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Metrological Regulation for Load Cells
Part 1: Metrological and Technical Requirements

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OIML R 60-1
Réglementation métrologique des celleules de pesée
Partie 1: Exigences métrologiques et techniques,

Original version in: English

Contents

Part 1 Metrological and technical requirements

1. Introduction

The subject of this Recommendation, load cells comprise a distinct element or module within other complex instruments. Load cells do not produce distinct quantitative values that are inherently identified or associated with denominations or units. The data that can be extracted from a load cell is simply a measurement of change in the output of the load cell in relation to the input. This relative change must be converted by other elements or modules within an instrument into values that are meaningful measurements which can then be used to identify a quantity.

Although strain gauge technology was a primary focus in the initial development of R60, it is to be understood that load cells that operate using other principles may also be evaluated under this Recommendation.

2. Scope

2.1.

This Recommendation prescribes the principal metrological static requirements and static evaluation procedures for load cells used in the determination of conformity to this recommendation. It is intended to provide authorities with uniform means for determining the metrological characteristics of load cells used in measuring instruments that are subjected to metrological controls.

It is acknowledged that test procedures found in Part 2 of this Recommendation (see section 8) are useful in the evaluation of load cells that are currently found in service (i.e., primarily strain gauge design) however, there may be variations in designs for load cells that will require additional or modified test procedures to appropriately evaluate them. These additional test procedures may be annexed when necessary.

Except where otherwise specified, these requirements apply regardless of the technology or operating principle employed. The requirements and evaluation procedures in this Recommendation have been drafted to be non-specific with regard to load cell design and their operating principles.

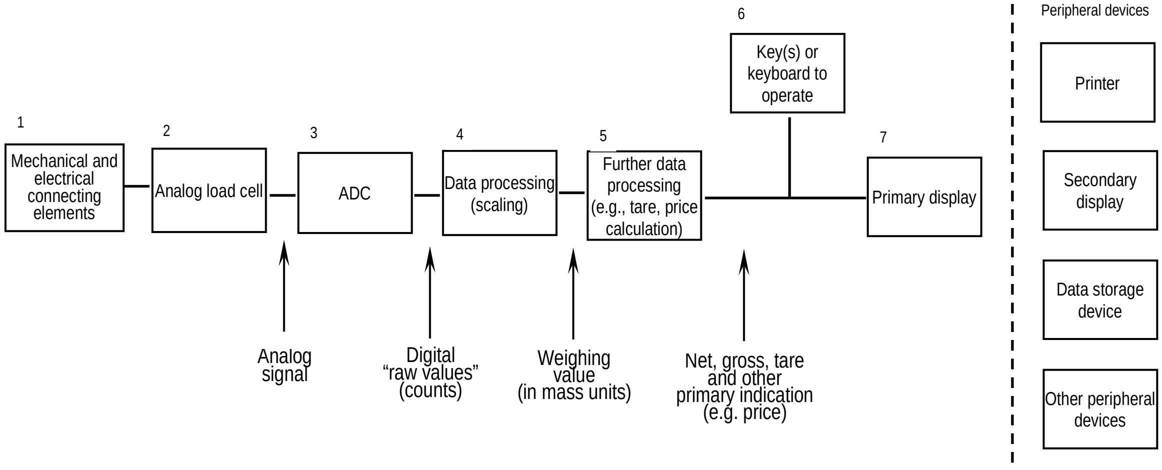
2.2.

This Recommendation utilizes the principle that several measurement errors shall be considered together when applying load cell performance characteristics to the permitted error envelope. Thus, it is not considered appropriate to specify individual errors for given characteristics (e.g., non-linearity, hysteresis, effects of influence factors), but rather to consider the total error envelope allowed for a load cell as the limiting factor. The use of an error envelope allows the balancing of the individual contributions to the total error of measurement while still achieving the intended final result.

Note: the error envelope may be defined as the boundary of the *combined individual errors* (see Table 4) as a function of the force introduced by the applied load (expressed in mass units) over the measuring range. The combined error determined may be positive or negative and include the effects of nonlinearity, hysteresis and temperature.

2.3.

“Weighing modules” as noted in OIML R76 [1], T.2.2.7 (see Annex A, A.2.1), are not covered by this recommendation. Weighing instruments that include load cells and which give an indication of mass are the subjects of separate Recommendations. While digital load cells may be covered under this Recommendation, a load cell that produces an output consisting of more than digital “raw counts” will not be covered under R60. In the illustration from OIML R76 below, the scope of R60 would not extend beyond module #3.



Analog load cell ____________________ 2
Digital load cell ____________________ 2 + 3
Electronic load cell __________________ 2 + 3 + (4)*
Load cells within scope of OIML R 60 _______ 2 + 3

* Numbers in brackets indicate options

From OIML R76:
Definition of typical modules within a weighing system (other combinations are possible)

Figure 1. Typical Components in a Weighing Instrument

3. Terminology (Terms and definitions)

The terms most frequently used in the load cell field and their definitions are given below (see 3.6 for an illustration of certain definitions). The terminology used in this Recommendation conforms to OIML V 1 International Vocabulary of Basic and General Terms in Metrology (VIM) [2], to OIML V 2 International Vocabulary of Terms in Legal Metrology (VIML) [3], to OIML D 9 Principles of metrological supervision [4], to OIML D 11 General Requirements for electronic measuring instruments [5], and to OIML B 3 OIML Certificate System for Measuring Instruments [6].

In addition, for the purposes of this Recommendation, the following definitions apply:

3.1. General definitions

3.1.1. durability [VIML 5.15]

Ability of a measuring instrument to maintain its performance characteristics over a period of use.

3.1.2. legal metrology [VIML 1.01]

practice and process of applying statutory and regulatory structure and enforcement to metrology.

(For notes, please refer to VIML)

3.1.3. load cell

measuring transducer that will produce an output in response to an applied load.. This output may be converted by another device into measurement units such as mass.

3.1.3.1. non-electronic load cell

load cell from which the output provides either measureable data or direct information representing the measurand value.

Note: The ratio between output and input may be adjustable and this type of load cell may utilize:

- passive electronics (e.g., strain gauges); and
- passive temperature compensation elements

3.1.3.2. electronic load cell

a type of digital load cell (3.1.3.3.) which is capable of performing the functions as described under “non-electronic” load cell (3.1.3.1.) and which also utilizes active electronics and would therefore be equipped with metrologically relevant software.

Note: This type of load cell may utilize the active electronics for:

- gaining an electronic representation of the measurand value;
- active temperature compensation; and
- similar functions being of influence to the measurand value.

3.1.3.3. digital load cell

electronic load cell which includes an analogue to digital conversion device providing a representation of the measurand value in some digital format.

3.1.4. marking [VIML 2.19]

affixing of one or more marks.

(For notes, please refer to VIML)

3.1.5. metrological supervision [VIML 2.03]

activity of legal metrological control to check the observance of metrology laws and regulations.

(For notes, please refer to VIML)

3.1.6. measuring transducer [VIM 3.7]

device, used in measurement, that provides an output quantity having a specified relation to the input quantity.

3.1.7. performance test

test to verify whether the load cell under test is capable of performing its intended functions.

3.1.8. rated operating condition [VIM 4.9]

operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system perform as designed.

(For notes, please refer to VIM)

3.1.9. sealing [VIML 2.20]

means intended to protect the measuring instrument against any unauthorized modification, readjustment, removal of parts, software, etc.

(For notes, please refer to VIML)

3.1.10. type (pattern) evaluation [VIML 2.04]

conformity assessment procedure on one or more specimens of an identified type (pattern) of measuring instruments which results in an evaluation report and / or an evaluation certificate.

(For notes, please refer to VIML)

3.1.11. type approval [VIML 2.05]

decision of legal relevance, based on the review of the type evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and results in the issuance of the type approval certificate.

3.2. Categories of Load Cells

3.2.1. Application of load

3.2.1.1. compression loading

applying a compressive force to the load receptor of a load cell.

3.2.1.2. tension loading

applying a tension force to the load receptor of a load cell.

3.3. Construction of load cells*

* See also sections 1 (Introduction) and 2.1

3.3.1. strain gauge

analog resistive element that is attached to a load cell structure and changes resistance depending on the deformation of the load cell structure when compression or tension forces are applied to the load cell.

3.4. Metrological characteristics of a load cell

3.4.1. humidity symbol

symbol assigned to a load cell that indicates the conditions of humidity under which the load cell has been tested.

3.4.2. load cell family

group of load cells, which for the purposes of type evaluation, are considered one a family and that are of:

a) the same material or combination of materials (for example, mild steel, stainless steel or aluminum);
b) the same design of the measurement technique (for example, strain gauges bonded to metal);
c) when used, the same type attachment of the strain gauge to the load cell (e.g., use of the same or similar adhesive);
d) the same method of construction (for example, shape, sealing of strain gauges, mounting method, manufacturing method); the same set of specifications (for example, output rating, input impedance, supply voltage, cable details); and
e) one or more load cell groups where all load cells within the group possess identical metrological characteristics (as listed in 5.1.5 – including: class; n_{max}; temperature rating; etc.).

Note: The examples provided are not intended to be limiting.

3.5. Range, capacity and output terms

3.5.1. load cell interval

subdivision of the load cell measuring range.

3.5.2. load cell measuring range

range between the maximum load of the measuring range D_{max} and minimum load of the measuring range D_{min}

Load cell measuring range = (D_{max} – D_{min})

3.5.3. load cell output

measurable quantity into which a load cell converts the measured input quantity.

3.5.4. load cell verification interval (v) load cell interval, expressed in units of mass, used in the test of the load cell for accuracy classification.

3.5.5. maximum capacity (E_{max})

largest value of a quantity expressed in units of mass, which may be applied to a load cell.

3.5.6. maximum load of the measuring range (D_{max})

largest value of a quantity expressed in units of mass which can be introduced to a load cell under test.

3.5.7. maximum measuring range

range of values of the quantity expressed in units of mass that may be applied to a load cell.

Note:

maximum measuring range is the range between maximum capacity E_{max} and minimum dead load E_{min}

[maximum measuring range = ($E_{max} – E_{min}$)]

3.5.8. maximum number of load cell verification intervals (n_{LC})

maximum number of load cell verification intervals into which the maximum measuring range may be divided.

3.5.9. minimum dead load (E_{min})

smallest value of a quantity (expressed in mass units) that may be applied to a load cell.

3.5.10. minimum dead load output return (DR)

difference of load cell output, expressed in units of mass at the minimum dead load (E_{min}), measured before and after application of a load of D_{max}

3.5.11. minimum load cell verification interval (v_{min})

smallest load cell verification interval in units of mass into which the maximum measuring range ($E_{max} – E_{min}$) can be divided.

3.5.12. minimum load of the measuring range (D_{min})

smallest value of a quantity expressed in units of mass, applied to a load cell under test.

3.5.13. number of load cell verification intervals (n)

total of load cell verification intervals into which the maximum measuring range, $E_{max} – E_{min}$ is divided.

3.5.14. relative minimum dead load output return Z

ratio of the maximum measuring range, to two times the minimum dead load output return, DR.

Note: This ratio is used to describe multi-interval instruments.

3.5.15. relative minimum load cell verification interval Y

ratio of the maximum measuring range, to the minimum load cell verification interval, v_{min}.

Note: This ratio describes the resolution of the load cell independent from the load cell capacity

3.5.16. safe load limit (E_{lim})

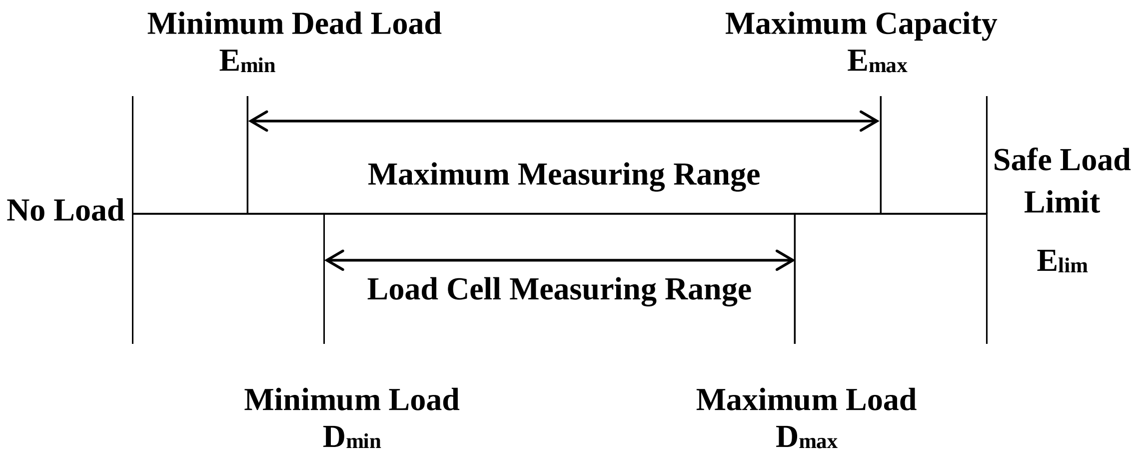
maximum load that can be applied without producing a permanent shift in the performance characteristics beyond those specified.

3.5.17. warm-up time

time between the moment power is applied to a load cell and the moment at which the load cell is capable of complying with the requirements.

3.6. Illustration of certain definitions

The terms that appear above the central horizontal line (related to parameters E_{min} and E_{max}) in Figure 2 below are parameters that are fixed by the design of the load cell. The terms that appear below that line (related to parameters D_{min} and D_{max}) are parameters that are variable, dependent on the conditions of the test of a load cell (in particular, those load cells used in weighing instruments).



The following statements apply: (see also 8.7.3.4)

a) $(D_{min} - D_{max}) \leq (E_{min} - E_{max})$

b) $E_{min} \leq D_{min} \leq (0.1\ E_{max})$, and $(0.9\ E_{max}) \leq D_{max} \leq E_{max}$

Figure 2. Illustration of certain definitions

3.7. Measurement and error terms

3.7.1. creep

change in load cell output occurring with time while under constant load and with all environmental conditions and other variables also remaining constant.

3.7.2. apportioning factor (p_{LC})

the value of a dimensionless fraction expressed as a decimal (for example, 0.7) representing that portion of an error observed in the (weighing) instrument which is attributed to the load cell alone.

Note: This value is used in determining MPE (see 3.7.10)

3.7.3. durability error [VIML 5.16]

difference between the intrinsic error after a period of use and the initial intrinsic error of a measuring instrument

3.7.4. expanded uncertainty

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. [Guide to the Expression of Uncertainty in Measurement, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2008] [7]

3.7.5. fault [VIML 5.12]

difference between the error of indication and the intrinsic error of a measuring instrument.

(For notes, please refer to VIML)

3.7.6. fault detection output

electrical representation issued by the load cell indicating that a fault condition exists.

3.7.7. hysteresis error

difference in load cell output readings for the same applied force between the reading obtained by increasing the load from minimum load (D_{min}), and the reading obtained by decreasing the load from maximum load (D_{max}).

3.7.8. initial intrinsic error [VIML 5.11]

intrinsic error of a measuring instrument as determined prior to performance tests and durability evaluations

3.7.9. load cell intrinsic error

error resulting from a load cell, determined under reference conditions.

3.7.10. maximum permissible error (MPE) [VIM 4.26]

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system.

(For notes, please refer to VIM)

3.7.11. measurement error [VIM 2.16)]

measured quantity minus a reference quantity value.

Note: The term “measurement error” in this Recommendation refers to load cell measurement errors.

(For additional notes, please refer to VIM)

3.7.12. measured quantity (value) [VIM 2.10)]

quantity value representing a measurement result.

(For notes, please refer to VIM)

3.7.13. non-linearity

deviation from the average of the values of load cell signals from a straight line through zero force applied and maximum force applied.

3.7.14. repeatability error

difference between load cell output readings taken from consecutive tests under the same loading and environmental conditions of measurement.

3.7.15. resolution [VIM 4.14]

smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.

(For note, please refer to VIM)

3.7.16. significant durability error [VIML 5.17]

durability error exceeding the value specified in the applicable Recommendation.

(For note, please refer to VIML)

3.7.17. significant fault [VIML 5.14]

fault exceeding the applicable fault limit value.

(For note, please refer to VIML)

3.7.18. span stability

capability of a load cell to maintain the load cell output of the load cell’s measuring range over a period of use within specified limits.

3.7.19. temperature effect on minimum dead load output

change of the signal output under minimum dead load due to a change in ambient temperature.

3.7.20. temperature effect on sensitivity

change in sensitivity due to a change in ambient temperature.

3.7.21. type approval mark [VIML 3.07]

mark applied to a measuring instrument certifying its conformity to the approved type

3.8. Influences and reference conditions

3.8.1. disturbance [VIML 5.19]

influence quantity having a value within the limits specified in the relevant Recommendation, but outside the specified rated operating conditions of a measuring instrument.

3.8.2. influence factor [VIML 5.17]

influence quantity having a value which ranges within the rated operating conditions of a measuring instrument.

(For notes, please refer to VIML)

3.8.3. influence quantity [VIM 2.52]

quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result.

(For examples and notes, please refer to VIM)

3.8.4. Rated operating condition [VIM 4.9]

operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system perform as designed.

(For note, please refer to VIM)

3.8.5. reference (operating) condition [VIM 4.11]

operating condition prescribed for evaluating the performance of a measuring instrument or measuring system or for comparison of measurement results.

(For notes, please refer to VIM)

3.9. Abbreviations

AC	Alternating Current
CH	Cyclic Humidity
DC	Direct Current
DR	Minimum Deadload Output Return
EMC	Electro Magnetic Compatibility
EUT	Equipment Under Test
IEC	International Electrotechnical Committee
ISO	International Organization for Standardization
I/O	Input/Output
LC	Load Cell
MPE	Maximum Permissible Error
NH	No Humidity
OIML	International Organization of Legal Metrology
SH	Steady-State Humidity
VIM	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms

4. Description of Load Cells

A load cell provides an output proportional to a force resulting from applying a load. Load cells may be used as a single transducer or applied together with other load cells in a system where the design allows such application. The term "load cell" in this Recommendation is not limited to any particular type of technology or design principle.

While many technologies are used in the design of load cells, those used in legal metrology applications are commonly designed to to provide an electrical output relative to a mechanical input. Both analog and digital outputs are recognized in load cells within that category. Although strain gauge technology was a primary focus in the development of R60, it is to be understood that load cells that operate using other principles may also be evaluated under this Recommendation. Variations of transducers that operate using alternative basis of input/output may include, but are not limited to: pressure (e.g., hydraulic, pneumatic); vibratory frequency; and magnetic forces.

The term load cell may describe an elemental component/module or a somewhat more complex instrument including constituents that perform functions such as signal filtering and analog-to-digital conversion.

5. Metrological requirements

5.1. Principle of load cell classification

The classification of load cells into specific accuracy classes is provided to facilitate their application to various measuring systems. In the application of this Recommendation, it should be recognized that the effective performance of a particular load cell may be improved by compensation means within the measuring system with which it is applied. Therefore, it is not the intention of this Recommendation to require that a load cell be of the same accuracy class for a load cell as the measuring system in which it may be applied. Nor does it require that a measuring instrument, indicating in units of mass for example, use a load cell which has been approved during a separate type evaluation. All data/items found in 5.1.1 to 5.1.7 shall be specified by the manufacturer

5.1.1. Accuracy classes and their symbols

Load cells shall be ranked, according to their overall performance capabilities, into one of the four accuracy classes whose designations are as follows:

Class A; Class B; Class C; Class D.

5.1.2. Maximum number of load cell verification intervals

The maximum number of load cell verification intervals, n_{LC}, into which the maximum measuring range $E_{max} – E_{min}$ (see 3.5.8) can be divided in a measuring system shall be within the limits presented in Table 1.

Maximum Number of Load Cell Verification Intervals (n_{LC}) according to accuracy class.				
	Class A	**Class B**	**Class C**	**Class D**
Lower Limit	**50 000**	**5 000**	**500**	**100**
Upper Limit	**Unlimited**	**100 000**	**10 000**	**1 000**

Table 1

5.1.3. Minimum load cell verification interval

The minimum load cell verification interval, v_{min}, shall be specified by the manufacturer (see 3.5.11 in combination with 3.5.15).

5.1.4. Supplementary classifications

Load cells shall also be classified by the intended manner in which a load is applied to the load cell wherever there would be a risk of confusing the manner of loading (i.e., compression loading, tension loading or, universal). A load cell may bear different classifications according to the intended manner in which a load is applied to the load cell. The manner of loading for which the classification(s) applies(y) shall be specified. For multiple capacity load cells, each capacity shall be classified separately.

5.1.5. Complete load cell classification

The load cell shall be classified corresponding to the following six parameters:

a) accuracy class designation (see 5.1.1 and 6.2.4.1);

b) maximum number of load cell verification intervals (see 5.1.2 and 6.2.4.5);

c) intended manner of the application of the load, if necessary (see 5.1.4 and 6.2.4.2);

d) special limits of working temperature, if applicable (see 6.2.4.3);

e) humidity symbol, if applicable (see 6.2.4.4); and

f) additional characterization information, as listed below in Figure 3, 5.1.6, and 5.1.7.

An example illustrating the six parts of the load cell classification is shown in Figure 3.

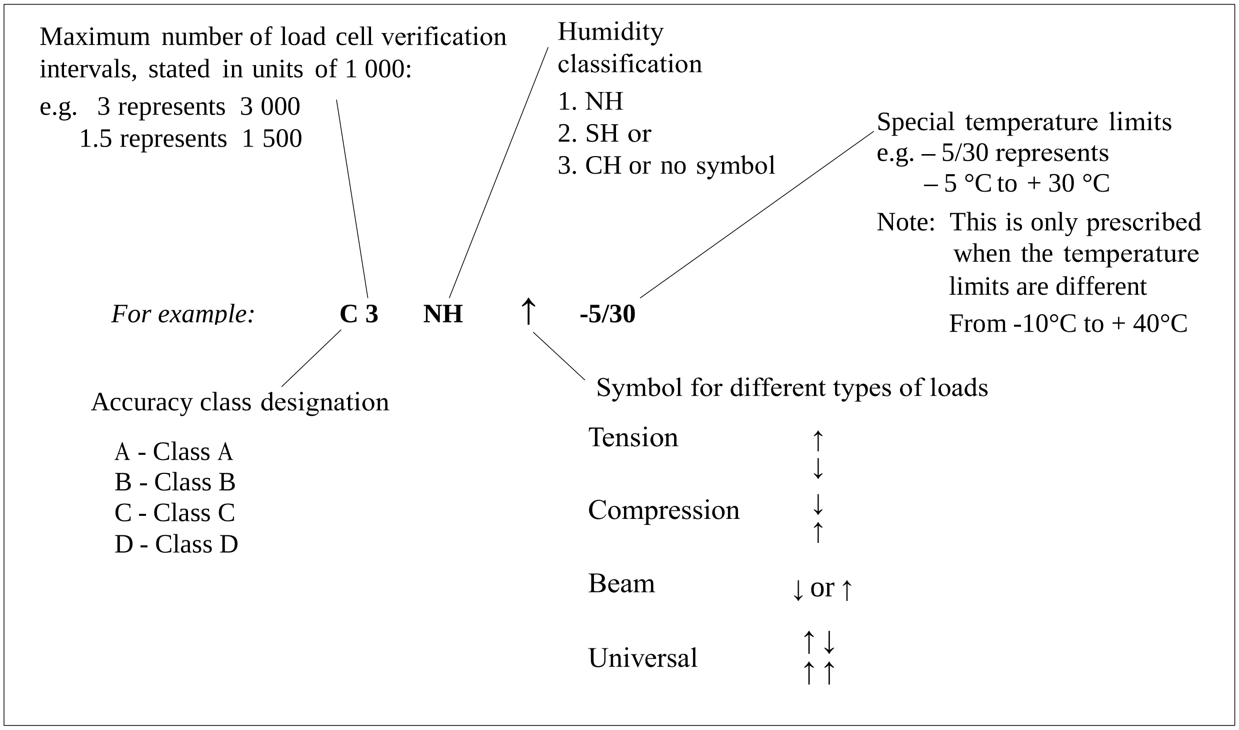


Figure 3. Complete load cell classification

5.1.6. Standard classification

Standard classifications shall be used; examples are shown in Table 2.

Classification symbol	**Description**
C2	Class C, 2 000 intervals
C3 ↓↑ 5/35	Class C, 3 000 intervals, compression, + 5 °C to + 35 °C
C2 NH	Class C, 2 000 intervals, not to be subjected to humidity test

Table 2. Examples of load cell classification

5.1.7. Multiple classifications

Load cells that have comprehensive classifications for the manner in which the load is applied to the load cell shall be accompanied by the relative information for each classification. Example is shown in Table 3. An illustration of the standard classification symbols, using an example is shown in Figure 3.

Classification Symbol	Description
C2 ↑	Class C, 2 000 intervals
C1.5 ↓	Class C, 1 500 intervals
C1 ↓↑ - 5/30	Class C, 1 000 intervals, compression, – 5 °C to + 30 C
C3 ↑↓ - 5/30	Class C, 3 000 intervals, tension, – 5°C to + 30 °C

Table 3. Examples of Multiple Classifications

5.2. Measuring ranges

5.2.1. Minimum load of the measuring range (D_{min}) (see 3.5.12)

The value of the smallest load applied to a load cell during test which is expressed in units of mass shall not be less than E_{min} (see 3.5.9).

5.2.2. Maximum load of the measuring range (D_{max}) (see 3.5.6)

The value of the largest load applied to a load cell during test which is expressed in units of mass shall not be greater than E_{max} (see 3.5.5).

5.3. Maximum permissible measurement errors

Under the rated operating conditions in 5.6, the maximum permissible error (MPE) shall not exceed the values stated in 5.5

The MPE is applicable after increasing as well as decreasing the force applied (i.e., they include hysteresis).

5.3.1. Maximum permissible errors for each accuracy class

The maximum permissible measurement errors for each accuracy class are related to the maximum number of load cell verification intervals (n_{LC}) specified for the load cell (see 5.1.2) and to the actual value of the load cell verification interval, v.

5.3.2. Type evaluation

The MPE (see 3.7.10) on type evaluation shall be the values derived using the expressions contained in the left column of Table 4. The apportioning factor, p_{LC} shall be chosen and declared (if other than 0.7) by the manufacturer and shall be in the range of 0.3 to 0.8

($0.3 \leq p_{LC} \leq 0.8$)[1].

Where "m" is the value (expressed in mass) representing the force introduced by the load applied

MPE	**Load, m**			
	Class A	**Class B**	**Class C**	**Class D**
$p_{LC} \times 0.5$ v	0 ≤ m ≤ 50 000 v	0 ≤ m ≤ 5 000 v	0 ≤ m ≤ 500 v	0 ≤ m ≤ 50 v
$p_{LC} \times 1.0$ v	50 000 v < m ≤ 200 000 v	5 000 v < m ≤ 20 000 v	500 v < m ≤ 2 000 v	50 v < m ≤ 200 v
$p_{LC} \times 1.5$ v	200 000 v < m	20 000 v < m ≤ 100 000v	2 000 v < m ≤ 10 000 v	200 v < m ≤ 1 000 v

Table 4. Maximum Permissible Errors (MPE) on Type Evaluation

The value of the apportioning factor, p_{LC} shall appear on the OIML certificate, if the value is not equal to 0.7. If the apportioning factor, p_{LC} is not specified on the certificate then the value 0.7 shall be assumed. The maximum permissible error may be positive or negative and is applicable to both increasing and decreasing loads.

[1]Associated with apportionment of error provisions contained within OIML R 76-1, 3.5.1 and 3.10.2.1 [1]; R 50-1, 2.2.3 [28]; R 51-1, 5.2.3.4 [28]; R 61-1, 5.2.3.3 [28]; R 106-1, 5.1.3.2 [28]; or R 107-1, 5.1.4.1 [28], when load cell is applied to such instruments.

The limits of error shown include errors due to nonlinearity, hysteresis and temperature effect on sensitivity over certain temperature ranges, specified in 5.6.1.1 and 5.6.1.2. Further errors, not included in the Table 4 limits of error, are treated separately.

5.4. Repeatability error

The maximum difference between the results of five identical load applications for classes A and B and of three identical load applications for classes C and D shall not be greater than the absolute value of the MPE for that load.

5.5. Permissible variation of results under reference conditions

5.5.1. Creep

The difference between the reading taken upon the application of a maximum load (D_{max}) and the reading observed within and after 30 minutes of exposure of 90% to 100% of E_{max} shall not exceed 0.7 times the absolute value of MPE for the applied load.*

Example:

Load cell class: C3 (declared by the manufacturer)

Apportioning factor: p_{LC} = 0.7 (declared by manufacturer)

Applied load: $D_{max} = E_{max}$ (test specification)

Maximum difference between the reading = 0.7 × (0.7 × 1.5v) = 0.735

The difference in readings taken after 20 minutes of exposure to 90% to 100% of E_{max} and at 30 minutes of exposure to 90% to 100% of E_{max} shall not exceed 0.15 times the absolute value of MPE.

Example:

Load cell class: C3 (declared by the manufacturer)

Apportioning factor: p_{LC} = 0.7 (declared by manufacturer)

Applied load: $D_{max} = E_{max}$ (test specification)

Maximum difference between the initial reading = 0.15 × (0.7 × 1.5v) = 0.1575

*Regardless of any value declared by the manufacturer for the apportioning factor, p_{LC}, the MPE for creep shall be determined from Table 4 using the apportioning factor, p_{LC} = 0.7.

5.5.2. Minimum dead load output return (DR) (see 3.5.10)

The difference between the initial reading of the minimum load output (D_{min}) and the reading of D_{min} at the conclusion of the creep test (5.5.1), shall not exceed half the value of the load cell verification interval (0.5 v).

Note:

It should be noted that DR is the minimum dead load output return expressed in mass units (g, kg, t). DR has to be adjusted in a value expressed in load cell verification intervals v.

5.6. Influence quantities (Rated operating conditions)

Load cells are to be evaluated under the conditions specified in 5.6.1 - 5.6.3. An evaluation may include additional special testing performed under conditions that vary from those specified in 5.6.1 - 5.6.3 if requested and specified by the applicant submitting the load cell for evaluation. This special testing may be performed in addition to, but not instead of testing under the specified conditions in 5.6.1 – 5.6.3.

Load cells that are equipped with functions typically performed by complete instruments (may be required to be evaluated against additional requirements contained in other OIML Recommendations for those complete instruments. These additional evaluations are outside the scope of this Recommendation (see 2.3. and Figure 1).

5.6.1. Temperature

5.6.1.1. Temperature limits

Excluding temperature effects on minimum dead load output, the load cell shall perform within the limits of error in 5.3.2 over the temperature range of – 10 °C to + 40 °C, unless otherwise specified as in 5.6.1.2 below.

Note: National legislation may prescribe alternate temperature limits outside of the range specified above as appropriate for local climatic conditions and the environmental conditions that can be anticipated.

5.6.1.2. Special limits

Load cells for which particular limits of working temperature are specified shall satisfy, within those ranges, the conditions defined in 5.3.2. The span of these ranges shall be at least:

5 °C for load cells of class A;
15 °C for load cells of class B;
30 °C for load cells of classes C and D.

5.6.1.3. Temperature effect on minimum dead load output

The minimum dead load output of the load cell over the temperature range, as specified in 5.6.1.1 or 5.6.1.2, shall not vary by an amount greater than the apportioning factor, p_{LC}, times the minimum load cell verification interval, v_{min}, for any change in ambient temperature of:

2 °C for load cells of class A;
5 °C for load cells of class B, C and D.

5.6.2. Barometric pressure

The output of the load cell shall not vary by an amount greater than the minimum load cell verification interval, v_{min}, for any incremental change in barometric pressure equivalent to 1 kPa.

5.6.3. Humidity

With respect to humidity conditions, this Recommendation defines 3 humidity classes: CH (cyclic humidity - as standard), NH (no humidity), and SH (steady-state humidity). In case of class NH, or SH, the class designation shall be marked on the load cell. In the case of class CH, class designation marking of the load cell is not mandatory.

5.6.3.1. Humidity error – CH or unmarked load cells

This requirement is only applicable to load cells marked CH or with no humidity symbol marking and not applicable to load cells marked NH or SH.

The influence of exposure to temperature cycles specified in 8.10.5.12 on the load cell output for minimum load shall not be greater than 4 % of the difference between the output on the maximum capacity, E_{max}, and that at the minimum dead load E_{min}.

The influence of exposure to temperature cycles specified in 8.10.5.12 on the load cell output for the maximum load shall not be greater than the load cell verification interval v.

5.6.3.2. Humidity error – SH marked load cells

This requirement is only applicable to load cells marked SH and not applicable to load cells marked NH or CH or with no humidity symbol marking.

A load cell shall meet the MPE applicable to the load applied as specified in Table 4, when exposed to conditions of relative humidity variations as specified in 8.10.6.11

5.7. Requirements for digital load cells

5.7.1. General requirements

In addition to the other requirements of this Recommendation, a digital load cell shall comply with the following requirements. The MPE shall be determined using an apportioning factor, p_{LC} greater than or equal to 0.7 and lesser than or equal to 0.9 ($0.7 \leq p_{LC} \leq 0.9$) substituted for the apportioning factor, p_{LC}, that is declared by the manufacturer and applied to the other requirements.

If a load cell is configured with substantial additional electronic functions (e.g., display of indications, frequency counter) that are typical of an electronic weighing instrument, it may be considered outside the scope of this Recommendation and need to undergo additional evaluation using requirements contained in other OIML Recommendations which are applicable to weighing instruments.

5.7.1.1. Faults

A digital load cell shall be designed and manufactured such that when it is exposed to electrical disturbances either:

a) significant faults do not occur; or

b) significant faults are detected and acted upon.

If significant faults do occur, and the load cell is equipped with the intelligence to detect and act upon significant faults through the instrument that the load cell is installed in, the reporting of and acting upon significant faults would then be evaluated under the appropriate Recommendation for the complete instrument.

Messages of significant faults should not be confused with other messages presented.

Note: A fault, in value that is equal to or smaller than the load cell verification interval, v, is allowed.

5.7.1.2. Acting upon significant faults

When a significant fault has been detected, either the load cell shall be made inoperative automatically or a fault detection output shall be issued automatically. This fault detection output shall continue until fault has been resolved.

5.7.1.3. Durability

The load cell shall be suitably durable so that the requirements of this Recommendation may be met in accordance with the intended use of the load cell.

5.7.1.4. Compliance with requirements

A digital load cell is presumed to comply with the requirements in 5.7.1.1 and 5.7.1.3, if it passes the examinations specified in 5.7.2 and 8.10.7

5.7.1.5. Application of the requirements in 5.7.1.1

The requirements in 5.7.1.1 may be applied separately to each individual cause or significant fault. The choice of whether 5.7.1.1 a) or 5.7.1.1 b) is applied is left to the manufacturer.

5.7.2. Functional requirements

5.7.2.1. Warm-up time

During the design warm-up time of a digital load cell there shall be no transmission of measurement results.

5.7.2.2. Mains power supply (AC)

A digital load cell that operates from a mains power supply shall be designed to comply with the metrological requirements if the mains power supply varies in voltage from – 15 % to + 10 % of the supply voltage.

5.7.2.3. Battery power supply (DC)

A digital load cell that operates from a battery power supply shall either continue to function correctly or not provide a measurement result whenever the voltage is below the value specified by the manufacturer.

5.7.2.4. Maximum allowable variations during voltage variations:

All functions shall operate as designed.
All measurement results shall be within maximum permissible errors.

5.7.2.5. Disturbances

When a digital load cell is subjected to the disturbances specified in 8.10.7.5 to 8.10.7.10 (also summarized in Table 5), the difference between the load cell output due to a disturbance and the load cell output without disturbance (fault) shall satisfy the conditions in 5.7.1.1.

Test	**Section 8.10 test procedure**	p_{LC}	**Characteristic under test**
Warm-up time	8.10.7.3		Influence factor
Power voltage variations	8.10.7.4		Influence factor
Short-time power reductions	8.10.7.5		Disturbance
Bursts (electrical fast transients)	8.10.7.6		Disturbance
Surge	8.10.7.7	1.0	Disturbance
Electrostatic discharge	8.10.7.8		Disturbance
Electromagnetic susceptibility	8.10.7.9		Disturbance
Immunity to conducted electromagnetic fields	8.10.7.10		Disturbance
Span stability	8.10.7.11		Influence factor

Table 5.

Performance and Stability Tests for a Digital Load Cell

5.7.2.6. Span stability: maximum allowable variation requirements (not applicable to class A load cells)

When a digital load cell is subjected to the span stability test specified in 8.10.7.11, the variation in the load cell span measurement results shall not exceed the greater of: half the load cell verification interval; or half the absolute value of the MPE for the applied test load D_{max}.

6. Technical Requirements

6.1. Software

Provision shall be made for appropriate sealing by mechanical, electronic and/or cryptographic means, making any change that affects the metrological integrity of the device impossible or evident.

Any embedded programming (i.e., firmware) that influences the raw count output of the load cell will be evaluated under the terms of this Recommendation. In addition, if the software modifies load cell performance, not exceeding the functions of analog to digital conversion and the linearization of the load cell output, then that software shall be evaluated under the terms in this Recommendation and in accordance with OIML D31 Edition 2008(E) [8] Any weighing instrument function shall be evaluated under other appropriate Recommendations for weighing instruments.

Functionality of any software which is not covered by this Recommendation, e. g. functionalities of weighing instruments, is outside the scope of this Recommendation and not evaluated. It may be required to undergo additional evaluations against other requirements contained in the applicable OIML Recommendations for weighing instruments.

The requirements which are relevant to the evaluation of load cells and provided in OIML D 31 Edition 2008 (E) [8] have to be fulfilled for the load cell by taking into account the following aspects.

a). In general, for load cells, the severity level I, examined with validation procedure A, is required.

b). For legally relevant software of digital load cells the following statements according to OIML D31 shall be applied.

1) The exception described in D 31, 5.1.1 [8] for an imprint of the software identification is allowed.

2) The level of conformity of manufactured devices to the approved type is according to D 31, 5.2.5 (clause a) [8].

3) Updating the legally relevant software of a load cell in the field is possible via verified or traced update according to D31, 5.2.6.2 and 5.2.6.3 [8]

4) The software documentation shall include descriptions according to the applicable requirements of D 31, 6.1.1 [8]

The validation procedures are described in D 31, 6.4 [8]

6.2. Inscriptions and presentation of load cell information

Technical information markings including load cell classifications as indicated in 5.1.5 must be specified for the load cell(s).

6.2.1. Mandatory markings on the load cell

The following mandatory markings shall be clearly an indelibly marked on the load cell:

a. Manufacturer’s name or trade mark

b. Manufacturer’s type designation or load cell model

c. Serial number

d. Maximum capacity as: E_{max} = (in units g, kg, t,)

e. Year of production

f. OIML certificate number (if applicable)

g. Type approval mark

If due to the limitation of the size of the load cell, it is impossible to apply all mandatory markings, the manufacturer’s name or trade mark, the load cell type designation, the serial number, and the maximum capacity shall be provided as a minimum on the load cell itself. All other mandatory information shall be provided in an accompanying document supplied by the manufacturer and submitted to the user. Where such a document is provided, the information required in 6.2.2 shall also be given therein.

6.2.2. Mandatory additional information

The following mandatory information shall be provided in a document accompanying the load cell supplied by the manufacturer and submitted to the user (or, if space permits, they may be marked on the load cell). Where the information provided is associated with a specific unit of measure, the unit (g, kg, t,) shall also be specified.

a. Manufacturer’s name or trade mark

b. Type designation

c. Accuracy class(es); see 6.2. 4.1

d. Type of load; see 6.2.4.2

e. Working temperature when required; see 6.2.4.3

f. Humidity symbol when required; see 6.2.4.4

g. Maximum capacity as: E_{max} =

h. Minimum dead load as: E_{min} =

i. Safe load limit as: E_{lim} =

j. Minimum load cell verification interval as v_{min} (or relative minimum dead load verification interval Y) =

k. Value of the apportioning factor, p_{LC}, if not equal to 0.7; and

l. Other pertinent conditions that must be observed to obtain the specified performance (for example, electrical characteristics of the load cell such as output rating, input impedance, supply voltage, cable details, mounting torque, etc.)

6.2.3. Non-mandatory additional information

In addition to the information required in 6.2.2, the following information may optionally be specified:

a. for a weighing instrument (for example a multiple range instrument according to OIML R 76) [1], the relative v_{min}, Y, where Y = E_{max} / v_{min} (see 3.5.15);

b. for a weighing instrument (for example a multi-interval instrument according to OIML R 76) [1], the relative DR, Z, where Z= E_{max} / (2 × DR) (see 3.5.14) and the value of DR (see 3.5.10) is set at the maximum permissible minimum dead load output return according to 8.10.1.

c. other information considered necessary or useful by the manufacturer.

6.2.4. Specific markings

6.2.4.1. Accuracy class designation

Class A load cells shall be designated by the character “A”, class B by “B”, class C by “C” and class D by the character “D”.

6.2.4.2. Designation of the type of load applied to the load cell

The designation of the type of load applied to the load cell shall be specified when it is not clearly apparent from the load cell construction, using the symbols shown in Table 6.**Tension**	↑ ↓
Compression	↓ ↑
Beam	↑ **or** ↓
Universal	↑↓ ↓↑

Table 6.

Symbols for Different Types of Load Transmission Principles

6.2.4.3. Working temperature designation

The special limits of working temperature, as referred to in 5.6.1.2, shall be specified when the load cell cannot perform within the limits of error in 5.3.to 5.6 over the temperature range specified in 5.6.1.1. In such cases, the limits of temperature shall be designated in degrees Celsius (°C).

6.2.4.4. Humidity symbols

a). A load cell not designed to meet performance criteria evaluated under 8.10.5 or 8.10.6 shall be marked by the symbol NH.

b). A load cell submitted for evaluation and designed to meet performance criteria evaluated under 8.10.5 shall be marked by the symbol CH or not be marked with any humidity classification.

c). A load cell submitted for evaluation and manufactured to meet performance criteria evaluated under 8.10.6 shall be marked by the symbol SH.

6.2.4.5. Maximum number of load cell verification intervals

The maximum number of load cell verification intervals for which the accuracy class applies shall be designated in actual units (e.g., 3 000) or, when combined with the accuracy class designation (see 6.2.4.1 above) to produce a classification symbol (see 5.1.6), it shall be designated in units of 1 000.

Annex A (Mandatory) Definitions from other applicable international publications

A.1 Definitions from OIML D 11 [4]

A.1.1 Electronic measuring instrument (OIML D 11, 3.1)

instrument intended to measure an electrical or non-electrical quantity using electronic means and/or equipped with electronic devices .

A.1.2 Module (OIML D11, 3.2)

device performing a specific function or functions and (usually) manufactured and constructed such that it can be separately evaluated according to prescribed metrological and technical performance requirements.

A.1.3 Device (OIML D 11, 3.3)

identifiable instrument or part of an instrument or of a family of instruments that performs a specific function or functions

A.1.4 Checking facility (OIML D11, 3.19)

facility incorporated in a measuring instrument which enables significant faults to be detected and acted upon

A.1.5 Automatic checking facility (OIML D 11, 3.19.1)

checking facility that operates without the intervention of an operator.

A.1.6 Permanent automatic checking facility (type P) (OIML D 11, 3.19.1.1)

automatic checking facility that operates at each measurement cycle.

A.1.7 Intermittent automatic checking facility (type I) (OIML D 11, 3.19.1.2)

automatic checking facility that operates at certain time intervals or per fixed number of measurement cycles.

A.1.8 Non-automatic checking facility (type N) (OIML D 11, 3.19.2)

checking facility that requires the intervention of an operator.

A.1.9 Durability protection facility (OIML D 11, 3.20)

facility incorporated in a measuring instrument that enables significant durability errors to be detected and acted upon.

A.1.10 Test (OIML D 11, 3.21)

series of operations intended to verify the compliance of the equipment under test (EUT) with specified requirements.

A.1.11 Test procedure (OIML D 11, 3.21.1)

detailed description of the test operations.

A.1.12 Performance test (OIML D 11, 3.21.4)

test intended to verify whether the EUT is able to accomplish its intended functions

A.1.13 Mains power (OIML D 11, 3.22)

primary external source of electrical power for an instrument, including all sub-assemblies. (Examples: public or local power grid (AC or DC) or external generator.

A.1.14 Power converter (power supply device) (OIML D 11, 3.23)

sub-assembly converting the voltage from the mains power to a voltage suitable for other sub-assemblies.

A.1.15 Auxiliary battery (OIML D 11, 3.25)

battery that is:

- mounted in, or connected to, an instrument that can be powered by the mains power as well; and
- capable of supplying power to the complete instrument for a reasonable period of time.

A.1.16 Back-up battery (OIML D 11, 3.26)

battery that is intended to maintain power supply for specific functions of an instrument in the absence of the primary power supply

Example: To preserve stored data.

A.2 Definitions from OIML R76 [1]

A.2.1 Weighing Module [T.2.2.7]

Part of the weighing instrument that comprises all mechanical and electronic devices (i.e. load receptor, load-transmitting device, load cell, and analog data processing device or digital data processing device) but not having the means to display the weighing result. It may optionally have devices for further processing (digital) data and operating the instrument.

Annex B (Mandatory) OIML Certificate of conformity for load cells - Format of certificate

Member State **OIML CERTIFICATE OF CONFORMITY** OIML certificate no.

Issuing Authority

Name: ....

Address: .... Person respon

....

Applicant

Name:

....

Address:

....

Manufacturer of the certified type (if the manufacturer is not the applicant) ....

Identification of the certified type: Load cell (construction principle, e.g., strain gauge, compression)....................

....

Model designation				
Maximum capacity, E_{max}				
Accuracy class				
Maximum number of load cell verification intervals, n_{max}				
Minimum verification interval, v_{min}				
Apportioning factor, p_{LC}				

(Additional characteristics and identification, as applicable according to R 60, 3.4.2 and 5.1.5, continued overleaf or on addendum if necessary)

This certificate attests the conformity of the above-mentioned type (represented by the samples identified in the associated test report(s) with the requirements of the following Recommendation of the International Organization of Legal Metrology - OIML):

R 60 *Metrological regulation for load cells* Edition .... for accuracy class ....

This certificate relates only to the metrological and technical characteristics of the type of instrument
concerned, as covered by the relevant OIML International Recommendation.
This certificate does not bestow any form of legal international approval.
The conformity was established by tests described in the associated test report no. ……, which includes ……. pages.

Identification(s) and signature(s) or stamp(s), of (as applicable):

Issuing Authority: CIML Member:

Date: .... Date: ....

Page 1. This certificate includes .... pages.

OIML certificate no.

* * *

Additional characteristics[1] and identification, as applicable to R 60, 3.4.2 and 5.1.5 *(continued)*

Model designation				
(Additional characteristics, per 3.4.2 and 5.1.5)				

Special conditions:

……

……

…………………………………………………………

……

……

……

……

……

……

……

……

Important note:

Apart from the mention of the certificate's reference number and the name of the OIML Member State in which the certificate was issued, partial quotation of the certificate or the associated test report is not permitted, though they may be reproduced in full.

[1] The table with the essential technical data may, upon request by the manufacturer, be placed on the certificate or on an addendum.

Page 2. This certificate includes .... pages.

B.1. Contents of addendum to certificate (Informative)

Addendum to certificate no. ....

(Name and type of the load cell) ....

B.2. Technical data

The essential technical data for the OIML certificates of conformity are listed on the certificate (at the request of the manufacturer) alternatively, in the case of limited space on the certificate the following information may be provided:

Table B.1 Technical data

Model designation	*Designation*	*Example*				*Units*
Classification		C4				
Additional markings		–				
Maximum number of load cell verification intervals	n_{LC}	4 000				
Maximum capacity	E_{max}	30 000				kg
Minimum dead load, relative	E_{min} / E_{max}	0				%
Relative v_{min} (ratio to minimum load cell verification interval)	$Y = E_{max} / v_{min}$	24 000				
Relative DR (ratio to minimum dead load output return)	$Z = E_{max} / (2 \times DR)$	7 500				
Rated output*		2.5				mV/V*
Maximum excitation voltage		30				V
Input impedance (for strain gauge load cells)	R_{LC}	4 000				Ω
Temperature rating		– 10/+ 40				°C
Safe overload, relative	E_{lim} / E_{max}	150				%
Cable length		3				m
Additional characteristics per 3.4.2 and 5.1.5**		–				

* *Note:* For load cells with digital output this refers to the number of counts for E_{max}

** *Note:* For load cells with digital output this is not required

Page 1. The Annex to the certificate includes .... pages.

Annex C (Informative) OIML Certificate of conformity for load cells

This Annex is provided as an example of supplemental information that may be included in the OIML Certificate format and is intended to compliment the OIML Certificate format found in Annex B.

Certificate history

Certificate release	Date	Essential changes
xxx	xxx	primary certificate

1. Technical Data

The metrological characteristics of the load cells type xxx are listed in Table C1. Further technical data are listed in the data sheet of the manufacturer at page 5 to 6 of this annex.

Table C1: Essential data

Accuracy class			C3
Maximum number of load cell intervals	n_{LC}		3000
Rated output		mV/V	2
Maximum capacity	E_{max}	kg	150 / 200 / 250 / 300 / 500 / 750
Minimum load cell verification interval	$v_{min} = (E_{max} / Y)$	kg	E_{max} / 15000
Minimum dead load output return	DR = (½ E_{max} / Z)	kg	½ E_{max} / 5000

Dead load: xxx%·E_{max}; Safe overload: xxx%·E_{max}; Input impedance: xxx Ω

2. Tests

The determination of the measurement error, the stability of the dead load output, repeatability and creep in the temperature range of –10°C to +40°C as well as the tests of barometric pressure effects and the determination of the effects of static damp heat have been performed according to OIML R60 (2015) as shown in Table C2 on the load cell nominated in the test report with the reference No. xxx, dated xxx.

Table C2: Tests performed

Test	R60 (2015)		tested samples	result
Temperature test and repeatability at (20 / 40 / -10 / 20°C)	5.3.1.1; 5.4	8.10.1	150 kg	+
Temp. effect on minimum dead load output at (20 / 40 / -10 / 20°C)	5.6.1.3	8.10.1.16	150 kg	+
Creep test at (20 / 40 / -10 / 20°C)	5.5.1	8.10.2	150 kg	+
Minimum dead load output return at (20 / 40 / -10 / 20°C)	5.5.2	8.10.3	150 kg	+
Barometric pressure effects at ambient temperature	5.6.2	8.10.4	150 kg	+
Damp heat test , static, marked SH	5.6.3.2	8.10.6	150 kg	+

3. Description of the load cell

{Example}

The load cells (LC) of the series xxx are double bending beam load cells. They are made of aluminium, the strain gauge application is hermetically sealed. Further essential characteristics are given in the data sheet, see chapter 6 of this annex.

Picture of load cell

Figure 1: Load cell type xxx

The complete type designation is indicated as follows in the example on the name plate:

Picture of name plate

Figure 2: Name plate

4. Documentation

{Example}

- Test Report No. xxx; C3; Y=xxx; Z=xxx; E_{max}=xxx kg; SN: xxx
- Datasheet No. Xxx
- Technical Drawing No. Xxx

5. Further information

The manufacturing process, material and sealing (i.e., environmental protection) of the produced load cells have to be in accordance with the tested patterns; essential changes must be identified and communicated to the issuing authority and are only allowed with the permission of the issuing authority based on the impact of those changes on the certification process.

Sufficient information shall be included to describe the patent design.

The typical errors related to linearity, hysteresis and temperature coefficient as indicated in the data sheet point out possible single errors of a pattern; however the overall error of each pattern is determined by the maximum permissible error according OIML R60 No 5.3.1.1.

The technical data, the dimensions of the load cell and the principle of load transmission are given in chapter 6 of this annex, have to be complied with.

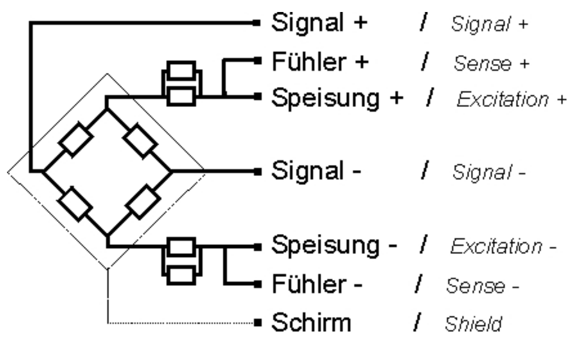
6. Data sheet and dimensions

Specifications of the Load Cell Family

Accuracy class acc. to OIML R60			C3
Rated output	C	mV/V	2,0 ± 0,2
Maximum capacity	E_{max}	kg	150 / 200 / 250 / 300 / 500 / 750
Max. number of load cell intervals	n_{LC}		3000
Min. load cell verification interval	v_{min}	kg	E_{max} / 15000
Minimum dead load output return (MDLOR)	DR	kg	½·E_{max} / 5000
Minimum dead load		%·E_{max}	0
Safe load limit		%·E_{max}	150
Ultimate load		%·E_{max}	300
Excitation voltage, recommended	U_{EXE}	V	10 – 12 DC
Excitation voltage, maximum		V	15 DC
Input resistance	R_{LC}	Ω	404 ± 10
Output resistance	R_{out}	Ω	350 ± 3
Insulation resistance	R_{ISO}	MΩ	≥ 2000
Compensated temperature range	T	°C	- 10 ... + 40
Load cell material			Aluminium
Cable length	L	m	2
Coating			Silicone rubber

Wiring

The load cell is provided with a shielded 4 or 6 conductor cable. The cable length is indicated in the accompanying document. The shield will be connected or not connected to the load cell according to customers preference.



Connections

Connections	4-wires	6-wires
Excitation +	red	red
Excitation –	black	black
Signal +	green	green
Signal –	white	white
Sense +	--	blue
Sense –	--	yellow
Shield	purple	purple
Cable length	2 m	

Picture of the load cell dimensions

Annex D (Informative) Selection of load cell(s) for testing - a practical example

D.1. This Annex describes a practical example showing the complete procedure for the selection of test samples out of a load cell family.

D.2. Assume a family consisting of three groups of load cells, differing in class, maximum number of load cell verification intervals, n_{max}, and maximum capacities, E_{max}. The capacities, E_{max}, overlap between the groups according to the following example:

Group 1: Class C, n_{max} = 6 000, Y = 18 000, Z = 6 000

E_{max}: 50 kg, 100 kg, 300 kg and 500 kg

Group 2: Class C, n_{max} = 3 000, Y = 12 000, Z = 4 000

E_{max}: 100 kg, 300 kg, 500 kg, 5 000 kg, 10 t, 30 t and 50 t

Group 3: Class B, n_{max} = 10 000, Y = 25 000, Z = 10 000

E_{max}: 500 kg, 1 000 kg and 4 000 kg

D.2.1. Summarize and sort the load cells with respect to E_{max} and accuracy as follows:

Class n_{max} Group	Y Z	<--- lowest			E_{max}, kg v_{min}, kg			---> highest			
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

D.2.2. Identify the smallest capacity load cells in each group to be tested, according to 9.4.4:

Class n_{max} Group	Y Z	<--- lowest			E_{max}, kg v_{min}, kg			---> highest			
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

In this example, select and identify:

C6 - 50 kg (full evaluation test required)

B10 - 500 kg (full evaluation test required)

Although load cell C3 - 100 kg is the smallest capacity in its group, its capacity falls within the range of other selected load cells having better metrological characteristics. Therefore, it is not selected.

D.2.3. Begin with the group with the best metrological characteristics (in this example, B10) and in accordance with 8.4.2, select the next largest capacity between 5 and 10 times that of the nearest smaller capacity load cell which has been selected. When no capacity meets this criterion, the selected load cell shall be that having the smallest capacity exceeding 10 times that of the nearest smaller capacity load cell which has been selected. Continue this process until all load cell capacities in the group have been considered.

Class n_{max} Group	Y Z	<--- lowest E_{max}, kg ---> highest v_{min}, kg										
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

In this example, select and identify:

B10 - 4 000 kg (full evaluation test required)

D.2.4. Move to the group with the next best characteristics (in this example, C6) and, in accordance with 8.4.2 select the next largest capacity between 5 and 10 times that of the nearest smaller capacity load cell which has been selected. When no capacity meets this criterion, the selected load cell shall be that having the smallest capacity exceeding 10 times that of the nearest smaller capacity load cell which has been selected. Continue this process until all load cell capacities in the group have been considered.

Class n_{max} Group	Y Z	<--- lowest				E_{max}, kg v_{min}, kg		---> highest			
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

*In this example, **there is no change** to the load cells selected. The capacities of the load cells C6 - 300 kg and C6 - 500 kg exceed the capacity of the load cell C6 - 50 kg by greater than 5 times but not greater than 10 times. However, a 500 kg load cell of better metrological characteristics (from group B10) has already been selected. Therefore, in order to minimize the number of load cells to be tested according to 8.3.1, neither cell is selected.*

D.2.5. Again, and repeating this process until all groups have been considered, move to the group with the next best characteristics (in this example, C3) and in accordance with 8.4.4, select the next largest capacity between 5 and 10 times that of the nearest smaller capacity load cell which has been selected. When no capacity meets this criterion, the selected load cell shall be that having the smallest capacity exceeding 10 times that of the nearest smaller capacity load cell which has been selected. Continue this process until all load cell capacities in the group and all groups have been considered.

Class n_{max} Group	Y Z	<--- lowest			E_{max}, kg v_{min}, kg			---> highest				
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

In this example, select and identify:

C3 - 30 000 kg (full evaluation test required) Proceeding from smallest to largest capacity, the only capacity of load cell which is greater than 5 times the capacity of an already selected load cell but less than 10 times that capacity is the C3 - 30 000 kg load cell. Since the capacity of the C3 - 50 000 kg load cell does not exceed 5 times the capacity of the next smaller selected load cell, which is C3 - 30 000 kg, according to 8.4.3 it is presumed to comply the requirements of this Recommendation.

D.2.6. After completing steps D.2.2 to D.2.5 and identifying the load cells, compare load cells of the same capacity from different groups. Identify the load cells with the highest accuracy class and highest n_{max} in each group (see shaded portion of table below). For those load cells of the same capacity but from different groups, identify only the one with the highest accuracy class and n_{max} and lowest v_{min}.

Class n_{max} Group	Y Z	<--- lowest E_{max}, kg ---> highest v_{min}, kg									
C3 3 000 2	12 000 4 000		100 0.0083	300 0.025	500 0.042			5 000 0.42	10 000 0.83	30 000 2.5	50 000 4.17
C6 6 000 1	18 000 6 000	50 0.0028	100 0.0055	300 0.0167	500 0.028						
B10 10 000 3	25 000 10 000				500 0.020	1 000 0.040	4 000 0.16				

Inspect the values of v_{min}, Y, and Z for all cells of the same capacity.

If any load cell of the same capacity has a lower v_{min} or higher Y than the identified load cell, that load cell (or load cells) is also liable for partial evaluation testing, specifically the conduct of additional temperature effect on minimum dead load, E_{min} and barometric pressure effect tests.

If any load cell of the same capacity has a higher Y than the selected load cell, that load cell (or load cells) is also liable for partial evaluation testing, specifically the conduct of additional creep and DR tests.

*In this example, **the load cells identified above also have the best characteristics of lowest v_{min}, highest Y and highest Z.** This is normally the case, but not always.*

D.2.7. If applicable, select the load cell for humidity testing in accordance with 8.4.5, that being the load cell with the most severe characteristics, for example the greatest value of n_{max} or the lowest value of v_{min}.

In this example, the load cell with the greatest value of n_{max} or the lowest value of v_{min} is the same load cell, therefore select:

B10 - 500 kg (humidity test required)

Note: The other B10 load cells also possess the same qualifications and are possible choices. The 500 kg load cell was chosen because it is the smallest of the applicable B10 capacities. Although the C6 - 50 kg load cell has the lowest v_{min} of 0.0028, the B10 load cells have the highest n_{max}, highest accuracy class, and the highest Y and Z.

D.2.8. If applicable, select the load cell for the additional tests to be performed on digital load cells in accordance with 8.4.6, that being the load cell with the most severe characteristics, for example the greatest value of n_{max} or the lowest value of v_{min}.

D.2.9. Summarizing, the load cells selected for test are:

In this example, no load cell in the family is equipped with electronics.

Summary	*Selected cells*
Load cells requiring full evaluation test	C6 - 50 kg B10 - 500 kg B10 - 4 000 kg C3 - 30 000 kg
Load cells requiring partial evaluation test	None
Load cell to be tested for humidity	B10 - 500 kg
Digital load cells for additional tests	None

Annex E (Informative) Load transmission to the load cell

This Annex is taken from the WELMEC 2.4 (European cooperation in legal metrology) Guide for Load Cells (Issue 2, published in August, 2001). With permission from WELMEC, the following portion of that document is reprinted here to provide guidelines for load cell evaluators, during load cell performance evaluations. Recognizing the critical role that load cell receptors and load transmission devices play in accurate measurements, this Annex is intended to provide information regarding the effect of load transmission and recommendations for test design and procedure. The annex is informational and not to be considered required practice.

For some types of load cells the kind of load transmission to the load cell has influence on the measurements and with this on the test results.

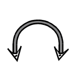
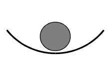
In this annex the standard load transmission devices are listed.

The manufacturer should define whether the load cell works with all standard load transmission devices for the type of load cell or with selected standard load transmission devices or with a load cell specific load transmission devices.

This information may be considered for the load cell tests and may be marked on the certificate.

Standard load transmission devices

Tables 1 and 2 identify different types of LCs, (compression, tension, ...) and typical load cell mounting devices suitable for them. The symbols below classify the mobility between one point of contact on the load cell and its counterpart on the load receptor or mounting base.

Symbol	Description
⇔	Movement possible normal to load axis Note: allows for temperature dilatation
|⇔|	Movement possible normal to load axis, with reversing force (spring-back effect) Note: allows for temperature dilatation, also used for damping of lateral shock
	Inclination possible Note: allows for tilt of load cell or deflection of load receptor, no movement normal to load axis possible
	Indicates auto-centering effect of the complete mounting assembly of one load cell

Remarks on the standard load transmission devices presented in Tables 1 and 2:

All combinations of load cell and transmitting device shown in Tables 1 and 2 can also be utilised in a completely reversed manner.

The load transmission device is independent of the encapsulation, potting or housing which are shown in the examples.

(a) Compression LCs (Table 1, upper part)
- The load transmissions 1 to 8 are presented for canister type LCs. Instead, all load transmissions may be constructed for S-type or ring type load cells.
- 6a shows a pendulum construction build as a complete unit.
- 6b and 6c show external pendulum rocker pins combined with ring-type LCs.
- The bearings for all compression load cells may be installed either below or above the LC.

(b) Tension LCs (Table 1, lower part)
- The load transmissions 1 and 2 are presented for canister type LCs. Alternatively, both load transmissions may be used for S-type LCs.

(c) Beam LCs (table 2, upper part)
- The drawings present double bending and shear beams, as well as plastic potted and encapsulated constructions; all these constructions may be combined with ether of the load transmissions 1 to 10.
- The direction of loading, which is given by the manufacturer, has to be observed.

(d) Single point LCs (Table 2, middle part)
- The load transmissions 1 to 10 for the beam LCs may be applied to all single point LCs.
- The direction of loading, which is given by the manufacturer, has to be observed.

(e) Double bending beam LCs (Table 2, lower part)
- The table shows examples of common constructions. Variations are possible provided the constructions allow enough horizontal flexibility between both ends.
- The direction of loading, provided by the manufacturer, has to be observed.

The single bending beams had been exempted for general acceptance, because very small displacements of the “force transducing point” may lead to a change of span and linearity.

Table 1: Schematic drawings for compression and tension LCs

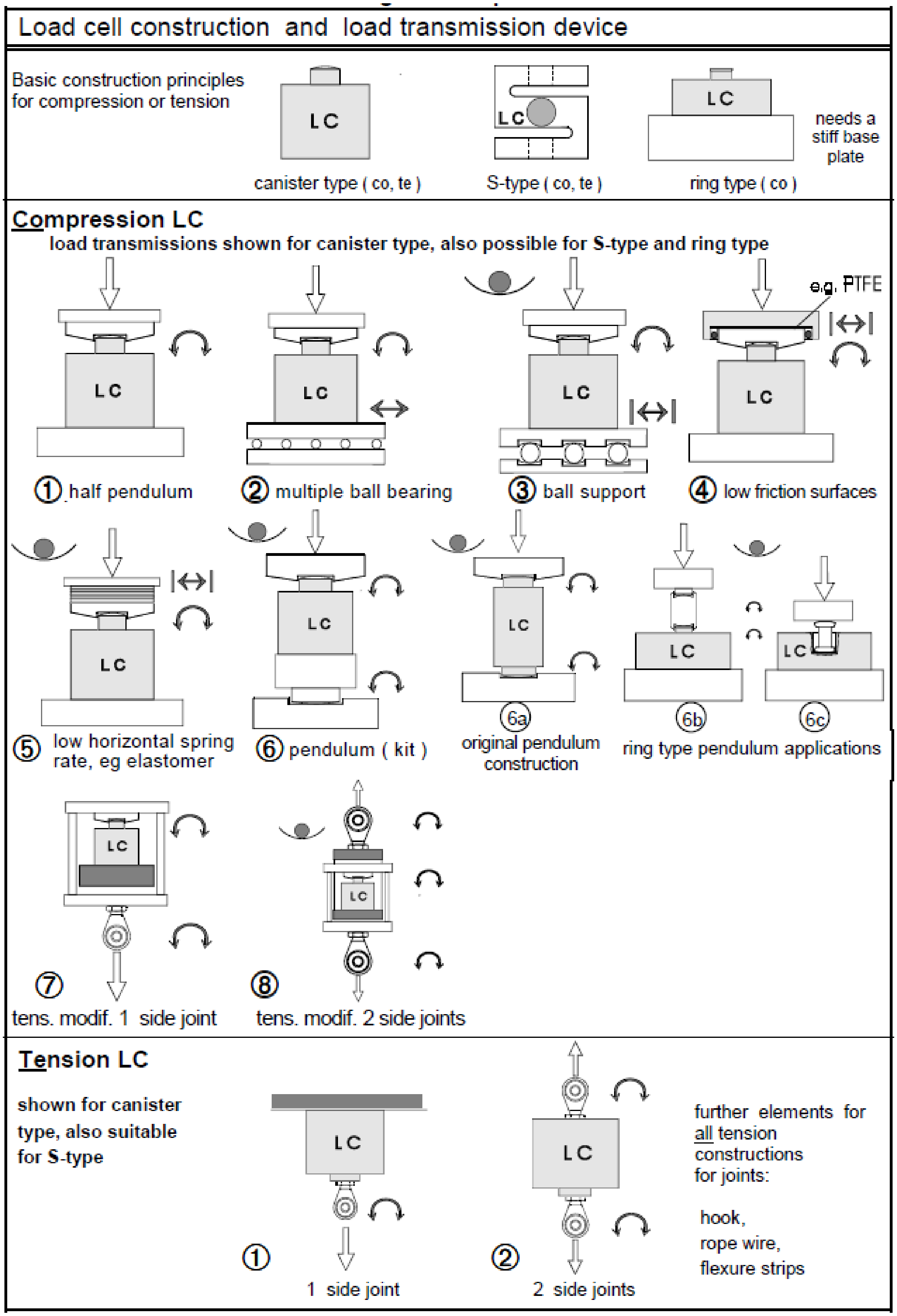


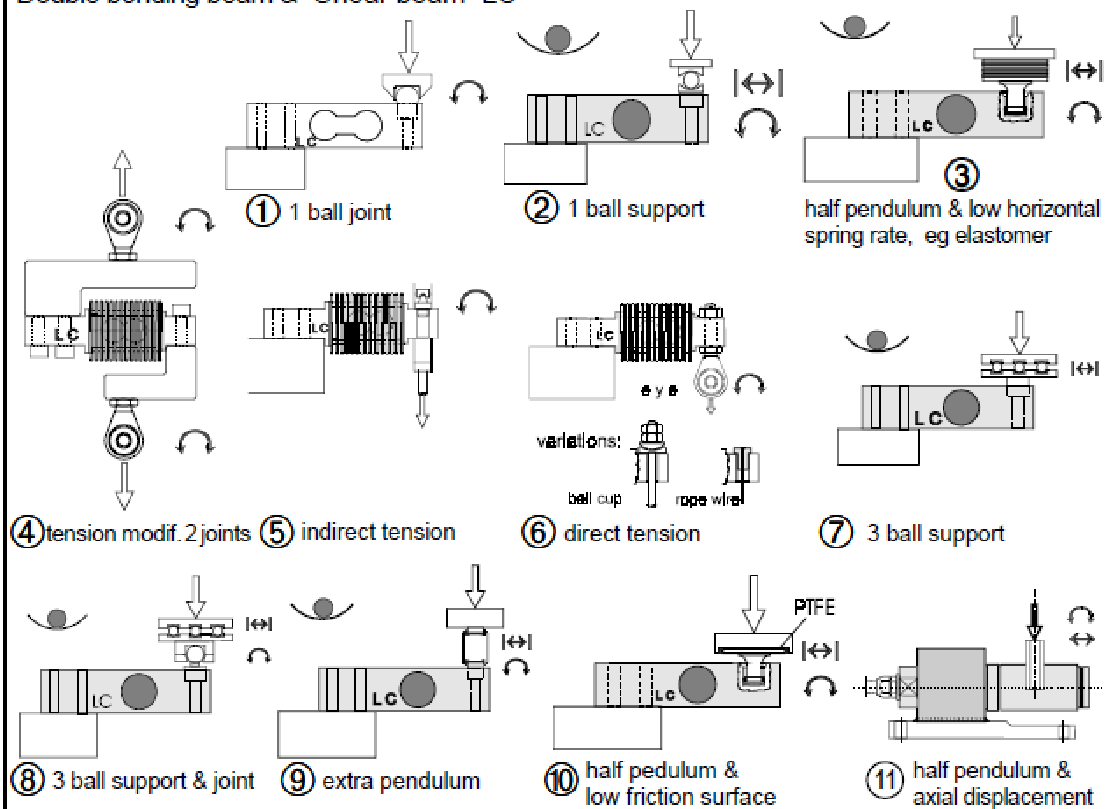
Table 2: Schematic drawings for beam LCs

Load cell construction and load transmission device

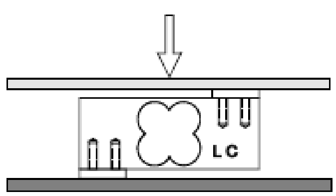
The load transmission device is independent of the encapsulation, potting or housing and the mounting at the fixed end shown below

Beam LC - Cantilever beam

Double bending beam & Shear beam LC



Single point LC

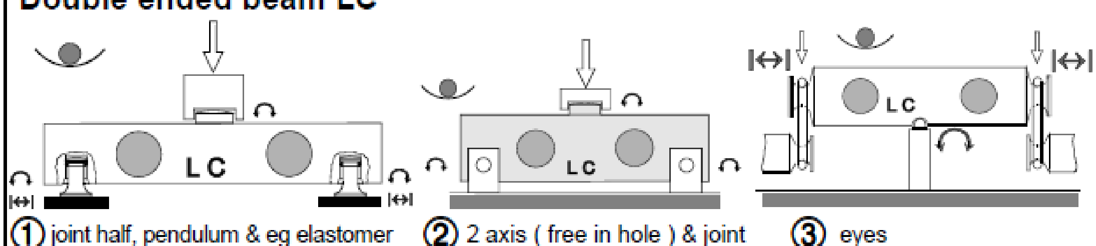


The single point LC has no degree of freedom for horizontal displacement or inclination, using more than one LC in a load receptor discoupling elements are necessary.

The load transmissions 1 to 10 for the beam LCs may be applied.

Max. platform dimensions may be mentioned in the TC or the TAC.

Double ended beam LC



Constructions with fixed clamping at the two ends need for minimum displacement and inclination some elasticity of the supporting construction.

Bibliography

[1] "OIML R76 Non-automatic weighing instruments," 2006.

[2] "OIML V 2-200 International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)," 2012.

[3] "OIML V2 International Vocabulary of Terms in Legal Metrology (VIML)," 2013.

[4] "OIML D9 Principles of metrological supervision," 2004.

[5] "OIML D11 General requirements for electronic measuring instruments.," 2013.

[6] "OIML B3 OIML Basic Certificate System for OIML Type Evaluation of Measuring Instruments," 2011.

[7] "Guide to the Expression of Uncertainty in Measurement, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, JCGM 100," 2008.

[8] "OIML D31 General requirements for software controlled measuring instruments," 2008.

[9] "ISO 8601 Data elements and interchange formats - Information interchange - Representation of dates and times," 2004.

[10] "IEC Publication 60068-2-30," 2005-08.

[11] "IEC Publication 60068-3-4," 2001- 08.

[12] "IEC Publication 60068-2-78," 2012.

[13] "IEC Publication 61000-2-1," 1990-05.

[14] "IEC Publication 61000-4-1," 2006-10.

[15] "IEC Publication 61000-4-29," 2000 - 08.

[16] "IEC Publication 61000-4-11," 2004- 03.

[17] "IEC Publication 61000-6-1," 2005 - 03.

[18] "IEC Publication 61000-6-2," 2005-01.

[19] "IEC Publication 61000-4-4," 2012 - 04.

[20] "IEC Publication 61000-4-5," 2014 - 05.

[21] "IEC Publication 61000-4-2," 2008 - 12.

[22] "IEC Publication 61000-4-3," 2010 - 04.

[23] "IEC Publication 61000-4-6," 2013 - 10.

[24] "OIML R61-1 Automatic gravimetric filling instruments," 2004.

[25] "OIML R50-1 Continuous totalizing automatic weighing instruments (belt weighers)," 1997.

[26] "OIML R51-1 Automatic catchweighing instruments," 2006.

[27] "OIML R107-1 Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)," 2007.

[28] "OIML R106-1 Automatic rail-weighbridges," 2011.