TC9/SC2 WG Durability – 18 Mar 2009

Durability requirement for Belt Weighers

Members of Working Group:

1. United States
2. Australia (Chair)
3. Sweden

Durability : Ability of an instrument to maintain its performance characteristics over a period of use (OIML R76, T.4.4)

1. Background

At the OIML TC9/SC2 meeting held in London on 4 and 5 February 2009, proposals for introduction of a Durability test were discussed.

A substantial majority of OIML member states represented at the meeting indicated that in-principle it would be desirable to include some form of durability test, however a number of member states indicated that they felt such a test should not be included (including for reasons such as concern that it would not be possible to develop a repeatable and practical test).

Consequently the meeting established a Working Group to prepare information to be circulated to all P-members of TC9/SC2, and to form the basis for a vote of P-members to determine whether or not TC9/SC2 should continue with work to develop more detailed proposals regarding durability testing of Belt Weighers.

2. The current situation

2.1 Belt Weighers

The current (1997) edition of OIML R50-1 contains a durability requirement (see Appendix 1), but no specific durability test or evaluation. It appears to rely on an assumption that if the instrument passes tests such as influence factor and disturbance tests, and an in-situ test, it will be sufficiently durable.

In the United States a requirement for 'permanence' is included in Handbook 44 and a corresponding 'permanence test' is included in the requirements of, NCWM Publication 14. (see Appendix 2).

2.2 Non-automatic Weighing Instruments

OIML R76-1:2006 contains both a durability requirement and a related span-stability requirement (see Appendix 3). Adherence to the Durability requirement is assumed if the instrument passes an endurance test (which is a simulation of a period of use - 100,000 load applications compressed into a short period of time). The span-stability requirement is tested by observing changes in span throughout the sequence of type approval tests, and is (according to apportioning of error clauses 3.10.2.1 and 3.10.2.2) assumed to apply primarily to analog elements of an electronic indicator of an instrument.

2.3 Other OIML documents

The treatment of durability in other OIML recommendations ranges from no-mention, through approaches similar to 2.1 & 2.2 above to, for example, the case of OIML

R137:2006 “Gas meters, Part 1 – requirements” which specifies a durability test “The durability test is the equivalent of 2000 hours at Qmax to be conducted within 120 days”.

In addition to the OIML recommendations, the need for consideration of in-situ performance over time is clear from OIML D16:1986 “Principles of Assurance of Metrological Control”, which indicates (clause 2.2) the need to identify elements that contribute to the degradation of measurement accuracy, which may occur at any step in the measurement process.

OIML D16 also includes examples of accuracy degradation factors which may occur during instrument design and manufacture, or installation. Some of these examples (quoted below) are particularly relevant to the issue of durability discussed in this paper:

— designs which do not anticipate environmental conditions,
— designs which do not anticipate likely equipment combinations or configurations,
— factory tests which do not replicate all conditions of use, including environmental conditions,
— untested combination of measuring instruments assembled into a complex configuration,
— all possible modes of operation of a complex ensemble of instruments have not been considered,

3. The problem

Concern was expressed at the meeting, including by belt weigher manufacturers, that some belt weighers approved according to current R50 requirements do not maintain performance within maximum permissible errors for acceptable periods of time. It was suggested that in some cases performance outside maximum permissible errors would occur within weeks or a couple of months of initial verification and commencement of in-service operation.

The manufacturers expressed concern that as a result of such situations belt weighers have a poor reputation in the bulk measurement industry, that the reputation extends unfairly to belt weighers which do maintain acceptable performance, and that this reflects badly on approvals based on OIML R50. Currently R50 does not appear to provide any pressure or incentive for manufacturers to meet other than short term type approval & initial verificatiion requirements (where users, and enforcement authorities - can be left to deal with the disadvantages of failure to maintain performance in the longer term).

The difficulty with belt weighers is that time is one of the factors contributing to the measurement, and in addition the forces (including vibrations, non vertical forces etc) on the instrument are more complex than those on a NAWI, which is why developing an 'endurance test' (simultation of a period of use) is difficult, and why therefore a true 'durability test' (actual period of use) may be desirable.

The lack of durability of some belt weighers was felt to be related more to mechanical durability aspects rather than electronic durability, possibly involving non-vertical forces, belt tension, belt/idler interactions, vibrations (including changes over time), or other influences not well identified. Simulation tests or tests similar to the R76-1 span stability test would not be expected to identify this lack of durability - hence there was a belief amongst some at the meeting that durability testing of a complete belt weigher system is essential.

4. Possible solutions

4.1 Durability test at type approval

4.1.1 By conducting a laboratory test

If it were possible to develop a practical test which could adequately ascertain durability in the laboratory, in a reasonable time period, and without undue investment in testing resources, this would be desirable.

However the size of belt weighers systems, including the weighing elements, belting and drive mechanisms, together with the method of operation and dynamic load forces (not necessarily vertical) would seem to preclude this.

Pros: Testing would be consistent with existing type approval procedures.

Cons: It is difficult to develop a test which would reproduce or simulate the conditions of a real world installation, without requiring an excessive investment in testing resources.

Capacities of equipment are generally over the 100 kg limit of the endurance test equipment used for NAWI testing.

Forces in-situ include horizontal components whereas the NAWI endurance test involves only vertical force components.

In-situ operation involves additional influences such as vibrations, belt tension, and dust.

4.1.2 By conducting an in-situ durability test at type approval

It has been proposed that an in-situ durability test be required as part of the type approval process. This would involve testing of a sample instrument installed in-situ, and re-testing of this same sample instrument (without adjustment of it – other than zero setting operations which are carried out automatically, or by the user) following operation of the instrument for either a period of time, or a particular delivery quantity.

Changes between performance in these two tests would be required to be within specified limits.

Further details of proposed test arrangements are given in Appendix 4. If TC9/SC2 members voted in favour of including a requirement of this type, the proposed test arrangements would be subject to further comment and development by TC9/SC2.

Pros: Test would involve a durability evaluation of an example of the type, under real world or close to real world conditions (including installation and operation aspects).

Type approval authorities would not need to invest in additional test equipment.

The test would provide a degree of confidence in durability before type approval was granted (helping to avoiding inadequate equipment being placed in the field).

Cons: The time required for type evaluation and approval would be likely to be extended.

The applicant for type approval would need to provide facilities for conduct of the durability test (or negotiate with users to provide facilities, including product). Hence the conditions for testing may not be under the strict control of the testing authority. Conditions related to weather, work schedules, and logistical arrangements would not always lend themselves to an efficient and timely schedule for durability testing. It is noted however that this already applies to some extent for all in-situ testing.

Some jurisdictions may have difficulties with the legal status of an instrument installed for the conduct of a durability test (if it were to be used for trade during or prior to the durability test). See 4.1.3 below.

4.1.3 By conducting an in-situ durability test following national (or regional) type approval, but prior to issuing of an OIML Certificate.

Some jurisdictions have indicated concern regarding the delay which might occur in conducting a durability test, and also regarding the legal status of an instrument undergoing durability testing (if for example the instrument was to be used for trade). However other jurisdictions have concern at the potential (using mutual recognition arrangements) for non-durable equipment to spread internationally.

Hence a possible compromise regarding this would be for jurisdictions to issue a national or regional type approval (some jurisdictions may be able to use a form of provisional approval, as described in clause 6.1.2 of OIML D19:1998) prior to carrying out an in-situ durability test. However it would be made clear that an OIML Certificate should not be issued until a durability test had been carried out – including possibly by another qualified testing authority.

Pros: Could satisfy concerns of some regarding the legal status of an instrument used for durability testing prior to type approval (if the product delivered was for use for legal purposes).

Reduction in the possibility of worldwide proliferation of equipment which is not sufficiently durable.

Cons: The time required for type evaluation and approval would be likely to be extended.

The conditions for testing may not be under the strict control of the testing authority. Conditions related to weather, work schedules, and logistical arrangements would not always lend themselves to an efficient and timely schedule for permanence testing. It is noted however that this already applies to some extent for all in-situ testing.

4.2 Durability test at initial verification

If legally possible in particular jurisdictions, this could involve a 'two-part' initial verification, where the first part of the initial verification involved 'normal' performance testing, and the second part involved a further performance test following a period of time, period of operation, and/or quantity delivered.

Pros: The test would involve a direct durability evaluation of the particular installation.

Cons: Use of the instrument for legal purposes between the first and second parts of the initial verification may not be legally possible, or may have legal ambiguities.

4.3 Consideration of durability at subsequent verification / in-service inspection

An approach to subsequent verification could be suggested or recommended in R50, whereby periods between subsequent verifications are altered based on the performance of an instrument in the field. On its own this would be only a partial solution to the problem, as it would not assist in preventing non-durable equipment from being put into service, however if combined with durability testing at type approval this could form a comprehensive solution to the durability problem.

Pros: An incentive to production of equipment having better durability is provided (e.g. in the form of extended periods between subsequent verification).

The diverse site conditions of individual installations would be taken into consideration in determining periods for subsequent verification.

Cons: Type approval would not provide any substantial confidence to an instrument purchaser that an instrument was able to operate durably.

Subsequent verification is generally a matter for national (or local) control. However this does not preclude OIML making suggestions or recommendations regarding such matters – these may be useful or instructive in some jurisdictions (see clause 8.4.1 of OIML R76-1:2006, which provides some basic guidance regarding subsequent verification).

4.4 Addressing durability issues through withdrawal of type approval

Should the durability problem not be able to be addressed prior to type approval, or other ways such as those indicated above, it may be necessary to address the issue by withdrawal of type approvals where durability deficiencies become evident. The VIML envisages such issues as being a reason for withdrawal of type approval (see clause 2.10 of OIML V1:2000), and this possibility is also mentioned in OIML D19:1988 (clause 6.0).

Pros: No additional tests may be necessary (at type approval).

Cons: Withdrawal would indicate a basic failure of the type approval system.

May have dire consequences to instrument users who have designed a plant around particular belt weighing equipment.

Unless the instrument type is actually installed for legal purposes, problems may not become evident and an approval for unsatisfactory equipment may persist. It has been suggested that some manufacturers may obtain an approval to assist marketing into areas where legal measuring instruments are not required. This may create a situation where equipment actually installed for legal use is at a disadvantage.

APPENDIX 1

OIML R50-1:1997 clauses regarding durability

T.5.3 Initial intrinsic error

The intrinsic error of a belt weigher as determined prior to performance tests and durability evaluations.

T.7.4 Durability test

A test to verify whether the EUT is capable of maintaining its performance characteristics over a period of use.

4.1.3 Durability

The requirements in 4.1.1 and 4.1.2 shall be met durably in accordance with the intended use of the instrument.

4.1.4 Evaluation for compliance

The pattern of an electronic instrument is presumed to comply with the requirements in 4.1.1, 4.1.2, and 4.1.3 if it passes the examination and tests specified in Annex A.

APPENDIX 2

US Permanence Requirement

In the United States, NIST Handbook 44 includes the following regarding 'permanence' (in section 1.10, General Code).

G-S.3. Permanence.
All equipment shall be of such materials, design, and construction as to make it probable that, under normal service conditions:

(a) accuracy will be maintained,
(b) operating parts will continue to function as intended, and
(c) adjustments will remain reasonably permanent.

Undue stresses, deflections, or distortions of parts shall not occur to the extent that accuracy or permanence is detrimentally affected.

Criteria for a permanence test are included in NCWM Publication 14, and for belt conveyor scales the test is:

14. Permanence Test
The scale shall be used over a six-month period and tested after that time. The zero adjustment change shall not exceed the (4%) zero window without ending the permanence test. The security means must not be broken. The tests described for the initial set of tests shall be repeated at the end of the six-month period. The results must be within tolerance.

Note that there is allowance for zero adjustment during the interim period after the initial and prior to the subsequent testing.

The National Conference on Weights and Measures (NCWM) in its 2004 annual report attempted to establish a level of minimum use between the intial and subsequent (permanence) test for vehicle type, and "all other scales":

65.a.4. Minimum Use Requirements prior to Subsequent Test for Permanence

- A minimum of 300 weighing operations are required during the test period. If the test site is at the applicant's or manufacturer's location, the applicant or manufacturer is to log the date, time, and weight.
- The person conducting the weighing is to initial each testing.
- Only loads that reflect "normal" use will be counted during the permanence-testing period.1
- For vehicle scales with a nominal capacity over 75 000 lb:
    - 50 % of the loads must be above 50 000 lb or 80 % of the CLC, whichever is greater; and
    - 100 % of the loads must be above 20 000 lb or 50 % of the CLC, whichever is greater.
- For all other scales:
    - 50 % of the loads must be above 50 % of the scale capacity; and
    - 100 % of the loads must be above 20 % of the scale capacity.
- Substitution or strain-test loads for the minimum use requirements are acceptable as long as all above conditions are met.
- The minimum number of days that a device is required to be in use is 20. A minimum number of weighing operations to be conducted each day for the test period is not specified; however, the weighments should represent the scale's normal in-service use.

APPENDIX 3

OIML R76-1:2006 main clauses regarding durability

T.4.4 Durability

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

T.5.5.7 Durability error

Difference between the intrinsic error over a period of use and the initial intrinsic error of an instrument.

T.5.5.8 Significant durability error

Durability error greater than e.

Note 1: A durability error can be due to mechanical wear and tear or due to drift and ageing of electronic parts. The concept of significant durability error applies only to electronic parts.

Note 2: For a multi-interval instrument, the value of e is that appropriate to the partial weighing range.

Errors, occurring after a period of instrument use, are not considered to be significant durability errors, even when they exceed e, if they are clearly the result of the failure of a device/component, or of a disturbance and for which the indication:

- cannot be interpreted, memorized, or transmitted as a measurement result;
- implies the impossibility to perform any measurement; or
- is so obviously wrong that it is bound to be noticed by all those interested in the result of measurement.

T.5.5.9 Span stability

Capability of an instrument to maintain the difference between the indication at maximum capacity and the indication at zero over a period of use within specified limits.

3.9.4.3 Durability

The durability error due to wear and tear shall not be greater than the absolute value of the maximum permissible error.

Adherence to this requirement is assumed if the instrument has passed the endurance test specified in A.6, which shall be performed only for instruments with Max ≤ 100 kg.

A.6 Endurance test (3.9.4.3)

Note: Applicable only to instruments of classes II, III and IIII with Max ≤ 100 kg.

The endurance test shall be performed after all other tests.

Under normal conditions of use, the instrument shall be subjected to the repetitive loading and unloading of a load approximately equal to 50 % of Max. The load shall be applied 100 000 times. The frequency and speed of application shall be such that the instrument attains an equilibrium when loaded and when unloaded. The force of the load applied shall not exceed the force attained in a normal loading operation.

A weighing test in accordance with the procedure in A.4.4.1 shall be performed before the endurance test is started to obtain the intrinsic error. A weighing test shall be performed after the completion of the loadings to determine the durability error due to wear and tear.

If the instrument is provided with an automatic zero-setting or zero-tracking device, it may be in operation during the test, in which case the error at zero point shall be determined according to A.4.2.3.2.

APPENDIX 4

Proposal for an In-Situ Durability Test at Type Approval

In R50, a requirement for an in-situ durability test at type evaluation could be included.

Such a requirement (under type evaluation, at 5.1.3.4 in the document) would aim to demonstrate satisfactory performance within maximum permissible errors of an operational belt weigher installation over a period of use of (at least) (400 hours), or a quantity of delivery (e.g. 100 x QMax x 1hr).

This testing could be carried out either on an installation which is in use for legal purposes (if that is possible according to the particular national regulations), or on an installation which is not in use for legal purposes (e.g uses for internal process measurements within a plant). In either case the installation shall closely represent a typical in-service situation. A degree of flexibility in relation to this should be adopted (OIML D11, identifies flexibility as one of the principles of metrological assurance).

It is the responsibility of the manufacturer to identify and ensure that access is provided to a suitable facility for durability testing (the suitability of the installation to be agreed between the type approval authority and the manufacturer), and also to ensure that sufficient product is available for conduct of the test (and/or arrangements are made for recirculation of product). It is assumed that a manufacturer will either have access to such a site for their own testing purposes, or will negotiate with other parties to provide such facilities.

Note that the equipment used for durability testing may be a different sample to that used for other testing (e.g. i.e. influence factor and disturbance testing). Hence it may be possible to minimise delays by carrying out the durability testing concurrently with other type testing, if necessary.

The following is proposal for a possible in-situ durability test.

<u>Proposed</u>

T.3.11 Durability

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

It is proposed that a durability test shall be carried out in-situ (a material test). Therefore it will not be under reference conditions, and it would not be appropriate to define a "Durability error" in terms of intrinsic error. Hence delete T.4.6.6.

T.6.4 Durability test

A test to verify whether the EUT is capable of maintaining its performance characteristics over a period of use.

2.8.6 Durability (under "In-situ tests")

When subjected to a durability test (see 5.1.3.4) the instrument shall be able to maintain performance within the maximum permissible errors for in-service use at the conclusion of the test, and in addition the difference between the errors determined at the start of the durability test, and those determined at the conclusion of the test shall not exceed the absolute value of the maximum permissible errors for in-service use.

5.1.3.4 Durability (under “Type evaluation tests”)

A durability test shall be carried out in-situ on a complete belt weigher installation, with a product normally intended to be weighed on the instrument. Alternative products having similar wear and tear characteristics may also be used (subject to agreement between the applicant and testing authority).

An in-situ material test (the ‘initial test’) shall be carried out, in accordance with 5.1.3.1 (Type evaluation, material tests).

Following a period of operation (see below), a further in-situ material test (the ‘final’ test) shall be carried out, in accordance with 5.1.3.2 (Type evaluation, material tests).

The instrument shall be operated between the ‘initial test’ and ‘final test’ shall for a period agreed between the applicant and the testing authority. This period shall be the lesser of the following:

- for a period of operation of at least 400 hours, or
- the period required to for a total quantity of delivery of 100 x Qmax x 1hr, whichever is the less.

During the period between the ‘initial test’ and ‘final test’ the instrument shall be sealed and without adjustment – other than zero setting operations which are carried out automatically, or by the user)

The initial verification maximum permissible errors in 2.2.1 Table 1 shall apply to the ‘initial test’. The in-service maximum permissible errors in 2.2.1 Table 1 shall apply to the ‘final test’. In addition, the difference between the errors determined at the initial test, and those determined at the ‘final test’ shall not exceed the absolute value of the in-service maximum permissible errors in 2.2.1 Table 1.

The durability test may be carried out on an installation which is 'not for legal purposes', or (if acceptable under national regulations and procedures of the appropriate metrological authority) on an installation permitted as 'for legal purposes' on a provisional basis.

The instrument used for durability testing may be a different sample to that used for other testing (e.g. i.e. influence factor and disturbance testing). Hence it may be possible to minimise delays by carrying out the durability testing concurrently with other type testing, if necessary.

APPENDIX 5

Proposal to address Durability issues under 'subsequent metrological control'

In R50, a provision under 'subsequent metrological control' (i.e. clause 5.3) could be included to indicate the desirability of subsequent verification and in-service inspection periods according to demonstrated historical performance of an installation (i.e. methods such as described in clause 3 of OIML D10). The concept is also suggested in OIML D16.

The following wording is suggested. Should the committee consider it worthwhile additional detail (and/or an Annex to R50 outlining possible methods of applying the OIML D10 methods to Belt Weighers) could be produced.

> 5.3 Subsequent metrological control
> Subsequent metrological control may be performed according to national regulations.
>
> It is recommended that arrangements for subsequent metrological control incorporate means for reviewing intervals for subsequent verification and in-service inspection such as those described in clause 3 of ILAC-G24/OIML D10 (2007) "Guidelines for the determination of calibration intervals of measuring instruments", so as to provide an incentive to produce equipment which is durable when installed and used, and as a deterrent to non-durable equipment.
>
> Should a type of instrument be found to not be of adequate durability, action may need to be taken to withdraw the type approval of that instrument.

Excerpt from ILAC-G24/OIML D10 (2007) "Guidelines for the determination of calibration intervals of measuring instruments"

3. Methods of reviewing calibration intervals

Once calibration on a routine basis has been established, adjustment of the calibration intervals should be possible in order to optimize the balance of risks and costs as stated in the introduction. It will probably be found that the intervals initially selected do not give the desired optimum results due to a number of reasons, for example:

- instruments may be less reliable than expected;
- the usage may not be as anticipated;
- it may be sufficient to carry out a limited calibration of certain instruments instead of a full calibration; and
- the drift determined by the recalibration of the instruments may show that longer calibration intervals may be possible without increasing risks, etc.

A range of methods is available for reviewing the calibration intervals. The method chosen differs according to whether:

- instruments are treated individually or as groups (e.g. by manufacturer's model or by type);
- instruments exceed the calibration by drift over time or by usage;

- instruments show different types of instabilities;
- instruments undergo adjustments; and
- data are available and importance is attached to the history of calibration of the instruments.

The so-called “engineering intuition” which fixed the initial calibration intervals, and a system which maintains fixed intervals without review, are not considered as being sufficiently reliable and are therefore not recommended.

[The clause goes on to indicate various methods to review calibration intervals].

Excerpt from OIML D16:1996 (clause 3.4)

Verification of the continued compliance of a measurement process with legal requirements is necessary wherever measurement accuracy may degrade with time. Frequent, periodic verification is usually appropriate for new instruments whose reliability is unknown. It may be possible to discontinue periodic verification or at least to lengthen the intervals between verifications if, as experience is gained, data indicate that the instrument does not degrade appreciably during its useful life. Also, experience may show that the verification intervals of instruments which appear to degrade with age should be shortened after several years of service.

Verification intervals should not be arbitrarily established and then held fixed, but should be adjusted on the basis of actual experience. Where possible, legal metrology officials should keep data by pattern (model number) and by serial number for each instrument so that those with consistently good performance and those with consistently poor records of compliance can be identified. Where data show that a pattern is highly reliable, surveillance can be reduced and resources reallocated to areas where compliance is poor.