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| **SAWE_Logo_300x104.jpg****SOCIETY OF ALLIED****WEIGHT ENGINEERS, INC.** | **RECOMMENDED****PRACTICE****Document No.****SAWE FD RP O-3:2019-02** |
| *Aerospace • Marine • Offshore • Land Vehicle • Allied Industries*Executive Director375 Redondo Ave Unit #624Long Beach, CA 90814 | Date Issued 27 August 2019  |

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|  **Generic Weighing Procedure for Assemblies and Modules in the Offshore Oil Industry** |

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| **Revision Letter** | **-** |

**Prepared by**

**Offshore Industry Committee of the**

**Standards & Practices Committee of the**

**Society of Allied Weight Engineers, Inc.**

**(SAWE, www.sawe.org)**

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Change Record

| **Rev** | **Date** | **Description** | **Entered by** |
| --- | --- | --- | --- |
| - | TBD | * Initial Issue
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|  |  |  |  |

Details changes listed below will be moved to the Development record at publication!

| **Rev** | **Date** | **Description** | **Entered by** |
| --- | --- | --- | --- |
| - | 10 May 2011 | Working Draft created | D. Bennett |
| CD 01 | 21 Mar 2016 | Committee Draft created using the new RP template form, for public review | A Schuster |
| CD 02 |  | Revised sections to include:* 6.2 – calibration certificate date 2 days prior & 14 days after weighing
* 7.1 – calibration company either local or from country of purchase
* 7.2 – added ASTM & ISO calibration standards that should be used
* 7.3 – at each point
* 7.4 – submit example certificate 14 days prior to weighing vs 48 hours
* 9.4 – submit results to Weight Lead
* 10 – updated references to reflect 7.2
 | D Bennett&A Schuster |
| CD 03 | 24 Jun 2018 | Revisions:* All bulleted lists replaced with numbered lists to improve referring to specific items.
* Revised Definitions of Terms.
* Deletion of Terms not used in the document.
* Revised Definitions of Terms
* Deleted Sections 4.3 and 5. Not appropriate to this document.
* Replaced “weight measuring device” with “load cell”
* Replaced “accuracy” with “uncertainty”.
* Post-weighing calibrations only if absolutely necessary.
* Added Figures to explain specific terms.
* Addition of Appendix A to determine weighing uncertainty.
* Added importance of resisting requirement for ‘Intermediate Weighings’
 | D. Bennett |
| CD 04 | 10 Oct 2018 | * Title revised
* Document revised to be more generic.
* Reverence to Fabricator & Contractor are removed.
* Revised Definition of Terms to align with RP O-1
* Deleted Section 4.3 Codes. Development of identification codes for Assemblies and Modules is a project responsibility and dependent on project requirements.
* Section 5.1 updated to note possible weighing of an entire topsides.
* Throughout document, ‘accuracy’ has been replaced with ‘uncertainty’.
* Revised 5.6.10 to reflect normal practice of calibrating load cells prior to a weighing, or series of weighings for a specific project.
* Revised 5.7 to include input from the Weight Control Lead.
* Revised last paragraph of 6.1 to improve requirement for post-weighing recalibration of load cells.
* Revised 7.1.3 to have the final weight prediction completed by the Fabricator and Weight Control Lead,
* Revised 7.1.13 to include comment about interchanging hydraulic jacks with integral load cells.
 | D. Bennett |
| PD | 1 June 2019 | * posted in April through June
* No comments were received
 | A Schuster |
| FD-01 | 18 June 2019 | Converted to the current SAWE SnP-2 RP template * Put RP on a 5 year maintenance cycle on the disclaimer page,
* Eliminated subheading 7.1 because there was no 7.2, and changed the title of 7.0 to include the “Activities during a Weighing”
* Converted all NBs to Italic text to add emphasis
* Converted Canadian to American English spelling,
	1. spelling like: organise to organize
	2. NB to Take Note
* Changed Figure 1 thru 4 to Figures 4-1 thru 4-4 and made changes throughout the documents to match.
* Added the definition of Weight Data in section 2 Purpose to Section 4.1 Definition of Terms
* replaced Weight Control Engineer, with Weight Control Lead, for consistency sections 6.3, 7, 8 & 8.1
* add symbols used in the appendix A to section 4.2
* Changed “document” in the second paragraph of the purpose to “Recommended Practice” and then refer/ed to the document/RP as “it”
 | A Schuster |
| FD-02 | 27 Aug 2019 | **Peer Review Comments by R. Zimmerman** **Cover Page & Disclaimer Address should be:** 375 Redondo Ave Unit #624, Long Beach, CA 90814Resolution: Correction made**Cover** “© 2016”? Shouldn’t this be © 2019?Resolution: andy will fix it**Page 7 Section 4.1** Under Weight Correction Factor, “*weight and CG to be added to or subtracted from the Predicted Weight to obtain the Weighed Weight data determined during the weighing*.” Center of Gravity values are not additive, they are summed weighted averages. This definition has the possibility of creating a dangerous situation if taken literally as written.Resolution: added that the RP was to be used by the Weight Control Lead, who by definition knows that CGs are not additive.**Page 9 Section 5.1** “*The VCG shall be based on calculations. It is generally assumed that weighing results data consistent with the predicted weight data indicate that the calculated VCG will approximate the actual VCG within a similar level of uncertainty to that of the horizontal CG*.” This is just an assumption – 2 axis CG measurements, which is what the planar measurements being undertaken here is - do not determine any third axis CG. The resultant calculated 3rd axis CG is based on the faith that the 3rd axis data has been entered and calculated correctly.No action Required, Robert is now OK with the text as is.**Page 15 Section7.1 ¶10 – Is the word “Revie”** really the right word? I suspect that the correct word is “Review”. Resolution: correction made**Page 19 Final equation is touted as Total Uncertainty (%).** If this is to be expressed as a percentage as the equation indicates, it should be multiplied by 100.Resolution: correction made**Page 19 No mention of CG uncertaint**y. The equations on this page are all for weight, not CG.The equation for a center of gravity uncertainty along the X axis would look like this:where the  symbol signifies the uncertainty of a parameter (weight or Xcg) as specified by the subscript.Resolution – not to add the equation, but it to add it in the first update.**D Bennet 8/27 comment:** * 4 Weighing Correction Factor “See Figure 4-1…” should be “See Figures 4-1…”.

7.10 “insure” should be “ensure”. |  |

Foreword

This document shall be maintained periodically by the review of the entire document; action to revise or reaffirm it shall be on a schedule not to exceed five years from the date of its approval.

Questions regarding this document may be made by e-mail to: STANDARDS@sawe.org.

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# Scope

This document describes the Weighing Procedure to be used to weigh completed Assemblies or Modules for the fabrication of the Topsides portion of an Offshore Oil facility.

Presented in this procedure are methods to be employed for the preparation and reporting of the weighing of an Assembly or Module.

All timeframes noted in this document should be considered as minimums. Project requirements shall dictate actual timeframes to be used.

Responsibilities noted in this document should be modified to align with specific project requirements.

# Purpose

Weight Control of offshore installations is critical to ensure that any Assembly, Module or Topsides may be installed using the proposed method, with minimum hook-up, and that the overall design caters for the most severe operating criteria identified.

This Recommended Practice establishes the requirements for weighing Assemblies, Modules or a complete Topsides facility. It presents methods for preparation before a weighing and reporting results after a weighing has been completed. It also establishes methods employed to determine the center of gravity from weighing results. It is to be used by the project Weight Control Lead.

**Note:**

The term ‘weight data’ is used throughout in this document. Unless otherwise noted, this term is considered to include both weight and CG (centre of gravity) information.

All weight data presented by Fabricators shall be presented in units defined by project requirements. CG data shall be presented in the project defined coordinate system.

# Associated Documents

None.

# Definitions, Abbreviations, Acronyms

## Definition of Terms

The following words and phrases are defined for use within this document:

**As-Built Weight** – the mathematical combination of the as-weighed weight data, plus weight data for permanent items not installed at the time of the weighing plus adjustments for permanent items relocated during the weighing. See Figure 4-3.

**Assembly** – (per ISO 19901-5) designed and fabricated group of bulk and equipment items which form one unit.

**As-Weighed Weight** – weighed weight data plus weighing correction factor, less temporary items present during a weighing. See Figure 4-2.

**Center of Gravity** – The point through which all weights which make up the topsides, facility, or ship and its contents may be assumed to act. This center has the conventional meaning used in mechanics, i.e. it is the point at which the sum of the moments of all the weights in the topsides, facility, or ship, with reference to any axis through this point, is equal to zero.

**Consistent Results** – results obtained during the weighing of an Assembly or Module that meet the requirement that a single reading during a weighing shall not vary from the mathematical average of three consecutive readings by greater than the project defined uncertainty for the calibration of the load cells – e.g. +/-0.5%.

**Fabricator** – Organization (e.g. ship yard) contracted to fabricate the Assembly or Module.

**Fabrication Supports** – structural supports on which an Assembly or Module is supported during fabrication.

**Final Weighed Weight –** the average of the three readings obtained during the weighing process.

**Hook-up** – the process of interconnecting several Assemblies or Modules to complete a Topsides. This typically includes installation of structural elements, piping systems, cabling, etc. to create a function facility.

**Load cell** – a calibrated compression device utilizing electronic strain gauges to measure an applied weight. *TAKE NOTE*: *Load cells are accepted as the ‘standard’ for weighing offshore assemblies and modules. Using pressure transducers on hydraulic jacks are an alternative if project is able to accept increased uncertainty (up to +/-5%*).

**Module** – a contractually predefined building block that will be combined with other modules to complete a larger facility. Often associated with Topside construction.

**Predicted Weight** – weight data expected to be measured during the weighing process of an Assembly or Module. See Figure 4-1.

**Predicted Weight Report** – document created by the fabricator detailing the latest estimated weight data - determined immediately prior to the weighing of an Assembly or Module. See Section 5.2.

**Project** – design, construction, fabrication and installation of an offshore platform.

**Reading** – weight data gathered during the process of placing an Assembly or Module onto load cells.

**Relocated Item** – a permanent item that is placed in a temporary location during the weighing operation, and returned to its permanent location after the weighing.

**Temporaries** – (per ISO 19901-5) components, assemblies or utility items temporarily installed during a specific loading condition and removed afterwards, either prior to or after installation. Items temporarily used during Fabrication, Transportation and Installation, e.g. guides, stops, bumpers, scaffolding etc.

**Weight Data –** The term ‘weight data’ is used throughout in this document. Unless otherwise noted, this term is considered to include both weight and CG (centre of gravity) information. All weight data presented by Fabricators shall be presented in units defined by project requirements. CG data shall be presented in the project defined coordinate system.

**Weighed Weight** – weight data of an Assembly or Module determined by using calibrated load cells while following an agreed to procedure.

**Weighing** - process of using load cells to determine the weight data of an Assembly or Module.

**Weighing Certificate** - a single-page summary of the as-weighed weight data for an Assembly or Module as it is expected to be transferred from the Fabricator’s responsibility to a lift or transport contractor. A weighing certificate is presented to a transportation contractor immediately prior to acceptance of the Assembly or Module onto their vessel. It is created to satisfy requirements of marine warranty surveyors or insurance companies.

**Weight Control Lead –** the person appointed by the Project to be solely responsible for monitoring and reporting weight data for the completed Topsides and its separate Modules.

**Weighing Correction Factor** – weight and CG to be added to or subtracted from the Predicted Weight to obtain the Weighed Weight data determined during the weighing. See Figures 4-1 thru 4.4

**Weighing Procedure** – a document submitted by the Fabricator detailing how the weighing of an Assembly or Module is to be completed. See Section 5.6.

**Weighing Report** – a document completed by the Fabricator that includes all data gathered to determine the predicted weight data plus all values gathered during a weighing operation to determine a Weighed Weight**.** See Section 8.

**Weighing Support** – structural support on which load cells are installed. These may be the same as or different from the Fabrication Supports.

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| --- |
| Weight data for all permanent items expected to be installed at completion of fabrication |
| Plus: Weight data of Temporary items present for the weighing |
| Less: Weight data of Permanent items not installed for the weighing |
| Less: Weight data for Permanent Items relocated during the weighing (permanent location) |
| Plus: Weight data for Permanent items relocated during the weighing (temporary location) |
| **Equals: Predicted Weight data** |

Figure 4‑1 - Determination of Predicted Weight Data

|  |
| --- |
| Weighed Weight data measured during weighing |
| Plus: Weighing Correction Factor |
| Less: Weight data of Temporary items present for the weighing |
| **Equals: As-Weighed Weight Data** |

Figure 4‑2 - Determination of As-Weighed Weight Data

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| As-Weighed Weight data |
| Plus: Weight data of Permanent items not installed for the weighing |
| Less: Weight data for permanent items relocated (temporary location) |
| Plus: Weight data for Permanent items relocated (permanent location) |
| **Equals: As-Built Weight Data** |

Figure 4‑3 - Determination of As-Built Weight Data

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| --- |
| Predicted Weight data |
| Less: Weighed Weight data measured during weighing |
| **Equals: Weighing Correction Factor** |

Figure 4‑4 - Determination of Weighing Correction Factor

## Abbreviations, Acronyms and Symbols

The table below lists items used in the document in alphabetical order.

Table 4‑1 Abbreviations, Acronyms and Symbols

| **Symbol** | **Description** |
| --- | --- |
| ∆Weighing | Total Uncertainty of overall weighing result |
| ∆Wx | Uncertainty in single accepted weighing reading (*x = 1, 2 or 3)* determined in (1) |
| CG | Centre of Gravity |
| *i* | Number of Load Cells used |
| m | Meter |
| m/s | Meters per second |
| RP | Recommended Practice |
| s | Second |
| U*n* | Uncertainty for Load Cell n at measured weight wn |
| w*n* | Weight measured on Load Cell n |

# Weighing of Assemblies or Modules

## Weighing Requirements

All Assemblies and Modules shall have their weights measured and CG determined – per Project requirements - using an approved procedure and calibrated load cells. If the capacity of the proposed weighing system permits, an entire Topsides may also be weighed.

The Weighing shall be performed using hydraulic jacks to raise the Assembly or Module from its temporary fabrication supports, and calibrated load cells to measure loads and determine the horizontal CG.

The horizontal CG of the Module or Assembly shall be determined from the weight distribution measured with the load cells. The VCG shall be based on calculations. It is generally assumed that weighing results data consistent with the predicted weight data indicate that the calculated VCG will approximate the actual VCG within a similar level of uncertainty to that of the horizontal CG.

Weighing a Module or Assembly using a single crane-mounted load cell (load link) shall not be permitted as it is impossible to determine the location of the horizontal CG within an acceptable level of uncertainty.

## Schedule of Weighings

Weighings shall be scheduled as late in the fabrication process as is practicable. Weighings provide results with the least amount of uncertainty if they are performed immediately prior to departure of the Assembly or Module from the Fabricator’s facilities. Scheduling a weighing will be dependent on project requirements – e.g. load-out schedule and amount of remaining work to be completed.

## Number of Weighings

Unless stipulated otherwise, the Fabricator shall plan for and execute one weighing for each Assembly or Module required to be weighed.

Intermediate weighings (i.e. before 99% completion) should only be performed in special circumstances – e.g. the weight control program has not provided management with sufficient confidence in the values determined. Performing an intermediate weighing requires determination of which permanent items have or have not been installed at that time. If not done with a higher level of detail than if the weighing were done at the end of fabrication - when it is assumed that only a minor amount of fabrication is remaining to be performed - weighing results may not meet the expected level of uncertainty.

The large weight of temporaries present during an intermediate weighing is an additional complication. The weight of temporaries present will significantly exceed the 1% limit defined elsewhere in this document. Results of an intermediate weighing should be considered as ‘indicative only’ and should be used carefully to ascertain if changes to design or transportation method are warranted.

The time and manpower required to perform surveys of outstanding permanent work and temporaries for an intermediate weighing will impact the fabrication schedule. For the weighing uncertainty to meet project requirements, all fabrication work may have to cease during the time of surveying the permanent and temporary items – up to the completion of the weighing process.

## Notice of Weighing Date

The Fabricator is to provide the Weight Control Lead with a minimum of four-week written notice prior to the date of a weighing. The date is to be reconfirmed a minimum of five-working days prior to the scheduled date.

## Witnessing of Weighings

The project Weight Control Lead shall witness the weighing of all Assemblies and Modules.

## Weighing Procedure

A minimum of three months prior to the expecting weighing date, the Fabricator shall submit a written weighing procedure to the project Weight Control Lead for approval.

The Weighing Procedure shall include, but is not limited to:

1. Structural details of weighing supports and load spreaders (if required) used to distribute the weight of the Assembly or Module to the locations of the load cells.
2. Calculations demonstrating that supports, jacking points, foundations will not be over stressed during weighing operations.
3. A schematic diagram showing the arrangement of hydraulic jacks, hydraulic pumps, control systems and interconnecting pipework to be used during the weighing operation.
4. A diagram showing the connections between the load cells, recording devices and control panels.
5. A dimensioned drawing showing proposed locations (in the project coordinate system) of load cells beneath the Assembly or Module.
6. A description of the load cells and recording equipment devices to be used, giving their rated capacity and expected uncertainty. All weight measuring systems shall incorporate a digital read-out or similar device that gives a continuous reading for each load cell, plus a total of all weights measured. Dial gauges are not permitted. Fabricators are encouraged to use a system that provides an instantaneous print-out of the weighing readings from all load cells. All load cells shall be of identical manufacture and capacity.
7. A description, including all safety measures, of the method to be used to control the vertical movement of the Assembly or Module during the weighing operations. Systems used to raise an Assembly or Module shall be controlled by a single device to prevent differential rising – i.e. twisting or racking - of the item. The hydraulic system shall have a separate emergency stop button capable of signaling the system to hold hydraulic devices in-place at any time.
8. Example calibration certificates for all load cells (including spares) to be used during the weighing. Copies of the actual calibration certificates shall be submitted to the Weight Control Lead for review and approval a maximum of two-business days after the calibrations have been completed and a minimum of fourteen-days before the scheduled weighing date. The Weighing shall not proceed until calibration certificates are approved. See Section 6 for additional information.
9. A statement that provisions shall be made for recalibration of specific load cells within fourteen-days of completion of the weighing. Post-weighing calibration certificates for all load cells shall be submitted to the project Weight Control Lead within seven-days of their recalibration. Refer to Section 6.2 for additional information.
10. A statement that the load cells have not been used for another weighing since their calibration before the weighing, and will not be used for another weighing before they are re-calibrated after completion of the weighing. When weighing of multiple items is required for a specific project, it is permissible to perform the calibration prior to the initial weighing, and use the load cells for subsequent weighings for that project. Weighing of other items – not related to the specific project – shall be permitted only with project approval.
11. Confirmation that spare load cells, recording and lifting devices will be available and in working order such that equipment failure will not cause undue delay or cancellation of a weighing. Spare load cells are to have approved calibration certificates in-place prior to start of the weighing. A minimum of two or 10% (whichever is greater) additional load cells shall be present at the time of the weighing.
12. A statement that load cells will be sized in capacity such that the weight applied during the weighing operation will be within the range of between 20% and 80% of the devices’ rated capacity. *TAKE NOTE*: *The lower 20% limit is based on historical information showing load cell calibrations are not consistent at low loads. Upper 80% limit used to provide a margin of safety to allow for a small level of ‘shock loading’ (as the weight is applied to the load cell) without impacting the calibration of the load cell, and in case the load distribution on the load cells is not precisely as expected.*
13. A statement confirming that a weighing will not take place if the ambient temperature lies outside the manufacturer’s recommended environmental operational range (temperature and humidity) for the load cells. Recommended environmental operating ranges shall be included in the procedure. Inclusion of a copy of the user’s manual for the load cells is recommended.
14. Provide the method and information for the equipment to be used for measurement of wind speed at the time of weighing. A Weighing will not be permitted if the measured wind speed (10-minute average) exceeds 5 m/s, or gusts 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. Use of crane mounted wind speed measuring devices may be acceptable if the height of the device is considered. *Take Note: If wind speeds - of any value or direction – are expected to impact determining the CG, the weighing shall be postponed until favorable wind conditions prevail. Determining the impact of the wind on the measured CG is not an exact calculation as Assemblies and Modules will have varying sail areas and wind resistances. Application of available formulae (typically from building code documents) are not applicable due to the significant difference between the smooth surface of a building and the rough surface of an Assembly or Module.*
15. A statement that the weighing shall take place during time of suitable natural lighting. Artificial lighting meeting local health and safety requirements may be used to permit a safe operation during times of insufficient natural lighting.
16. Example calculation of determination of CG based on the results of the weighing method used.
17. A description of the method to be used to determine the aggregate weight data of temporary items that may be present during the weighing operation.
18. A description of how (based on the weighing results) the statistical variation of readings from load cells (based on calibration uncertainty) shall be combined to produce an aggregate uncertainty for the weighed weight and CG. See Appendix A for example calculations.
19. A statement that there shall be no workers present on the Assembly or Module at the time of the Weighing. See Section 7, item 9 for additional information.
20. A statement that during the weighing, access to the area immediately beneath the Assembly or Module shall be restricted to those directly involved with the weighing operation.
21. Example calculations showing how permanent items not present for the weighing are mathematically added to the weighing results, and how temporary items not forming part of the permanent items are mathematically removed from the weighing results.
22. A statement confirming that the weighing equipment shall not be demobilized until the results are accepted by those witnessing the weighing.
23. An anticipated schedule (year and month) for the weighing. The actual weighing date shall be provided to the project Weight Control Lead a minimum of four-weeks prior to the date.
24. The geographic location (address) for the weighing.
25. A list of projects (names and weights) – of comparable weight – that have been weighed using a similar system as proposed in the procedure.
26. If Fabricator employees are to be used for the weighing operation, include an organization chart listing names and roles of key personnel.
27. If used, the name and contact information of weighing subcontractor to be employed, along with documentation showing relevant experience.
28. Method to be used to insure the levelness of the Assembly or Module during all steps of the weighing operation. During the weighing and raising operations, the Assembly or Module will be kept level within the greater of 2mm or 1/1000 of the distance between adjacent jacking points

## Predicted Weight Report

The Fabricator – with assistance from the Weight Control Lead - shall submit a written Predicted Weight Report that shall include, but is not limited to:

1. A detailed listing of permanent items not installed for the weighing. This may be in the form of photographs and annotated drawings showing their location(s) on the Assembly or Module.
2. A detailed listing of temporary items expected to be present for the weighing. This may be in the form of photographs and annotated drawings showing their location(s) on the Assembly or Module.
3. A detailed listing of permanent items expected to be installed in temporary location(s) for the weighing and returned to their permanent location subsequent to the weighing. This may be in the form of photographs and annotated drawings showing their location(s) on the Assembly or Module.
4. A mathematical aggregation of the weight data for the items noted above, resulting in a single weight and CG referred to as the ‘predicted weight”.

# Calibration of Load cells

## Calibration

The Fabricator shall ensure that the calibration of load cells is carried out by a specialized testing firm that is accredited by a suitable national association in either the country in which the weighing is to be performed, or the country in which the appointed weighing subcontractor is based.

The location of the calibration shall be determined to reduce transportation needs for load cells requiring post-weighing recalibration. The recalibration shall be performed by the same firm and in the same laboratory employed to complete the original calibrations.

Load cells shall be calibrated a maximum of three-months prior to a weighing. Calibrations shall be in accordance with a recognized standard and be done over the full range of capacity of the load cell. Accepted calibration standards are current revisions of ISO 376 or ASTM E74.

Once calibrated, load cells shall not be used for any weighings other than those directly related to the Project. Load cells shall not be released for use on other work until required post-weighing calibrations have been completed and accepted.

Fabricator shall provide to the Weight Control Lead with three-week written notice of the date and location of the calibration. The Weight Control Lead, shall be afforded the opportunity of witnessing the calibration.

Where the reading given by the load cell is dependent on the length of cable between the load cell and the display, the calibration is to be for the combined system – i.e. load cell, display, amplification devices and interconnecting cable.

Post-weighing recalibration should be reserved for load cells that have been used but may have produced spurious results. Recalibration of load cells that have produced acceptable values may result in a recalibration that casts doubt on the original results due to damage caused to the load cell while being handled between the weighing and the recalibration. Recalibrations should be considered if it is expected to reduce uncertainty in the weighing data obtained. Unless load cells can easily be recalibrated within the same country as they were originally calibrated (i.e. a short transportation time), recalibration should be considered only if necessary. Requirement for recalibration shall be agreed to by all parties involved in the weighing process.

## Uncertainty of Calibration

All load cells are to be calibrated to an uncertainty specified by the Project. This is typically +/-0.5% (or better) expanded uncertainty relative to the appropriate national standard, at each calibration point over the load cell’s entire range of capacity.

## Calibration Certificates

If the load cells are scheduled for calibration after submission of the weighing procedure, but before the proposed weighing date, example calibration certificates may be submitted with the procedure. Example calibration certificates shall represent the typical information provided for calibrations performed by the laboratory selected to complete the calibrations for the load cells to be used for the weighing.

Final copies of the calibration certificates shall be submitted to the Weight Control Lead for review and approval a minimum of fourteen-days prior to the proposed weighing date. Weighings shall not proceed until calibration certificates are approved.

Fabricators shall retain the originals of the calibration documents.

A calibration certificate shall include, but is not limited to:

1. date of calibration,
2. name, address and contact information (telephone number) of the organisation performing the calibration,
3. manufacturer, model number and serial number and uncertainty of each load cell being calibrated,
4. manufacturer, model number and serial number of the machine performing the calibration,
5. date that the calibration machine was last calibrated and the standard used,
6. tabular results of calibration of the load cell indicating the load applied by the calibration machine and the subsequent reading from the load cell, *TAKE NOTE: Tabular calibration data (i.e. uncertainty at applied load for a pre-determined number load increments) for the load cells is required to determine the uncertainty of the weight reading at the measured value. See formula (1) in Appendix A. Simple calibration documents stating the load cell meets the required level of uncertainty would not be acceptable as they would not provide the necessary data from which interpolations may be made to derive uncertainty for a given applied load.*
7. temperature range over which the calibration is valid,
8. standard to which load cells have been calibrated.

# Weighing Operation – Activities during a Weighing

The weighing operation shall include, but is not be limited to:

1. Remove - as far as is practicable - items not forming part of the permanent weight. This will include the following:
	1. all temporary construction aids, construction equipment and items not forming part of the permanent weight,
	2. all rainwater, snow and ice accumulated on decks (Weight data for water accumulated in deck drain boxes should be considered only if greater than an agreed to limit – i.e. 0.1% of the predicted weight.),
	3. all fluids (hydro-test, contents of tanks/vessels for which weight data cannot be determined with reasonable uncertainty, etc.) other than operational liquids (i.e. permanent lube oils and coolants). Consideration should be given to keeping fluids that are installed prior to the weighing and are required for use immediately after the weighing. Returning fluids may have a detrimental impact on the fabrication schedule. Such fluids may be retained only if weight data may be determined.
2. Finalize the list of temporary items, which for safety or other considerations must remain in-place, the list of permanent items that are not installed and the list of permanent items relocated from their permanent positions. These lists will include clear identification of the item, its weight and approximate location. Include a photographic record documenting the temporary items to remain, and the location of permanent items that are not installed. These lists will be compiled by the Fabricator, and confirmed by the Weight Control Lead prior to commencement of a weighing. The total weight of temporaries present for the weighing shall not exceed 1% of the estimated weight of permanent items present. If permitted by the Project, the weight of temporary items that have been weighed per project requirements may be excluded from the 1% weight limit.
3. The Fabricator and Weight Control Lead shall agree on the final version of the predicted weight report a minimum of 48-hours before the scheduled weighing. This shall include a summary of calculations to determine the expected weight data to be measured; inclusive of temporaries present, permanent items excluded and permanent items relocated for the weighing.
4. Erect barricades to limit access to the Assembly or Module to authorized personnel only during the weighing operation.
5. Disconnect all high frequency electrical sources, such as weld sets, in close proximity to the weighing equipment. *TAKE NOTE*: *Welding during a weighing must be stopped as spurious electrical current may flow through and damage a load cell*.
6. Disconnect any restraints (e.g. external scaffolding connected to the Assembly or Module and supported from ground) that will impact the measured weight data as it is raised from its supports. During a preliminary test weighing, raise the Assembly or Module an additional height (e.g. 25mm). If the weight should increase, investigate for items supported from the ground and still connected to the Assembly or Module.
7. Remove welded connections between the Assembly or Module and fabrication supports. *TAKE NOTE: Failure to remove welded connections may result in an overload of the hydraulic system or the load cells during the raising process.*
8. Ensure that raising the Assembly or Module does not also raise with it any items (e.g. electrical cables, hoses, piping connections, etc.) that have not been accounted for in the list of temporary items noted above. *TAKE NOTE Rigid connections to site services should be released.* *The weights of cables and hoses running to the ground should be considered in the temporaries.*
9. Ensure that there are no personnel present on the Assembly or Module at the time of weighing. Note: This is done for safety as all external access to the Assembly or Module is released during a weighing – preventing safe access/egress.
10. Revie the location(s) of the load cells to ensure compliance with locations specified in the weighing procedure. Flag any device that has been relocated. Measure new location and update relevant documents after the weighing.
11. Immediately prior to the weighing to check that the temporary items noted in the predicted weight report are still present, the missing permanent items have not been installed and the relocated permanent items have not been moved.
12. Perform a test weighing to ensure all lifting and measuring systems are functioning correctly.
13. Perform an initial recording of all load cell data once the Assembly or Module is free of its fabrication supports. Return the Assembly to its fabrication supports to give a ‘no load’ reading on the load cells. Raise the Assembly or Module and record a second set of load cell data. If, following the second reading, there is any question of the validity of the first reading, load cells may be replaced – to the approval of the Weight Control Lead. When jacks with integral load cells are used, interchanging may not be practical due to the effort required to move large jacks. Should there be a notable difference between readings, the process will be repeated and the weighing equipment repaired or replaced as necessary. The weighing is complete when three consecutive and consistent results are obtained. The average of the accepted three consecutive and consistent readings will constitute the weighed weight of the Assembly or Module.
14. Ensure that between obtaining each set of load cell data, the Assembly or Module is removed from the load cells so as to present a ’no load’ on all read-outs. A minimum air-gap of 10mm shall be required between the load-cells and the Assembly or Module being weighed, at the time of the ’no load’ condition. If a ‘no load’ condition is not possible, make note of the values from the load cells before placing the Assembly or Module onto the load cells. Include these values in the Weighing Report.
15. During the weighing operation, the Assembly or Module shall be kept level within the greater of 2mm or 1/1000 of the distance between adjacent support points. *TAKE NOTE: Level may be controlled by the weighing system or by surveying the structure and making adjustments to the height of specific hydraulic jacks. This is required to prevent ‘racking’ of the structure and potentially damaging components.*

# Weighing Report

## Content

The Fabricator shall submit the weighing results to the Weight Control Lead in the form of a written Weighing Report that shall include, but is not limited to:

1. a revised copy of the Predicted Weight Report including any adjustments made after its final submission prior to the weighing,
2. the date, time and location for the weighing,
3. a list of all personnel (names and position) and sub-contractors involved in the weighing operation,
4. detailed weighing results including a copy all readings taken with signatures of attending representative(s) of the Fabricator, and the Weight Control Lead,
5. a detailed dimensioned drawing showing the location of the load cell(s). Any deviations in the location of the device (from the approved procedure) are to be flagged and explained,
6. explanation(s) of errors and reasons for substitution of load cells,
7. detailed calculations used to determine the as-built weight data (see Figure 4-3),
8. reconciliation of the difference between the predicted and as-measured weights, if the difference is greater than 0.5% of the predicted weight,
9. explanatory notes regarding any deviations made from the approved procedure,
10. for weighings performed outdoors, environmental conditions (air temperature, relative humidity, wind speed and direction) at the time of recording the weighing readings,
11. results of level surveys taken during the weighing operation,
12. calculations to determine the aggregate uncertainty for the weighed weight (see Appendix A),
13. if required, a completed Weighing Certificate,
14. copies of calibration certificates for the load cells,

## Submission

A preliminary weighing report shall be issued to the Weight Control Lead within five working days of the completion of a weighing. Comments shall be returned to the Fabricator within ten-working days of receipt of the report. The Fabricator shall incorporate the comments and re-issue the weighing report within five-working days of receipt of the comments.

# Post-Weighing Activities

After the weighing has been completed, the Fabricator shall monitor and report permanent items installed and temporary items removed from the Assembly or Module and not recorded in the Weighing Report.

Prior to the departure of the Assembly or Module from the Fabricator’s facilities, the Fabricator shall submit an addendum to the Weighing Report to the Weight Control Lead. This addendum will present a detailed accounting of the weight data for the additional permanent and temporary items and determine their impact on the overall weight data for the Assembly or Module. This addendum shall be submitted a minimum of 48-hours prior to the departure of the Assembly or Module.

# References

[1] ISO 19901-5, Weight Control during Engineering and Construction,

[2] Weight Control Procedure for the Project

[3] ISO 376:2011. Metallic materials - Calibration of force-proving instruments used for the verification of uniaxial testing machines

[4] ASTM E74- 13e, Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines, Active Standard ASTM E74 Developed by Subcommittee: E28.0

[5] SAWE Weight Engineer’s Handbook, May 2011

# Appendix A – Determination of Weighing Uncertainty

Determination of the aggregate uncertainty associated with weighing results is a function of the number of load cells used and the uncertainty of each load cell at the weight being measured.

The uncertainty for a single weighing reading is expressed as:

$∆Wᵪ= \sqrt{(U₁w₁)²+(U₂w₂)²+...+(Uᵢwᵢ)²}$ (1)

where:

 *∆*Wᵪ = Uncertainty in single accepted weighing reading (*x = 1, 2 or 3)*

 U*n* = Uncertainty for Load Cell n at measured weight wn

w*n* = Weight measured on Load Cell n

*i* = Number of Load Cells used

The uncertainty for the average of the three accepted results is expressed as:

$∆Weighing= \sqrt{(ΔW₁)²+(∆W₂)²+...+(∆Wᵢ)²}$ (2)

where:

 ∆Weighing = Total Uncertainty of overall weighing result

∆Wx = Uncertainty in single accepted weighing reading (*x = 1, 2 or 3)* determined in (1)

Expressed as a percentage of the total average weight, the overall uncertainty of the weighing is expressed as:

$Total Uncertainty \left(\%\right)= \frac{∆Weighing}{Average Weight}$ x 100

The greater the number of load cells used, the lower the level of uncertainty. It may be possible to use a sufficient number of load cells of slightly higher uncertainty to achieve an overall weighing uncertainty that meets the project’s requirements.