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Metrological Regulation for Load Cells  
Part 1: Metrological and Technical  
Requirements  
Part 2: Metrological controls and  
performance tests

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**Metrological Regulation for Load Cells**

**Part 1: Metrological and Technical Requirements**

**Part 2: Metrological controls and performance tests**

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OIML R 60-1 et -2

**Réglementation métrologique des cellules de pesée**

**Partie 1: Exigences métrologiques et techniques,**

**Partie 2: Contrôles métrologiques et essais de performance**

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	<h1>Part 1 Metrological and technical requirements</h1>
	<h2>1. Introduction</h2> <p>The 2<sup>nd</sup> Committee Draft copy of OIML R60 Parts 1&amp;2 represents changes to the previous 1<sup>st</sup> CD based on the Project Group's (TC9 p1) comments.</p> <p>A characteristic that sets this Recommendation apart from others is that, while other Recommendations apply to complete measuring instruments, 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.</p> <p>To assist the reader in the review of the formatting of this First Committee Draft, the document has been placed in a tabular form using the following numbering scheme. As illustrated below in "2 Scope", the left-hand column contains reference numbers that are associated with the 2000 edition of R60. Paragraphs that appear without a reference number in the left-hand column represent new entries in the document.</p> <p>Part 1 (Metrological and Technical Requirements) and Part 2 (Metrological Controls and Performance Tests) of this Recommendation are a combined publication, Part 3 (Test Report Format) is a separate document.</p>
1 (2000 Ed.)	<h2>2. Scope</h2>
1.1	<h3>2.1.</h3> <p>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. Except as 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.</p>
1.2	<h3>2.2.</h3> <p>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</p>

	<p>the individual contributions to the total error of measurement while still achieving the intended final result.</p> <p>Note: the error envelope may be defined as the curves that provide the boundary of the maximum permissible 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 errors determined may be positive or negative and include the effects of nonlinearity, hysteresis and temperature.</p>
1.3	<p><b>2.3.</b></p> <p>“Weighing modules” as per R76, T.2.2.7 (see Annex A, A.5.1), are not covered by this recommendation. Instruments which are comprised of load cells and which give an indication of mass are the subjects of separate Recommendations.</p>
2	<p><b>3. Terminology (Terms and definitions)</b></p> <p>The terms most frequently used in the load cell field and their definitions are given below (see 3.7 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) [1], to OIML V 2 International Vocabulary of Terms in Legal Metrology (VIML) [2], to OIML D 9 Principles of metrological supervision [3], to OIML D 11 General Requirements for electronic measuring instruments [4], and to OIML B 3 OIML Certificate System for Measuring Instruments [5].</p> <p>In addition, for the purposes of this Recommendation, the following definitions apply:</p>
2.1	<p><b>3.1. General definitions</b></p>
2.1.2	<p>3.1.1.</p> <p>load cell</p> <p>measuring transducer that, in response to an applied load will produce an output. This output may be converted by another device into measurement units such as mass.</p>
2.1.3	<p>3.1.2.</p> <p>load cell equipped with electronics</p> <p>load cell employing an assembly of electronic components having a recognizable function of its own.</p> <p><i>Note:</i> Passive elements such as strain gauges are not considered electronic components for the purpose of this recommendation</p> <p><i>Note:</i> Load cells equipped with electronics that produce an output in digital form are often referred to as “digital load cells”.</p>

2.1.4	<p>3.1.3.</p> <p>performance test</p> <p>test to verify whether the load cell under test is capable of performing its intended functions.</p>
	<b>3.2. Categories of Load Cells</b>
2.1.1	3.2.1. Application of load
2.1.1.1	<p>3.2.1.1.</p> <p><i>compression loading</i></p> <p>compressive force applied to the load receptor of a load cell.</p>
2.1.1.2	<p>3.2.1.2.</p> <p><i>tension loading</i></p> <p>tension force applied to the load receptor of a load cell.</p>
	<b>3.3. Construction of load cells</b>
	<p>3.3.1.</p> <p>strain gauge</p> <p>analog resistive element that is bonded to a load cell structure and changes resistance depending on the compression or tension deformation of the load cell structure</p>
	<p>3.3.2.</p> <p>tuning fork (vibration of)</p> <p>device used to detect a change of resonance frequency of a tuning fork caused by an external load.</p>
2.2	<b>3.4. Metrological characteristics of a load cell</b>

2.2.2	<p>3.4.1.</p> <p>humidity symbol</p> <p>symbol assigned to a load cell that indicates the conditions of humidity under which the load cell has been tested.</p>
2.2.3.	<p>3.4.2.</p> <p>load cell family</p> <p>for the purposes of type evaluation, a load cell family consists of load cells that are of:</p> <ul style="list-style-type: none"> <li>• the same material or combination of materials (for example, mild steel, stainless steel or aluminum);</li> <li>• the same design of the measurement technique (for example, strain gauges bonded to metal);</li> <li>• 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</li> <li>• one or more load cell groups.</li> </ul> <p><i>Note:</i> The examples provided are not intended to be limiting.</p>
2.2.3.1	<p>3.4.2.1.</p> <p><i>load cell group</i></p> <p>all load cells within a family possessing identical metrological characteristics (as listed in 6.1.5 – including: class; <math>n_{\max}</math>; temperature rating; etc.).</p>
2.3	<b>3.5. Range, capacity and output terms</b>
2.3.1	<p>3.5.1.</p> <p>load cell interval</p> <p>part of the load cell measuring range into which that range is divided.</p>
2.3.2	<p>3.5.2.</p> <p>load cell measuring range (<math>D_R</math>)</p>

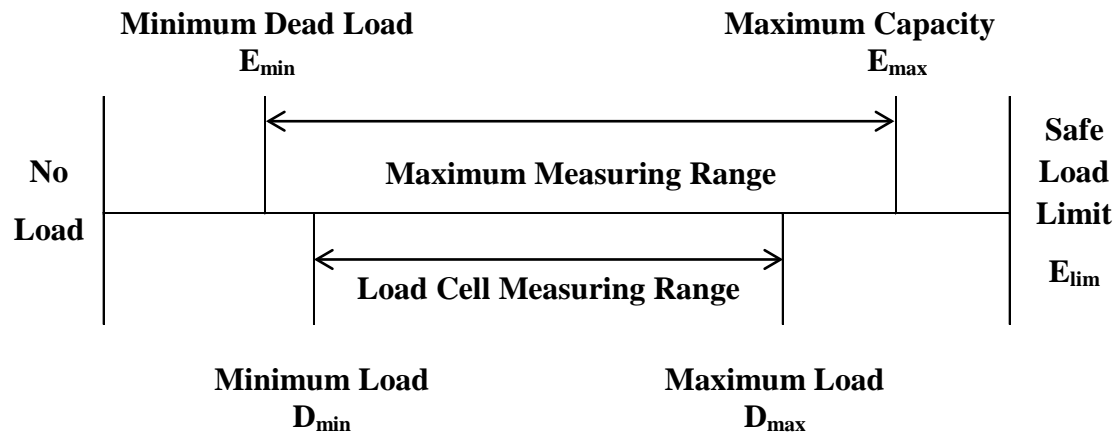


	<p>range of values of the measured quantity for which the result of measurement should not be affected by an error exceeding the maximum permissible error (MPE) (see Annex A: A.1.11).</p> <p>DR is the range between the maximum load of the measuring range <math>D_{\max}</math> and minimum load of the measuring range <math>D_{\min}</math> <math>DR = (D_{\max} - D_{\min})</math></p>
2.3.3	<p>3.5.3.</p> <p>load cell output</p> <p>measurable quantity into which a load cell converts the measured input quantity.</p>
2.3.4	<p>3.5.4.</p> <p>load cell verification interval (v)</p> <p>load cell interval, as a ratio of the output signal (mV)/excitation signal (V), expressed in units of mass, used in the test of the load cell for accuracy classification.</p>
2.3.5	<p>3.5.5.</p> <p>maximum capacity (<math>E_{\max}</math>)</p> <p>largest value of a force introduced to a load cell expressed in units of mass, without exceeding the MPE (see Annex A: A.1.11).</p>
2.3.6	<p>3.5.6.</p> <p>maximum load of the measuring range (<math>D_{\max}</math>)</p> <p>largest value of force introduced to a load cell during test or use (expressed in units of mass).</p>
	<p>3.5.7.</p> <p>maximum measuring range (<math>E_R</math>)</p> <p>range between maximum capacity <math>E_{\max}</math> and minimum dead load <math>E_{\min}</math>  <math>[E_R = (E_{\max} - E_{\min})]</math></p>
2.3.7	<p>3.5.8.</p> <p>maximum number of load cell verification intervals (<math>n_{\max}</math>)</p> <p>maximum number of load cell verification intervals into which the load cell measuring range may be divided for which the result of measurement shall not be affected by an error exceeding</p>

	the MPE (see Annex A: A.1.11).
2.3.8	<p>3.5.9.</p> <p>minimum dead load (<math>E_{\min}</math>)</p> <p>smallest value of force introduced by a load (expressed in mass units) that may be applied to a load cell without exceeding the MPE (see Annex A: A.1.11).</p>
2.3.9	<p>3.5.10.</p> <p>minimum dead load output return (DR)</p> <p>the observed difference in load cell verification intervals at minimum dead load (<math>E_{\min}</math>), measured before and after application of a load of <math>D_{\max}</math></p>
2.3.10	<p>3.5.11.</p> <p>minimum load cell verification interval (<math>v_{\min}</math>)</p> <p>smallest load cell verification interval into which the load cell measuring range can be divided.</p>
2.3.11	<p>3.5.12.</p> <p>minimum load of the measuring range (<math>D_{\min}</math>)</p> <p>smallest value of a quantity which is applied to a load cell during test or use.</p> <p><i>Note: For the limits on <math>D_{\min}</math> during testing, see 9.7.3.3.</i></p>
2.3.12	<p>3.5.13.</p> <p>number of load cell verification intervals (n)</p> <p>number of load cell verification intervals into which the load cell measuring range is divided.</p>
2.3.13	<p>3.5.14.</p> <p>relative DR or Z</p> <p>ratio of the load cell measuring range <math>D_R</math>, to two times the minimum dead load output return, DR.</p> <p><i>Note: This ratio is used to describe multi-interval instruments.</i></p>

2.3.14	<p>3.5.15.</p> <p>relative <math>v_{\min}</math> or Y</p> <p>ratio of the load cell measuring range <math>D_R</math>, to the minimum load cell verification interval, <math>v_{\min}</math>.</p> <p><i>Note: This ratio describes the resolution of the load cell independent from the load cell capacity</i></p>
2.3.15	<p>3.5.16.</p> <p>safe load limit (<math>E_{\lim}</math>)</p> <p>maximum load that can be applied without producing a permanent shift in the performance characteristics beyond those specified.</p>
2.3.16	<p>3.5.17.</p> <p>warm-up time</p> <p>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.</p>
2.6	<p><b>3.6. Illustration of certain definitions</b></p> <p>The terms that appear above the central horizontal line in Figure 1 below are parameters that are fixed by the design of the load cell. The terms that appear below that line are parameters that are variable, dependent on the conditions of use or in the test of a load cell (in particular, those load cells used in weighing instruments).</p>

Figure 1. Illustration of certain definitions



2.4 3.7. Measurement and error terms

2.4.1

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.

2.4.2

3.7.2.

apportionment factor ( $p_{LC}$ )

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

*Note: This value is used in determining MPE (see Annex A: A.1.11)*

2.4.3

3.7.3.

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] [6]

2.4.5	<p>3.7.4.</p> <p>fault detection output</p> <p>electrical representation issued by the load cell indicating that a fault condition exists.</p>
2.4.6	<p>3.7.5.</p> <p>hysteresis error</p> <p>difference in load cell output readings for the same applied force between the reading obtained by increasing the load from minimum load (<math>D_{\min}</math>), and the reading obtained by decreasing the load from maximum load (<math>D_{\max}</math>).</p> <p>(see 6.2.1 and 6.2.2)</p>
2.4.8	<p>3.7.6.</p> <p>load cell intrinsic error</p> <p>error resulting from a load cell, determined under reference conditions (see Annex A, A.1.7).</p>
2.4.10	<p>3.7.7.</p> <p>non-linearity</p> <p>deviation from the average of the values of load cell signals from a straight line through zero force applied and maximum force applied.</p>
2.4.12	<p>3.7.8.</p> <p>repeatability error</p> <p>difference between load cell output readings taken from consecutive tests under the same loading and environmental conditions of measurement.</p>
2.4.15	<p>3.7.9.</p> <p>span stability</p> <p>capability of a load cell to maintain the difference between the load cell output at maximum load, <math>D_{\max}</math>, and the load cell output at minimum load, <math>D_{\min}</math>, over a period of use within specified limits.</p>
2.4.16	<p>3.7.10.</p> <p>temperature effect on minimum dead load output</p> <p>change in minimum dead load output due to a change in ambient temperature.</p>

2.4.17	<p>3.7.11.</p> <p>temperature effect on sensitivity</p> <p>change in sensitivity due to a change in ambient temperature.</p>																		
2.5	<p><b>3.8. Influences and reference conditions</b></p> <p>For definition of terms: “influence quantity”; “rated operating conditions”; and “reference conditions” refer to Annex A</p>																		
	<p><b>3.9. Abbreviations</b></p>																		
	<table border="0"> <tr><td>AC</td><td>Alternating Current</td></tr> <tr><td>DC</td><td>Direct Current</td></tr> <tr><td>EMC</td><td>Electro Magnetic Compatibility</td></tr> <tr><td>IEC</td><td>International Electrotechnical Committee</td></tr> <tr><td>ISO</td><td>International Organization for Standardization</td></tr> <tr><td>I/O</td><td>Input/Output</td></tr> <tr><td>MPE</td><td>Maximum Permissible Error</td></tr> <tr><td>OIML</td><td>International Organization of Legal Metrology</td></tr> <tr><td>VIM</td><td>International Vocabulary of Metrology – Basic and General Concepts and Associated Terms</td></tr> </table>	AC	Alternating Current	DC	Direct Current	EMC	Electro Magnetic Compatibility	IEC	International Electrotechnical Committee	ISO	International Organization for Standardization	I/O	Input/Output	MPE	Maximum Permissible Error	OIML	International Organization of Legal Metrology	VIM	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms
AC	Alternating Current																		
DC	Direct Current																		
EMC	Electro Magnetic Compatibility																		
IEC	International Electrotechnical Committee																		
ISO	International Organization for Standardization																		
I/O	Input/Output																		
MPE	Maximum Permissible Error																		
OIML	International Organization of Legal Metrology																		
VIM	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms																		
	<p><b>4. Description of Load Cells</b></p> <p>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 weighing 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.</p> <p>While many technologies are used in the design of load cells, those used in legal metrology applications are commonly designed to provide an output relative to an input stimulus based on electrical current. Both analog and digital outputs are recognized in load cells within that category. 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.</p> <p>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.</p>																		

3	<h2>5. Units of measurement</h2> <p>The units of measurement resulting from the output of a load cell that is incorporated as a component of a weighing instrument are required to conform to the Recommendation(s) applicable to the weighing instrument.</p>																				
4	<h2>6. Metrological requirements</h2>																				
4.1	<h3>6.1. Principle of load cell classification</h3> <p>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 within the measuring system with which it is applied. Therefore, it is not the intent of this Recommendation to require that a load cell be of the same accuracy class as the measuring system in which it may be used. Nor does it require that a measuring instrument, giving indications of mass for example, use a load cell which has been separately approved. All data/items under 6.1.1 to 6.1.7 shall be specified by the manufacturer</p>																				
4.2	<h4>6.1.1. Accuracy classes and their symbols</h4> <p>Load cells shall be ranked, according to their overall performance capabilities, into four accuracy classes whose designations are as follows:</p> <p>Class A; Class B; Class C; Class D.</p>																				
4.3	<h4>6.1.2. Maximum number of load cell verification intervals</h4> <p>The maximum number of load cell verification intervals, <math>n_{\max}</math>, into which the load cell measuring range can be divided in a measuring system shall be within the limits fixed in Table 1.</p>																				
Table 1	<table><tr><th colspan="5">Table 1. Maximum Number of Load Cell Verification Intervals (<math>n_{\max}</math>) according to accuracy class.</th></tr><tr><th></th><th>Class A</th><th>Class B</th><th>Class C</th><th>Class D</th></tr><tr><th>Lower Limit</th><td>50 000</td><td>5 000</td><td>500</td><td>100</td></tr><tr><th>Upper Limit</th><td>Unlimited</td><td>100 000</td><td>10 000</td><td>1 000</td></tr></table>	Table 1. Maximum Number of Load Cell Verification Intervals ( $n_{\max}$ ) 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
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Upper Limit	Unlimited	100 000	10 000	1 000																	

4.4	<p>6.1.3. Minimum load cell verification interval</p> <p>The minimum load cell verification interval, <math>v_{\min}</math>, shall be specified by the manufacturer as per 3.5.11 in combination with 3.5.15.</p>
4.5	<p>6.1.4. Supplementary classifications</p> <p>Load cells shall also be classified by the type of load applied to the load cell wherever there would be a risk of confusing the type of loading (i.e., compression loading, tension loading or, universal). A load cell may bear different classifications for different types of load applied to the load cell. The type of load for which the classification(s) applies(y) shall be specified. For multiple capacity load cells, each capacity shall be classified separately.</p>



4.6

## 6.1.5. Complete load cell classification

The load cell shall be classified according to six parts:

- accuracy class designation (see 6.1.1 and 7.2.4.1);
- maximum number of load cell verification intervals (see 6.1.2 and 7.2.4.5);
- type of load, if necessary (see 6.1.4 and 7.2.4.2);
- special limits of working temperature, if applicable (see 7.2.4.3);
- humidity symbol, if applicable (see 7.2.4.4); and
- additional characterization information, as listed below in Figure 2, 6.1.6, and 6.1.7.

An example illustrating the six parts of the load cell classification is shown in Figure 2.

Figure 2

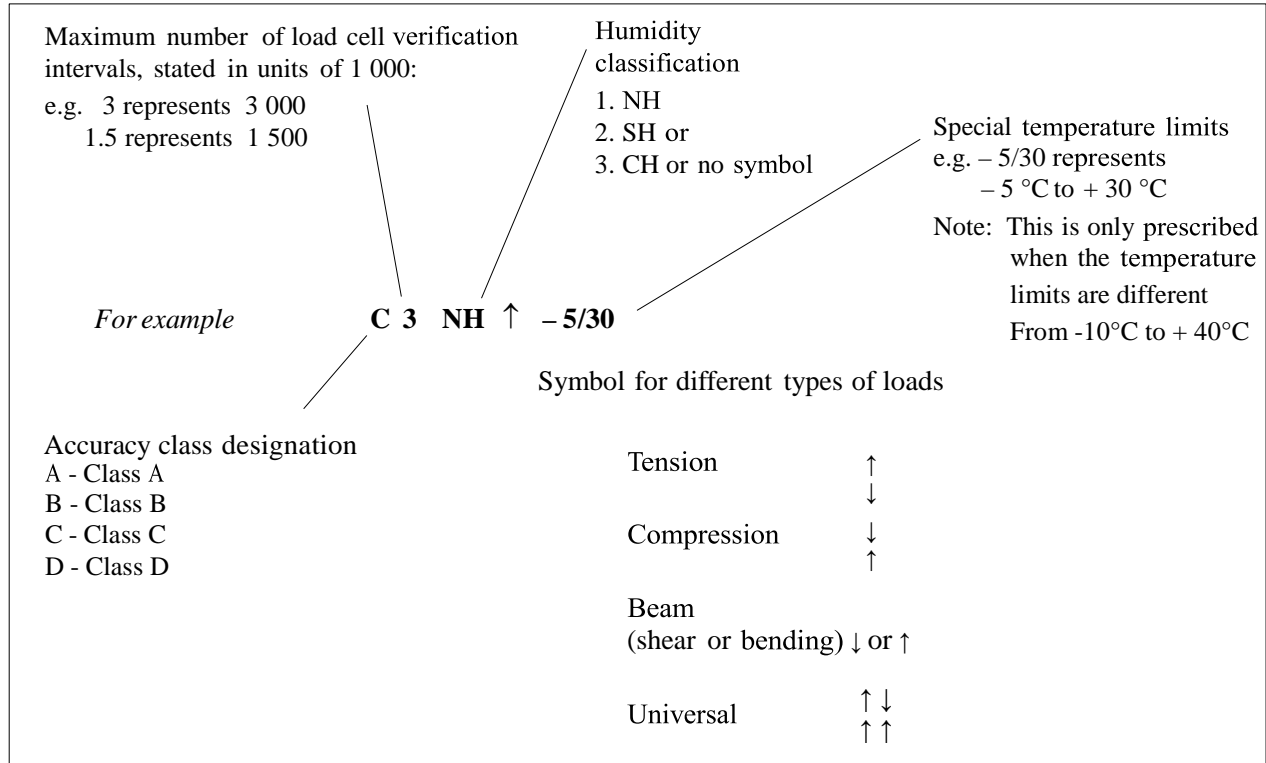


Figure 2: Complete Load Cell classification

4.6.7

## 6.1.6. Standard classification

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

<b>Table 3</b>	<table border="1"> <tr> <th colspan="2">Table 2. Examples of load cell classification</th></tr> <tr> <th>Classification symbol</th><th>Description</th></tr> <tr> <td>C2</td><td>Class C, 2 000 intervals</td></tr> <tr> <td>C3 ↓ 5/35 ↑</td><td>Class C, 3 000 intervals, compression, + 5 °C to + 35 °C</td></tr> <tr> <td>C2 NH</td><td>Class C, 2 000 intervals, not to be subjected to humidity test</td></tr> </table>	Table 2. Examples of load cell classification		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		
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C2 NH	Class C, 2 000 intervals, not to be subjected to humidity test												
<b>4.6.8</b>	<p><b>6.1.7. Multiple classifications</b></p> <p>Load cells that have complete classifications for different types of load shall be designated using separate information for each classification. Examples are shown in Table 3. An illustration of the standard classification symbols using an example is shown in Figure 2.</p>												
<b>Table 4</b>	<table border="1"> <tr> <th colspan="2">Table 3. Examples of Multiple Classifications</th></tr> <tr> <th>Classification Symbol</th><th>Description</th></tr> <tr> <td>C2 ↑</td><td>Class C, 2 000 intervals, shear beam</td></tr> <tr> <td>C1.5 ↓</td><td>Class C, 1 500 intervals, bending beam</td></tr> <tr> <td>C1 ↓ - 5/30 ↑</td><td>Class C, 1 000 intervals, compression, – 5 °C to + 30 °C</td></tr> <tr> <td>C3 ↑ - 5/30 ↓</td><td>Class C, 3 000 intervals, tension, – 5 °C to + 30 °C</td></tr> </table>	Table 3. Examples of Multiple Classifications		Classification Symbol	Description	C2 ↑	Class C, 2 000 intervals, shear beam	C1.5 ↓	Class C, 1 500 intervals, bending beam	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
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	<p><b>6.2. Measuring ranges</b></p>												
	<p><b>6.2.1. Minimum load of the measuring range (<math>D_{\min}</math>) (see 3.5.12)</b></p> <p>The smallest value of mass applied to a load cell during test or use shall not be less than <math>E_{\min}</math> (see 3.5.9).</p>												
	<p><b>6.2.2. Maximum load of the measuring range (<math>D_{\max}</math>) (see 3.5.6)</b></p> <p>The largest value of force introduced to a load cell during test or use shall not be greater than <math>E_{\max}</math> (see 3.5.5). For the limits on <math>D_{\max}</math> during testing, see 9.7.3.3.</p>												
<b>5</b>	<p><b>6.3. Maximum permissible measurement errors</b></p> <p>Under the rated operating conditions in 6.6, the maximum permissible error (MPE) shall not exceed the values stated in 6.5</p> <p>These MPEs are applicable after increasing as well as decreasing the force applied (i.e., they include hysteresis).</p>												

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

### 5.1 6.3.1. 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 ( $n_{\max}$ ) specified for the load cell (see 6.1.2) and to the actual value of the load cell verification interval,  $v$ .

#### 5.1.1 Table 5

#### 6.3.1.1. Type evaluation

The MPE (see Annex A: A.1.11) on type evaluation shall be the values derived using the expressions contained in the left column of Table 4. The apportionment 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  
( $0.3 \leq p_{LC} \leq 0.8$ )<sup>1</sup>.

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

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

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

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

The limits of error shown in include errors due to nonlinearity, hysteresis and temperature effect on sensitivity over certain temperature ranges, specified in 6.6.1.1 and 6.6.1.2. Further errors, not included in the Table 4 limits of error, are treated separately.

<sup>1</sup> Associated with apportionment of error provisions contained within OIML R 76-1, 3.5.1 and 3.10.2.1 [8]; R 50-1, 2.2.3 [22]; R 51-1, 5.2.3.4 [21]; R 61-1, 5.2.3.3 [20]; R 106-1, 5.1.3.2 [24]; or R 107-1, 5.1.4.1 [23], when load cell is applied to such instruments.

5.4	<b>6.4. Repeatability error</b>  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.
5.3	<b>6.5. Permissible variation of results under reference conditions</b>
5.3.1	6.5.1. 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 value of MPE for the applied load.*  The difference in readings taken after 20 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.  *Regardless of any value declared by the manufacturer for the apportionment factor, $p_{LC}$ , the MPE for creep shall be determined from Table 4 using the apportionment factor, $p_{LC} = 0.7$ . “
5.3.2	6.5.2. Minimum dead load output return  The difference in the value of load cell output preceding a 30 minute period of exposure to a load of 90% to 100% of $E_{\max}$ and the value of load cell output following the removal of that maximum load shall not vary by more than half the value of the load cell verification interval ( $0.5v$ )
5.5	<b>6.6. Influence quantities (Rated operating conditions)</b>  Load cells are to be evaluated under the conditions specified in 6.6.1 - 6.6.3. In addition, load cells that are equipped with functions typically performed by weighing instruments (e.g., analog to digital conversion) may be required to be evaluated against additional requirements contained in other OIML Recommendations for those weighing instruments. These additional evaluations are outside the scope of this Recommendation.
5.5.1	6.6.1. Temperature
5.5.1.1	6.6.1.1. <i>Temperature limits</i>  Excluding temperature effects on minimum dead load output, the load cell shall perform within the limits of error in 6.3.1.1 over the temperature range of $-10\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$ , unless otherwise specified as in 6.6.1.2 below.  <i>Note:</i> National legislation may prescribe alternate temperature limits with a range of $50\text{ }^{\circ}\text{C}$ or more as appropriate for local climatic conditions and the environmental conditions that can be anticipated.

5.5.1.2	<p>6.6.1.2. <i>Special limits</i></p> <p>Load cells for which particular limits of working temperature are specified shall satisfy, within those ranges, the conditions defined in 6.3.1.1. The span of these ranges shall be at least:</p> <p>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.</p>
5.5.1.3	<p>6.6.1.3. <i>Temperature effect on minimum dead load output</i></p> <p>The minimum dead load output of the load cell over the temperature range, as specified in 6.6.1.1 or 6.6.1.2, shall not vary by an amount greater than the apportionment factor, <math>p_{LC}</math>, times the minimum load cell verification interval, <math>v_{min}</math>, for any change in ambient temperature of:</p> <p>2 °C for load cells of class A;  5 °C for load cells of class B, C and D.</p>
5.5.2	<p>6.6.2. Barometric pressure</p> <p>The output of the load cell shall not vary by an amount greater than the minimum load cell verification interval, <math>v_{min}</math>, for a change in barometric pressure of 1 kPa over the range from 95 kPa to 105 kPa.</p>
5.5.3	<p>6.6.3. Humidity</p> <p>With respect to humidity conditions, this Recommendation defines 3 humidity classes: CH (as standard), NH, and SH. 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.</p>
5.5.3.1	<p>6.6.3.1. <i>Humidity error – CH or unmarked load cells</i></p> <p>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.</p> <p>The influence of exposure to temperature cycles specified in 9.10.5.12 on the load cell output for minimum load shall not be greater than 4 % of the difference between the output on the maximum capacity, <math>E_{max}</math>, and that at the minimum dead load <math>E_{min}</math>.</p> <p>The influence of exposure to temperature cycles specified in 9.10.5.12 on the load cell output for the maximum load shall not be greater than the load cell verification interval <math>v</math>.</p>

5.5.3.2	<p data-bbox="326 142 971 176"><b>6.6.3.2. Humidity error – SH marked load cells</b></p> <p data-bbox="326 218 1503 289">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.</p> <p data-bbox="326 331 1479 403">A load cell shall meet the applicable MPE when exposed to conditions of relative humidity variations as specified in 9.10.6</p>
6	<p data-bbox="232 424 1016 457"><b>6.7. Requirements for load cells equipped with electronics</b></p>
6.1	<p data-bbox="280 487 678 520"><b>6.7.1. General requirements</b></p> <p data-bbox="280 562 1503 705">In addition to the other requirements of this Recommendation, a load cell equipped with electronics shall comply with the following requirements. The MPE shall be determined using an apportionment factor, <math>p_{LC}</math>, equal to 1.0 (<math>p_{LC} = 1.0</math>) substituted for the apportionment factor, <math>p_{LC}</math>, that is declared by the manufacturer and applied to the other requirements.</p> <p data-bbox="280 772 1503 974">If a load cell is configured with substantial additional electronic functions (e.g., a/d conversion, signal amplification, 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 complete weighing instruments.</p>
6.1.1	<p data-bbox="326 1020 553 1054"><b>6.7.1.1. Faults</b></p> <p data-bbox="326 1096 1503 1167">A load cell equipped with electronics shall be designed and manufactured such that when it is exposed to electrical disturbances either:</p> <ul style="list-style-type: none"> <li data-bbox="326 1209 797 1243">a) significant faults do not occur; or</li> <li data-bbox="326 1285 959 1318">b) significant faults are detected and acted upon.</li> </ul> <p data-bbox="326 1360 1414 1394">Messages of significant faults should not be confused with other messages presented.</p> <p data-bbox="326 1436 1414 1470"><i>Note:</i> A fault equal to or smaller than the load cell verification interval, <math>v</math>, is allowed.</p>
6.2	<p data-bbox="326 1516 846 1549"><b>6.7.1.2. Acting upon significant faults</b></p> <p data-bbox="326 1591 1503 1701">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 the user acts on the fault or the fault disappears.</p>

6.1.2	<p>6.7.1.3.     <i>Durability</i></p> <p>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.</p>																		
6.1.3	<p>6.7.1.4.     <i>Compliance with requirements</i></p> <p>A load cell equipped with electronics is presumed to comply with the requirements in 6.7.1.1 and 6.7.1.3, if it passes the examinations specified in 6.7.2 and 9.10.7</p>																		
6.1.4	<p>6.7.1.5.     <i>Application of the requirements in 6.7.1.1</i></p> <p>The requirements in 6.7.1.1 may be applied separately to each individual cause or significant fault. The choice of whether 6.7.1.1 a) or 6.7.1.1 b) is applied is left to the manufacturer.</p>																		
	<p>6.7.2.     Functional requirements</p>																		
6.3.5	<p>6.7.2.1.     <i>Disturbances</i></p> <p>When a load cell equipped with electronics is subjected to the disturbances specified in 9.10.7.1 (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 not exceed the minimum load cell verification interval, , or the load cell shall detect and react to a significant fault.</p>																		
6.3.6	<p>6.7.2.2.     Span stability maximum allowable variation requirements (not applicable to class A load cells)</p> <p>When a load cell equipped with electronics is subjected to the span stability test specified in 9.10.7.1 and 9.10.7.11, the variation in the load cell span measurement results shall not exceed half the load cell verification interval or half the absolute value of the MPE for the test load applied, whichever is the greater on any of the measurements.</p>																		
	<table><tr><th colspan="4">Table 5. Performance and Stability Tests for a Load Cell Equipped with Electronics</th></tr><tr><th>Test</th><th>Section 9.10 test procedure</th><th><math>p_{LC}</math></th><th>Characteristic under test</th></tr><tr><td>Warm-up time</td><td>9.10.7.3</td><td rowspan="3">1.0</td><td>Influence factor</td></tr><tr><td>Power voltage variations</td><td>9.10.7.4</td><td>Influence factor</td></tr><tr><td>Short-time power reductions</td><td>9.10.7.5</td><td>Disturbance</td></tr></table>	Table 5. Performance and Stability Tests for a Load Cell Equipped with Electronics				Test	Section 9.10 test procedure	$p_{LC}$	Characteristic under test	Warm-up time	9.10.7.3	1.0	Influence factor	Power voltage variations	9.10.7.4	Influence factor	Short-time power reductions	9.10.7.5	Disturbance
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6.1.3	<p>6.7.2.3.    <i>Compliance with requirements</i></p> <p>A load cell equipped with electronics is presumed to comply with the requirements in 6.7.1.1 and 6.7.1.3, if it passes the examinations specified in 6.7.2.1 and 6.7.2.2</p>																		
6.1.4	<p>6.7.2.4.    <i>Application of the requirements in 6.7.1.1</i></p> <p>The requirements in 6.7.1.1 may be applied separately to each individual cause or significant fault. The choice of whether 6.7.1.1 a) or 6.7.1.1 b) is applied is left to the manufacturer.</p>																		
	<h2>7. Technical Requirements</h2>																		



**7.1. 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) [7]. 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) [7] have to be fulfilled for the load cell by taking into account the following aspects.

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

For load cells, communicating via an open network, the severity level II, examined with validation procedure B, is required. For achieving the severity level II, the use of cryptographic methods for protection are necessary.

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

The exception described in D 31, 5.1.1 [7] for an imprint of the software identification is allowed.

The level of conformity of manufactured devices to the approved type is according to D 31, 5.2.5 (clause a) [7].

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 [7]

The software documentation shall include descriptions according to the applicable requirements of D 31, 6.1.1 [7]

The validation procedures are described in D 31, 6.4 [7]

4.7	<p><b>7.2. Inscriptions and presentation of load cell information</b></p> <p>Technical information markings including load cell classifications as indicated in 6.1.5 Complete Load Cell Classification must be specified for the load cell(s).</p>
4.7.2	<p>7.2.1. Mandatory markings on the load cell</p> <p>The following mandatory markings shall be clearly and indelibly marked on the load cell:</p> <ol style="list-style-type: none"> <li>Name or trade mark</li> <li>Manufacturer's type designation or load cell model</li> <li>Serial number</li> <li>Maximum capacity as: <math>E_{\max}</math> = (in units g, kg, t, N, kN, or MN)</li> <li>Year of production</li> </ol> <p>If due to the limitation of the size of the load cell, it is impossible to apply all mandatory markings, the minimum of the load cell type designation and the serial number shall be provided on the load cell itself. All other mandatory information shall be provided in an accompanying document supplied by the manufacturer. Where such a document is provided, the information required in 7.2.2 shall also be given therein.</p>
4.6.6.1	<p>7.2.2. Mandatory accompanying additional information</p> <p>The following mandatory information shall be provided in a document accompanying the load cell and submitted to the user (or, if space permits, they may be marked on the load cell).</p> <ol style="list-style-type: none"> <li>Where the information provided is associated with a specific unit of measure, the unit (i.e., g, kg, t, N, kN, or MN) shall also be specified. Name or trade mark</li> <li>Type designation</li> <li>Accuracy class(es); see 7.2. 4.1</li> <li>Type of load; see 7.2.4.2</li> <li>Working temperature</li> <li>Humidity symbol</li> <li>Maximum capacity as: <math>E_{\max}</math> =</li> <li>Minimum dead load as: <math>E_{\min}</math> =</li> <li>Safe load limit as: <math>E_{\lim}</math> =</li> <li>Minimum load cell verification interval as <math>v_{\min}</math> =</li> <li>Value of the apportionment factor, <math>p_{LC}</math>, if not equal to 0.7; and</li> <li>OIML certificate number (if applicable)</li> <li>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.)</li> </ol>

### 7.2.3. Non-mandatory additional information

In addition to the information required in 7.2.2, the following information may optionally be specified:

- for a weighing instrument (for example a multiple range instrument according to OIML R 76) [8], the relative  $v_{\min}$ ,  $Y$ , where  $Y = E_{\max} / v_{\min}$  (see 3.5.15);
- for a weighing instrument (for example a multi-interval instrument according to OIML R 76) [8], the relative DR,  $Z$ , where  $Z = E_{\max} / (2 \times DR)$  (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 9.10.1.
- other information considered necessary or useful by the manufacturer.

### 7.2.4. Specific markings

4.6.1

#### 7.2.4.1. 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”.

4.6.3

#### 7.2.4.2. 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.

Table  
2

Table 6. Symbols for Different Types of Load Transmission Principles	
<b>Tension</b>	↑ ↓
<b>Compression</b>	↓ ↑
<b>Beam (shear or bending)</b>	↑ or ↓
<b>Universal</b>	↑↓ ↓↑

4.6.4

#### 7.2.4.3. Working temperature designation

	<p>The special limits of working temperature, as referred to in 6.6.1.2, shall be specified when the load cell cannot perform within the limits of error in 6.3.to 6.6 over the temperature range specified in 6.6.1.1. In such cases, the limits of temperature shall be designated in degrees Celsius (°C).</p>
<p>4.6.5 4.6.5.1 4.6.5.2 4.6.5.3</p>	<p>7.2.4.4. <i>Humidity symbols</i></p> <ul style="list-style-type: none"> <li>a). A load cell not designed to meet performance criteria evaluated under 9.10.5 or 9.10.6 shall be marked by the symbol NH.</li> <li>b). A load cell submitted for evaluation and designed to meet performance criteria evaluated under 9.10.5 shall be marked by the symbol CH or not be marked with any humidity classification.</li> <li>c). A load cell submitted for evaluation and manufactured to meet performance criteria evaluated under 9.10.6 shall be marked by the symbol SH.</li> </ul>
4.6.2	<p>7.2.4.5. <i>Maximum number of load cell verification intervals</i></p> <p>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 7.2.4.1 above) to produce a classification symbol (see 6.1.6), it shall be designated in units of 1 000.</p>

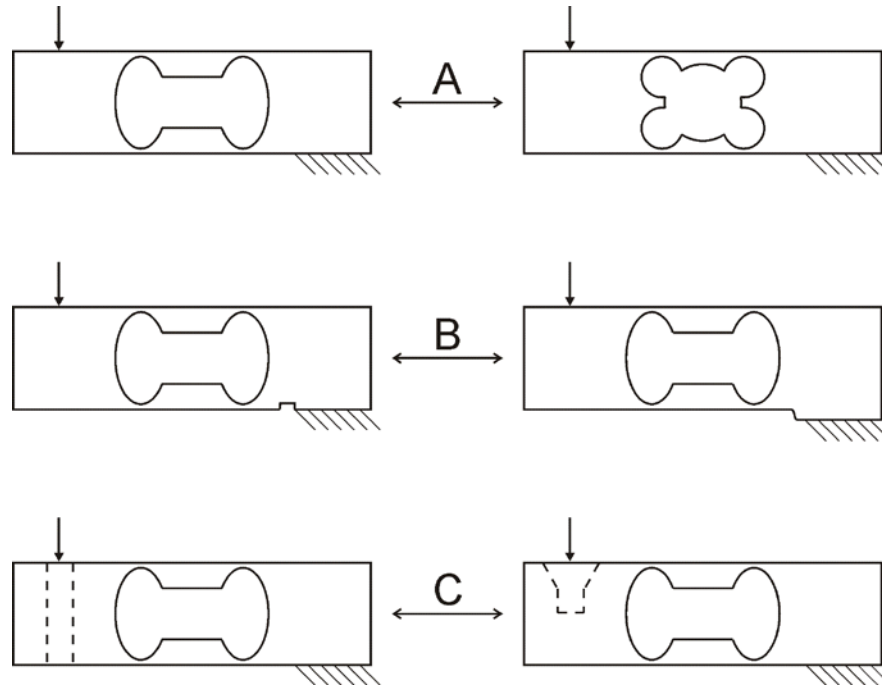
	<b>Part 2 Metrological controls and performance tests</b>
7	<b>8 Metrological controls</b>
7.1	<b>8.1 Liability to legal metrological controls</b>
7.1.1	<p>8.1.1 Imposition of controls</p> <p>This Recommendation prescribes performance requirements for load cells used in devices or systems subjected to legal metrological control. National legislation may impose metrological controls that verify compliance with this Recommendation. Such controls, when imposed, may include type evaluation.</p>
	<p><b>8.2 Responsibility for compliance with the requirements</b></p> <p>Notwithstanding the kind of legal metrological control in a country, the manufacturer (or their formal representative) has the full responsibility that the load cells comply with the requirements in Part 1 (Metrological and technical requirements) at the moment they are delivered to the user.</p> <p>After assignment, the responsibility of compliance with the requirements in Part 1 (Metrological and technical requirements) is that of the owner of the load cell as long as the load cell is in use. The operational presence of the load cell in his premises is considered as “in use”.</p>
5.6	<p>8.2.1 Measurement standards</p> <p>The expanded uncertainty, <math>U</math> (for coverage factor <math>k = 2</math>), for the combination of the force-generating system and the indicating instrument used during the tests to observe the load cell output shall be less than 1/3 times the MPE of the load cell under test. [<i>Guide to the Expression of Uncertainty in Measurement</i>, 2008] [6]</p>
Annex A	<b>9 Type evaluation</b>

A.1	<p><b>9.1 Scope</b></p> <p>This section provides test procedures for type evaluation testing of load cells.</p> <p>Wherever possible, test procedures have been established to apply as broadly as possible to all load cells within the scope of OIML R 60.</p> <p>The procedures apply to the testing of load cells only. No attempt has been made to cover testing of complete systems that include load cells.</p>
7.2	<p><b>9.2 Test requirements</b></p> <p>Test procedures for the type evaluation of load cells are provided in Section 9 and the Test Report Format is provided in Part 3. Initial and subsequent verification of load cells independent of the measuring system in which they are used is normally considered inappropriate if the complete system performance is verified by other means.</p>
	<p><b>9.3 Selection of specimens for evaluation</b></p> <p>Type evaluation shall be carried out on at least one specimen, which represents the type. The evaluation shall consist of the examination and tests specified in 9.6 and 9.7</p> <p>In case the applicant wants to have approved several versions or measuring ranges, the issuing authority decides which version(s) and range(s) shall be supplied.</p> <p>If a specimen does not pass a specific test as a result of the design of the type and therefore has to be modified, the applicant shall carry out this modification to all the specimens supplied for test. After this modification, at least 2 different specimens shall be subjected to the entire complement of tests. If the modification has been applied to all sub-types of the family which have the common design defect that required modification, it is then required that the other specimens that have been submitted shall be completely tested.</p> <p>If during the evaluation the specimen experiences malfunction or breakage that necessitates a repair in order to complete the test, the applicant shall verify whether this repair concerns an incident or whether a modification will need be made to the design. In the latter case the modification is to be applied to all specimens supplied for the test and the applicable documentation to be updated accordingly.</p> <p>If the issuing authority has reason to believe that a modification or repair could cause a different outcome for test result(s) than the result(s) which was observed prior to any modification, these tests shall be repeated. The reason for repeating a test shall be given within the scope of the test report.</p>
7.3.1	<p>9.3.1 Number of load cells to be tested</p> <p>The selection of load cells to be tested shall be such that the number of load cells to be tested is</p>

	minimized as well as optimized. (see practical example in Annex D).
7.3	<p><b>9.4 Selection of load cells within a family</b></p> <p>In order to accelerate the test procedure, the testing laboratory may carry out different tests simultaneously on different units. In this case, the issuing authority decides which version or measuring range will be subjected to a specific test.</p> <p>All accuracy and influence tests including span test for digital load cells, shall be performed on the same unit. Disturbance tests on digital load cells may be (simultaneously) carried out on not more than 2 an additional load cell instruments.</p> <p>Where a family composed of one or more groups of load cells of various capacities and characteristics is presented for type evaluation, the following provisions shall apply.</p>

### 9.4.1 Load cell shape

When classifying load cells on the basis of the shape design, additional consideration should be given to design criteria such as the geometrical characteristics of the areas of the load cell created during fabrication. Examples for load cells with identical outer dimensions but different geometries are shown below.



- A. difference of geometry in the area of fixing/load introduction (i.e., groove, base, offset)
- B. difference of geometry in the inner of fixing/load introduction (i.e., drilling, thread, dropping)
- C. difference of geometry in the area of thin places (i.e., round or oval drilling)

7.3.2

### 9.4.2 Load cells of the same capacity belonging to different groups

Where load cells of the same family and same capacity belong to different groups, the selection of a load cell for testing requires a choice between characteristics of the load cells. In this case, the load cell requiring the most onerous tests shall be selected. This selection will result in the load cell with the best metrological characteristics being tested.

7.3.3

### 9.4.3 Load cells with a capacity in between the capacities tested

Load cells of the same family with a capacity in between the capacities tested, as well as those above the largest capacity tested, but not over 5 times above the largest capacity tested, are deemed to fulfill the requirements of this Recommendation. This is under the provision that along with the change of capacity there is no change of measurement principle or material used



	in construction of the load cell (e.g., from bending beam to shear beam or stainless steel replacing aluminum).
7.3.4	<p>9.4.4 Smallest capacity load cell from the group</p> <p>For any family, the smallest capacity load cell from the group with the best characteristics shall be selected for testing. For any group, the smallest capacity load cell in the group shall always be selected for test unless that capacity falls within the range of allowed capacities of selected load cells having better metrological characteristics according to the requirements of 9.4.2 and 9.4.3.</p>
7.3.5	<p>9.4.5 Ratio of largest capacity to the nearest smaller capacity</p> <p><b><u>[TC9 p1 Project Group Convener's Note: Paragraph wording was modified in 1CD per comments. This language has been further modified in order to clarify the intent. TC9 p1 to determine preference between modified language and 2000 edition language. Include the preferred language when responding with comments]]</u></b></p> <p><b><i>Amended paragraph:</i></b></p> <p>When the selection for testing of two load cells ranked adjacent to each other in terms of capacity within the series of load cells from the same group is made, if the ratio between the capacities of the two cells is greater than 5:1 another load cell shall be selected from within the group. The selection should ensure that the larger capacity of the two is between 5 and 10 times the capacity of the next load cell in the series that 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.</p> <p><b><u>OR</u></b></p> <p><b><i>Wording from R60 2000 edition:</i></b></p> <p>When the ratio of the largest capacity load cell in each group to the nearest smaller capacity having been selected for test is greater than 5, then another load cell shall be selected. The selected load cell shall have a 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.</p>
7.3.6	<p>9.4.6 Humidity test</p> <p>If more than one load cell of a family has been submitted for testing, only one load cell shall be tested for humidity when applicable.</p>

	<p><b>9.4.7 Selection of load cells equipped with electronics</b></p> <p>For load cells and load cell families equipped with electronics (that do not differ between load cells in the family) all applicable tests shall be performed on the load cell with the minimum, <math>\mu\text{V}/v_{\min}</math> as input for the analogue to digital converter.</p> <p>(Same principle as OIML R76 [8], Annex C, Table 12)</p> <p>Notwithstanding this requirement, the criteria for assignment of a load cell to a family and the selection of test specimens found in 9.4.1 to 9.4.5 shall be observed.</p>
	<p><b>9.5 Documentation</b></p> <p>The documentation submitted with the application for type approval shall include:</p> <ul style="list-style-type: none"> <li>a) description of its general principle of measurement;</li> <li>b) mechanical drawings (including documents on the load transmission(s) as per Annex E);</li> <li>c) electric/electronic diagrams;</li> <li>d) installation requirements (physical and electrical) if appropriate;</li> <li>e) operating instructions that shall be provided to the user if appropriate;</li> <li>f) documents or other evidence to support and demonstrate the manufacturer's belief that the design and characteristics of the load cell will comply with the requirements of this Recommendation; and</li> <li>g) documentation relative to software if appropriate.</li> </ul> <p>If the testing laboratory deems this necessary, it can require more detailed documentation; either to be able to study the quality of the instrument, or to be able to fully define the approved type, or both.</p> <p>If the manufacturer does not prescribe a specific load transmission it will be the responsibility of the test laboratory to decide what kind of load transmission is to be used for testing. (see also Annex E)</p>

**9.6 Examinations**

Examinations and testing of load cells are intended to verify compliance with the requirements of Part 1 of this Recommendation.

The load cell and the documentation shall be given a visual inspection to obtain a general appraisal of its design and construction and the documentation shall be studied.

In particular, the following aspects shall be examined:

- a. accuracy classes and their symbols (6.1.1 and 7.2.4.1);
- b. maximum number of verification intervals (6.1.2 and 7.2.4.5);
- c. measuring ranges (3.5.2 and 3.6);
- d. apportioning of errors (3.7.2);
- e. construction (3.3);
- f. software (7.1) (if applicable);
- g. inscriptions (7.2); and
- h. installation instructions/recommendations.

A.3

**9.7 Performance Tests**

A.2

**9.7.1 Purpose**

The following test procedures for quantitative determination of load cell performance characteristics are established to ensure uniform type evaluation.

A.3.1

**9.7.2 Test equipment**

The basic equipment for type evaluation tests consists of a force-generating system and a suitable indicating instrument, which measures the output of the load cell (see 8.2.1).

A.3.2.2

**9.7.2.1 Environmental conditions**

Tests shall be performed under stable environmental conditions. The ambient temperature is deemed to be stable when the difference between extreme temperatures noted during the test does not exceed one fifth of the temperature range of the load cell under test, without being greater than 2 °C.

Except for the parameter being tested, the reference conditions in Table 8 shall be kept by the testing laboratory during the tests

<b>Table 8</b>		
	<b>Influence</b>	<b>Value</b>
a)	Temperature	20 °C ± 2 °C

	<table><tr><td>b)</td><td>Humidity</td><td>65 % RH ± 5 %</td></tr><tr><td>c)</td><td>Atmospheric pressure</td><td>Ambient pressure, stable within 10 hPa</td></tr><tr><td>f)</td><td>AC mains voltage <sup>(1)</sup></td><td><math>U_{\text{nom}} \pm 1 \%</math></td></tr><tr><td>g)</td><td>AC mains frequency <sup>(1)</sup></td><td><math>f_{\text{nom}} \pm 0,5 \%</math> <sup>(2)</sup></td></tr><tr><td>j)</td><td>Conducted radio-frequency fields <sup>(1)</sup></td><td>&lt; 0,2 V e.m.f. <sup>(2)</sup></td></tr><tr><td>k)</td><td>Electrostatic discharge</td><td>none</td></tr><tr><td>l)</td><td>Power frequency magnetic field</td><td>&lt; 1 A/m <sup>(2)</sup></td></tr><tr><td>m)</td><td>Bursts (transients) on signal, data and control lines <sup>(1)</sup></td><td>negligible <sup>(2)</sup></td></tr><tr><td>n)</td><td>Surges on signal, data and control lines <sup>(1)</sup></td><td>negligible <sup>(2)</sup></td></tr><tr><td>o)</td><td>AC mains voltage dips, short interruptions and voltage variations <sup>(1)</sup></td><td>negligible <sup>(2)</sup></td></tr><tr><td>p)</td><td>Bursts (transients) on AC and DC mains <sup>(1)</sup></td><td>negligible <sup>(2)</sup></td></tr><tr><td>r)</td><td>Surges on AC and DC mains power <sup>(1)</sup></td><td>None <sup>(2)</sup></td></tr><tr><td colspan="3"><sup>(1)</sup> If applicable  <sup>(2)</sup> As in a normal laboratory condition these conditions can be expected to be fulfilled without specific measures, it is usually not deemed necessary to measure/monitor these values.</td></tr></table>	b)	Humidity	65 % RH ± 5 %	c)	Atmospheric pressure	Ambient pressure, stable within 10 hPa	f)	AC mains voltage <sup>(1)</sup>	$U_{\text{nom}} \pm 1 \%$	g)	AC mains frequency <sup>(1)</sup>	$f_{\text{nom}} \pm 0,5 \%$ <sup>(2)</sup>	j)	Conducted radio-frequency fields <sup>(1)</sup>	< 0,2 V e.m.f. <sup>(2)</sup>	k)	Electrostatic discharge	none	l)	Power frequency magnetic field	< 1 A/m <sup>(2)</sup>	m)	Bursts (transients) on signal, data and control lines <sup>(1)</sup>	negligible <sup>(2)</sup>	n)	Surges on signal, data and control lines <sup>(1)</sup>	negligible <sup>(2)</sup>	o)	AC mains voltage dips, short interruptions and voltage variations <sup>(1)</sup>	negligible <sup>(2)</sup>	p)	Bursts (transients) on AC and DC mains <sup>(1)</sup>	negligible <sup>(2)</sup>	r)	Surges on AC and DC mains power <sup>(1)</sup>	None <sup>(2)</sup>	<sup>(1)</sup> If applicable  <sup>(2)</sup> As in a normal laboratory condition these conditions can be expected to be fulfilled without specific measures, it is usually not deemed necessary to measure/monitor these values.		
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	9.7.3 Test conditions																																							
A.3.2.1	<p>9.7.3.1 Acceleration of gravity</p> <p>The mass standards used to generate the force applied during testing shall be corrected, if necessary, for the site of testing and the value of the gravity constant, <i>g</i>, at the test site shall be recorded with the test results. The value of the mass standards used to generate the force shall be traceable to the appropriate national or international standard of mass.</p>																																							

A.3.2.3	<p data-bbox="345 142 737 176"><i>9.7.3.2 Loading conditions</i></p> <p data-bbox="345 218 1529 432">Particular attention shall be paid to loading conditions to prevent the introduction of errors not inherent to the load cell. Factors such as surface roughness, flatness, corrosion, scratches, eccentricity, etc., should be taken into consideration. Loading conditions shall be in accordance with the requirements of the load cell manufacturer. The loads shall be applied and removed along the sensitive axis of the load cell without introducing shock to the load cell.</p> <p data-bbox="345 470 1529 646">The installation of the load cell in the force-generating system shall be done with particular care, since the effect on the metrological performance caused by mounting/dismounting the load cell on/from the force-generating system should be negligible in order to establish the magnitude of the test parameter. If possible, the load cell should not be dismantled from the force-generation system during the entire period of the test.</p>
A.3.2.4	<p data-bbox="345 672 789 705"><i>9.7.3.3 Measuring range limits</i></p> <p data-bbox="345 747 1529 890">With consideration to the capability of the force-generating system, the minimum load, <math>D_{\min}</math>, shall be as near as possible to but not less than the minimum dead load, <math>E_{\min}</math>, and shall not be higher than the value of <math>E_{\min}</math> increased by 10% of <math>E_{\min}</math>. The maximum load, <math>D_{\max}</math>, shall be not less than 90 % of <math>E_{\max}</math>, nor shall it be greater than <math>E_{\max}</math> (refer to Fig. 1).</p>
A.3.2.5	<p data-bbox="345 953 751 987"><i>9.7.3.4 Reference standards</i></p> <p data-bbox="345 1024 1503 1092">All standards and measuring instruments used for the tests shall be traceable to national or international standards.</p>
A.3.2.6	<p data-bbox="345 1155 743 1188"><i>9.7.3.5 Stabilization period</i></p> <p data-bbox="345 1226 1529 1293">A stabilization period for the load cell under test and the indicating instrument shall be provided, as recommended by the manufacturers of the equipment used.</p>
A.3.2.7	<p data-bbox="345 1356 797 1390"><i>9.7.3.6 Temperature conditions</i></p> <p data-bbox="345 1428 1529 1684">It is important to allow sufficient time for temperature stabilization of the load cell to be achieved. Particular attention shall be devoted to this requirement for large load cells. The loading system shall be of a design which will not introduce significant thermal gradients within the load cell. The load cell and its connecting means (cables, tubes, etc.) which are integral or contiguous shall be at the same test temperature. The indicating instrument shall be maintained at room temperature. The temperature effect on auxiliary connecting means shall be considered in determining results.</p>
A.3.2.8	<p data-bbox="345 1747 842 1780"><i>9.7.3.7 Barometric pressure effects</i></p> <p data-bbox="345 1818 1529 1885">Where changes in barometric pressure may significantly affect the load cell output, such changes shall be considered.</p>

	<p><i>9.7.3.8 Humidity effects</i></p> <p>When a load cell is marked with the symbol CH or is not marked with a humidity symbol, it shall be subjected to the humidity test, as specified in 9.10.5.</p> <p>When a load cell is marked with the symbol SH, it shall be subjected to the humidity test, as specified in 9.10.6</p> <p>Load cells marked with the symbol NH shall not be subjected to the humidity tests as described in 9.10.5 and 9.10.6.</p>
<i>A.3.2.10</i>	<p><i>9.7.3.9 Indicating instrument checking</i></p> <p>Some indicating instruments are provided with a convenient means for checking the indicating instrument itself. When such features are provided, they shall be utilized frequently to ensure that the indicating instrument is within the accuracy required by the test being performed. Periodic check on calibration status of the indicating instrument shall be performed.</p>
<i>A.3.2.11</i>	<p><i>9.7.3.10 Other conditions</i></p> <p>Other conditions specified by the manufacturer such as input/output voltage, electrical sensitivity, input impedance of the indicator, etc. shall be taken into consideration during the test.</p>
<i>A.3.2.12</i>	<p><i>9.7.3.11 Time and date format</i></p> <p>All time and date points shall be recorded such that the data can later be presented in test reports in absolute, not relative, units of local time and date. The date shall be recorded in the ISO 8601 (Representation of dates and times) [9] format of ccyy-mm-dd.</p> <p><i>Note:</i> “cc” may be omitted in cases where there is no possible confusion as to the century.</p>
<b>13.4.2</b>	<p><b>9.7.4 Error under rated operating conditions</b></p> <p>The type of load cell is presumed to comply with the provisions specified in 6.3 to 6.5 of this Recommendation, if it passes the tests (9.10), confirming that the error of the measuring instrument does not exceed the maximum permissible error specified in 6.3.1 under the reference conditions in 9.7.3.</p>
<b>5.2</b>	<b>9.8 Rules concerning the determination of errors</b>
<b>5.2.1</b>	<p><b>9.8.1 Conditions</b></p> <p>The limits of error shown in Table 4 shall apply to all load cell measuring ranges complying</p>

with the following conditions:

$$n \leq n_{\max}$$

$$v \geq v_{\min}$$

5.2.2

### 9.8.2 Limits of error

The limits of error shown in Table 4 shall refer to the error envelope defined in 2.2 and 6.3.1 which is referenced to the straight line that passes through the minimum load output and the load cell output for a load of 75 % of the measuring range taken on ascending load at 20 °C. This is based upon the initial 20 °C load test. See Part 3 (Test Report Format for Type Evaluation).

5.2.3

### 9.8.3 Initial readings

During the conduct of the tests, the initial reading shall be taken at a time interval after the initiation of loading or unloading, whichever is applicable, as specified in Table 9.

Table 6

Table 9. Combined Loading and Stabilization Times to be Achieved Prior to Reading

Change in load		Time allowed for:					
		Classes C&D		Class B		Class A	
Greater than	Up to and including	Loading	Stabilization	Loading	Stabilization	Loading	Stabilization
0 g	10 kg	5 sec	5 sec	8 sec	8 sec	10 sec	10 sec
10 kg	100 kg	10 sec	10 sec	15 sec	15 sec	20 sec	20 sec
100 kg	1 000 kg	15 sec	15 sec	23 sec	23 sec	30 sec	30 sec
1 000 kg	10 000 kg	20 sec	20 sec	30 sec	30 sec	40 sec	40 sec
10 000 kg	100 000 kg	25 sec	25 sec	38 sec	38 sec	50 sec	50 sec
100 000 kg		30 sec	30 sec	45 sec	45 sec	60 sec	60 sec

5.2.3.1

### 9.8.3.1 Loading/unloading times

The loading or unloading times shall be as shown in Table 9. The tests shall be conducted under constant conditions. Time shall be recorded in the test report in absolute, not relative values.

5.2.3.2	<p data-bbox="347 142 993 178">9.8.3.2 <i>Loading/unloading times impracticable</i></p> <p data-bbox="347 218 1531 289">When the specified loading or unloading times cannot be achieved, the following shall apply.</p> <p data-bbox="394 308 1531 489">a) In the case of the minimum dead load output return test, the time may be increased from 100 % to a limit of 150 % of the specified time provided that the permissible variation of the result is proportionally reduced from 100 % to 50 % of the allowable difference between the initial reading of the minimum load output upon unloading and the reading before loading.</p> <p data-bbox="443 508 613 543">For example:</p> <p data-bbox="443 562 1531 634">(1). A change in load of 10 kg, loading time is increased to 7.5 seconds (150% of 5 s), MPE is reduced to 50%; or</p> <p data-bbox="443 653 1531 724">(2). A change in load of 1500 kg, loading time of 20 seconds is increased to 25 seconds (125% of 20 seconds), MPE is reduced to 75%.</p> <p data-bbox="394 743 1268 779">b) In all cases, the actual times shall be recorded in the Test Report.</p>
5.3	<p data-bbox="250 848 935 884"><b>9.9 Variation of results under reference conditions</b></p>
5.3.1	<p data-bbox="298 938 500 974">9.9.1 Creep</p> <p data-bbox="298 1014 1531 1157">A load, <math>D_{\max}</math> (between 90% and 100% of <math>E_{\max}</math>) shall be applied at which time an initial reading shall be taken. Subsequent readings shall be taken after 20 minutes and again after 30 minutes of exposure to the load of <math>D_{\max}</math>. Variation between these readings shall comply with the limits specified in 6.5.1</p>
5.3.2	<p data-bbox="298 1197 854 1232">9.9.2 Minimum dead load output return</p> <p data-bbox="298 1272 1531 1432">A load, <math>D_{\min}</math> shall be applied for at least 30 minutes at which time an initial reading shall be taken. A load, <math>D_{\max}</math> (between 90% and 100% of <math>E_{\max}</math>) shall be applied for approximately 30 minutes after which the load shall be returned to <math>D_{\min}</math>. After the load cell has stabilized (refer to Table 9), a subsequent reading of load cell output shall be taken.</p> <p data-bbox="298 1451 1531 1522">The difference between the initial reading and the subsequent reading shall not exceed the value in 6.5.2.</p>
	<p data-bbox="298 1568 766 1604">9.9.3 Hysteresis error (see 3.7.5)</p> <p data-bbox="298 1644 1531 1749">Difference between load cell output readings for the same applied load shall be obtained by observing the output resulting from an increase of the load from minimum load, <math>D_{\min}</math>, and the output resulting from a decrease of the load from maximum load, <math>D_{\max}</math>.</p>
A.4	<p data-bbox="250 1789 613 1824"><b>9.10 Test procedures</b></p> <p data-bbox="250 1864 1531 1894">Each of the tests below is presented as a “stand alone” individual test. However, for the efficient</p>



	<p>conduct of the load cell tests, it is acceptable that the increasing and decreasing load, creep, and minimum dead load output return tests be conducted at the given test temperature before changing to the next test temperature (see 9.11, Figures 3 and 4). The barometric pressure and the humidity tests are conducted individually following completion of the above tests.</p>
<i>A.4.1</i>	<p>9.10.1 Determination of measurement error, repeatability error and temperature effect on minimum dead load output.</p> <p>This test is applied to verify compliance with the provisions in 6.3, 6.4, and 6.6.1.3.</p>
<i>A.4.1.1</i>	<p>9.10.1.1 Check test conditions</p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions, prior to performing the following tests.</p>
<i>A.4.1.2</i>	<p>9.10.1.2 Insert load cell</p> <p>Insert the load cell into the force-generating system, load to the minimum test load, <math>D_{\min}</math>, and stabilize at 20 °C (<math>\pm 2</math> °K).</p> <p>In case the total temperature range has been shifted, the initial (reference) temperature may differ from 20°C (e.g. range from -20°C to 30°C, reference / initial temperature: 10°C).</p>
<i>A.4.1.3</i>	<p>9.10.1.3 Preload load cell</p> <p>Preload the load cell by applying the maximum test load, <math>D_{\max}</math>, three times, returning to the minimum test load, <math>D_{\min}</math>, after each load application. Wait 5 minutes before commencing with further tests.</p>
<i>A.4.1.4</i>	<p>9.10.1.4 Check indicating instrument</p> <p>Check the indicating instrument according to 9.7.3.9.</p>
<i>A.4.1.5</i>	<p>9.10.1.5 Monitor load cell</p> <p>Monitor the minimum test load output until stable.</p>
<i>A.4.1.6</i>	<p>9.10.1.6 Record indication</p> <p>Record the indicating instrument indication at the minimum test load, <math>D_{\min}</math>.</p>

<i>A.4.1.7</i>	<p><i>9.10.1.7</i> Test load points</p> <p>All test load points in a loading and unloading sequence shall be spaced at approximately equal time intervals. The readings shall be taken at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
<i>A.4.1.8</i>	<p><i>9.10.1.8</i> Apply loads</p> <p>Apply increasing loads up to the maximum test load, <math>D_{\max}</math>. There shall be at least five increasing load points, which shall include values at or near those at which the maximum permissible error changes, as listed in Table 4 in 6.3.1.1.</p>
<i>A.4.1.9</i>	<p><i>9.10.1.9</i> Record indications</p> <p>Record the indicating instrument indications at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
<i>A.4.1.10</i>	<p><i>9.10.1.10</i> Decrease test loads</p> <p>Decrease the test loads to the minimum test load, <math>D_{\min}</math>, using the same load points as described in 9.10.1.8.</p>
<i>A.4.1.11</i>	<p><i>9.10.1.11</i> Record indications</p> <p>Record the indicating instrument indications at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
<i>A.4.1.12</i>	<p><i>9.10.1.12</i> Repeat procedures for different accuracy classes</p> <p>Repeat the operations described in 9.10.1.7 to 9.10.1.11 four more times for accuracy classes A and B or two more times for accuracy classes C and D.</p>
<i>A.4.1.13</i>	<p><i>9.10.1.13</i> Repeat procedures for different temperatures</p> <p>Repeat the operations described in 9.10.1.3 to 9.10.1.12, first at the higher temperature, then at the lower temperature, including the approximate temperature range limits for the accuracy class intended; then perform the operations in 9.10.1.3 to 9.10.1.12 at 20 °C (<math>\pm 2</math> °K).</p>
<i>A.4.1.14</i>	<p><i>9.10.1.14</i> Determine magnitude of measurement error</p>

	<p>The magnitude of the measurement error shall be determined based on the average of the results of the tests conducted at each temperature level and compared with the maximum permissible measurement errors in 6.3.1.1</p>
<i>A.4.1.15</i>	<p><i>9.10.1.15</i> Determine repeatability error</p> <p>From the resulting data, the repeatability error may be determined and compared with the limits specified in 6.4.</p>
<i>A.4.1.16</i>	<p><i>9.10.1.16</i> Determine temperature effect on minimum dead load output</p> <p>From the resulting data, the temperature effect on minimum dead load output may be determined and compared with the limits specified in 6.6.1.3.</p>
<i>A.4.2</i>	<p>9.10.2 Determination of creep error.</p> <p>This test is applied to verify compliance with the provisions in 6.5.1.</p>
<i>A.4.2.1</i>	<p><i>9.10.2.1</i> Check test conditions</p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions prior to performing the following tests.</p>
<i>A.4.2.2</i>	<p><i>9.10.2.2</i> Insert load cell</p> <p>Insert the load cell into the force-generating system, load to the minimum test load, <math>D_{\min}</math>, and stabilize at 20 °C (<math>\pm 2</math> °K).</p>
<i>A.4.2.3</i>	<p><i>9.10.2.3</i> Preload load cell</p> <p>Preload the load cell by applying the maximum test load, <math>D_{\max}</math>, three times, returning to the minimum test load, <math>D_{\min}</math>, after each load application. Wait one hour.</p>
<i>A.4.2.4</i>	<p><i>9.10.2.4</i> Check indicating instrument</p> <p>Check the indicating instrument according to 9.7.3.9.</p>
<i>A.4.2.5</i>	<p><i>9.10.2.5</i> Monitor load cell</p> <p>Monitor the minimum test load output until stable.</p>

<i>A.4.2.6</i>	<p><i>9.10.2.6</i> Record indication</p> <p>Record the indicating instrument indication at the minimum test load, <math>D_{\min}</math>.</p>
<i>A.4.2.7</i>	<p><i>9.10.2.7</i> Apply load</p> <p>Apply a constant maximum test load, <math>D_{\max}</math>.</p>
<i>A.4.2.8</i>	<p><i>9.10.2.8</i> Record indications</p> <p>Record the initial indicating instrument indication at the time intervals specified in Table 9 in 9.8.3. Continue to record periodically thereafter, at recorded time intervals over a 30-minute period, ensuring that a reading is taken at 20 minutes.</p>
<i>A.4.2.9</i>	<p><i>9.10.2.9</i> Repeat procedures for different temperatures</p> <p>Repeat the operations described in 9.10.2.3 to 9.10.2.8, first at the higher temperature, then at the lower temperature, including the approximate temperature range limits for the accuracy class intended.</p>
<i>A.4.2.10</i>	<p><i>9.10.2.10</i> Determine creep error</p> <p>With the resulting data, and taking into account the effect of barometric pressure changes according to 9.7.3.7, the magnitude of the creep error can be determined and compared with the permissible variation specified in 6.5.1.</p>
<i>A.4.3</i>	<p><i>9.10.3</i> Determination of minimum dead load output return (DR)</p> <p>This test is applied to verify compliance with the provisions in 6.5.2.</p>
<i>A.4.3.1</i>	<p><i>9.10.3.1</i> Check test conditions</p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions prior to performing the following test.</p>
<i>A.4.3.2</i>	<p><i>9.10.3.2</i> Insert load cell</p> <p>Insert the load cell into the force-generating system, load to the minimum test load, <math>D_{\min}</math>, and stabilize at 20 °C (<math>\pm 2</math> °K).</p>

<i>A.4.3.3</i>	<p><i>9.10.3.3</i>    Preload load cell</p> <p>Preload the load cell by applying the maximum test load, <math>D_{\max}</math>, three times, returning to the minimum test load, <math>D_{\min}</math>, after each load application. Wait one hour before commencing any further tests.</p>
<i>A.4.3.4</i>	<p><i>9.10.3.4</i>    Check indicating instrument</p> <p>Check the indicating instrument according to 9.7.3.9.</p>
<i>A.4.3.5</i>	<p><i>9.10.3.5</i>    Monitor load cell</p> <p>Monitor the minimum test load output until stable.</p>
<i>A.4.3.6</i>	<p><i>9.10.3.6</i>    Record indication</p> <p>Record the indicating instrument indication at the minimum test load, <math>D_{\min}</math>.</p>
<i>A.4.3.7</i>	<p><i>9.10.3.7</i>    Apply load</p> <p>Apply a constant maximum test load, <math>D_{\max}</math>.</p>
<i>A.4.3.8</i>	<p><i>9.10.3.8</i>    Record indications</p> <p>Record the initial indicating instrument indication at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded. Record the time at which the load is fully applied and maintain the load for a 30-minute period.</p>
<i>A.4.3.9</i>	<p><i>9.10.3.9</i>    Record data</p> <p>Record the time of initiation of unloading and return to the minimum test load, <math>D_{\min}</math>.</p>
<i>A.4.3.10</i>	<p><i>9.10.3.10</i>   Record indication</p> <p>Record the indicating instrument indication at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
<i>A.4.3.11</i>	<p><i>9.10.3.11</i>   Repeat procedures for different temperatures</p> <p>Repeat the operations described in 9.10.3.3 to 9.10.3.10, first at the higher temperature, then</p>

	at the lower temperature, including the approximate temperature range limits for the accuracy class intended.
A.4.3.12	<p>9.10.3.12 Determine minimum dead load output return (DR)</p> <p>With the resulting data, the magnitude of the minimum dead load output return (DR) can be determined and compared with the permissible variation specified in 9.9.2.</p>
A.4.4	<p>9.10.4 Determination of barometric pressure effects (Atmospheric pressure).</p> <p>This test is applied to verify compliance with the provisions in 6.6.2.</p> <p>This test shall be conducted unless there is sufficient design justification to show that the load cell performance is not affected by changes in barometric pressure. The justification for not conducting this test shall be noted in the test report.</p>
A.4.4.1	<p>9.10.4.1 Check test conditions</p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions prior to performing the following test.</p>
A.4.4.2	<p>9.10.4.2 Insert load cell</p> <p>At room temperature, insert the unloaded load cell into the pressure chamber at atmospheric pressure.</p>
A.4.4.3	<p>9.10.4.3 Check indicating instrument</p> <p>Check the indicating instrument according to 9.7.3.9.</p>
A.4.4.4	<p>9.10.4.4 Monitor load cell</p> <p>Monitor the output until stable.</p>
A.4.4.5	<p>9.10.4.5 Record indication</p> <p>Record the indicating instrument indication.</p>
A.4.4.6	<p>9.10.4.6 Change barometric pressure</p> <p>Change the barometric pressure in increments of 1 kPa within a range of 5 kPa greater than atmospheric pressure to 5 kPa less than atmospheric pressure and record the indicating instrument indication.</p>

A.4.4.7	<p><i>9.10.4.7 Determine barometric pressure error</i></p> <p>With the resulting data, the magnitude of the barometric pressure influence can be determined and compared with the limits specified in 6.6.2.</p>
A.4.5	<p>9.10.5 Determination of humidity effects for load cells marked CH or not marked.</p> <p>This test is applied to verify compliance with the provisions in 6.6.3.1.</p>
A.4.5.1	<p><i>9.10.5.1 Check test conditions</i></p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions prior to performing the following test.</p>
A.4.5.2	<p><i>9.10.5.2 Insert load cell</i></p> <p>Insert the load cell into the force-generating system, load to the minimum test load, <math>D_{\min}</math>, and stabilize at 20 °C (<math>\pm 2</math> °K)..</p>
A.4.5.3	<p><i>9.10.5.3 Preload load cell</i></p> <p>Preload the load cell by applying the maximum test load, <math>D_{\max}</math>, three times, returning to the minimum test load, <math>D_{\min}</math>, after each application. Wait 5 minutes.</p>
A.4.5.4	<p><i>9.10.5.4 Check indicating instrument</i></p> <p>Check the indicating instrument according to 9.7.3.9</p>
A.4.5.5	<p><i>9.10.5.5 Monitor load cell</i></p> <p>Monitor the minimum test load output until stable.</p>
A.4.5.6	<p><i>9.10.5.6 Record indication</i></p> <p>Record the indicating instrument indication at the minimum test load, <math>D_{\min}</math>.</p>
A.4.5.7	<p><i>9.10.5.7 Apply load</i></p> <p>Apply a maximum test load, <math>D_{\max}</math>.</p>

A.4.5.8	<p>9.10.5.8 Record indications</p> <p>Record the initial indicating instrument indication at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
A.4.5.9	<p>9.10.5.9 Remove load</p> <p>Remove the test load to the minimum test load, <math>D_{\min}</math>.</p>
A.4.5.10	<p>9.10.5.10 Record indication</p> <p>Record the indicating instrument indication at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
A.4.5.11	<p>9.10.5.11 Repeat procedures for different accuracy classes</p> <p>Repeat the operations described in 9.10.5.7 to 9.10.5.10 four more times for accuracy classes A and B or two more times for accuracy classes C and D.</p>
A.4.5.12	<p>9.10.5.12 <i>Conduct damp heat, cyclic test</i></p> <p>Conduct a damp heat, cyclic test in accordance with IEC 60068-2-30 Ed. 3.0 (2005-08) Environmental testing Part 2: Tests. Test Db and guidance: Damp heat cyclic (12 + 12-hour cycle. Background information concerning damp heat, cyclic tests is given in IEC 60068-3-4 Ed. 1.0 (2001) Environmental testing - Part 2: Tests. Guidance for damp heat tests.</p> <p><i>Test procedure in brief:</i></p> <p>This test consists of exposure to 12 temperature cycles of 24-hour duration each. The relative humidity is between 80 % and 96 % and the temperature is varied from 25 °C to 40 °C, in accordance with the specified cycle.</p> <p><i>Test severity:</i></p> <p>40 °C, 12 cycles.</p> <p><i>Initial measurements:</i></p> <p>According to 9.10.5.1 to 9.10.5.11 above.</p> <p><i>State of load cell during conditioning:</i></p> <p>Load cell placed in the chamber with the output connection external to the chamber, and switched off. Use variant 2 of IEC 60068-2-30 Ed. 3.0 (2005-08) when lowering the</p>



	<p>temperature.</p> <p><i>Recovery conditions and final measurements:</i></p> <p>According to 9.10.5.13 below.</p> <p><i>Reference to IEC Publication:</i></p> <p>IEC 60068-2-30 Ed. 3.0 (2005-08) [10] IEC 60068-3-4 Ed. 1.0 (2001) [12]</p>
A.4.5.13	<p><i>9.10.5.13 Remove load cell from chamber</i></p> <p>Remove the load cell from the humidity chamber, carefully remove surface moisture, and maintain the load cell at standard atmospheric conditions for a period sufficient to attain temperature stability (normally 1 to 2 hours).</p>
	<p><i>9.10.5.14 Repeat test procedures</i></p> <p>Repeat 9.10.5.1 to 9.10.5.11 ensuring that the minimum test load, <math>D_{\min}</math>, and the maximum test load, <math>D_{\max}</math>, applied are the same as previously used.</p>
A.4.5.14	<p><i>9.10.5.15 Determine the magnitude of humidity-induced variations</i></p> <p>The difference between the average of the reading of the minimum load output and of the maximum output attributed to cyclic changes in humidity as determined using test procedures in 9.10.5 shall not exceed the limits specified in 6.3.1.1</p> <p>The difference between the average of the reading of the maximum load, <math>D_{\max}</math>, attributed to cyclic changes in humidity as determined using test procedures in 9.10.5 shall not exceed the limits specified in 6.3.1.1</p>
A.4.6	<p>9.10.6 Determination of humidity effects for load cells marked SH.</p> <p>This test is applied to verify compliance with the provisions in 6.6.3.2.</p>
A.4.6.1	<p><i>9.10.6.1 Check test conditions</i></p> <p>Refer to the test conditions in 9.7.3 to ensure that proper consideration has been given to those conditions prior to performing the following tests.</p>
A.4.6.2	<p><i>9.10.6.2 Insert load cell</i></p> <p>Insert the load cell into the force-generating system, load to the minimum test load, <math>D_{\min}</math>, and stabilize at 20 °C (<math>\pm 2</math> °C ).</p>

<i>A.4.6.3</i>	<p><i>9.10.6.3 Preload load cell</i></p> <p>Preload the load cell by applying the maximum test load, <math>D_{\max}</math>, three times, returning to the minimum test load, <math>D_{\min}</math>, after each load application. Wait 5 minutes before commencing any further tests.</p>
<i>A.4.6.4</i>	<p><i>9.10.6.4 Check indicating instrument</i></p> <p>Check the indicating instrument according to 9.7.3.9.</p>
<i>A.4.6.5</i>	<p><i>9.10.6.5 Monitor load cell</i></p> <p>Monitor the minimum test load output until stable.</p>
<i>A.4.6.6</i>	<p><i>9.10.6.6 Record indication</i></p> <p>Record the indicating instrument indication at the minimum test load, <math>D_{\min}</math>.</p>
<i>A.4.6.7</i>	<p><i>9.10.6.7 Test load points</i></p> <p>All test load points in a loading and unloading sequence shall be spaced at approximately equal time intervals. The readings shall be taken at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
<i>A.4.6.8</i>	<p><i>9.10.6.8 Apply loads</i></p> <p>Apply increasing loads up to the maximum test load, <math>D_{\max}</math>. There shall be at least five increasing load points which shall include loads approximating to the highest values in the applicable steps of maximum permissible measurement errors, as listed in Table 4 in 6.3.1.1.</p>
<i>A.4.6.9</i>	<p><i>9.10.6.9 Record indications</i></p> <p>Record the indicating instrument indications at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>

A.4.6.10	<p><i>9.10.6.10 Decrease load</i></p> <p>Decrease the test load to the minimum test load, <math>D_{\min}</math>, using the same load points as described in 9.10.6.8.</p>
A.4.6.11	<p><i>9.10.6.11 Conduct damp heat, steady state test</i></p> <p>Conduct a damp heat, steady state test in accordance with IEC 60068-2-78 Ed 1.0 (2001) Environmental testing Part 2: Tests. Test Ca: Damp heat, steady state, IEC 60068-2-78 Ed 1.0 (2001) Environmental testing - Part 2: Tests. Test Cb: Damp heat, steady state, primarily for equipment and IEC 60068-3-4 Ed 1.0 (2001) Environmental testing - Part 2: Tests. Guidance for damp heat tests.</p> <p><i>Test procedure in brief:</i></p> <p>This test involves exposure of the load cell to a constant temperature and a constant relative humidity. The load cell shall be tested as specified in 9.10.6.1 to 9.10.6.10:</p> <ul style="list-style-type: none"> <li>a) at a reference temperature (20 °C or the mean value of the temperature range whenever 20 °C is outside this range) and a relative humidity of 50 % following conditioning;</li> <li>b) at the high temperature of the range specified in 6.6.1 for the load cell and a relative humidity of 85 %, 48 hours following temperature and humidity stabilization; and</li> <li>c) at the reference temperature and relative humidity of 50 %.</li> </ul> <p><i>State of load cell during conditioning:</i></p> <p>Place the load cell in the chamber with the output connection external to the chamber, and switched on. Use IEC 60068-2-78 (2008) when lowering the temperature.</p> <p><i>Reference to IEC Publication:</i>  IEC 60068-2-78 (2008) [11]  IEC 60068-3-4 Ed 1.0 (2001) [12]</p>
A.4.6.12	<p><i>9.10.6.12 Recording indications</i></p> <p>Record the indicating instrument indications at time intervals as near as possible to those specified in Table 9 in 9.8.3. These two time intervals shall be recorded.</p>
A.4.6.13	<p><i>9.10.6.13 Determine the magnitude of humidity-induced variations</i></p>

	With the resulting data, the magnitude of humidity-induced variations can be determined and compared with the limits specified in 6.6.3.2.
A.4.7	<p>9.10.7 Additional test for load cells equipped with electronics (Disturbances).</p> <p>These tests are applied to verify compliance with the provisions in 6.7.2.1, and 6.7.2.2.</p>
6.4.1	<p>9.10.7.1 <i>Performance and stability tests</i></p> <p>A load cell equipped with electronics shall pass the performance and stability tests according to 9.10.7.2 to 9.10.7.10 for the tests given in Table 5.</p>
Table 7	
A.4.7.1	<p>9.10.7.2 <i>Evaluation of error for digital load cells</i></p> <p>For load cells possessing a digital output interval greater than 0.20v, the changeover points are to be used in the evaluation of errors, prior to rounding as follows. At a certain load, L, the digital output value, I, is noted. Additional loads, for example 0.1 v, are successively added until the output of the load cell is increased unambiguously by one digital output increment (I + v). The additional amount of load, Δ L, added to the load cell gives the digital output value prior to rounding, P, by using the following formula:</p> $P = I + 1/2 v - \Delta L$ <p>where:</p> <p>I = the indication or digital output value;</p> <p>v = the load cell verification interval; and</p> <p>Δ L = additional load added to the load cell.</p> <p>The error, E, prior to rounding is:</p> $E = P - L = I + 1/2 v - \Delta L - L$ <p>and the corrected error, E<sub>c</sub>, prior to rounding is:</p> $E_c = E - E_o \leq MPE$ <p>where E<sub>o</sub> is the error calculated at the minimum test load, D<sub>min</sub>.</p>

A.4.7.2

*9.10.7.3 Warm-up time**Test procedure in brief:*

Stabilize the load cell at 20 °C ( $\pm 2$  °K) and disconnect from any electrical supply for a period of at least 8 hours prior to the test.

Insert the load cell into the force-generating system.

Preload the load cell by applying a maximum test load,  $D_{\max}$ , then, returning to the minimum test load,  $D_{\min}$ , three times.

Allow the load cell to rest for 5 minutes. Connect the load cell to the power supply and switch on.

*Record data:*

As soon as a measurement result can be obtained, record the minimum test load output and the maximum test load,  $D_{\max}$ , applied.

*Loading and unloading:*

The maximum test load output shall be determined at time intervals as close as possible to those specified in Table 8 in 9.8.3 and recorded and the load should be returned to the minimum test load,  $D_{\min}$ . These measurements shall be repeated after 5, 15 and 30 minutes.

For load cells of class A, the provisions of the operating manual for the time following connection to electrical supply shall be observed.

## A.4.7.3

9.10.7.4 *Power voltage variations*

This test is applied to verify compliance with condition of both variations in a DC mains network and variation in AC mains power voltage (single phase).

*Test procedure in brief:*

This test consists of subjecting the load cell to variations of power voltage.

A load test is performed in accordance with 9.10.1.1 to 9.10.1.12 at 20°C ( $\pm 2$  °K), with the load cell powered at reference voltage. The test is repeated with the load cell powered at the upper limit and at the lower limit of power voltage.

*Before any test:*

Stabilize the load cell under constant environmental conditions.

*Test severity:**Mains power voltage variations:*

- a) upper voltage limit ( $V + 10\%$ );
- b) lower voltage limit ( $V - 15\%$ ).

*Battery power voltage variations:*

- a) upper voltage limit (not applicable);
- b) lower voltage limit (specified by the manufacturer, below  $V$ ).

The voltage,  $V$ , is the value specified by the manufacturer. If a range of reference mains power voltage ( $V_{\min}$ ,  $V_{\max}$ ) is specified, then the test shall be performed at an upper voltage limit of  $V_{\max}$  and a lower voltage limit of  $V_{\min}$ .

*Maximum allowable variations:*

All functions shall operate as designed.

All measurement results shall be within maximum permissible errors.

*Note:* Where a load cell is powered by a three-phase supply, the voltage variations shall apply to each phase successively and all phases simultaneously.

*Reference to IEC Publication:*

IEC Publication 61000-4-11 (2004-03) Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests. Section 5.2 (Test levels – voltage variation), Section 8.2.2 (Execution of the test – voltage variation). [13]

A.4.7.4

*9.10.7.5 Short-time power reductions (see 6.7.1.5)**Test procedure in brief:*

This test consists of exposing the load cell to specified short-time power reductions.

A test generator capable of reducing the amplitude of one or more half cycles (at zero crossings) of the AC mains voltage shall be used. The test generator shall be adjusted before connecting to the load cell. The mains voltage reductions shall be repeated ten times at intervals of at least 10 seconds.

*Test load:*

During the test, the effect of any automatic zero-setting or zero-tracking features shall be switched off or suppressed, for example by applying a small test load. The test load need not be greater than necessary to accomplish this suppression.

*Before any test:*

Stabilize the load cell under constant environmental conditions.

Test severity:

Reduction:	100 %	50 %
Number of half cycles:	1	2

*Reference to IEC Publication:*

IEC Publication 61000-4-11 (2004-03) Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests. Section 5.1 (Test levels – voltage dips and short interruptions), Section 8.2.1 (Execution of the test – voltage dips and short interruptions). [13]

A.4.7.5

*9.10.7.6 Bursts (electrical fast transients) (see 6.7.1.5)**Test procedure in brief:*

This test consists of exposing the load cell to specified bursts of voltage spikes.

*Test instrumentation:*

In accordance with IEC 61000-4-4 (2004-07), No. 6.

*Test set-up:*

In accordance with IEC 61000-4-4 (2004-07), No. 7.

*Test procedure:*

In accordance with IEC 61000-4-4 (2004-07), No. 8.

*Before any test:*

Stabilize the load cell under constant environmental conditions. The test shall be applied separately to:

- a) power supply lines;
- b) I/O circuits and communication lines, if any.

*Test load:*

During the test, the effect of any automatic zero-setting or zero-tracking features shall be switched off or suppressed, for example by applying a small test load. The test load need not be greater than necessary to accomplish this suppression.

*Test severity:*

Level 2 (in accordance with IEC 61000-4-4 (2004-07), No. 5)

Open circuit output test voltage for:

- power supply lines: 1 kV;
- I/O signal, data, and control lines: 0.5 kV.

*Reference to IEC Publication:*

IEC Publication 61000-4-4 (2004-07) Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques - Section 4: Electrical fast transient/burst immunity test. Basic EMC publication. [14]

*9.10.7.7 Surge (see 6.7.1.5)**Test procedure in brief:*

This test is only applicable in those cases where, based on typical situations of installation, the risk of a significant influence of surges can be expected. This is especially relevant in cases of outdoor installations and/or indoor installations connected to long signal lines (lines longer than 30 m or those lines partially or fully installed outside the buildings regardless of their length).



This test shall be conducted unless there is justification provided regarding the specific details of the intended use and installation which would render this test unnecessary. The justification for not conducting this test shall be noted in the test report.

The test is applicable to power lines, communication lines (internet, dial up modem, etc.), and other lines for control, data or signal mentioned above (lines to temperature sensors, gas or liquid flow sensors, etc.).

It is also applicable to DC powered load cells where the (excitation) power supply comes directly from DC mains.

The test consists of exposing the load cell to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referenced standard. The characteristics of the generator shall be adjusted before connecting the load cell.

*Before any test:*

Stabilize the load cell under constant environmental conditions.

The test shall be applied to power supply lines, communication lines (internet, dial-up modem, etc.), and other lines for control, data or signal mentioned above (lines to temperature sensors, gas or liquid flow sensors, etc.).

On AC mains supply lines at least 3 positive and 3 negative surges shall be applied synchronously with AC supply voltage in angles 0°, 90°, 180° and 270°. On any other kind of power supply, at least three positive and three negative surges shall be applied.

*Test load:*

The test shall be performed with one small test load.

Both positive and negative polarity of the surges shall be applied. The duration of the test shall not be less than one minute for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the surge energy being dissipated in the mains.

*Test severity:*

Level 2

Amplitude (peak value) Power supply lines: 0.5 kV (line to line) and 1 kV (line to earth)

*Reference to IEC Publication:*

IEC Publication 61000-4-5 [15]

A.4.7.6	<p><b>9.10.7.8 Electrostatic discharge (see 6.7.1.5)</b></p> <p><i>Test procedure in brief:</i> This test consists of exposing the load cell to specified direct and indirect electrostatic discharges.</p> <p><i>Test generator:</i> In accordance with IEC 61000-4-2 (2008-12) Ed 2.0 Consolidated edition, No. 6.</p> <p><i>Test set-up:</i> In accordance with IEC 61000-4-2 (2008-12) Ed 2.0 Consolidated edition, No. 7.</p> <p><i>Test procedure:</i> In accordance with IEC 61000-4-2 (2008-12) Ed 2.0 Consolidated edition, No. 8.</p> <p><i>Discharge methods:</i> 1. This test includes the paint penetration method, if appropriate; 2. For direct discharges, the air discharge shall be used where the contact discharge method cannot be applied.</p> <p><i>Before any test:</i> Stabilize the load cell under constant environmental conditions.</p> <p><i>Discharge type:</i> At least 10 direct discharges and 10 indirect discharges shall be applied.</p> <p><i>Time interval:</i> The time interval between successive discharges shall be at least 10 seconds.</p> <p><i>Test load:</i> During the test, the effect of any automatic zero-setting or zero-tracking features shall be switched off or suppressed, for example by applying a small test load. The test load need not be greater than necessary to accomplish this suppression.</p> <p><i>Test severity:</i> Level 3 (in accordance with IEC 61000-4-2 (2008-12) Ed 2.0 Consolidated edition, No. 5). DC voltage up to and including 6 kV for contact discharges and 8 kV for air discharges.</p> <p><i>Reference to IEC Publication:</i> IEC Publication 61000-4-2 (2008-12) Ed 2.0 Consolidated edition, Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test. [16]</p>
A.4.7.7	<p><b>9.10.7.9 Electromagnetic susceptibility (see 6.7.1.5)</b></p> <p><i>Test procedure in brief:</i></p>

This test consists of exposing the load cell to specified electromagnetic fields.

*Test generator:*

In accordance with IEC 61000-4-3 (2006-02) Ed 3.0 Consolidated edition, No. 6.

*Test set-up:*

In accordance with IEC 61000-4-3 (2006-02) Ed 3.0 Consolidated edition, No. 7.

In accordance with IEC 61000-4-3 (2006-02) Ed 3.0 Consolidated edition, No. 8.

*Before any test:*

Stabilize the load cell under constant environmental conditions.

*Electromagnetic field strength:*

The load cell shall be exposed to electromagnetic fields of the strength and character as specified by the severity level.

*Test load:*

If test is conducted while load cell is installed as a component in a weighing instrument, then during the test, the effect of any automatic zero-setting or zero-tracking features enabled through the weighing instrument shall be switched off or suppressed, for example by applying a small test load. The test load need not be greater than necessary to accomplish this suppression.

*Test severity:*

Level 2 (in accordance with IEC 61000-4-3 (2006-02) Ed 3.0 Consolidated edition, No. 6)

*Frequency range:* 26 MHz to 2 000 MHz;

*Field strength:* 10 V/m;

*Modulation:* 80 % AM, 1 kHz sine wave.

*Reference to IEC Publication:*

IEC Publication 61000-4-3 (2006-02) Ed 3.0 Consolidated edition, Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test. [17]

*9.10.7.10 Immunity to conducted electromagnetic fields*

*Test procedure in brief:*

The test consists in exposing the load cell to disturbances induced by conducted radio-frequency fields.

*Test generator:*

In accordance with IEC 61000-4-6.

	<p><i>Test set-up:</i></p> <p>In accordance with IEC 61000-4-6.</p> <p><i>Before any test:</i></p> <p>Stabilize the load cell under constant environmental conditions.</p> <p><i>Electromagnetic field strength:</i></p> <p>The EUT shall be exposed to conducted disturbances of the strength and character as specified by the severity level.</p> <p><i>Test load:</i></p> <p>The test shall be performed with one small test load only.</p> <p><i>Test severity:</i></p> <p>Frequency range: 0.15 MHz-80 MHz  RF amplitude (50 <math>\Omega</math>): 10 V (emf)  Modulation: 80 % AM, 1 kHz, sine wave</p> <p><i>Reference to IEC Publication:</i></p> <p>IEC 61000-4-6 (2003-05) with amendment 1 (2004-10) Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 6: Immunity to conducted disturbances, induced by radio-frequency fields [18]</p>
A.4.7.8	<p><i>9.10.7.11 Span stability (see 6.7.2.2) (not applicable to class A load cells)</i></p> <p><i>Test procedure in brief:</i></p> <p>The test consists in observing the variations of the output of the load cell under reasonably constant (<math>\pm 2</math> °K) conditions (e.g., in a normal laboratory environment) at various intervals before, during and after the load cell has been subjected to performance tests. The performance tests shall include (as a minimum) the temperature test and, if applicable, the damp heat test</p> <p>The load cell shall be disconnected from the mains power supply, or battery supply where fitted, two times for at least 8 hours during the period of test. The number of disconnections may be increased if the manufacturer specifies so or at the discretion of the approval authority in the absence of any such consideration.</p> <p>For the conduct of this test, the manufacturer's operating instructions shall be considered. The load cell shall be stabilized at sufficiently constant ambient conditions after switch-on for at least 5 hours, but at least 16 hours after any temperature or humidity tests have been</p>

performed.

*Test duration:*

The time necessary to carry out all the required tests in this Section but not to exceed 28 days, for temperature and humidity tests.

*Time between measurements:*

Between 1/2 day (12 hours) and 10 days (240 hours), with an even distribution of the measurements over the total duration of the test.

*Test loads:*

A minimum test load,  $D_{\min}$ ; the same test load shall be used throughout the test.

A maximum test load,  $D_{\max}$ ; the same test load shall be used throughout the test.

*Number of measurements:* At least 8.

*Test sequence:*

Identical test equipment and test loads shall be used throughout the test.

Stabilize all factors at sufficiently constant ambient conditions.

Each set of measurements shall consist of the following:

- Preload the load cell by applying the maximum test load,  $D_{\max}$ , three times, returning to the minimum test load,  $D_{\min}$ , after each load application;
- stabilize the load cell at the minimum test load,  $D_{\min}$ ;
- read the minimum test load output and apply the maximum test load,  $D_{\max}$ . Read the maximum test load output at time intervals as near as possible to those specified in Table 8 in 9.8.3, and return to the minimum test load,  $D_{\min}$ . Repeat this four more times for accuracy class B or two more times for accuracy classes C and D;
- determine the span measurement result, which is the difference in output between the mean maximum test load outputs and the mean minimum test load outputs. Compare subsequent results with the initial span measurement result and determine the error.

*Record the following data:*

- date and time (absolute, not relative);
- temperature;
- barometric pressure;
- relative humidity;
- test load values;
- load cell outputs;
- errors.

Apply all necessary corrections resulting from variations in temperature, pressure, etc. between the various measurements.

Allow for full recovery of the load cell before any other tests are performed.

Where differences of results indicate a trend of more than half the allowable variation specified above, the test shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

A.5.1

### 9.11 Test sequence

The recommended test sequence for each test temperature when all tests are carried out in the same force-generating system is shown in Figure 3.

Figure  
A.1

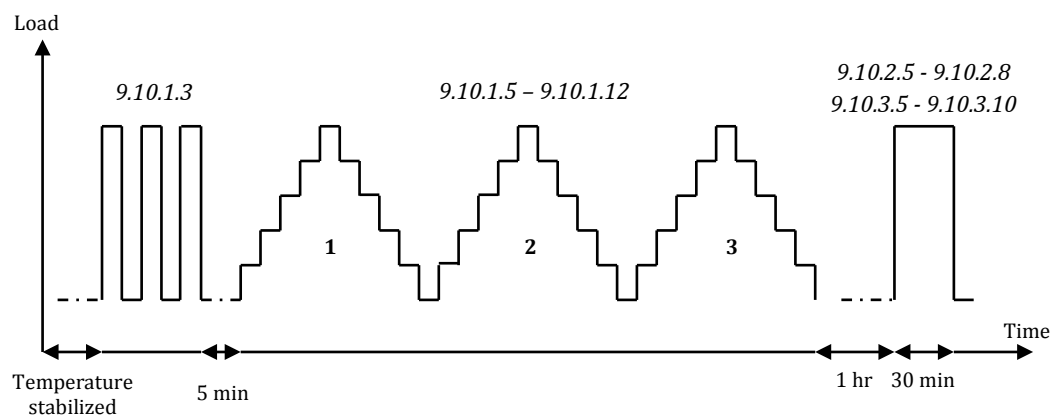


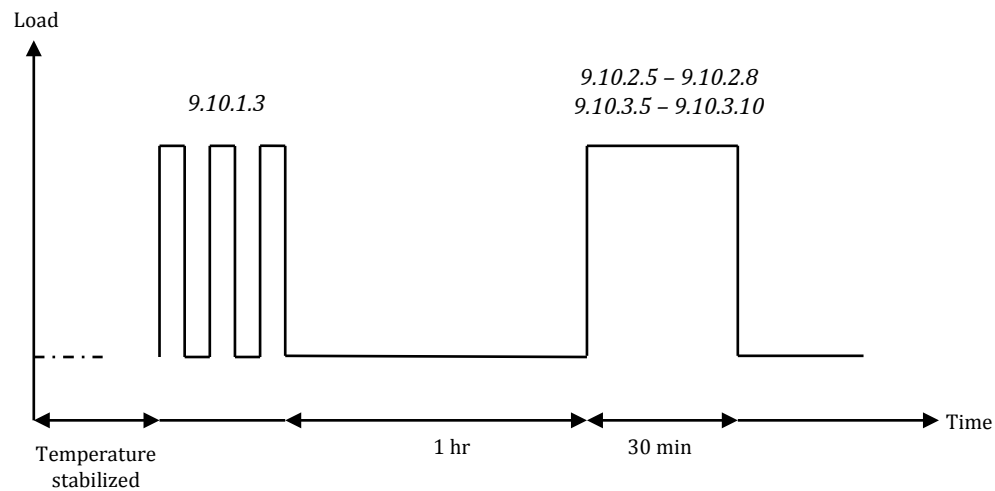
Figure 3 Recommended test sequence for each test temperature when all tests are carried out in the same machine

A.5.2

#### 9.11.1 Test sequence for minimum dead load output return

The recommended test sequence for each test temperature for the minimum dead load output return (DR) and creep tests when carried out in a force-generating system different to that used for the load tests is shown in Figure 4.

A.5.2  
Figure  
A.2



*Figure 4 Recommended test sequence for each test temperature for the minimum dead load output return (DR) and creep tests when carried out in a machine different from that used for the load tests*

4.8

## 9.12 OIML certificate

4.8.1

### 9.12.1 Preparation of certificate

The OIML certificate shall be prepared according to the rules contained within the OIML Publication OIML Certificate System for Measuring Instruments. The format of the certificate shall be as specified in Annex B, OIML Certificate of conformity for load cells.

4.8.2

### 9.12.2 Reference of values on certificate

Regardless of the evaluation result of any load cell in a load cell family, the certificate to be issued should not provide for any characteristics or values which are beyond those that the manufacturer has requested and for which the manufacturer intends to guarantee, for example, by expressing the relevant characteristics and values in its data sheet.





## **Annex A (Mandatory) Definitions from other applicable international publications**

### **A.1 Definitions from VIM [1]**

#### **A.1.1 Measured quantity value [VIM 2.10)]**

Quantity value representing a measurement result  
(For notes, please refer to VIM)

#### **A.1.2 Measurement error [VIM 2.16)]**

Measured quantity minus a reference quantity value.  
(For notes, please refer to VIM)

#### **A.1.3 Measurement repeatability [VIM 2.21]**

Measurement precision under a set of repeatability conditions of measurement

#### **A.1.4 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)

#### **A.1.5 measuring transducer [VIM 3.7]**

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

#### **A.1.6 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)

#### **A.1.7 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)

#### **A.1.8 Sensitivity of a measuring system [VIM 4.12]**

### Sensitivity

Quotient of the change in an indication of a measuring system and the corresponding change in a value of a quantity being measured

#### A.1.9 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)

#### A.1.10 Resolution of a displaying device [VIM 4.15]

Smallest difference between displayed indications that can be meaningfully distinguished

#### A.1.11 Maximum permissible measurement error [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)

## **A.2 Definitions from the VIML [2]**

#### A.2.1 legal metrology [VIML 1.2]

Part of metrology relating to activities which result from statutory requirements and concern measurement, units of measurement, measuring instruments and methods of measurement and which are performed by competent bodies.  
(For notes, please refer to VIML)

#### A.2.2 metrological supervision [VIML 2.3]

Control exercised in respect of the manufacture, import, installation, use, maintenance and repair of measuring instruments, performed in order to check that they are used correctly as regards the observance of metrology laws and regulations.  
(For notes, please refer to VIML)

#### A.2.3 type (pattern) evaluation [VIML 2.5]

Systematic examination and testing of the performance of one or more specimens of an identified type (pattern) of measuring instruments against documented requirements, the results of which are contained in the evaluation report, in order to determine whether the type may be approved

#### A.2.4 type approval [VIML 2.6]

Decision of legal relevance, based on the evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and is suitable for use in the regulated area in such a way that it is expected to provide reliable measurement results over a defined period of time

#### A.2.5 preliminary examination [VIML 2.12]

Partial examination of certain elements of a measuring instrument of which verification will be completed at the place of installation or an examination carried out before certain elements of the measuring instrument are fitted

#### A.2.6 verification by sampling [VIML 2.14]

Verification of a homogeneous batch of measuring instruments based on the results of examination of a statistically appropriate number of specimens selected at random from an identified lot

#### A.2.7 inspection of a measuring instrument [VIML 2.21]

Examination of a measuring instrument to ascertain all or some of the following:  
verification mark and/or certificate is valid;  
no sealing marks are damaged;  
after verification the instrument suffered no obvious modification;  
its errors do not exceed the maximum permissible in-service errors  
(For notes, please refer to VIML)

#### A.2.8 inspection by sampling [VIML 2.22]

inspection of a homogeneous batch of measuring instruments based on the results of evaluation of a statistically appropriate number of specimens selected at random from an identified lot

#### A.2.9 marking [VIML 2.23]

Affixing of one or more of the marks as described in (VIML) 3.7, 3.8, 3.9 and 3.10  
(For notes, please refer to VIML)

#### A.2.10 verification mark [VIML 3.7]

Mark applied to a measuring instrument certifying that the verification of the measuring instrument was carried out with satisfactory results  
(For notes, please refer to VIML)

#### A.2.11 rejection mark [VIML 3.8]

Mark applied to a measuring instrument in a conspicuous manner to indicate that the measuring instrument does not comply with the statutory requirements and obliterating the previously applied verification mark

#### A.2.12 sealing mark [VIML 3.9]

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

### **A.3 Definitions from OIML D 11 [4]**

(For definitions in OIML D 11 that are copied from the VIM, see E.1)

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

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

(For notes, please refer to OIML D 11)

#### A.3.2 Electronic device (OIML D 11, 3.2)

Device employing electronic sub-assemblies and performing a specific function. Electronic devices are usually manufactured as separate units and are capable of being tested independently  
(For notes, please refer to OIML D 11)

#### A.3.3 Electronic sub-assembly (OIML D 11, 3.3)

Part of an electronic device, employing electronic components and having a recognizable function of its own. Examples: amplifiers, comparators, power converters.

(For notes, please refer to OIML D 11)

#### A.3.4 Electronic component (OIML D11, 3.4)

Smallest physical entity that uses electron or hole conduction in semi-conductors, gases or in a vacuum.

#### A.3.5 Examples: electronic tubes, transistors, integrated circuits. Initial intrinsic error (OIML D 11, 3.8)

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

#### A.3.6 Fault (OIML D 11, 3.9)

Difference between the error of indication and the intrinsic error of a measuring instrument.  
(For notes, please refer to OIML D 11)

A.3.7 Significant fault (OIML D 11, 3.10)

Fault greater than the value specified in the relevant Recommendation  
(For notes, please refer to OIML D 11)

A.3.8 Durability error (OIML D 11, 3.11)

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

A.3.9 Significant durability error (OIML D 11, 3.12)

Durability error greater than the value specified in the relevant Recommendation.  
(For notes, please refer to OIML D 11)

A.3.10 Influence factor (OIML D 11, 3.13.1)

Influence quantity having a value within the rated operating conditions of a measuring instrument specified in the relevant Recommendation.

A.3.11 Disturbance (OIML D 11, 3.13.2)

Influence quantity having a value within the limits specified in the relevant Recommendation, but outside the specified rated operating conditions of a measuring instrument.  
(For notes, please refer to OIML D 11)

A.3.12 Rated operating conditions [OIML D 11, 3.14]

Conditions of use giving the range of values of influence quantities for which specified metrological characteristics of a measuring instrument are intended to lie within given limits.

A.3.13 Performance (OIML D 11, 3.16)

Ability of a measuring instrument to accomplish its intended functions.

A.3.14 Durability (OIML D 11, 3.17)

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

A.3.15 Automatic checking facility (OIML D 11, 3.18.1)

Checking facility that operates without the intervention of an operator.

A.3.16 Permanent automatic checking facility (type P) (OIML D 11, 3.18.1.1)

Automatic checking facility that operates at each measurement cycle.

A.3.17 Intermittent automatic checking facility (type I) (OIML D 11, 3.18.1.2)

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

A.3.18 Non-automatic checking facility (type N) (OIML D 11, 3.18.2)

Checking facility that requires the intervention of an operator.

A.3.19 Durability protection facility (OIML D 11, 3.19)

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

A.3.20 Test (OIML D 11, 3.20)

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

A.3.21 Test procedure (OIML D 11, 3.20.1)

Detailed description of the test operations.

A.3.22 Test program (OIML D 11, 3.20.2)

Description of a series of tests for certain types of equipment.

A.3.23 Performance test (OIML D 11, 3.20.3)

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

A.3.24 Durability test (OIML D 11, 3.20.4)

Test intended to verify whether the EUT is able to maintain its performance characteristics over a period of use.

A.3.25 Mains power (OIML D 11, 3.21)

Primary external source of electrical power for an instrument, including all sub-assemblies. (Examples: public power (AC or DC), generator, external battery or other DC supply systems)

**A.3.26 Power converter (power supply device) (OIML D 11, 3.22)**

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

**A.3.27 Auxiliary battery (OIML D 11, 3.23)**

Battery that is:

Mounted in, or connected to, an instrument that can be powered by the mains power as well;  
and

Capable of completely powering the instrument for a reasonable period of time.

**A.3.28 Back-up battery (OIML D 11, 3.24)**

Battery that is intended to power specific functions of an instrument in the absence of the primary power supply. Example: to preserve stored data.

**A.4 Definitions from OIML B 3 [5]****A.4.1 Category of instruments [B 3, 2.2]**

Identification or classification of instruments according to unique metrological and technical characteristics that may include the measured quantity, the measuring range, and the principle or method of measurement.

**A.4.2 Family of measuring instruments [B 3, 2.3]**

Identifiable group of measuring instruments belonging to the same manufactured type within the same category that have the same design features and metrological principles for measurement but which may differ in some metrological and technical performance characteristics, as defined in the relevant Recommendation.

**A.4.3 Module [B 3, 2.4]**

Identifiable part of a measuring instrument or of a family of measuring instruments that performs a specific function or functions and that can be separately evaluated according to prescribed metrological and technical performance requirements in the relevant Recommendation.

**A.4.4 Family of modules [B 3, 2.5]**

Identifiable group of modules belonging to the same manufactured type that have similar design features but may differ in some metrological and technical performance requirements as defined in the relevant Recommendation

## **A.5 Definitions from OIML R76 [8]**

### **A.5.1 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.

### **A.5.2 Influence quantity [T.6.1]**

Quantity that is not the subject of the measurement but which influences the values of the measurand or the indication of 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 responsible:

.....

### *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).....

.....

<i>Model designation</i>				
Maximum capacity, $E_{\max}$				
Accuracy class				
Maximum number of load cell verification intervals, $n_{\max}$				
Minimum verification interval, $v_{\min}$				
Apportionment factor, $p_{LC}$				

(Additional characteristics and identification, as applicable according to R 60, 3.4.2 and 6.1.5, 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: OIML Member:**

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

OIML certificate no.

\* \* \*

Additional characteristics<sup>1</sup> and identification, as applicable to R 60, 3.4.2 and 6.1.5 (*continued*)

<i>Model designation</i>				
(Additional characteristics, per 3.4.2 and 6.1.5)				

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.

<sup>1</sup> The table with the essential technical data may, upon request by the manufacturer, be placed on the certificate or on an addendum.

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

**Addendum to test certificate no.** .....

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

**B.2. Technical data**

The essential technical data for the test certificates 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:

<b>Table E.1 Technical data</b> <i>Model designation</i>	<i>Designation</i>	<i>Example</i>				<i>Units</i>
Classification		C4				
Additional markings		—				
Maximum number of load cell verification intervals		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				$\Omega$
Temperature rating		– 10/+ 40				°C
Safe overload, relative	$E_{\lim} / E_{\max}$	150				%
Cable length		3				m

Additional characteristics per 3.4.2 and 6.1.5**		—				
--	--	---	--	--	--	--

\**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

**B.3. Tests**

The tests listed in Table E.2 have been carried out in accordance with OIML R 60:

-at the laboratory ..... (*insert laboratory name*)

-as documented in the test report no. .... (*insert test report number*)

**Table E.2 Tests performed with load cell:**

Serial no.: .....

Class: .....

$E_{\max}$ : .....

$n_{\max}$ : .....

Y: .....

Z: .....

<i>Test</i>	<i>R 60 Ref.</i>	<i>Approved</i>	<i>Institute</i>
Temperature test and repeatability at 20 °C, 40 °C, – 10 °C, 20 °C	6.3.1.1, 6.4; 9.10.1		
Temperature effect on minimum dead load output at 20 °C, 40 °C, – 10 °C, 20 °C	6.6.1.3; 9.10.1		
Creep at 20 °C, 40 °C, – 10 °C	6.5.1; 9.10.2		
Minimum dead load output return at 20 °C, 40 °C, – 10 °C	6.5.2; 9.10.3		
Barometric pressure effects at room temperature	6.6.2; 9.10.4		
Damp heat, cyclic: marked CH (or not marked)	6.6.3.1; 9.10.5		
Damp heat, steady state: marked SH	6.6.3.2; 9.10.6		

<b>Additional tests for load cells equipped with electronics</b>	6.7; 9.10.7		
Warm-up time	9.10.7.3		
Power voltage variations	9.10.7.4		
Short time power reductions	6.7.1.5; 9.10.7.5		
Bursts (electrical fast transients)	6.7.1.5; 9.10.7.6		
Electrostatic discharge	6.7.1.5; 9.10.7.8		
Electromagnetic susceptibility	6.7.1.5; 9.10.7.9		
Span stability	6.7.2.2; 9.10.7.11		





# Annex C (Mandatory) OIML Certificate of conformity for load cells (Alternate proposal)

## 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 1. Further technical data are listed in the data sheet of the manufacturer at page 5 to 6 of this annex.

Table 1: 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 $v_{min} = (E_{max} / Y)$		$E_{max} / 15000$
Minimum dead load output return $DR = (\frac{1}{2} E_{max} / Z)$		$\frac{1}{2} E_{max} / 5000$

Dead load:  $xxx\% \cdot E_{max}$ ; Safe overload:  $xxx\% \cdot E_{max}$ ; Input impedance:  $xxx \Omega$

## 2. Tests

The determination of the measurement error, the stability of the dead load output, repeatability and creep in the temperature range of  $-10^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$  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 (2000) as shown in Table 2 on the load cell nominated in the test report with the reference No. xxx, dated xxx.

Table 2: Tests performed

Test	R60 (2000)	tested samples	result
Temperature test and repeatability at (20 / 40 / -10 / 20°C)	6.3.1.1; 9.10.1 6.4	150 kg	+
Temp. effect on minimum dead load output at (20 / 40 / -10 / 20°C)	6.6.1.3 9.10.1. 16.7	150 kg	+
Creep test at (20 / 40 / -10 / 20°C)	6.5.1 9.10.2	150 kg	+

Minimum dead load output return at (20 / 40 / -10 / 20°C)	6.5.2	9.10.3	150 kg	+
Barometric pressure effects at ambient temperature	6.6.2	9.10.4	150 kg	+
Damp heat test , static, marked SH	6.6.3.2	9.10.6	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<sub>max</sub>=xxx kg; SN: xxx
- Datasheet No. Xxx
- Technical Drawing No. Xxx

### 5. Further information

The manufacturing process, material and sealing of the produced load cells have to be in accordance with the tested patterns; essential changes are only allowed with the permission of the issuing authority.

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 5.1.

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

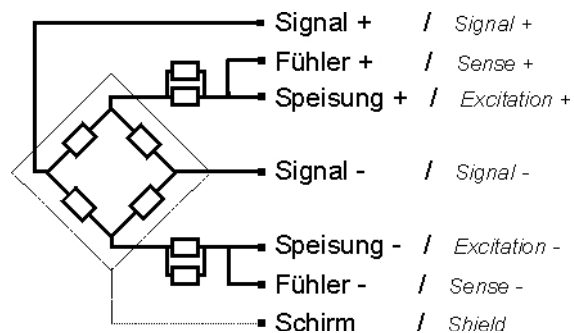
Specifications of the Load Cell Family

Accuracy class acc. to OIML R60		C3
Rated output C <sub>n</sub>	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	$V_{\min}$		$E_{\max} / 15000$
Minimum dead load output return (MDLOR)	$DR$		$\frac{1}{2} \cdot E_{\max} / 5000$
Minimum dead load		$\% \cdot E_{\max}$	0
Safe load limit		$\% \cdot E_{\max}$	150
Ultimate load		$\% \cdot E_{\max}$	300
Excitation voltage, recommended		V	10 – 12 DC
Excitation voltage, maximum		V	15 DC
Input resistance	$R_{LC}$	$\Omega$	$404 \pm 10$
Output resistance	$R_{out}$	$\Omega$	$350 \pm 3$
Insulation resistance		M $\Omega$	$\geq 2000$
Compensated temperature range		$^{\circ}\text{C}$	- 10 ... + 40
Load cell material			Aluminium
Cable length		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	

Load cell dimensions in mm

**Picture of the load cell dimensions**

Figure 3: Dimensions of the load cell type xxx in mm

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

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

Class	Y	<--- lowest $E_{\max}$ , kg ---> highest									
$n_{\max}$											
Group	Z	$v_{\min}$ , kg									
C3	12 000		100	300	500			5 000	10 000	30 000	50 000
3 000											
2	4 000		0.0083	0.025	0.042			0.42	0.83	2.5	4.17
C6	18 000	50	100	300	500						
6 000											
1	6 000	0.0028	0.0055	0.0167	0.028						
B10	25 000				500	1 000	4 000				
10 000											
3	10 000				0.020	0.040	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 9.4.5, 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	Y	<--- lowest $E_{\max}$ , kg ---> highest									
$n_{\max}$											
Group	Z	$v_{\min}$ , kg									
C3	12 000		100	300	500			5 000	10 000	30 000	50 000
3 000											
2	4 000		0.0083	0.025	0.042			0.42	0.83	2.5	4.17
C6	18 000	50	100	300	500						
6 000											
1	6 000	0.0028	0.0055	0.0167	0.028						
B10	25 000				500	1 000	4 000				
10 000											
3	10 000				0.020	0.040	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 9.4.5 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	Y	<--- lowest $E_{\max}$ , kg ---> highest									
$n_{\max}$											
Group	Z	$v_{\min}$ , kg									
C3	12 000		100	300	500			5 000	10 000	30 000	50 000
3 000											
2	4 000		0.0083	0.025	0.042			0.42	0.83	2.5	4.17
C6	18 000	50	100	300	500						
6 000											
1	6 000	0.0028	0.0055	0.0167	0.028						
B10	25 000				500	1 000	4 000				
10 000											
3	10 000				0.020	0.040	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 9.3.1, 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 9.4.4, 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	Y	<div> <div>&lt;--- lowest</div> <div>E<sub>max</sub>, kg</div> <div>---&gt; highest</div> </div>									
n <sub>max</sub>											
Group	Z	v <sub>min</sub> , kg									
C3	12 000		100	300	500			5 000	10 000	30 000	50 000
3 000											
2	4 000		0.0083	0.025	0.042			0.42	0.83	2.5	4.17
C6	18 000	50	100	300	500						
6 000											
1	6 000	0.0028	0.0055	0.0167	0.028						
B10	25 000				500	1 000	4 000				
10 000											
3	10 000				0.020	0.040	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 9.4.3 it is presumed to comply the requirements of this Recommendation.

**D.2.6.** After completing steps A.2.2 to A.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<sub>max</sub> 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<sub>max</sub> and lowest v<sub>min</sub>.

Class	Y	<div style="display: flex; justify-content: space-between; width: 100%;"> <span>&lt;--- lowest</span> <span><math>E_{\max}</math>, kg</span> <span>---&gt; highest</span> </div>									
$n_{\max}$											
Group	Z	$v_{\min}$ , kg									
C3	12 000		100	300	500			5 000	10 000	30 000	50 000
3 000											
2	4 000		0.0083	0.025	0.042			0.42	0.83	2.5	4.17
C6	18 000	50	100	300	500						
6 000											
1	6 000	0.0028	0.0055	0.0167	0.028						
B10	25 000				500	1 000	4 000				
10 000											
3	10 000				0.020	0.040	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 9.4.6, that being the load cell with the most severe characteristics, for example the greatest value of  $n_{\max}$  or the lowest value of  $v_{\min}$ .

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 load cells equipped with electronics in accordance with 9.4.7, 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.

<i>Summary</i>	<i>Selected cells</i>
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
Load cells equipped with electronics for additional tests	None



## Annex E (Informative) Load transmission to the load cell

This Annex is taken from the WELMEC (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 either of the load transmissions 1 to 10.
- The direction of loading, which is given by the manufacturer, has to be observed.

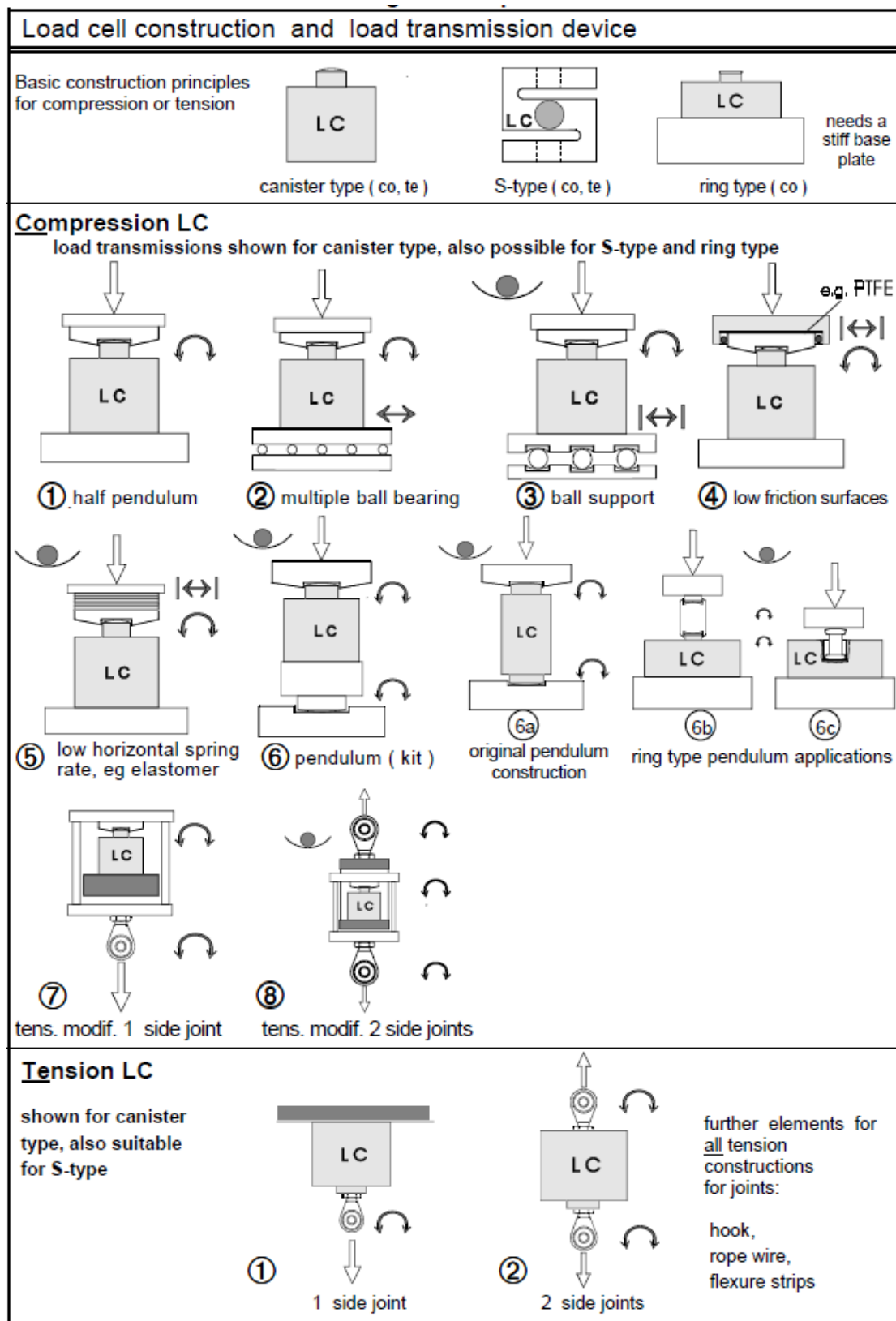
(d) Single point LCs (Table 2, middle part)

- 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**

<b>Load cell construction and load transmission device</b> The load transmission device is independent of the encapsulation, potting or housing and the mounting at the fixed end shown below	
<b>Beam LC - Cantilever beam</b> Double bending beam & Shear beam LC	
<b>Single point LC</b>	<p>The single point LC has no degree of freedom for horizontal displacement or inclination, using more than one LC in a load receptor decoupling elements are necessary.</p> <p>The load transmissions 1 to 10 for the beam LCs may be applied.</p> <p>Max. platform dimensions may be mentioned in the TC or the TAC.</p>
<b>Double ended beam LC</b>	
<p>Constructions with fixed clamping at the two ends need for minimum displacement and inclination some elasticity of the supporting construction.</p>	



# Bibliography

Reference Identifier	Publication Title	Description
[1]	"ISO/IEC Guide 99 OIML V 2-200 International Vocabulary of Metrology - Basic and General Concepts and Associated Terms," 2012.	Vocabulary, prepared by a joint working group consisting of experts appointed by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML
[2]	"OIML V2 International Vocabulary of Terms in Legal Metrology," 2000.	Vocabulary including only the concepts used in the field of legal metrology. These concepts concern the activities of the legal metrology service, the relevant documents as well as other problems linked with this activity. Also included in this Vocabulary are certain concepts of a general character which have been drawn from the VIM.
[3]	"OIML D9 Principles of metrological supervision," 2004.	Provides elements to be considered for developing a model of metrological supervision in Member States which can be used as a basis for the harmonization of metrological supervision at an international level.
[4]	"OIML D11 General requirements for electronic measuring instruments.," 2004.	Contains general requirements for electronic measuring instruments
[5]	"OIML B3 OIML Basic Certificate System for OIML Type Evaluation of Measuring Instruments," 2011.	Gives rules for issuing, registering and using OIML Certificates of conformity
[6]	"Guide to the Expression of Uncertainty in Measurement, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML," 2008.	This Guide establishes general rules for evaluating and expressing uncertainty in measurement that are intended to be applicable to a broad spectrum of measurements. It was prepared by a joint working group consisting of experts nominated by the BIPM, the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), and the International Organization of Legal Metrology (OIML).
[7]	"OIML D31 General requirements for software controlled measuring instruments," 2008.	Specifies the general requirements applicable to software related functionality in measuring instruments and gives guidance for verifying the compliance of an instrument with these requirements.
[8]	"OIML R76 Non-automatic weighing instruments," 2006.	Specifies the general requirements applicable to software related functionality in measuring instruments and gives guidance for verifying the compliance of an instrument with these requirements.

[9]	"ISO 8601 Data elements and interchange formats - Information interchange - Representation of dates and times," 2004.	International standard covering the exchange of date and time-related data to provide an unambiguous and well-defined method of representing dates and times, so as to avoid misinterpretation of numeric representations of dates and times
[10]	"IEC Publication 60068-2-30 Ed. 3.0," 2005.	Determines the suitability of components, equipment and other articles for use and/or storage under conditions of high humidity when combined with cyclic temperature changes. Amendment No. 1 replaces the third paragraph of Clause 8, Recovery.
[11]	"IEC Publication 60068-2-78," 2008.	<p>Provides a test method for determining the suitability of electrotechnical products, components or equipment for transportation, storage and use under conditions of high humidity. The test is primarily intended to permit the observation of the effect of high humidity at constant temperature without condensation on the specimen over a prescribed period.</p> <p>This test provides a number of preferred severities of high temperature, high humidity and test duration. The test can be applied to both heat-dissipating and non-heat dissipating specimens. The test is applicable to small equipment or components as well as large equipment having complex interconnections with test equipment external to the chamber, requiring a set-up time which prevents the use of preheating and the maintenance of specified conditions during the installation period.</p>
[12]	"IEC Publication 60068-3-4 Ed. 1 Environmental testing," 2001.	Provides the necessary information to assist in preparing relevant specifications, such as standards for components or equipment, in order to select appropriate tests and test severities for specific products and, in some cases, specific types of application. The object of damp heat tests is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics. Damp heat tests may also be utilized to check the resistance of a specimen to some forms of corrosion attack.

[13]	"IEC Publication 61000-4-11," 2004.	<p>Defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz AC networks. It does not apply to electrical and electronic equipment for connection to 400 Hz AC networks. Tests for these networks will be covered by future IEC standards. The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to voltage dips, short interruptions and voltage variations. It has the status of a Basic EMC Publication in accordance with IEC Guide 107.</p>
[14]	"IEC Publication 61000-4-4," 2004.	<p>Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/burst on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.</p> <p>The standard defines:</p> <ul style="list-style-type: none"> <li>– test voltage waveform;</li> <li>– range of test levels;</li> <li>– test equipment;</li> <li>– verification procedures of test equipment;</li> <li>– test set-up; and</li> <li>– test procedure.</li> </ul> <p>The standard gives specifications for laboratory and post installation tests.</p>
[15]	"IEC Publication 61000-4-5," 2005.	<p>Relates to the immunity requirements, test methods, and range of recommended test levels for equipment to unidirectional surges caused by overvoltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment. Establishes a common reference for evaluating the performance of equipment when subjected to high-energy disturbances on the power and inter-connection lines.</p>

[16]	"IEC Publication 61000-4-2," 2008.	Relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. Additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures. The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.
[17]	"IEC Publication 61000-4-3 Ed. 3.0," 2006.	Applies to the immunity of electrical and electronic equipment to radiated electromagnetic energy. Establishes test levels and the required test procedures. Establishes a common reference for evaluating the performance of electrical and electronic equipment when subjected to radio-frequency electromagnetic fields.
[18]	"IEC Publication 61000-4-6," (2003-05).	Relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances coming from intended radio-frequency (RF) transmitters in the frequency range 9 kHz - 80 MHz. Equipment not having at least one conducting cable (such as mains supply, signal line or earth connection), which can couple the equipment to the disturbing RF fields is excluded. This standard does not intend to specify the tests to be applied to particular apparatus or systems. Its main aim is to give a general basic reference to all concerned product committees of the IEC. The product committees (or users and manufacturers of equipment) remain responsible for the appropriate choice of the test and the severity level to be applied to their equipment.
[19]	"IEC Publication 60529 Ed. 2.1," 2001-02.	Applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV. Has the status of a basic safety publication in accordance with IEC Guide 104.
[20]	"OIML R61 Automatic gravimetric filling instruments," 2004.	This OIML Recommendation prescribes the metrological requirements and evaluation procedures for instruments that fill containers with predetermined and virtually constant mass of product from bulk by automatic weighing.

[21]	"OIML R51 Automatic catchweighing instruments," 2006.	This OIML Recommendation prescribes the metrological requirements and evaluation procedures for weighing instruments used to weigh pre-assembled discrete loads or single loads of loose materials.
[22]	"OIML R50 Continuous totalizing automatic weighing instruments (belt weighers)," 1997.	This OIML Recommendation prescribes the metrological requirements and evaluation procedures for belt weighers used in the measurement of mass.
[23]	"OIML R107 Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)," 2007.	This OIML Recommendation prescribes the metrological requirements and evaluation procedures for weighing instruments that weigh bulk product by dividing it and determining the mass in discrete loads, and summing the results.
[24]	"OIML R106 Automatic rail-weighbridges," 2011.	This OIML Recommendation prescribes the metrological requirements and evaluation procedures for automatic weighing instrument having one or more load receptor(s), inclusive of rails for conveying railway vehicles, that determines the mass of wagons and/or the whole train by weighing them in motion