ORGANISATION INTERNATIONALE

DE MÉTROLOGIE LÉGALE

INTERNATIONAL RECOMMENDATION

Metrological regulation for load cells

Réglementation métrologique des cellules de pesée

OIML R 60

Edition 1991 (E)

FOREWORD

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TERMINOLOGY

The terms most frequently used in the load cell field and their definitions are given below. (See Figure 1 for the illustration of certain definitions).

T.1. Load cell

A force transducer which, after taking into account the effects of the acceleration of gravity and air buoyancy at the location of its use, measures mass by converting the measured quantity (mass) into another measured quantity (output).

T.2. Load cell output

The measurable quantity into which a load cell converts the measured quantity (mass).

T.3. Accuracy class

A class of load cells which are subject to the same conditions of accuracy.

T.4. Load cell interval

Part of the load cell measuring range into which that range is divided.

T.5. 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.

T.6. Minimum load cell verification interval (v_{min})

The smallest load cell verification interval into which the load cell measuring range can be divided.

T.7. Minimum dead load (E_{min})

The smallest value of a quantity (mass) which may be applied to a load cell without exceeding the maximum permissible error.

T.8. Maximum capacity (E_{max})

The largest value of a quantity (mass) which may be applied to a load cell without exceeding the maximum permissible error.

T.9. Compression loading

A compressive force applied to a load cell.

T.10. Tension loading

A tension force applied to a load cell.

T.11. Non-linearity

The deviation of the increasing load cell calibration curve from a straight line.

T.12. Hysteresis error

The difference between load cell output readings for the same applied load, one reading obtained by increasing the load from minimum load and the other by decreasing the load from maximum load.

T.13. Creep

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

T.14. Minimum dead load output return

The difference in load cell output at minimum dead load, measured before and after load application.

T.15. Repeatability error

The difference between load cell output readings taken from consecutive tests under identical loading and environmental conditions.

T.16. Temperature effect on minimum dead load output

The change in minimum dead load output due to a change in ambient temperature.

T.17. Temperature effect on sensitivity

The change in sensitivity due to a change in ambient temperature.

T.18. Load cell measuring range

The range of values of the measured quantity (mass) for which the result of measurement should not be affected by an error exceeding the maximum permissible error.

T.19. Safe load limit

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

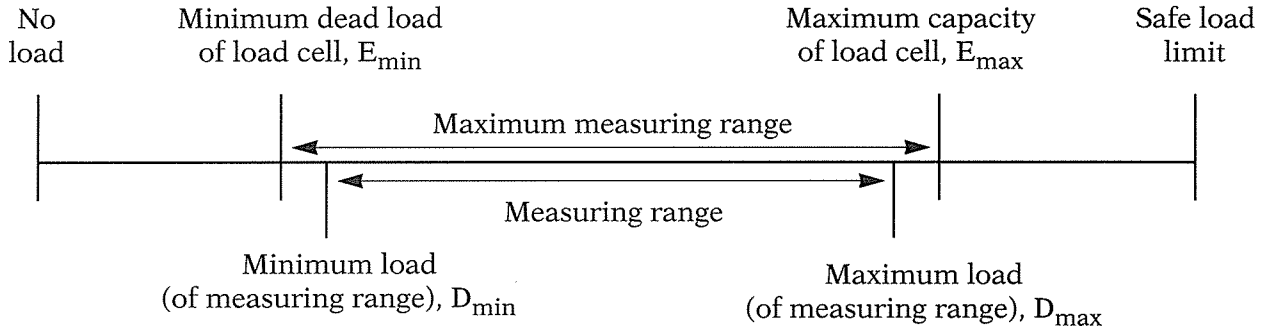

Figure 1

Illustration of certain definitions

Note: The terms that appear above the center horizontal line 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).

METROLOGICAL REGULATION
for LOAD CELLS

Chapter I

GENERAL

1. Scope

1.1. This Recommendation prescribes the principal metrological characteristics and evaluation procedures for load cells used in the static measurement of mass. It is intended to provide authorities with uniform means for determining the metrological characteristics of load cells used in measuring instruments which are subjected to metrological controls.

1.2. Instruments which are associated with load cells and which give an indication of mass, are the subject of separate Recommendations.

2. Principles of the Recommendation

The approach taken by this Recommendation recognizes that several load cell errors must be considered together when fitting load cell performance characteristics to the error envelope permitted. It must be recognized that it is possible to have low non-linearity and hysteresis errors and moderate temperature errrors or, conversely, to have moderate non-linearity and hysteresis errors and low temperature errors. Thus, it is not considered appropriate to specify individual error limits for given characteristics (non-linearity, hysteresis, etc.), but rather to consider the total error envelope allowed for a load cell as the limiting factor. The use of an error envelope concept allows balancing individual contributions to the total error of measurement while still achieving the intended end result.

3. Units of measurement

The unit of measurement of mass is the kilogram (kg).

Chapter II

CLASSIFICATION OF LOAD CELLS

4. Principle of load cell classification

4.1. General

The classification of load cells into specific accuracy classes is provided to facilitate their application to various mass 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, use a load cell which has been separately approved.

4.2. Accuracy classes

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

Classe A

Classe B

Classe C

Classe D

4.3. Maximum number of load cell intervals

The maximum number of load cell intervals (n_{max}) into which the load cell measuring range can be divided in a measuring system shall be within the limits fixed in Table 1.

Table 1

	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

4.4. Minimum load cell verification interval

The minimum load cell verification interval (v_{min}) shall be specified.

4.5. Supplementary classifications

Load cells shall also be classified by the type of service in which they fall under a particular accuracy classification, i.e., compression loading or tension loading. A load cell may bear different classifications for different loading services. The loading service(s) for which the classification(s) applies(y) shall be specified. For multiple capacity load cells each capacity shall be classified separately.

4.6. Complete classification

The load cell classification shall include five parts: (1) alphabetical classification, (2) maximum number of load cell intervals, (3) direction of loading, if necessary, (4) special limits of working temperature, if necessary and (5) non-humidity classification, if necessary.

4.6.1. The accuracy class shall be indicated as follows:

Class A cells shall be marked A
Class B cells shall be marked B
Class C cells shall be marked C
Class D cells shall be marked D

4.6.2. The maximum number of load cell intervals for which the accuracy class applies shall be included and stated in units of 1 000.

4.6.3. The direction of loading shall be designated when it is not clearly apparent from the load cell construction. In such cases appropriate loading direction indications shall be provided as follows:

Tension: ↑ ↓

Compression: ↓ ↑

Beam (shear or bending): ↑ or ↓

Universal: ↑ ↓ ↓ ↑

4.6.4. The special limits of working temperature as mentioned in Chapter IV, point 10.1.2, shall be designated when the load cell cannot perform within the limits of error in Chapter III over the temperature ranges, specified in Chapter IV, point 10.1.1. In such cases the limits of temperature shall be indicated in degrees Celsius (°C).

4.6.5. When a load cell is not to be subjected to the humidity test as specified in point 15.5, it shall be marked with the symbol NH.

4.6.6. Additional information

In addition to the information required in points 4.6.1 to 4.6.5 the following information shall be provided for each load cell:

- name and address of the manufacturer or his trademark,
- if appropriate, manufacturer's own designation,
- serial number and year of manufacture,
- minimum dead load, maximum capacity, safe load limit,
- minimum load cell verification interval (v_{min}),
- other pertinent conditions that must be observed to obtain the specified performance (for example, electrical characteristics of the cell).

4.6.7. Standard classifications shall be used. Examples are as follows:

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

4.6.8. Multiple classifications

In addition to the information required in points 4.6.1 to 4.6.6, load cells which have complete classifications for different services shall provide separate information for each classification. Examples are as follows:

Classification symbol	Description
C2 ↑	Class C, 2 000 intervals, beam
C1.5 ↓	Class C, 1 500 intervals, 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

4.7. Presentation of information

The information required according to point 4.6 may be marked on the load cell or alternatively, in an accompanying document. Where a document is provided, the serial number of the load cell shall be marked on the load cell and also given in the document.

Chapter III

MAXIMUM PERMISSIBLE ERRORS

5. Maximum permissible load cell errors

The maximum permissible load cell errors for each accuracy class, the indicated load cell output having been adjusted to zero at minimum dead load, are related to the maximum number of load cell intervals specified for the load cell (see point 4.3.) and to the actual value of the load cell verification interval (v).

5.1. The maximum permissible errors on pattern evaluation and initial verification shall be as shown in Table 2.

Table 2

Maximum permissible errors	Load m			
	Class A	Class B	Class C	Class D
0.35 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
0.7 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
1.05 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 maximum permissible load cell errors may be positive or negative and are applicable to both increasing and decreasing loads.

The above limits of error include errors due to non-linearity, hysteresis, and temperature effect on sensitivity over certain temperature ranges, specified in Chapter IV. Further errors, not included in the above limits of error, are treated separately.

5.2. The maximum permissible errors for in-service verification, if necessary, shall be equal to twice the values in Table 2.

6. Rules concerning the determination of errors

6.1. The above limits of error shall apply to all load cell measuring ranges complying with the following conditions:

$$n \leq n_{max}$$
$$v \geq v_{min}$$

6.2. The above limits of error shall refer to that error envelope defined in point 5 which is referenced to that straight line which passes through minimum load output and the load cell output for a load of 75 % of the measuring range taken on ascending load at 20 °C.

6.3. During the conduct of the tests, the initial reading shall be taken at a time interval after the initiation of a load application or removal, whichever is applicable, according to Table 3.

The loading or unloading times shall be approximately one-half the time specified. The remaining time shall be utilized for stabilization. The tests shall be conducted under constant conditions.

Table 3

Change in load		Time
Greater than	To and including	
0 kg	10 kg	10 seconds
10 kg	100 kg	15 seconds
100 kg	1 000 kg	20 seconds
1 000 kg	10 000 kg	30 seconds
10 000 kg	100 000 kg	50 seconds
100 000 kg	–	60 seconds

Note: When the specified loading times cannot be achieved, the actual loading times shall be recorded in the test report.

7. Permissible variation of results

7.1. Creep

With a constant load of 90-100 % of maximum capacity of the load cell applied to the load cell, the difference between the initial reading and any reading obtained during the next 30 minutes shall not exceed 0.7 times the absolute value of the maximum permissible error for the applied load. The difference between the reading obtained at 20 minutes and the reading obtained at 30 minutes shall not exceed 0.15 times the absolute value of the maximum permissible error.

7.2. Minimum load output return

The difference between the initial reading of the minimum load output after returning to minimum load and the reading for the same load prior to the application of a load of 90-100 % of maximum capacity of the load cell, which has been applied for 30 minutes, shall not exceed one-half the value of the load cell verification interval (0.5v).

7.3. Humidity (not applicable to load cells marked NH)

7.3.1. The difference between the initial reading of the minimum load output and the reading for the same load obtained after the conduct of the humidity test according to point 15.5, 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.

7.3.2. The difference between the average of the three output values at the maximum load for load cells of accuracy classes C and D, and five output values for load cells of accuracy classes A and B, (corrected for the minimum load output) obtained before the conduct of the humidity test according to point 15.5 and the average ot the three output values for load cells of accuracy classes C and D, and five output values of load cells of accuracy classes A and B obtained for the same maximum load (corrected for the minimum load output) after the conduct of the humidity test, shall not be greater than the value of the load cell verification interval (1 v).

8. Measurement standards

The combined measurement uncertainty of the load generating system and the indicating instrument used to observe the output of the load cell under test shall be less than 1/3 times the maximum permissible errors for the load cell under test.

Chapter IV

METROLOGICAL QUALITIES

9. Repeatability error

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

10. Influence quantities

10.1. Temperature

10.1.1. Temperature limits

Excluding temperature effects on minimum dead load output, the load cell shall perform within the limits of error in Chapter III over the following temperature ranges (unless otherwise specified):

Classes A and B: + 10 °C to + 30 °C
Classes C and D: – 10 °C to + 40 °C

10.1.2. Special limit

Load cells for which particular limits of working temperature are specified shall satisfy, within those ranges, the conditions defined in Chapter III.

These ranges shall be at least equal to:

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

10.1.3. Temperature effects on minimum load output

The minimum load output of the load cell over the temperature range specified in points 10.1.1 or 10.1.2 shall not vary by an amount greater than 0.7 of the minimum load cell verification interval (v_{min}) for any change in ambient temperature of:

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

The minimum load output shall be taken after the load cell has thermally stabilized at the ambient temperature.

10.2. Barometric pressure

The output of the load cell shall not vary by an amount greater than the minimum load cell verification interval (v_{min}) for a change in barometric pressure of 1 kPa over the range from 95 kPa to 105 kPa.

10.3. Humidity

When a load cell is marked with the symbol NH, it shall not be subjected to the humidity test as specified in 15.5.

Chapter V

METROLOGICAL CONTROLS

11. Liability to legal metrological controls

11.1. This Recommendation prescribes performance requirements for load cells used in the measurement of mass. States may through legislation impose metrological controls which verify adherence to the Recommendation. Such controls, when imposed, may include: pattern evaluation, initial verification, and subsequent or periodic verification.

11.2. Test procedures for the pattern evaluation of load cells are provided in Chapter VI. Initial and subsequent verification of load cells independent of the measuring system in which they are used is not normally considered appropriate if the complete system performance is verified by other means.

Chapter VI

TEST PROCEDURES FOR PATTERN EVALUATION

12. Scope

This chapter provides recommended test procedures for pattern evaluation testing of load cells used in the measurement of mass.

12.1. Wherever possible test procedures have been established to apply as broadly as possible to all load cells within the scope of the Recommendation.

12.2. The procedures apply to the testing of load cells only. No attempt has been made to cover testing of complete systems which include load cells.

13. Purpose

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

14. Test conditions

14.1. The basic equipment for pattern evaluation tests consists of a force-generating system and a suitable linear instrument which measures the output of the load cell (see point 8).

14.2. Before adequate testing and evaluation of load cells can be performed, careful attention shall be given to the environmental and test conditions under which such evaluations are to be made. Significant discrepancies are frequently a result of insufficient recognition of such details. The following shall be thoroughly considered prior to any pattern evaluation testing program.

14.2.1. Acceleration of gravity – The acceleration of gravity varies by as much as 0.55 % over the surface of the earth. If deemed necessary, when standard masses are used in testing, gravity corrections should be made and the value of g at the test site recorded with the test results.

14.2.2. Environmental conditions – Tests shall be performed under stable environmental conditions. With regard to stable ambient temperature, the 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 considered load cell, without being greater than 2 °C.

14.2.3. Loading conditions – Particular attention shall be given to loading conditions to prevent the introduction of error 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. The minimum load shall be as near to the minimum dead load of the load cell as permitted by the force-generating system.

14.2.4. Reference standards – Periodic (depending on use) verification of standards should be made.

14.2.5. Stabilization – A stabilization period for the load cell under test and the readout instrumentation shall be provided, as recommended by the manufacturers of the equipment used.

14.2.6. Temperature conditions – 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.

14.2.7. Barometric pressure effects – Where changes in barometric pressure may significantly affect the load cell output, such changes shall be considered.

14.2.8. Stability – An indicating instrument and a loading means shall be used which will provide sufficient stability to permit readings within the limits specified in point 8.

14.2.9. Instrument checking – Some indicating instruments are provided with a convenient means for checking of the instruments 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 verification of the instrument calibration shall also be performed.

14.2.10. Other conditions – Other conditions specified by the manufacturer such as input/output voltage, electrical sensitivity, etc., shall be taken into consideration during the test.

15. Test procedures

Each of the tests below are presented as "stand alone" individual tests. However, for the efficient 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 Figures 2 and 3 in the Appendix). The barometric pressure and the humidity tests are conducted individually following completion of the above tests.

15.1. Determination of load cell errror, repeatability error and temperature effect on minimum dead load output

15.1.1. Refer to the test conditions, in point 14, to ensure that proper consideration has been given to those conditions prior to performing the following tests. Insert the load cell into the force-generating system, load to minimum load, and stabilize at 20 °C.

15.1.2 Exercise the load cell by applying a load of maximum load three times, returning to minimum load after each load application.

15.1.3. Check the instrument according to point 14.2.9.

15.1.4. Monitor minimum load output until stable. Record instrument indication at minimum load.

15.1.5. All test load points in a loading and unloading sequence shall be spaced at approximately equal time intervals. The reading shall be taken at a time which is as near as possible in agreement with Table 3 in point 6.3. These two time intervals shall be recorded.

15.1.6. Apply increasing loads to maximum load. Increasing load points shall be at least five in number and shall include loads approximating the highest values in the applicable steps of maximum permissible load cell errors as listed in Table 2, Chapter III, point 5.

15.1.7. Record instrument indications as far as possible in agreement with Table 3 in point 6.3.

15.1.8. Remove test loads to minimum load in the same manner.

15.1.9. Record instrument indications as far as possible in agreeement with Table 3 in point 6.3.

15.1.10. Repeat the operations described in points 15.1.5 to 15.1.9 four more times for accuracy classes A and B or two more times for accuracy classes C and D.

15.1.11. Repeat the operations described in points 15.1.2 to 15.1.10 for both lower temperatures and higher temperatures including the approximate temperature range limits for the accuracy class intended.

15.1.12. Repeat the operations described in points 15.1.2 to 15.1.10 at 20 °C.

15.1.13 The magnitude of load cell error shall be determined on the basis of the average of the results of the tests conducted at each temperature level and compared with the maximum permissible load cell errors in Chapter III, point 5.

15.1.14. From the resulting data, the repeatability error may be determined and compared with the limits specified in Chapter IV, point 9.

15.1.15. From the resulting data, the temperature effects on minimum dead load output may be determined and compared with the limits specified in Chapter IV, point 10.1.3.

15.2. Determination of creep

15.2.1. Refer to the test conditions, in point 14, to ensure that proper consideration has been given to those conditions prior to performing the following test. Insert the load cell into the force-generating system, load to minimum load, and stabilize at 20 °C.

15.2.2. Exercise the load cell by applying maximum load three times, returning to minimum load after each load application. Wait one hour.

15.2.3. Check the instrument according to point 14.2.9.

15.2.4. Monitor minimum load output until stable.

15.2.5. Apply the load and record the initial indication in accordance with Table 3 in point 6.3 and continue to record periodically thereafter, at recorded time intervals over a 30 minute period, ensuring that a reading is taken at 20 minutes.

15.2.6. Repeat the operations described in points 15.2.2 to 15.2.5 for both lower temperatures and higher temperatures including the approximate temperature range limits for the accuracy class intended.

15.2.7. With the resulting data, and taking into account the effect of barometric pressure changes according to point 14.2.7, the magnitude of the creep can be determined and compared with the permissible variation specified in Chapter III, point 7.1.

15.3. Determination of minimum dead load output return

15.3.1. Refer to the test conditions, in point 14, to ensure that proper consideration has been given to those conditions prior to performing the following test. Insert the load cell into the force-generating system, load to minimum load, and stabilize at 20 °C.

15.3.2. Exercise the load cell by applying maximum load three times, returning to minimum load after each load application. Wait one hour.

15.3.3. Check the instrument according to point 14.2.9.

15.3.4. Monitor minimum load output until stable. Record instrument indication at minimum load.

15.3.5. Apply the load in accordance with Table 3 in point 6.3 and maintain the load for a 30 minute period.

15.3.6. Return to minimum load and record instrument indication in accordance with Table 3 in point 6.3.

15.3.7. Repeat the operations described in points 15.3.2 to 15.3.6 for both lower temperatures and higher temperatures including the approximate temperature range limits for the accuracy class intended.

15.3.8. With the resulting data, the magnitude of minimum dead load output return can be determined and compared with the permissible variation specified in Chapter III, point 7.2.

15.4. Determination of effects of barometric pressure

15.4.1. Refer to the test conditions, in point 14, to ensure that proper consideration has been given to those conditions prior to performing the following test.

15.4.2. At room temperature, insert the unloaded load cell into the pressure chamber at atmospheric pressure.

15.4.3. Check the instrument according to point 14.2.9.

15.4.4. Monitor output until stable. Record instrument indication.

15.4.5. Change barometric pressure to a value of approximately 1 kPa lower or higher than atmospheric pressure and record instrument indication.

15.4.6. With the resulting data, the magnitude of the barometric pressure influence can be determined and compared with the limits specified in Chapter IV, point 10.2.

15.5. Determination of the effects of humidity

15.5.1. Refer to the test conditions in point 14, to ensure that proper consideration has been given to those conditions prior to performing the following test. Insert the load cell into the force-generating system, load to minimum load, and stabilize at 20 °C.

15.5.2. Exercise the cell by applying maximum load three times, returning to the minimum load after each application.

15.5.3. Check the instrument according to point 14.2.9.

15.5.4. Monitor minimum load output until stable. Record the instrument indication at minimum load.

15.5.5. Apply a test load of 90-100 % of the maximum capacity of the load cell and record the initial indicated value in accordance with Table 3, in point 6.3. Return to minimum load and record the instrument indication.

15.5.6. Repeat point 15.5.5 four more times on load cells of accuracy classes A and B, and two more times on load cells of accuracy classes C and D.

15.5.7. Conduct a cyclic damp heat test in accordance with IEC Publication 68-2-30, Second Edition, 1980, Basic Environmental Testing Procedures, Part 2: Tests Db, Damp heat cyclic (12 + 12 hour cycles). Background information concerning damp heat cyclic tests is given in IEC Publication 68-2-28, Second Edition, 1980, Basic Environmental Testing Procedures, Part 2, Guidance for damp heat tests.

Test procedure in brief: the test consists of exposure to 12 temperature cycles of 24 hour duration each. The relative humidity is between 80 and 96 % RH, and the temperature is varied from 25 °C to 40 °C in accordance with the specified cycle.

Test severity: 40 °C, 12 cycles.

Initial measurements: per 15.5.1 through 15.5.6 above.

State of specimen during conditioning: load cell placed in the chamber with the output connection external to the chamber, and switched off. Use variant 2 of IEC 68-2-30, Part 2: Test Db, when lowering the temperature.

Recovery conditions and final measurements: per point 15.5.8 below.

15.5.8. 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). Repeat points 15.5.1 through 15.5.6 ensuring that the minimum load and the test loads applied are the same as previously used.

15.5.9. With the resulting data, the magnitude of humidity induced variations can be determined and compared with the limits specified in Chapter III, point 7.3.

APPENDIX

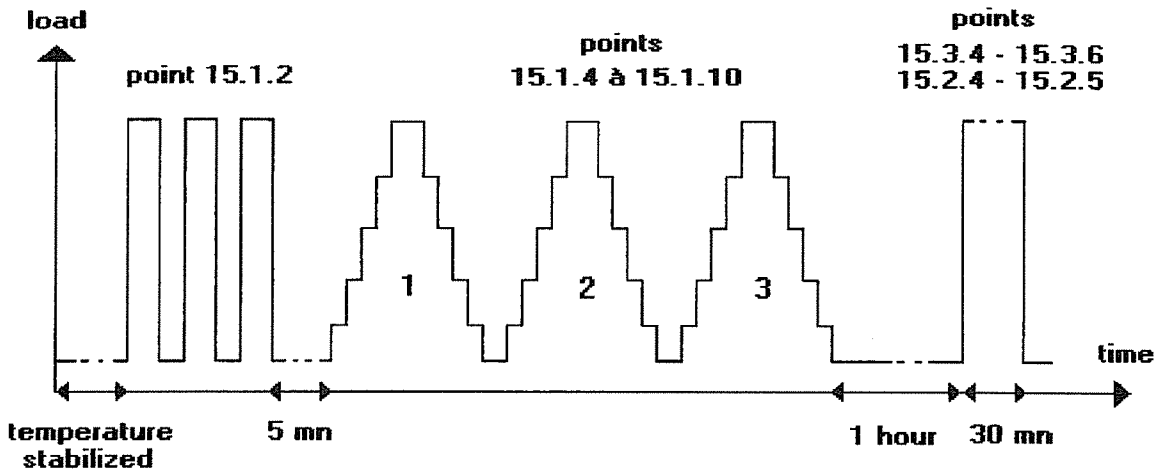

Figure 2

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

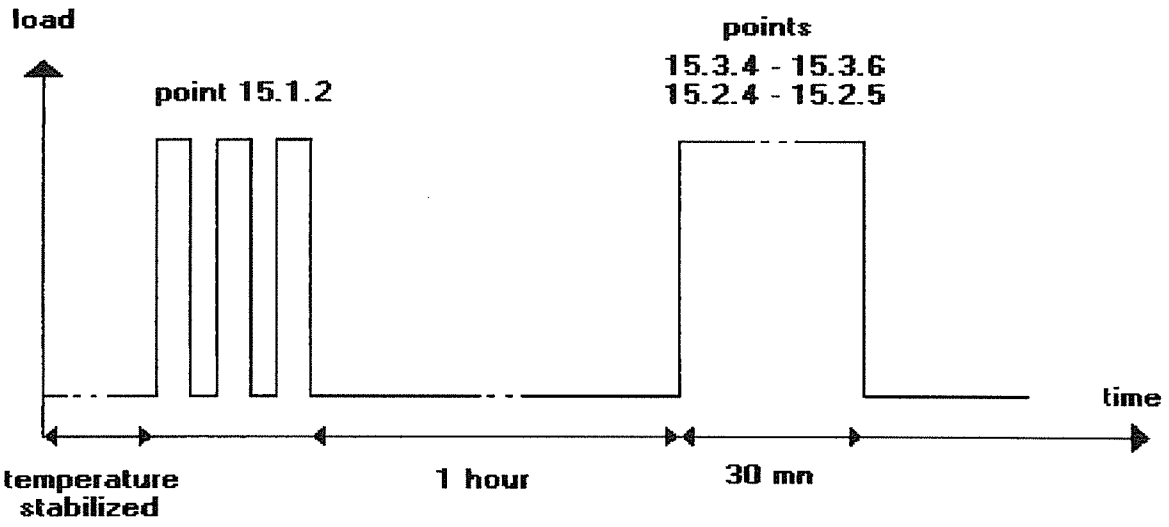

Figure 3

Recommended test sequence for each test temperature
for the minimum dead load output return and creep tests
when carried out in a machine different than that used for the load tests

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