Scale Manufacturers Association

(SMA)

Standard

Load Cell Specifications

(SMA LCS 04-99)

Provisional First Edition

Approved By SMA

Pending Final Comment

April 24, 1999

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Scale Manufacturers Association

Specification for Load Cell Standardization

Table of Contents

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Purpose

1.1. The purpose of this standard is to assist users in the selection and installation of load cells. To this end this standard provides for manufacturers:

1.1.1. A rating system designed specifically for load cells that describes their construction, **degree of ingress protection**, and materials of construction.

1.1.2. A list of specifications to be made available to the user along with the terminology and units of measure to be used.

1.1.3. The terminology to be used when referring to the conductors of the load cell cable, along with a color code to be used for new load cell models.

2. Scope

2.1. Section 4 of this standard, Construction and Protection **(CP) Code**, applies to all load cells.

2.2. Section 5 of this standard, Load Cell Specifications, applies specifically to analog strain gage load cells. However, many of the specifications apply regardless of the technology employed, and may be used where appropriate.

2.3. Section 6 of this standard, Cable Terminology and Color Code, applies to analog strain gage load cells.

3. Definitions

3.1. The terms defined in this section are shown bold throughout this document to assist in referencing these definitions.

CALIBRATION CURVE: The characteristic curve of **load cell output** relative to true applied load.

COMBINED ERROR: (the combined effect of **non-linearity**, **hysteresis** and **temperature effect on rated output**) The maximum deviation from the straight line drawn between the **zero load output** and a point equal to 75% of **rated output** at **standard test conditions** and measured on both increasing and decreasing loads and at the extremes of **the compensated temperature range**. [expressed as a percentage of **rated output**]

CONSTRUCTION AND PROTECTION CODE: See **CP CODE.**

CP CODE: The CP or Construction and Protection Code is a coding system that indicates the construction, **degree of ingress protection**, and materials of construction of a load cell.

DEGREE OF INGRESS PROTECTION: The extent of protection provided by the load cell against ingress of water and condensing moisture, verified by standardized test methods.

HYSTERESIS: The maximum difference between **load cell output** readings for the same applied load; one reading obtained by increasing the load from zero and the other by decreasing the load from **rated capacity**. [expressed in percent of **rated output**.]

LEGAL FOR TRADE: A load cell that has been manufactured to meet criteria defined by authorized agencies for use in a system where goods or services are exchanged for monetary compensation.

LOAD CELL ENCLOSURE: All parts of a load cell including the spring element that provide protection of the electrical components (passive or active) against the ingress of water or condensing moisture.

LOAD CELL FAMILY: Consists of load cells that are of:

- The same material or combination of materials (e.g., stainless steel, aluminum).
- The same design of measurement technique (e.g., strain gages bonded to metal).
- The same method of construction (e.g., shape, sealing of strain gages, mounting method, manufacturing method).
- The same set of specifications (e.g., output rating, input impedance, supply voltage, cable details).
- One or more load cell groups.

LOAD CELL GROUP: All load cells within a **load cell family** possessing identical metrological characteristics (e.g., class, Nmax, temperature rating).

LOAD CELL OUTPUT: The **signal** into which a load cell converts the measured quantity (load: weight or force).

LOAD CELL VERIFICATION INTERVAL (v): The load cell interval, expressed in units of mass, used in the test of the load cell for accuracy classification.

MAXIMUM CAPACITY (E_{max}): The largest value of a quantity that may be applied to a load cell without exceeding the **maximum permissible error**.

MAXIMUM LOAD (D_{max}): The largest value of a quantity that can be applied to a load cell during test or use. This value shall not be greater than the **maximum capacity**.

MAXIMUM PERMISSIBLE ERROR (MPE): The extreme values of the permitted error for the combined effect of **non-linearity**, **hysteresis**, and **temperature effect on rated output** over the specified **compensated temperature range**. [used in relation to **legal for trade** load cells and is stated in **load cell verification intervals**].

MINIMUM DEAD LOAD (E_{min}): The smallest value of a quantity that may be applied to a load cell without exceeding the **maximum permissible error.**

MINIMUM LOAD (D_{min}): The smallest value of a quantity that is applied to a load cell during test or use. This value shall not be less than E_{min}.

NON-LINEARITY: The maximum deviation of the **calibration curve** from a straight line drawn between the load cell **signal** at **minimum load** and 75% of the **rated capacity**. [Expressed as a percentage of the **rated output** and measured on increasing load only.]

RATED CAPACITY (R.C.): The **maximum load** (applied on the primary loading axis) the load cell is designed to measure within its specifications.

RATED OUTPUT: The load cell **signal** at **rated capacity.**

SIGNAL: (for analog load cells) The absolute level of measurable quantity produced at the signal terminals of the load cell.

STANDARD TEST CONDITIONS: The environmental conditions under which measurements should be made when measurements under any other conditions may result in disagreement between various observers at different times and places.

These conditions are as follows:

Temperature: 20° +/- 2° C. (68° +/- 3.6° F)
Relative Humidity: 90% or less
Barometric Pressure: 98 +/- 10 kPa (29 +/- 3 inches Hg)

TEMPERATURE EFFECT ON RATED OUTPUT: The change of **signal** at **rated capacity** for a specified change of temperature at steady state temperature conditions. [Expressed as a percentage of applied load per °C]

TEMPERATURE RANGE, COMPENSATED: The range of temperature over which the load cell is compensated to meet all specification.

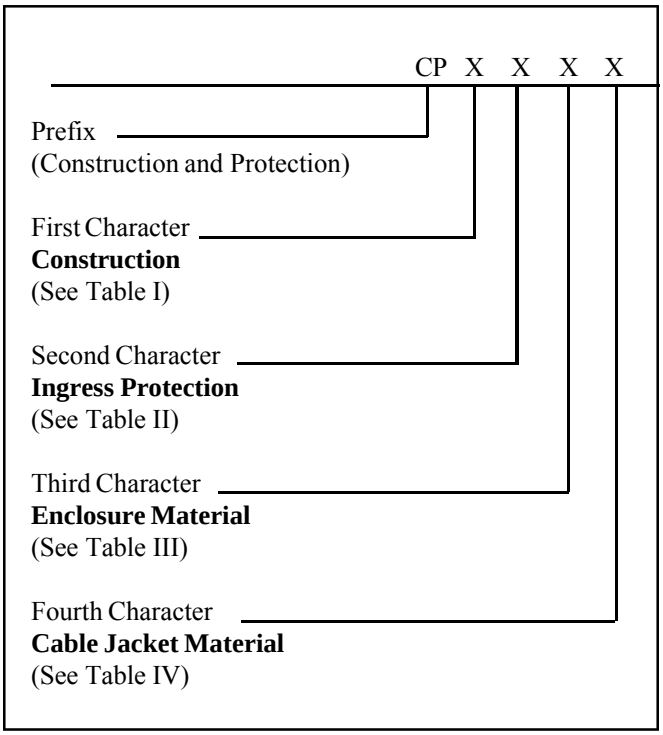
4. Construction and Protection (CP) Code

4.1. Introduction

4.1.1. This section describes a coding system by which a manufacturer can describe the construction, the **degree of ingress protection**, and the materials of construction of a load cell. It also provides test methods and acceptance criteria by which the **degree of ingress protection** can be determined.

4.2. Arrangement of CP Code

4.2.1. The construction, **degree of ingress protection**, and materials of construction of a load cell are described by a **CP Code** which consists of a four character string with the prefix "CP", as described below:



4.2.2. The first character describes the load cell construction, as detailed in Table I.

4.2.3. The second character rates the **degree of ingress protection**, as detailed in Table II. Verification testing for load cell ingress protection is specified in section 4.3.

4.2.4. The third character represents the material that is used for the **load cell enclosure**, as detailed in Table III.

4.2.4.1. When various materials are used, the first alphabetical letter shall be used to describe the **load cell enclosure**. For example, if the load cell spring element is made of 17-4 PH (letter G) and the protective covers that seal the enclosure are made of 316 stainless steel (letter H), then the third character shall be letter G.

4.2.5. The fourth character represents the material that is used for the outer jacket of the transmission cable, as detailed in Table IV.

4.2.6. If the load cell manufacturer chooses to not specify a particular character, or a suitable designation does

not exist in Tables I through V, a dash ("-") shall take the place of the missing character.

4.2.6.1. The following examples illustrate the use and arrangement of letters in the **CP Code**.

CP 44DV (using all characters);
CP 44-U (third character not specified);
CP 8SG- (fourth character not specified);
CP 7--- (second, third, and fourth characters not specified).

4.3. Ingress Protection Tests

4.3.1. The following tests shall be conducted to establish the second character (ingress protection): the cyclic damp heat test detailed in section 4.3.2. and the water tests detailed in section 4.3.3.

4.3.1.1. The cyclic damp heat test shall be performed first. The time between tests shall not exceed 48 hours during which time the cell shall be maintained at **standard test conditions**.

4.3.1.2. The results of these tests shall be evaluated as detailed in section 4.3.4.

4.3.1.3. The number of test samples shall be as detailed in section 4.3.5.

4.3.2. Perform a cyclic damp heat test as follows:

4.3.2.1. Prepare the load cell and perform initial testing according to sections 15.5.1. through 15.5.6. of OIML R 60 1991. In 15.5.6. treat Handbook 44 and non **legal for trade** load cells as described for accuracy classes C and D.

4.3.2.2. Perform a cyclic damp heat test according to section 15.5.7. of OIML R 60 1991, with the exception that the test severity should be in accordance with Table V.

4.3.2.3. Complete the testing according to section 15.5.8. of OIML R 60 1991.

4.3.2.4. Evaluate the results in accordance with section 4.3.4.

4.3.3. Perform water tests as follows:

4.3.3.1. Prepare the load cell and perform initial testing according to sections 15.5.1. through 15.5.6. of OIML R 60 1991. In 15.5.6. treat Handbook 44 and non **legal for trade** load cells as described for accuracy classes C and D.

4.3.3.2. Perform the water tests specified in Table VI, following the procedures detailed in IEC529, second edition 1992.

4.3.3.3. Complete the testing according to section 15.5.8. of OIML R 60 1991.

4.3.3.4. Evaluate the results in accordance with section 4.3.4.

4.3.4. The limits that apply to the tests specified in 4.3.2. and 4.3.3. are as follows:

4.3.4.1. The difference between the initial reading of the **minimum load** output and the reading for the same load obtained after the conduct of the test, shall not be greater than 4% of the difference between the output at the **maximum capacity** of the load cell and the **minimum dead load** of the load cell.

4.3.4.2. The difference between the average of the output values at the **maximum load** (corrected for the **minimum load** output) obtained before the test and the average of the output values obtained for the same **maximum load** (corrected for the **minimum load** output) after the test, shall not be greater than:

4.3.4.2.1. The value of the **load cell verification interval** (1v) for **legal for trade** load cells.

4.3.4.2.2. The manufacturer's **combined error** specification for non **legal for trade** load cells.

4.3.5. The tests specified in 4.3.1. shall be performed on one test sample per **load cell family**. A load cell from each **load cell group** shall be tested if the **load cell family** consists of more than one **load cell group**. The lowest **CP Code** shall be applied to the **load cell family**, or a **CP Code** may be applied to each **load cell group**.

Table I: CP Code First Character – Construction

First Character	Description	
	Summary	Detail
1	Open	Open faced components.
2	Minimal coating, open entry	Components with minimal coating (i.e. thin layer spray, lacquer, laminated gages, gage coating)
3	Potted, potted cable entry	All components including the connection points to the transmission cable are fully potted.
4	Potted, cable gland	All components are fully potted; the transmission cable enters the load cell enclosure via a cable gland or construction providing an equal level of protection.
5	Potted, additional protection, cable gland	All components are fully potted; additional protection is provided (i.e. metal covers, rubber boot) the transmission cable enters the load cell enclosure via a high integrity cable gland or construction providing an equal level of protection.
6	Weld sealed, cable gland	All components are protected by metal barriers (i.e. cups, plates, tubes, and bellows) which are welded or soldered to the enclosure, the transmission cable enters via a high integrity cable gland or construction providing an equal level of protection.
7	Weld sealed, glass-to-metal or barrier cable entry	All components are protected by metal barriers that are welded or soldered to the enclosure. The cable enters via a high integrity cable gland. Moisture penetration through the cable is prevented with a glass-to-metal barrier or any other barrier or construction which provides the same function.
8	Potted and weld-sealed, glass-to-metal or barrier cable entry	All components are fully potted and protected by metal barriers that are welded or soldered to the enclosure, the cable enters via a high integrity cable gland. Moisture penetration through the cable is prevented with a glass-to-metal barrier or any other barrier or construction which provides the same function.
S	Special construction	Special construction of which the protection against the ingress of water exceeds 8 above.

Table II: CP Code Second Character – Ingress Protection

Second Character	Description	
	Summary	Detail
1	No protection	Not-protected
2	Vertically dripping	Protected against vertically falling water drops: Vertically falling drops shall not cause errors that exceed that specified in 4.3.4.
3	Spraying	Protected against spraying water: Water sprayed at an angle up to 60° on either side of the vertical shall not cause errors that exceed that specified in 4.3.4.
4	Splashing	Protected against splashing water: Water splashed against the load cell from any direction shall not cause errors that exceed that specified in 4.3.4.
5	Jetting	Protected against water jets: Water projected in jets against the load cell from any direction shall not cause errors that exceed that specified in 4.3.4.
6	Temporary immersion	Protected against the effects of temporary immersion in water: Ingress of water when the load cell is temporarily immersed in water under standardized conditions of time and pressure, shall not cause errors that exceed that specified in 4.3.4.
7	Powerful jetting or temporary immersion	Protected against powerful water jets or the effects of temporary immersion in water: Water projected in powerful jets against the enclosure from any direction or temporary immersion under standardized conditions of time and pressure shall not cause errors that exceed that specified in 4.3.4.
8	Powerful jetting or continuous immersion	Protected against powerful water jets or the effects of prolonged immersion in water: Water projected in powerful jets against the enclosure from any direction or prolonged immersion under standardized conditions of time and pressure shall not cause errors that exceed that specified in 4.3.4.
S	Specified by the manufacturer	Protected against conditions that exceed those of 8 above as specified by the manufacturer: The conditions as specified by the manufacturer shall not cause errors that exceed that specified in 4.3.4.

Table III: CP Code Third Character – Enclosure Material

Third Character	Description	
	Summary	Detail
A	Aluminum, untreated	Aluminum, untreated
B	Aluminum, treated	Aluminum, treated; e.g. anodized.
C	Tool steel, coated	Tool steel, coated; e.g. lacquer, paint, epoxy.
D	Tool steel, plated	Tool steel, plated; e.g. nickel, chrome.
E	Stainless steel, ≤ AISI 304	Stainless steel; Corrosion resistance equal to or less than AISI 304 (DIN 1.4301)
F	Stainless steel, between AISI 304 and 316	Stainless steel; Corrosion resistance between AISI 304 and 316 (DIN 1.4301 and 1.4404)
G	Stainless steel, 17-4 PH	Stainless steel; 17-4 PH (AISI 630 / DIN 1.4542) or 15.5 PH (Din 1.4542).
H	Stainless steel, ≥ AISI 316	Stainless steel; Corrosion resistance equal to or greater than AISI 316 (DIN 1.4404)
S	Material identification specified by the manufacturer	Special material, superior in corrosion resistance to those listed above.

Table IV: Cable Outer Jacket Material

Fourth Character	Cable Outer Jacket Material
O	Polyolefin
V	Poly-vinyl-chloride (PVC)
U	Poly-urethane (PUR)
I	Silicone
E	PTFE
S	Special material, superior in chemical resistance to materials listed above.

Table V: Test Severity - Cyclic Damp Heat Test

Second Character	Test Severity	
	Upper Temp. (C)	# Cycles
1	-	-
2	40	2
3	40	4
4	40	6
5	40	9
6	40	12
7	40	15
8	40	21
S	40	>21

Table VI: Water Tests

Second Character	Test Means and Test Conditions	Brief Description of Test Means and Conditions
1	No tests required	-
2	IEC529, Second edition 1992, Table VIII, second characteristic numeral 1.	Drip box with water flow rate of 1mm/min, duration of test 10 min.
3	IEC529, Second edition 1992, Table VIII, second characteristic numeral 3.	Spray nozzle with water flow rate of 10 l/min, duration of test at least 5 min.
4	IEC529, Second edition 1992, Table VIII, second characteristic numeral 4.	As for numeral 3, spray +/- 180° from vertical
5	IEC529, Second edition 1992, Table VIII, second characteristic numeral 5.	Water jet hose nozzle 6,3 mm diameter, distance 2.5 to 3m, water flow rate 12.5 l/min, duration of test at least 3 min.
6	IEC529, Second edition 1992, Table VIII, second characteristic numeral 7.	Immersion tank, water-level 1m above mounting surface of the load cell, duration of test 30 min.
7	IEC529, Second edition 1992, Table VIII, second characteristic numerals 6 and 7.	Water jet hose nozzle 12.5 mm diameter, distance 2.5 to 3m, water flow rate 100 l/min, duration of test at least 3 min. Immersion tank, water-level 1m above mounting surface of the load cell, duration of test 30 min.
8	IEC529, Second edition 1992, Table VIII, second characteristic numerals 6 and 8.	Water jet hose nozzle 12.5 mm diameter, distance 2.5 to 3m, water flow rate 100 l/min, duration of test at least 3 min. Immersion tank, water-level 2m above mounting surface of the load cell, duration of test 96 hrs.
S	IEC529, Second edition 1992, Table VIII, second characteristic numerals 6 and 8. Water level and duration of the test specified by the manufacturer.	Water jet hose nozzle 12.5 mm diameter, distance 2.5 to 3m, water flow rate 100 l/min, duration of test at least 3 min. Immersion tank, water-level >2m above mounting surface of the load cell, duration of test >96 hrs.

5. Load Cell Specifications

5.1. Table VII indicates the load cell data and specifications that shall be provided by the load cell manufacturer. The notes on Table VII indicate the data and specifications to be provided on:

1. Each load cell and an accompanying document, if any.
2. Each load cell or an accompanying document.
2. Sales type literature.
3. Detailed specification sheets.

5.1.1. Manufacturers shall use the terminology and units of measure (English or SI as appropriate for the particular market) used in Table VII.

6. Cable Terminology and Color code

6.1. The following terminology shall be used when referring to the individual conductors of an analog load cell cable:

6.2. The following color code shall be used for new 4-wire load cell models:

Conductor	**Color**
+ Excitation	Green
- Excitation	Black
+ Signal	White
- Signal	Red
Shield	Bare or clear

6.3. The following color code shall be used for new 6-wire load cell models:

Conductor	**Color**
+ Excitation	Green
- Excitation	Black
+ Signal	White
- Signal	Red
+ Sense	Blue
- Sense	Brown preferred (see 6.3.1)
Shield	Bare or clear

6.3.1. Brown is the preferred color for -Sense, but any color not already assigned may be used.

Table VII: Load Cell Data and Specifications

GENERAL	**DATA/SPECIFICATION**	**English units**	**SI units**	*Notes*
Manufacturer's name:				*(1) (3) (4)*
Model No.:				*(1) (3) (4)*
Serial No.:				*(1)*
MECHANICAL DATA				
Rated Capacity (R.C.) (7):		lb	kg	*(1) (3) (4)*
Minimum dead load:		lb	kg	*(2) (3) (4)*
Safe load limit:		%R.C.	%R.C.	*(2) (3) (4)*
Ultimate load limit:		%R.C.	%R.C.	*(2) (3) (4)*
				(2) (3) (4)
Maximum Platform Size (9):	x	in. x in.	mm x mm	*(4)*
Off center load error (Load = XX% R.C.) (9):	±	%Load/in.	%Load/mm	*(4)*
Safe side load:		%R.C.	%R.C.	*(4)*
Deflection @R.C.:		In.	mm	*(3) (4)*
Spring element material:				*(3) (4)*
Spring element finish:				*(4)*
Mounting screw: Size/thread type:				*(4)*
Grade:				*(4)*
Torque:	±	in. lb	Nm	*(4)*
Engaged thread length:	±	In.	mm	*(4)*
Net Weight of load cell:		lb	kg	*(3) (4)*
CERTIFICATE DATA				
Certificate No.:				*(3) (4)*
Issuing body:				*(3) (4)*
Accuracy class:				*(2) (3) (4)*
Maximum No. of load cell intervals (Nmax):				*(2) (3) (4)*
Single/Multiple (6):				*(2) (3) (4) (6)*
Humidity symbol (5):				*(2) (5)*
Minimum load cell verification interval (Vmin):		lb	kg	*(2) (3) (4)*

Table VII: Load Cell Data and Specifications - Continued

METROLOGICAL DATA –non legal for trade				
Non-linearity:	±	%R.C.	%R.C.	*(2) (3) (4)*
Hysteresis:	±	%R.C.	%R.C.	*(2) (3) (4)*
Non-repeatability:	±	%R.C.	%R.C.	*(2) (3) (4)*
Combined error:	±	%R.C.	%R.C.	*(2) (3) (4)*
30 minute Creep (at 90 to 100% R.C.):	±	%load.	%load.	*(2) (3) (4)*
Temperature effect on: Zero load output:	±	%R.C./°F	%R.C./°C	*(2) (3) (4)*
Output:	±	%Load/°F	%Load/°C	*(2) (3) (4)*
ELECTRICAL DATA				
Rated Output:	± %	mV/V	mV/V	*(2) (3) (4)*
Excitation voltage: Recommended:		V AC/DC	V AC/DC	*(3) (4)*
Maximum:		V AC/DC	V AC/DC	*(3) (4)*
Cable length:		ft	m	*(3) (4)*
Color code: +/- Excitation:	/			*(2) (3) (4)*
+/- Signal:	/			*(2) (3) (4)*
+/- Sense:	/			*(2) (3) (4)*
Shield:				*(2) (3) (4)*
Terminal resistance :Excitation:	± %	ohms	ohms	*(2) (3) (4)*
Signal:	± %	ohms	ohms	*(2) (3) (4)*
Zero load output:	±	%R.C.	%R.C.	*(3) (4)*
Insulation resistance (at volts):	>	Mohms	Mohms	*(4)*
ENVIRONMENTAL DATA				
Temperature compensation range (8):		°F	°C	*(3) (4)*
Operating temperature range:		°F	°C	*(4)*
Safe storage temperature range:		°F	°C	*(4)*
Construction and Protection (CP) Code:				*(3) (4)*
Warm-up time:		min	min	*(4)*
Barometric pressure effect on zero load output:	±	lb/in. Hg	kg/kPa	*(3) (4)*

Notes:
(1) = Data to be applied to each load cell and to an accompanying document, if any.
(2) = Data to be supplied on the cell or in an accompanying document.
(3) = Data to be provided in sales type brochures.
(4) = Data to be provided on detailed specification sheets.
(5) = OIML R60 only.
(6) = Handbook 44 only.
(7) = Also referred to as maximum capacity (E max).
(8) = Also referred to as termperature limits.
(9) = Single point load cells only.

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