corrective actions shall be initiated by the project management in order that weight or CoG variations do not occur, or their impact is minimized.

6.3 Content

6.3.1 General

The WB consists of different types of weights associated with their respective CoGs per relevant loading condition. Refer to example in Annex C.

6.3.2 Weight reserves

A weight reserve including CoG may be added on top of the budget weight.

The value and location of the weight reserve will depend upon the concept type and the project weight policy.

Any relevant variation orders issued by the client after the contract has been issued may affect the weight reserve and may necessitate a WB revision.

6.3.3 Future weights

Future weights are not included in the weight reserve, but shall be identified separately in the WB for the future loading condition.

6.3.4 Loading conditions and parameters

6.3.4.1 General

In cooperation with the structural and marine disciplines, as well as project management, a set of relevant loading conditions and associated weight budgets and CoG envelopes shall be defined for weight management and reporting purpose.

Agreement between the client and the contractor shall be reached for:

a) the weight reserves;

b) the implication of free surface effects on the stability for floating conditions (either temporarily or permanently) installation;

c) the variable weights, relevant maxima and associated positions.
Variable weights may include, but shall not be limited to weights on laydown areas, stores, etc. see Annex E;

d) weights during commissioning;

e) tensions from appurtenances and mooring.

6.3.4.2 Loading condition selection

The necessary loading conditions shall be dependent on the type of the facility as well as the construction and installation methods used.

6.3.5 Formats and levels

The WB format shall, as a minimum requirement, present a NTE weight and CoG for each assembly, module and/or facility for each relevant loading condition.

The format may be further developed in order to present a maximum permissible weight for each main weight contributor (e.g. structural, piping and equipment) and one common figure for the rest of the design. Individual values for both bulk and equipment for all disciplines may also be given.

Refer to example in Annex C.

6.3.6 CoG envelopes

The WB shall include CoG envelopes for weight management and weight reporting purposes.

The CoG envelopes may be either two-dimensional or three-dimensional depending on the facility being controlled.

7 Weight management during project execution phases

7.1 Conceptual design

7.1.1 General

During the conceptual design phase several options for the field development are considered and evaluated. The main objectives of this phase are to:

a) identify a single preferred overall approach to the project;

b) select the type of sub-structure and deck structure to be used;

c) develop preliminary layouts and P&IDs for the topsides.

The conceptual design shall be checked against the following constraints by establishing a concept upper bound weight constraint:

a) capacity of installation cranes and vessels;

b) transport and float-over barge capacity and stability;

c) construction yard and transport route limitations;

d) for brownfield projects, the existing capacities for supporting the additional load;

e) for greenfield projects, the load carrying capacities of the supporting structure;

f) the predicted weight shall have an accuracy of ±25 % with confidence level of 80 % at end of the conceptual design stage. Higher allowances may be applied if the checklist is not fully compliant;

g) conceptual design weight shall be greater than 110 % of the predicted weight and less than 95 % of the concept upper bound weight.

The weight estimate at the end of the conceptual design stage shall:

a) ensure that the concept design weight remains within the constraints for the project (i.e. within T&I capacity and the substructure loading limit);

b) provide the concept design weight for in-place structural analysis;

c) provide the concept design weight and CoG for transport and Installation analysis;

d) provide the predicted weight to the accuracy required for cost estimate;

e) test the robustness of the concept design to potential future weight growth and associated CoG excursion;

f) identify major design options available to mitigate potential future weight growth and associated CoG excursion that could impact the feasibility of a concept option;

g) support concept readiness for handover to the FEED;

7.1.2 Estimating principles

For methods of estimating, see Annex F.

In the conceptual phase, the master equipment list (MEL) and volumetric and area based norms should be used as basis for the estimate.

A weight estimate may be determined by using the MEL with one or a combination of the following methods:

a) Analogues (or benchmarks) from previous projects with similar characteristics can be used. Suitable analogues are selected by matching the installation specification with characteristics of previous projects that include the following see Table 2.

    a. Predicted wt = analogue wt. x analogue variability factor.

    NOTE: Where the analogue variability factor is based on the range of weights of previous projects with similar characteristics.

b) Relevant area and volume requirements can be identified, and layout drawings can be established. Based on the layout drawings, weight for bulk and structures can be estimated using area/volume density factors.

    a. Predicted wt = predicted area (based on layout for MEL) x area contingency factor.

    b. Predicted wt = predicted area (based on layout for MEL)x area weight variability factor.

c) Equipment weight per system can be established.
Based on this, weight for bulk and structures can be generated for each system.

d) Predicted wt = Σ j(MEL wt. x MEL allowance factor x bulks weight variability factor for system “j”).

e) Historical topside dry to operating weight ratios can be used to estimate coincident operating increases.

Table 2 — Analogues characteristics

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

Weights estimates can be also established based on benchmarks when MEL is not available.

7.1.3 Deliverables

As a minimum the deliverables provided on completion of the conceptual design phase shall include:

a) concept design weight & concept upper bound weight;

b) conceptual design weight checklist;

c) dry and operating weight summary for the major building blocks (topsides, modules, sub-structures etc.);

d) weights distributed by areas and split in equipment, structural and bulk;

e) bulk split in disciplines;

f) data source, basis for input data;

g) method of estimating;

h) benchmarking analysis report using historical data (from industry and company);

i) weight databases if available;

j) preliminary laydown and storage areas and loads;

k) preliminary global and local module origins.

7.2 FEED

7.2.1 General

FEED constitutes the development of the preferred facility design from the conceptual phase to a point where all design variables have been resolved, and sizes, volumes and contents are optimized to the point where a weight report can be compiled using the project MEL and discipline estimates, rather than the historic volumetric calculations used in the conceptual phase.

During the FEED the module or integrated deck area designations shall be established. The size, volume and weight of each module/assembly shall be defined. A preliminary MEL and weight database for each module/assembly shall be produced, with appropriate design allowances applied so that predicted weights can be calculated.

7.2.2 Weight management Procedure

A weight management procedure for use during the FEED phase shall be issued by the contractor's weight management discipline as stated in the contract at the start of the FEED phase.

The procedure shall document the weight reporting responsibilities of the engineering disciplines and contractors:

a) The contractor or responsible organization shall establish and document a plan showing how weight management tasks are distributed between the engineering disciplines.

b) The contractor or responsible organization shall produce weight documents to substantiate methods of obtaining the weight data at various stages of the project. This documentation shall, as a minimum specify:

   1) the estimating methodology used at during the project phase(s) covered by the procedure;

   2) the weight allowances applied at various project stages;

   3) weight reporting boundaries between various components of the installation e.g. topside, sub-structure or hull;

   4) the process to be followed if predicted weight exceeds budget weight. e.g by either increasing the budget weight by management of change (MOC) or implementing weight reduction;

   5) assessment of CoG for the loading conditions;

   6) assessment of weights for hook-up scope material (if applicable);

   7) assessment of loading conditions

   8) weight management philosophies;

   9) transfer of weight management responsibility through the various phases of the project (if applicable).

c) The procedure shall define the:

   1) input requirements;

   2) global coordinate system;

   3) area designation system;

   4) loading conditions to be reported;

   5) all codes (installation, status, weight allowance, etc.) utilized in the weight management system;

   6) discipline checklist.

7.2.3 Estimating principles

For methods of estimating, see Annex F.

In the FEED phase, the master equipment list (MEL) and WTO's should be used as basis for the estimate.

As a minimum there are typical two different ways to use the MEL information to establish a weight estimate:

a) Relevant area and volume requirements can be identified as layout drawings are created. Weight for bulk and structures can be estimated using area/volumetric factors.

b) Equipment weight per system can be established, and weight for bulks can be generated based on the equipment weights per system.

When the progress of engineering is sufficient for a WTO, this can be used to determine weight for certain bulk disciplines. Allowance shall be added to account for materials not yet identified.

7.2.4 Weight budget

A WB in accordance with requirements set in clause 6, is recommended to be established during the FEED phase. The weight estimate shall set the key parameters for the WB including NTE weights.

7.2.5 Deliverables

The deliverables provided as part of the FEED phase shall be, but not limited to:

a) weight management procedure;

b) periodic FEED weight report including the following:

    1) weight and CoG summary for each loading condition;

    2) weights and CoGs reported by area, discipline, structural, equipment and bulks;

    3) WTO for designed structures prepared to support the estimated weights;

    4) WTO for sized piping prepared to support the estimated weights;

    5) split between topside and substructure clearly defined;

    6) specified weight allowance;

    7) up-to-date register of design decisions with weight implications;

    8) weight risks and opportunities register;

    9) overall probabilistic weight impact of the risks and opportunities.

NOTE A comparison of the weight estimate to previous project analogues measured by area density, volumetric density and discipline ratio to equipment weight should be included.

c) weight database if available;

d) weight data input to detail engineering phase;

e) preliminary laydown and storage areas and weights;

f) preliminary global and local module origins.

7.3 Detail engineering

7.3.1 General

Detail engineering involves the development of the preferred facility design from FEED to a point where construction of the installation can commence.

During the detail engineering phase, the weight of the facility shall be controlled by the WMG, and constantly refined by means of substituting the ETCs with net WTOs and reducing the allowances in-line with the status of the updated weight information (vendor information, WTOs, equipment weighings etc.).

The predicted weights shall be monitored against the defined budget weights.

7.3.2 Weight management procedure

A weight management procedure for use during the detailed engineering phase shall be issued to the client by the contractor's weight management discipline within the timeframe as stated in the contract.

The procedure shall document the weight reporting responsibilities of the engineering disciplines and any sub-contractors.

The procedure shall describe the:

a) weight management philosophies;

b) transfer of weight management responsibility through the various phases of the project (if applicable);

c) distribution of tasks, responsibilities and authorities;

d) methods of obtaining the weight data which as a minimum, shall contain a description of:

- the estimating methodology used;
- the level of weight allowances applied.

e) input requirements;

  - for all codes utilized for weight management, (discipline codes, weight phase codes, weight status codes including weight allowance, etc.).

7.3.3 Weight Budget

A WB in accordance with requirements set in clause 6 shall be established if not established during the FEED phase.

7.3.4 Deliverables

7.3.4.1 Weight report

Project weight reporting shall be the result of systematic compilation and documentation. The formal weight policy and weight objective shall be adhered to, thus forming the project weight-management activities and requirements. The weight report shall be based upon agreed project procedures and work instructions.

The frequency of weight reporting should be monthly.

NOTE The frequency of weight reporting may be every two months for facilities which are not weight and CoG sensitive.

7.3.4.2 Weight report requirements

Required content for weight reports is dependent on the requirements of the client. As a minimum, the required content of a weight report shall be as summarised in Table 3:

Table 3 Weight report content

EXECUTIVE SUMMARY		— a short summary of project main focus areas (loading condition weights and CoGs), — a brief description of variations in weight and CoG and the WB since the previous weight report. (See examples in Annex G).
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 description 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 listing of reference material used to create the weight report. (i.e. layout drawings, 3D model, plot plans, MEL, discipline input, etc.): — 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 revision.
3	Loading condition summaries	General loading condition reporting requirements: — short introduction to the loading condition; — 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 W; — description of weight variations to the previous weight report.

3.1 Dry installed loading condition	— se requirements above.
3.2 Operating installed loading condition	— se requirements above.
3.3/4/5… Other loading conditions summaries	— se 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.
5 Potential weight variation register	— listing of possible weight risks (increases) and savings (reductions). List includes possible changes to scope and design that are to be processed through a management of change 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 Area plan and global reference system	— drawing or sketch indicating the main area codes and global coordinate system see Annex K.
6.4 Weight phase codes	— table showing the relevant weight phase codes used in the weight database.
6.5 References	— table showing the reference documents, standards, procedures and specifications etc. for the report.
6.6 Report schedule	— schedule indicating the planned cut-off and issued dates for the report.
6.7 Design data	— configuration of the principal design data for the project.
6.8 Other	— other useful information.
NOTE For floating facilities a separate section regarding stability and operating capacities may be inserted before chapter 6	

7.3.4.3 Project weight database

An electronic transfer of the project weight database as specified by client, see Annex I.

The weight database shall reflect a the topside operating philosophy, reflecting coincident operating weights see Annex E.

7.4 Construction

7.4.1 General

The fabricator shall be responsible for interfacing with the WDC and providing all necessary information for update and validation of the weight database and weight report for their scope of work, and for organizing weighings as specified.

The weight management should be performed by the engineering contractor during construction. The weight management may be performed by the fabricator.

7.4.2 Weight management procedure

The fabricator shall submit a weight management procedure for client approval for use during the construction phase. The procedure shall specify details of the method and format of weight reporting assistance that will be provided, including WTOs for the following:

a) material substitutions;

b) field corrections;

c) field run items;

d) fabricator designed materials;

e) onboard construction items, scaffolding (temporary items).

These WTOs shall be continuous updated and provided until sail-away.

7.4.3 Deliverables

7.4.3.1 Weight report

A construction weight report shall be the result of systematic compilation and documentation. The formal weight policy and weight objective shall be adhered to, thus forming the project weight-management activities and requirements. The weight report shall be based upon agreed project procedures and work instructions.

The frequency and type of weight report shall be dependent on the project requirements. As a minimum frequency weight reporting every two months is recommended.

7.4.3.2 Weight data

An electronic transfer of the project weight database to WDC, as specified by client, see Annex I.

7.4.3.3 Weighing reports

Weighing reports for each assembly, module and topsides required to be weighed, refer to 10.5.6 for detailed information.

7.5 Installation

7.5.1 General

The Installation contractor shall be responsible for interfacing with the WDC and providing all necessary information for update and validation of the weight database and weight report.

7.5.2 Weight management procedure

The Installation contractor shall submit a weight management procedure for client approval for use during the installation phase. The procedure shall specify details of the method and format of weight reporting assistance that will be provided, including WTOs for the following :

a) material substitutions;

b) field corrections;

c) field run items;

d) installation contractor designed materials;

e) onboard construction items, scaffolding (temporary items).

These WTOs shall be continuously updated and provided until completion.

7.5.3 Deliverables

7.5.3.1 Weight data

An electronic transfer of the project weight database to WDC, as specified by client, see Annex I:

a) informing the WMG of day to day additions and removals from the platform;

b) WTOs for all installation equipment, materials, containers, and other items taken offshore, or brought back on-shore;

c) weighing of the above prior to dispatch offshore;

d) informing WMG of the commissioning sequence and providing a hydrotest schedule;

e) weight and location of materials, equipment and containers brought on-board;

f) weight and location of materials, equipment and containers taken to the beach;

g) schedule of systems under test;

h) weight and location of consumables brought on-board (food, fuel etc.).

Care shall be taken when monitoring the weight of consumables brought on-board, as these may be consumed – not accrue.

7.6 Operating

7.6.1 General

The dry and operating weight and CoG of a facility shall be controlled throughout its operating phase. The output from the facility’s weight database is the prime document used by client structural engineers and structural integrity management (SIM) engineers when conducting assessment or re-analyses of structures. Range of permissible facility overall weights and envelope of associated LCG, VCG, and TCG shall be available to ensure operation within safe parameters.

7.6.2 Weight management Procedure

An operating phase weight management procedure shall be produced by the WDC at the start of an installation’s Operating phase. Its purpose is to clearly define the roles and responsibilities of:

a) the client;

b) the modification design contractor(s);

c) the weight database custodian.

It shall include a simple weight management flow diagram showing implementation of a typical modification and its weight and CoG change from: inception – to weight database update – to SIM model update – to final close-out, ref Annex E.

7.6.2.1 Design contractor

Weight and CoG changes resulting from modifications undertaken during the Operating phase shall be recorded on weight management input sheets to be completed by the client's incumbent design contractor(s). These shall be included in both client produced, and contractor's design work packs, and issued to the client appointed weight database custodian for recording, review, and input.

7.6.2.2 Weight Database Custodian

The topside weight database shall be maintained by the appointed weight database custodian, and kept regularly updated with all weight and CoG changes and modifications i.e. additions, relocations and removals.

The weight database custodian should be appointed at the start of a facility's operational life.

7.7 Decommissioning

An accurate, up-to-date detailed weight database for a facility is an essential document to assist with the safe engineering of its removal. It is recommended to perform a site survey at the facility in order confirm the status of the weight database.

Typical weight management deliverables for decommissioning are:

a) the dry and operating weight and CoG of each lifted assembly or component as part of a reverse engineering program;

b) the dry and operating weight and CoG of the sub-structure;

c) a detailed weight database including all bulk and tagged equipment;

d) a breakdown of the piping in each module, by line diameter, with the dry and operating weights to help calculate cost of purging, cutting and removal of volatile lines prior to decommissioning;

e) the dry and operating weight of all items of equipment in each module listed by tag mark equipment number;

f) the dry and operating weight of each tank and vessel in each module, and the contents listed by tag mark;

g) the weight of structural steelwork in each module, broken down by drawing number.

8 Requirements for "as-built" weight documentation

An electronic copy of the weight database containing a complete set of designed quantities, including unit weights, CoG and specified attribute information and descriptions, shall be provided, see Annex I.

If a 3D model is applied for the project, the records within the weight database shall be consistent with those in the model with corrections for non-modelled items.

The database fields, their format as well as the coding, shall be in accordance with contractual requirements.

An "as-built" weight and CoG report shall be provided.

An "as-built" master equipment list (MEL), shall be provided.

In order to provide the level of documentation required, a thorough weight management activity shall be maintained by all disciplines.

9 Requirements for suppliers' weight data and weighing of equipment and assembled bulks

9.1 General

Purchase orders shall include provisions for suppliers to make submissions of weight and CoG data at milestones as noted in 9.2 or as defined in the relevant project documents.

Items provided under bulks purchase orders (e.g. structural steel, piping components, electrical cables, etc.) are not typically considered as individual items – as in the case of items of equipment. However, due the uniqueness of assemblies of bulk items (e.g. valves complete with controlled actuators, architectural wall panels complete with in-fill steel, etc.), supplier submission of weight and CoG data may be specified by the project – following the same requirements as items of 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, items of equipment and assembled bulks shall be weighed as described in 9.3.

NOTE Refer to Annex A for an example of a weighing summary.

9.2 Submission of weight data

The supplier shall submit weight data:

a) as a part of the bid documents (bid);

b) within a timeframe specified by the project after awarding the purchase order (initial);

c) prior to start of fabrication (i.e. documents are approved for construction) (preliminary);

d) if a design change results in a weight change exceeding an agreed project magnitude value (revised);

e) at completion of fabrication and prior to weighing; (final calculated);

f) after completion of a weighing (included in the weighing certificate) (weighed).

The weight data shall contain information about:

a) as-installed dry weight and CoG – inclusive of any permanent fluids e.g. lubricants, hydraulic oils, coolants, etc;

b) weight and CoG of normal operating content (content being stored within or flowing through the item);

c) weight and CoG of permanent fluids (e.g. lubricants, hydraulic oil, coolants) installed in the item;

d) total weight of the item in normal operating condition (this is the combination of weight and CoG values for items 1 to 2 noted above);

e) hydro-test weight and CoG (where applicable);

f) transport weight and CoG.

9.3 Weighing requirements

9.3.1 Equipment

At completion of fabrication of items of 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.

9.3.2 Bulk

Individual bulk items (e.g. structural steel, piping, cable tray, etc.) are not expected to be weighed. However, when it is not possible to accurately determine the weight of an assembly created from multiple bulk components, a weighing may be performed to confirm the weight of the assembly. The requirement to weigh assemblies of bulks shall be at the discretion of the project.

9.4 Weighing procedure

The supplier shall, as part of their scope of work, submit a written weighing procedure to the client for approval within a defined time frame – e.g. three months of purchase-order issue. The procedure shall – as a minimum – include the following information:

a) a list of all items (equipment or bulks) to be weighed using the proposed method and devices. Equipment identification and purchase order under which the equipment is being supplied is to be per the project specific identification nomenclature;

b) 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, etc.);

c) confirmation where the weighing will be performed: indoors or outdoors;

d) structural details of supporting frames beneath, or lifting spreader bars above (if required) used to distribute the weight of the equipment 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) confirmation that the weighing will be performed prior to installation of any packaging or transport material being installed on the item being weighed;

g) a description of the measuring, recording and lifting devices to be used, giving rated capacity, expected uncertainty and environmental operating range (temperature and humidity);

h) example calibration certificates for all weight measuring devices (including spares) to be used during the weighing;

i) identification of the calibration standard used and the organisation responsible (name and address) for performing the calibration of the weight measuring devices;

j) confirmation that spare measuring, recording and lifting devices will be available and in working order to prevent that failure of weighing devices will cause undue delay or cancellation of a weighing;

k) confirmation that weighing devices will be operating within the range of 20 % to 80 % of the devices' calibrated capacity (see 9.5.2);

l) confirmation that the weighing will be performed by either:

- the supplier using in-house weighing system and workforce;
- the supplier using a hired weighing system (weighing devices);
- or by a specialist third-party weighing sub-contractor;

m) confirmation that environmental conditions (e.g. temperature, humidity, wind, precipitation and wind) will be considered prior to starting a weighing in an outdoor location (see 9.8);

n) example calculation illustrating how the overall weight and CoG of the item will be determined from the data collected using the proposed weighing method;

o) a layout drawing showing the proposed location of the load-cells relative to the reference point for the item;

p) example calculations showing how permanent items not present for the weighing are to be mathematically added to the weighing results, and how temporary material (packaging, tools, etc.) not forming part of the permanent items are to be mathematically removed from the weighing results;

q) the expected schedule (month and year) for weighing the item;

r) the geographic location (address) for the weighing;

s) if used, the name and contact information of specialist weighing subcontractor to be employed for the weighing.

9.5 Weighing devices

9.5.1 Type of weighing device

Weighing of any item of equipment or assembled bulks with an estimated 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 loadcell where the load cell is supported from the ground and the object to be weighed is loaded on to the top of the load cell. This method shall be used to establish the horizontal CoG for the item. 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.

9.5.2 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 by a national accreditation body for the country in which the weighing is to be performed.

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

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

9.5.3 Maximum relative uncertainty for weighing devices

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

For items with an estimated weight greater than or equal to 100 kN (10 t) at completion of fabrication, the maximum relative measurement uncertainty shall not exceed ± 1 %.

For items with an estimated weight less than 100 kN (10 t) at completion of fabrication, the maximum relative measurement uncertainty shall not exceed ± 1,0 %.

9.5.4 Capacity of weighing device

To account for possible weight underestimation and provide a level of safely 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.

9.5.5 Spare weighing devices and ancillaries

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

9.6 Notification and witnessing of weighing

The supplier shall notify the client in writing of the planned date, time and location of the weighing operation as defined by the client. The supplier shall notify – as defined by the client – in advance of the confirmed date, time and location of the weighing operation.

Client shall be afforded opportunity to witness weighings.

9.7 Scheduling of weighings

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

9.8 Environmental conditions during a weighing

A weighing to be performed in an outdoor location shall only proceed if all of the following environmental conditions are present:

a) the ambient temperature or relative humidity is 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.

9.9 Weighing operation

Weighing of equipment and assembled 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 average 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 stabilisation 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) have been removed from contact with the item being weighed) is to 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 demobilised until the results are deemed to be satisfactory by those witnessing the weighing.

9.10 Temporary objects present during a weighing

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

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

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

9.11 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.

9.12 Weighing Certificate

Suppliers shall submit for review and approval, a weighing certificate within a timeframe defined by the client. The weighing certificate shall – as a minimum – include the following:

a) the actual weighed weight, read out from the weighing device;

b) detailed list and summary weight and CoG of temporary items (if any) present during the weighing;

c) 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 for normal operating condition;

g) the resulting total operating weight and CoG;

An example of a weighing certificate is provided in Annex A.

10 Requirements for weighing of major assemblies

10.1 General

As a minimum, assemblies , modules, complete topsides, etc. shall be weighed at the end of the construction process to confirm the overall weight and CoG of the assembly, module or topside. However, it's recommended that two weighings are performed where the first weighing is performed when the assembly is 70 % to 85 % complete with respect to weight.

Weighings shall be performed using strain-gauge compression load cells and a system of hydraulic jacks to raise and lower the assembly. Alternative weighing devices may be proposed, however, acceptance shall be at the client's discretion.

For a floating facility a displacement measurement will normally be performed. Guidelines for a displacement measurement is given in Annex D.

10.2 Weighing procedure

The contractor shall, as part of their scope of work, submit a written weighing procedure to the client for approval within a defined time frame – e.g. three months in advance of the planned weighing date. The procedure shall – as a minimum – include the following information:

a) a description of the assembly or assemblies to be weighed using this procedure. Include project name, client, and module 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);

c) a confirmation where the weighing will be performed: indoors or outdoors ;

d) structural details of supporting foundations at the locations of the load cells;

e) a confirmation that differential settlement of the supports or weighing points (i.e. locations of the load cells) will not be cause for requiring additional structural supports;

f) 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;

g) calculations demonstrating that supports, jacking points, foundations or spreader bars will not be over stressed during weighing operations;

h) 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 weighing devices;

i) a description of the load cells, data recording system (measured weights, level of assembly, etc.) and lifting devices;

j) a description of the measuring, recording and lifting devices to be used, giving rated capacity, expected uncertainty and environmental operating range (temperature and humidity);

k) rated capacity, expected uncertainty and environmental operating range (temperature and humidity) of the load cells;

l) confirmation that the load cell output will be provided on a digital display or similar device and provides a continuous reading for each load cell;

m) rated capacity of the individual hydraulic jacks and the complete hydraulic system;

n) a description, including all safety measures, of the method to be used to control the vertical movement of the assembly during the weighing operations;

o) example calibration certificates for all weight measuring devices (including spares) to be used during the weighing;

p) identification of the calibration standard used and the organisation responsible (name and address) for performing the calibration of the load cells;

q) confirmation that spare load cells, recording devices and hydraulic system parts will be available and in working order such that failure of weighing devices will not cause undue delay or cancellation of a weighing;

r) confirmation that weighing devices will be operating within the range of 20 % to 80 % of the devices' calibrated capacity (see 10.3.5);

s) confirmation that the weighing will be performed by either;

   1. the contractor using in-house weighing system and workforce;
   2. the contractor using a hired weighing system (load cells and / or hydraulic system);
   3. or by a specialist third-party weighing sub-contractor;

t) confirmation that environmental conditions (e.g. temperature, humidity, wind, precipitation and wind) will be considered prior to starting a weighing in an outdoor location (see 10.4.2);

u) example calculation illustrating how the overall weight and CoG of the assembly will be determined from the data collected using the proposed weighing method;

v) example calculations illustrating how the overall weighing system uncertainty, the uncertainty of the weighing results will be calculated from the data gathered during the weighing;

w) confirmation that the total weight of temporary items present during the weighing does not exceed the limits set in 10.4.4;

x) confirmation there will be no workforce present on the assembly at the time of the weighing;

y) confirmation that the area immediately adjacent to and beneath the assembly has restricted and monitored access during the weighing;

z) a dimensioned layout drawing showing the proposed location of the load-cells relative to project reference system for the assembly;

aa) example calculations showing how permanent items not present for the weighing are to be mathematically added to the weighing results, and how temporary items not forming part of the permanent works (e.g. temporary items) are to be mathematically removed from the weighing results;

bb) confirmation the weighing system is mobilised until the results are deemed to be satisfactory by those witnessing the weighing;

cc) the expected schedule (month and year) for weighing the assembly;

dd) confirmation that the notification of the weighing will follow periods noted in 10.4.1;

ee) the geographic location (address) for the weighing;

ff) if used, the name and contact information of specialist weighing subcontractor to be employed for the weighing.

10.3 Weighing system

10.3.1 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 10.3.3. Acceptance of alternative load cells shall be approved by the client. A mix of different types of devices during a weighing operation is not permitted.

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.

10.3.2 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 or similar device that gives a continuous reading for each device. Dial gauges shall not be permitted. The precision of the display shall be in accordance with the precision of the weight measuring device. 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 – i.e. a resolution of 1 kN (0,1 t) or better for a 600 kN (600 t) load cell reading with 0,5 % uncertainty.

10.3.3 Uncertainty of weighing system

Individual load cells shall have a maximum measurement uncertainty within ± 0,5 %, k = 2 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 and issued by a member of International Laboratory Accreditation Cooperation (ILAC) or International Accreditation Forum, INC (IAF).

The maximum measurement uncertainty of the weighing system shall be within ± 1,0 %, k = 2 of actual weighed weight. The measurement uncertainty of the weighing result shall be calculated after principles given in the GUM.

The uncertainty associated with the results of the weighing process shall be acceptable to the organisation responsible for lifting or transporting the assembly, module or topside.

See Annex H for further information.

10.3.4 Calibration of load cells

A competent laboratory that can ensure traceability and adequate procedures shall perform load cell calibrations. The laboratory shall meet the requirements of ISO/IEC 17025, or be accredited by a national 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.

Calibrated load cells shall not be used for any other weighing – unless specifically permitted by the project for which they have been calibrated. The client representative shall be notified in writing of the calibration date and location at least two weeks in advance.

The calibration shall be completed in one of the following two manners – depending on the output of the read-out device:

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 until 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, accuracy of measurement, and reference to the master load cell shall be included on the calibration certificates.

The client shall retain the right to have specific load cells re-calibrated after the weighing if it is agreed that the readings recorded for them is under scrutiny.

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

10.3.5 Capacity of weighing system components

The weighing operation shall be planned in such a way that the load cells and jacking (lifting) devices are operating within 20 % to 80 % of the rated capacity of the load cells as stated by the load cell manufacturer. If load cells are installed for purposes other than weighing the assembly (i.e. raising the assembly for placement of taller supports), the loads applied shall not exceed 80 % of their rated capacity.

10.3.6 Spare load cells and ancillaries

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

10.3.7 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.

10.3.8 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 shall be monitored to ensure the difference in elevation between adjacent jacking points is kept to the lesser of 2 mm or 1/1000 of the distance between the jacking points.

10.4 Preparations prior to the weighing

10.4.1 Notification and witnessing of weighings

The contractor shall notify the client representative in writing of the planned date, time and location of the weighing operation, as defined by the client.

The contractor shall notify the client representative in writing of the confirmed date, time and location of the weighing operation, as defined by the client.

The client shall decide either to witness the weighing or to authorize the contractor to perform the weighing at the contractor's own discretion.

10.4.2 Environmental conditions during a weighing

A weighing to be performed in an outdoor location shall only proceed if any of the following environmental conditions are present:

a) the ambient temperature or 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) at a height of 2 m above ground level, does not exceed 5 m/s, or gusts does not exceed 2,5 m/s more than the measured wind speed;

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 lighting to permit a safe weighing operation, or there is sufficient artificial lighting available.

10.4.3 Weighing prediction report

A weighing prediction report shall be developed 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 contractor shall submit a preliminary weighing prediction report to the client a minimum of 72 hours prior to the weighing operation, with a final update immediately prior to the weighing. The client and contractor shall agree to the information in the report prior to the start of any weighing operation.

The report shall contain at least the following information:

a) total theoretical weight and CoG for the assembly to be weighed;

b) list or database (item description, weight and CoG) and summaries for all permanent items present for the weighing;

c) list or database (item description, weight and CoG) and summaries for all permanent items not present for the weighing;

d) list or database (item description, weight and CoG) and summaries for all temporary items present for the weighing.

10.4.4 Temporary items during the weighing

When possible, unnecessary temporary items (i.e. those no longer required on the assembly) 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. This does not apply to designed temporary items which form part of the assembly's structural integrity and foundations such as load-out frames, grillage etc.

Temporary items weighed separately prior to assembly weighing shall be excluded from the total weight of temporary items present for the weighing.

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

10.5 Weighing operation

10.5.1 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 (see 10.5.2) results. Additional weighing cycles may be carried out at the discretion of the client representative.

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 completed 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 requested by the client representative – 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.

10.5.2 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 and recorded, and wind speed and direction recorded.

10.5.3 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 average of the three accepted weighing results by more than the levels of weighing system uncertainty defined in 10.3.3.

Reference are also made to Annex B for guidance of weighing result accuracy.

10.5.4 CoG calculations

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

10.5.5 Weighing certificate

If requested by the client, the results of the weighing operation shall be presented on a weighing certificate – signed by the weighing contractor, contractor and client representative. This shall be provided within a timeframe specified by the client.

The weighing certificate shall contain at least the following information:

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.

10.5.6 Weighing report

The contractor shall submit for review and approval, a report of the weighing operation within a timeframe defined by the client. The weighing report shall – as a minimum – include the following:

a) name and contact information for the contractor and (if used) weighing subcontractor;

b) list of names and contact information for key personnel present (representative(s) from contractor, client, weighing contractor, etc.);

c) copy of all data (load cell readings, environmental conditions, level survey results, etc.) recorded during the weighing – signed by representatives from the contractor, client and (if used) the weighing subcontractor (see A.2);

d) calibration certificates of all load cells – including spares;

e) plan view drawing of the assembly showing the locations of the load cells (dimensioned in the project coordinate system) and identification information – i.e. load cell serial numbers;

f) detailed list and summary weight and CoG of temporary items present during the weighing;

g) detailed list and summary weight and CoG of permanent items not installed at the time of the weighing;

h) copy of final weighing prediction report including any modifications made up to immediately before the weighing;

i) log showing chronological order of weighing operation activities – i.e. start time, time of recording readings, discovery of device faults and resolution, etc.;

j) any deviation from the approved weighing procedure;

k) calculations showing determination of the as-weighed weight and CoG;

l) if issued, a copy of weighing certificate.

Annex A
(informative)

Weighing certificates

A.1 Equipment and bulks weighing certificate

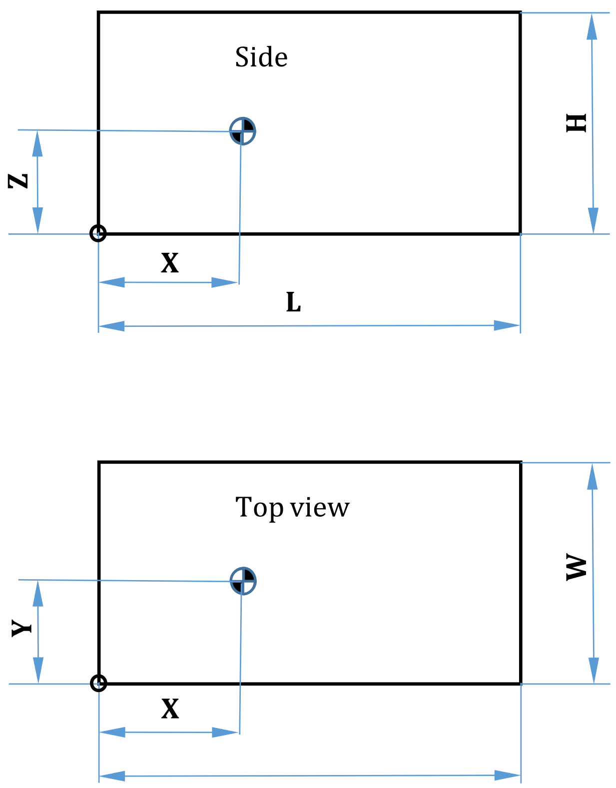
<table>
<tr><td colspan="5">Equipment and Bulk weighing certificate
Page 1 of 2</td></tr>
<tr><td>Project:</td><td colspan="4">Client:</td></tr>
<tr><td>Item/tag No.:</td><td colspan="4">Bid package No.:</td></tr>
<tr><td colspan="5">Description:</td></tr>
<tr><td colspan="5">Purchase Order No.:</td></tr>
<tr><td colspan="5">Supplier:</td></tr>
<tr><td rowspan="2">Weighed components
or other items</td><td rowspan="2">Date</td><td colspan="3">Dry weight (Unit:)</td></tr>
<tr><td colspan="2">Calculated
(purchase order)</td><td>Recorded</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Total dry weight this item/Tag No.:</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Weighing device</td><td colspan="3" rowspan="3">NOTE CoG should be shown on sheet 2.</td></tr>
<tr><td colspan="2">Make:</td></tr>
<tr><td colspan="2">Type:</td></tr>
<tr><td colspan="2">Range:</td><td>Approved:</td><td>Date:</td><td>Signature:</td></tr>
<tr><td colspan="2">Serial number:</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Calibration date:</td><td>Supplier:</td><td></td><td></td></tr>
<tr><td colspan="2">Calibration authority:</td><td>Purchaser:</td><td></td><td></td></tr>
<tr><td colspan="5">Document number:</td></tr>
</table>

Bulk and equipment 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 for skid, including items excluded during weighing:					



Local datum point

Local CoG

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) =

NOTE 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.

A.2 Major assembly weighing certificate

Major assembly weighing certificate Page 1 of 2	
Project:	Client:
Assembly/Area.:	Location of weighing:
Wind speed	Temperature (°C)
Weighing operation time start/end:	Weighing operation date:

Load cell reference	Load cell reading at weighing (Unit:)				
	1st	**2nd**	**3rd**	**4th** (if req.)	**Average**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

	Weighing results		
	Weight (Unit:)	East/LCG (m)	North/TCG (m)
Predicted			
1st			
2nd			
3rd			
4th			
Average			

Major assembly weighing certificate **Page 2 of 2**						
Project:				Client:		
Assembly/Area.:				Location of weighing:		
Load cell reference	**Load cell serial number and coordinates at weighing**					
	1st	**2nd**	**3rd**	**4th** (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.

Number of attachments:

Annex B
(normative)

Accuracy of major assemblies weighing predictions

B.1 Accuracy of weighing predictions

The accuracy of a module or assembly weighing result compared with its weighing prediction report should be within the following tolerances:

Predicted weight

The accuracy of the weighing prediction report should be within the following tolerances:

Table B.1 — Predicted weight accuracy

Weighing	Accuracy
Weight	±1 % of prediction

Predicted CoG

The accuracy of a module or assembly CoG prediction should be expected to fall within the following percentages of its length and width (measured centre to centre of main trusses or supporting points beneath):

Table B.2 — Predicted CoG accuracy

Weighing	East	North
CoG	±0,50 %	±0,50 %

Example for final weighing of module 20,000 m long × 10,000 m wide

The East CoG should be within 20,000 m × 0,005 = ± 100 mm

The North CoG should be within 10,000 m × 0,005 = ± 50 mm

B.2 Post weighing reconciliation

Any predicted values that fall outside the above weight and CoG accuracy ranges should result in undertaking a post-weighing reconciliation of the weighing prediction report. This should begin immediately on completion of the weighing and continue until the inaccuracies can be sufficiently explained and resolved to the client representative’s satisfaction.

Once the post-weighing reconciliations have been satisfactorily concluded, the necessary weight and CoG corrections may be added to the weight database.

Annex C
(informative)

Example weight budget (WB) summary

Table C.1 — Topsides operating weight budget

Area code	Facility area/module	Budget weight	Management reserves	Planned futures	Opera-tional reserves	NTE	Centre of gravity		
		t	t	t	t	t	E	N	El
A	Utilities area								
B	Mud module								
C	Derrick substr./ derrick								
D	Flare boom								
E	Living quarters								
F	Process deck 1 and 2								
G	Process deck 3, 4, 5 and pipe-rack								
H	Well bay								
I	Hook-up								
J	Total								

Annex D
(informative)

Guidelines for displacement measurement of floating facilities

D.1 General

D.1.1 Procedure for displacement measurement

This annex gives guidelines for the minimum requirements for a displacement measurement in order to provide reliable and accurate results for weight management purposes. When formal inclining experiments are performed, the individual requirements from the classification society in question should be followed.

Data obtained from the lightweight survey and inclining experiment applied for safety reasons by the classification society can be used by the weight discipline provided certain requirements are fulfilled.

This method gives a lower degree of accuracy as compared with weighing using load cells.

The contractor should prepare a displacement measurement procedure incorporating the classification society requirements in question. The contractor's procedure should be made available to the client representative at least one month in advance of the planned displacement measurement date.

D.1.2 Displacement measurement subcontractor

The displacement measurement should be conducted by the contractor and/or classification society in question. Both the client representative and the contractor should be present during the measurement.

Major elements of displacement for floating facilities is shown in Figure D.1.

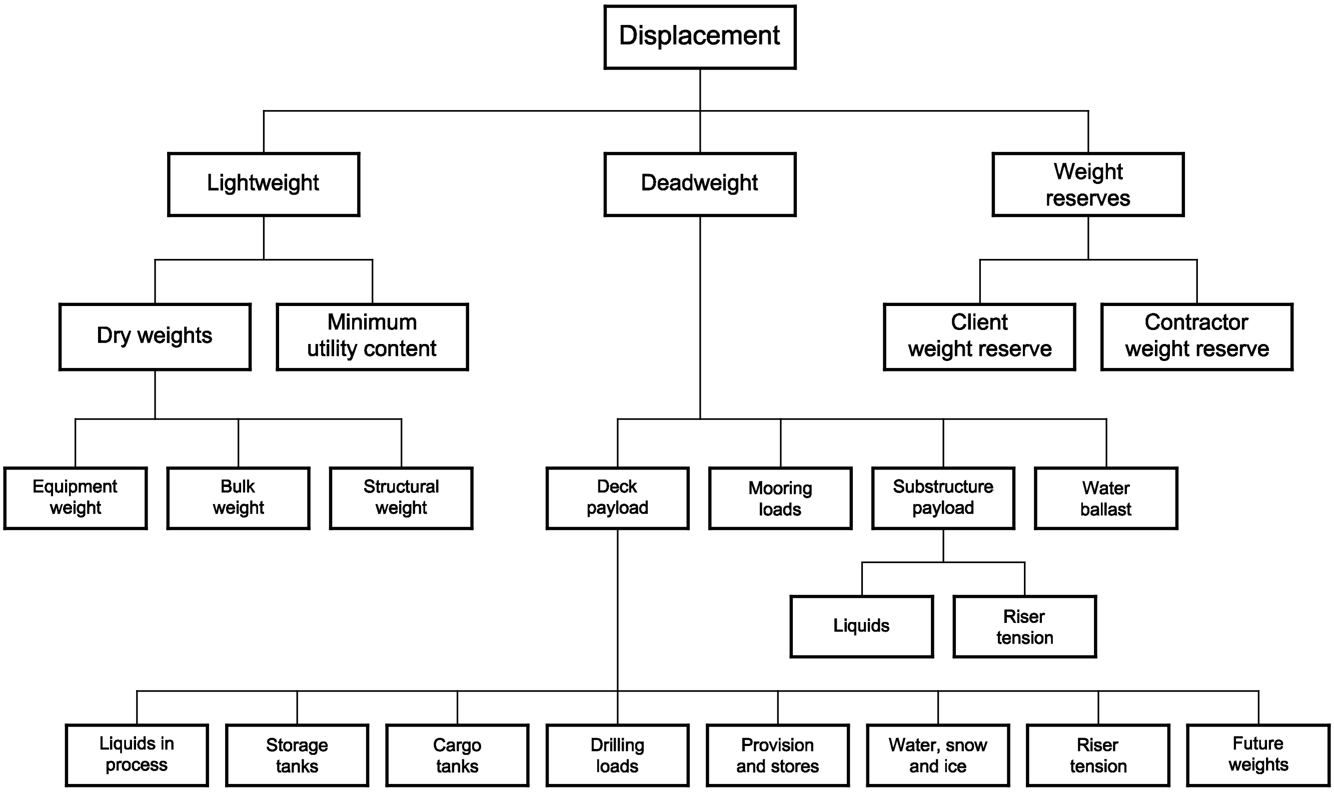


Figure D.1—Weight displacement summary, design operating condition

D.2 Environmental conditions for displacement measurement

The following requirements should be implemented:

a) a sheltered location should be found in which the measurement can be carried out;

b) sufficient time, approximately 12 h, should be allowed for the measurement operation;

c) good weather should be forecast;

d) the wind speed should be below 5 m/s;

e) there should be no significant swell;

f) the maximum wave height should be 1,0 m and there should be no substantial current;

g) the floating structure should be free-floating;

h) time and location should be indicated, as well as water depth.

D.3 Displacement measurement

D.3.1 Displacement measurement procedure

The contractor should submit his proposed displacement measurement procedure for approval at least one month in advance of the planned measurement date.

The displacement measurement procedure should cover at least the following subjects:

a) description of devices and method;

b) assessment of measurement accuracy;

c) dimensional sketches of the measurement arrangement;

d) contractor's organization of the measurement operation.

e) mathematics to be used for interpretation of the results.

f) determination of impact of free surface area in partially filled tanks and vessels.

D.3.2 Notification

The client representative should be notified in writing of planned displacement measurement dates 15 working days in advance.

D.3.3 Preparation of the displacement measurement

D.3.3.1 Displacement measurement prediction report

The contractor should make a preliminary displacement measurement prediction report prior to the measurement. This report should be presented to the project no later than 24 h prior to the measurement operation with a final update immediately prior to the displacement measurement.

The report should contain at least the following information:

a) total theoretical weight and CoG for the assembly to be measured;

b) expected draught on the measurement locations on both sides aft, forward and midships;

NOTE For semi-submersibles, the measured draught in the measurement locations should be at all columns.

c) listings with weight and CoG summaries for all items included in the measurement;

d) general arrangement plan “as-carried-out”;

e) draught-mark position survey;

f) listing of weight and CoG for liquids in tanks;

g) listing of permanent items temporarily located;

h) listing and summation of all temporary items including CoG, including any ballast and consumables.

D.3.3.2 Temporary items and foreign forces

The following requirements should be implemented:

a) anchors should be raked and the floating structure, if necessary, assisted by tugs;

b) floating structure should be free-floating;

c) the minimum number of personnel should be on board during test;

d) no fresh water should be consumed or produced during the measurement operation;

e) the minimum number of cables and hoses, etc. should be connected; those hoses which are connected should be slack.

D.3.4 Equipment for displacement measurement

Any device directly affecting readout of measurement results should be calibrated and have a known measurement uncertainty. This includes:

a) hydrometers (densitometers) for measuring specific gravity of the water in which the floating structure is floating;

b) thermometer for measuring seawater temperature;

c) steel measuring tape or similar for checking draught marks and draught measurements;

d) throttled transparent plastic tube or other suitable water-level measuring device for draught measurements;

e) equipment for measuring wind velocity.

D.3.5 Displacement measurement operation

If an adequate draught-mark position survey is not available, the draught marks should be checked by measuring against a known datum level on the vessel.

Two sets of draught measurements should be executed at a minimum of six locations in sequence. A third set and any subsequent draught measurement sets may be needed if one of the following problems has arisen:

a) inconsistent draught measurements; or

b) adverse environmental conditions.

The draught measurements are considered consistent if the total displacement based on each set of draught measurements does not vary from the average by more than 0,5 % and the horizontal shift in CoG is less than 0,3 % of the floating structure's dimension in the same direction. In case of inconsistent draught results, efforts should be made to identify any activity on board that might have caused movement of significant weights.

D.3.6 Displacement measurement certificate

The displacement measurement result should be presented on a displacement measurement certificate, and signed by a representative from the measurement contractor, contractor and client representative.

The displacement measurement certificate should at least contain information about:

a) floating structure identification;

b) time, date and location of measurement;

c) temperature, wind speed and wind direction;

d) water depth and estimated wave height;

e) dimensional sketch of draught measurement locations;

f) draught readings and time at which they were taken;

g) specific gravity of water in which the floating structure is floating;

h) recorded total weight and CoG for the measured assembly;

i) reference to the global coordinate system for the measured assembly;

j) identification of displacement measurement equipment used.

D.3.7 Displacement measurement report

Within seven days of the displacement measurement operation, the contractor should submit a report of the measurement operation, which should include:

a) measurement results;

b) calculation of CoG;

c) displacement measurement certificate (fully signed);

d) detailed list of installed items;

e) final prediction report;

f) assessment of the accuracy of measurement results.

Annex E
(informative)

Weight management during operations

E.1 Weight management during operations

E.1.1 General

Regular assessment and re-analysis ensure that the local and global design parameters are not exceeded by the weight impact of the modifications a facility undergoes in its operating phase.

The dry and operating weight and CoG data stored in a facility's weight database may also be used for:

a) provision of weight and CoG of equipment to assist deck crew with offshore movements and change-outs;

b) provision of weight and CoG data for future decommissioning of the installation;

c) provision of weight and CoG data for presentation to verification bodies and certifying authorities.

A high degree of confidence in the accuracy of a facility's operating weight and CoG is required; otherwise proposed load factors in ISO 19902, and ISO 19901-9 become inadequate. It is therefore critical that weight databases used in SIM models have:

a) the complete topsides dry and operating weight, with laydown and storage;

b) no significant dry and operating weight or CoG errors;

c) no significant omissions;

d) no consistent un-conservatism in the weight estimate of the items;

e) no consistent conservatism in the weight estimate of the items (for brownfield project viability);

f) no operating practices on the platform that lead to significantly higher loads than those reported in the weight database.

Reference is made to ISO 19902:2007, subclause A.9.1.

The load factors in ISO 19902 do not allow for any significant weight errors, or weight omissions (often referred to as known unknowns, and unknown unknowns).

E.1.2 References to operating weight management and SIM in other ISO standards

An up-to-date topside weight database is required in order to check whether the magnitude of weights and CoG changes have triggered the need for a SIM reassessment of the facility in accordance with ISO 19902:2007, clause 24.

A SIM system is recommended in ISO 19902:2007, 23.1, see also ISO 19901-9.

In ISO 19904-1:2006 subclauses 5.5.4 and 5.5.7 contain requirements for the update of the weight database for the structure’s operating phase.

E.2 Coincident operating weights

E.2.1 Common topside operating philosophy

It is recommended that all facility weight databases adopt a common operating philosophy as stated below.

The common operating philosophy reflects a condition when the facility is fully operating. drilling is underway.

The facility weight database comprises an inventory of the dry and operating weight and CoG of each component broken down by module and discipline. When summarized, these will reflect a snapshot impression of the maximum topside operating weight and CoG that may be experienced under normal operating conditions.

Movable items should be located in logically fixed locations e.g. cranes in parked position, forklift in its normal parking space, drilling derrick, substructure and skid base located over a corner drill slot, etc.

The maximum in-place operating condition will be a summation of the dry weights, plus operating increases from work force, equipment, bulks, contents, laydown areas, storage areas, setback area, and fully laden pipe rack applied simultaneously.

The topside weight database should not attempt to reflect the worst topside load case, as this requires the application of a number of variable factors and environmental forces should be added to the SIM model by the structural engineer e.g.:

a) stuck casing (hook load);

b) drilling modules and moveable items in most onerous location;

c) worst combination of environmental forces;

d) worst combination of hydrotest;

e) ice and snow accretion.

Likewise, transient live loads are omitted, as they are already accounted for elsewhere, i.e. workforce and luggage located in the accommodation module, and transient loads located on laydown and storage areas.

E.2.2 Coincident operating weights

See ISO 19902 for the coincident operating weights that should be included in a topside weight database for a typical oil and gas producing facility.

E.3 Drilling weight load matrix

See Table E.1 for coincident drilling weights which should be reflected in the topside weight database.

Table E.1 Drilling load and operating load combinations

	Drilling load and operating load combinations			
	A	B	C	D
	Full 9⅝” casing on pipe rack — Storm	Full 9⅝” casing on pipe rack — Operating	Stuck casing	Stuck drill string
Hook load (rated capacity of the derrick. not listed in weight report – applied by SI engineer)	Zero	Zero	X [d]	X [d]
Setback load (for longest hole including Bottom Hole Assembly +5 % rejects)	X [acg]	X [ac]	X [ac]	Zero [f]
Pipe rack load (9 5/8” casing string for longest hole, +5 % rejects)	X [a]	X [a]	X [e]	X [a]
Containers on pipe rack coincident with 9 5/8” casing load.	X [b]	X [b]	X [b]	X [b]
P-tank powder storage for cement, bentonite, and baryte (full- aerated)	X [a]	X [a]	X [a]	X [a]
Extreme wind (not listed in topside weight database – applied by SI engineer)	X [h]	X [h]	X [h]	X [h]
Operating wind (not listed in topside weight database – applied by SI engineer)	X [h]	X [h]	X [h]	X [h]
Snow and Ice accretion (not listed in topside weight database – applied by SI engineer)	X [h]	X [h]	X [h]	X [h]
Drill Water tanks (full)	X [a]	X [a]	X [a]	X [a]
Sack store (full)	X [a]	X [a]	X [a]	X [a]
Active and reserve mud tanks (HP and LP systems full)	X [a]	X [a]	X [a]	X [a]

NOTE 1 All other operating loads will be 100 % of those reported in the topside weight database

NOTE 2 Attempts to rationalize drilling loads should be avoided, as these are common conditions

NOTE 3 Full to normal operating level switches as shown on P&IDs

NOTE 4 100 % full of the normal operating fluid flowing through it

[a] 100 % of reported weight database loads

[b] 100 % of reported weight database load for supply containers and fixed containers e.g. tea shack, tool house, paint store, laboratory

[c] Setback load represents the drill string for longest hole plus 5 % rejects, plus Bottom Hole Assembly. It is stacked in 90’ stands (triples)

[d] The hook load for a typical derrick rating i.e. 1 000 000 lbs. = 454 t.

[e] Calculated for a full load of 9 ⅝" casing (approx. 80 % of hole length) plus 5 % rejects for the longest well. It is assumed 50 % of casing, plus supply and fixed containers remain on the pipe rack, while the remainder of the casing is hanging on the hook
[f] Assumed zero, as the drill string is hanging on the hook
[g] If sufficient warning is received for an approaching 100-year return storm, it is possible the drill string in the setback area may be run down the hole to reduce wind load profile
[h] These loads should not be listed in the weight database. They shall be calculated and applied by the Structural Integrity engineer

Annex F
(informative)

Requirements for topside weight estimation — new builds/green field

F.1 General

Topside weight estimation is an important activity in early phase concept development for new offshore installations. Estimated weights for topside units are important input and basis for a number of activities:

a) Weight information is one of the main input parameters for cost estimating and planning.

b) Weight information is vital for transport, lifting and installation analyses.

c) Weight information is vital for analysis of substructure capacity.

d) Weight information is vital for stability analysis, loading conditions and platform operations.

The objective for weight estimation is to predict, from the start of concept development, a topside weight as close to the final as-built weight as possible.

This annex describes weight estimation activities to take place in the early phase development of a project, covering screening/feasibility phase, concept selection phase and FEED phase prior to the detail engineering and construction phase.

F.2 Topside weight estimation methodology

All estimated weights should be given as values covering both the identified elements, as well as the anticipated, but yet unidentified/unspecified elements, giving the assumed as-built weight for the chosen concept.

Weight estimates are established by use of different methods:

a) Simple analytical models calibrated against relevant previous projects are used in the early stages, especially in screening and feasibility phases. Weights are then estimated from assumed functions and capacities and scaled based on earlier project experiences.

b) When there is sufficient knowledge about main equipment, normally after the first process simulations, the MEL should be used as basis for determining the weights of other disciplines by application of experience weight factors. This method is normally used in feasibility and concept phases, and also in FEED. Different ways to use the MEL information to establish weight estimates are given in 1) and 2).

   1) Based on MEL information, relevant topside area and volume requirements can be identified, and layout drawings can be established. Based on the layout drawings, weight for bulk and structural can be estimated based on experience area/volume density factors.

   2) Based on MEL information, equipment weight per system can be established. Based on this, weight for bulk and structural can be estimated based on experience factors for bulk and structural per system.

c) When the progress of engineering is sufficient for a Weight Take-Off (WTO) for certain disciplines, WTOs can be used for determining the weight for these disciplines. Weight allowance should then be added to account for items not yet identified. This method is applicable for some disciplines in FEED in combination with experience factors. Reported weights based on WTO shall always be verified by experience factor estimates.

F.3 Recommended weight estimation requirements

The following recommendations are used for new builds/green fields:

a) The MEL and the equipment layout should be basis for the weight estimate.

b) Weights should be reported on areas (construction units).

c) Weights in each area should be reported by equipment, structural and bulk.

d) Bulk should be reported by disciplines.

e) Structural should be reported by primary, secondary and outfitting/tertiary.

f) WTO for designed structure should be prepared, based on 3D models and /or available drawings.

g) WTO for piping should be prepared, based on 3D models and /or available drawings. Material grade should be given.

h) Weight allowance should be specified.

i) Division between topside and substructure should be clearly defined. Weights should be calculated and reported separately for the topsides and substructure.

j) CoG should be calculated.

k) Lift weight for each lifting item should be prepared.

l) Source of weight data should be given (vendor information, calculated, reference project etc.).

m) Weight accuracy and confidence level for the established weight estimate should be given, based on the chosen estimating method and level of details (i.e. weight accuracy ± 10 % with a confidence level of 80 %). The weight accuracy may be verified by statistical simulations.

n) Layout drawings and coordinate system should be given.

F.4 Master Equipment List (MEL)

The MEL is of vital importance in weight estimation. Irrespective of chosen weight estimation method, MEL is the main input and basis for the weight estimate.

Weight for each listed equipment item shall be given. Weight allowances should be used and clearly stated in the equipment list. Weight allowance should be added based on concept development and maturity.

MEL shall also include temporary equipment needed for any defined temporary operation. These items should be marked as temporary.

F.5 Weight allowance

When weight estimates are based on MEL and WTOs, a weight allowance should be added to the reported weights to account for inaccuracies and incompleteness in the definition of items. The amount of weight allowance should be determined based on experience, judgment of concept maturity and development of engineering. The amount of weight allowance added should always be specified.

When weights are estimated by comparative methods, scaling or by experience factor estimates, no weight allowance is needed as the basis for these methods are determined from existing, complete facilities, and the estimated weights are considered to be expected values.

Annex G
(informative)

Executive summary description

G.1 General

The executive summary is a one page "dashboard" summary of the weight status and trends presented in the report. The executive summary varies from project to project depending on the risks and concerns for the project or customer. The summary should address 80 % to 90 % of the issues.

An example is shown in Figure G.1.

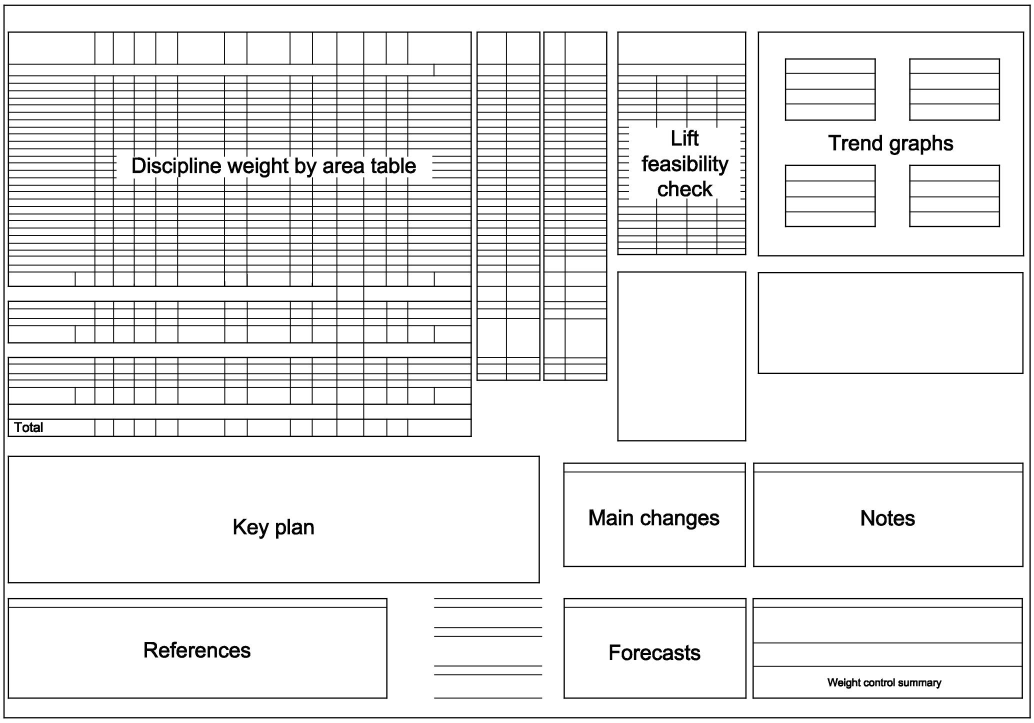


Figure G.1 — Example of an executive summary

G.2 Trend for weight and CoG

The trends are time-based trends of weight and CoG for the project. The CoG(s) that are plotted vary from project to project, based on the issues. For a module or topside the CoG envelope may be presented. For a ship or submersible hull, the KG curve may be presented. Each trend chart should have a bold limiting curve or line, with one or two trend lines shown. A future weight and CoG point should be plotted for each trend line that shows the impact of the potential changes on the currently reported weight.

G.3 Comparison to budget

Comparison to budget is a simple table that shows overall weight changes since the beginning of the project. It presents the weight budget by discipline (structure, piping, outfitting, equipment and electrical), current weight allowance, and current gross weight.

G.4 Loading conditions

G.4.1 General

This is a table of the loading conditions using the current weight and CoG. The loading conditions are a limited set of all the conditions developed by the naval architect. Typically, the loading conditions used to establish the WB, construction and extreme operating conditions or any other critical loading condition are used. The construction conditions may include launch, integration, tow out, commissioning and inclining experiment. The extreme conditions are those that are close to the edge of the weight limit or CoG envelope.

G.4.2 Management reserve analysis

Management reserve analysis is a table of the current values of net allowance, and gross weight along with the CoGs. It compares the gross weight to the NTE limits to determine the amount of management reserve.

G.4.3 Changes to this report

A list of the changes that is included in the report together with description of change, weight impact and CoG information should be provided.

G.4.4 Potential changes for next report

A list of the potential changes that may impact the weight or CoG should presented in the trend charts. Potentials may include the impact of weight changes from:

a) drawing calculations that have not been completely checked

b) design changes that have not been completed

c) rumoured weight changes from vendors, etc.

G.5 Additional summaries (depending on project)

Additional summaries that could be provided are:

a) additional loading conditions;

b) construction modules weight summaries;

c) lift weight summaries (including temporary items);

d) cost account weight summaries;

e) material take-off weight summaries;

f) summary of the weight and CoG history over the life of the project;

G.6 Discipline by Area (DA) weight summary

The DA summary is a table of the weight for each discipline and area. The disciplines are usually those identified on the organization chart or upon customer request by their definition of disciplines. These are not usually the same. The weight should be rounded to the nearest whole number.

Annex H
(informative)

Weighing result uncertainty

Multi-point weighing systems are used in the offshore oil industry to determine the overall weight and centre of gravity for both major assemblies and items of equipment weighing greater than or equal to 100 kN (10 t). These systems are not calibrated as a complete arrangement – i.e. all load cells calibrated simultaneously as a whole system. Calibrations are performed on each load cell to be used, as well any required spare load cells.

Calibration data for the individual load cells is analysed to determine the overall uncertainty of the entire system for each weighing result. The uncertainty in the weighing results is a function of the number of load cells used and the level of uncertainty associated with each load cell at the applied load.

The mathematics to determine the uncertainty of the results of a multi-point weighing system is based on the uncertainty of individual load-cells at the measured loads is expressed as:

$$\delta w = \sqrt{(LC1 \times U1)^2 + (LC2 \times U2)^2 + \cdots (LCn \times Un)^2}$$

where:

δw is the uncertainty of the weighing result based on the uncertainty of individual load cells at the measured loads;

LCn is the measured load for load cell number n;

Un is the uncertainty of load cell n at the measured load LCn, determined from calibration data.

The overall weighing system uncertainty (as a percent) is expressed as:

$$An = \frac{\delta w}{Wn} \times 100$$

where:

An is the overall uncertainty (as a percent) of weighing result n, where n = 1, 2 or 3 (three accepted weighing results);

Wn is the total weight of Module equal to summation of all load cells values for weighing result n, where n = 1, 2 or 3

Based on the equations above and using the three accepted weighing results, the average Module weight and uncertainty is expressed as:

$$Module\ Weight = \frac{(W1 \pm A1) + (W2 \pm A2) + (W3 \pm A3)}{3}$$

where:

W is total weight of Module for weighing result 1, 2 or 3

A is overall uncertainty of weighing result 1, 2 or 3

This is simplified to an average weight and an average uncertainty as:

$$Module\ Weight = \frac{(W1 + W2 + W3)}{3} \pm \frac{(A1 + A2 + A3)}{3}$$

Worked Example

Using the equations above, the following worked example determines the overall uncertainty for a weighing using eight loadcells.

Table H.1 presents the load cell readings recorded during the weighing process for the three accepted results.

Table H.1 — Raw data (measured values) gathered during the Module weighing.

LOAD CELL READINGS IN TONNES LCn			
Load cell Number	Weighing #1	Weighing #2	Weighing #3
1	217,2	218,9	214,1
2	219,3	217,1	212,9
3	201,3	205,2	197,2
4	202,2	205,1	196,0
5	214,1	207,2	207,8
6	206,3	208,1	205,2
7	205,7	204,8	215,4
8	202,6	201,7	211,6
Total Wt	1,669	1,668	1,660
	W1	W2	W3

Table H.2 provides the uncertainty data (based on the calibration curve for each load cell) at the value measured during the weighing. For simplicity, it is assumed in this example that load cell calibration has been performed at equal intervals (i.e. 50 t) over the entire range of 300 t capacity load cells.

Table H.2 — Load cell uncertainty values for the data presented in Table H.1.

LOAD CELL UNCERTAINTY ±*Un*			
Load cell Number	Weighing #1	Weighing #2	Weighing #3
1	0,0036	0,0035	0,0037
2	0,0039	0,0038	0,0036
3	0,0037	0,0038	0,0035
4	0,0033	0,0033	0,0031
5	0,0043	0,0040	0,0039
6	0,0037	0,0038	0,0037
7	0,0043	0,0043	0,0048
8	0,0037	0,0036	0,0040

Table H.3 summarises the calculated values determined from equations above.

Table H.3 —Total uncertainty based on Table H.1 and Table H.2.

PRODUCT (LCn x Un)^2			
Load cell Number	Weighing #1	Weighing #2	Weighing #3
1	0,61	0,59	0,63
2	0,73	0,68	0,59
3	0,55	0,61	0,48
4	0,45	0,46	0,37
5	0,85	0,69	0,66
6	0,58	0,63	0,58
7	0,78	0,78	1,07
8	0,56	0,53	0,72
Σ(LCn x Un)^2	5,1	4,9	5,1
δw	2,3	2,2	2,3

Due to the variability of the load cell readings and the individual uncertainty of the load cells, δw values differ slightly across the three results – between ±2.2 t and ±2.3 t.

Using the values from Tables A-1 and A-2 in the third equation above, calculates the overall weight and associated uncertainty as;

$$Module\ Weight = \frac{(1{,}669 + 1{,}668 + 1{,}660)}{3} \pm \frac{(2.3 + 2.2 + 2.3)}{3}$$

$$Module\ Weight = 1{,}666 \pm 2.2\ t$$

Annex I
(informative)

Weight management database structure

Each record in the weight management database should as a minimum contain the following information in separate data fields:

Discipline code: The discipline code according to the project's numbering system.

System code: The system code according to the project's numbering system.

Area code: The area code according to the project's numbering system.

Drawing/document number: The drawing/document number from which the weight has been identified or calculated.

Drawing/document revision: The revision of the drawing/document from which the weight has been identified or calculated.

Piece number: The unique piece within a drawing/document number.

Piece description: The description for the referred piece, e.g. HE200A.

Number off: Number of identical pieces. Only integer numbers.

Quantity: The quantity of each piece, e.g. 2,350 m for the length of an HE200A beam, 3,1 m^2 for the quantity of a plate.

Unit: The unit of the quantity for each piece, e.g. ea, m, m^2 etc.

Unit weight: The unit weight of each piece in kg/unit.

Weight: The weight of each piece in kg, the product of Number off × Quantity × Unit weight, e.g. 1 × 2,350 × 42,3 = 99,5 kg for one HE200A with a length of 2,350 m.

Content: The weight of the content in kg in a piping line, vessel, tank etc. Required if not reported as separate records with a corresponding weight phase code.

Weight status code: A coding to identify the weight allowance for each piece number.

Weight phase code: A coding to identify during which loading condition a piece number is present.

Coordinates: The global coordinates in platform east, north and elevation direction.

Content coordinates: The global coordinates for the content in platform east, north and elevation directions. Required only if content **is not** reported as separate records in the database.

Originator code: The originator code according to the project's numbering system of the organization or contractor who have calculated or revised the weight data for a piece number.

Date: The date when a piece number was entered or revised in the weight management database.

Remarks: Any qualifying notes to the record.

Annex J
(informative)

Weight management of concrete structures

J.1 General

Since reinforced concrete offshore structures are often required to float during either their construction or installation phases, proper weight management must be applied to ensure a successful completion.

While concrete offshore structures contains components made from steel and other material (e.g. internal decks, j-tubes, conductor guides, etc.), the majority of the weight of the structure will be constructed from reinforced concrete. Development of weight estimates for the non-concrete portions of the structure should be done following methods employed for conventional facilities.

Estimating weights and CoG's for the concrete portion of the structure requires procedures unique to the nature of reinforced concrete. The as-built volume of concrete as well as its in-place density are the determining factors for calculating the overall weight and CoG for the structure.

J.2 Concrete Density

Early in the design phase of a concrete structure, a series of material tests are performed to develop a concrete mix design (e.g. proportions of cement, aggregates, water, admixtures, etc.) that meets the project specifications (e.g. strength, durability, density, etc.). This work will also define the codes and standards to be followed during the mix design process, construction. These codes and standards will dictate the testing methods used to measure the plastic, cured and in-place density of the concrete.

Based on the results of the mix design work and required material properties of the concrete, project documents will define the target density and acceptable range for the average density (kg/m^3) for the in-place concrete for the entire structure, or individual concrete elements.

During the construction process, testing of the concrete density (plastic and in-place) will monitor the quality of concrete being installed. An indicative in-place concrete density may be determined from the plastic concrete. This will be useful only if testing has been done to show a relationship between the concrete density in its plastic state versus that in its cured state.

A more accurate method of measuring the concrete density is an analysis of core samples taken from the in-place material. Densities calculated from core samples will be the basis for determining the weight of the concrete portion of the structure. Project documents will detail the methods and standards used to locate and extract the cores, as well as methods to test the density of the core. The quantity of cores required will be defined in project documents, and will depend on the location of the concrete element (i.e. slab, wall, roof, etc.) and the difficulty involved in producing the cores.

If, during the construction process, the in-place density from the concrete cores shows an acceptable correlation to the target concrete density, a reduction in the required number of core samples to be taken may be considered.

A statistical analysis of the core density results should be done for each concrete element poured per the construction sequence, as well as the completed structure. The resultant average density and uncertainty (calculated using the standard error of the mean with a confidence interval of 95%) are determined and reported in the project weight report per concrete element.

J.3 Concrete volume

During preliminary design work, concrete volumes are determined from available information (e.g. drawings and incomplete 3D model). As the design develops, concrete volumes are revised to include the impact of design changes. Design concrete volumes may be updated to reflect the chosen construction sequences.

The uncertainty associated with the concrete design volumes will depend on the methods used in their calculation – with manual calculations having a greater uncertainty than data from a 3-D model of the structure. It may not be necessary to determine this uncertainty as design volumes will be replaced with as-built volumes as construction progresses.

Once construction has commenced, accurate as-built concrete element volumes and geometry are developed for the in-place material. The uncertainty associated with this data will depend on the method used; manual measurement (tape measure on formwork or completed concrete) will have a greater uncertainty than using an optical method to create a 3-D model of the as-built geometry.

Using a device located within the concrete production facility (e.g. weighing devices on bulk material, weighing device on the output from the concrete mixing drum, etc.) are not considered suitable methods for determining the weight volume of material installed in the concrete forms. These methods should be used only by the concrete production facility to monitor their production rates.

It is assumed that until the as-built dimensions of the concrete elements are determined, the CoG of each concrete element is assumed to be that of the geometric centroid of the element itself. Once as-built data is available, adjustments may be made to the assumed CoG to consider the as-built condition.

J.4 Concrete weight and CoG

During the preliminary design phase, the total weight for the concrete structure may be defined using the total calculated volume and target concrete density. If concrete of varying density is used for different concrete elements, the weight of each element will be determined using the target density for that element. The volume of permanent openings in the concrete element should be deducted from overall volumes of concrete elements.

As construction progresses and concrete elements are completed, weights for the elements will be refined using the as-built volume and measured concrete density. Weights for incomplete elements will be determined using the design volume and target concrete density.

Until as-built volume and geometry data is available, the CoG for a concrete element is assumed to be its geometric centroid – with consideration given to concrete displaced by reinforcing material within the element. Once the as-built volume and geometry is developed, the CoG will be adjusted to account for the variation between the design and as-built conditions.

The weight and CoG of concrete displaced by reinforcing material and items embedded in the concrete is to be considered in weight and CoG calculations for elements and the overall structure. The overall weight and CoG of the as-built structure will be the aggregate weight and CoG of all the concrete elements.

J.5 Concrete reinforcement

The second major component of a concrete structure is the reinforcing material – deformed steel bars (rebar) ranging from 10 mm to 50 mm in diameter.

During preliminary design, rebar weight is estimated based on an assumed density of rebar per cubic metre of concrete. This density will vary depending on the structural loads applied to the concrete element in which the reinforcement is placed. An allowance (1 % to 2 %) should be made for material required to support the rebar in the correct position (e.g. tie-wire, spacers, stools, etc.) while the concrete is being poured. Horizontal concrete elements (e.g. slabs and roofs) will require more supporting material than vertical concrete elements.

As the design advances, specific rebar sizes, lengths, quantities and placement within each concrete element are developed. Rebar weights are then calculated per concrete element by applying industry norms for rebar unit weights (kg/m) – replacing weights estimated from assumed rebar densities only as rebar design per concrete element is completed.

During the construction phase, unit weight norms for rebar will be replaced with unit weights determined from weighing random samples of material delivered to site – taking care to develop unit weights for each diameter of rebar provided by each supplier as deliveries are made to the construction site. A minimum of thirty-five random samples (1000 mm in length) should be taken for each size of rebar material to provide a statistically acceptable sample size. Assumed unit weights for rebar end-to-end connectors should also be verified by weighing random samples.

It is assumed that until the distribution of rebar (by diameter and location) is defined per concrete element, the CoG of all rebar within an element will be that of the geometric centroid of the concrete element itself. As the distribution of the rebar within a concrete element is determined, the CoG will be refined based on the rebar size (diameter), length and geometric location.

The weight and CoG of the rebar and supporting material is to be considered in weight and CoG calculations for elements and the overall structure.

J.6 Weight reporting

Creating the weight report for a concrete structure should follow the methodology of a topsides weight report. The report should contain summaries of weight and CoG presented by separate concrete elements and the overall structure.

Information regarding the development of the concrete density should be included to allow illustration of trends (by element and entire structure) and permit possible adjustment of the concrete mix to return the average density to the required value.

Annex K
(informative)

Coordinate systems

It is recommeneded that the position and orientation of all coordinate systems used to locate the weight items are defined early in the project and presented in the weight reports.

Two kinds of coordinate systems may be used:

— local coordinate systems, used to facilitate the reporting of CoG of a sub-component of the facility, e.g. hull, topside, modules and other assemblies;

— global coordinate system, used to report CoG of the facility as a whole.

If local coordinate systems are used, their position relative to the global coordinate systems needs to be presented in the weight report.

When using different coordinate systems for the facility, the position of the coordinate system of each assembly/module relative to the global coordinate system needs to be presented in the weight report.

The WMG shall verify the CoG data reported by the disciplines, looking for inconsistencies in the CoG position of items and in the coordinate systems used.

A validation routine for checking the CoG of each weight item relative to the selected coordinate system should be established. This might be done by manually checking the CoGs or by a computer aided checking routine.

It is advised that the coordinate system is created so that negative coordinates are avoided. It should also be set up in a way that the easting, northing and elevation cannot be interchanged. To avoid interchanging of the coordinates the following system may be used:

a) East: 100,000 m

b) North: 300,000 m

c) Elevation: 500,000 m

Table K.1 Coordinate systems

Type of facility	East (x)	North (y)	Elevation (z)
Topsides of fixed structures	at the middle of the cellar deck, positive to the east	at the middle of the cellar deck, positive to the north.	top of steel the lowest deck, positive upwards
Barge type FPSOs	at transon stern, positive fwd	at hull centerline, positive to starboard	at the baseline or keel, positive upwards
Ship-Shaped FPSOs	at the aft perpendicular, positive fwd	at hull centerline, positive to starboard	at the keel, positive upwards
Semi-Submersibles	at the centre of the columns, positive to the east	at the centre of the columns, positive to the north	at the baseline or keel, positive up
Fixed substructures	at the centre of legs, positive to the east	at the centre of the legs, positive to the north.	at the waterline, positive upwards

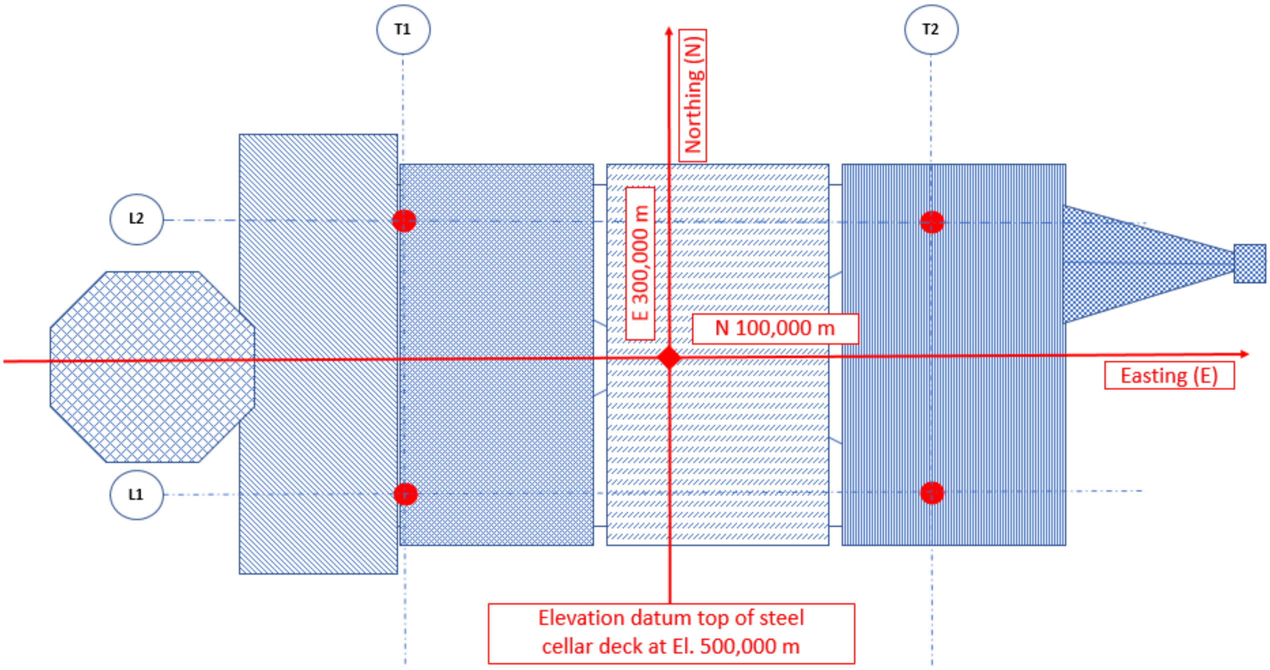


Figure K.1—Example of CoG, plan

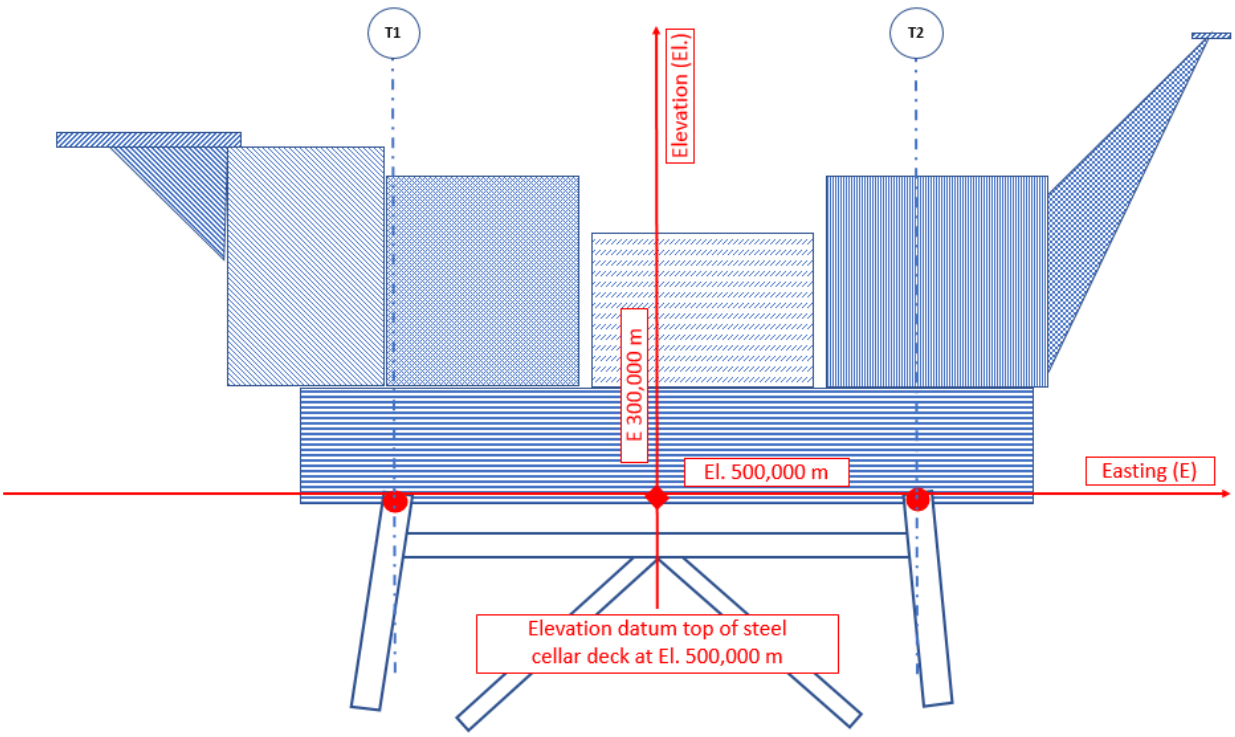


Figure K.2—Example of CoG, elevation

Bibliography

[1] ISO 19900:2019, *Petroleum and natural gas industries — General requirements for offshore structures*

[2] ISO 19901-6:2009, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 6: Marine operations*

[3] ISO 19901-7: 2013, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

[4] ISO 19901-9, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 9: Structural integrity management*

[5] ISO 19902:2007, *Petroleum and natural gas industries — Fixed steel offshore structures*

[6] ISO 19903: 2019, *Petroleum and natural gas industries — Concrete offshore structures*

[7] ISO 19904-1:2006, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Monohulls, semi-submersibles and spars*

[8] ISO 19905 (all parts), *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units*

[9] ISO 19906: 2019, *Petroleum and natural gas industries — Arctic offshore structures*

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

[11] ASTM Designation F 1321–92: *Standard Guide for Conducting a Stability Test (Lightweight Survey and Inclining Experiment) to Determine the Light Ship Displacement and Centres of Gravity of a Vessel*

[12] Det Norske Veritas: Classification Notes No. 20.2 *Lightweight determination — Ships (Inclining test and lightweight survey).* February 1990

[13] Det Norske Veritas: *Instruction to surveyors for classification of Mobile Offshore Units. Units under construction. Hull and Equipment.* No. I-B31 General Survey.

