UK WEIGHING FEDERATION

TECHNICAL ARTICLES

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Unit 3 Curo Park, Frogmore, St Albans, Herts, AL2 2DD

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The Handbook is intended to be a living document and kept up to date with changes as they occur. If any errors are discovered or sections that require updating or expanding then please notify the UKWF as soon as possible.

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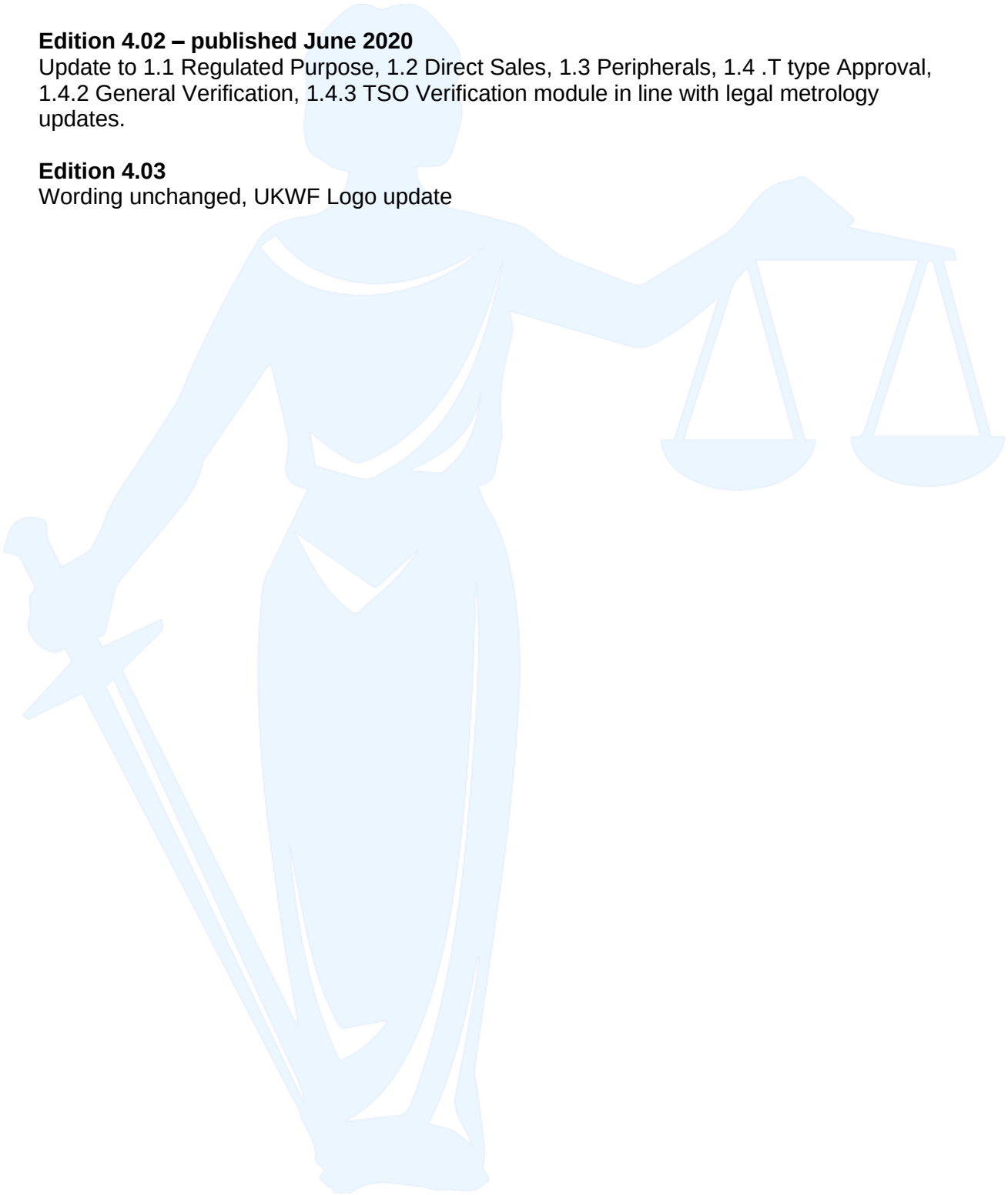
Update to 1.1 Regulated Purpose, 1.2 Direct Sales, 1.3 Peripherals, 1.4 .T type Approval, 1.4.2 General Verification, 1.4.3 TSO Verification module in line with legal metrology updates.

Edition 4.03
Wording unchanged, UKWF Logo update



1 - LEGAL REQUIREMENTS

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1.1 REGULATED PURPOSE

If a non-automatic weighing instrument is used for one of the following purposes it will then need to be initially verified or re-qualified where necessary before it can be used, equally, if it is not used for one of the regulated purposes it will not need to be initially verified or re-qualified. If the customer would like the accuracy of an instrument that is not used for a regulated purpose to be determined this should be done in line with *the UKWF Calibration Code of Practice*

***(a) Determination of mass for commercial transactions*;**
This is the application that we will most often see in our day to day work and will include the traditional buying and selling by weight between consumers and traders and business to business transactions; it will include such things as jewellers, scrap metal merchants, and post office scales amongst a wide range of other possible transactions It would also include the situation of a client using an instrument to check the quantity of a product from a supplier. If, in the event of a discrepancy between the customers weights and the supplier's weights, if it is the customers scale that is used to determine the final weight, that scale will need to be initially verified

(b) Determination of mass for the calculation of a toll, tariff, tax, bonus, penalty, remuneration, indemnity or similar type of payment
This would include any weighing equipment that is used to determine a fee such as the scale that may be used to weigh lorries on to ferries or waste going to landfill. It could also include such things as instruments used to determine the wages for workers picking fruit

(c) Determination of mass for the application of laws or regulations or for an expert opinion given in court proceedings;
This would include any weighing equipment used for law enforcement such as a road traffic weighbridge. Other interesting examples that fall under this category would be scales that are used in coroner's enquiries, and scales covered by safety legislation where a weight declaration is required. An example of this would be the SOLAS (Safety of Life at Sea) Requirements. This is an International Treaty to which the UK is party which creates a legal obligation for the weight of all goods that are intended to be shipborne cargo to have the weight declared by the shipper before they are loaded. Similarly, The Air Operations Regulations requires the weight of passengers and baggage to be determined before flying from a heliport. Any scales in use for these purposes, will be covered by this requirement.

(d) Determination of mass in the practice of medicine for weighing patients for the purposes of monitoring, diagnosis and medical treatment
This covers a wide range of instruments that can be found in all aspects of medicine. The weighing does not need to be completed by a medical practitioner. These instruments will also be covered by the Medical Devices Regulations 2017/745. They will invariably be found in hospitals but also doctor's surgeries and use in the community by such people as midwives and health visitors

(e) Determination of mass for making up medicines on prescription in a pharmacy and determination of mass in analyses carried out in medical and pharmaceutical laboratories;
This relates to the use of weighing instruments in the making of medicines.

(f) Determination of price on the basis of mass for the purposes of direct sales to the public and the making up of pre-packages;
The important point of this clause is that instruments used for the making up of pre-packages are controlled. These will be non-automatic weighing instruments that are used by packers for making up or checking of packages for the *Packaged Goods Regulations*[1]

[1] The Weights and Measures (Packaged Goods) Regulations 2006- Regulation 9

What is the difference between a NAWI and an AWI?

The general difference between the two is that a NAWI requires the intervention of an operator during the weighing process, for example to deposit on or remove from the load receptor the load to be measured and also to obtain the result.

However, it is not always easy from the above brief definition to determine which requirements the instrument has to meet. In these situations, the following interpretation (taken from section 3.1.9 of WELMEC Guide 2, 2015 of the definition of a NAWI or an AWI should be used only when doubt exists in applying the definitions contained in EC Directive 2014/31/EC and the relevant OIML recommendations.

> *"An instrument capable of performing consecutive weighing cycles without any intervention of an operator is always regarded to be an AWI. If an instrument needs the intervention of an operator, it is regarded to be an NAWI only in the case where the operator is required to determine or verify the weighing result.*
>
> *Determining the weighing result includes any intelligent action of the operator that affects the result, such as deciding when an indication is stable or adjusting the weight of the weighed product.*
>
> *Verifying the weighing result means making a decision regarding the acceptance of each weighing result on observing the indication. The weighing process allows the operator to take an action which influences the weighing result in the case where the weighing result is not acceptable.*
>
> *Note: the necessity to give an instruction to start the weighing process or to release a load is not relevant in deciding the category of instrument."*

Automatic Weighing Instruments

For automatic weighing instruments the definitions in the Weights and Measures Act 1985 still applies.

Section 7 of the Act says:

7. "Meaning of 'use for trade'

(1) In this Act 'use for trade' means, subject to subsection (3) below, use in Great Britain in connection with, or with a view to, a transaction falling within sub-section (2) below where -

(a) the transaction is by reference to quantity or is a transaction for the purposes of which there is made or implied a statement of the quantity of goods to which the transaction relates, and

(b) the use is for the purpose of the determination or statement of that quantity.

(2) A transaction falls within this subsection if it is a transaction for -

(a) the transferring or rendering of money or money's worth in consideration of money or money's worth, or

(b) the making of a payment in respect of any toll or duty.

(3) Use for trade does not include use in a case where -

(a) the determination or statement is a determination or statement of the quantity of goods required for dispatch to a destination outside Great Britain and any designated country, and

(b) the transaction is not a sale by retail, and

(c) no transfer or rendering of money or money's worth is involved other than the passing of the title to the goods and the consideration for them."

Any automatic weighing instruments that are used in applications that fall under the definition of use for trade as set out in Section 7 need to have a type examination certificate and be verified before they can be used for trade. The one exception to this is automatic checkweighers which do not need to be approved.

1.2 DIRECT SALES, PRICE COMPUTING AND WEIGH LABELLING

General
Where a weighing instrument is used for direct sales to the public, the relevant mandatory information must be clearly displayed simultaneously to the operator and the customer. It is not uncommon to see a weighing instrument with two displays; the additional, secondary display is generally mounted for the benefit of the customers when it would be impossible for them to see the primary display.

When in use, a weighing instrument must be installed in a manner that ensures that the operator has access to the controls and has clear sight of the weighing platform.

It is the responsibility of the operator of a weighing instrument to ensure that it is at zero before each transaction. It is, therefore, essential that the weight display and a zero setting device are available.

Modes of Tare Operation
Tare values, which must correspond to the scale interval of the instrument, are used to remove the weight of the container from the calculation of the price to pay. Consecutive tare operations are permitted. For example, a pre-set tare may be applied with the selection of a PLU then a semi-auto tare may be applied, adding the value of an additional container. A pre-set tare operation can not be modified or cancelled while any subsequent tare operation is still in use.

While it is permissible to increase a tare value by repeated operations of a tare device, a tare value can not be reduced by the same method. Before a lower tare value can be established the instrument must be returned to zero.

In general, the semi-auto tare facility is used for direct sale to the public. It is possible to store a tare value but unless all the items transacted from that instrument have the same container value there is a danger of an incorrect NET weight. This problem is overcome by using a “one shot” tare. An empty container is tared; a full container replaces the empty one without allowing the instrument to see zero. Once the transaction is complete and the scale pan is clear the tare drops out and the instrument returns to zero.

Direct sales to the public can be carried out on two basic types of weighing instruments, price computing, and weight only instruments.

1.3 INTERFACES, PRINTERS AND PERIPHERAL DEVICES

Background
All weighing Instruments when used for a legally controlled purpose are required to comply with all of the applicable relevant legislation. In legal metrology, the weighing instrument comprises of the weighing module (load cell, load receptor, indicator and all the necessary software and electronics necessary for the weighing operation to be performed) and any other associated equipment connected to it; so for example, an in-store Point of Sale (POS) system, comprising of a load receptor, weight display, scanner, printer, cash draw, keyboard, data display and card reader is regarded for legal metrology purposes as a weighing instrument. The Type examination certificate for the instrument will detail not only the weighing elements, but also the connected elements and all must satisfy the legal requirements.

If the procedure for type examination had to cover all of the possible elements of a weighing system, many of which would be common to many different weighing systems, the Type Examination process would be both time consuming and expensive, and the result would be that many elements would be tested over and over again.

Non-automatic Weighing Instruments
Under the NAWI Directive, there has been developed what is known as the “modular” system. The Directive recognised that many elements of a weighing system are common, many can be tested in their own right and different elements can be combined to produce a weighing instrument.

WELMEC Working Group 2 (WG2) took on board the development of the modular system to enable manufacturers and the Type examinations organisations to understand how the various elements could be tested and to set out some guidance that would illustrate how the modular system could operate. That Guidance is contained in WELMEC Guide 2.5 “Guide for modular approach and testing PCs and other digital peripheral devices”. The Guide, currently at Issue 2 dated September 2000, can be downloaded free of charge from the WELMEC web-site at www.welmec.org.

Definitions
In developing the Guide, WELMEC WG2 soon recognised that there needed to be very clear definitions of what elements of the weighing system can be regarded as modules and what elements are not modules but “peripherals”.

They came up with the following definitions:

> **Module**
> *A module is a part of a NAWI that is necessary for obtaining the weighing result and any primary indication related to it. A module is capable of being tested separately and of having partial error limits p_i assigned to it.*
> *A device connected to a NAWI via a non-protective interface is regarded as a module. The connection needs to be secured and if nothing is connected to it, the interface itself needs to be secured.*
> *Examples of modules of a NAWI: load cell, indicator, display, price-computing POS device, software, weighing module (here they mean a “digitally working instrument including mechanical structures but without a display” which is therefore not a NAWI).*

> **Peripheral**
> *A peripheral is an additional device to the NAWI, connected externally or built in, which repeats or further processes the weighing result and/or any primary indication*

without changing the original characteristics as specified in the Type Approval Certificate of the NAWI.
A peripheral shall be connected to the instrument via a protective interface.
Examples of peripherals of a NAWI: printers, supplementary displays, alibi printer, alibi data storage device, personal computer (PC), non-price-computing POS device which receives all primary indications from the NAWI and only prints them on a ticket.

Protective Interface
The following two definitions gave rise to the concept of the "protective" interface, and whilst there is no specific definition of a protective interface the Guide does give advice which is helpful. It describes two types of protective interface:

- *the interface prevents the introduction into the instrument of unauthorised data, parameters or instructions.*
- *the interface provides protection which covers the manner in which data related to primary indications are transmitted to a peripheral device under legal control.*

Modules and Test Certificates
To facilitate the use of modules, WELMEC WG2 developed the concept of Test Certificates (TC). Any module can be submitted for examination and testing to the applicable requirements of the Directive and the European Standard. If the module passes the tests, the Notified Body issues a TC which describes the module and its essential characteristics. Manufacturers can then, with the agreement of the owner of the TC, use that module in their instrument if the Type Examinations Certificate (TAC) for the instrument allows the use of modules.

The most common use of TCs in Type Examinations is for load cells. Many load cell manufacturers obtain a TC for their load cells, the weighing instrument manufacturer then applies for the Type Approval for his instrument and asks for a clause to be incorporated into the TAC, allowing the use of any load cell having a TC (or OIML R60 Certificate) issued by a Notified Body.

When using a TC for a load cell, the manufacturer will be required to complete a "Compatibility of Modules" form, which requires him to do some technical checks to ensure that the technical characteristics of the load cell and indicator are such that they will perform together to the accuracy levels required by the TAC. Details of the Compatibility of Modules form can be found in WELMEC Guide 2, "Directive 2009/23/EC, Common Application non-automatic weighing instruments." The Guide also lists websites where spreadsheets can be found which will simplify the completion of the form. (See also section 3.1 on compatibility of modules).

Peripherals
Certain peripheral devices are allowed to be connected to the NAWI without any specific controls. The most common example of this is simple recipient (non-intelligent) printers, i.e. the printer receives data from the weighing instrument and merely prints it onto a label, ticket or receipt without any further processing. In such cases, the only requirement is that the printer bears the CE conformity mark indicating that it meets all of the other applicable EC legislation such as the EMC Directive and the Low Voltage Directive.

At other times peripherals may need a Test Certificate. The simplest example is what is known as an "alibi printer" i.e. a printer that is connected to a weighing instrument to provide a long term record of weighments in systems where the weight data is sent straight to a computer for invoicing purposes or similar. In this case, a simple recipient printer can be used to provide a tally roll record but because this record is a requirement of the Directive, the printer needs to undergo some testing to ensure it meets the essential requirements of the Directive.

Detailed requirements

The whole question of modules, peripherals and interfaces is one which arises frequently in WELMEC and perhaps the only real answer is to say that in any case of doubt guidance should be sought from the Notified Body who are/will be responsible for issuing the Type Examination Certificate. Readers who are considering using the modular approach for NAWI manufacture should consult WELMEC Guide 2.5; and for AWI the WELMEC Guide 8.8 for the specific details of the tests that will be applied and the requirements that

1.4 APPROVAL AND VERIFICATION OF WEIGHING INSTRUMENTS

Weighing instruments used for controlled applications need to satisfy the essential requirements of the relevant directives and associated UK regulations.

In general terms, a particular model of instrument will require a type approval and then each unit will require initial verification when it is put in to service. Alternatively, an instrument can undergo unit verification which effectively combines the two processes and would be the typical approach for a one-off installation. Once an instrument has obtained type approval, the manufacturer must provide an EC declaration of type conformity to declare that individual units have been manufactured in conformity with the approval type and satisfy the provisions of the relevant directive.

Verification can be performed by an approved third party (typically a local authority) or by the manufacturer, if approved to do so (known as self-verification).

If a unit undergoes modification or repair then it will require re-verification to the appropriate standards before being put back in to service. Any unit may also be subject to in-service inspection by a trading standards officer.

For the differentiation between automatic and non-automatic weighing, see section 1.1 on controlled applications.

Non-Automatic Weighing Instruments (NAWIs)
Prior to regulations implementing the NAWI Directive, non-automatic weighing machines were controlled under national approval and regulations emanating from the Weights and Measures Act 1985. During the transition period between 1st January 1993 and 1st January 2003 national type approvals that had not expired due to time could continue to be used for the manufacture and verification of machines, however, new designs of machines could only be approved and verified under the regulations implementing the NAWI Directive. Any national approval that was still in force at 1st January 2003 was deemed to have expired on that date.

Equipment that was verified under the national regulations can continue in use and can be repaired and re-verified even though the national type approval has now expired. The appropriate regulations are the Weighing Equipment (Non-Automatic Weighing Machines) Regulations 2000 (SI 2000 No. 932).

Since 1st January 2003, all equipment put in to service comes under the NAWI directive 2009/23/EC (previously 90/384/EC). This is implemented into UK law by the Non-Automatic Weighing Instruments Regulations 2000 (SI 2000 No. 3236). The most common route for ensuring that the Essential Requirements of the Directive are met is through the application of the European Standard EN 45501. If the weighing instrument complied with EN 45501 then it automatically satisfies the essential requirements and will be eligible for an EC Type Approval. The standard covers both the type approval and verification.

Automatic Weighing Instruments
From 30th October 2006, the Measuring Instruments Directive governs new designs of automatic weighing instruments. (Instruments already in service will continue to be controlled by the national regulations under which they are initially type approved and verified. National Type Approvals that were in force on 30th October will remain valid until their normal expiry date and can be used for national verification of the instruments to which they apply.)

The EU Commission has published in the Official Journal C269 dated 4th November 2006 (2006/C 269/01) the references to the Normative Documents with respect to the OIML recommendations. These can be found on the Commission website.

The Normative Documents address al the provision of the MID, i.e. both the general and instrument specific requirements, in tabular form, in relation to the relevant paragraphs of the respective OIML recommendations and makes comments, in general terms only, of any differences. The range of AWIs regulated in the UK together with the regulations that apply and the relevant OIML recommendation are as follows:

Regulation	OIML Recommendation
The Measuring Instruments (Automatic Discontinuous Totalisers) Regulations 2006 SI 2006/1255	R107 Discontinuous totalising automatic weighing instruments (totalising hopper weighers)
The Measuring Instruments (Automatic Rail-Weighbridges) Regulations 2006 SI 2006/1256	R106 Automatic rail-weighbridges
The Measuring Instruments (Automatic Catchweighers) Regulations* 2006 SI 2006/1257	R51 Automatic catchweighing instruments
The Measuring Instruments (Automatic Gravimetric Filling Instruments) Regulations 2006 SI 2006/1258	R61 Automatic gravimetric filling instruments
The Measuring Instruments (Beltweighers) Regulations 2006 SI 2006/1259	R50 Continuous totalising automatic weighing instruments (belt weighers)

**Automatic checkweighers and weight-graders, although designated as catchweighers, are not prescribed in the UK, and consequently, do not require type approval. However, to enable manufacturers to distribute to other member states, The NMO can issue approval documentation.*

The MID will offer manufacturers alternative conformity assessment modules as shown below (for electronic systems or systems containing software):

B + F (type approval plus “third-party verification”
B + D (type approval plus “self-verification”)
G (unit verification)
H1 (full quality system approval plus design examination)

The NMO is a Notified Body for each of these conformity assessment modules, with the exception of module F.

Notified bodies
A full list of all notified bodies for type approval and verification of non-automatic and automatic weighing instruments is given on the Nando (New Approach Notified and Designated Organisations) website:

http://ec.europa.eu/enterprise/newapproach/nando

1.4.1 TYPE APPROVAL OF WEIGHING INSTRUMENTS

Under the NAWI and Measuring Instruments Directives, EC Type examination certificates can only be issued by Notified Bodies who have been designated in a Member State for this task. The National Measurement Office (NMO) is the designated Notified Body in the UK for issuing EC TACs for both non-automatic and automatic weighing instruments. Member States of the EC are obliged to accept type-approval certificates issued by Notified Bodies of other Member States. It must be remembered that this may different after the UK has left the EU. These notes will be updated to reflect this.

To grant a type examination certificate, the examining body must assess the equipment against the essential requirements of the relevant Directive. In general, the examining body will refer to harmonised standards, OIML normative documents (MID only) and WELMEC guidelines. If the equipment satisfies the related harmonised standard(s) or normative document then it is presumed to conform to the applicable essential requirements of the directive. WELMEC guidelines give interpretations from a legal metrological point of view.

Alternatively, a manufacturer can request to have an instrument assessed against the essential requirements of the associated directive independently of the standards, normative documents and guidelines. However, the manufacturer will need to demonstrate how the instrument satisfies the essential requirements.

Non Automatic Weighing Instruments (NAWIs)
The harmonised standard for non-automatic weighing instruments is EN45501(2015) which is based on OIML recommendation R76(20060. This details the test procedures and criteria to be met.

The following WELMEC guidelines may be relevant:

2 Directive 2009/23/EC: Common Application
- 2.1 Guide for Testing Indicators
- 2.2 Guide for Testing Point of Sale Devices
- 2.3 Guide for Examining Software
- 2.4 Guide for Load Cells
- 2.5 Guide for Modular Approach and Testing of PCs and other Digital Peripheral Devices

7.2 Software Guide(Measuring Instruments Directive 2014/32/EU)
7.3 Reference Architectures-Based on WELEMC 7.2
7.4 Exemplary Applications of WELEMC Guide 7.2

To reduce the amount of examination and testing needed to approve a NAWI, it is possible to test modules of a NAWI separately and issue them with individual Test Certificates (TC). These TCs can then be quoted in Type Approval Certificates (TACs), rather than examining and testing the entire NAWI. This method is known as the modular approach. TCs can be issued for modules such as indicators, load cells and point of sale devices, as well as for peripheral devices such as computers and printers.

For countries outside of the EU, the NAWI or module can be approved in accordance with the relevant OIML Recommendation (R60 for load cells and R76 for complete NAWIs and other modules). An OIML Certificate of Conformity and Test Report will be issued which may then be used to assist in the gaining of approvals in other countries.

Automatic Weighing Instruments (AWI)
Until harmonised standards have been developed, notified bodies will refer to normative documents (derived from OIML recommendations) and WELMEC guides. The OIML recommendations for the various types of AWI are listed in section 1.4.

The WELMEC guides that may apply include the following:

2.6	Guide for the testing of automatic catchweighing instruments
7.2	Software Guide (Measuring Instruments Directive 2014/32/EU)
7.3	Reference Architectures-Based on the WELEMC Guide 7.2
7.4	Exemplary Applications of WELEMC Guide 7.2
8.1	Terms and definitions in MID and their relation to terms defined in other international metrologically relevant documents
8.2	Guide for Measuring Instruments Directive 2014/32/EU-Application of Module H1
8.3	Application of Module B: EU -type examination under Directive 2014/32 (MID) or 2014/31/EU (NAWID)
8.4	Application of Module D: EU -type examination under Directive 2014/32 (MID) or 2014/31/EU (NAWID)
8.5	Measuring Instruments Directive 2014/32/EU Assessment of Notified Bodies in Charge of Type Examination Presumption of Conformity based onEN17065
8.6	Measuring Instruments Directive 2014/31, Presumption of Conformity of the Quality System of Manufacturers with Module D or H1 when EN9001:2015 is applied
8.7	Measuring Instruments Directive 2014/32/EU - Assessment of Notified Bodies Designated for Module F based on EN ISO/IEC 17020
8.8	Guide on the General and Administrative Aspects of the Voluntary System of Modular Evaluation of Measuring Instruments

Type Approval typically involves testing and examination of the AWI to ensure that the instrument satisfies the essential requirements. Testing covers the environmental (temperature and humidity) and electrical (immunity to disturbances) performance of the instrument, as well as a range of other weighing performance checks, e.g. span stability. The examination stage is used to check the functionality of the instrument. Unlike NAWIs, there is normally a requirement for on-site testing of a complete instrument at the type approval stage. Due to the physical size or mode of operation it is normally not feasible to test the complete instrument in the laboratory.

In addition, part of the approval process requires the determination of the accuracy class of the instrument when weighing actual material or vehicles (as appropriate). Therefore, laboratory testing is usually undertaken on a simulator, with the on-site testing of a complete instrument then performed. N.B. this tends not to apply to catchweighers (e.g. weigh-price labellers) as the complete instrument can normally be tested in the laboratory.

1.4.2 VERIFICATION

Under the current legislation, initial verification by an approved person from a Notified Body, or by a “self-verifier” are equally valid and the procedures are generally the same no matter who carries out the initial verification. In cases where the manufacturer can demonstrate to the satisfaction of his assessment body that he has controlled procedures and operations in his production process that negate the need for specific tests to be carried out on the completed instrument, then he need not carry out all the tests that an approved person from a notified would. The actual verification process will depend on the type of equipment being verified.

Non-automatic weighing instruments (NAWIs)
NAWIs come under the Non-automatic Weighing instruments Regulations 2016(2016 No.1152)

The test loads that should be applied must meet the requirements of 3.7.1 of EN45501 (2015) Further information can be found in part 4.4 of the Non-automatic Weighing Instruments Guidance notes mentioned in section 7.3 above. Weights used for initial verification and re-qualification should be within the tolerances outlined in OIML R111[2], for class III instruments the weights should be at the standard of M1 or higher for class II instruments they should be F2 or higher.

It is advised that M1 or F2 weighs should be calibrated annually by either a local weights and measures authority or a UKAS approved laboratory. It is important to stress that the periodicity of the calibration is not stipulated in law, the obligation is to ensure that they stay within calibration.

When testing instruments at the place of use, instead of 100% of standard weights any other constant load may be used, provided that standard weights of at least ½ max are used. This can be reduced further to 1/3 max if the repeatability error is not greater than 0.3 e and 1/5 max if the repeatability error is 0.2e. The repeatability error should be determined with a load approximately of the value where any weight substitution may be made

The International Organisation of Legal Metrology OIML drafted a standard in 2006 (OIML recommendation R76) to cover specifications and testing of NAWIs, this became European Norm EN45501 that was later adopted in this country as British Standard BS EN 45501(2015) The regulations in force today are derived from the above and linked directly to them..

Section 8.3 of EN 45501 / OIML R76 details the assessment required for initial verification (i.e. when the unit is put in to service). This refers to several of the sub-sections of the standard for the specific tests to be performed. The tests can be summarised as follows:

- Checking of a declaration of conformity.
- Visual inspection of basic metrological characteristics (e.g. Min, Max, e, d, etc), markings and suitability of use.
- Errors on loading and unloading; gross, net and tare weighing (sections 3.5.1, 3.5.3, 4.6.2, 4.7.3; appendices A4.4 – A.4.6)
- Accuracy of zero setting and tare setting (A.4.2.3 & A.4.6.2)
- Repeatability tests (section 3.6.1 and appendix A.4.10)
- Eccentric loading tests (section 3.6.2 and appendix A.4.7)
- Discrimination tests (section 3.8 and appendix A.4.8)

Other tests may be performed in special cases and if the instrument is to be used in a different location then any difference in gravity shall be considered, if appropriate.

[2] OIML R111-1 (2004). Weight of Classes E1, E2, F1, F2, M1, M1-2, M2-3 and M3: Metrological and technical requirements

Automatic weighing instruments
The regulations in force depend on the type of instrument to be verified and the verification procedures will be outlined in the associated OIML recommendation.

In general the verifier will have to:

- Ensure that the unit under test complies with the type approval certificate
- Check the markings on the instrument
- Test the unit with the product or equipment to be processed and from the test results determine the accuracy class
- Ensure that the errors are within the appropriate maximum permissible limits

In addition to test weights verification may require a separate control instrument for comparative static reference tests.

1.4.3 VERIFICATION BY A TRADING STANDARDS OFFICER

A local authority may be a notified body to be able to verify a weighing instrument. An approved person from that notified will perform the actual initial verification testing as described in section 1.4.2 but the submitter will have to prepare for the verification and is responsible for ensuring that various matters are addressed.

A copy of the Type Examination Certificate (TEC) must be available on site plus any test certificates, if required. The approved person from the notified body is entitled to ask to see a copy of the documentation prior to the test.

The equipment must be complete and working prior to the appointment time. It would be advisable to calibrate and/or check it as well, because if it fails the approved person will charge a fee and may well leave the site with another appointment to be made. The checks should include that the necessary inscriptions and any company seals are in place.

The submitter should ensure that the inspector is aware of any issues specific to the site, for example health and safety requirements such as a site induction.

The approved person from a notified body will want to check the calibration status of the weights used to test the instrument, if hiring in a test unit for weighbridge verification then the submitter must ensure that a current calibration certificate is available.

A problem that is occurring more often now is that not all local Trading Standards Services are Notified Bodies under the NAWI regulations, or the regulations applying to the type of AWI, which means that their staff cannot verify this type of equipment. This is due to resource pressures within local government. If this occurs, then it may be necessary to bring in an outside approved person to verify the equipment; check that their insurance is valid, and they can verify the type of instrument.

The approved person will test the equipment and must fill in a test report form which shows the results of all tests applied to that instrument, which may be required in any future dispute. Upon passing they will then deliver a Certificate of Conformity to the submitter, or if the equipment fails, a notice of refusal to verify.

1.4.4 SELF-VERIFICATION

European Self-verification or UK Weights and Measures Act 1985 Self-verification?
The term “self-verification” has become the colloquial expression for the process whereby an organisation that is suitably accredited/authorised can carry out the conformity assessment and performance testing on weighing instruments that it has manufactured or, in certain circumstances, has repaired, installed or distributed. In contrast, “verification” is the term used when weighing equipment undergoes performance testing and conformity assessment carried out by a Notified Body such as a Trading Standards Department or an accredited third party organisation.

There are now three types of self verification:

- UK national self verification, which has its origins under the Weights and Measures Act 1985
- EC Declaration of Type Conformity which has its origins in the Non-Automatic Weighing Instruments Directive (NAWI) 2009/23/EC
- Declaration of Conformity to Type based on quality assurance of the production process, with its origin in the Measuring Instruments Directive (MID) 2004/22/EC

In practice, there is little difference between the last two, and the obligations that have to be met by the manufacturer are very similar. It should be noted, however, that there is a subtle difference in the way these requirements have been implemented in UK legislation. A manufacturer who is accredited as a “self-verifier” under the NAWI Directive is also allowed to carry out re-verification of the products that he can initially verify, because the NAWI concerned do not fall under the control of the Weights and Measures Act 1985 after they have been placed on the market and taken into service. However, the MID has been implemented in the UK on a different basis; Automatic Weighing Instruments (AWI) that are subject to the MID do become subject to the Weights and Measures Act 1985 once they have been placed on the market and taken into service, therefore re-verification can be carried out either by a Notified Body or by a manufacturer, repairer, installer or distributor that is accredited under the UK national self-verification system. A table showing who can verify is given at the end of this document.

European Self-verification (EC Declaration of Type Conformity under NAWI Directive 2009/23/EC)
Non Automatic Weighing Instruments (NAWI’s), (weighing instruments that require the action of gravity to determine the mass and require the intervention of an operator during weighing), which are first placed on the EU market and put into use in EU member states must comply with the NAWI Directive.

NAWI’s used for controlled applications must have gone through EC type-examination and been given an EC Type Approval Certificate. They must be manufactured in conformity with the EC Type Approval Certificate and must be labelled and CE marked in accordance with the NAWI Directive and other applicable directives.

These NAWI’s must be subject to initial conformity assessment (verification) procedures whereby either:

- a NAWI notified body examines and tests the instrument and applies the conformity assessment mark (i.e. TSO Verification) or
- a manufacturer who has in place a quality system which has been approved by a NAWI notified body as complying with the Directive gives his own EC Declaration of Type Conformity and applies the conformity assessment mark (i.e. self-verification)

Getting Quality System approval to make EC Declarations of Type Conformity
An organisation, in the EU or outside it, who is the "manufacturer" of NAWI's can apply in writing to a European Commission Notified Body that has NAWI Directive Annex II(2) approval to assess their quality management system, as complying with the Annex II paragraph 2.3 of the Directive. In the UK, these notified bodies include:

BSI Management Systems
SGS UK Ltd
NMO

The "manufacturer" must undertake to carry out the obligations arising from the approved quality system and to maintain the approved quality system to ensure its continuing suitability and effectiveness. They must make available all relevant information including the documentation of the quality system presented in a systematic and orderly manner in the form of written rules, procedures and instructions with a view to ensuring a proper understanding of the quality programmes, plans, manuals and records and the "design documentation" of the instruments.

The Notified Body will evaluate the quality system to determine whether it satisfies the requirements referred to in paragraph 2.3.2 of Annex II to the NAWI Directive. If it does, the Notified Body will grant to the "manufacturer" an approval of the quality system; which then permits the "manufacturer" to make EC Declarations of Type Conformity.

Making EC Declarations of Type Conformity
Providing the "manufacturer" adequately implements the approved quality system; carries out all the examinations and tests consistent with his obligations in the quality system and is satisfied that the instruments conform with the Type Approval Certificate and meet the requirements of the NAWI Directive, he can apply the CE marking including the green M and the identification number of the notified body that approved the quality system. If the manufacturer has appointed authorised representatives within an EU Member State then they may also carry out these functions, provided that they are operating under the manufacturers control and approved quality system. The manufacturer or his authorised representative shall draw up a written declaration of conformity detailing compliance with the NAWI Directive and any other applicable directives.

Note: the Directive uses terminology that is sometimes confusing and this is a good example:

"EC Declaration of Type Conformity" is the process whereby the approved manufacturer carries out the activities defined in his quality system, and applies the CE mark, the green M and the Notified Body number

"Declaration of Conformity" is the document that identifies the model type and declares that it complies with all the relevant identified directives.

Keeping the approval to make EC Declarations of Type Conformity
Notified Bodies that have approved the quality systems carry out what is known as EC surveillance. They periodically carry out audits in order to ensure that the manufacturer is maintaining and applying the quality system and provide the manufacturer with an audit report. They carry out visits at the places of manufacture, inspection, testing and storage. They can carry out full or partial audits, announced or unannounced. The "manufacturer" is required, in respect of each instrument, to keep available for inspection the documentation of the quality system; the design documentation of the instrument; and all related quality records. The manufacturer is also required to inform the notified body of any changes in his quality system.

Self-verifying repaired NAWI Directive Instruments
Once a NAWI Directive weighing instrument has had its first conformity assessment, i.e. EC Declaration of Type Conformity or EC Verification (see section 1.4.2) and has been put into use, it ceases to come under the full first-placed-on-the-market arrangements detailed above. If it has undergone any repair or maintenance process which has affected its metrological

integrity or accuracy it should be submitted for re-qualification. Manufacturers who have an approved quality system can also re-qualify any instruments included in the scope of their approval that have been rejected by an authorised officer and repaired, or that underwent significant repair such that they should be re-qualified before being placed back into use.

They follow the same basic process for examination and conformity assessment but finish the process by applying a re-qualification crown and alongside it the notified body number of the notified body that approved their system. Additionally they are not required to issue a declaration of conformity.

Definition of a manufacturer

Unfortunately, the scope of the legislation for EC self-verification is significantly different to that for UK national self-verification as the EC system is limited to only manufacturers, whereas the UK system included installers and repairers (and therefore the distinction is less of an issue). It will be up to the notified body that assesses the company for self-verification to determine whether it qualifies as a manufacturer for a range of instruments and hence be eligible for approval.

When a company has the design, component production and instrument assembly all completely under their direct control then it is more than likely that they will be considered a manufacturer. However, the situation has become blurred from both sides in that traditional manufacturer's contract out many services and, especially with the modular approach, an organisation may well be able to assemble an instrument from components without actually being the manufacturer.

To satisfy an assessor that they qualify as a manufacturer, the company will have to show that they have exercised control over the design of the instrument, even if they have assembled an indicator sourced from another manufacturer holding the TAC to a platform with load cells from another manufacturer holding test certificates. In any case, they will have to show that they have the full support of the component manufacturers in attaining approval for self-verification so that they can demonstrate that they will be able to keep the necessary information up to date. Other actions that will support qualification as a manufacturer include:

- labelling the instrument under the companies own name or own brand
- holding the type approval certificate or test certificate (either as the manufacturer or as a parallel approval)
- making the full CE declaration of conformity and hence taking full legal responsibility for compliance with all applicable EC directives

European Self-Verification (Declaration of conformity to type based on quality assurance of the production process under MID 2004/22/EC)

Automatic Weighing Instruments that are used for applications that come under the heading "Use for Trade", as defined in Section 7 of the Weights and Measures Act 1985, must either be type approved under Section 12 of that Act and be stamped either by a Weights and Measures Inspector or an authorised self-verifier under Section 11 of the Act; or be manufactured under a European Type Approval granted under the MID and then be initially verified either by a Notified Body or an accredited manufacturer.

The process and requirements for a manufacturer to become accredited under the MID are essentially the same as those under the NAWI Directive. The same rules relating to documentation of the Quality System, record keeping, auditing, training and so on apply. The accreditation to be a self-verifier under this Directive however does not extend to the re-verification of instruments that have been repaired following either rejection by a Trading Standards Officer or failure such that a repair was necessary that could have impacted on the metrological performance of the instrument. (See the Table "Who can verify?")

Who can verify?

	INITIAL VERIFICATION				REVERIFICATION			
	TSO	Notified Body	Manufacturer	Repairer, Installer or adjuster	TSO	Notified Body	Manufacturer	Repairer Installer or adjuster
Any Weighing Instrument Type Approved under Sec 12 of the Weights and Measures Act 1985	Yes	No, unless the Notified Body is also a Trading Standards Department in which case they act as a TSD and not as a Notified Body	Yes if he is an "authorised verifier" under Section 11A of the Weights and Measures Act 1985	Yes if he is an "authorised verifier" under Section 11A of the Weights and Measures Act 1985	Yes	No, unless the Notified Body is also a Trading Standards Department in which case they act as a TSD and not as a Notified Body	Yes if he is an "authorised verifier" under Section 11 of the Weights and Measures Act 1985	Yes if he is an "authorised verifier" under Section 11 of the Weights and Measures Act 1985
Non-automatic weighing instrument Type Approved under the NAWI Directive	No	Yes	Yes, if accredited for that purpose by a Notified Body	No	No	Yes	Yes, if accredited for initial verification by a Notified Body	No
Automatic Weighing Instrument Type Approved under the Measuring Instruments Directive	No	Yes	Yes, if accredited for that purpose by a Notified Body	No	Yes	No, unless accredited as an "authorised verifier" under Sec 11 of the Weights and Measures Act 1985	No, unless he has an accreditation as an "authorised verifier" under Sec 11 of the Weights and Measures Act 1985	No, unless he has an accreditation as an "authorised verifier" under Sec 11 of the Weights and Measures Act 1985

1.5 AVERAGE WEIGHT

Refer to Articles 1.5.1 & 1.5.2

1.5.1 AVERAGE WEIGHT REGULATIONS

General

Packaged goods may be produced by weight or by volume as appropriate, these notes only consider quantity checking by weight. With the proper conversions, goods packed by volume may be checked by weight but the conversion factors used are the responsibility of the packer.

The Weights and Measures (Packaged Goods) Regulations 2006 came into force on 6th April 2006. The previous legislation, contained in Part V of the Weights and Measures Act 1985 and The Weights and Measures (Packaged Goods) Regulations 1986, was repealed by these new Regulations. The 2006 regulations apply to all packages made up in quantities of 5g to 25kg, where the packer intended all the packages to be of the same nominal quantity, whereas the old regulations specified Prescribed Goods which were subject to the regulations, whilst other goods not in the prescribed list could be packed to the average system on a voluntary basis. The new regulations therefore have a much wider scope than the previous legislation.

Types of checkweigher

The type of checkweigher used following a packing operation may be automatic or manual.

Automatic checkweighers are capable of checking every package at high speed and they have the advantage that they can be integrated into the filling operation to provide feedback of the accuracy of the fill, this will allow for any drift in the dispensing operation. Any packages which are outside the tolerances can be automatically rejected to ensure that no under tolerance packs enter the supply chain. These checkweighers will usually have an integrated statistical package so that production records can be automatically produced to demonstrate compliance with the legislation.

Manual checkweighers are used where samples of the production process are checked using a non-automatic instrument. Data collection systems, either stand-alone or integrated, can be used with manual checkweighers to simplify the task of analysing the data.

The law for packers

The Weights and Measures (Packaged Goods) Regulations 2006 (SI 2006 No 659) contains the requirements that packers have to meet. The regulations cover the making up and marking of packages. Previous regulations defined the type of weighing equipment that could be used for making up and checking packages, this has now been replaced with a simplified requirement that packers use equipment which is suitable for the purpose. An additional change is to remove the distinction that previously existed between equipment used for making up packages and that is used for checking them. Under the old legislation, packers had to use prescribed and verified equipment for making up packages but could use unverified equipment for checking; now any equipment used for making up or checking packages must comply with all relevant weights and measures legislation, including European Directives such as the Non-automatic Weighing Instruments Directive and the Measuring Instruments Directive. However, packers who were legitimately using unverified equipment for checking packages before these regulations were introduced can continue to use that equipment without the need to have it verified.

Guidance

A document entitled “Code of Practical Guidance for packers and importers No1” was produced to provide guidance on the previous regulations to packers and importers. Certain parts of the Code were given statutory effect by means of references in the regulations, this has not been reproduced in the 2006 regulations and many parts of the Code are now

irrelevant. However, the Code still contains reference material, particularly in the Appendices that may be helpful in understanding of average quantity control in general. The Guidance provided on the 1986 regulations is, however, no longer relevant. BIS have published Guidance Notes to the 2006 regulations which can be downloaded from the BIS website.

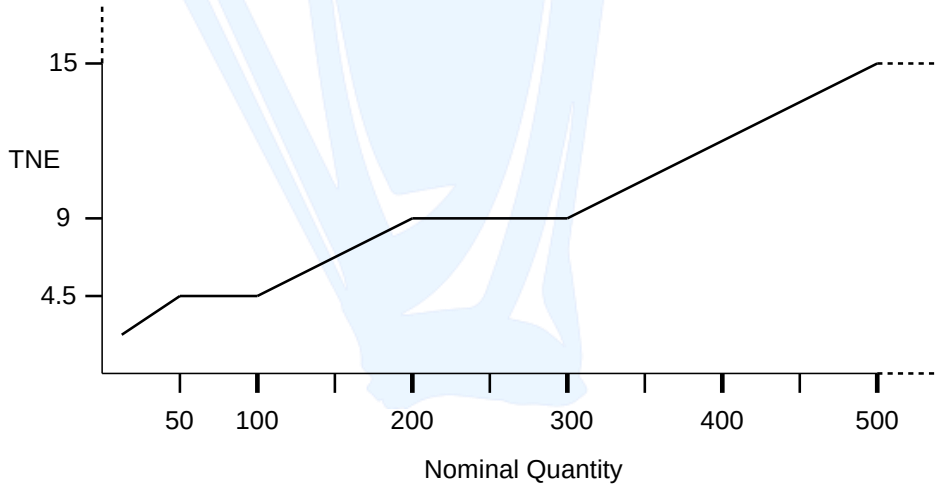
When a packer is using an automatic checkweigher the necessary records are usually part of the operation of the system. When using a non-automatic weighing instrument, the packer will need to have a documented sampling scheme and must maintain records of the samples. The guidance document makes recommendations about the sampling plans which can be used when samples are taken from production and also shows how the data can be analysed.

It is the duty of the packer to ensure that the equipment used for making up and checking packages remains accurate at all times.

It is accepted that for any given filling process there will always be some deviation of the pack to pack fill value. The legislation sets limits on these small deviations to ensure that they are within acceptable limits. An important concept is the 'Tolerable Negative Error' or TNE, which is calculated from the nominal quantity being packed; see table below from schedule 3 of the 2006 Regulations.

Nominal quantity in grams or millilitres	Tolerable Negative Error (TNE)	
	As a percentage of nominal quantity	g or ml
5 to 50	9	-
from 50 to 100	-	4.5
from 100 to 200	4.5	-
from 200 to 300	-	9
from 300 to 500	3	-
from 500 to 1,000	-	15
from 1,000 to 10,000	1.5	-
from 10,000 to 15,000	-	150
above 15,000	1	-

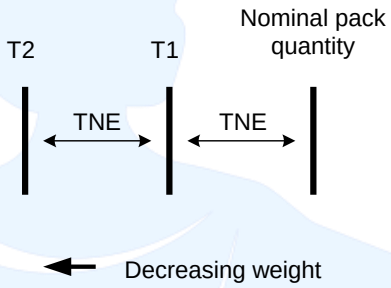
It can be seen from the table that as the nominal quantity increases, the banding of the TNE alternates between a fixed value and a percentage of the nominal weight. The graph below shows the effect of the banding over the 5g to 500g range.



When calculating the values for the percentage bands, the TNE should be rounded up to the nearest 0.1g

Given a nominal quantity and a TNE the tolerance limit, ‘T1’ and the absolute tolerance limit, ‘T2’ can be calculated.

Any package whose contents are less that the nominal quantity minus the TNE is referred to as a ‘non-standard package’.

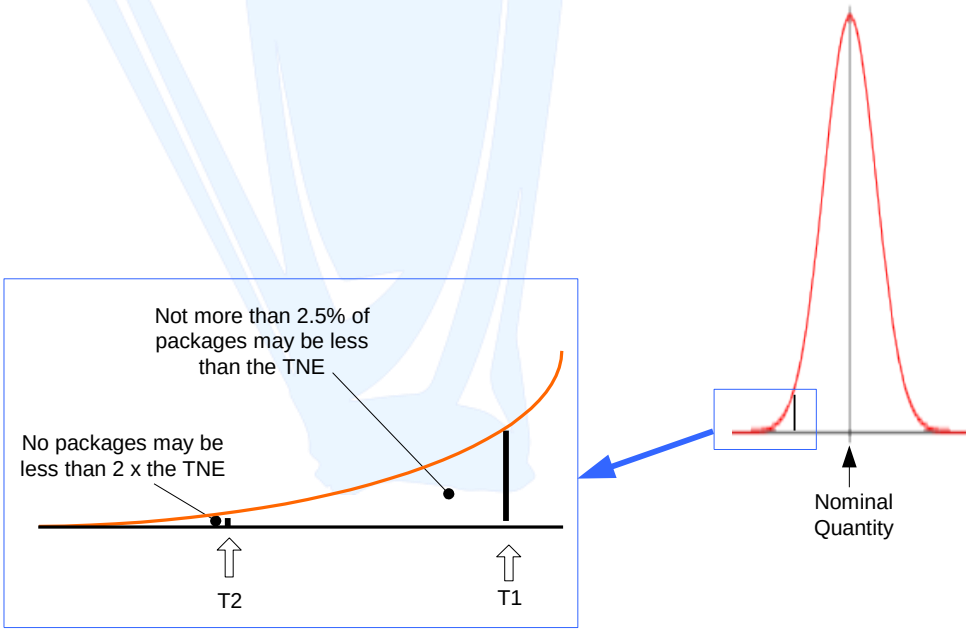


The three packers’ rules (taken from regulation 4 of the 2006 regulations) are:

(1) the contents of the packages shall not be less on average than the nominal quantity;
(2) the proportion of packages having a negative error greater than the tolerable negative error shall be sufficiently small for batches of packages to satisfy the requirements specified in Schedule 2 [of the Regulations];
(3) no package shall have a negative error greater than twice the tolerable negative error.

Note that previous regulations have given an explicit limit of 2.5% in rule 2 for the proportion of packages below T1, whereas the 2006 regulations give varying limits depending on the method of sampling and the sample size. However, in all cases in schedule 2, the acceptable limits equate to a value greater than 2.5%.

A graphical illustration of the T1 and T2 tolerance levels is given below. This shows the classic normal distribution of package weights from a filling system.



Equipment

Equipment used for making up packages, or for checking them after making up, must be suitable for the purpose and must comply with other relevant metrology legislation.

The 2006 regulations differ from the previous legislation in that there is no detailed description in the type of equipment that is permitted to be used. The determination of whether a particular piece of equipment is suitable will depend on the circumstances of the case and the nominal quantity of the product being packed. The size and capacity of the equipment must bear a sensible relationship in respect of the scale interval to the quantity being packed. The NMO guidance notes state that equipment that enables the quantity to be determined to 0.2 TNE will be appropriate. Less sensitive equipment can be used but greater allowance should then be given compensate for errors so leading to higher “give away” by the packer to compensate for those possible errors.

Using the recommended minimum scale division of 0.2 TNE, the following table can be derived:

Min scale division	Min TNE	Pack size
0.1g	0.5g	> 5.5g
0.2g	1g	> 11g
0.5g	2.5g	> 28g
1g	5g	> 112g
2g	10g	> 334g
5g	25g	> 1667g
10g	50g	> 3334g
20g	100g	> 6667g

Glossary

Nominal quantity, Q_n	The quantity marked on the container.
Negative error	The amount by which the actual contents fall short of the nominal.
Tolerable negative error, TNE	The negative error in relation to a particular nominal quantity, as defined by the regulations.
Tolerance limit, T_1	The nominal quantity minus the tolerable negative error, i.e. $T_1 = Q_n$ - TNE
Absolute tolerance limit, T_2	The nominal quantity minus twice the tolerable negative error, i.e. $T_2 = Q_n – 2*TNE$
Non-standard package	A package whose contents are less than the tolerance limit, T_1
Inadequate package	A package whose contents are less than the absolute tolerance limit, T_2
Target quantity, Q_t	The average contents which an operation is intending to produce.
Tolerance Under T_u	Packers in-house limit for under fill
Tolerance Over T_o	Packers in-house limit for overfill
Minimum target quantity Q_t (min)	The lowest level a packer can aim the average contents if he is to ensure compliance
Range	Difference between min. and max. in process unit.
Standard deviation	Describes the scattering of the individuals of the sample or long term.
Drift	Describes the scattering of the individuals of the sample or long term like standard deviation. Dimension is %. So this is a product independent value about the process-machine capability.
Batch	Number of packages of the same type forming a homogeneous collection for QC purposes.
Group	A number of packages of the same type and production run, forming the subject of the test.
Dimension	The used process unit (i.e. g, ml or kg, l).

References

The Code of Practical Guidance for Packers & Importers
The Weights and Measures (Packaged Goods) Regulations 2006
The Weights and Measures (Packaged Goods) Regulations 2006 – Guidance Note dated 6th April 2006, reference no URN 06/1087 – available from NMO

1.5.2 USE OF AUTOMATIC CHECKWEIGHERS

Whichever method of quality control is employed, it is essential that records are kept of all sampling checks and, in the case of checkweighers, that the average weight of all production batches is recorded. These records must be saved for at least one year or possibly longer depending upon the shelf life of the product. In addition, recording adjustment changes to filling machines will be included in the records, this has been mandatory since April 2006.

Automatic Checkweighers
Checkweighers have evolved over time from the simple grading checkweighers, which simply accepted or rejected packs on the basis of a single set point, to average recording checkweighers which calculate and display statistical information about the production process.

Grading checkweighers may still be used for packages that have a minimum weight requirement. They may also be used to remove inadequate packs on a product line complying with average weights, but control by sampling will still be required to ensure that the average weight is maintained, and that non-standard packs are properly controlled. Counting checkweighers introduced in the late 70s may still be used to ensure compliance with average weight requirements, providing that product assessment is carried out to establish a suitable target weight.

The majority of automatic checkweighers produced today are average recording checkweighers. These machines inspect every pack and remove non-standard and inadequate product, calculate and record the average weight for a given batch size, and operate a suitable alarm if the average weight falls below the nominal net weight. Many checkweighers can be set to always enable the packer to maintain the 3 Packers rules. With optional features such as automatic mean weight correction they can prevent a defective batch by controlling the average weight.

The same Average Recording Checkweighers may also be configured to inspect packages to minimum weight requirements.

Certification or pattern approval
In the UK, automatic checkweighers do not have to be certified or approved. Due to the requirements of the 1979 Weights & Measures Act the onus is on the packer to ensure that the machine in use is suitable for the application. Therefore, the packer must assess the performance of the machine by off line sampling, and then decide if an allowance is necessary due to the error of measurement.

Since October 2006, checkweighers fall under the control of the MID (Measuring Instruments Directive). The regulations implementation in the UK uses the optionality of the European Directive to keep Checkweighers as non-prescribed devices and therefore, there is no change from the former legislation above. Checkweighers for use in the UK market do not need to be approved. In doing this, the UK are taking advantage of the optionality of the Directive, which enables member States to choose whether to regulate instruments and to prescribe specific measurement tasks for which they must be used. This means that, as is currently the case, different member States may regulate different instruments and for different purposes than is the case in the UK.

A manufacturer wishing to export an instrument not prescribed in the UK to a member state, where such instruments are prescribed, would need to have the instrument assessed for Conformity.

Since the accuracy of an automatic checkweigher is highly dependent upon the package and the environmental conditions, the packer must assess the performance for all package types

and sizes. If the error calculated for a given package is greater than 1/4 TNE (Tolerable Negative Error) for that nominal net pack weight, then the packer must increase the T1 & T2 set points by an amount equal to 1/2 the error minus 1/8 of the TNE. If the variation in packaging weight (the tare weight) is excessive then a further allowance will be required. Where the standard deviation of the tare weight exceeds 1/10 TNE then the packer must add an allowance of 0.85 times the standard deviation of the tare weight.

Having established the accuracy of the checkweigher after installation, the packer must perform frequent checks on the machine to ensure that performance is maintained. The Code of Practical Guidance suggests that tests are initially carried out every hour or every 10,000 packs, until the performance and stability of the checkweigher has been established. The checks may then be relaxed to once per shift or once per day. If re-calibration is found to be necessary, then the frequency of testing must be increased once again until the problem is cleared and the machine performance stabilizes.

Many packers prefer to carry out checks every hour, so that if a problem occurs it can be rectified quickly. Many checkweighers have a check mode, a simple but effective check may be performed by passing a normal production pack over the machine 20 times. The checkweigher will then display the mean weight and give an indication of variance or deviation. By also weighing this test pack on standard bench scales, the mean error is calculated by finding the difference between the actual weight and the checkweigher average weight reading. The calibration process is designed to minimize mean error, so if this is excessive simply re-calibrate.

With the use of proven software connected to checkweighers, the accuracy of the checkweigher can be monitored and functions such as drift from nominal and standard deviation can be seen in real time and therefore allowing the checkweigher monitoring to be simplified.

The variation from one reading to another gives an indication of the random error. This is often expressed as 1, 4 or 6 times the sample standard deviation (although officially the zone of indecision is based upon 6 times the sample standard deviation). The random error is influenced by checkweigher repeatability; the stability, size & shape of the package and any disturbances such as vibration and air currents. Therefore, the random error cannot be improved by re-calibrating the machine. If the random error is higher than normal, check for sources of vibration (both internal to the checkweigher and externally generated), and check the condition of the transport components.

The reject mechanism should also be checked by passing an out of tolerance pack at regular intervals.

Summary

After installing a checkweigher, introducing a new package size to an existing line, or major service or repair to a machine, carry out checks to establish the mean & random error and record these values.

Check whether the zone of indecision (equal to 6 times the standard deviation) exceeds 1/4 TNE (make allowances to T1 & T2 set points if necessary).

During production, check the performance of the checkweigher & the reject device on an hourly basis. Compare results to limits established during initial assessment.

Document test procedures to ensure that all staff checks the equipment at the same frequency, in a consistent manner.

Record the results of all tests and the time, date and person who carried them out.

For average weight operation, ensure that the checkweigher produces a production batch report every hour or every 10,000 packs.

Save batch reports (or summary data from batch reports) for 12 months.

Discuss your methods & procedures with the local Trading Standards Officer.

1.6 VEHICLE WEIGHING

1.6.1 STATIC VEHICLE WEIGHING

Weighbridges are the work horses of modern weighing, providing valuable weight data from a diverse range of vehicle activities and having a major impact on overall efficiency, safety and profitability. The increased use of modern instrumentation, user-friendly software and communication technology is rapidly increasing the scope of weighbridges, thereby expanding their operational and data collection capabilities.

Certification
Weighbridges are classed as non-automatic weighing instruments (NAWIs) and if the weight data is used as part of any commercial or legislative transaction* they require approval to European weights and measures standards in accordance with directive 2009/23/EC. This Directive is implemented in the UK through the Non-automatic Weighing Instruments Regulations 2000 (SI 2000 No. 3236). Some users insist their weighbridges are weights and measures approved, even if they are not used for commercial transactions. This ensures that the weighbridges are maintained and certified for optimum precision.

**This includes checking vehicles for overloading. Weighbridges are also widely used at ports and terminals to ensure ships and ferries are correctly loaded.*

Statistics show that the average value of transactions conducted over weighbridges typically ranges from £200 for general waste and aggregate, up to £20,000 for chemicals and metals. Errors in weighbridge equipment can therefore have important financial implications for businesses. For example, based on 50 weighings per day, an error of just one 20 kg weight increment per transaction can cost between £10 and £300 per day.

Most weighbridges in the UK are approved to either 1 part in 2,500 (e.g. 50,000 kg with a minimum verification interval of 20 kg) or 1 part in 3,000 (60,000 kg with minimum verification interval of 20 kg). Higher resolution weighbridges are produced (e.g. 20,000 kg x 5 kg or 60,000 kg x 10 kg) but these are usually limited to indoor use because of the adverse affects of influence factors such as wind. For outdoor NAWIs, the OIML (R76) give a strong recommendation that *'a value of n = 3 000 should not be exceeded' with further recommendations that for 'road or rail weighbridges the verification scale interval should not be less than 10 kg'.*

This limit should also apply to each weighing range of combinations of instruments or of multiple range instruments or to each partial weighing range of multi-interval instruments.

Multi-range instruments are useful where weighbridges are used to weigh a range of vehicle types from cars or small vans up to trucks. A typical example would be where a 60,000 kg weighbridge provides a minimum verification interval of 10 kg for the first 30,000 kg after which the instrument automatically switches to an interval of 20 kg for the remainder of the range. This allows both smaller and larger vehicles to be weighed with the same proportional accuracy.

Once a weighbridge has been installed and verified, there is no legal requirement for the weighbridge to be reverified unless any repairs involve critical components such as load cells or weigh indicators. However, weighbridges are subject to inspection by Local Trading Standards Officers. These inspections involve full weight testing for linearity, hysteresis and eccentric loading. Checks are also made to ensure the weighbridge has not been replaced and that critical parts of the measuring chain are still 'as they were' at the last inspection. The frequency of the inspections is determined from a risk analysis study, which takes into account how and where a particular weighbridge is operated. Typically inspections will take place every

two to three years. Those installations designated as public weighbridges are inspected more frequently - usually at 6-8 month intervals. (Public weighbridges are those where the owner makes the weighbridge available for use by the general public and other businesses, usually on payment of a fee. In these circumstances, the weighbridge operator needs a certificate of competence which is issued by the local Trading Standards Office following an examination and test of the operators' competence. There are also specific requirements about record keeping.)

Calibration
Refer to section 3.3 of the Technical Articles.

Choice
Weighbridges come in a wide range of sizes and designs, manufactured from steel, steel-concrete composite and pre-stressed concrete. Designs include pit mounted, surface mounted, modular and portable. Typical capacities range from 30 to 100 tonnes, in lengths of 9, 15 and 18 metres. Widths typically vary from 3 to 4.5 metres. The common factor for all these variants is that they need to be robust, accurate and reliable. The majority of weighbridges are verified for trade use. Whether this is to check the weight of goods purchased or despatched, for onsite check for overloading or law enforcement. The choice for a particular application will depend on factors including maximum vehicle sizes and weights, available space, usage and, of course, budget. Most weighbridges are operated in a drive-through manner. In other words, the vehicles drive on at one end and off at the other. However, in applications where space is at a premium, vehicles may go on and off from the same end. For plants where vehicles are weighed in and out, the obvious choice is to operate two separate weighbridges. Not only does this streamline traffic flow, but it also gives the opportunity to service one bridge whilst keeping the other operational. However, this is clearly a more expensive option and in many applications one weighbridge is sufficient.

Load cells
Most mechanical weighbridges have now given way to fully electronic versions where the weighbridge deck or deck sections are supported on a number of strain gauge load cells, connected to weight instrumentation. Load cell types include traditional analogue and digital versions of column cells, double ended shear beams and cantilever beams. Digital load cells are growing in popularity, offering a number of installation and operational advantages. Load cell capacities must be selected so that they can support not just the deck and maximum weighing capacity, but also cope with overloaded vehicles, shock loads and excess loads when vehicles come onto or leave the weighbridge (including braking and acceleration forces). Load cell approvals (R60) specify a minimum verification interval v_{min} for particular models. The value of v_{min} divided by the square root of the number of load cells in the weighbridge, must be less than the minimum scale interval 'd'.
The mounting of load cells is crucial to ensure correct load introduction under all operating conditions and to prevent damage to the cells.

Weighbridge Types
Pit mounted weighbridges have weigh decks that are flush with the ground. As a result, they pose no restrictions to vehicle movement on site. Mechanical weighbridges were installed in pits so when these are upgraded or replaced, the new pit mounted weighbridges provide a very cost effective answer.

Surface weighbridges offer one of the strongest designs and the side frames ensure vehicles always drive centrally through the bridge. Approach and departure ramps can either be of steel construction or pre-cast in concrete on-site. Removable steel ramps have the advantage of being able to be moved with the bridge if relocation is required, leaving the site level.

Portable weighbridges have special load cell assemblies and feet, allowing temporary installation with minimum foundation preparation. Steel ramps provide vehicle access. Careful consideration must be given to the integrity and flatness of the mounting surface.
Concrete weighbridges can offer advantages for certain applications, for instance where corrosive liquids may be present or to avoid problems from spillages of oil based substances. Pour-on-site composite versions provide a cost effective solution for medium use operations. These consist of a steel outer frame, inner strengthening beams and reinforcing mesh. Once the unit is assembled on site, the ready mixed concrete is poured in and when the deck has cured, the load cells are fitted. Alternatively, the complete weighbridge can be constructed at the factory and delivered to site.

Weighbridges with modular or multiple decks are growing in popularity, especially as steel prices continue to increase. Although they incorporate more load cells than single piece bridges, this cost is more than offset by the reduction in steel costs. Furthermore, because the modules are constructed in lighter steel they are easier to handle, transport and install.

Environmental Considerations
Weighbridges are expected to operate in the harshest of environments, fully open to the elements. Therefore, a well structured finishing procedure is essential to provide optimum longevity. In a typical coating process, all steel is shot-blasted to remove mill scale and surface imperfections prior to painting. This ensures maximum adhesion of the surface coating applications. In parallel, sound design principles ensure a well drained deck and no hidden traps underneath where corrosion can occur. For maximum protection, the underside of the weighbridges should be coated in a proprietary self-sealing water repellent coating. Hot dip galvanised steel work offers the best protection for applications in particularly harsh environments.

Load cells should be weld sealed with glass to metal cable entry to provide sealing to IP67 minimum. Cables should be protected against abrasion, heat and rodent damage.

Lightning can cause serious damage to weighbridge components, with the deck acting as an ideal receptor for the huge voltages generated during electric storms. Damage can be limited by using load cells with built-in lightning protection and implementing a good earthing regime in and around the weighbridge.

If weighbridges are installed in designated hazardous areas they must meet ATEX requirements. Refer to section 1.8 on hazardous environment applications.

Construction
Weighbridge decks should be constructed to ensure minimum deflection under all loading conditions. Excessive deflection can affect weighing accuracy and introduce premature fatigue failure.

The foundations of any weighbridge are crucial to their performance. It is of little use having the most accurate load cells and well designed weighbridge structure if the foundations are unlevel or unstable. For pit weighbridges, adequate drainage is also important to prevent flooding. Where applicable, it is possible to install weighbridges on sloping terrain using special steel wedges in the load cell mounting assemblies, or adapted mounting kit assemblies for certain types of load cells.

Significant end to end forces can be generated when vehicles drive on and off the weighbridge, especially if heavy braking occurs. Such forces can damage critical components such as load cells and can also cause serious damage to the surrounding structure. Built-in restraints restricting end-to-end and side-to-side movement are therefore an important part of any weighbridge design.

Instrumentation
In the simplest standalone layout, the weighbridge is typically linked to a basic weight indicator. This will allow rudimentary weighing processes to be carried out and allow operators to initiate zero, tare and print functions (if a suitable ticket or tally roll printer is connected).

For more complex applications the weight indicator may have pre-programmed function keys, memory recall and a key pad for data entry. Interface cards may offer further integration with modern communication protocols including Ethernet. The indicator may provide the capability to operate with more than one weighbridge.

In legal for trade approved installations, regulations relating to the compatibility of modules must be complied with. (See section 3.1)

Modern technology
Traditionally the weighing process in many weighbridge applications has been relatively slow and data collection has been confined to local printouts of tickets and daily tally rolls. Now more emphasis is being placed on developing key peripheral areas. This is aimed at speeding up throughput of vehicles, improving security and extending weighbridge operational periods, together with improving and simplifying data collection and distribution. Technologies employed include Ethernet communication for remote access, automatic vehicle recognition systems, smart card or key readers, wireless interfacing, the world wide web and GSM. Bespoke, yet configurable, software packages can now be tailored for specific applications and are designed for the seamless integration with existing management systems such as ERP.

Driver operated systems
Driver operated systems (often referred to as unmanned weighbridge systems) have been one of the most effective developments for weighbridge operational efficiency. Such systems offer a number of advantages and remove the need to have permanently manned weighbridges. Operation is usually via a designated swipe card or key and the unit provides a complete material handling management system which is easy to use by both vehicle and site operators. Not only does the system speed up weighing operations, but it also extends the available working period for weighbridges. Terminals are located alongside the weighbridge for easy driver access. Operational conditions will dictate if there are terminals at both ends of the weighbridge. Where applicable, the terminal may have two identical displays at different levels to accommodate different vehicles. The terminals must be given suitable (and substantial) mechanical protection to avoid physical damage from the vehicles driving across the weighbridge.

There are essentially two modi operandi, colloquially known as double weighing and single weighing.

Double weighing is carried out on vehicles not registered in the database for a particular site. In this case, the driver stops the vehicle on the weighbridge and either swipes the card or presents the key to the terminal. The terminal then stores the weight and issues a ticket with the inbound weight data. After loading or unloading has taken place, the driver returns to the weighbridge and, having presented the card or key again, receives a ticket automatically calculating the weight of material delivered or collected.

In the single weighing mode, when a card or key for a known vehicle is presented, the terminal retrieves previously stored data relating to that vehicle's registration number and tare weight. Using this information, the terminal then issues a ticket showing the calculated net weight of material being delivered or collected, thereby removing the need for a second weighing.

Data from such systems can be distributed as required within the site or to a central location off site via land line, mobile phone or email to designated recipients. Rapid and effective data

collection allows rapid invoicing without the problems associated with manual transcription to spread sheets.

Vehicle recognition

Vehicle recognition systems are effective in increasing vehicle throughput at weighbridges whilst introducing an effective security system. They are particularly effective at remote sites and at those where 'out-of-hours' weighing is required, where they are used in conjunction with driver-operated terminals. Recognition technologies employed include automatic number plate recognition systems using cameras and those which rely on the vehicles being fitted with transponders containing key vehicle details.

For automatic or remote weighing in a typical system, the weighbridges usually have entry and exit barriers. Vehicles approaching the entrance are picked up by the camera and the number plate is checked against the database. If the vehicle is registered it is allowed through the first barrier onto the bridge to be weighed. At this point the driver presents his card or key at the control terminal positioned outside the window and this initiates the weighing.

Simple 'command prompts' guide the driver through the weighing process and as soon as the weighing has been successfully carried out, the vehicle is allowed off the weighbridge. Such systems can also maintain a current and historical record of vehicles on site, allowing a comprehensive vehicle movement log to be maintained at both single and multiple sites.

Service and support

Service and support is a critical issue for weighbridge operators especially for equipment working in harsh environments. New developments are bringing important changes to the way in which servicing can be optimised and this is particularly useful at remote unmanned sites. Any weighbridge breakdowns have a rapid and major impact on daily operations and therefore, effective servicing and trouble shooting is very important. However, traditional methods of servicing do not necessarily cater for the changes in the working pattern of a particular weighbridge. Typically, estimates are made to establish the frequency of servicing, often with the emphasis on minimising costs.

Most of us are familiar with the built-in service monitors on modern cars, which assess servicing requirements based on a combination of factors including time, mileage and how the car is driven. This technology is now available for weighbridges advising, for instance, when the next service is due based on time, number of weighments or a combination of both. The system can also record a history of peak loads, which may be above normal operating capacity and detrimental to the working of the bridge. This information can be useful in determining why, for instance, a particular weighbridge is going out of calibration or suffering from excessive component failure.

Although regular servicing and maintenance can help to minimize problems, predicting what and when things will go wrong is very difficult with traditional analogue weighbridges. Digital load cell technology offers remote maintenance service support capability, which can save considerable time and effort especially for equipment operating in harsh, remote areas.

With such a system installed, any problems with the weighing equipment are automatically flagged up at the supplier's offices. Details are immediately forwarded to the local engineer who can then dial into the weighing system remotely and make a risk assessment of the situation. In many cases, the engineer can carry out a range of checks and, where possible, rectify the problem without having to visit the site. If not, then if appropriate, plans can be made to carry out any remedial work during the next scheduled visit, thereby minimising the disruption to the site operation.

Conclusion

Modern weighbridge systems can offer considerably more than weight information and their integration with other technologies is bringing dramatic changes to a wide range of industries. However, the quality of the data they provide is still totally dependent on sound mechanical design principles and well defined installation procedures.

1.6.2. IN-MOTION VEHICLE WEIGHING

The weighing of vehicles on an axle-by-axle basis is vital to ensure correct weight distribution, as well as compliance with the maximum gross vehicle weight limits permitted in the UK.

Each overloaded axle is considered by the enforcement authorities as a separate offence in law, as is the gross weight and operators, and drivers of commercial vehicles therefore have an obligation to ensure that the maximum allowed axle weights for their vehicle are not exceeded. Operators may be liable for significant fines for overloading, and persistent overloaders may also have their operating licence curtailed or suspended at the discretion of the traffic commissioners. Vehicle prohibition is also being routinely used to prevent overloaded vehicles from moving until the load is redistributed or removed.

This is particularly costly for companies working to 'just in time' delivery schedules, as contracts may be cancelled as a result of this significant delay.

Conventional platform weighbridges, particularly surface mounted systems, are obviously perfect for producing accurate gross weights, but are frequently unsuitable for obtaining axle weight information and so other technologies have to be considered.

Axle weighing systems are available in both static and in-motion versions the latter being particularly suited to weighing long multi-axle combinations where correct positioning of an individual axle for static weighing may be difficult and time-consuming.

With in-motion systems, vehicles can be driven over the weighing platform at speeds normally restricted to 5 kph and a display and print out of each axle weight and the accumulated gross weight is readily available. On the latest systems, the legally permitted weights for each vehicle type are stored in memory and an instant overload warning is produced when appropriate.

These systems were first available in the early 1960's and quickly found a niche as front line law enforcement tools with over 70 systems being installed at strategic locations around the country by the then Department of Transport.

The systems were designed strictly for Law Enforcement and Non-Trade weighing applications and a typical weighing accuracy was ±100 kg per axle.

Developments in loadcell technology and faster processing speeds of modern instrumentation have dramatically improved the accuracy of these systems to the point where a few manufacturers have achieved the 0.5% accuracy needed for O.I.M.L and EC approval Class III for trade use, as an In-Motion Road Vehicle Weighbridge. In-motion weighbridges cannot be Type Approved and Verified for use for trade as there are no regulations covering them as such, they are often however, Type Approved and verified as "static" weighbridges.

These systems are being increasingly used for commercial weighing of low value products such as waste and building materials, whilst also ensuring these vehicles do not contravene the Road Traffic Act in respect of weight distribution.

Many thousands of systems have been installed world-wide as law enforcement agencies and fleet operators alike take advantage of this low cost technology to weigh vehicles of any size and weight in a matter of seconds. Unlike the conventional platform weighbridge, the axle weigher cannot be outgrown and with a capacity of up to 40,000 kg per axle, vehicles of upwards of 240,000 kg can be weighed with ease.

The conventional weighbridge still has its place where high accuracy is demanded but the axle weigher fills an important gap for fleet operators who need to resolve a security or overloading problem quickly and cost effectively.

In recent years, there has also been a substantial growth in the demand for portable weighing systems for fleets of all sizes.

A wide choice of systems is now available and unlike their earlier relations, portability is no longer a problem. New aircraft specification aluminium is now used to great effect to produce systems, which can be easily transported and installed by one man in a matter of minutes. The systems usually consisting of two weighing platforms are placed on a level surface and again, a choice of static or in-motion technology is readily available. The later models may also incorporate cable free RF technology, which allows the user to read the axle weights at a distance of up to 40 metres from the weighing devices. This is particularly important in inclement weather where the weighing console can be located in a vehicle adjacent to the weighing area and the system operated from internal batteries or the vehicle battery system.

Site levels do play a vital role in the performance of both static and in-motion, fixed and portable axle weighing systems. This is largely overcome by careful site construction or the provision of roll out levellers for the portable systems, which remove much of the weight transfer created within mechanical suspension systems as vehicle wheels are driven up on to the weighing platforms.

In the case of permanent axle weighing installations, a distance of 4m before and after the weighing equipment is required to be constructed in concrete to a surface tolerance of +/-3mm. The balance of the approaches for a vehicle's length before and after the weigher needs to be on a consistent gradient, but the surface levels are not as vital, and in most cases do not need any additional reconstruction. (Except in the case of enforcement installations where a strict Code of Practice for the construction of the site applies.)

These systems provide a valuable cost effective alternative to the conventional platform weighbridge and their size and weight dramatically reduces transportation, installation and maintenance costs.

References

OIML Recommendation R134 "Automatic instruments for weighing road vehicles in motion. Total vehicle weighing."

1.7 AUTOMATIC WEIGHING INSTRUMENTS

A full discussion of automatic weighing instruments is outside the scope of this issue of the Technical Articles. However, a brief summary is presented here.

All non-automatic weighing instruments (NAWIs) are governed by the NAWI regulations, whether used for controlled applications or not. In contrast, automatic weighing instruments (AWIs) are only subject to control if they are in use for trade and they are a prescribed type having specific regulations.

Automatic weighing instruments have recently come under new regulations implementing the Measuring Instruments Directive (the MID). The following types of instrument are prescribed for trade use in the UK and an EC type approval will be performed according to the Essential Requirements of the Directive; the instrument will then need to be verified before it can be taken into use:

Continuous totalising automatic weighing instruments (belt weighers)	The Measuring Instrument (Beltweighers) Regulations 2006 – SI 2006 No 1259
Automatic catchweighing instruments	The Measuring Instrument (Catchweighers) Regulations 2006 – SI 2006 No. 1257
Automatic gravimetric filling instruments	The Measuring Instrument (Automatic Gravimetric Filling Instruments) Regulations 2006 – SI 2006 No. 1258
Automatic rail-weighbridges	The Measuring Instrument (Automatic Rail-weighbridge) Regulations 2006 - SI 2006 No. 1256
Discontinuous totalising automatic weighing instruments (totalising hopper weighers)	The Measuring Instrument (Automatic Discontinuous Totalisers) Regulations 2006 – SI 2006 No. 1255

Automatic weighing instruments of these types which were type approved and verified under the previous national regulations can continue in use for trade and can be re-verified to those regulations, although they are now repealed as far as new instruments are concerned.

See also section 1.1 on controlled applications which includes a definition differentiating between non-automatic and automatic instruments and the various sections under 1.4 on type approval and verification.

1.8 INDUSTRIAL PROCESS WEIGHING IN HAZARDOUS AREAS

EXPLOSION PROTECTION
In addition to the type approval and certification of industrial weighing systems concerned with accuracy, equipment that is also used in a 'Hazardous Area' must be certified as compliant with the requirements of the Standards for "Explosion Protection". Such requirements provide for its safe use in an area in which a potentially explosive mixture of gas, vapour, mist or dust may be present due to the operation of an industrial process.

European Standards for Explosion Protection are applied to the design, construction, selection, installation, operation, inspection and maintenance of such equipment put into service in the United Kingdom (and indeed throughout Europe).

A common misconception is that any ATEX-approved components can be connected together to form a system. However, it is important to show that the compatibility of the various components have been assessed and that the complete system is compliant.

The plant owner's perspective
It is the industrial plant owner's responsibility (hereafter referred to as the owner) to define the hazards that may be present on their plant by undertaking 'Area Classification'. This process has to be done in accordance with, and by applying, the British Standard, BS EN 60079 Part 10.

Area classification will form part of a risk assessment that is used to determine the likely locations of the hazard(s) and the likely duration. Where there is a higher probability of presence for a longer period of time, the higher the reliability of the type of explosion protection is required. The result is to classify the hazardous areas of the plant into Zones:-

Non-hazardous area: An area in which no explosive gas/air mixture is expected (often referred to as 'Safe Area').

Zone 0, 1, 2 (for Gases, vapours and mists)
and/or
Zone 20, 21, 22 (for dusts).

The definitions of these are provided for reference at the end of the section.

The nature of the hazard(s); the ease of flammability, and other physical properties of the ignitable substances appearing in the zones, will need to be known such that the ignition prevention requirements of suitable apparatus may be specified:-

- the Apparatus Group, i.e. II, IIA, IIB or IIC
  and
- the Temperature Rating, i.e. T1, T2, T3, T4, T5 or T6

These are defined in the Standard BS IEC 60079 Part 0 or EN50014, which cites the general requirements for explosion protection in hazardous areas (other than mines).

Once known, the owner can purchase weighing apparatus that is certified to be adequately safe in the appropriate zones of use.

The manufacturers' approach

The manufacturers offer weighing equipment that is certified to European Standards for Explosion Protection. There are a number of different types of protection that may be used depending on a variety of factors. The type of protection used defines the permitted zones of use; according to the Standard BS EN 60079 Part 14: Installation of explosion protected apparatus in hazardous areas.

One of the most common types of protection used for electronic industrial weighing applications that are made suitable for integration into process control systems is known as "Intrinsic Safety". This is referred to as 'I.S.' or, more correctly now, 'Ex i'. It requires that circuit design is made incapable of causing the ignition of flammable atmospheres. This is achieved by reliably limiting the levels of energy and power, even under specified fault conditions, in apparatus and circuits entering a hazardous area. The construction Standard to which apparatus is certified as compliant is EN50020.

Ex ia circuits are permitted in Zone 0 (the most onerous degree of hazard), or Zone 1 and 2.
Ex ib circuits are only permitted in Zones 1 and 2.

The explosion protection marking seen on apparatus, say, EEx ia IIB T4 (which is also referred to as it's safety code) can be interpreted as meaning:-

EEx: Explosion protected to conform to a European Standard
ia: Permitted to be mounted or connected into a Zone 0
IIB: Permitted to be mounted or connected into hazardous areas requiring IIA or IIB grade of apparatus
T4: Permitted to be mounted or connected into hazardous areas where the hazard's ignition temperatures are not below 135ºC (Maximum ambient temperatures limits must also be observed.)

Often, a weighing application comprises several component hardware modules:-

- the system power supply;
- the operator control;
- local and/or remote ancillary devices such as printers, indicators etc.; and
- the weighing platform, incorporating the loadcell(s).

These component modules, together with any cabling and junction boxes, are interconnected to provide the function that the purchaser needs for the application.

Intrinsically Safe Apparatus

Some or all of these modules may be located in one or more zones of the hazardous area depending on the application. They must be marked with appropriate safety codes indicating how each module is protected. Intrinsically safe apparatus is marked 'Ex i'. Where a module is marked, typically "[EEx ia] IIC", the square brackets indicate that it is 'Associated Apparatus' and MUST be mounted in a safe area, although it is connected to apparatus in the hazardous area according to the manufacturer's instructions.

Some intrinsically safe weighing systems use external mounted 'Shunt Zener Diode Safety Barriers' (Barriers) that are located in between the Hazardous Area mounted modules (usually loadcells) and the Safe Area modules. These are the safety devices that specifically limit the fault energy and power available to the hazardous area circuits to within safe limits. These are normally mounted in enclosures in the safe area and also require connection to a suitable earthing system (known as an Intrinsic Safety Earth) in accordance with the Installation Standard BS EN60079-14:2003.

Weighing systems may be battery-operated and can be self-contained for mounting completely in the Hazardous Area. Where there is a facility for charging the battery whilst in the Hazardous Area, or for bringing out communication signals to external weighing equipment mounted in the Safe Area, barriers will also be required to interface the signals between areas.

In other cases, the energy limiting circuits (the function performed by the Barriers) are built into the electronics of the modules. In these cases, safety earthing may or may not be required, depending on the design and the safety certification, which will state if it is necessary. In all cases, the manufacturer will supply installation information which must be followed.

Other types of protection

In some cases, other types of explosion protection may be used for some modules or parts of the weighing system. These could be as listed below with a brief description of how they prevent ignition of a surrounding flammable atmosphere:

Ex p, Ex o, Ex q and **Ex m** are considered as “separation” techniques; the use of inert gas, liquid, semisolid (particulate) or solid media, respectively, to surround an ignition capable electrical arrangement. Thus, contact with a flammable gas/air mixture is physically prevented. An additional effect is that heat generated by the arrangement may be dispersed through the media. Arcing and sparking may be quenched by the fluid medium in the case of Ex o.

Ex e and **Ex n** avoid being ignition capable by considering the mechanical design and layout of an electrical arrangement. Electrical components are mounted in an enclosure. A flammable gas/air mixture is not specifically prevented from entering and surrounding the internal electrical components. The design prevents the electrical arrangement from causing ignition by the elimination of sparking and control of heating effects. Although it is thought that they use the same basic concepts, the philosophy is very different between the two types and these must not be confused. Ex e apparatus is carefully designed and constructed so as to completely prevent any sparking effect occurring. In addition, the heating effects caused by the conduction of electricity are reduced. It is therefore of much higher integrity than Ex n, which simply relies on normal industrial design to avoid excess heating and sparking with little additional precautions taken and no faults considered.

Ex d permits ignition to occur inside a strong enclosure where a gas/air mixture may enter and be ignited by ignition-capable electrical equipment contained within. The resultant flame must not be transmitted to the outside surrounding atmosphere through any joint. Thus the enclosure is said to be ‘flame-proof’ and is designed to withstand the force of an internal explosion.

Ex s is applied where none of the above types of protection are actually used but ignition prevention is adequately guaranteed.

The Installation

It is the owner’s responsibility to ensure that equipment is installed correctly. This is also in accordance with the Standard, BS EN 60079 Part 14. Thereafter, its safe operation will be determined by the requirements of the apparatus certification depending on the type of explosion protection used. The manufacturer’s instructions must also be followed where safety is concerned.

After installation, the equipment must be operated safely and properly maintained to ensure its continued safe operation for the life of the installation, according to existing health and safety Law. The requirements for an initial inspection to verify the correct installation and then subsequent periodic inspections are given, together with some guidance, in another Standard, BS EN 60079 Part 17.

An 'Intrinsically Safe System'
Where pieces of Ex i-certified apparatus are connected together using cables, they form an 'Intrinsically Safe System'. The combination of apparatus must be correctly matched together and shown to meet the Ex i requirements. This is in accordance with Standard, BS EN 60079 Part 25, which is known as the 'Systems Standard'.

Where a manufacturer or weighing equipment supplier provides a standard range of intrinsically safe apparatus-certified devices that are connected together in an application, a Systems Certificate may have been obtained from a testing authority. This is not mandatory for the manufacturer. If obtained, such a certificate permits the safe interconnection of that apparatus and provides information, such as maximum cable parameters, that the installation in the hazardous area must meet. The systems certificate cannot state the actual installation conditions, as they are unique to each given application.

The Systems Standard requires the production of a 'Descriptive System Document' (DSD). This details the safety considerations of the actual installation. Its purpose is to demonstrate that all aspects of the installation meet the Ex i requirements and are therefore safe. Suggested formats are included in the Standard for guidance.

The DSD must include information from the apparatus certification, provided by the manufacturer or supplier of apparatus. It may cite a system certificate, if there is one, but must show that the apparatus, when connected together, meets the system requirements for Ex i and that the maximum cable parameter values have not been exceeded.

The owner is ultimately responsible for the preparation of the DSD; the manufacturer may provide much of the required initial safety information, such as that stated on the individual apparatus certificates. The installer, who may, of course, be a third party, may be required to complete the DSD as part of their contractual obligations. The document is then passed on to the owner. It is always the owner's responsibility to ensure the safety of the installation. The DSD is effectively the means by which safety is proved.

The DSD is therefore a key document. It is subsequently used for inspection and maintenance because it details all the safety aspects of the given application.

Other types of protection
Other types of protection, for example; Ex d, e, n and/or p, may be used on a weighing arrangements or a part of them depending on the application and suitability. This is much less common than Ex i. The requirements for that type of protection must be followed for installation and maintenance purposes. Whilst no DSD is required, safety must be described as required by the ATEX Directives.

ATEX and DSEAR
In the UK, as from 1st July 2003, all explosion protected apparatus provided by manufactures and suppliers must comply with the ATEX Directives. In addition, any hazardous area installation commenced after this date must comply with the requirements of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR). As from 1st July 2006, existing installations must be shown to comply with ATEX and DSEAR.

In essence, these Directives and Regulations merely formalise the requirement for users to put into place properly documented safety assessments and solutions such that plant risks are adequately minimised. It requires that personnel are adequately trained and supervised. Management systems must be in place for a safe system of work, such that risks are identified and controlled. A 'responsible person' shall be appointed to oversee these matters.

The DSD's for all Ex i circuits shall be included, together with other safety related documents, in a justification of safety, often referred to as a 'Safety Case', as required by the DSEAR. The

Safety Case describes the hazards and the management of all related activities that show how steps are taken to minimise the risks posed.

Conclusion
The Standards and Directives mentioned in this section cover a specific situation where equipment is used in Hazardous Area. This is in addition to Standards for weighing accuracy. Personnel who design, install, operate and maintain a plant in which potentially explosive atmospheres can exist should be familiar at appropriate levels with these Standards. The emphasis is on good management and adequate training to understand the risks and the precautions taken for safety.

Reference section
Relevant Standards are listed in Section 2.3.5 (ATEX documentation)

Definition (and determination) of Zones is to BS EN 60079-10

Zone 0	An area in which an explosive gas/air mixture is continually present or present for long periods
Zone 1	An area in which a gas/air mixture is likely to occur in normal operation
Zone 2	An area in which a gas/air mixture is not likely to occur in normal operation, and if it occurs, it will exist only for a short time
Zone 20	An area in which combustible dust, as a cloud, is present continuously or frequently, during normal operation, in sufficient quantity to be capable of producing an exposable concentration of combustible dust in mixture with air, and / or where layers of dust of uncontrollable and excessive thickness can be formed.
Zone 21	Zone 21 is a Zone not classified as Zone 20 in which combustible dust, as a cloud, is present continuously or frequently, during normal operation, in sufficient quantity to be capable of producing an explosible concentration of combustible dust in mixture with air.
Zone 22	Zone 22 is a Zone not classified as Zone 21 in which combustible dust, as a cloud, is present continuously or frequently, during abnormal operation, in sufficient quantity to be capable of producing an explosible concentration of combustible dust in mixture with air.

Apparatus Grouping

Required Hazardous Area Apparatus Group (determined by ease of ignition of hazardous gas in BSEN60079-20)	Apparatus Group useable I the Hazard
IIC	IIC Only
IIB	IIC and IIB
IIA	IIA, IIB and IIC

'Temperature Rating'

Temperature mark on apparatus	Maximum surface temperature to which gas has access
T1	450°C
T2	300°C
T3	200°C
T4	135°C
T5	100°C
T6	85°C

[If no other mark appears on the apparatus it is assumed ambient temperature range is –20°C to +40°C.]

1.9 SOFTWARE

General
Unless you are using a completely mechanical weighing instrument, it's almost certain that it is controlled by software in one form or another. It would also be fair to say that if your system uses a weight only instrument then there is software within the other areas that will also require consideration.

Apart from the obvious requirement that the software controls correctly, it is imperative that the software is secure. Security is required to ensure that changes to that software can either not be carried out, or, if changes are made then there is an indication. This security can also encompass both stored and transmitted data to provide confidence in its validity.

Once a weighing instrument or, say an EPOS device, has been type approved, certain aspects of the operating software is classified as legal metrology relevant and the approval restrictions will be applied to it. Changes to these areas are not permitted without authority and possible changes in the type approval certificate (weighing instruments) or the EC test certificate (EPOS software).

The software used in weighing instruments and other systems, for example an EPOS system, is often divided into two categories, legal metrology relevant and non-relevant to facilitate practical future development.

Legal metrology relevant software
The legal metrology relevant areas of the software will include those processes or routines that deal with the metrology data or the control of data to and from this area. For example, procedures that calculate weight data from raw A/D data, procedures that process and store calibration, and even the procedures that ensure that valid data comes from the A/D and valid weight data is passed on for processing. This classification would include procedures in an EPOS system, as well as a weighing instrument, which takes weight information and calculates prices.

It is important that these procedures are not accidentally altered. Equally as important is the need to prevent malicious alterations, but today's use of normal computers and high technology tools make this almost impossible, so it has become necessary to provide a means of tamper indication.

The most secure form of software is that which is contained in ROM or some other form of one-shot memory and is recognised as "embedded". Although secure, it is necessary that these components are either sealed in position or that some form of tamper indication is available.

Those instruments that use a PC for processing also use freely programmable software. This form of software is perceived as the most vulnerable to both accidental and malicious attack. A common security measure is to provide an indicator in the form of a checksum or CRC. This information is published in the certificate and the system provides a means of comparison.

Software submitted for approval must be produced in a controlled fashion, usually demonstrated by a form of issue version identification. Any alteration to the status of a software package should be reflected in a change to its version identification and submitted for any relevant changes to the certificate.

Non-relevant software
It would be unreasonable to require changes to a certificate if a software modification did not affect its legal metrology relevant area. For example, changes to move the position of an

item on the screen or to alter a colour feature. This type of software is not relevant to the legal metrology; therefore, it need not be included within the security measures. It is still necessary to maintain some form of modification control and in these cases it might prove useful to use an issue identification system that clearly indicates the use of separated software. For example, the first issue of the software could be identified as **Issue 01.01** where the number to left of the point would relate to the legally relevant part of the software and the number to the right to the non legally relevant part; the Type Approval Certificate would then say that any software with an issue number 01.xx. is acceptable. Thus when the non-legally relevant part of the software was updated, e.g. to alter the position of some information on the screen, the software issue identification would be updated to **Issue 01.02** but it would still be acceptable under the Type Approval Certificate.

Controlled updating

With today's technology, it is possible to carry out remote updates to software in the field. If this is to be carried out, updates either direct or remote must be authorised and controlled. Remote updating poses a number of questions, the most important of which are, has the update been completed successfully and does the instrument or system still operate correctly?

References

WELMEC 2.3 Guide for Examining Software
WELMEC 7 Guidelines for Examining and Testing Interfaces and Peripheral Equipment
WELMEC 7.2 Software Guide (Measuring Instrument Directive 2004/22/EC)
BS EN 45501

1.10 METRICATION

When the UK joined the EEC, one of the obligations it took on was to implement the EC Directives relating to units of measurement. The EC produced a number of Directives on this subject, culminating in Council Directive of 20 December 1979 on the approximation of the laws of the Member States relating to units of measurement (No 80/181/EEC).

This Directive made it compulsory for EC Member States to use only metric units of measurement “for economic, public health, public safety or administrative purposes”.

A number of derogations were negotiated by various UK Governments, but finally, on 1st January 2000, it became mandatory to only use metric units for trade purposes. At first, enforcement of this compulsory metrication was patchy to say the least, and a number of high profile Court cases challenging the legality of compulsory metrication clouded the issue. Finally, however, on 3rd February 2004, the European Court of Human Rights issued a judgment that made it clear that compulsory metrication was lawful and that no individual had suffered a violation of the rights and freedoms set out in the European Convention on Human Rights. This ended any opposition and since then enforcement of metrication has gone ahead quietly and generally quite efficiently.

There is a little confusion still existing, due to one final concession negotiated in 1999. Under the concession, pre-packaged goods marked with the quantity in metric units can also carry a “supplementary indication” of quantity in other units, such as the “lb” or the ounce. This was agreed basically to allow packers to dual mark products for sale in both Europe and USA, as the USA still requires pre-packs to be marked with quantity in imperial units. The concession for supplementary indications also means that it is possible for weighing instruments that indicate quantity in both metric units and imperial units **at the same time** to be Type Approved and then verified. What is clear is that weighing instruments that primarily indicate in Metric units, but can, by means of a push button or other command, indicate in Imperial units as an alternative, do not fulfil the supplementary indication criteria, and as such cannot be Type Approved or verified. The European Commission has now indicated that the concession to allow the use of supplementary units, which was due to end in 2010, will be made permanent.

As most beer drinkers will know, there is a notable exception to the compulsory use of metric units for trade purposes; the pint is still a legal unit for dispensing draught beer and cider, and strangely, it can still be used for selling pre-packed milk in returnable containers (bottles to you and me).

1.11 CE MARKING

Ironically, the main objectives of CE marking are to remove barriers to free trade within the EU, though the process is seen by many manufacturers as a burden. The underlying intention is that products bearing the CE mark may be traded freely within the EU. The guide to the New Approach Directives (introduction) states:

> *"Member States must presume that products bearing the CE marking comply with all the provisions of the applicable directives providing for its affixing. Accordingly, Member States may not prohibit, restrict or impede the placing on the market and putting into service in their territory of products bearing the CE marking, unless the provisions relating to CE marking are incorrectly applied.!*

Manufacturers of any products to be placed on the market must ensure that those products comply with all relevant directives and the CE marking indicates compliance with those directives. The definition of CE mark in the Decision 768/2008/EC reads:

> *"a mark by which a manufacturer indicates that the product is in conformity with the applicable; requirements set out in the Community harmonisation legislation provided for its affixing:"*

The source legislation requiring CE marking is rather fragmented with; Council Decision 768/2008/EC providing overall requirements for conformity assessment and affixing the mark, Directive 93/68/EEC amending the relevant sections of the specific technical directives, and the individual technical directives themselves. The specific technical directives that typically would have to be considered for weighing equipment include:

2004/108/EC	Electromagnetic compatibility (EMC) directive	General electrical equipment
2006/95/EC	Low voltage directive	Equipment designed for use with a voltage rating between 50 and 1000V a.c. and/or 75 and 1500V d.c.
2009/23/EC	Non-automatic weighing instruments directive	Weighing instruments used for controlled applications
2006/42/EC	Machinery directive	Equipment with powered moving parts and machinery accessories
93/42/EC	Medical Devices	Instruments used for the purposes outlined in the Directive

It is the responsibility of the manufacturer to determine which directives are applicable. The guide to the New Approach directives gives a full list of directives that require CE marking. In addition to the CE marking, a declaration or certificate of conformity must be produced, identifying the directive(s) concerned and any technical standards used.

Conformity assessment

Council Decision 2008/768 EC describes 8 different methods (modules) of conformity assessment, which may be combined, resulting in quite a complex scheme. However, it is the individual specific technical directives that determine the method(s) of conformity assessment(s) to be used for each. To identify these methods, the original directives must be combined with the amendments listed in Directive 93/68/EEC.

In practice, there are two different general principles: either the manufacturer makes a declaration of conformity based on the equipment design, examination and testing (where testing may be carried out by a third party and a test report produced), or in addition to the manufacturer's declaration, a notified body issues a type-approval certificate for the product and each unit is then tested, affixed with the identification number of the notified body performing the tests, and issued with a certificate of conformity (unit verification).

References

Guide to the implementation of directives based on the New Approach and the Global Approach.
Council decision 2008/768
Directives 93/68/EEC, 90/384/EEC, 98/37/EC, 2004/108/EC, 2006/42/EC, 2006/95/EC

1.12 ROHS AND WEEE DIRECTIVES – APPLICATION TO WEIGHING INSTRUMENTS

WEEE Directive

The WEEE Directive 2002/96/EC as amended by Directive 2003/108/EC has been implemented in UK regulations Waste Electronic and Electrical Equipment Regulations 2006.

The intention of the Directive is to promote the re-use and/or, recycling of electrical and electronic equipment at the end of its normal life, or where this is not possible reduce pollution by requiring the environmentally sound disposal of such equipment. Targets are set for the amount of re-use and recycling that should be achieved.

The Directive imposes the responsibility for financing the treatment of waste electrical and electronic equipment (WEEE) on Producers. A Producer is a person or organisation that:

- manufactures and sells electrical and electronic equipment under his own brand or,
- resells under his own brand equipment produced by others or,
- imports or exports electrical or electronic equipment on a professional basis into a Member State.

A number of approved Schemes have been set up under which the Scheme Operator arrange for the collection, transport and treatment of WEEE on behalf of Producers. These Schemes are responsible for ensuring that WEEE is collected and dealt with correctly and that the mandatory recycling and re-use targets imposed by the Directive are achieved. All Producers were required to initially register with one of the Approved Schemes by the 15th March 2007 and thereafter annually. At the time of initial registration, the Producer must supply the Scheme with accurate data concerning the total weight of electrical and electronic equipment that he has placed on the UK market in the calendar year 2006. The Producer must also state the split between equipment intended for use by consumers and that intended for professional use. Producers may change Schemes if they wish but must do so by the 30th October in any year and they will then remain in the new Scheme. Failure to register with a Scheme will be an offence.

Retailers, i.e. those who sell equipment direct to consumers, will be required either to offer a take-back service, whereby a consumer buying a new piece of equipment can give an old item of equipment performing the same function to the retailer to dispose of safely, or to join a retailer Scheme whereby facilities are provided where consumers can safely dispose of electrical and electronic equipment without charge. There is no direct equivalent for Producers selling equipment for professional use, but they will be required to fund the safe disposal. (Producers may reach a contractual agreement with their professional customers under which, the user will assume the responsibility for the cost of safe disposal, but how this will be monitored and controlled is not yet known.)

The UKWF has reached an arrangement with WEEE Link, one of the Approved Schemes to provide WEEE registration and systems for the weighing industry. UKWF Members are of course free to register with any of the Schemes. Not all members, however, will need to register and those who do register should be aware that not all of their products come under the scope of the WEEE Directive. The following extract from the notes of a meeting between the UKWF and WEEE Link explain the position:

> *"Agreed that the following items are outside the scope of the regulations as they are not supplied directly to end user (except possibly as spare parts in which case they are still outside the scope of the regulations)*
>
> - *Indicators*
> - *Load Cells*

- *Other peripheral equipment (e.g. remote display units)*

Agreed that weighbridges that are intended to be connected to, or form part of control systems (e.g. incoming and outgoing weighbridges incorporated into a waste treatment plant control system), are at the moment classified as being part of a fixed installation and, as such, are outside the scope of the regulations.

It is likely that this exemption will be removed during future amendment of the EC Directive; however weighbridges also fall under the heading of large scale stationary industrial tools and thus, will remain exempt. However, such equipment will fall under Category 6 of Schedule 1 to the regulations and as such, will be subject to the RoHS Directive; this is not considered to be a major problem as the vast majority of electrical / electronic components used in weighing instruments are only available in RoHS compliant form.

(NOTE: These exemptions do not apply to portable weighbridges)

Similarly, large capacity dormant platform machines are also regarded as exempt."

RoHS Directive

The RoHS Directive has recently been recast as Directive 2011/65**.** The new directive defines the same ten groups of instrument as the previous directive and the WEEE directive. The important change is that, although previously exempted, all types of non-automatic and automatic weighing instruments will fall within either category 8 or 9 of annex 1 of the Directive (Category 8. Medical Equipment; Category 9. Monitoring and control instruments, including industrial monitoring and control instruments.)

At present, the implementing regulations are still "The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2005". It is likely that the regulations implementing the new directive will be introduced in 2013 and will implement the effect of the changes by 22nd July 2014.

The following table outlines whether the RoHS Directive (2011/65/EC) will have effect on different types of weighing equipment:

Weighing Machine Type / Description	WEEE Category	RoHS Applies?
Non-automatic Weighing Instruments		
Stand alone retail weighing instruments	9	Yes
Stand alone industrial weighing instruments	9	Yes
Stand alone retail weighing instruments with in-built printer	9	Yes
Stand alone industrial weighing instruments with in-built printer	9	Yes
Retail weighing instruments with networking capability	9	Yes
Industrial weighing instruments with networking capability	9	Yes
Retail weighing instruments incorporated in EPOS Systems	3	Yes
Retail weighing instruments connected to computers for data management purposes	9	Yes
Industrial weighing instruments connected to computers for data management purposes	9	Yes
Retail Weighing Instruments connected to cash registers for cash handling purposes	3 or 9	See Note 1 below
Domestic weighing instruments (Kitchen / bathroom)	2 & 9	Yes
Medical weighing instruments	8	Yes
Automatic weighing instruments		
Gravimetric Filling Machines	9	Yes
In-motion Rail Weighbridges	9	Yes
Discontinuous Totalisers	9	Yes
Continuous Totalisers	9	Yes
Checkweighers	9	Yes
Weigh/Price Labellers	9	Yes

It is impossible to provide a detailed list of weighing instrument types because there are now so many variants and options possible, however, the descriptions listed above should encompass the vast majority of equipment. In the event that a particular instrument does not fall precisely within one of the descriptions listed above or has additional features / facilities to those listed, then the following test should be applied:

- Is the primary function of the instrument weighing for use for trade (as defined in Section 7 of the Weights and Measures Act 1985) or weighing for one of the controlled applications set out in Article 1.2.a of the NAWI Directive 2009/23/EC in a professional environment? If so, the instrument will be considered as falling within category 9 and will therefore be exempted from the RoHS Directive.

(Note: This is one of those awkward cases where there is no clear answer and the situation would need to be judged on a case by case basis. If, for example, the weighing instrument and cash register were sold together and the cash register was capable of working even if

the weighing instrument were switched off, then it would be difficult to distinguish this case from a typical POS system. If, however, the weighing instrument was the primary unit and had the ability to produce a totalised receipt but the use of a simple cash drawer was optional, then it may well be that the weighing instrument is still exempt from the RoHS Directive.)

The Federation is grateful to the NMO for their guidance in this matter. The Federation accepts and understands that the interpretation of legislation is, in the final instance, a matter for the Courts and that the guidance from the NMO is given on that understanding. Members are advised to seek their own legal advice should they have any serious doubts or questions on aspects of the legislation.

1.13 THE WASTE BATTERIES AND ACCUMULATORS REGULATIONS 2009

The regulations apply to Producers of all types of batteries and accumulators, regardless of shape, volume, weight, composition or use. Both disposable batteries and rechargeable batteries (accumulators) are covered.

"Producers" are defined as "any person in the UK that, irrespective of the selling technique used (distance sellers included) places batteries **including those incorporated into appliances or vehicles** on the market for the first time in the UK on a professional basis." So if you manufacture batteries in the UK or import equipment into the UK for sale in the UK, and that equipment contains a battery, no matter how large or small that battery may be, you are regarded as a battery producer. The obligations you have depend upon whether you are dealing with "portable batteries" or "industrial batteries".

Portable battery means any battery or battery pack which is:

- Sealed
- Can be hand-carried by an individual person without difficulty and
- Is neither an automotive battery nor an industrial battery.

(Remember it is irrelevant whether the battery is an individual item or incorporated into the product (such as a button type battery on a printed circuit board in a computer or weighing machine) the person placing that product on the market in the UK for the first time is regarded as the battery producer.)

Producers who place more than one tonne of portable batteries on the market in a year **must** join a Battery Compliance Scheme (similar to the WEEE schemes that already exist). The scheme will then deal with your registration with the Environment Agency, collect and collate data from members, pay the fees and then recharge their members accordingly. Details of approved schemes can be found on the Environment Agency website (www.environment-agency.gov.uk).

Small producers, i.e. those placing less than a tonne of portable batteries on the market in a year need to register with the relevant environment agency (if you have not yet registered you should do so immediately), and report their sales data to the agency by the 31st January each year. Small Producers have no collection, treatment or recycling obligations.

There is one other aspect to consider. If you are a **Distributor** of portable batteries, you will have an obligation to take back portable batteries. You are regarded as a Distributor of Portable Batteries if you sell portable batteries to end users professionally. So, for example, if you sell portable batteries as spares for your products you are a Distributor and if you sell more than 32kg of batteries per year then you have an obligation to accept back waste batteries without charge.

Industrial Battery means any battery or battery pack of any size or weight which is:

- designed exclusively for industrial or professional use, or
- unsealed but is not an automotive battery, or
- sealed but is not classified as a portable battery

The obligations on Producers of Industrial Batteries are a little more onerous. They are:

- The producer must register with BERR
- Take Back of waste batteries from January 2010. Take Back must be
    - free from an end user if you supply new industrial batteries to that end user during the calendar year, or

  - free from an end user on request when that end user is unable to return waste industrial batteries to his supplier – the battery must be of the same chemistry as those that the producer places on the market, or
  - free from any end user that is unable to dispose of waste industrial batteries by either of the two methods above.
- Publish on or before 1st December each year how an end user of industrial batteries may request take back of waste industrial batteries
- Ensure that waste industrial batteries for which they have taken responsibility are delivered to and accepted by an approved battery treatment operator or exporter.
- Report annually to BERR the total tonnage, and the chemistry, of industrial batteries placed on the UK market
- Report the tonnage and chemistry information on batteries collected and delivered to an approved treatment operators.
- Keep records for 4 years and make them available to BERR on demand.

A producer's obligation to take back batteries does not end once he has taken back the amount of batteries he has placed on the market.

Disclaimer

The above notes are NOT an authoritative Guide to the Regulations; they are intended for brief reference only on the principles. For detailed Guidance you are strongly recommended to obtain the Government Guidance Notes referred to above.

References

More detailed guidance on these Regulations can be found in Government Guidance Notes which can be downloaded from the web-sites of BERR (www.berr.gov.uk) DEFRA (www.defra.gov.uk) or the Environment Agency (www.environment-agency.gov.uk).

1.14 MEDICAL WEIGHING

Introduction
The Non-automatic Weighing Instruments (NAWI) Directive was made part of UK law on 1 January 1993. The Directive not only controls the technical and performance characteristics of NAWI, but also specifies which tasks require the use of "controlled" NAWI. One of those specified tasks is:

> *"Weighing patients for the purposes of monitoring, diagnosis and medical treatment"*

This means that from 1 January 2003, when the full effects of the Directive come into force, all new weighing instruments used for medical weighing will have to comply with the requirements of the Directive. These notes are intended to make users and purchasers of medical weighing instruments aware of the requirements.

The Non-automatic Weighing Instruments Regulations 2000
The Directive is implemented in the UK by the Non-automatic Weighing Instruments Regulations 2000. Under these Regulations, the design of medical weighing instruments must be approved by a Notified Body (in the UK this is the National Measurement Office) and all product from the production line must be individually verified for conformity and accuracy by a Trading Standards Officer or other approved verifier. Each instrument must be covered by a Declaration of Conformity and bear the 'Green M' label indicating conformity with the Directive and the Regulations.

Medical weighing instruments purchased and in use before 1 January 2003 can continue in use indefinitely, even though they may not meet the requirements of the NAWI Regulations.

Medical weighing instruments not used for medical practice, for example in health clubs, fitness centres and slimming clubs, do not have to conform to the NAWI Regulations.

From 1 January 2000, only metric units have been legal for controlled purposes. Weighing instruments that have both metric and imperial (lb. & oz.) indications can continue in use, but the Notified Bodies have told us that they will not be granting Type Approval for new models unless they have both indications available at the same time.

Accuracy Classes
The Regulations define 4 accuracy classes. Classes I and II are for very high accuracy instruments, Class III for weighing scales in general use for trade and Class IIII where a lower level of accuracy is acceptable, such as weighing waste or ballast. The maximum permissible error (mpe) on the weighing instrument is related to its accuracy Class and its resolution (division size).

Selection of Accuracy Class for Required Applications
The UKWF believe that Class IIII scales only have sufficient accuracy for the checking of a patient's weight for record purposes, as typically carried out in the GP's consulting room. Where a weighing result is required for diagnostic purposes or treatment, we recommend that a Class III instrument should be used.

In hospitals, there is a multiplicity of weighing scales used for both critical and non-critical weighing and for weighing babies through to obese adults. We recommend that whatever the intended application of the scales, only Class III instruments are used in hospitals. Scales are often moved from department to department, and that could result in inappropriate Class IIII instruments being used for more critical applications.

Recommended Minimum Classes for specific applications

Purpose:	Hospitals	Hospital associated medical centres	Ante / Post Natal Clinics	Medical Practice Treatment Rooms	GP Consulting Rooms	Mobile / Visiting Health care	Nursing Homes
Monitoring	III	III	III	III	IIII	IIII	IIII
Diagnosis	III	III	III	III	III	III	III
Treatment	III	III	III	III	III	III	III

Selection of Class III Weighing Scales for a required application

Within the Class III accuracy specifications, there is a range of accuracies that may be chosen. In some instances, even a Class III specification may not be accurate enough for a particular medical requirement. Accuracy is generally proportional to the size of weighing interval and purchasers should take this into account when making their choice.

Recommended maximum scale interval for specific applications

	Adults	Young Children	Babies
Checking weight for records	500g	200g	50g
Regular monitoring to assess weight change	200g	100g	10/20g
Measuring weight to assist medical diagnosis	200g	50/100g	10/20g
Measuring weight for critical treatment eg dialysis	50/100g	20/50g	5g
Recording birth weight			20g
Measuring weight before and after breast feeding			10g
The above figures were taken from a limited survey of medical practitioners and specialist scales distributors			

CE Marking

All instruments conforming to the Directive must carry the ‘Green M’ label as well as the CE mark. (They will also have a 4 digit number indicating the organisation responsible for the verification of the instrument.) Weighing instruments that do not conform to the NAWI requirements may bear the CE mark to demonstrate conformity to other EC Directives such as the EMC, Low Voltage and Medical Devices Directives, but such instruments cannot legally be used for medical purposes.

Enforcement

Enforcing the regulations will be the responsibility of Trading Standards Officers (TSOs) from the local Council. They will have the power to enter premises and inspect and test weighing instruments. If the instruments are outside the permitted error allowance, the TSO may have them put out of use straight away. We recommend that medical establishments ensure that their weighing instruments are calibrated at yearly intervals to ensure they hold their accuracy to the required standards.

1.15 CRANE SCALES

Crane scales are to be regarded as lifting equipment and legislation treats them as such. The Lifting Equipment Regulations 1998 (LOLER) came into force on 5th December 1998 and cover all crane scales and Loadlinks. They implement the Lifting provisions of the Amending Directive to the Use of Work Equipment Directive (AUWED, 95/63/EC). The Regulations apply in all premises and work situations subject to the HSW Act and build on the requirements of the Provisions and Use of Work Equipment Regulations.

LOLER requires that all crane scales are:

Strong and stable enough for the particular use and marked to indicate safe working load
The regulation requires that (a) machinery and (b) accessories are clearly marked to **indicate** their safe working loads (SWL). Most 'traditional' lifting equipment, i.e. machinery and 'conventional' accessories, should be marked *with* the SWL, as should other equipment which presents similar risks.

Positioned and installed to minimise any risks
The crane scale should sufficiently strong, stable and suitable for the proposed use. Similarly, the load and anything attached (e.g. timber pallets, lifting points) must be suitable and positioned or installed to prevent the risk of injury, e.g. from the equipment or the load falling or striking people.

Used safely i.e. the work is planned and organised by competent people
The person appointed to plan the lift (referred to as the 'competent person') will normally be an in-house employee. They should have adequate practical and theoretical knowledge and experience to plan the lifting operation properly. The plan should address issues such as "the lift" remaining safe for the whole of the operation, i.e. from where the load starts to where it finishes.

Subject to ongoing thorough examination and, where appropriate, inspection by competent people
The crane scale should be checked:

1) When lifting equipment is first 'supplied', (i.e. used for the first time by that employer);
2) Periodically during the lifetime of equipment
3) Following exceptional circumstances

It is usual practice for the competent person carrying out a thorough examination to be employed by a separate company, e.g. a third party examining company. However, the regulation does not prohibit an employer from selecting a member of its own staff to carry out thorough examinations provided that he/she is competent.

In capacities of up to 50T, crane scales must have an ultimate strength of 5:1 and when first supplied, must be proof tested before calibration. Generally, proof testing involves loading the crane scale three times with a load of 2 x SWL.

Once the crane scale is proof tested, calibration is performed in the usual way, tested at equal points through the range and adjusted, as required.

References
The Lifting Operations and Lifting Equipment Regulations 1998, SI 1998 No. 2307.
Simple Guide to LOLER – download from the HSE website.
Safe use of lifting equipment. Lifting Operations and Lifting Equipment Regulations.
1998. Approved Code of Practice and guidance L113.
HSE Books 1998 ISBN 0 7176 1628 2.

2. DOCUMENTATION

CONTENTS LIST

2.1 LEGAL METROLOGY DOCUMENTATION

EC Directives
EC directives oblige member states (through the Treaty of Rome) to incorporate their requirements into national law. One of the objectives is to remove barriers to free trade and promote free movement of goods and services within the EU. They also make it easier for nations outside the EU to trade with member states as there is one set of standards rather than differing regulations between each nation.

Most of the directives that apply to weighing equipment are “new approach” directives. As such, the directives are limited to specifying the “essential requirements”. Conformity with these requirements may be met through specific technical solutions identified in separate “harmonised standards” or “normative documents”. One other characteristic is the requirement for CE marking to show that the equipment conforms to the requirements each of the applicable directives.

The principle of having separate harmonised standards or normative documents allows the technical details to be produced by specialist technical groups (such as, CEN, CENELEC, ETSI and OIML) rather than having to pass through the full EU legislative procedure. There is a “presumption of conformity” in that if the equipment complies with the relevant standard or normative document, it is presumed to conform to the essential requirements of the directive. Note: The normative document route is only applicable to automatic weighing instruments.

In theory, a manufacturer has the option of not working to the specified standard or normative document but proving through other means that the equipment conforms to the essential requirements of the directive. In practice this would be a very arduous method.

Acts and Regulations
The primary legislation in the UK has traditionally come from the Weights and Measures Act 1985 for GB (with similar provisions for NI). Various sections within the Act authorise the Secretary of State to make regulations and orders for specific weights and measures matters.

For the implementation of EC Directives, these are transposed into UK law under the 1972 European Communities Act (ECA). An example of this is the Non-automatic weighing instruments regulations 2000, which implement the NAWI directive 2009/23/EC

The W&M Act and the ECA and the associated regulations and orders form the national metrological legislation. All other documentation (i.e. directives, standards, guides etc.) only have indirect legal relevance.

WELMEC
WELMEC is a collaboration of national legal metrology organisations across the member states of the EU (European Union) and EFTA (European Free Trade Association). Various committees within WELMEC address specific subjects and produce guides on the implementation of European legislation. WELMEC is consulted in the formation of European legislation and hence plays a major part in its content. Additionally, members will be heavily involved in their own national legislation.

Although the WELMEC guides have no legislative powers themselves, if the guidance within them is followed, it can be assumed that an application complies with the essential requirements of the directive. However, if an approach is adopted that does not follow the guidance or even contradicts it, any application will have to provide very thorough proof that it is compliant and undergo very rigorous examination.

OIML

The International Organisation of Legal Metrology (OIML) is an intergovernmental treaty organization consisting of the legal metrology authorities of member states, established to promote the global harmonization of legal metrology procedures. Member authorities will work to the standards defined by OIML.

The OIML website states “Cooperative agreements are established between the OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML Publications and those of other institutions”. To illustrate this, the content of European harmonised standard EN45501 for NAWIs is taken directly from OIML R76, the International Recommendation for NAWIs, and OIML definitions are referred to directly in Directive 2009/23/EC, whereas the content of normative document on automatic gravimetric filling instruments is based on OIML R61, the International Recommendation for AGFIs.

OIML produce various publications including International Recommendations such as R76 Non-automatic weighing instruments and R60 Metrological regulation for load cells. Issuing Authorities established by OIML Member States may provide OIML certificates and test reports indicating compliance with the relevant recommendation. Any certificate must be registered with OIML and there is a fee for this registration. Although acceptance of OIML certificates by national metrology services is voluntary this is now widespread.

2.1.1 EC DIRECTIVES

Listed below are the key EC Directives that are linked to the weighing industry. They will also appear in section 2.1.2, which covers how they are regulated and implemented in UK legislation.

Directive 2009/23/EC on Non-automatic Weighing Instruments
The directive consists of 19 articles and 8 annexes. Article 1 includes the definition of a non-automatic weighing instrument and the often quoted second clause (article 1.2(a))providing a list of categories of use, for which the essential requirements of the directive must be satisfied. The remainder of the articles are largely administrative or procedural and refer to the annexes.

The annexes form the bulk of the directive. Annex I specifies the essential requirements that must be satisfied for all categories listed in article 1.2(a). The essential requirements specify the criteria that must be met (for example the maximum permissible errors) but not the methods of testing and proving conformity. Detailed test methods are specified in the relevant harmonised standard which is EN 45501 (equivalent in content to OIML R76).

The remainder of the annexes cover type approval, verification, notified bodies, documentation and markings required.

Directive 2004/22/EC on measuring instruments
The Measuring Instruments Directive (MID) consists of 27 Articles and a large number of Annexes. The MID covers a whole range of measuring equipment, including automatic weighing instruments of the following types:

- Automatic Gravimetric Filling Machines
- Automatic Checkweighers
- Automatic Catchweighers
- Continuous Totalisers
- Discontinuous Totalisers
- Automatic Rail Weighbridges

The MID contains general and instrument specific “essential requirements” (Annex 1 plus MI Annexes) which the equipment must meet it is used for controlled applications. However, unlike the NAWI Directive which details applications that must be controlled in all Member States, the MID leaves it up to each Member State to define the applications that it will control. If a Member State decides not to control a particular type of automatic weighing instrument, it cannot then impose any country specific requirements. For example, the UK has decided it will not control automatic checkweighers and therefore, a manufacturer can place any design of checkweigher on the UK market without the need for any form of Type Approval or verification. As well as the general essential requirements in Annex 1, for example for automatic gravimetric filling instruments, these can be found in Annex MI-006, Chapter I and Chapter III.

Other Annexes deal with the various forms of conformity assessment, including Type Approval, Design Examination, and verification. Requirements in relation to notified bodies technical documentation and markings required can be found in the directive itself.

OTHER METROLOGICAL DIRECTIVES

71/317/EEC on 1 g to 50 kg medium accuracy weights

74/148/EEC on weights from 1 mg to 50 kg of above medium accuracy

73/360/EEC on non-automatic weighing machines

Superseded by 2009/23/EC (the NAWI Directive).

75/410/EEC on continuous totalizing weighing machines
Superseded by the MID.

78/1031/EEC on automatic checkweighing and weight grading machines
Superseded by the MID.

References

All of the directives are available from the commission website for legislation (EUR-Lex): http://eur-lex.europa.eu/en/index.htm

Note that the first part of the number of a directive (2 or 4 digits) represents the year of issue and the second is the document number. The most direct method of finding a document is to search by “Natural number” and enter the two figures.

2.1.2 ACTS AND REGULATIONS

The Weights and Measures Act 1985
The primary legislation governing weights and measures in GB is the Weights and Measures Act 1985. This supersedes all previous weights and measures acts. The equivalent for NI is the 1981 Northern Ireland Order.

The Act includes the following:

- Units and standards of measure with requirements for holding national, local and working standards for the UK
- Requirements for weighing and measuring for trade, transactions of goods, and packaged goods
- Definition of offences and possible defences
- Roles and responsibilities of various bodies and individuals including the Secretary of State, the Department of Innovation, Universities and Skills (in practice implemented through NMO), Local Weights and Measures Authorities, and Inspectors
- Authority for the Secretary of State to make Orders and Regulations for specific matters

The Act also includes various schedules which are enabled by specific sections within the main body and contain more detailed information such as definitions of units of measure, lists of units which may be used for trade and those which may not, primary standards, etc.

The European Communities Act 1972
The primary legislation used to implement European Directives e.g. in the field of legal metrology, for the UK is the European Communities Act 1972 (ECA).

Unlike the W&M Act, all provisions in relation to the control of weighing and measuring instruments are contained within the Regulations themselves.

REGULATIONS

Non-automatic Weighing Instruments Regulations 2000, SI 2000/3236 implements under the ECA directive 2009/23/EC on non-automatic weighing instruments and provides the structure for metrological control in the UK. This includes an expansion of controlled applications from “use for trade” as defined by the W&M Act 1985 to include other uses such as medical weighing and application of laws and regulations, as well as type-approval and unit verification procedures described by the NAWI directive. Separate in use provisions made under the W&M Act cover how NAWI can be used on the GB market place. Equivalent in use provisions exist for NI.

The Weighing Equipment (Non-automatic Weighing Machines) Regulations 2000, SI 2000/932 consolidate and revoke a series of previous regulations on non-automatic weighing machines and provide the provisions for control on the use of existing machines with GB national approval in GB. Equivalent provisions exist for NI.

Weights Regulations 1986, SI 1986/1683 define the specifications for “traders” weights in GB; denominations, markings, shapes and limits of error. Equivalent provisions exist for NI.

The Weights and Measures (Local and Working Standard Weights and Testing Equipment) Regulations 1986, SI 1986/1684 as amended by SIs 1991/1775 and 1994/1851 provides, in sections 4 and 5, for certain aspects of the standards and equipment used by inspectors (Trading Standards Officers) to be set out in Regulations. These aspects include the limits of error and intervals between calibrations. Equivalent provisions exist for NI.

Measuring Instruments (EEC Requirements) Regulations 1988, SI 1988/186
Implemented under the ECA the following directives:

- 71/316/EEC on common provisions for both measuring instruments and methods of metrological control
- 71/317/EEC on weights from 5 g to 50 kg of medium accuracy
- 73/360/EEC on non-automatic weighing machines
- 74/148/EEC on weights from 1 mg to 50 kg of above medium accuracy
- 75/410/EEC on continuous totalizing weighing machines (Superseded by the MID)
- 78/1031/EEC on automatic checkweighing and weight grading machines (Superseded by the MID)

REGULATIONS AMENDING THE W&M Act 1985

The Units of Measurement Regulations 1986, SI 1986/1082 consolidate and revoke previous regulations and define units of measurement. They do not affect the units which may lawfully be used for trade but simply provide definitions.
Section 8(5)(b) updated (regulation 10).

The Weights and Measures Act 1985 (Metrication) (Amendment) Order 1994, SI 1994/2866 together with SI 1994/2867 (below) end the authorised use, except in specified circumstances, of imperial units of measurement.
Section 8(2) and Schedules 3 to 7 amended.

The Units of Measurement Regulations 1994, SI 1994/2867
Sections 1, 3 and 27 and Schedules 1, 5 and 11 amended (The Units of Measurement Regulations 1986 also amended).

The Deregulation (Weights and Measures) Order 1999, SI 1999/503 provides for self-verification of machines by an approved verifier within GB and requires acceptance of machines tested by “official testers” elsewhere in the European Economic Area (EEA) by an Inspector.
Sections 11, 14, 16, 74, 75, 79, 84 and 94 amended; new sections 11A, 11B and 15A and Schedule 3A added.

The Units of Measurement Regulations 2009, SI 2009/3046 amend the Weights and Measures Act 1985 by removing a deadline of 31 December 2009 for the end of the authorised use of non-metric units in conjunction with metric units.

REGULATIONS GOVERNING AUTOMATIC WEIGHING INSTRUMENTS
Part A below details the GB Regulations that applied to automatic weighing instruments that were in use before the Measuring Instruments Directive came into force on 30th October 2006 and continue to apply to those instruments outside the scope of MID. Although now superseded in relation to MID instruments, these Regulations continue to apply to that equipment whilst it remains in use. Any equipment that has a national Type Approval under the 1985 Weights and Measures Act can continue to be manufactured, verified and taken into service until the Type Approval Certificate expires.

Part B below details the UK Regulations, implementing the provisions of the Measuring Instruments Directive, under the ECA, that relate to Automatic Weighing Instruments (AWIs). The instrument specific regulations provide the structure for metrological control in the UK. Separate in use provisions made under the W&M Act cover how AWIs can be used on the GB market place. Equivalent in use provisions exist, in most cases, for NI.

PART A
The Weights and Measures Regulations 1963, SI 1963/1710
Although mostly revoked by succeeding regulations, still governs dynamic axle weighers (road).

The Weighing Equipment (Filling and Discontinuous Totalising Automatic Weighing Machines) Regulations 1986, SI 1986/1320
Automatic weighing equipment:
- filling instruments (gravimetric filling instruments now approved under SI 2000/388)
- discontinuous totalisers

The Weighing Equipment (Automatic Gravimetric Filling Instruments) Regulations 2000, SI 2000/388
Automatic gravimetric filling instruments which sub-divide from bulk into pre-determined quantities

The Weighing Equipment (Beltweighers) Regulations 2001, SI 2001/1208
Beltweighers (continuous totalising automatic weighing machines). Replaced SI 1983/914

The Weighing Equipment (Automatic Rail-weighbridges) Regulations 2003, SI 2003/2454
Automatic rail-weighbridges

The Weighing Equipment (Automatic Catchweighing Instruments) Regulations 2003, SI 2003/2761
Automatic catchweighers, e.g. weigh-price labellers, garbage weighers, front-end loaders

PART B

The Measuring Instruments (Automatic Discontinuous Totalisers) Regulations 2006; SI 2006/1255

The Measuring Instruments (Automatic Rail Weighbridges) Regulations 2006; SI 2006/1256

The Measuring Instruments (Automatic Catchweighers) Regulations 2006; SI 2006/1257

The Measuring Instruments (Automatic Gravimetric Filling Instruments) Regulations 2006; SI 2006/1258

The Measuring Instruments (Beltweighers) Regulations 2006; SI 2006/1259

The Measuring Instruments (Non prescribed Instruments) Regulations 2006/1270
These regulations provide for the conformity assessment i.e. approval and verification, of instruments not prescribed in the UK e.g. checkweighers, by, or on behalf of, UK notified bodies, which are regulated on other Member States markets.

2.1.3 WELMEC DOCUMENTATION

The principal aim of WELMEC is to establish a harmonised and consistent approach to European legal metrology. Currently 30 countries are represented on the WELMEC committee and the contact details for these individuals can be found on the following website: http://www.welmec.org/

Much of WELMEC's work is done by its Working Groups. These groups produce guidance documents which are important for the manufacturers and suppliers of weighing instruments, and are detailed below:

Guide	Title	Version	Produced by
1	An Introduction to WELMEC	5	Secretariat
2	Directive 90/384/EEC: Common Application	4	WG2 (Weighing instruments)
2.1	Guide for Testing Indicators	4	WG2 (Weighing instruments)
2.2	Guide for Testing Point of Sale Devices	3	WG2 (Weighing instruments)
2.3	Guide for Examining Software	3	WG2 (Weighing instruments)
2.4	Guide for Load Cells	2	WG2 (Weighing instruments)
2.5	Guide for Modular Approach and Testing of PCs and other Digital Peripheral Devices	2	WG2 (Weighing instruments)
2.6	Guide for the Testing of Automatic Catchweighing Instruments	3	WG2 (Weighing instruments)
2.7	Explanations and Interpretations	1	WG2 (Weighing instruments)
4.1	Guide for Notified Bodies performing Conformity Assessment of Measuring Instruments	2	WG4 (EN4500 standards)
5.1	European Directory of Legal Metrology	-	WG5 (Market supervision)
5.2	Guide on market surveillance	2	WG5 (Market supervision)
5.3	Risk Assessment Guide for Market Surveillance: Weighing and Measuring Instruments	1	WG5 (Market supervision)
6	Introduction to WELMEC documents on "e"-marked pre-packages	3	WG6 (Pre-packages)
6.1	Application of Directives 75/106/EEC and 76/211/EEC concerning the marking and quantity control of “e”-marked pre-packages: Definition of terms	1	WG6 (Pre-packages)
6.2	An Application of Directives 75/106/EEC and 76/211/EEC concerning the marking and	1	WG6 (Pre-packages)

	quantity control of “e”-marked pre-packages: Translation of terms		
6.3	Guidance for the Harmonised Implementation of Council Directive 76/211/EEC	2	WG6 (Pre-packages)
6.4	Guide for packers and importers of e-marked pre-packed products	1	WG6 (Pre-packages)
6.5	Guidance on Controls by Competent Department’s on “e”-marked Pre-packages	1	WG6 (Pre-packages)
6.6	Guide for the recognition of procedures	1	WG6 (Pre-packages)
6.7	Guidance for Market Control of Pre-packages for Competent Departments	1	WG6 (Pre-packages)
6.8	Guidance for the verification of drained weight, drained washed weight, and deglazed weight and extent of filling of rigid food containers	1	WG6 (Pre-packages)
6.9	Pre-packages - Uncertainty of Measurement	1	WG6 (Pre-packages)
7	Guidelines for Examination and Testing of Interfaces and Peripheral Equipment	1	WG7 (Software)
7.1	Software Requirements on the Basis of the Measuring Instruments Directive (MID)	2	WG7 (Software)
7.2	Software Guide (Measuring Instruments Directive 2004/22/EC)	5	WG7 (software)
8.1	Terms and definitions in MID and their relationship to terms defined on other international metrologically relevant documents	1	WG8 (MID)
8.16-1	Guide for Measuring Instruments Directive 2004/22/EC Automatic Catchweighers; Corresponding Tables OIML R51-1 1995 - MID-006-II	1	WG8 (MID)
8.16-2	Guide for Measuring Instruments Directive 2004/22/EC Automatic Gravimetric Filling Machines; Corresponding Tables OIML R61-1 2004 - MID-006-III	1	WG8 (MID)
8.16-3	Guide for Measuring Instruments Directive 2004/22/EC Discontinuous Totalisers; Corresponding Tables OIML R107-1 1997 - MID-006-IV	1	WG8 (MID)
8.16-4	Guide for Measuring Instruments Directive 2004/22/EC Continuous Totalisers; Corresponding Tables OIML R50-1 1997- MID-006-V	1	WG8 (MID)
8.16-5	Guide for Measuring Instruments Directive 2004/22/EC Automatic Rail Weighbridges; Corresponding Tables OIML R106-1 1997 - MID-006-VI	1	WG8 (MID)

9	WELMEC Type Approval Agreement	5	Secretariat
10.1	Guide for Pattern Examination	1	WG10 (Measuring Systems for Liquids Other Than Water)

WELMEC Working Groups are continuously working on many aspects of legal metrology and it is always worth checking the WELMEC website, www.welmec.org, to ensure that you have the latest version of any document. The WELMEC Guides are freely downloadable from the same site.

2.1.4. OIML PUBLICATIONS

The International Organization of Legal Metrology (OIML) is an intergovernmental treaty organization whose membership includes Member States, countries which participate actively in technical activities, and Corresponding Members; countries which join the OIML as observers. It was established in 1955 in order to promote the global harmonization of legal metrology procedures.

OIML publications are available to download free of charge from the OIML website, http://www.oiml.org/publications/

The main recommendations that are relevant to the weighing industry are as follows:

Ref	Title	Edition
R47-EN	Standard weights for testing of high capacity weighing machines	1979
R50-1-EN	Continuous totalizing automatic weighing instruments (belt weighers). Part 1 : Metrological and technical requirements - Tests	1997
R51-1-EN	Automatic catchweighing instruments. Part 1 : Metrological and technical requirements - Tests	2006
R52-EN	Hexagonal weights – Metrological and technical requirements	2004
R60-EN	Metrological regulation for load cells	2000
R60-sup-EN	Metrological regulation for load cells: Certificate transformation requirements	2000
R61-1-EN	Automatic gravimetric filling instruments. Part 1 : Metrological and technical requirements - Tests	2004
R61-sup-EN	Automatic gravimetric filling instruments: Certificate transformation requirements	2004
R76-1-EN	Non-automatic weighing instruments. Part 1 : Metrological and technical requirements - Tests (integrate Amendment No. 1 of 1994)	2006
R79-EN	Labelling requirements for pre-packaged products	1997
R87-EN	Quantity of product in pre-packages	2004
R106-1-EN	Automatic rail-weighbridges. Part 1 : Metrological and technical requirements - Tests	2011
R107-1-EN	Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). Part 1 : Metrological and technical requirements – Tests	2007
R111-1-EN	Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3 Part 1: Metrological and technical requirements	2004
R125-EN	Measuring systems for the mass of liquids in tanks	1998
R134-1-EN	Automatic instruments for weighing road vehicles in motion. Total vehicle weighing	2006

2.1.5. EN STANDARDS FOR LEGAL METROLOGY

Following Harmonised European Standards is one of the methods that manufacturers can use to demonstrate compliance with the essential requirements of European Directives in many fields.

Directive 2009/23/EC dealing with Non-automatic weighing instruments (NAWI) details the essential requirements that NAWI must meet before they can be placed on the European market and/or be taken into use in the EC. When the Directive was adopted in 1990, the European Commission issued a mandate to CEN/CENELEC, two of the bodies that develop European Standards, to produce a Standard that would ensure compliance with the Essential Requirements of the Directive. They came up with EN 45501, which was then recognised by the European Commission as being a Harmonised Standard giving as presumption of conformity to the Essential Requirements. The Standards making organisations in each of the Member States then transposed EN 45501 into a national standard. So in the UK, we now have BS EN 45501;1994 Specification for Metrological aspects of non-automatic weighing instruments, which is the exact equivalent of EN 45501:1992 as amended and corrected.

EN 45501 was itself an almost exact copy of OIML R 76-1 1992, Non-automatic weighing instruments Part 1 Metrological and technical requirements – Tests.

When the Measuring Instruments Directive 2004/22/EC was drafted, the provision regarding the use of Harmonised Standards was include, but the Directive also introduced a new concept, that of the “Normative Document”. Under this provision the European Commission can adopt documents developed by other organisations which will provide the same presumption of conformity as a Harmonised Standard.

Using this principle, the EC has agreed, with the advice of the Measuring Instruments Committee to give a number of OIML Recommendations the status of Normative Documents. This will avoid the need for CEN/CENELEC to go through the process of turning the Recommendations into European Standards and will overcome the problem that now exists with EN 45501 in that it did not keep up with the amendments to R76-1 1992, and is now even further out of step as a new revision of R76 was adopted in 2007.

The following list details the OIML Recommendations that have been adopted as Normative Documents:

R50-1:1997	Continuous Totalising automatic weighing instruments
R51-1: 2006	Automatic Catchweighing instruments
R61-1:2004	Automatic Gravimetric Filling instruments
R106-1:1997	Automatic Rail weighbridges
R107-1:2007	Discontinuous totalizing automatic weighing instruments

WELMEC have published Guidance documents detailing the Essential Requirements of the Measuring Instruments Directive and the corresponding provision of the OIML Document. These documents can be downloaded from the WELMEC website. They are:

WELMEC Guide 8.16-1	Automatic Catchweighers
WELMEC Guide 8.16-2	Automatic Gravimetric Filling Instruments
WELMEC Guide 8.16-3	Discontinuous Totalisers
WELMEC Guide 8.16-4	Continuous Totalisers
WELMEC Guide 8.16-5	Rail Weighbridges

2.2 GUIDANCE NOTES

There are many sources of information providing additional guidance on a wide variety of subjects related to weighing. Some specific sets of guidance notes are discussed in following subsections:

- NMO guidance notes for the NAWI regulations
- European Commission guidance notes on the New Approach directives
- The packers guide
- The WELMEC Guides

In addition to these, guides and information are provided by the following organisations.

WELMEC
The WELMEC guides are listed in section 2.1.3 and are used by regulatory authorities to provide a common interpretation of European metrology legislation.

OIML
Many of the relevant OIML documents are strictly 'recommendations' but they provide essential information regarding the standards and procedures used in legal metrology. These are listed in section 2.1.4.

NMO
The National Measurement Office produce various notes for guidance in addition to those on the NAWI regulations referred to in section 2.2.1. These can be obtained from the NMO website.

National Physical Laboratory (NPL) / Institute of Measurement and Control (IMC)
The NPL and IMC have a variety of guides on the measurement of mass and weight and industrial weighing. The guides are available from the NPL website.

United Kingdom Accreditation Service (UKAS) / European Accreditation (EA)
The UKAS and EA guides cover calibration and uncertainty. The guides are available from the respective websites.

European Commission
The so-called 'Blue Guide' to the New Approach directives is discussed in section 2.2.2. This guide is available from the Europa website.

Health and Safety Executive (HSE)
Amongst the many guides produced by the HSE, there are two in particular that may be of interest to the weighing industry on risk assessments and lifting operations and lifting equipment. These are available from the HSE website.

2.2.1. NAWI REGULATIONS 2000; NOTES FOR GUIDANCE

The Notes for Guidance on the NAWI Regulations 2000 has been published by the National Measurement Office (NMO) and is available to download free of charge from their website:

http://www.bis.gov.uk/assets/nmo/docs/legislation/legislation/nawi/nawi-amendment-nfg

The initial sections include some background information, conformity assessment procedures, and notes on the implementation of the NAWI directive 2009/23/EC

The bulk of the guide analyses the Regulations clause-by-clause with comment on each one. The notes relate the regulations to other documents such as the NAWI and other directives, the harmonised standard EN45501 (OIML R76), and other regulations. They also provide details of various associated organisations such as WELMEC, UKAS, EMeTAS, OIML, etc.

The annexes provide additional information as follows:

Annex 1	Extracts from the Weights and Measures Act 1985
Annex 2	Verification paths flowchart
Annex 3	Gravity Table
Annex 4	Form of the information on judicial remedies
Annex 5	Bibliography
Annex 6	Descriptions of the stickers and the identification number
Annex 7	Descriptions of supplementary legislation
Annex 8	Applicability of Regulations
Annex 9	Guidance notes for use by approving authorities undertaking initial verification of non-automatic weighing instruments in accordance with the International Recommendation R76-1 Edition 1992 *(notes providing a consolidation of the tests described in R76)*

2.2.2 GUIDE TO THE IMPLEMENTATION OF DIRECTIVES BASED ON THE NEW APPROACH AND THE GLOBAL APPROACH

The CE marking on a product indicates that it complies with all relevant directives. The so-called “new approach” directives that have adopted the CE mark are the more technical directives that have separated out the “essential requirements” specified in the directives themselves from the detailed technical standards that are used to demonstrate compliance.

The Guide is a lengthy (112 page) document that discusses all aspects of the New Approach and Global Approach directives and CE marking. It is written from an EU point of view, so much of the emphasis is on the requirements of member states rather than users of equipment or those involved in the supply chain. However, it is an invaluable resource in helping to understand the principle of CE marking, as it comes directly from the European Commission and provides an overview of all aspects.

The Blue Guide is at present being reviewed, but it remains a useful document in the understanding of the operation and function of new approach directives.

The Guide includes the following sections:
1. Introduction
2. Scope of the New Approach directives
3. Responsibilities (including manufacturer, authorised representative, importer, distributor, assembler/installer and user/employer)
4. Compliance with directives
5. Conformity assessment procedure
6. Notified bodies
7. CE marking
8. Market surveillance
9. External aspects

The following quotes are taken from the Guide:

Introduction
A new regulatory technique and strategy was laid down by the Council Resolution of 1985 on the New Approach to technical harmonisation and standardisation, which established the following principles.

- Legislative harmonisation is limited to essential requirements that products placed on the Community market must meet, if they are to benefit from free movement within the Community.
- The technical specifications of products meeting the essential requirements set out in the directives are laid down in harmonised standards.
- Application of harmonised or other standards remains voluntary, and the manufacturer may always apply other technical specifications to meet the requirements.
- Products manufactured in compliance with harmonised standards benefit from a presumption of conformity with the corresponding essential requirements.
- New Approach directives are based on the following principles.
- Harmonisation is limited to essential requirements.
- Only products fulfilling the essential requirements may be placed on the market and put into service.
- Harmonised standards, the reference numbers of which have been published in the Official Journal and which have been transposed into national standards, are presumed to conform to the corresponding essential requirements.

- Application of harmonised standards or other technical specifications remains voluntary, and manufacturers are free to choose any technical solution that provides compliance with the essential requirements.
- Manufacturers may choose between different conformity assessment procedures provided for in the applicable directive.

New Approach directives are addressed to the Member States, which have an obligation to transpose them into their national legislation as appropriate.

Scope

2.3. Placing on the market and putting into service

- Placing on the market is the initial action of making a product available for the first time on the Community market, with a view to distribution or use in the Community. Making available can be either for payment or free of charge.
- Putting into service takes place at the moment of first use within the Community by the end user. However, the need to ensure, in the framework of market surveillance, that products are in compliance with the provisions of the directives when being put into service is limited.
- A product must comply with the applicable New Approach directives when it is placed on the Community market for the first time and put into service.
- Member States are obliged:
  - not to prohibit, restrict or impede the placing on the market and putting into service of products that comply with the applicable New Approach directives; and
  - to take any measures necessary to ensure that products are placed on the market and put into service only if they do not endanger the safety and health of persons, or other interests covered by the applicable directives, when correctly constructed, installed, maintained, and used in accordance with their purpose.

Responsibilities

3.1. Manufacturer

- A manufacturer, in the meaning of New Approach, is the person who is responsible for designing and manufacturing a product with a view to placing it on the Community market on his own behalf.
- The manufacturer has an obligation to ensure that a product intended to be placed on the Community market is designed and manufactured, and its conformity assessed, to the essential requirements in accordance with the provisions of the applicable New Approach directives.
- The manufacturer may use finished products, ready-made parts or components, or may subcontract these tasks. However, he must always retain the overall control and have the necessary competence to take the responsibility for the product.

3.2. Authorised representative

- The manufacturer may appoint any natural or legal person to act on his behalf as an authorised representative.
- For the purposes of New Approach directives the authorised representative must be established inside the Community.
- The authorised representative is explicitly designated by the manufacturer, and he may be addressed by the authorities of the Member States instead of the manufacturer with regard to the latter’s obligations under the New Approach directive in question.
- The manufacturer remains generally responsible for actions carried out by an authorised representative on his behalf.

3.3. Importer/person responsible for placing on the market

- An importer (a person responsible for placing on the market)– in the meaning of New Approach directives – is any natural or legal person established in the Community who places a product from a third country on the Community market.
- The importer must ensure that he is able to provide the market surveillance authority with the necessary information regarding the product, where the manufacturer is not established in the Community, and has no authorised representative in the Community.
- The natural or legal person who imports a product into the Community may, in some situations, be considered as the person who must assume the responsibilities placed on the manufacturer according to the applicable New Approach directives.

3.4 Distributor

- Provisions regarding distribution are in general not included in New Approach directives.
- A distributor is to be considered as any natural or legal person in the supply chain who takes subsequent commercial actions after the product has been placed on the Community market.
- The distributor shall act with due care in order not to place clearly non-compliant products on the Community market. He shall also be capable of demonstrating this to the national surveillance authority.

3.5. Assembler and installer

The installer and assembler of a product, which is already placed on the market, should take necessary measures to ensure that it still complies with the essential requirements at the moment of first use within the Community. This applies to products where the directive in question covers putting into service, and w here such manipulations may have an impact on the compliance of the product.

3.6 User (employer)

- New Approach directives do not lay down obligations for users, apart from those related to putting into service.
- Community legislation concerning the health and safety of the workplace has an impact on the maintenance and use of products covered by New Approach directives that are used at the workplace.

Compliance with directive

4.1. Essential requirements

- Essential requirements lay down the necessary elements for protecting the public interest.
- Essential requirements are mandatory. Only products complying with essential requirements may be placed on the market and put into service.
- Essential requirements must be applied as a function of the hazards inherent to a given product.

4.3. Presumption of conformity

- Conformity with a national standard that transposes a harmonised standard, whose reference has been published, confers a presumption of conformity with the essential requirements of the applicable New Approach directive that is covered by such a standard.
- References (such as titles, identification numbers) of harmonised standards are published in the Official Journal for the directive in question.

Editor’s note: The website link given in the guide is no longer current but the documents referred to can be found at: http://ec.europa.eu/enterprise/sectors_en.htm

The NAWI and MID directives can be found through the "Metrology, pre-packaging" tab.

- Member States must publish the reference of the national standard that transposes a harmonised standard. It is useful to indicate in the publication the link with the legislation in question.
- The application of harmonised standards, which give a presumption of conformity, remains voluntary in the field of New Approach directives. Thus, the product may be manufactured directly on the basis of the essential requirements (83).

Conformity assessment procedure

5.1. The modules

- Conformity assessment is subdivided into modules, which comprise a limited number of different procedures applicable to the widest range of products.
- The modules relate to the design phase of products, their production phase or both. The eight basic modules and their eight possible variants can be combined with each other in a variety of ways in order to establish complete conformity assessment procedures.
- As a general rule, a product is subject to conformity assessment according to a module during the design as well as the production phase.
- Each New Approach directive describes the range and contents of possible conformity assessment procedures, which are considered to give the necessary level of protection. The directives also set out the criteria governing the conditions under which the manufacturer can make a choice, if more than one option is provided for.

5.4. EC declaration of conformity

- The manufacturer or the authorised representative established within the Community must draw up an EC declaration of conformity as part of the conformity assessment procedure provided for in the New Approach directives.
- The EC declaration of conformity should contain all relevant information to identify the directives, according to which it is issued, as well as the manufacturer, the authorised representative, the notified body if applicable, the product, and where appropriate a reference to harmonised standards or other normative documents.

CE marking

7.1 Principles of CE marking

The CE marking symbolises the conformity of the product with the applicable Community requirements imposed on the manufacturer.

The CE marking affixed to products is a declaration by the person responsible that:

- the product conforms to all applicable Community provisions, and
- the appropriate conformity assessment procedures have been completed.

7.2 Products to be CE marked

- The CE marking is mandatory and must be affixed before any product subject to it is placed on the market and put into service, save where specific directives require otherwise.
- Where products are subject to several directives, which all provide for the affixing of the CE marking, the marking indicates that the products are presumed to conform to the provisions of all these directives.
- A product may not be CE marked, unless it is covered by a directive providing for its affixing.

Market surveillance

8.1. Principles of market surveillance
Market surveillance is an essential tool for the enforcement of New Approach directives.

- The purpose of market surveillance is to ensure that the provisions of applicable directives are complied with across the Community. Citizens are entitled to an equivalent level of protection throughout the single market, regardless of the origin of the product. Further, market surveillance is important for the interest of economic operators, because it helps to eliminate unfair competition.
- Member States must nominate or establish authorities to be responsible for market surveillance. These authorities need to have the necessary resources and powers for their surveillance activities, ensure technical competence and professional integrity of their personnel, and act in an independent and non-discriminatory way respecting the principle of proportionality.

Notified bodies should, basically, be excluded from the responsibility of market surveillance activities. This is to avoid conflicts of interest.

New Approach directives provide for two different tools that enable surveillance authorities to receive information on the product: the EC declaration of conformity and the technical documentation. These must be made available by the manufacturer, the authorised representative established within the Community, or under certain circumstances by the importer or person responsible for placing on the market. Other natural or legal persons, such as notified bodies, distributors, retailers, suppliers or subcontractors, cannot be obliged to make these available. However, they can assist the surveillance authority in obtaining them. Further, the surveillance authority may request the notified body to provide information on the conduct of conformity assessment for the product in question. …The EC declaration of conformity must be made avail-able for the market surveillance authority immediately upon request. Therefore, it should be kept inside the Community.

2.2.3. THE PACKERS GUIDE

The “Code of practical guidance for packers and importers (Weights and Measures Act 1979)” is more colloquially known as “The Packers Guide”. It was published by the DTI and HMSO (Her Majesty’s Stationery Office) and, although it refers to the 1979 Act which has now been superseded, it was explicitly referred to in The Weights and Measures (Packaged Goods) Regulations 1986. The guide is again referred to in the guidance note to the 2006 Regulations published by the DTI and is still considered relevant to average weight control, although reference to any requirements of the 1986 Regulations is no longer valid. It must, however, be remembered that the packers guide does not have the legal significance that it had under the Packaged Goods Regulations 1986.

The main focus of the guide is to provide information on how to comply with legislation if operating to an “average system” that was effectively implemented in the 1979 Act and the associated packaged goods regulations. There is also an Inspectors’ Manual that the packers guide refers to and suggests that packers may also wish to be familiar with the guidance for inspectors.

The guide is made up of 6 chapters and 8 appendices as follows.

Chapter 1 Background to the average system
Basic information outlining the average system. This chapter notes that:

> “…the *average* contents must not be less [than the nominal quantity]. The legislation achieves this object by requiring the packer or importer of packages to ensure that, whenever an Inspector carries out what is known as a *reference test* on a group of packages, the test is passed.”

However, without an inspector continually performing such a test, a packer will not know if he is complying with the law. The text goes further to say:

> “Although the primary legal duty of a packer or importer is to ensure that the Inspectors’ reference test is passed, he can do this by ensuring that his packages comply with three rules, referred to in this Code as the *Three Rules for Packers*.
>
> *Rule 1* The actual contents of the packages shall be not less, on average, than the nominal quantity.
>
> *Rule 2* Not more than $2^1/_2$% of the packages may be non-standard, i.e. have negative errors larger than the TNE specified for the nominal quantity.
>
> *Rule 3* No package may be inadequate, i.e. have a negative error larger than twice the specified TNE.”

Regulation 4(1) of the 2006 regulations lists the three packers’ rules with rule 2 requiring that “the proportion of packages … shall be sufficiently small”. The inspectors reference tests defined in schedule 2 of the 2006 regulations specify the number of non-standard packages (“defective packages” in the 2006 regulations) for various test schemes, all of which are equivalent to more than $2^1/_2$%, meaning that compliance with the above packers rules should ensure a reference test is passed allowing for statistical uncertainty.

The guide does emphasise the need to carry out checks and maintain records:

> “To ensure that the packages he is producing or importing comply with the law at all times, the packer or importer is required to carry out checks on the contents of the packages … and must keep for one year records of the checks.”

Although:

> "A packer who is making up each package using equipment prescribed in Part II of Schedule 4 to the 1979 Regulations is however exempt from this requirement."

Note that the 2006 regulations state that the relevant date for keeping records is the date by which the product ought to be consumed, or one year after the packages have left the possession of the packer or importer, whichever occurs first (regulation 9).

The table of tolerable negative errors (TNE) is reproduced from the 1979 regulations and is the same as that in schedule 3 of the 2006 regulations:

Nominal quantity (Q_n) g or ml		Tolerable negative error (TNE) as % of Q_n	g or ml
5 to	50	9	-
50 to	100	-	4.5
100 to	200	4.5	-
200 to	300	-	9
300 to	500	3	-
500 to	1,000	-	15
1,000 to	10,000	1.5	-
10,000 to	15,000	-	150
above	15,000	1	-

The meaning of the 'e' mark is also explained:

> "The 'e' mark … is not obligatory but, when used, is a guarantee recognised throughout the EEC that the goods to which it is applied have been packed by weight or volume in accordance with the relevant EEC Directive."

Chapter 2 Packers' and importers' responsibilities

Duties and responsibilities are described in relation to; the Inspectors' test, labelling, checks and records, export, equipment, and density determination.

With regard to equipment for checking packages, it states:

> "Non-automatic weighing machines used for checking packages after they have been made up … may be stamped or not."

But also:

> "The accuracy of the equipment is to be verified every working day by applying stamped weights equal to the nominal quantity of the packages checked, and also to the maximum capacity of the equipment."

Note that this is now superseded by the guide on the 2006 Regulations which stipulates that non-automatic weighing instruments must be stamped and the use of unverified instruments is not legal.

Chapter 3 Quantity control of packages

Control systems are discussed but reference is made to the appendices which go in to significantly more detail.

Chapter 4 Rectification of unacceptable packages

Possible reasons for requiring rectification are given together with procedures for handling them and various methods of rectification.

Chapter 5 The National Metrological Co-ordinating unit

The role and function of the unit are described. (This unit has now been abolished, SI 1987 No. 2187.)

Chapter 6 Importers
The definition of an importer is given together with their duties. A worked example is also provided giving a demonstration of a sampling scheme and associated calculations and records.

Appendix A Glossary
Terms specific to the Code and the subject matter are defined.

Appendix B The e-mark
The definition of the e-mark is reproduced from the Measuring Instruments (EEC Requirements) Regulations 1975.

Appendix C Control by sampling
This appendix provides very detailed information on the requirements of sampling procedures based on statistical methods. These procedures include the requirement on the packer to:

> "…obtain more information about his filling process and to use that information to set up an effective control system."

and:

> "A packer needs information about the performance in order to decide at what level to direct the filling process i.e. the target quantity, Q_t"

It explains that:

> "Under very favourable circumstances and tight control it might be possible for the minimum target quantity [Q_t] to coincide with the nominal quantity, Q_n, …"

i.e. the packer is likely to have to set a target value higher than the nominal quantity to allow for various factors.

It is worth noting that the procedures described are much more than checking that the samples comply with the Three Rules for Packers, as the samples taken may not necessarily be representative of the production batch as a whole. Also, a complete sampling system must include a consideration of the sampling frequency, the possibility of false errors and procedures to follow if results are outside of specified limits.

The guide gives details of how to perform an initial process capability study and obtain the necessary information to determine the target quantity and set up a control system. The following factors are discussed:

a. process variability allowance;
b. additional allowance for wandering average;
c. sampling allowance;
d. storage allowance;
e. tare variability allowance (where checks are made on gross weights);
f. miscellaneous factors.

It is worth noting that the sampling allowance factors have the effect that the more frequent the sampling and the more items per sample, the lower the target quantity needs to be above the nominal quantity.

Appendix D Control by checkweighers
The use of automatic checkweighers is permitted within the guide but procedures must be put in place to ensure that they are operating correctly. This appendix details the requirements of those procedures and gives some worked examples.

Appendix E Use of measuring container bottles
Measuring container bottles and templets are permitted. However, by its nature no weighing is required.

Appendix F An ‘off the peg’ control system
A simplified control system is described that is easier to implement than following the detailed requirements outlined in appendix C but is more restrictive.

Appendix G Assessment of alternative control systems
Different control systems are evaluated, mainly for the benefit of packers who already have systems in place and need to determine whether they are sufficient to comply with the legislation.

Appendix H Modification of the 1979 Act in respect of class B packages
Sections of the 1979 Act as amended by the 1979 Regulations are reproduced.

2.3 OTHER LEGAL REQURIEMENTS

See Articles:

2.3.1. CE MARKING DOCUMENTATION

In European law, the so-call “New Approach” separates essential requirements from the detailed technical specifications. The directives themselves identify the essential requirements and the technical specifications and tests are detailed in harmonised standards, which are incorporated into national standards. The essential requirements identified in the directives must be satisfied and compliance with the harmonised standards is sufficient to prove that. However, a manufacturer (or other body having to satisfy such a directive) may choose another method to prove that the essential requirements are met.

Each directive will identify the possible routes to compliance and some of those routes require the involvement of a notified body for examination and/or verification. The directives will require the following:

- The manufacturer or representative to affix the CE mark to each product. Specific directives may allow the mark to be displayed on the packaging and/or documentation as an alternative. Depending on the directive and the route to compliance, the identification number of the notified body may also be required.
- A Declaration of Conformity to be at the disposal of the national authorities with some directives requiring a copy supplied with each unit (or a batch of units delivered to a single user).
- A technical documentation file including information such as; a technical description, tests and standards applied, any other steps taken to ensure compliance.

Depending on the route to compliance, additional information such as procedures, reports & records relating to the quality system may also be required.

Some of the directives and compliance methods require the Declaration of Conformity, the technical file, and other documentation to be available for 10 years after the last product has been manufactured.

National legislation will implement the directives and the following is a non-exhaustive list of directives that may have to be considered for weighing equipment:

2009/23/EC	Non-automatic weighing instruments
2004/22/EC	Measuring instruments (automatic weighing instruments)
2004/108/EC	Electromagnetic compatibility (EMC)
2006/95/EC	Electrical equipment designed for use within certain voltage limits (low voltage directive)
2006/42	Machinery
94/9/EC	Equipment and protective systems for use in potentially explosive atmospheres
93/42/EC	Medical Devices

Some of the above directives will have been amended by directive 93/68/EEC to bring them in to line with the general requirements for CE marking and Decision 768/2008 which details those requirements with modules for the various phases of conformity assessment procedures.

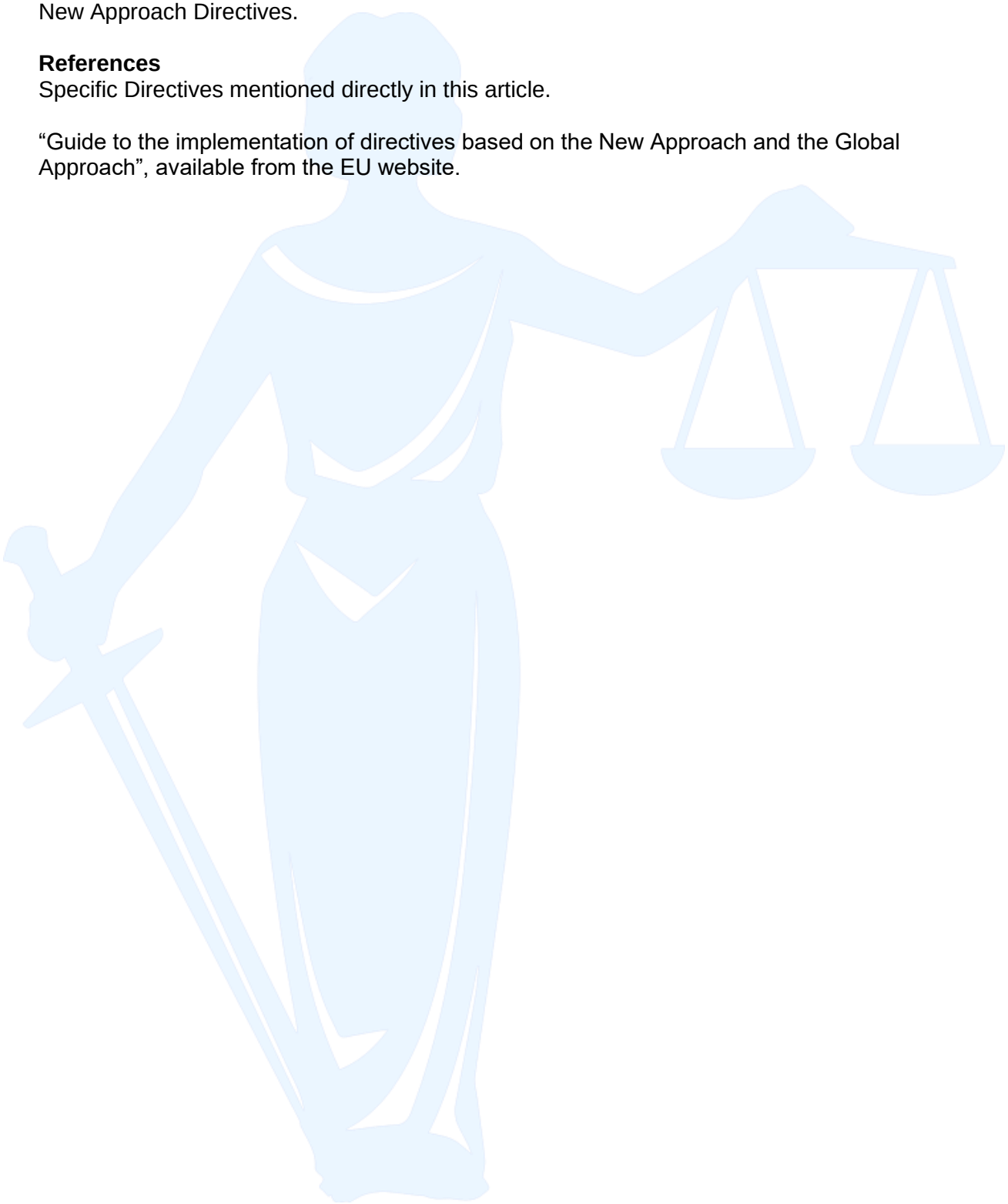
The exact format of the Declaration of Conformity is not specified, but an example layout is given in an annex to this article for an item of equipment relating to the EMC Directive.

See also sections on specific Directives and the general section on the notes for guidance on New Approach Directives.

References

Specific Directives mentioned directly in this article.

“Guide to the implementation of directives based on the New Approach and the Global Approach”, available from the EU website.



Example layout for a Declaration of Conformity

DECLARATION of CONFORMITY

MANUFACTURERS NAME

MANUFACTURERS ADDRESS

TYPE of EQUIPMENT

MODEL NUMBER

I hereby declare that the equipment specified above conforms with the protection requirements of the **EC DIRECTIVE 2004/108/EC** on Electromagnetic Compatibility (EMC), having applied the following standards;

BS EN 61000-6-1:2007
EMC GENERIC IMMUNITY STANDARD
(RESIDENTIAL, COMMERCIAL and LIGHT INDUSTRY)

BS EN 61000-6-3:2007
EMC GENERIC EMISSION STANDARD
(RESIDENTIAL, COMMERCIAL and LIGHT INDUSTRY)

SIGNED

FULL NAME

POSITION

DATE

2.3.2 ELECTROMAGNETIC COMPATIBILITY (EMC) DOCUMENTATION

The Electromagnetic Compatibility (EMC) Directive 2004/108/EC is incorporated into UK law by the Electromagnetic Compatibility Regulations SI 2006 3418. The Directive is applicable to most electronic appliances with “active” components which are likely to produce, or be affected by, electrical interference. The EMC Directive changes made since the original publication are in essence procedural and do not affect the route to compliance for non-complex installations. For most applications within the industry, the self certification route to compliance should be used. For complex installations, guidance should be obtained from a notified body or similar.

The Directive requires anyone placing relevant equipment on the market to;

1. Affix a CE mark to the product or, if this is impractical, the packaging and/or documentation.
2. Raise a Declaration of Conformity (DoC).
3. Compile a technical documentation file.

The “self certification” route to compliance.
There is no specific requirement to test equipment to a particular Standard, but there is the requirement to be able to demonstrate compliance. If a manufacturer DOES carry out testing to a relevant Harmonised EMC Standard (one published in the Official Journal of the European Community) then he can PRESUME conformity to the Directive without any further reasoning. If the manufacturer decides to demonstrate compliance by using a set of tests not Harmonised by publication in the Official Journal, he cannot presume conformity and may have to justify that the test plans he used are sufficiently rigorous.

In the majority of cases, this route is the cheapest and simplest method of demonstrating compliance as it does not require the intervention of a notified body.

Test requirements
The electrical noise produced by the equipment must meet limits which tend to be the same irrespective of the standard that is applied (there are two sets of levels, one for the Residential, commercial & light industry environment and one for the Industrial environment), the requirements being associated with noise being generated down the power cable on to the public supply network (inducted) and to that radiated from the enclosure and cables (radiated).

There are requirements for Immunity (similar to those requirements set by EN45501 for the Non Automatic Weighing Instruments Directive) which require the equipment to work as intended (bearing in mind the expectations of the user and consequences of a failure) when subjected to continuous and transient interference; again there are different sets of interference test levels depending on the intended operating environment.

As the manufacturer is the person who is going to raise the DoC, it is he who will define the normal operation of the equipment and the significance of any failure (this is usually done in conjunction with a test house or test department to produce an EMC Test Plan to set the scope of the testing). He will then incorporate the test results into the mandatory Technical Documentation with, when necessary, an explanation as to why the performance of the item is deemed to comply with the protection requirements of the Directive.

Test standards

There are no specific Harmonised EMC test standards for weighing equipment. While this would seem to be a problem in certifying this type of equipment, in reality, the test requirements are very similar for all types of equipment - general test levels are usually identical and product specific test Standard simply specify additional testing or a particular method of testing which is applicable to that equipment. In the situation where there is no specific product Standard, the Generic EMC Standards are used.

There are four Generic Standards;

BS EN 61000-6-1:2007
EMC Immunity for the residential, commercial & light industry environment.
BS EN 61000-6-2:2005
EMC Immunity for the industrial environment.
BS EN 61000-6-3:2007
EMC Emissions for the residential, commercial & light industry environment.
BS EN 61000-6-4:2007
EMC Emissions for the industrial environment.

The complete suite of tests for a particular piece of equipment is dependant on how it is powered (AC /DC / Internal battery) and the type and length of any interface cables. The performance criteria for a test is set by the Standard but the interpretation of the significance of the results is decided by the manufacturer – the test house or department can explain the performance of the equipment when subjected to interference and state an opinion, but it is the manufacturer who is going to sign the DoC.

References

The Electromagnetic Compatibility (EMC) Directive 2004/108/EC

The Electromagnetic Compatibility Regulations SI 2006 3418

2.3.3. LOW VOLTAGE EQUIPMENT DOCUMENTATION

The low voltage directive, “Electrical equipment designed for use within certain voltage limits” 2006/95/EC, replaces the previous directive 73/23/EEC. The directive is applicable to equipment with a supply voltage of 50 – 1000V AC or 75 – 1500V DC. If equipment itself takes a supply voltage of less than 75V DC but a mains adaptor is supplied with the equipment then it will all be subject to the requirements of the directive.

The Directive requires anyone placing relevant equipment on the market to;

1. Affix a CE mark
2. Raise a Declaration of Conformity (DoC)
3. Compile technical documentation.

The “self certification” route to compliance
There is no specific requirement to test equipment to a particular Standard, but there is the requirement to be able to demonstrate compliance. If a manufacturer DOES carry out testing to a relevant Harmonised EMC Standard (one published in the Official Journal of the European Community) then he can PRESUME conformity to the Directive without any further reasoning. If the manufacturer decides to demonstrate compliance by using a set of tests not Harmonised by publication in the Official Journal, he cannot presume conformity and may have to justify that the test plans he used are sufficiently rigorous.

In the majority of cases, this route is the cheapest and simplest method of demonstrating compliance as it does not require the intervention of a notified body.

Test standards
A list of test standards for this directive can be found on the Europa website in the following document:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2006:208:0001:0089:EN:PDF

2.3.4 MACHINERY DIRECTIVE REQUIREMENTS

Introduction
In common with the other CE marking directives, the Machinery Directive 2006/42/EC is primarily a free market measure. However, it also provides for a widely applicable framework for safety assessment and even when it is not strictly applicable, it can provide a good basis for risk assessment and documentation in order to demonstrate due diligence on the part of a manufacturer or supplier.

Directive 2006/42/EC is fully implemented into UK law by The Supply of Machinery (Safety) Regulations 2008 (SI 2008 No.1957) All new machinery introduced into the EEA must now comply with this Directive.

Scope
The definition of machine is very broad and will include an assembly fitted with, or intended to be fitted with, a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application.

There are some specific exclusions from the Directive - for example military equipment and machines which are already covered by other, more specific, directives (e.g. lifts and medical devices). However, there is also a general exclusion from the Machinery Directive for equipment which falls within the scope of the Low Voltage Directive and which presents hazards which are primarily of an electrical nature. This is an important exclusion and will be relevant to many weighing applications where, although there are moving parts, they do not present any significant hazards.

Second-hand machinery which was first used within the EEA prior to the date of the implementation of the directive (i.e. before 1 January 1995) is excluded from having to comply with the Directive itself. However, any machinery which was manufactured before 1 January 1995 must be made to comply with the Directive if it is subsequently brought into Europe from outside, just as any newer machinery would that is manufactured outside the EU.

Equipment manufactured for the manufacturer's own use is not excluded from the requirements, but may be subject to slightly lesser obligations with respect to marking and documentation.

In the context of weighing and lifting equipment, it’s important to understand that lifting accessories such as chains, strops, shackles and load-cells are all also within the scope of the Directive, whether or not they meet the strict definition of being ‘an assembly of linked parts’.

History
The original Machinery Directive was numbered 89/392/EEC. This was modified by a number of amendments which extended the scope to equipment which was originally excluded, and clarified the requirements. Then, in 1998, Directive 98/37/EC provided a consolidation of the previous directives into one document, although it made no changes in the actual requirements. Finally, in 2006, the Commission completed work on a replacement Directive, 2006/42/EC, which is the one in force at the moment.

Requirements
The requirements of the directive can essentially be split into two sections – the ‘essential protection requirements’ and administrative provisions.

The essential protection requirements demand that machine manufacturers identify the hazards which their products contain and then assess the risks which these hazards present

to users. Any risks thus identified must be reduced to as low a level as is reasonably practicable.

Annex I of the Directive gives a comprehensive list of the potential hazards which may arise from the design and operation of machinery, and gives general instructions on how the risks from these hazards must be avoided. Detailed requirements are laid out in a series of safety standards. The standards are drafted by multi-national committees of industry experts and reflect design requirements for particular pieces of machinery much more closely than could ever be achieved by specific legislation. Once a standard has been accepted by the European Commission (the process of 'harmonisation'), it is given the 'EN' prefix. This means conformity with the requirements of the standard gives a 'presumption of conformity' with the requirements of the Directive.

Because so many standards are required to cover the full range of machines covered by the Directive, the European Standards bodies have devised a hierarchy which can be applied in every situation. The most basic standards, known as 'Type A standards', set out requirements for the safety of machines only in the most general terms: indeed, part 2 of EN ISO 12100 is essentially a reproduction of annex 1 of the Machinery Directive. 'Type B' standards deal with more specific issues: design of emergency stops (EN ISO 13850); prevention of unexpected start-up (EN 1037); pneumatic systems (EN 983); temperature of touchable surfaces (EN ISO 13732-1) and many others. Finally, 'Type C' standards deal with specific classes of machinery: for example, EN 619 and EN 620 deal with safety of conveyors; EN 415 deals with packaging machinery and EN 201 deals with injection moulding machines.

The administrative provisions of the Directive (at least so far as manufacturers are concerned) are primarily aimed at forcing manufacturers to provide documentary evidence that the machinery complies with the Directive. This is done via the creation of a "Technical File". The general form and content of the Technical File is dictated in the Directive and manufacturers must be able to make this information available for inspection by the authorities (the HSE in the UK) for up to 10 years after date on which the machine was sold. However, except for Annex IV machines (see below), there is no obligation to produce a copy of the file unless demanded to do so by the enforcement authority, and only the enforcement authority has a right to see it. The manufacturer does not have to provide a copy to the customer unless they choose to.

Machinery meeting the requirements of the Directive is required to have the CE symbol clearly affixed to indicate compliance. It must also show the year of manufacture, some form of serial number, and other ratings as required by the relevant standards. An item of equipment may only display the CE mark when the equipment satisfies all relevant directives; for instance, machines with electrical controls must also comply with the requirements of the Low Voltage and EMC Directives.

Where volume production is envisaged, the Directive requires that control measures must be identified to ensure that all of the machines manufactured will conform to the provisions of the Directive.

Finally, the manufacturer must prepare and sign an 'EC Declaration of Conformity'. This is basically a statement which confirms the identity of the manufacturer and the machinery for which they are claiming compliance, and is signed to confirm that the correct procedures have been followed.

Annex IV machines

The vast majority of machinery may be self-certified by the manufacturer. What this means is that so long as the administrative and protection requirements of the Directive are properly completed, the manufacturer can perform all of the assessment and documentation procedures in-house and does not need to submit to any form of external test or approval.

However, annex IV of the Directive contains a list of about 15 types of machine which are subject to special procedures. Machines in this list must either be made fully in accordance with the provision of the relevant type C standard, or they must be subject to a type examination by a Notified Body. In either case, a copy of the technical file for the machinery must be lodged with a Notified Body before the CE mark is applied.

Declaration of Incorporation

The application of the CE mark under the Machinery Directive is in effect a statement which confirms that the machinery fully complies with the requirements of the Directive and is safe to use. Clearly, this is not appropriate for partly completed machines which are intended to be incorporated into another machine or which cannot function unless they are built into a complete production line. For these circumstances, instead of signing a Declaration of Conformity, the manufacturer does what they can to assess the machine they have built and to mitigate any risks to the user, and then signs a document called a 'Declaration of Incorporation'. This basically states that the machinery is incomplete and must be made to fully conform with the requirements of the Directive before it is brought into service. The manufacturer must provide information on the residual risks which the machine contains and on the assessment work which they have completed.

The Declaration of Incorporation is a concept which exists only in the Machinery Directive and so, if other CE marking directives apply (e.g. a check-weigher which is intended for incorporation into a packaging line, and which is covered by the EMC and Low Voltage directives as well as being a machine) then the machinery must carry the CE mark for these directives even though it is not CE marked as a machine.

Future Developments

In December 2006, after a long gestation, the European Commission finally published a new Machinery Directive, 2006/42/EC. So far as the vast majority of manufacturers and users are concerned, the basic requirements of the Directive remain unaltered, and in particular the assessment and documentation requirements are basically the same. Annex IV is also untouched. In general terms, the key differences between the new and old directive are:

- Greater clarity and more explanations of the scope and certain definitions;
- A narrowing of the scope of the exclusion which permits certain equipment also covered by the LVD to be excluded from the scope of the Machinery Directive;
- Greater clarity in the requirements for partly completed machinery

The Directive 2006/42/EC is implemented via the Supply of Machinery (Safety) Regulations 2008.

References

The European Commission have a special section on machinery with a great deal of useful information on their EUROPA server. This includes the full text of the directive and lists of the current harmonised standards.

Main Europa page on the Machinery Directive:
(http://europa.eu.int/comm/enterprise/mechan_equipment/machinery/index.htm).

List of current harmonised standards:
(http://europa.eu.int/comm/enterprise/newapproach/standardization/harmstds/reflist/machines.html)

For details of draft standards, the New Approach web site is a good EU-funded resource. (http://www.newapproach.org/Directives/ProductFamilies.asp?98/37/EC)

The UK government's Department for Business, Enterprise and Regulatory Reform (BERR) publishes a number of useful guides on the Directive and these are available for download from the following address:.
(http://www.berr.gov.uk/dius/innovation/regulations/ecdirect/page12543.html)

2.3.5 ATEX DOCUMENTATION

The term 'ATEX' is taken from the French 'Atmospheres Explosibles', which refers to two specific European Directives issued in 1994 and 1999. These are aimed at industrial premises that operate with Hazardous Areas (See section 1.8).

The first one, 94/9/EC, is called the 'Product' Directive or the '100a'. It defines 'equipment and protective systems designed for use in potentially explosive atmospheres'. The UK issued this as a Statutory Instrument: SI 1996 No. 192; "Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres", which came into force as from 1st March 1996.

The second, 1999/92/EC, is called the 'Safety of Workers' Directive or the '137'. It states the requirements that must be met for the use of equipment covered by the first directive in a place where a potentially flammable atmosphere may be present.

Only in the UK, the 'Safety of Workers' Directive has been combined with the Chemical Agents Directive. Together, these have been issued and implemented as the Dangerous Substances and Explosive Atmospheres Regulations (referred to as DSEAR). The opportunity was taken by authorities in the UK to repeal old Regulations that were considered to be out of date. The UK issued this as a Statutory Instrument: SI 2002 No. 2776; "The Dangerous Substances and Explosive Atmospheres Regulations 2002", which came into force in all parts from 1st July 2003.

From 1st July 2003, all new installations involving hazardous areas must use ATEX compliant 'equipment and protective systems'.

Installations completed before this date must have been shown to comply with the DSEAR and therefore the ATEX Directives before 1st July 2006.

The need for ATEX
The Directives have been put in place to establish a uniform approach to explosion protection throughout Europe, principally to facilitate trade between member nations. It achieves this by ensuring that all equipment and protective systems for use in hazardous areas meet stated technical requirements that apply in all EC countries. As a result, trade barriers cannot be raised on the basis that equipment is unsuitable. It is comprehensive and thorough in its approach.

Health and Safety Law that is already in place in the UK requires industry to operate with safety in mind. ATEX formalises this approach, specifying what organisational and technical requirements must be in place. In summary, it requires:-

- Proper management of hazardous areas
- Good communication throughout organisations by appropriate documentation
- Competency of personnel through proper training at all levels
- Identification of hazardous areas
- Marking and identification of apparatus
- Safe working procedures

ATEX Compliance
The Product Directive requires that if 'equipment and protective systems' are to be designed, manufactured or supplied as intended for use in hazardous areas, they must be assessed to determine if they could be 'ignition capable'. If not, then no further consideration is required.

If they can provide a source of ignition, by whatever means, then precautions must be taken in the design, manufacture, installation, operation and maintenance, such that they are

adequately protected by type(s) of explosion protection that meet the requirements of European Standards.

This applies to equipment and protective systems, whether it is electrical or non-electrical. The ATEX 100a Directive lays down 'Essential Health and Safety Requirements' (E.S.R.s) in Annex II that must be met. The process of assessment of ignition capability is to be performed by the manufacturer; the organisation 'placing the equipment on the market'. Thus, manufacturers of weighing equipment must determine if their products designed for use in the hazardous area are ignition-capable.

Where electricity is used, there is a risk that heat or sparks could be generated. Protection must be applied according to the existing European EN50 series Standards discussed under 'Hazardous Areas' (section 1.8 of the Technical Articles). Thus, the apparatus is certified to these Standards and marked accordingly. The certification process will also confirm that the apparatus meets the requirements of the ATEX 100a Product Directive and additional marking is applied.

In addition, any non-electrical aspect of any products that may be ignition capable must also be assessed and certified to a new series of Standards in EN13463. If equipment uses springs, for example, this may be cause for concern owing to the likelihood of breakage and the potential creation of frictional sparking and/or heating. The accumulation or generation of static charge must be considered. Mechanical movement and stored energy in load-cells are normally quite small and so, the risk of ignition may be adequately low. In contrast, electric motors are an example of where rotating bearings are used in equipment; mechanical failure would cause rubbing of surfaces and would therefore generate considerable heat.

The material used in construction of equipment may also need to be considered. For example, if aluminium is used for load-cells, which contains a high percentage of magnesium, then there may be a risk of 'thermite reaction' from impact with rusty iron. This can liberate incendive sparks. Maintaining a low percentage of magnesium reduces the risk. Where this is not possible, other precautions may need to be taken to ensure that impact risks are adequately low.

Once equipment has been designed and certified it is placed in one of three categories:

Equipment	Level of Protection	Permitted Zones of use
Category 1	Very High Level of protection	Used in Zone 0, 1 or 2
Category 2	High Level of protection	Used in Zone 1 or 2
Category 3	Normal Level of protection	Used in Zone 2 only

Standards

British Standards for explosion protected apparatus have been harmonised with European Standards: BS5501 has now been replaced with the EN50 series. More recently, the IEC Standards are being adopted in Europe and are issued as, in the case of the UK, BS EN 60079 series. It is the same document as the IEC79 Series for electrical apparatus and systems.

In Europe, Standards for non-electrical equipment are also emerging; BS EN 13463. Part 1 covers the requirements for all explosion-protected non-electrical equipment whilst subsequent parts (some currently still in draft form) detail the types of protection for certification and assessment purposes; the important standards are referred to at the end of this section.

Marking

Equipment complying with the ATEX 100a Directive will now be additionally marked, for example:

CE ⟨Ex⟩ II 1 G/D

- The CE mark confirms that the product meets all relevant European Directives
- The Ex in the Hexagon now means that the Product meets the ATEX Directive when used as part of the above marking system
- The Roman II indicates the suitability for Surface industry use in Hazardous Areas
- The Arabic 1 permits the use of the apparatus in Zone 0 as it has a very high level of protection applied
- G allows the use of the apparatus in Gaseous and Vapour hazards
- D permits its use in Dust hazards

The EEx marking discussed in Section 1.8 of the Technical Articles will also appear after the ATEX Marking. Thus, all apparatus must be marked to show that it is suitable for the place in which it is to be used.

	Category 1	**Category 2**		**Category 3**	
Equipment Type	***Electrical AND Non-Electrical***	***Electrical***	***Non-Electrical***	***Electrical AND Non-Electrical***	***Annex ref***
Certification Phase					
Certification by Notified Body	Required	Required			III
Certification by manufacturer			Permitted	Permitted	VIII
Unit verification by Notified Body	Universal option				IX
Surveillance					
QA of production by Notified Body	Required				VI
QA of product by Notified Body		Required			VII
QA by manufacturer			Permitted	Permitted	VIII

The above table shows the various options available to a manufacturer when designing hazardous area equipment. All ‘Category 1’ equipment must be certified by a Notified Body, as must ‘Category 2’ electrical. ‘Category 2’ non-electrical and all ‘Category 3’ equipment can be self-certified. The appropriate Annexes of the Directive are given for reference and should be consulted.

In addition, manufacturers must have appropriate Quality Assurance (QA) in place as stated in the appropriate Annexes.

The ATEX Product Directive permits a new system of manufacturer ‘self-certification’. The manufacturer can assess the design to a recognised construction Standards without gaining external certification. The design documentation would then be submitted to a Notified Body (NB) for safe keeping but would not be assessed by the NB unless there is cause for concern that the equipment is unsafe. This arrangement relieves the financial overhead on manufacturers for the certification of equipment used in lower risk circumstances.

The Universal Option alternative covers submission to a NB of an arrangement of items for independent testing. The other requirements are set out in the Directive and manufacturers must be familiar with these.

One important criteria is that of the requirement for manufacturers to supply adequate instructions for safe use and operation. This has always been good practice and a selling point but never before been formalised as a legal obligation.

The Safety of Workers (137) Directive
The principle aim of this Directive is to place clear requirements on the owners of industrial plants containing hazardous areas.

Owners of industrial plants must implement formal systems relating to:

- Proper Area Classification
- Identification of Hazards
- Provision of Personal Protective Equipment
- Plant modification review procedures
- Inspection and Maintenance requirements and routines
- Training and competency assessment of personnel and contractors
- Appointment of a 'responsible person' competent to oversee the safety of the above systems

The '137' Directive cross-refers to the '100a', to use the same technical terminology, for example choosing Category 2 equipment for a Zone 1 hazard.

Owners must familiarise themselves with the detailed requirements of this Directive and implement it according to their plant operational arrangements. Thus, the Directive may be regarded as one aimed principally at management.

Documentation
The '137' Directive requires the generation of an 'Explosion Protection Document' (EPD) in which all aspects of safety, both technical and organisational, are formally laid down.

The 'Apparatus Certificates of Conformance' issued by Notified Bodies or manufacturers must also state compliance with the ATEX requirements. These will form part of the EPD. In addition, Area Classification, including the supporting calculations; other instructions, provided by manufacturers; system descriptive documents, covering Ex i interconnected apparatus; procedures for inspection and maintenance and 'Permit to Work' systems will all need to be cited.
The 'EPD' thus becomes a central repository for all safety-related information. Work on any site must be co-ordinated and controlled by the owner in a safe manner by reference to the information it contains.

DSEAR in the UK
The implementation of the '137' Directive in the UK was combined with the requirements of another, called the Chemical Agents Directive. These two have been issued under the Dangerous Substances and Explosive Atmospheres Regulations (2002); it is known as the 'DSEAR'.

The DSEAR provides requirements under each of the following section headings:

1. Citation and commencement.
2. Interpretation.
3. Application.
4. Duties under these Regulations.
5. Risk assessment.
6. Elimination or reduction of risks from dangerous substances.
7. Places where explosive atmospheres may occur
8. Arrangements to deal with accidents, incidents and emergencies.

9. Information, instruction and training.
10. Identification of hazardous contents of containers and pipes.
11. Duty of co-ordination.
12. Extension outside Great Britain.
13. Exemption certificates.
14. Exemptions for Ministry of Defence etc.
15. Amendments.
16. Repeals and revocations.
17. Transitional provisions.

Owners of companies must indicate how they have complied with the requirements embodied in the above sections, by reference to adequate documentation and procedures. The DSEAR does not refer to the production of an EPD. In the UK, the 'Control of Substances Hazardous to Health', (COSHH: 2002) and the 'Management of Health and Safety at work', (MHS: 1999) are regulations which require owners to implement, and then to document, procedures which demonstrate compliance. The DSEAR recognises this and permits the integration of safety documentation within a 'Risk Assessment'. This is sometimes referred to as a Safety Case or a Technical File in other UK regulations.

The owner is ultimately responsible for the generation of such documentation. The DSEAR does not prescribe how this should be done, as the individual owners must generate the systems to suit the operation of their plant.

Conclusion

For all new equipment and protective systems installed after 1st July 2003, Certificates of Conformance to the explosion protection Standards, provided by equipment manufacturers, will state that the equipment complies with the minimum requirements, (the ESRs) of the ATEX 100a Directive.

Retrospectively, the owners must assess their premises to ensure that their equipment and the installations meet the requirements of the ATEX 100a Directive and DSEAR respectively.

Installations completed before 1st July 2003 will need to be re-examined to ensure that they meet the criteria outlined in this section. The owner may choose to do this, requesting supporting documentation from the manufacturers and suppliers. Alternatively, the owners may request that the manufacturers/suppliers provide assessments for their equipment.

The onus has always been placed on the manufacturers to provide the specification for their products, from which the owners must select equipment suitable for their application. The explosion protection and, now through ATEX, the documentation provided by the manufacturer becomes a significant part of the owners' evaluation. The formal date set for completion of this assessment was by 1st July 2006.

When first introduced, the Directives and Regulations were viewed as yet another burden on the processing industry and its suppliers. Ultimately, this must be set against the need to raise and maintain the standard of safety. The European-wide approach will be successful if it influences the management of safety at a philosophical level. Signs are that this is happening and other countries are now monitoring its progress with a view to adopting ATEX.

Further information on the implementation of ATEX can be found on a website:
http://europa.eu.int/comm/enterprise/atex/index.htm

General References of Key Standards

Standard	Title	Notes
EN 1127	Explosive atmospheres - Explosion prevention and protection Part 1 - Basic concepts and methodology	Key document providing philosophy
EN 13463	Non-electrical equipment for potentially explosive atmospheres. Part 1: Basic method and requirements Part 2: Protection by flow restriction “fr” Part 3: Protection by flameproof “d” Part 4: Protection by inherent safety “g” Part 5: Protection by constructional safety “c” Part 6: Protection by controlled ignition sources “b” Part 7: Protection by pressurisation “p” Part 8: Protection by liquid immersion 'k'	Non-electrical apparatus methods of protection
EN50281	Electrical apparatus for use in the presence of combustible dust Part 1-1: Electrical apparatus protected by enclosures - Construction and testing Part 1-2: Electrical apparatus protected by enclosures - Selection and installation Part 2-1: Test methods - Methods for determining the ignition temperatures of dusts	Dust hazards European
BS IEC 61241	Electrical apparatus for use in the presence of combustible dusts. Part 0: General requirements Part 14: Selection and installation of apparatus	Dust hazards International
EN50014	General requirements for electrical apparatus for use in hazardous areas	Being replaced by IEC79-0
EN50020 EN50039	Requirements for type of protection “i” Intrinsically safe systems	Replaced by IEC79-25
BS EN 60079 (IEC79)	Electrical apparatus for explosive gas atmospheres Part 0: General requirements Part 11: Electrical apparatus with type of protection “i” Part 14: Electrical installations in hazardous areas (other than mines) Part 17: Recommendations for inspection and maintenance of electrical installations in hazardous areas (other than mines) Part 19: Repair and overhaul for apparatus used in explosive atmospheres (other than mines or explosives) Part 25: Intrinsically safe systems Part 27: FISCO and FNICO	Electrical apparatus

2.4 GENERAL DOCUMENTS REQUIRED

There are a number of documents that are necessary when supplying weighing instruments or placing them on the market. The list below identifies these documents and gives advice on retention and content. Unless specified the document can be kept centrally, i.e. a copy does not have to accompany the instrument.

Documentation

Type Approval Certificate
For prescribed weighing instruments that are used for a legally controlled purpose. The prescribed types are: non-automatic weighing instruments, beltweighers, gravimetric filling machines, in-motion rail weighbridges and discontinuous totalisers. The Type Approval Certificate (TAC) describes the weighing instrument and any peripheral equipment that may be connected to it. If initial verification by a Trading Standards Officer is required, the TSO is entitled to ask for a copy of the TAC. Where the TAC is issued in another EU Member State in a language other than English, the TSO can ask for a translation to be provided - this can be an unofficial translation. The TAC remains valid for weighing equipment in use even after it has expired as far as new instruments are concerned. It should be retained as long as the instrument is in service.

EC Declaration of Conformity (D of C)
The D of C is drawn up by the manufacturer, or in the case of instruments imported from outside the EU it can be drawn up by the importer. It certifies that the instrument complies with all relevant Directives and if compliance with the Directives has been achieved by following harmonised standards, it should list all of the relevant standards that have been used. It will identify the manufacturer, the model / type, and must be signed on behalf of the manufacturer / importer. The document is required to be retained for 10 years after the last instrument of that type has been put on the market.

Design Documentation (Technical File)
The design documentation should be held by the manufacturer or importer. It will include drawings, circuit diagrams, schematics, design calculations and any other relevant drawings / specifications needed for production and if necessary, type approval. It should be retained for as long as the D of C. Where testing has been performed during the design/ prototype production phases or has been performed to confirm compliance with Directives such as the Low Voltage Directive or EMC Directive, the test results / reports should form part of the Design Documentation. The documentation need not be stored in one place as a specific file but it must be available to be compiled into a **Technical File,** should an enforcement official or market surveillance authority require it. It may be kept in an electronic format rather than as a set of papers, but if it is kept in electronic format it should be securely backed up.

Verification Records
Companies that are accredited for “self-verification” (including re-verification) will be required under their accreditation to store the records, including the results of tests performed during verification, for assessment and monitoring by the organisation that accredited them. Records may be stored electronically. They should be retained for at least three years.

Service Instructions
These documents should be available to anyone authorised or permitted to carry out servicing. There is no legal obligation to make them available to anyone else but for instruments that are submitted for Type Approval the service instructions will normally form part of the documentation submitted in support of the application for approval. Many manufacturers now make them available on their websites.

User's instructions
These normally accompany the instrument when it is supplied to the end user, though where a number of instruments of the same type are supplied it may be sufficient to only supply one or two sets. Again, where Type Approval is required these instructions will normally be included in the submission documentation. There is no legal obligation to supply user's instructions for weighing machines as such, but where the machine is also covered by the Machinery Directive then users instructions in the official language(s) of the country of use are mandatory. Where there are no users instructions supplied, the manufacturer must accept responsibility for warranty even if the fault was caused by misuse, if that misuse was foreseeable.

Certificate of Conformance
Under the NAWI Directive and the MID, where verification is carried out by a Notified Body, the verifier must issue a Certificate of Conformity after the verification is completed. This Certificate should be retained by the manufacturer / submitter and must be made available to enforcement agencies and market surveillance authorities when requested.

Compatibility of Modules data sheets
Where a TAC allows the use of alternative modules, such as load cells, the manufacturer must complete a Compatibility of Modules data sheet before submitting the complete instrument for verification. The verifier is entitled to request a copy of the sheet before verifying the instrument. For serial production instruments, it is only necessary to complete one sheet for the range. The sheet should be retained as part of the design documentation / Technical File.

Labelling
There are certain pieces of information that should be included on any weighing instrument. Unless specified in the TAC, the information must be permanently and indelibly marked on the instrument.

Type Approval details
The information required here will be such things as Max, Min, e, TAC number and Class number, plus any other data specified in the TAC. For automatic weighing instruments this will include any operational parameters that could affect weighing performance, (e.g. operating speed, packs per minute, maximum throughput).

Manufacturers name or mark
This is mandatory for Type Approved instruments and must be sufficient to identify the manufacturer / importer. It is mandatory also under other Directives and should therefore be on all instruments whether type approved or not. A registered Trade Mark will be accepted as sufficient to identify the manufacturer.

Weighing Capacity
Non-automatic weighing instruments that are not type approved must be marked with the maximum weighing capacity (in the form Max ……) as well as the manufacturers name or mark.

Electrical Safety Information
For electrical / electronic instruments sufficient electrical safety information to allow connection to the appropriate power supply must be provided. This may be the maximum input voltage, earthing requirements or any other data necessary for the safe connection and operation of the instrument.

CE Mark
Any instrument that is placed on the market and is subject to one or more of the New Approach Directives (NAWI, EMC, Low Voltage, Machinery) must carry the CE mark indicating compliance with all relevant Directives. Some, but not all Directives require the CE mark to be

accompanied by the last two digits of the year in which the CE mark was affixed. As a general rule, it is best to include this information even where it is not specifically required by a Directive.

“M” mark
Instruments which are controlled either by the NAWI Directive or the MID, are required to carry an “M” mark to indicate compliance with the Directives. For NAWI this is a black M on a green background – there is no defined specification for the M on instruments covered by MID, but it would seem sensible to use the same “M” mark as for NAWI.

“Not to be used for direct sales to the public”
This marking is mandatory on NAWI of less than 100kg weighing capacity which are intended for industrial use but are of a design similar to that of an instrument intended for retail transactions. The marking should appear close to the display.

3. GOOD PRACTICE

CONTENTS

3.1 COMPATIBILITY OF MODULES

Background
An EC type approval document will often allow the use of alternative loadcells and weighing platforms provided that certain conditions are met. A typical example of the wording from a type approval document is given below;

Any compatible loadcell(s) may be used providing the following conditions are met:

- There is a respective OIML Certificate of Conformity (R60) or a test certificate (EN45501) issued for the loadcell by a Notified Body responsible for type examination under Directive 2009/23/EC.

- The certificate contains the loadcell types and the necessary loadcell data required for the manufacturer's declaration of compatibility of modules (WELMEC 2, Issue 5, 2005) and any particular installation requirements. A loadcell marked NH is allowed only if humidity testing to EN45501 has been conducted on this loadcell.

- The compatibility of the loadcells and indicator is established by the manufacturer by means of the compatibility of modules calculation, contained in the above WELMEC 2 document, at the time of verification or declaration of EC conformity of type.

- The loadcell transmission must conform to one of the examples shown in the WELMEC Guide 2.4, "Guide for Loadcells", or as shown in the drawing 'Module load cell', Annex 3.

It can be seen from the above that the key to establishing whether or not a particular indicator and loadcell is to carry out the compatibility of modules calculation. When the compatibility calculations show that the complete instrument will meet the essential requirements it can be submitted for verification. The compatibility of modules calculations should be submitted with the rest of the documentation to the notified body carrying out the initial verification.

Where a type approval certificate is not available, a combination of modules, each having its own test certificate, may be connected together to form a complete weighing instrument. In this case, the compatibility of modules calculation should be submitted with the application for EC type examination or EC unit verification.

The WELMEC 2 document gives guidance on the completion of this calculation.

The WELMEC guidelines may seem to be daunting at first but they are based on sound engineering principles and on ensuring that the configuration of the assembled instrument is within the specifications given for the components. A basic summary of these is given in the following.

Summary of requirements

Criteria	Considerations	WELMEC condition
Resolution		
Accuracy class of the instrument is within that specified for indicator and load cells	Specified accuracy classes for indicator and load cells (e.g. indicator class III and load cells class C3)	1
Number of intervals for the instrument is within limits for the indicator	Specified number of intervals for the indicator	4
Number of intervals for the instrument is within limits for the load cell	Specified number of intervals for the load cells	6a
The interval of the instrument is not below the minimum for the load cell	Minimum interval for the load cell	7
The interval is compatible with the minimum output dead load return value for the load cells	Minimum dead load output return for the load cells (multi-range or multi-interval instruments only)	6b / 6c
Capacity		
The load on a load cell is within the maximum specified	Scale capacity, dead load, no. of load cells, lever works, initial zero, non-uniform distribution (NUD)	5
Electrical		
The signal per interval is greater than the minimum required for the indicator	Minimum signal for the indicator, mV/V for the load cell, cell capacity, scale capacity, no. of cells	8
The load cell resistance is within range specified for the indicator	Specified range for the indicator, load cell input resistance, no. of cells	9
The resistance of any connecting cable is within that specified for the indicator	Maximum specified for the indicator, cable length, cable cross section	10
Temperature		
The temperature range of the instrument is within the limits for both indicator and load cells	Temperature ranges for the indicator and load cell	2
Errors		
Combined effect of errors of components	Fractions of the permissible errors for each component	3

WELMEC 2 Requirements

The WELMEC 2 document lists 10 requirements, each of which need to be checked to establish if a particular combination of modules is acceptable. The requirements from WELMEC 2 are listed below with explanatory comments in italics:

1. Accuracy class of weighing instrument, compatible to class of indicator and load cell(s).

   This is to ensure that the classes of the individual components are compatible, it would not be acceptable to attempt to verify an instrument as a Class II machine if it used an indicator which was only suitable for Class III or IIII.

2. Temperature limits of the weighing instrument compared with the temperature limits of the load cell(s) and the electronic indicator.

   Some modules may have a restricted temperature range and not cover the full range of -10ºC to +40ºC. This can be important when considering Class III machines using modules intended for Class I and II instruments, these often have a restricted temperature range.

3. Sum of the squares of the fractions p_i of the maximum permissible errors of load cell(s), connecting elements and indicator (EN 45501, No. 3.5.4) must not exceed 1.

   Each module of a weighing instrument is allowed a fraction (p_i) of the total maximum permissible error. A loadcell may be given a p_i of 0.7, an indicator may have a p_i of 0.5 and other parts have a p_i of 0.5. These values should be stated in the approval documentation. The compatibility assessment will check that the squares of the individual errors does not exceed 1.

   $p_1^2 + p_2^2 + p_3^2 \leq 1$

4. Number of verification scale intervals of the weighing instrument must not exceed maximum number of verification scale intervals of the electronic indicator

   If an indicator is certified for a maximum of 3000 scale intervals it would not be acceptable to use it on a system with a resolution of 4000 scale intervals.

5. Maximum capacity of load cell(s) must be compatible with the Max of the weighing instrument (EN 45501, No 4.12.1). (Explanation of “NUD” and suggested equation for Q are given in Section 3.1.6.6.).

   This calculation is used to ensure that the loadcells will not be overloaded during use. The capacity of the loadcell(s) will need be take the maximum load, the deadload of the weighing platform, any additive tare, the initial zero setting range plus any expected overload. In general, where the loadcell capacity is twice the maximum plus any deadload this factor can be disregarded and Q = 1.

6. **a)** Compatibility of the maximum number of verification scale intervals of load cell(s) to the number of verification scale intervals of the weighing instrument (EN 45501, No 4.12.2).

   The maximum number of intervals given in the loadcell approval must not be less that the maximum number of verification intervals for the complete system. Loadcells are often given codes to show the maximum number of verification scale intervals, for example C3 = 3000 intervals. A 5000 division instrument could not be verified with C3 loadcells.

6. **b)** Compatibility of minimum dead load output return of the load cell to the verification scale interval of a **multi interval instrument** (Condition corresponding to EN45501, No4.12.2, as agreed by WELMEC WG2 Decision 8 dated 23 November 1994).

   In the case of a loadcell used in a multi interval equipment the deadload return figure after the maximum load has been applied for 30 minutes shall be less than half of the smallest verification scale interval (e_1) of the equipment after the reduction ratio and the number of loadcells has been taken into account.

   $DR \leq 0.5\ e_1\ R/N$

   This condition does not need to be checked for a single range instrument.

6. **c)** Compatibility of minimum dead load output return of the load cell to the verification scale interval of a **multiple range instrument** (Condition corresponding to EN45501, No4.12.2, as agreed by WELMEC WG2 Decision 8 dated 23 November 1994).

   In the case of a loadcell used in a multiple range equipment the deadload return figure after the maximum load has been applied for 30 minutes shall be less than the smallest verification scale interval (e_1) of the equipment after the reduction ratio and the number of loadcells has been taken into account.

   $DR \leq e_1\ R/N$

   This condition does not need top be checked for a single range instrument.

6. **d)** Compatibility of minimum dead load of the load cells to the actual dead load of the load receptor.

   Where the loadcell approval document specifies a minimum load this must be less than the actual deadload of the weighing platform. This is often specified as zero or not given on the loadcell approval and can be disregarded in most cases.

7. Minimum load cell scale interval (EN 45501 No 4.12.3) must be compatible to verification scale interval of the weighing instrument.

   The minimum loadcell interval must not be greater than the scale verification interval after the number lo loadcells and the reduction ratio have been taken into account.

   $Vmin \leq e\ R / \sqrt{N}$

   The minimum loadcell scale interval is usually not given directly, the loadcell certificate will have a figure which must be divided by the maximum capacity on order to calculate the minimum interval;

   $Vmin = E_{max} / Y$

8. Actual input voltage per verification scale interval must not be less than the minimum input voltage per verification scale interval for the electronic indicator.

   When a scale is loaded each scale interval will result in a certain signal from the loadcell, usually in the order of microvolts. This requirement establishes that the indicator can resolve the loadcell signal with sufficient accuracy. The output from the loadcell is calculated using the sensitivity of the loadcell (mV/V), the excitation voltage from the indicator, the maximum capacity of the loadcell, the scale interval, the number of loadcells used and the reduction ratio of the weighing system. This must be equal to

or greater then the minimum figure given in the type approval or test certificate for the indicator.

9. Actual load cell impedance must be within the allowed range of load cell impedance for the electronic indicator.

   The number of loadcells any particular indicator can drive will depend on the excitation power available from the indicator and the resistance of the loadcell(s) used. As additional loadcells are added the equivalent impedance is reduced and more power is required from the indicator to maintain the excitation voltage.

10. Cable length per wire cross section of the connection cable between the junction box for the load cell(s) and the indicator must not exceed the value specified for the indicator.

    Using an excessive length of cable between the indicator and the loadcells can result in errors due to the resistance of the cable. This is less important in cases where a six wire connection system is in use, here a separate pair of wires is used to sense the excitation voltage at the loadcell. If it is mentioned the connecting cable will be specified in terms of its length and cross sectional area, the figure will be given as m/mm^2. For example with a cable specified as 50 m/mm^2 a length of 100m could be used if it had a cross sectional area of 2mm^2.

For each of the applicable conditions shown above a pass/fail is awarded. Any single failure means that the combination of modules does not meet the conformity requirement and the system must be redesigned.

The calculation can be done manually and recorded on the sample forms which are given in WELMEC 2 or a spreadsheet can be used to perform the calculations.

References

WELMEC 2 Directive 90/384/EEC: Common Application - Non-automatic weighing instruments

OIML R60 Metrological regulations for loadcells

EN45501 Metrological aspects of non-automatic weighing instruments

3.2 NOTES ON THE CORRECT USAGE OF WEIGHING EQUIPMENT

However accurate the weighing instrument may be, incorrect use will prejudice the weighing result.

Firstly, the correct equipment must be specified for the intended use. In particular, the division size should be appropriate, noting the fact that for equipment of similar technology, the higher the capacity the coarser the weighing resolution.

The equipment must be installed properly to ensure that the effects of any external influences are minimised. This is the responsibility of the person or organization carrying out the installation.

In use, note should be taken of the following:

General weighing applications

- Ensure that the scales are balanced, or display zero before weighing
- If a container or protective covering is used, ensure that this is allowed for by pressing the appropriate ‘tare’ or ‘zero’ key.
- Ensure that the load is not in contact with anything other than the weighing platform.
- Ensure that no part of the weighing platform or load receptor is touching an external object such as a wall or cable.
- Minimise the effects of external influences such as air currents (small devices), wind (large devices), vibration, etc.
- If the weighing instrument is portable and moved from one location to another, ensure that it is maintained in a level position and located on a firm and even surface.

Medical weighing

- Ensure the patient’s clothing is not touching any fixed part of the scales or surroundings.
- When using chair scales ensure the patient’s feet are not touching the ground, nor arms brushing against an adjacent fixture.
- When monitoring periodical weight change, ensure that the patient always wears clothing of similar weight.
- Do not weigh young children on scales of high capacity designed for adults. The weighing interval may be too coarse resulting in a higher than acceptable percentage error.

Crane scales or hanging scales

- Safety is more of an issue with scales with a suspended load because of the potential damage or injury that could be caused in the event of mechanical failure. Users must ensure that the equipment is rated for its intended purpose and inspected regularly.
- Moving loads may cause the displayed weight to vary. Some scales may be equipped with a hold function to assist with determining the actual weight.

3.3 CALIBRATION

All members of the UKWF that offer calibration services are obliged under conditions of membership to comply with the calibration codes of practice. There is one code of practice for NAWIs and another for cementitious product batching equipment.

Compliance with the codes will be monitored by the UKWF. In general, those members registered to ISO 9001:2008 will be required to incorporate the codes of practice into their quality control system and declare their compliance by questionnaire. Those members not registered will be required to undergo a regular audit. The codes themselves will also be subject to regular review by the UKWF. Any companies registered to ISO 9001:2008 or accredited by UKAS are likely to have additional requirements defined by their quality systems.

For any equipment used for controlled purposes the Weights and Measures Act 1985 and associated regulations will apply. The legislative requirements will always take precedence; members are required to act in accordance with the legislation and if equipment is found to be in breach, whether through calibration or any other considerations, members are required to inform the customer and notify them of their legal obligations or to seek advice from a Trading Standards Officer.

The tolerances of the test weights to be used will depend on the instrument to be calibrated. Both codes of practice give requirements and recommendations and section 3.2 of the Technical Articles on weights reproduces a table from UKAS guide LAB 14 giving recommendations of test weight tolerances.

The acceptable tolerances for the instrument being calibrated are subject to agreement with the customer. Again, legislative requirements take precedence and the codes of practice give recommended tolerances otherwise.

The scope of the calibration tests and procedures is similarly subject to agreement with the customer. The NAWI code of practice defines a series of tests and classifies them as “mandatory”, “recommended” and “optional” depending on whether it is an initial or a routine calibration. The following table is reproduced from the UKWF NAWI calibration code of practice, edition 4:

Test	**Initial Calibration**	**Routine Calibration**
Repeatability	Recommended	Recommended
Eccentric Loading	Mandatory	Mandatory
Linearity / Hysteresis	Mandatory	Mandatory
Weighing with Tare	Recommended	Optional
Sensitivity	Recommended	Optional

Please refer to the codes of practice for more detailed information.

3.4 WEIGHTS

Introduction
It normally starts with a phone call from a potential customer, “I need some weights …”.
As with any enquiry for any piece of weighing equipment, the first and most important point to establish is to what purpose the requested item is going to be put. With weights it can be very broadly broken down into, is the weight in “use for trade” and does it therefore need to be stamped or is it to be used for calibration or test purposes?

3.4.1 STAMPED WEIGHTS OR THOSE IN “USE FOR TRADE”

Key questions to be answered here should be:

a) When does a weight need to be stamped?
b) What weights can be stamped?
c) Who can stamp a weight and what does that involve?

a) According to the Weights & Measures Act 1985, part II, section 7, “use for trade” means being used in connection with a transaction which itself “is by reference to quantity or is a transaction for the purposes of which there is made or implied a statement of the quantity of goods to which the transaction relates and the use is for the purpose of the determination or statement of that quantity”.

In possibly plainer English and for practical purposes, a weight must be stamped if it is being used as part of a transaction wherein its known value is being directly used to determine the quantity of the product being measured and that determined quantity is then being used as a basis for a value which will be charged for the product.

With the prevalence now of electronic weighing equipment in our country, these instances are obviously far fewer than before the advent of load cell technology. A typical example these days could be the use of stamped weights with a mechanical counter scale in an environment such as an outdoor market where electronic scales may not be suitable.

Another example of where a stamped weight can be used is as part of an average weight system as defined in the code of practical guidance for packers and importers, chapter 1, section 28, where non-automatic weighing machines for that use “may be stamped or not” providing that “the accuracy of the equipment is to be verified every working day by applying stamped weights…”

b) As imperial units were removed from the Schedules by the Metrication Order 1999, the only unit of measurement of mass or weight legal for use in the UK in a stamped application is metric, that being the kilogram, the gram and the milligram. Any weight marked with any other unit cannot be stamped and cannot therefore be used in an “in use for trade” application.

As per The Weights Regulations 1985, schedule 3, part V, section 3, the following metric weights are lawful for use for trade:-

25kg 20kg 10kg 5kg 2kg 1kg 500g 200g 100g 50g 20g 15g 10g 5g 4g 3g 2g 1g 500mg 400mg 300mg 200mg 150mg 100mg 50mg 20mg 10mg 5mg 2mg 1mg

Obviously, all the above weights are offered as standard with the exception of the 4g, 3g, 400mg, 300mg and 150mg. These, for whatever reason, have fallen by the wayside as the 5, 2, 1 sequence has become the accepted industry standard.

As per The Weights Regulations 1986, part II, the following shapes must be adhered to in the manufacture of weights suitable for use for trade:

25kg must be of the irregular octahedronal form
20 to 5kg can be of the rectangular form
10kg to 1g can be of the cylindrical form
2kg to 100g can be of the hexagonal form
500 to 1mg can be of the flat or wire type

Taken in conjunction with the additional criteria laid down in the same regulations for the density and hardness of the materials which these weights can be manufactured from, the following types are those offered as standard:

25 to 5kg iron bar
2kg to 100g iron hexagonal
10kg to 1g brass cylindrical
500 to 1mg flat or wire type alloy or nickel

Other criteria covered in this section include the finish of the weights, stating that they may “be painted, coated or otherwise treated to inhibit corrosion”, their adjusting holes, “no metric weight less than 20g shall have an adjusting hole” and “an adjusting hole shall be in the form of a cavity in a plane surface of the weight”, and their marking, “all weights other than wire weights shall be marked with a durable and legible indication of their purported mass”.

Lastly, the weights must be adjusted as per the Prescribed Limits of Error laid down in Table 1 of schedule 4 of the 1986 Regulations. These limits are always a positive value above the purported mass of the weights, in other words a weight which is tested and found to be below this mass or above the prescribed limit cannot be stamped fit for use for trade. Please see section 3.4.3 where this table is reproduced.

The actual testing and stamping of these weights falls with the local weights & measures authorities to perform. Section 4 of part I of the 1985 Weights & Measures Act calls upon each authority to maintain “local standards”, as per Schedule 3 “being proper and sufficient for the purposes of this Act”. Paragraph 4 goes on to state that “no article shall be used as a local standard unless there is for the time being in force a certificate of its fitness for the purpose issued by the Secretary of State”.

The local or working standard which an inspector uses to test a weight submitted for stamping must be itself traceable through the tertiary and secondary standards back to the primary standard itself. The stamping itself consists of exactly that. On establishing that the weight satisfies all the requirements of the legislation, the inspector will mark either the material (normally lead) which has been used to adjust the weight or, in the case of a solid weight with no adjusting chamber, the bottom of the weight itself with the crown symbol, the year of stamping and the unique identifying mark of the set of weights which were used for the purpose of testing by comparison.

The inspectors are also empowered to “retest” a weight which has already been stamped and to obliterate the original stamp with a six-pointed star if the weight is found “to be heavier or lighter than its purported mass by more than the prescribed limit of error”, or if it does no longer satisfy any of the other laid down criteria. For example, the finish of the weight may have deteriorated to such an extent that the marking of the purported mass is no longer visible.

If a weight is not required for a trade application then it is probably to be used for the calibration of weighing equipment or for the periodic checking of weighing equipment. Weights for either of these purposes could be described as “test weights”.

3.4.2 TEST WEIGHTS

These weights, in terms of their construction, accuracy and suitability for the designated purpose, are governed primarily by specifications laid down in the OIML (Organisation Internationale De Metrologie Legale) R111 (2004). Although not a legally binding document in its own right, most of the recommendations laid down in it have been incorporated in EC member states' subsequent own legislation.

R111 recognises seven different classes of weight in terms of their accuracy, the coarsest being M3 which is referred to as "domestic" and the finest being E1 which could be a "primary standard". The range of weights is the same as with those legal for trade with the exception of the 25kg not being recognized, it being a throwback to the old imperial 56lb weight, and the range is further extended through 50kg and on upwards to 5000kg.

The maximum permissible errors for weights up to 50kg in size are shown in section 3.3 of OIML R111 under the heading of Table 1. This is reproduced here in section 3.4.4.

Irrespective of whether a test weight is being used to calibrate or check the accuracy of a weighing machine, the type and accuracy of the weight suitable for either purpose will be determined by the displayed resolution of the weighing machine itself. This resolution being the ratio between the weighing machine's capacity and it's displayed weighing increment or division.

The United Kingdom Accreditation Service (UKAS), from their "Calibration of weighing machines", edition 4, November 2006, section 4 offer a "possible selection table of weights for calibration of weighing machines". This can be used as a guideline for determining which standard of weight should be used to calibrate or test a weighing machine according to its capacity and division. Please see section 3.4.5 for this table.

Weights being used for either of these purposes may also very well have to be "certified" or "calibrated". Whether they have to be or not will be determined by any relevant quality standards which are in place either, for example, in terms of the service which the calibrating agent might be offering or operating under, or in terms of the quality system which the user or operator might adhere to. The certification itself should be able to provide proof in the form of traceability to a national standard that the test weights being used to perform the task were themselves accurate to a stated tolerance when last tested and/or certified or calibrated.

A service or calibration engineer should therefore be testing or calibrating the weighing machine with weights which can be proved to be sufficiently accurate for the displayed resolution of the machine taking into account any uncertainty in the actual accuracy of those weights. For example, a weight adjusted to the M1 tolerance may be in theory sufficiently accurate to calibrate the weighing machine as per the UKAS guidelines in Table 1, but the possible uncertainty of its actual weight might be so great that it is in fact not suitable.

Using a 1kg weight for example, the testing authority might have issued a certificate of calibration for it stating that the measured value found was 1000.05g (within the specified tolerance for M1) but that there was an uncertainty of measurement of +/- 10mg giving it an actual possible weight of 1000.06g (outside the specified tolerance for M1).

The condition or material from which the test weight is made should also be taken into consideration. For instance, an iron weight with a painted finish, even though it might be of sufficient accuracy for the purpose, might not be acceptable in a particularly clean environment such as a laboratory.

Although there is no legislation which specifies how regularly test weights should themselves be recalibrated, the accepted industry norm for weights of F2 class or below is once every 12

months. However, if the weights are being used with such a frequency that their accuracy cannot be guaranteed for this length of period, or they are being used in an environment where again their accuracy might be questionable after this amount of time, then a shorter time interval would be recommended.

As a general rule, and as per UKAS recommendations in sections 2.3 of Lab14 (edition 4, November 2006), weights other than cast iron should not be handled with bare hands and contact between the weights should be avoided. Both of these measures combined will prolong the accuracy of the weights.

3.4.3 THE WEIGHTS REGULATION 1986
REGULATION 10, SCHEDULE 4, PRESCRIBED LIMITS OF ERROR

Table 1

1. Purported mass of the weight	2. Prescribed limits or error passing as fit for use for trade (+ only)	3. Prescribed limits of error in relation to the obliteration of the stamp (±)
25 kg	4000 mg	4000 mg
20 kg	3200 mg	3200 mg
10 kg	1600 mg	1600 mg
5 kg	800 mg	800 mg
2 kg	400 mg	400 mg
1 kg	200 mg	200 mg
500 g	100 mg	100 mg
200 g	50 mg	50 mg
100 g	30 mg	30 mg
50 g	30 mg	30 mg
20 g	20 mg	20 mg
15 g	20 mg	20 mg
10 g	20 mg	20 mg
5 g	10 mg	10 mg
4 g	10 mg	10 mg
3 g	5 mg	5 mg
2 g	5 mg	5 mg
1 g	5 mg	5 mg
500 mg	2.5 mg	2.5 mg
400 mg	2.5 mg	2.5 mg
300 mg	2 mg	2 mg
200 mg	2 mg	2 mg
150 mg	2 mg	2 mg
100 mg	1.5 mg	1.5 mg
50 mg	1.2 mg	1.2 mg

3.4.4. OIML R 111

TABLE 1: MAXIMUM PERMISSIBLE ERRORS

Nominal Weight	±δ*m* in mg						
	Class E_1	Class E_2	Class F_1	Class F_2	Class M_1	Class M_2	Class M_3
5000 kg			25,000	80,000	250,000	800,000	2,500,000
2000 kg			10,000	30,000	100,000	300,000	1,000,000
1000 kg		1,600	5,000	16,000	50,000	160,000	500,000
500 kg		800	2,500	8,000	25,000	80,000	250,000
200 kg		300	1,000	3,000	10,000	30,000	100,000
100 kg		160	500	1,600	5,000	16,000	50,000
50 kg	25	80	250	800	2,500	8,000	25,000
20 kg	10	30	100	300	1,000	3,000	10,000
10 kg	5	16	50	160	500	1,600	5,000
5 kg	2.5	8.0	25	80	250	800	2,500
2 kg	1.0	3.0	10	30	100	300	1,000
1 kg	0.5	1.6	5	16	50	160	500
500 g	0.25	0.80	2.5	8.0	25	80	250
200 g	0.10	0.30	1.0	3.0	10	30	100
100 g	0.05	0.16	0.5	1.6	5	16	50
50 g	0.030	0.10	0.30	1.0	3.0	10	30
20 g	0.025	0.080	0.25	0.8	2.5	8	25
10 g	0.020	0.060	0.20	0.6	2.0	6	20
5 g	0.016	0.050	0.16	0.5	1.6	5	16
2 g	0.012	0.040	0.12	0.4	1.2	4	12
1 g	0.010	0.030	0.10	0.30	1.0	3	10
500 mg	0.008	0.025	0.08	0.25	0.8	2.5	
200 mg	0.006	0.020	0.06	0.20	0.6	2.0	
100 mg	0.005	0.016	0.05	0.16	0.5	1.6	
50 mg	0.004	0.012	0.04	0.12	0.4		
20 mg	0.003	0.010	0.03	0.10	0.3		
10 mg	0.003	0.008	0.025	0.08	0.25		
5 mg	0.003	0.006	0.020	0.06	0.20		
2 mg	0.003	0.006	0.020	0.06	0.20		
1 mg	0.003	0.006	0.020	0.06	0.20		

3.4.5 A POSSIBLE SELECTION TABLE OF WEIGHTS FOR CALIBRATION OF WEIGHING MACHINES

Taken from UKAS guide LAB 14 Calibration of Weighing Machines, edition 3, October 2004, table 1

Capacity	**Resolution**							
	100 g	**10 g**	**1 g**	**100 mg**	**10 mg**	**1 mg**	**0.1 mg**	**< 0.1 mg**
Up to 50 g		M3	M3	M3	M2	F2	E2	E1
Up to 100 g	M3	M3	M3	M3	M1	F1	E1	E1
Up to 500 g	M3	M3	M3	M2	F2	E2		
Up to 1 kg	M3	M3	M3	M2	F2	E1		
Up to 5 kg	M3	M3	M2	F2	E2			
Up to 10 kg	M3	M3	M1	F1	E1			
Up to 50 kg	M3	M2	F2	E2				
Up to 100 kg	M3	M1	F1					
Up to 500 kg	M2	F2	E2					
Note: This table should be interpreted in conjunction with paragraphs 4.2.2 and 4.2.4 of the text								

The cited paragraphs are as follows:

“4.2.2. The design and accuracy of weights used for in-house calibrations should be appropriate to the weighing machine being calibrated, and where possible should have a 95% confidence level uncertainty of calibration less than half the smallest digit size or recorded scale interval of the weighing machine to be calibrated. Where groups of weights are to be used to make up a single load, this criterion should be applied to the arithmetic sum of the weight’s individual calibration uncertainties.”

“4.2.4. Weighing machines as described in Table 1 can usually be calibrated using calibrated weights in the pattern of the designated OIML class. The table assumes that the uncertainty of calibration of the weights used will be 1/3 of its specified maximum permissible error. In most cases it will be possible to obtain smaller calibration uncertainties than this and it may therefore be possible to use a weight of a lower class. However, when selecting suitable weights, attention should still be given to properties of the weights other than accuracy, such as magnetism, corrosion and wear resistance. In most laboratory applications, it would not be appropriate to select a class lower than M1.”

3.5 ERRORS OF UNCERTAINTY

General
The principle of determining the uncertainty of any type of scientific or engineering based measurement follows similar guidelines. There are a number of guidelines available but because these have to cater for any type of measurement, they tend to be all-encompassing and it is not always quite so obvious how to adapt it to a particular requirement.

The response of many people in the Weighing Industry when faced with tackling measurement uncertainty is "why bother, I already use calibrated weights"?

As a purely hypothetical illustration consider the following; You were caught speeding in your car by a policeman with a hand-held speed gun and then prosecuted for travelling at 49mph in a 40mph limited area. Following this prosecution, you enquire of the accuracy of the hand held speed gun and are told ±10%. You assume fair play as you were accused of travelling well over 44mph.

However on making further enquires, you discover the following:

- The gun was calibrated in a test laboratory strapped to a bench and hand operation can add a further ±4mph uncertainty to the readings;
- The specification of the hand gun quotes a possible error of ±1% per °C. As the calibration was performed at 20 °C and the temperature at the time of the offence was measured at 10°C, the measurement has a further uncertainty of ±10%.

Are you still satisfied the prosecution was fair?

What Constitutes an Uncertainty?
The obvious answer has to be anything that can influence the measurement process. However, what you actually need to include in the uncertainty calculation will depend upon the significance of the effect upon the measurement.

There are some uncertainties less obvious than others. For instance, if you use calibrated weights the drift between calibrations can be significant. In order to account for this drift, the actual value of the weight needs to be recorded at the time of calibration and a record kept. From this record the drift can be calculated.

A fairly comprehensive list of the types of uncertainty associated with the weighing process can be found in Measurement Good Practice Guide No. 71, 2004, 'The Measurement of Mass and Weight' published by The Institute of Measurement and Control and available as a download from the NPL website:

http://publications.npl.co.uk/npl_web/pdf/mgpg71.pdf.

Make a list of all the possible effects that can influence the measurement, including the value of the effect. This is often expressed in parts per million (ppm).

Rank the uncertainty types in their order of influence.

Some effects will be more dominant than others. So there will be major influences and minor ones.

There is a school of opinion that because of the summation process used in the uncertainty calculation, anything less than one tenth of the most major influence will have an insignificant effect on the final result. Some people will of course disagree and include everything.

As a practical example: If you are vessel weighing, the influence of both connecting pipes and wind speed could be greater than 1,000ppm. So you probably need not consider the effect of gravity variation due to the Lunar phase changes which will be in the order of 0.1ppm if the weighing system is measuring force (e.g. load cells). However, if you have a force generating machine in a National Standards Laboratory and were trying to achieve an uncertainty of better than 1ppm, the Lunar gravity change would become significant.

Different types of uncertainty
The collection and summation of these uncertainties use statistically-based processes. There are some quite comprehensive guidelines published that describe the decision making and statistical processes in detail. Two are listed below:

“EA-4/02, 1999, Expressions of the Uncertainty of Measurements in Calibration” published by the European co-operation for Accreditation and available on their website:

“M3003 The Expression of Uncertainty and Confidence in Measurement” published by UKAS and available on their website:

There are two additional guides by UKAS that discuss the subject: LAB 12 The Expression of Uncertainty in Testing and LAB 14 Calibration of Weighing Machines, both also available from the UKAS website above.

Although the above publications give a comprehensive guide, a brief overview of the process is given below.

The uncertainties can be banded into two types:-

The ones that follow a normal type distribution and the ones that don't. These are known as type A and type B. A simplified descriptive example, showing the different types of measurement uncertainty, is shown below.

Standard Uncertainty
1) Standard Uncertainty of the **resolution** of the indicator $\mathbf{u_{res}}$

This is a rectangular distribution and therefore a type B.

$u_{res} = \frac{a}{2\sqrt{3}}$ Where a is the resolution of the indicator

2) Standard Uncertainty of the **repeatability** of the indicator $\mathbf{u_{rep}}$

This is a normal distribution and therefore a type A

$$u_{rep} = \frac{1}{\sqrt{n}} \left(\frac{100}{d_m} \sqrt{\frac{1}{(n-1)} \sum_{j=1}^{j=n} (d_J - d_m)^2} \right)$$

Where
n = N° of readings
d_J = value for each test
d_m = mean of value

This part of the above equation:-

$$\sum_{j=1}^{j=n} (d_J - d_m)^2$$

may look complicated but it is only the mean of all the load readings at this particular point (say 2kg on the way up), subtracted from each individual reading at this load value. This is then squared. This process is repeated for all the individual readings at this point. All these squared readings are then added together.

If you don't want the answer in percent leave out the100. If you want the answer in ppm, replace the 100 by 10^6.

3) Standard Uncertainty of the **applied force u_{std}**

This is often a normal distribution and therefore a type A. Sum the uncertainties quoted on the calibration certificate(s) for all the weights used.

4) Uncorrected **drift of the standard** weight(s) since their last calibration **u_{drift}**

This is a rectangular distribution and therefore a type B. Usually at least 1x the uncertainty of calibration for each weight used; but the actual drift can be estimated from the trends of the calibration histories.

5) Air buoyancy correction **u_{AB}**

This is a rectangular distribution and therefore a type B. If the span of the weighing instrument is adjusted before calibration then uncertainty limits of 1ppm for stainless steel weights or 3ppm for cast iron weights could be used. Note: the ppm values are derived from the instrument's range under test (often the capacity of the instrument).

Combining Uncertainties
The **combined standard uncertainty** (u_c) is calculated from the square root of the sum of the squares of the individual standard uncertainties.

$$u_c = \sqrt{u_{res}^2 + u_{rep}^2 + u_{std}^2 + u_{drift}^2 + u_{AB}^2}$$

Expanded Uncertainty (u_{exp})
The calculation of the expanded uncertainty is simply the coverage factor (k) multiplied by the combined uncertainty (u_c)

$u_{exp} = k \times u_c$

The generally accepted practice is to use a coverage factor of k = 2 and use this to calculate the expanded uncertainty. Normally this will give a confidence level of approximately 95%.

Note: The value for the coverage factor (k) may have to be modified, if the random contributions (usually repeatability) are relatively large compared with the other contributions. Modification of the coverage factor (k) is dealt with in UKAS document M3003.

The above notes are for guidance only. Each measurement process is likely to be unique and will therefore require its own tailor made uncertainty contributions.

3.6 LOAD CELL INSTALLATION

WEIGHING PRINCIPLES

The strain gauge load cell has become established as the most widely used load transducer, in all areas of weight measurement from retail scales, process industry through to medical applications.

This influence has brought a great deal of pressure to bear on manufacturers who have to comply with now internationally recognized standards in order to sell their products, e.g. OIML. Process industries have benefited from this pressure which has resulted in improved accuracy and reliability. In addition, the rapid growth of software based electronics and high performance components means that the errors which the signal conditioning electronics used to contribute to system accuracy are now negligible.

The result is that weighing system performance is invariably totally dependant on the mechanical design of the weighing system and the load cell performance.

The object of this booklet is to provide a background of information to help the user to obtain the maximum benefit from his load cells with the minimum of expensive mistakes that poor design can bring.

Remember that no amount of electronic sophistication will be able to overcome a mechanically unsound design.

The guide is essentially a practical document with complicated calculations

Weighing of Materials
The ever increasing cost of materials, more stringent environmental considerations and customer required repeatable quality have placed higher demands on the process industries and this has reflected in much higher standards being required for the basic measurement method, weighing.

Generally, liquids can be measured very accurately as the load cell method is non-intrusive and is not subject to wear and tear and gradual degrading of accuracy. Additionally, final control of material by solenoid valves etc. can be used to give precise shut-off characteristics.

Weighing and feeding of solid materials need a great deal of care as the many varied types of solid materials means that each substance must be assessed before deciding on the fundamental control and weighing method.

For example, hard granule pellets can be controlled by a dosing screw satisfactorily, but destructible pellets which, with mechanical abrasion become powderised, need a control and weighing method carefully selected for the duty.

Powders can usually be weighed and dispensed satisfactorily but certain powders become fluidised and thus take up the flow characteristics of a liquid and again, great care must be taken when selecting the final weighing and control method.
Display of weight of material can be achieved by many and varied methods from simple local display to electronics with remote indication, batch control instruments and recipe extraction microprocessors with control of stock.

Finally, a satisfactory mechanical solution must be achievable before weighing accuracy and repeatability can be achieved. Clever as modern electronics are, they cannot compensate for inadequate mechanical design.

This handbook is intended as a guide for the user of load cells and covers the areas of correct design for weighing, and selection of load cells.

Note:
The first time user of load cells is recommended to start with the glossary section!

LOAD CELL INTRODUCTION

Modern strain gauge load cells provide a signal that can be directly related to the load or weight that is applied. This signal, though small, is amplified by modern electronics to be presented to the user in digital display form or as an output to process control electronics, plant control computers or data loggers.

The load cells can be used for weighing the contents of scales, platforms, vessels, bins, hoppers and other similar containers. Since the load cells measure all the vertical forces acting on the container, and its support structure, it is important that all restraints, (i.e. forces other than the container weight and the material being weighed) are kept to a minimum, are elastic and are repeatable. Small, elastic and repeatable restraints can be removed by field calibration, but other restraints, such as a pipe supported too close to a vessel can prevent accurate weighing.

As the weighing performance is determined by the load path, the load cell location and the load cell itself rather than the associated instruments, it is essential to consider:

- The application of only the load required to be weighed, and that load applied to the load cell in the correct way.
- The location and number of load cells.
- The type of load cell to be used.
- The mechanical fittings to be used to apply the weighed load to the best advantage of the type of load cell selected.

Principle of Construction

A strain gauge load cell comprises a stress member of either steel or high grade aluminium which is strategically placed directly in the load path. This stress member will be one of 4 types which are either used in compression, tension, bending or shear mode. Each of these stress members with their physical characteristics require to be located and supported in a manner that allows for full benefits to be derived, and in addition they each need to be protected from effects that will impair their performance.

The gauges are usually connected into a 4-arm Wheatstone bridge configuration. Compensation resistors for zero, balance and sensitivity changes with temperature, are fitted. Cell sensitivity can also be standardised. load cells are often fitted with a 6 wire (sensor) circuit as standard. The stressed member is housed in a protective case with the correct type of environmental sealing appropriate for the application.

USING STRAIN GAUGE LOAD CELLS

Invariably process weighing involves weighing structures that have been designed to contain materials firstly and be able to accommodate weighing components secondly, factors other than the choice of and number of load cells and fittings affect weighing performance.

This structure and the surrounding process plant arrangement determines:
- The precautions necessary to avoid process attachments causing weighing errors.
- Supporting structures causing interference with the weighing structure.
- Side loads being applied to cause weighing errors or load cell damage.

These topics are detailed in the section titled “Do’s and Don’ts of Structures for Accurate Weighing”.

Having ensured that the load to be weighed is the total weight the load cells will need to support, the load cells and fittings must be selected for the operating environment and weighing performance required.

Factors involved include:
- Number of load cells (and possible pivots).
- Type of Load Cell(s).
- Location of Load Cell(s).
- Type of fitting(s) required.
- The maximum weight of product and vessel or platform weight.
- Any special precautions required.

These topics are covered in the section titled “Load Cell & Fitting Selection”.

The physical structure of the hopper, tank, silo, bin or platform is the main factor in the locating of the load cells. The structure which supports the vessel and contents has to be borne in mind when the location of the cells is selected.

DO’S AND DON’TS OF STRUCTURES FOR ACCURATE WEIGHING CORRECT AND INCORRECT PROCESS FITMENTS

Any pipe work that is fixed firmly to the weighed vessel will affect accuracy and repeatability (A). Where possible friction free pipe entries should be used (B), or suitable (F) flexible connections used.

The support bracket (C) is cantilevered out too far and is liable to bend under load. The bracket is applying a load to the side of the vessel, which itself exaggerates this effect as the vessel is not strong enough to support it. The beam also deflects under load, rotating the load cell away from the vertical. A serious aspect under these conditions is the increase of non axial loading and subsequent bending of the stress member during loading. Ideally the bracket should be mounted above the centre of gravity but may well have to be mounted at or below the centre of gravity to compensate for ‘bulbous’ expansion of the vessel due to loadings. The correct example (D) shows how the errors can be overcome. The aspect-ratio of the bracket should be about 30 degrees to the vertical. If necessary the side of the vessel should be strengthened.

Side Loads

Side loads can cause inaccurate readings in load cell installations and the main causes are;
1. Vessel and support structure expanding and contracting differentially.
2. Attachments to the vessel used to put in and take out material.
3. Forces applied by the method of loading.
4. Non vertical loading of the cells where non-parallel surfaces are used.
5. Wind loads.
6. Poor horizontal tolerancing of load cell attachments between top fitting location and load cell base plate.

Note:
Normally, freedom to move vertically is required and the vessel needs to be restrained in the lateral direction.

Lateral Restraining and Process Pipework

Tie rods used to limit horizontal movement need to be correctly designed and installed. The stiffness of the tie rods must be kept within allowable limits. Permanently attached pipework also has the same effect and like the tie rods, can support some of the load that the load cell will be measuring.

Flexible couplings fitted in the horizontal section of pipework is the usual method of reducing the effect of stiff pipework. In addition, pipework clamps and supports will need to be kept as far as possible from the vessel. An unrestrained length of piping at least 20 diameters of the pipe is generally regarded as a minimum.

Ideally when flexible couplings are fitted, they should be immediately adjacent to the weighed vessel with the permanent pipework supported on the immediate outboard flexible pipework joint.

Care should always be taken in the selection of suitable flexible bellows which possess low enough vertical stiffness when mounted horizontally. However special care may be required when:

1. Transported material might fill flexible bellows convolutions, which will have the effect of converting the bellows to a straight section of pipe.
2. The transported product must remain at an elevated temperature requiring a heated or insulated flexible coupling.

It should be stressed that identical precautions to avoid weighing errors should be taken with electrical conduit and trunking connecting weighing structures to surrounding non weighed structure. Despite their apparent small size considerable errors due to stiffness can occur especially where maximum weights are below 1000Kg.

Length of tie bars should also be greater than 20 times the diameter. The rods must be mounted perpendicular to the load cell axis as no force should be applied in the vertical mode. The tie bars should be expertly adjusted and be horizontal. Figure show a tie rod arrangement which eliminates rotational movement. (Not to scale)

Avoiding Errors from Structural Frameworks.

Where two hoppers are mounted on the same support structure, and it is required to know the contents of each or they each contain a different material, they must be physically separate, as adding or removing material from one hopper will affect the readings on the adjacent hopper since they are jointly supported on the same 4 Load Cells.

The correct method will be to support each individual hopper on 3 or 4 load cells and weighing interaction will not take place, (assuming the support structures are correctly designed).

It is quite usual that when several vessels in a plant area are weighed, the load cell bases, or base fittings are fixed to a common structural support frame. If this frame is not of adequate stiffness, coupled frame distortion due to varying weight in one hopper can generate weight errors in another hopper. Even if only a single hopper is weighed inadequate structural base frame stiffness can cause:

1. Repeatability and hysteresis Errors
2. Errors due to large induced vibration signals in the load cell output from surrounding process plant.
3. Errors due to static frame distortion from the “man on the walkway” syndrome. (Mainly occurs on maximum weights below 250 kg).
4. Errors due to large low frequency structural vibration modes in the structural framework caused by process plant which cannot be filtered out without compromising speed of weighing.
5. Possible cures for such problems include:

6. Selection of a mounting arrangement which allows a small amount of movement above the load cell.

Provide each weighed vessel with a separate rigid base frame onto which the load cell and fittings mount. Place in strategic positions additional structure to ground members.
Neither of the above approaches are as satisfactory as adequate support structural steelwork. Structural frameworks can impose special requirements on load cell mountings where:
1. Only poor horizontal hole tolerances are possible.
2. Static loading safety factors are low leading to larger than normal deformation.
3. Large temperature variations can occur causing substantial thermal expansion and contraction.

Therefore, load cell fittings may need to be selected with these special factors in mind as well as the need to apply the load correctly to the load cell that has been selected.

Lift-off and Overturning Prevention

Many types of load cells do not inherently prevent the load path from being interrupted by forces in an upward or sideways direction. For instance, a weighed vessel could be lifted off four compression load cells by collision, or an outside silo overturned by a strong wind if precautions are not taken.

It is imperative in all situations where lift-off or overturning is not prevented by inherent load cell design or the design of the load cell fittings:
1. Alternative means should be provided such as normally loose, hold-down bolts or spaced brackets.
2. A well designed integrated mounting is fitted.

Particular application areas where up and side forces of considerable magnitude are present include:
- All vehicle mounted systems.
- All water borne systems (barges, ships, oil rigs, trawlers)
- Large outside silos (wind effects) and bunkers.
- Other areas which are not so obvious include:
- Vessels susceptible to fork-lift truck or vehicle collision even if indoors.
- Vessels where high speed material charging or discharging can create reaction or centrifugal side loads.

LOAD CELL AND FITTINGS SELECTION

Number of Weighing Points

As already outlined the physical design of the plant or material to be weighed normally determines the number of points through which the load is to be concentrated for weighing purposes. This is particularly true of plant retrofitting of weighing where say a three legged hopper is obviously suited to three point weighing. Usually weighing can take place at between one and four support points on a single weighed structure with more points only used in unusual circumstances. Typical cases are:

Single Point Weighing.

Restricted to low capacity vessels suspended from a single load cell.
Used for platforms up to 500 kg with a single point load cell.
Used with complex mechanics to present loads to the load cell to a single lever or tension rod.

Two Point Weighing

Used for weighing of linear structures such as girders often with one load cell and one pivot and automatic sack fillers.

Three Point Weighing
The most common approach to vertical cylindrical vessels weighing and the simplest mechanically stable and self leveling weighing arrangement.

Four Point Weighing
The most common approach to scales rectangular and square vessels or containers, and the most common weighing arrangement.

More than Four Point Weighing
Usually only used if either the vessel construction or weight in relation to load cell capacity requires more than four load cells.

Often a larger or long load is weighed by a split arrangement consisting of two, four load cell frames or platforms but with a single indicator. This is a common approach to a very long linear weighing problems such as joists or tubes where two or three such four load cell combinations may be used.

Multiple Point Weighing 4 to 8 Load Cells
Large chemical spheres. Long rail weighbridges.

Load Cell and Pivot Combinations
After selecting the number of points for any number more than one, a choice of combinations of load cells and pivots instead of all active load cells is possible. Pivots are mechanical units based on a precision bearing and are physically interchangeable with load cells of equal capacity for that load cell type. The most effective combinations of load cells and pivots are:

Two Point Weighing:
One load cell and one pivot.

Three Point Weighing:

Four Point Weighing:

More than Four Weighing Points:
One load cell with pivots for the remainder of weigher points. Usually used only in lower performance systems because of the requirement for near perfect load distribution.

In order that the cost saving which pivots can bring is not lost in poor weighing performance, two points should be noted:

- Just as with load cells the pivot material and sealing must be suitable for the operating environment.
- The accuracy of a three or more point weighing system involving pivots depends critically on uniform distribution of the variable (not fixed or tare) weight and also low deformation of structural frames above and below the load cells and pivots.

The requirement for uniform live load distribution usually restricts pivot system to liquids. Use of pivots in weighing solids is usual only in lower performance systems since few processes can guarantee a uniform level of material inside the vessel.

Selection of Load Cell Type
The three main factors in selecting load cell type are load range, required accuracy and mechanical suitability. In order to clarify an often confusing series of choices some generalised guides are given below in these three areas:

Mechanical Suitability
Inherent lift-off protection:
- *Aluminium single point load cell.*

Inherently suitable for hanging loads:
- *Tension load cell, folded shear beam or "S" beam.*

Suitable for Vertical Measurement requiring additional lift-off and overturning precautions:
- *Compression bending beam or shear beam load cell.*

Aluminium load cells are in general less well sealed and less tolerant of environmental attack than steel and in particular stainless steel load cells.

A number of other factors not directly related to performance or capacity may influence the selection of load cell type. Some are listed below:

After making simplifying assumptions about sources of load error, type of fittings, number of load cells, indicator and temperature variations, a guide to installed process weighing system performance is given below.

Errors may substantially increase from those given because of the use of pivots when weighing solids and poor weighing system design. Most load cells are specifically designed to survive for long periods in the average industrial process or scale environment. However, the key factors of temperature, sealing and exposure to chemicals must be considered for the load cells selected for any application.

Definition of Load Cell Errors

The definition of errors is as follows:
- Non-linearity, the maximum deviation from the true value when applying the load. (Example shows Negative Non-Lin).
- Total Error, the maximum deviation from the true value when either applying or removing the load. (The greater of Bl or B2).
- Hysteresis, the maximum variation between the Load Curve (Ascend) and the Load Curve (Descend). (Example shows Positive Hysteresis).

N.B. - The True Value is a straight line drawn between Tare and Full Load.

LOAD CELL OPERATING ENVIRONMENT

Temperature
Virtually all load cells are suitable for operation from -10°C to +40°C with full rated specification. The following points should be noted:

The compensated temperature range (over which changes in output vary with temperature has been minimised) may be more restricted than the quoted operational temperature range.

The load cell storage temperature range may need to be considered to prevent damage in extremes e.g. unheated storage in sub-arctic areas, or even tropical areas where the temperature can exceed 40°C ambient.

Applications which expose the load cells to direct sunlight even through normal glass, can, via solar gain create far higher temperatures than expected. Temperatures of 50°C to 60°C in Britain and up to 90°C in the Indian sub-continent are not uncommon.

Applications, such as offshore oil extraction, which expose load cells to high wind chill factors (essential accelerated evaporate cooling due to a combination of wind and a wet surface) can create unexpectedly low temperatures.

In either wind chill or solar gain situations, large errors can occur when not all the load cells in a set are exposed to the same extent such as shadow effects in sunlight.

For higher temperature applications, the PVC insulation within standard load cell cables does not retain suitable mechanical characteristics above 70°C (normal). A change to high temperature cable and cable gland can allow occasional use above 100°C since the internal construction of bonded strain gauge load cells is not comprised until temperature well in excess of 120°C are reached.

Sealing

Virtually all load cells for industrial applications are sealed to IP65 (low pressure hose proof) with the exception of certain aluminium bending and single point load cells designed to be installed within low profile platforms which offer liquid protection to the load cell.
IP65 should be considered as the minimum suitable rating for general industrial process weighing where wash-down conditions can occur during:

- Accidental periods of normal operation.
- Cleaning for general process plant servicing.
- Lubricant spillage during normal process plant servicing.
- Routine plant cleaning.

Situations where IP65 Sealed Load Cells may not be adequate include:

- Where standing water may temporarily immerse the load cell during wash-down situations.
- Where ice and/or snow build-up in outside or semi-sheltered locations may effectively immerse load cell sealing areas.
- Where wave action on ship-deck or shore locations may temporarily immerse load cells.

In these cases sealing should be IP66 or IP67.

Where any doubt exists totally welded load cells should be selected. The cost will be higher but long term costs will be lower.

The same amount of care when selecting a load cell for immersion or wash-down conditions should be applied to junction boxes where the load cell cables terminate. Condensed moisture droplets inside a junction box can be ‘pumped’ down the inside of cable into the load cell by changes of temperature, thus causing errors.

Finally, particular care should be exercised in selecting load cells for use in steam cleaned plant which provides a difficult combination of temperature, pressure and liquid requiring at least IP67 sealing.

Chemical Environment

The load cell material including cable and cable gland should be resistant to any expected chemical contamination even if only present occasionally. Points to note are:

(a) Aluminium load cells should be used only in certain solutions. For instance not where powder or solids leakage can become corrosive from the addition of moisture or where even if within a platform flooding with corrosive chemicals around the platform base might occur.

(b) Check for compatibility with the disinfectants or cleaning agents used at wash-down times.

(c) Where the precise nature or quantity of contaminations is unknown but may be corrosive, such as in even slightly subsurface installations in steel or chemical works specify all welded stainless steel load cells.

(d) For extreme conditions even 1P68 glands may be inadequate to withstand hose wash down and in these circumstances welded stainless steel load cells with the additional protection of a threaded conduit adapter permanently attached to the load cell. The

load cell cable is threaded down inside a hose or conduit which is screwed to the threaded adapter on the load cell

(e) If the same type of fittings are used at the junction box end of the cable, the load cell and cable can be protected from much higher pressure and chemical attack. (This method can be particularly useful on food processing plants where infestation is a major problem).

Other Environmental Factors

Shock and Vibration:
Many load cell applications require more resistance to shock and vibration in the transit and during installation than when commissioned and operating. This can also be true where major civil or structural work is completed after load cell installation.

Radiation:
Although most standard load cells are not suitable for radiation, a radiation hardening package including a change of cable to Kapton can usually be supplied as a manufacturing option. This allows operation in levels up to 10 rad.

Electrical:
There are three important rules for load cell siting and the electrical environment.

- **NEVER** site steel load cells in area of high alternating magnetic fields as they will be damaged by heating from circulating eddy currents.
- **NEVER** site any load cell in an r.f. eddy current heating field or it will be damaged.
- **NEVER** allow any load cell to carry welding currents as part of the return circuit. It will be DESTROYED. If any possibility exists then install a substantial copper/stainless steel braid by-pass strap between fittings base and top fitting attachment point. If the top fitting incorporates a completely insulating shock absorber then the by-pass strap is not required.

Practical Load Cells
In addition to combined error (the sum of linearity, repeatability and hysteresis), when measuring varying weights, the practical load cell has other imperfections which can have a bearing on installed weighing system performance. These are detailed below.

Sensitivity Tolerance
A set of normal load cells can have a sensitivity spread at equal weight of +/-.l to +1-10% of full output depending on load cell type and manufacturer Uneven load distribution can then lead to weighing errors. The remedy is to specify a set of “rationalised” load cells, a normal manufacturing option which matches all sensitivities to +1-0.1% of full output. This match is sufficiently close to remove the error even on 0.05% system with bad load distribution. In platform applications where ‘cornering’ or sensitivity matching adjustments are provided for each of the four load cells as part of the indicator rationalisation of load cells is unnecessary.

Zero Load Output
At zero load, load cells still produce an output typically from 1% to 5% of full output, depending on type and manufacturer. It is important that indicator zero adjustment range can accept this as well as any tare weight.

Creep
The output of a load cell at constant weight is not constant but slowly moves or ‘creeps’ from the instant the load is placed on the load cell. Creep is a significant error in many process weighing applications and is defined over different time period for different types of load cells e.g.:
Stainless steel all welded bending beams of combined error 0.05% creep not more than 0.025% over 30 minutes.
The operating temperature range for which creep is specified is also important as creep can change with temperature.

Overload to Zero Shift
If a load cell is gradually loaded beyond its capacity there comes a point when on load removal a permanent shift in zero load output will be observed. This point is typically at 150% to 200% of load capacity depending on type of load cell and manufacturer. This is because the elastic limit of the load cell element has been exceeded and the load cell has lost the ability to return to its original state.

Overload to failure of mechanical integrity
As increasing overloads are placed on a load cell, eventually it literally collapses. This point is typically from 300% to 500% of load capacity depending as type of load cell and manufacturer. It is to guard against the safety implications of loss of mechanical integrity that alternate load route via jacking bolts, by-pass bolts or brackets should always be used particularly in suspended load tension applications.

Load Cycling and Fatigue
If rapid and repeated load cycling is envisaged for sustained period of time then fatigue damage will eventually build up in the load cell. The symptom will be increasing zero load output both in size and repeatability. With rapid filling and emptying cycles as part of the weighing process care should be taken in selecting and installing the load cell. In many such instances reverse loads when emptying the vessel or hopper contributes significantly to the accumulating fatiguing of the load cell element.

Physical Deformation
Although possessing no moving parts in the conventional sense, load cells do require to physically deform as part of their transducer action.

Load Cell Operating Life
There is no clear-cut answer to the question ‘how long do load cells last?’ What can be said falls into two parts:

A well installed modem process weighing system with correct periodic servicing and recalibration will give at least 10 years trouble-free service to original performance specification.

There are numerous systems world-wide in which the original load cells are currently connected to their third or fourth generation of electronics that have been replaced due to obsolescence or wear and tear and are still functioning to their original specification.

Load Cell Electrical Characteristics
The full bridge load cell is a four-wire device with each wire connected to the junction point of a full form version Wheatstone bridge.

Through one part of opposing bridge connections the load cell is supplied with excitation.

From the other part of opposing bridge connections the load cell output is taken.

Electrically the load cell is a proportional sensor. That is the output voltage is a varying proportion of the excitation voltage depending on the load applied. Typical electrical parameters are:

Excitation:
A d.c.. Voltage of typically 10 volts. Nominal 15 volts maximum.

Output:
A low level analogue voltage of from lOmV to 25mV at 10 volts excitation depending on load cell type.

NOTE
For a 350 ohm load cell bridge the input impedance load is typically 350 to 440 ohms. The output source resistance is typically 350 +/- 3 ohms.

LOAD CELL TYPES AND ACCESSORIES

Shear Beam Load Cells

Shear beam load cells are now firmly established in the weighing industry and offer a wider selection of mounting options and solutions to weighing problems than any other individual load cell type. They are virtually unaffected by end loading and can accept higher side loads than any other type of cell.

A wide range of adapters are now available to assist the vessel designer in accommodating the load cells into his structure. These designs will allow for small amounts of structural misalignment and allow shock absorbers to be incorporated into the mechanical package. By far the most useful method for utilizing shear beam load cells is the integrated mechanical interface mounting.

For example, a well-designed unit will incorporate built in lift off prevention, latitudinal restraint and built in jacking facility for transport and site installation. This unit will allow a fully kitted out vessel to be transported and erected with the load cells installed but not carrying any load, which is supported on the jacks until the installation is ready for commissioning. By correct design the identical mounting plates can incorporate a pivot arrangement in place of the load cell for lower cost, lower accuracy systems.

Bending Beam Load Cells

With load cells of the ‘bending’ type many mounting configurations and options are available.

An integrated mounting is available. Additionally ball and cup arrangements are popular, self-aligning devices. The integrated mounting unit is now available in lower capacities to incorporate dual cantilever bending beam load cells. All the application advantages that applied to shear beams equally relate to the inclusion of the bending beam load cell.

It is also worth remembering that where lighter weights are involved the lower capacity load cell is more likely to be damaged inadvertently during construction. The damage is only discovered when actual commissioning takes place, which will then most likely cause unwanted delays. The allows installation and erection of the vessel with the load totally supported on the built in jacks and can be used with or without the load cells in situ.

Tension Load Cell

When using tension load cells the main points to be borne in mind are that.

(a) The load cells will allow the vessel to adopt a natural alignment position.
(b) The load cell will be the main supporting member of the vessel.
(c) The load must be presented to the tension load cell so as to avoid bending moments on the load cell.
(d) When more than one tension load cell is used to support a vessel a means of ensuring that each load cell is supporting its share of the load. This is easily achieved by turnbuckle or adjustable links.
(e) The installation of safety check links or chains is recommended on suspended load applications.

T-End Fasteners

The high performance shear beam load cell is often fitted into industrial weigh platforms because of its type of construction, low profile and excellent performance.

As the need for a weigh platform to give the correct reading irrespective of the location of the load on the platform, most manufacturers have found it necessary to fit an adjustable electrical resistance network into the circuit to balance out outputs to overcome errors as described above. An mV/V/Ohm adjusted load cell however, when combined with the self-aligning foot makes electrical adjustments for cornering errors unnecessary. Load cells for this application can be selected and supplied as a matched set.

Canister Load Cells

During the development of measurement of weight by using load cells the compression or canister load cell has retained an important place in all forms of vessel weighing. Typical load cell capacities range from 100g through to several hundreds of tonnes.

The canister load cell has many useful features in that it is compact with regard to load capacity, easy to install with low holding down forces required, it is easy to seal against the elements and is simple to install in the load path. In addition, catastrophic failure is very rare.

In order to obtain the best results from a canister load cell it is necessary to ensure that the load is applied vertically through the axis and that loading angles of more than 10-15 are avoided.

In essence, lateral restraints to counteract rotational forces and overturning protection should be considered where appropriate.

SINGLE POINT LOAD CELLS

The single point, ‘centre cell’ or moment insensitive load cell, has seen an enormous increase in its use during recent years.

This type of load cell has revolutionized the small platform and retail scale market and has found acceptance in many industrial applications. Its main advantages are that it offers simplicity of design, high performance combined with low cost. It is easy to design into a mechanical structure and with the latest special protective coatings of critical areas can be used in a wide range of diverse applications.

Fig: 8.1 shows a typical single point scale application and the relatively easy means of protecting the load cell from severe overloading.

Many single point load cells incorporate a built in adjustable overload stop to prevent overload but additional stops are desirable to prevent twisting of the load cell when a severe force is applied from outside the centre line. These stops will need to be set accurately and this usually means a fine thread form and a means of locking in the chosen set position.

When using such load cells it is important not to exceed the manufacturers recommendations for torque fixings and care will have to be taken not to damage the cell by excessive twisting action or ‘kick back’ from a pre-set type torque wrench.

Setting Overload Stops

Different scale designs will require an overload stop mechanism appropriate to that design, but in general for optimum protection against distortion of the load cell, the cell movement should be restricted to its rated capacity (in practice the scale weighing range is restricted to approximately 80% of the load cell capacity).

Side Load Protection

A successful platform design will not only protect the load cell from overload but will also incorporate a degree of side load protection to ensure long operating life.

Environmental Protection

In general the majority of single point load cells are incorporated into scales which themselves provide the environmental protection. With the development of solid to the touch yet flexible silicon compounds a high degree of protection against moisture is available. The coating of

sensitive to moisture areas of the load cell with those compounds also provide a higher degree of mechanical protection useful during the scale manufacturing process.
The combination of splashguards and silicon coating will provide a high degree of protection without detracting from the load cell performance, see Fig: 8.3.

HIGH SPEED WEIGHING
An alternative to the Linear Voltage Differential Transformer (LVDT) for use in high-speed check weighing machines has centered on two viscous damped single point load cells.

In general terms, high speed weighing is divided into two categories of load application.

Firstly, where the component to be weighed is transferred across the weigh platform (usually by belt conveyor) and in this mode there is little or no shock-loading factor to be accommodated. Secondly, where the product to be weighed is dropped into a weigh hopper from an elevated storage hopper. The weighing containers usually have bottom exiting flap doors and the tare weight of the container is often much higher than the net product weight.
With this mode of weight application high shock or impact loads are inflicted on the sensor. As indicated above, two such diverse applications have resulted in two different mechanical solutions, both of which use the highly accurate off centre load cell as the load sensor.

Where the high tare to product ratio is applicable a means of backing off the high tare weight whilst at the same time the full weight range of the load cell available is required.
It follows therefore that it is necessary to select the correct load cell for a given application.

Principles of operation
An undamped cantilever load cell can behave like a very stiff spring. Consequently when preloaded with a weight and shock excited by another weight, the sensor ‘rings’ for an appreciable time. A settling time of several seconds may be acceptable in platform scale applications but it is not acceptable for high speed repetitive weighing.

Settling time is the elapsed time from the instant of loading to the time the load cell’s signal remains within the users specified accuracy. Settling time is affected by the following parameters:-

(a) Total mass on the module and its distance from the mounting centre.
(b) Impact loading characteristics.
(c) Environmental temperature change.
(d) For optimum performance, the user must specify the above parameters

Damping and effect of temperature
The damping characteristics are factory adjusted for minimum settling time under user specified conditions. Upward increases in temperature will cause the settling time to increase and vice versa. Theses parameters need to be considered when ordering from the factory.

However in the temperature range of 10°C to 30°C the settling time will be within specified limits (See data sheet).

Load Cell Life
Damped load cells are not impervious to external vibrations. They are designed to damp its own natural tendency to vibrate when a load is applied reasonably quickly. This does not however mean that it rejects vibrations applied to it through its mountings. It is therefore essential to minimize such vibrations to ensure accurate readings. This can be achieved by mounting the load cell on a separate frame isolated from the heavier rotating parts of the machine, or by introducing anti-vibration mounts or shock absorbers between the load cell and the mounting frame.

Applying the load
The load should be transported onto the weighing platform in such a way that it creates the minimum disturbance. If the load traverses across a platform, it should, if possible, avoid knocking the platform edge (i.e. no step). If the load is lowered onto the platform it should ideally be a controlled placement, not a drop load. For optimum performance the line of action of the applied load should act as near as possible to the centre line of the load cell in both horizontal planes to minimize eccentricity effects.

USE OF LOAD CELLS IN HAZARDOUS LOCATIONS

Note: This chapter is intended as a guide only and the company and the author cannot accept responsibility for misuse or misunderstanding of the contents. Before embarking on hazardous application of load cells competent authorities should be consulted.

General
There has been a vast expansion in the oil and petrochemical gas and associated industries in the last 50 years and where process plants were originally sited in open countryside away from significant population concentrations, the plants have now been engulfed in other light industrial manufacturing plants and domestic residential accommodation. Under these circumstances any explosion could have catastrophic consequences.

The increase in production volumes has also placed demands on the process control industries to measure and control gases and liquids on ever increasing, bigger plants. The requirement to ensure that non-spark propagating equipment only was used in areas where explosive conditions were likely to be present restricted the contents measurement of tanks and vessels to pneumatic or hydraulic measurement systems. Unfortunately, though cost effective, they were not accurate enough and transmission of readings was restricted to relatively short distances. As the automation of plants continued a need for reliable data was essential and ways were found to locate equipment, which previously was not suitable for use to be employed.

The early content measuring systems using strain gauge load cells were powered by thermionic valve amplifiers which were capable of significant spark generation thus prohibiting there use in hazardous applications. However, the gradual introduction of discreet semi-conductor devices and later integrated circuits with significant reduction in operating voltages and power, made possible lower cost, energy limiting systems to be used under hazardous and safe area systems was implemented.

Before proceeding it is necessary to understand how an explosion can take place.

Three components are required to create an explosion:-
(a) A quantity of fuel in the form of gas, vapour or in fine powder form.
(b) An oxidizing component, generally air or oxygen.
(c) A means of ignition - electrical or thermal.
If all three are present in due proportion at the same time a reaction can take place. Oxidation, combustion and explosion are all exothermic reactions.

Ignition triangle
An explosion requires all three elements to be present in the triangle and the technique is to eliminate one or more elements thus rendering the system ‘safe’.

NOTE: Depending on how the exothermic reaction energy is liberated the results can be a flame wave, a controlled combustion or an explosion.

Some materials can spontaneously explode without a means of ignition energy but here we are dealing with prevention of explosions which have been ignited by an electrical circuit fault.

In practice there are three alternatives methods of protection available in areas of potential explosion and they are:-

(a) Explosion containment whereby an explosion may occur but it is confined into a defined space and the enclosure is of sufficient mechanical strength to prevent propagation of the reaction to the surrounding atmosphere by rupturing the enclosure.

(b) Segregation techniques whereby electrical components or hot surfaces are isolated from the explosive atmosphere and these include methods such as air purging of cubicles in maintaining a higher than ambient internal pressure in the cubicle in order to exclude ambient potentially explosive mixtures or encapsulation.

(c) Prevention by limiting both thermionic and electrical energy to safe levels even in unfavourable circumstances.

NOTE: this guide is concerned with (c) only.

General comparison between most common methods

In practice it is acceptable to use a load cell which has been designed and manufactured to meet the required standards and has been examined and tested by an authorised body in conjunction with the correct zener barriers and installed in the prescribed manner to be certified as an intrinsically safe system.

TYPICAL APPLICATIONS

Use of load cells for the measurement of weight, force, and volume have been established for many years as the preferred non-intrusive means for improving efficiency, quality and reducing waste material. In addition load cells can be placed in locations that are dangerous to man.

Long reliable service can be expected if the basic rules contained in this book are adhered to. It is worth taking care at the design stage to ensure a good installation, as the cost of possession will then be minimal over many years.

There are numerous systems worldwide in which the original load cells are currently connected to their third or fourth generation of electronics which have been replaced due to obsolescence or wear and tear and are still functioning to their original specification.

GLOSSARY OF WEIGHING TERMS

FRO (Full Range Output)

Load Cell and weighing system performance.

FSO (Full Scale Output)

Specifications are quoted as a percentage of FRO or FSO.

Total Error

The maximum deviation from a straight line drawn between the no load and rated load outputs for both increasing and decreasing loads.

Combined Error

The sum of linearity, repeatability and hysteresis.

Linearity

The output deviation at intermediate loads from a straight line drawn between zero load and full load outputs.

Repeatability

The difference in load cell output with successive load cycling to the same load.

Creep

The variation in load cell output with time after loading from zero to a constant load

Creep Recovery

The variation in load cell output with time after removal of a constant load.

Full Load Output / Rated Load Output

The output of a load cell at its rated load capacity.

Sensitivity mV/V

The output of a load cell in millivolts (mV) per volt (V) of excitation at the rated load.

Excitation

The voltage used to excite the load cell. Usually 10 volts d.c. in amplitude.

Rationalization
A factory option quoted on most industrial load cells tighten sensitivity spread from +1-2 to +5% down to +1-0.1 to 0.2% for matched output sets for non-uniform loading application.
Side Load
Load applied at right angles to the normal load path. Usually the normal load path is vertically downwards.
Eccentric Load
Load applied to a load cell displaced from the normal load axis.
Overload Limit
Load Cells are specified to resist loads beyond rated capacity without permanent zero shift typically up to 150% of rated capacity. Beyond this overload limit, permanent zero shift may occur on load removal.
Insulation Resistance
Load Cell cable screens are not normally earthed at the load cell element. Insulation resistance is the resistance between each cable core (including screen) and local structural earth. Typical values would be more than 1000 mega-ohms at 100 volts d.c. unless coated with silicon type compounds.
Hysteresis
The difference in load cell output at the same load value, between increasing load and decreasing load.
350 ohm Bridge / Full bridge load cell
Virtually all industrial load cells use four bonded strain gauges in a full bridge or Wheatstone bridge configuration. Typical gauge resistance is 350 ohms giving an overall bridge resistance of 350 ohms.
Gross Weight
The total weight on the load cells including fixed structure or tare, container tare and contents to be weighed.
Tare Weight
That part of the weight on the load cells such as structure or container which is not required to be measured for process weighing purposes.
Net Weight / Live Load, Tare/Back Weight
That part of the weight on the load cells which is to be measured for weighing purposes. The fixed or structure weight on the load cells.
Zero Adjustment
The adjustment of weight measurement at zero live load or when both live load and removable tare are zero.
Span Adjustment
The adjustment of weight measurement at maximum live level.
Zero Drift
Variation in weight measurement with temperature or time, at zero live load or when both live load and removable tare are zero.
Span Drift
Variation in weight measurement with temperature or time at maximum live load.
Remote Sense, Six Wire Current
A method of using an additional pair of wires to a load cell at load cell summation junction box to remove the errors from long cable lengths usually stemming from varying cable temperatures.

HEALTH AND SAFETY

Health and Safety Guidelines
1. Do read the operating instructions before you attempt to use the equipment.
2. Do ensure all electrical connections are properly made and that all terminal block screws are fully tightened.

3. Do have the equipment checked periodically by a qualified engineer, besides ensuring that you will continue to have the best results, he can check that the installation has remained electrically safe.
4. Do not continue to operate the equipment if you have any doubt about it working normally or if it is damaged in any way. Disconnect the mains and consult a qualified engineer.
5. Do not remove any fixed cover unless you are qualified to do so and even then only after isolating the mains supply
6. Do not connect this equipment to the mains supply unless you are qualified to do so or you fully understand the equipment wiring diagram and installation instructions.
7. Do not use load cells to measure suspended loads without full consideration of safety aspects.
8. If in doubt contact your supplier.
9. Full advice should be sort from the appropriate authority before contemplating using load cells in defined hazardous areas.

3.7 PROTECTION SPECIFICATIONS

Although our industries have in-depth standards and test procedures to define load cell and weighing system performance, no standards have been developed to cover product suitability for specific environmental conditions.

In the absence of such standards, most manufacturers have adopted the international Index of Protection (IP rating) system (IP/IEC 529 or EN 60529) or National Electrical Manufacturers Association Standards (NEMA publication 250) to define the level of sealing for their products. Both standards provide good test procedures for environmental sealing when applied to the products for which they were intended - those being electrical enclosures, but they are not very well suited to weighing equipment.

IP Ratings
The IP standard describes a system for classifying the degree of protection provided by the enclosures of electrical equipment:

- Protection of persons against access to hazardous parts inside the enclosure.
- Protection of the equipment inside the enclosure against the ingress of solid foreign objects.
- Protection of equipment inside the enclosure against harmful effects due to the ingress of water.

Unfortunately, no definition is given for the term "harmful effects". Presumably, for enclosures, the main problem with water could be one of electrical shock to persons in contact with the enclosure, rather than malfunctioning of the unit. Furthermore, the standard only relates to water ingress and ignores moisture, chemicals, corrosion, etc.

The IP rating code is based on a two digit number. The first digit is the rating for solids and dusts, the second digit is the rating for liquids.

The commonly used categories to describe load cell and weighing equipment sealing are:

IP65	Protected against low pressure jets of water from all directions, limited entrance allowed
IP66	Protected against strong jets of water e.g. for use on ship decks, limited entrance allowed
IP67	Protected against the effects of immersion between 15cm and 1m
IP68	Protected against long periods of immersion under pressure

When a 7 or 8 designation is specified for a product, it is important to note that the standard clearly states that “an enclosure designated with a second characteristic numeral 7 or 8 is considered unsuitable for exposure to water jets (designated by second characteristic 5 or 6) and need not comply with requirements for numeral 5 or 6 unless it is dual coded, e.g. IP66 / IP68”. In other words, under certain conditions and for certain product designs, a product that has passed a half hour immersion test may not necessarily pass one which involves the use of high pressure water jets from all angles.

NEMA Standards

Classifications in the NEMA system run from NEMA 1 to NEMA 12, but load cell manufacturers concern themselves with NEMA 4 and NEMA 6. Unlike the IP system, NEMA does concern itself with environmental conditions such as corrosion, rust, freezing, oil and coolants.

NEMA 4 enclosures are intended for indoor and outdoor use, providing a degree of protection against windblown dust, rain, splashing water, and hose directed water. However, no consideration is given for the effects of internal condensation. NEMA 4X enclosures meet the same standards as NEMA 4 and are constructed of 304 stainless steel or other material offering equal corrosion resistance.

NEMA 6 enclosures are used where there is a chance of temporary immersion. This standard calls for the highest part of the enclosure to remain submerged in water, with its highest point 1.83 metres below the surface for 30 minutes. NEMA 6P enclosures are used where prolonged immersion may occur and resistance to corrosion is needed.

While it may seem that NEMA standards offer some advantages over the IP system for corrosion resistance, they only relate to external corrosion of enclosures. This is very limited when applied to the more complex load cell construction and the different effects of corrosion or water ingress.

References

British and EN standards can be obtained from the British Standards Institute (BSi) website. See the bibliography for full references.

NEMA standards can be obtained from the NEMA website:

http://www.nema.org/stds/

Search for publication number 250.

The NEMA website also provides a comparison between the NEMA standards and the IP ratings:

http://www.nema.org/stds/briefcomparison.cfm

3.8 RISK ASSESSMENTS

Risk Assessment – Health and Safety Law

General Duty on Employer
The Management of Health and Safety at Work Regulations 1999 place a general duty on employers to assess all risks to employees and 'others' that arise as a result of work activity.

'Others' includes the employees of another employer where, for example, work is being undertaken on a customer's premises. It also includes members of the public where work could put members of the public at risk.

Specific Risks
Requirements to assess specific risks are covered in other Regulations. The Approved Codes of Practice and/or Guidance Notes that accompany the Regulations give help on when and how this needs to be done. Examples of specific Regulations include:

- Control of Substances Hazardous to Health Regulations
- The Control of Noise at Work Regulations (Introduced April 2006)
- Display Screen Equipment Regulations
- Manual Handling Operations Regulations
- Fire Precaution Workplace Regulations
- Confined Spaces Regulations

General Requirement of a Risk Assessment

- It must be 'suitable and sufficient'
- Carried out by / under the supervision of a competent person
- Significant findings documented where employer has 5 or more employees
- Assessments should be reviewed periodically

HSE Guidance on Risk Assessment
Useful guidance on risk assessment has been published by the Health and Safety Executive (HSE) in a free publication entitled 'Five Steps to Risk Assessment'. This is available from the HSE website or from HSE Books.

It is suggested readers obtain a copy of the publication and read it in conjunction with this paper.

HSE Terminology – 'Hazard' and 'Risk'
The HSE define a 'hazard' as 'something that has the potential to cause harm'. A 'risk' is defined as' the likelihood that the potential for harm is realised'.

A hazard can be something that could give rise to danger – for example electricity. The risk is how likely it is that a person might get an electric shock whilst carrying out work on a particular task involving electricity.

A hazard can also be a particular work activity in itself such as:

- Installing a machine
- Operating a machine
- Working at height

If we consider working at height as a hazard one associated risk is how likely it is that a person might fall from a ladder whilst painting a house.

Carrying out a Risk Assessment – the Basics
Conducting a risk assessment starts with asking 3 simple questions in relation to a hazard – remember the hazard could well be the work activity itself.

1. What could go wrong or how might harm occur whilst we are doing this job?
2. How likely is it to go wrong – given the circumstances?
3. How bad would the injury be if it did go wrong?
   (Estimating likelihood and extent of the injury will be dealt with later.)

Consideration can then be given as to whether the risk is acceptable. Ideally risks should be eliminated. For example, if there is a risk of electric shock whilst servicing a machine, the risk of shock can be eliminated through effective electrical isolation. If the risk cannot be eliminated then it should be reduced to an acceptable level by introducing suitable risk controls.

Risk Controls
The Approved Codes of Practice that accompany Regulations suggest risk controls in an order of preference – a hierarchy. This is shown below.

- Elimination
- Substitution – a mobile tower is safer than a ladder
- Barriers, guards
- Use of rules, procedures – permit to work prior to starting job
- Warning signs
- Use of Personal Protective Equipment

Risk Assessment – Through Task Analysis
In order to explain the general principles of risk assessment we shall use an example of work which most people will be familiar with.

Let's suppose that you and your partner have recently purchased a large Victorian semi-detached house. You wish to restore some of the rooms to the Victorian style and plan to start with the hall, stairs and landing.

Tasks will include:
- Lifting existing carpets.
- Stripping paint from woodwork for re-varnishing.
- Removal of wallpaper / re-papering.
- Washing ceilings re-painting with emulsion.
- Sanding floor for re-staining.

Tools, equipment, materials:
- Assorted hand tools – brushes, scraper, wire wool
- Power tools – hot air paint stripper, industrial sander (hired in) portable sander, electric wall paper steamer (stripping paper)
- Ladders
- Paint /varnish stripper, various paints, wood stain and varnish.

If each task, listed above, is considered to be a hazard then a complete risk assessment can be conducted by brainstorming what could go wrong at each stage.

Lifting the carpets – what could go wrong, how might harm occur?
- Manual handling injury
- Accidentally kneeling on carpet grippers

Stripping paint from woodwork for re-varnishing – what could go wrong?

- Chemical burn from stripper
- Burns from hot-air stripper…and so on.

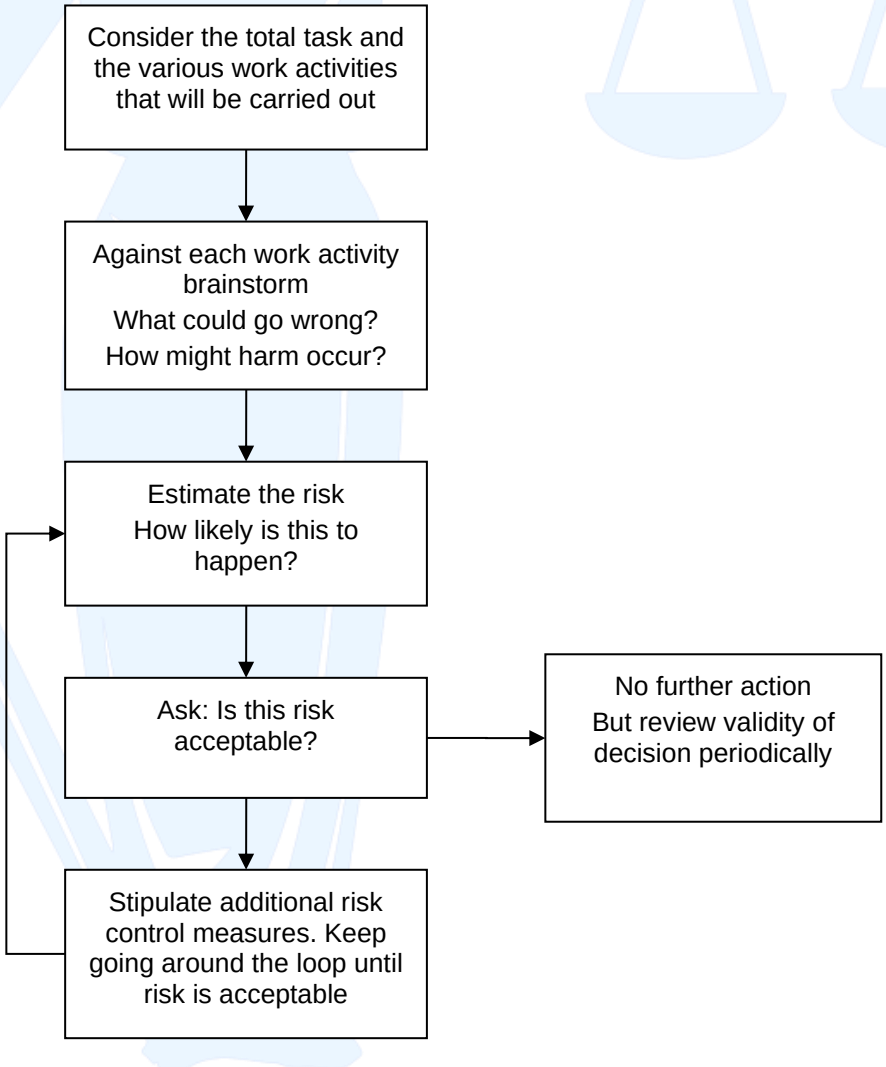
The process involves going through each operation in a systematic way so we can identify what could go wrong.

Consideration then needs to be given as to how likely it is to go wrong as well as how serious the injury, or other outcome, might be.

Thought then needs to be given as to whether the risk is acceptable – is it as low as we can get it?

If the risk is not acceptable then thought needs to be given to the additional risk controls that can be introduced to get the risk down to an acceptable level.

The flow chart below may be helpful.



The risk assessment in the flow chart is often a two-stage process; if the risk is not acceptable and additional risk controls are specified. A record is made of the 'initial risk' – before additional controls were specified. An assessment is then made with the specified controls in place – this is the 'residual risk'. (See Risk Assessment Form)

Estimating Likelihood and Severity

Various systems have been devised. Some organisations put numerical values on likelihood and severity. The overall risk is Likelihood Factor multiplied by the Severity Factor. Some organisations prefer to rank likelihood and severity in terms of high, medium and low. Example of a numerical scheme is given below.

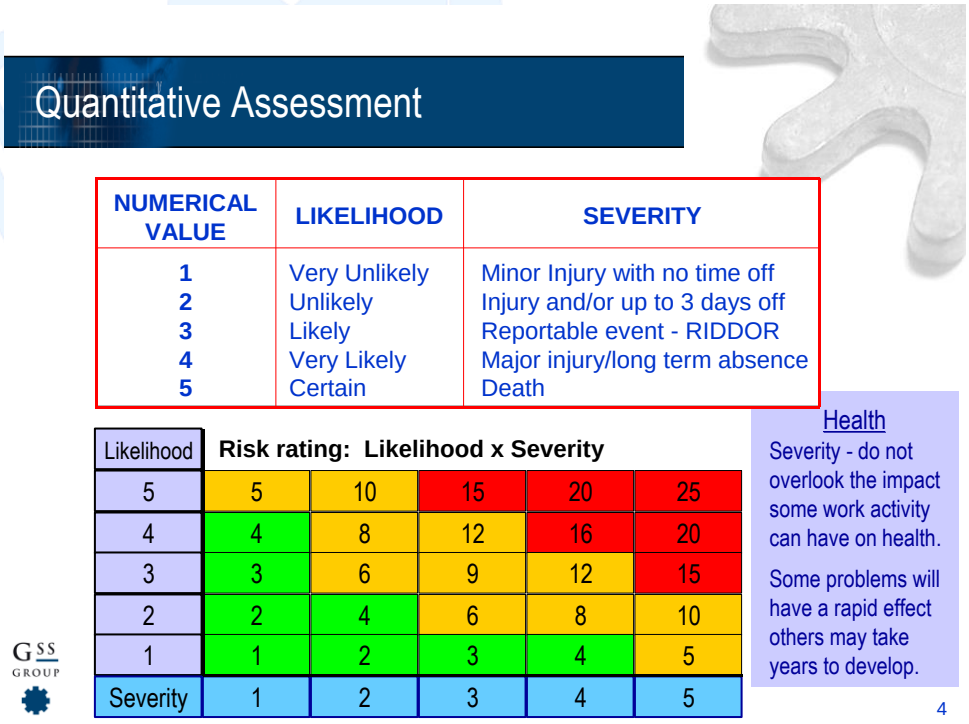
Likelihood – some organisations use a 1 – 5 rating. Guidance may be given on how to apply these.

1. Very unlikely to occur – might occur once
2. Unlikely to occur
3. Likely to occur
4. Very likely to occur
5. Certain to occur

Severity – when estimating severity it is important to base the estimate on the extent of an injury that will typically occur from a given event. The worst possible case scenario should not be used.

1. Minor injury with no lost time
2. Injury up to 3 days off work
3. Reportable injury under RIDDOR
4. Major injury/long term absence
5. Fatality

Under this system the lowest risk (Likelihood x Severity) has a factor of 1. The highest risk has a factor of 25. This would represent an unacceptable risk rating.



The chart above has been adapted from practices in the offshore oil and gas industry. The Safety Management System of a company may stipulate. Tasks in the red area must not proceed. Tasks in the brown area can only proceed when the method has been thoroughly reviewed by a Senior Manager. Jobs in the green area can go ahead.

Risk Assessment Form

Below is an alternative form to the one suggested by the HSE in 'Five Steps to risk assessment:

Task Analysis Risk Assessment Form

Assessed by: Assessment Date: Review Date:

Detail of task:

HAZARD Activity Equipment Substance	**RISK** What could go wrong? How could harm occur?	Initial Risk L x S = R			CONTROL MEASURES	Residual Risk L x S = R		

3.9 MARKET SURVEILLANCE

Introduction
If you import into or manufacture equipment in the EU, it must comply with all of the requirements of all of the directives that apply to it. It is your job to ensure that this is the case. Simply relying on the CE mark being present is not a sufficient defence to prevent possible investigation or prosecution. You will have to undertake some of your own tests and back them up with all of the technical information relating to the equipment.

What is market surveillance?
It is the responsibility of all governments to ensure that instruments that are placed on the on the market comply with all aspects of the Directives that apply to them.

If you take responsibility for manufacturing or importing weighing instruments it will be up to you to ensure that you comply with the requirements of all directives by carrying out checks on the instruments that you supply. A failure to carry out any checks may leave you open to action, and potential prosecution, by market surveillance authorities.

What is the difference between market surveillance and inspections?
Market Surveillance takes place when the instrument is first verified and put into use. This may be at the place that it is manufactured or imported, but if the accuracy is dependent upon where the instrument is used, such as weighbridges, the market surveillance will be carried out there.

Market surveillance will examine all of the technical aspects of the weighing instrument. In practice this will involve checking that the instrument complies with all aspects of the type approval certificates. It may involve a relatively cursory check, but could involve the market surveillance authorities examining all of the technical files relating to the instrument and may involve the testing of all aspects of the machine to ensure compliance. This can be very time consuming and the manufacturer or importer can be responsible for the any failure to comply with any of the requirements.

Inspection takes place after the instrument has been put into use, and will invariably be carried out by a local Weights and Measures Inspector. Inspection usually involves checking the accuracy of the instrument although some of the checks carried out when doing an inspection can be considered market surveillance.

Is the difference between market surveillance and inspection important?
The main difference between market surveillance and inspection is the powers available to the authorities if a manufacturer or importer does not comply with the requirements. If non-compliance is revealed during an inspection, the instrument can be rejected, a notice can be left or advice can be given. The effect of the enforcement invariably will only relate to that instrument.

If the non-compliance relates to a matter of meeting the requirements of the directives, the market surveillance authority can ask for all instruments in the market place with that non-compliance to be withdrawn, can issue a warning to all other European states informing them of the problem. In certain circumstance can withdraw the right of the manufacturer to make EC Declarations of Conformity for up to a month.

If manufacturers or importers are to avoid the draconian powers that can be used they must takes positive steps to ensure compliance

What should I do?
If you are a manufacturer, authorised representative or importer into the EU of equipment you must take positive steps to ensure that you are meeting the obligations of the directive. To do

nothing will leave you open to actions in the event of a non-compliance being discovered by the authorities.

These checks do not have to be a repeat of the type approval test, but will be at a lower level to ensure that you have taken steps to ensure compliance. You would only need to keep the paper work records suggested in 1) below for each type of instrument that you manufacture or import, The number of instruments that you should carry out checks on will be dependant upon the type and number of instruments and whether you operate as a manufacturer or importer. If you are an importer it should include a small number of instruments in each batch that you import.

1) Checking and keeping a copy of all aspects of the technical assessments that have taken place ensure compliance of the instrument. This would include not only those certificates or reports that relate to the weighing aspects, but any documentation that relates to electrical safety or electromagnetic immunity.

2) To ensure that all of the appropriate markings are on the instrument and that the markings relate to the instrument to which they are applied: Is the maximum capacity of the instrument and the range of the tare the same as the one marked?

3) To ensure the correct edition of the software is on the instrument.

4) Correct sealing of the instrument to ensure that the security of the instrument is maintained. This should include the security of any software.

5) If you are not verifying the instrument you may carry out some basic metrological tests. This should include the application of known loads to the instrument and may include such things as a checking the instrument when the instrument is very hot or very cold or leaving a load on the instrument to check it does not creep.

This list is not exhaustive, but is intended to give examples of the type of checks that could be done.

It may not be necessary to carry out the suggested checks on each instrument. Depending upon the nature of your business they could be done on a sample of each consignment.

A checklist is attached to this document which may be of use in designing the type of checks that you carry out on the instruments. You should always keep records of the checks so that any inspection or market surveillance authority can see what you have done.

Checklist for Market Surveillance

	Yes	No	Comments
The first two headings should be completed for each model of instrument			
Do you have a copy of the TAC and other Test Certificates on file?			
Do you have a copy of any test results associated with the machine on file?			
The following checks should be carried out on a reasonable number of instruments			
Correct application of CE Mark			
Correct Application of M mark			
Correct application and location of other markings- (Information on these markings)			
Does the data marked on the machine relate to the instrument to which it is applied?			
Is the software edition number the correct one?			
Do you have the Declarations of Conformity for all relevant directives?			
Is the instrument and the software appropriately secured?			

If completing as second stage verification, do you have the appropriate certificates for the 1st stage?			
Have you carried out metrological tests on the instrument			
Tested in extreme heat or cold			
Tested for creep			

3.10 WEIGHING INSTRUMENTS USED FOR BUYING AND SELLING GOLD, OTHER PRECIOUS METALS, PRECIOUS STONES AND PEARLS

Members will be aware that there has recently been an upsurge in the number of people wishing to sell gold and jewellery and consequently, an upsurge in the number of jewellers and other organisations offering to buy. Many jewellers are now placing advertisements offering to buy gold based on weight. (For instance, this morning a number of jewellers in Birmingham had signs outside their shops offering to buy gold at £12.20 per gram.) To do this, they obviously need to be using Type Approved and Verified weighing instruments as this falls under both the definition of "use of trade" in the Weights and Measures Act 1985 and "Commercial Transaction" in the Non-Automatic Weighing Instruments (NAWI) Directive.

More and more jewellers are therefore looking to buy suitable weighing instruments. The following notes are therefore intended as a reminder to members of the special conditions which apply to non-automatic weighing instruments used for the jewellery trade.

Use of Class II instruments
Regulation 28 (30 of the Non-Automatic Weighing Instruments Regulations 2000 (S.I. 2000 No. 3236)) states:

> *A person shall not use for trade any instrument other than an instrument of accuracy classification Class I or Class II in any transaction*
>
> *(a) to, or to articles made from gold, silver or other precious metals, including gold or silver thread of fringe;*
> *(b) to precious stones or pearls.*

Quite clearly, therefore, any jeweller seeking to buy a non-automatic weighing instrument must be advised that he must purchase a Class I or Class II instrument; a normal Class III retail scales is not suitable.

Use of auxiliary indication
The normal Class III retail weighing instrument the indicators that are displayed are unambiguous, e.g. a 15kg x 5g weighing instrument displays in intervals of 5g. This is known as the verification scale interval (*e*) and this is marked on the instrument in the format e = 5g. However, many Type Approved and Verified Class I and Class II instruments are equipped with auxiliary indicated devices; that is, they are verified to be accurate to one level, but for guidance purposes they indicate to a higher level. For example, a balance may be verified to 2kg x 0.1g, but will have an additional display that enables it to be read to 0.01g (often the extra digit is of a different colour or is distinguished in some way). This additional digit is known as the actual scale interval (*d*), as opposed to the verification scale interval. In such cases, the instrument will be marked with an additional marking showing that the verification scale interval *e* is equal to 10*d*.

Whilst this auxiliary indication is a useful facility for many applications it is considered that an auxiliary indication would be confusing to the general public and consequently, auxiliary indications are not permitted on instruments used for selling jewellery in the presence of the customer. Schedule 2, Article 14 of the NAWI regulations states that on "instruments used for direct sales to the public… auxiliary indicating devices and extended indicating devices are not permitted". A TSO/authorised officer would be acting within his powers if he rejected/disqualified any instrument with an auxiliary device being used for that purpose. The TSO could also reject or disqualify such instrument used for buying jewellery on the basis that it was unsuitable for its purpose, using his powers under regulation 27. If an instrument is used away from the customer, then this restriction does not apply.

Weighing below "Min"

Generally speaking, a NAWI may be used for weighing below its marked "Min" value provided that such use is occasional rather than normal. For example, a supermarket could use its 15kg x 5kg retail instrument with its marked "Min" value of 100g to weigh the occasional sale goods below 100g (often used when a customer wishes to purchase, say, 1 slice of ham at a deli counter), but if a TSO found that the supermarket was selling this quantity 50 times a day, every day, he could justifiably argue that the instrument was not suitable for the purpose for which it was being used and he could require it to be replaced with a more suitable instrument.

However, under Regular 28(2) of the regulations mentioned above, this concession of allowing occasional use of an instrument below its marked "Min" value is specifically prohibited when determining the weight of gold, silver, precious metals, precious stones, pearls, drugs and other pharmaceutical products.

Summary

When advising/supplying weighing instruments for use in the buying or selling of gold to and from the public, jewellers must be advised that:

1. the instrument must be Type Approved and Verified
2. the instrument must be Class I or Class II
3. the instrument for direct sales can not have any auxiliary indication
4. the instrument can not be used for weighing below its marked "Min" value.

3.11 IN-HOUSE CALIBRATION OF TEST WEIGHTS

In general, in-house calibration of test weights can be an acceptable solution providing it is in accordance with the quality system of a company and fully traceable weights are used. However, this does require that the reference weights are of an appropriate tolerance class.

OIML Recommendation R111-1: 2004 (E) defines 9 classes or categories of weights. These are E1, E2, F1, F2, M1, M1-2, M2, M2-3, and M3. E1 is the most accurate and M3 being the least accurate.

Of these, we are concerned with Classes M1 and higher. M1 is the class that a Trading Standards Officers Working Standard weights would fall into and it is the class which members would normally have their test weights calibrated to for normal testing, calibration and verification of Class III and IIII non-automatic weighing instruments. The maximum tolerance on a 1kg M1 weight is 50mg.

If we use an M1 weight to calibrate an M1 weight we can very quickly get well outside the maximum tolerance. Assume our M1 reference standard is 40 mg below the nominal value of 1kg. If we then use this to calibrate our test weight which we find is 45mg below the nominal value, we would assume that our test weight is within the tolerance, because its error is less than 50mg, but the error on our reference weight of -40mg means in reality that the overall error on our test weight is -95mg, well outside the tolerance.

For that reason OIML R 111-1: 2004 (E) requires that weights are calibrated against a higher class of weight, and as a rule of thumb it recommends that the uncertainty of the error of the reference weight should not exceed 1/3 of the tolerance on the weight being calibrated. As the tolerances between weight classes are generally in the ratio 3:1, (i.e. the tolerance on an F2 weight is approximately one third of the tolerance on an M1 weight) it is fairly obvious that F2 should be the lowest class of weight used when calibrating an M1 weight, preferably the reference standard should be F1 to reduce the margin of error as far as possible.

Copies of R111-1:2004(E) can be downloaded free of charge from the OIML website at www.oiml.org/publications

3.12 AUDITORS NOTES ON CALIBRATION

The UK Weighing Federation (UKWF) has compiled the following notes to assist Management Systems Auditors when considering the calibration of weighing instruments. These notes have been updated to reflect the requirements of ISO 9001:2008.

There is confusion and often misunderstanding about whether calibration should be carried out by UKAS Accredited Laboratories. Whilst there are odd occasions where this is necessary, in the vast majority of cases, particularly for weighing instruments that fall within the category of Class III or Class IIII instruments as defined in OIML (Organisation Internationale de Metrologie Legale) Recommendation R76, calibration to UKAS accreditation level is far more than necessary and the additional cost would not add any value to the veracity of the calibration certificate.

Non-Automatic Weighing Instruments are those that require the intervention of an operator at some stage during the weighing process.

The appropriate Clause of ISO 9001:2008 is 7.6 which, for ease of reference is reproduced here:

> *7.6 Control of monitoring and measuring equipment*
>
> *The organization shall determine the monitoring and measurement to be undertaken and the monitoring and measuring equipment needed to provide evidence of conformity of product to determined requirements.*
>
> *The organization shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.*
>
> *Where necessary to ensure valid results, measuring equipment shall:*
> *a) be calibrated or verified, or both, at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded (see 4.2.4);*
> *b) be adjusted or re-adjusted as necessary;*
> *c) have identification in order to determine its calibration status;*
> *d) be safeguarded from adjustments that would invalidate the measurement result;*
> *e) be protected from damage and deterioration during handling, maintenance and storage.*
>
> *In addition, the organization shall assess and record the validity of the previous measuring results when the equipment is found not to conform to requirements. The organization shall take appropriate action on the equipment and any product affected.*
> *Records of the results of calibration and verification shall be maintained (see 4.2.4).*

In 1999, recognising the need for a consistent approach to the calibration of non-automatic weighing equipment, the UKWF in consultation with the Trading Standards Institute, LACORS (Local Authorities Co-ordinating body on Regulatory Services) and the Institute of Measurement and Control drafted a practical guide to calibration of weighing instruments. The guide was issued in the form of a Code of Practice and UKWF members providing calibration services to their customers are required to adopt and follow the Code. Those members who are themselves ISO 9001:2008 certified are required to reference the Code in their QMS documentation so that compliance will be covered by both the internal audit system, and by the Certification Body; those UKWF members who are not ISO 9001:2008 certified are audited

by the Federation itself for compliance. In the following table we compare ISO 9001:2008 requirements against the UKWF Code of Practice.

ISO 9001:2008; Clause 7.6 Requirement	UKWF Calibration Code of Practice Summary of Requirement
The organization shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.	The UKWF Code requires that specific tests designed to reliably and consistently measure the weighing instruments performance are carried out and recorded during the calibration exercise. The tests are designed around those laid down by the OIML in Recommendation R76.
Where necessary to ensure valid results, measuring equipment shall *a) be calibrated or verified, or both, at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded.*	UKWF Members are required to carry out calibration using test weights that have been calibrated in a manner traceable to national standards. Members may either use the services of UKAS accredited Laboratories for the calibration of their weights, or have them calibrated by a Local Authority Trading Standards Department operating under section 74 of the Weights and Measures Act. In either case the calibration is directly traceable to the UK Primary Standards. Members are required to identify the calibration status of their test weights on the calibration certificate that they issue .
Where necessary to ensure valid results, measuring equipment shall….. *b) be adjusted or re-adjusted as necessary;*	UKWF Members are required to carry out both “As Found” and - if adjustment or repair has been necessary - “Definitive” tests on the weighing instruments that they calibrate.
Where necessary to ensure valid results, measuring equipment shall …. *c) have identification in order to determine its calibration status;*	The Code requires UKWF members to record serial numbers or other identification on the test records and on the calibration certificate that they issue.
Where necessary to ensure valid results, measuring equipment shall …. *d) be safeguarded from adjustments that would invalidate the measurement result;*	UKWF Members are required to affix a calibration label to the weighing instrument, identifying the calibration date. The label should be impossible to remove without destruction, and should, whenever possible be placed so that access to any adjustment facility is not possible without the label being broken.
Where necessary to ensure valid results, measuring equipment shall …. *e) be protected from damage and deterioration during handling, maintenance and storage.*	UKWF Members are trained in the handling and maintenance of weighing instruments and will provide advice and guidance to customers who may wish to store equipment during periods when it is not in use.
In addition, the organization shall assess and record the validity of the previous measuring results when the equipment is found not to conform to requirements. The organization shall take appropriate action on the equipment and any product affected.	The Code requires UKWF members to provide details of any errors found during the calibration. In normal circumstances weighing instruments are deemed to be satisfactory if they are performing within the tolerances laid down in Weights and Measures legislation, but where a customer wishes he may specify his own tolerances if the equipment is not legally controlled by the Weights and Measures legislation. In either instance the tolerances

	applicable are required to be recorded on the calibration certificate.
Records of the results of calibration and verification shall be maintained (see 4.2.4).	UKWF Members are required to provide their customers with a calibration certificate which must include details of the instrument calibrated, the date and place of calibration, the tests carried out and the results of those tests, as well as the information detailed above. In addition the Certificate is required to identify the calibrating organization, membership of the UKWF and the fact that the calibration has been carried out in accordance with the Code .

In addition to the above, the UKWF also requires Members to ensure that the personnel they use to carry out calibrations are adequately trained and that the training is recorded in their files. Compliance with the code is mandatory on Members offering calibration service.

Some users of weighing instruments have endeavoured to carry out calibration themselves. In such instances, it is unlikely that they are aware of the need to maintain traceability between the weights they use and national standards; they are unlikely to have been trained in correct calibration procedures; they are often unaware of what tolerances are acceptable; they are unlikely to be able to distinguish between those errors caused by malfunction and those caused by incorrect usage, and in the event of a problem they will still need to use a specialist to carry out any necessary corrective actions.

Copies of the UKWF Calibration Code of Practice for non-automatic weighing instruments can be obtained from the UK Weighing Federation; please contact the Federation Secretariat via our web-site www.ukwf.org.uk.

If you have any queries or questions relating to the Code or this note please contact the Federation's Technical Officer at technical2@ukwf.org.uk.

The Federation has also produced a Code of Practice for weighing instruments used for weighing cementitious products; the requirements are broadly similar to those for non-automatic weighing instruments and the same high standards of training, traceability, record keeping, certificate content and sealing are included. Copies are available from the UKWF Secretariat, if required.

BIBLIOGRAPHY

UK legislation and guides
Her Majesty's Stationery Office (HMSO) is still responsible for the publication of legislation and the management of Crown copyright but has been subsumed within the new Office of Public Sector Information (OPSI).

Online documents are available from OPSI, UK Acts 1988 onwards, UK Statutory Instruments (SIs) 1987 onwards:

Office of Public Sector Information: http://www.opsi.gov.uk

Specific metrological acts and regulations are listed in section 2.1.2. Other legislation is referred to in various other sections of the Technical Articles.

Other guides
The NMO have produced a set of guidance notes for the Non-automatic Weighing Instruments Regulations 2000 SI 2000 No. 3236. This is available from their website:

http://www.bis.gov.uk/assets/nmo/docs/legislation/legislation/nawi/nawi-amendment-nfg---final-version-feb-09.pdf

The European commission has published a guide to the "New Approach" directives and provides detailed information on CE marking. It can be downloaded from the following location:

http://ec.europa.eu/enterprise/policies/single-market-goods/files/blue-guide/guidepublic_en.pdf

The government has published guidance on the RoHS directive through the DTI website at the following address:

http://www.bis.gov.uk/assets/nmo/docs/rohs/support-literature/producer-support-booklet.pdf

Directives

CONSLEG The Office for Official Publications of the European Communities
2, rue Mercier
L-2985 Luxembourg
Tel: (352) 2929-1
http://publications.eu.int/
They have a searchable website where directives are available free of charge:
http://eur-lex.europa.eu/en/index.htm

Relevant directives include:

- the NAWI directive and the MID, discussed in section 2.1.1
- EMC, low voltage and machinery directives, sections 2.3.2, 2.3.3, 2.3.4
- ATEX directives, sections 1.8 and 2.3.5

Standards

British Standards Institute (BSi)
389 Chiswick High Road
London
W4 4AL
United Kingdom
Tel. 020 8996 9001
http://www.bsi-global.com/

Standards are also available at The Stationery Office, details above, and can be found by searching for the standard number at the following addresses:

http://www.bsonline.bsi-global.com/server/index.jsp

The main standard that is used in the weighing industry is the European harmonised standard for NAWIs that has been adopted as a British standard:

BS EN 45501 “Specification for metrological aspects of non-automatic weighing instruments”
ISBN: 058021950X

Note: the content of this standard is taken directly from OIML R76

There is also the standard for the Index of Protection (IP rating) that is often referred to for weighing and other industrial equipment:

BS EN 60529 “Specification for degrees of protection provided by enclosures (IP code)”
ISBN: 058020407 3

Other standards are too numerous to list here but the European Commission website includes a list of directives with links to lists of relevant EN standards:

http://europa.eu.int/comm/enterprise/newapproach/standardization/harmstds/reflist.html

OIML publications

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Tel: 01787 881165

Online publications are available from of charge from the main HSE website:
http://www.hse.gov.uk/pubns/index.htm

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GLOSSARY

The source of each definition is identified by the superscript number and listed out in full at the end of this glossary.

Accuracy classification
(1) classification as a Class I, Class II, Class III or Class IIII machine in accordance with the provisions of Schedule 1 to these **Regulations**;

Actual scale interval (d)
(3) Value expressed in units of mass of: the difference between the values corresponding to two consecutive scale marks, for analogue indication, or the difference between two consecutive indicated values, for digital indication.

Additive tare device
(1) a tare device which does not intrude upon any of the **weighing** ranges of the weight indicating and printing devices with which it is associated;

Approved pattern
(1) a pattern in respect of which a certificate of approval granted or deemed to have been granted under section 12 of the Act is in force;

Editors note: see also "Approved type" from (2)

Approved type
(2) a type in respect of which an EC type-approval certificate is in force;

Editors note: see also "Approved pattern" from (1)

Authorised person
(2) an inspector, or some other person employed by a local weights and measures authority, who is authorised by the chief inspector of weights and measures of that authority to exercise functions under these Regulations in its area;

Authorised representative
(2) in relation to a manufacturer, means his authorised representative established in the Community;

Automatic **catchweight** weighing **machine**
(1) an **automatic weighing** machine which determines, but does not **regulate**, the mass of individual items but does not include –

(a) an **automatic** checkweighing machine, that is to say, a machine which subdivides articles the mass of which varies on either side of a predetermined value, or
(b) an **automatic** weight grading machine, that is to say, a machine which subdivides articles of different mass for which there is no predetermined nominal mass;

Automatic weighing **machine**
(1) **weighing** equipment that includes a machine which accomplishes a **weighing** operation without intervention by an operator and which sets in motion an **automatic** process characteristic of the machine;

Automatic **zero tracking device**
(1) a device which is designed to correct small, slow changes within the zero setting range of the machine;

Automatic zero-setting device
(3) Device for setting the indication to zero automatically without the intervention of an operator.

Ballast
(1) any of the materials to which the expression ballast applies in Schedule 4 to the Act;
Editors note: This definition applies to the use of class IIII machines and not to substitution material used in calibration / verification.

Certificate of approval
(1) a certificate of approval of a pattern of **weighing** equipment granted or renewed by the Secretary of State under section 12 of the Act or any instrument having effect under paragraph 11 of Schedule 11 to the Act as if it were a certificate of approval so granted on 4th April 1979;

Counting machine
(1) a machine which, by **weighing** articles of uniform size and composition –

(a) determines the number of such articles placed on or removed from its load receptor, or
(b) detects when a pre-determined number of such articles have been placed on or removed from its load receptor;

Discrimination
(3) Ability of an instrument to react to small variations of load. The discrimination threshold, for a given load, is the value of the smallest additional load that, when gently deposited on or removed from the load receptor, causes a perceptible change in the indication.

Disqualification sticker
(2) (a) a sticker the design of which is published in the United Kingdom by the Secretary of State; or
(b) a sticker, symbol or other device the design of which is approved in another member State by the competent authority, and which indicates that an instrument to which it is affixed does not satisfy the requirements of regulation 5 or of corresponding provisions under the law of another member State;

EC type-approval certificate
(2) a certificate issued by the Secretary of State under regulation 10 or by an approved body designated by another member State, as the case may be;

EC type-examination
(2) the procedure whereby the Secretary of State or approved body designated by another member State verifies and certifies that a type conforms with the provisions of the NAWI Directive which apply to it;

EC unit verification
(2) the procedure whereby the manufacturer or his authorised representative ensures and declares that an instrument generally intended for a specific application, in respect of which a certificate referred to in paragraph 4.2 of Annex II to the NAWI Directive has been issued (that is to say, in the case of an instrument in respect of which application for the appropriate examinations and tests referred to in regulation 12(3) is made to the Secretary of State, a certificate referred to in regulation 12(4)(a)(ii)) conforms with the requirements of the NAWI Directive which apply to it;

EC verification
(2) the procedure whereby the manufacturer or his authorised representative ensures and declares in accordance with paragraph 3 of Annex II to the NAWI Directive that an instrument –

(i) has been checked in accordance with paragraph 3.3 (that is to say, in the case of an instrument subject to these Regulations, in accordance with regulation 11(4) under which the approved body carries out examinations and tests);
(ii) is, where appropriate, in conformity with the type described in the EC type approval certificate; and
(iii) satisfies the requirements of the NAWI Directive which apply to it;

Essential requirements
(2) the requirements in Annex I to the NAWI Directive which are set out in Schedule 2;

Gross value (G or B)
(3) Indication of the weight of a load on an instrument, with no tare or pre-set tare device in operation.

Harmonised standard
(2) a technical specification adopted by one or both of the European Committee for Standardisation and the European Committee for Electrotechnical Standardisation upon a remit from the Commission in accordance with Directive 98/34/EC of the European Parliament and of the Council of 22nd June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services[13] (as amended by Directive 98/48/EC[14]) or the Directives and Decisions repealed by Article 13 thereof;

Initial zero-setting device
(3) Device for setting the indication to zero automatically at the time the instrument is switched on and before it is ready for use.

Instrument
(2) a non-automatic weighing instrument (including ancillary equipment) which –

(a) requires the intervention of an operator during weighing; and
(b) serves to determine the mass or weight of any thing by using the action of gravity on that thing (whether or not it may also determine related matters such as price, quantity or magnitude on the basis of mass or weight);

Editors note: See also "Non-automatic weighing instrument" from (3)

Level indicating device
(1) a device which indicates when the structure to which it is attached is tilted away from its correct operating position;

Levelling device
(3) Device for setting an instrument to its reference position.

Live part
(1) a part of a machine which, when a force is applied to it, could cause an alteration of the indicated or printed value;

Maximum capacity
(1) the greatest load which a weight indicating or printing device is constructed to indicate or print, as the case may be, when all associated tare devices are set to zero;

Maximum capacity (Max)
(3) Maximum weighing capacity, not taking into account the additive tare capacity.

Maximum load
(1) the sum of the maximum capacity plus the maximum of any additive tare;

Maximum permissible error
(3) Maximum difference, positive or negative, allowed by regulation between the indication of an instrument and the corresponding true value, as determined by reference standard masses, with the instrument being at zero at no-load, in the reference position.

Maximum safe load (Lim)
(3) Maximum static load that can be carried by the instrument without permanently altering its metrological qualities.

Maximum tare effect (T = + …, T = – …)
(3) Maximum capacity of the additive tare device or the subtractive tare device.

Metrological characteristics
(1) those operational characteristics of a machine which are evaluated during testing of the machine in accordance with the appropriate provisions of **regulation** 37 of and Schedule 2 to these **Regulations**;

Minimum capacity (Min)
(3) Value of the load below which the weighing results may be subject to an excessive relative error.

Minimum reading distance
(3) The shortest distance that an observer is able freely to approach the indicating device to take a reading under normal conditions of use. This approach is considered to be free for the observer if there is a clear space of at least 0.8 m in front of the indicating device.

Module
(3) Part of an instrument which performs a specific function, can be examined separately and is subject to specified partial error limits.

Multi-interval instrument
(3) Instrument having one weighing range which is divided into partial weighing ranges each with different scale intervals, with the weighing range determined automatically according to the load applied, both on increasing and decreasing loads.

Multiple range instrument
(3) Instrument having two or more weighing ranges with different maximum capacities and different scale intervals for the same load receptor, each range extending from zero to its maximum capacity.

Multiple weighing
(1) determining the mass of a load by totalising the results of more than one static **weighing** operation during each of which the load is only partially supported by the load receptor;

Net value (N)
(3) Indication of the weight of a load placed on an instrument after operation of a tare device.

Non-automatic weighing instrument
(3) Instrument that requires the intervention of an operator during the weighing process, for example to deposit on or remove from the receptor the load to be measured and also to obtain the result.

The instrument permits direct observation of the weighing results, either displayed or printed; both possibilities are covered by the word "indication".

Note: Terms such as "indicate", "indicating component" and their derivatives do not include printing.

A non-automatic weighing instrument may be:

graduated or non-graduated,

self-indicating, semi-self-indicating or non-self-indicating.

Note: In this Recommendation a non-automatic weighing instrument is called an "instrument".

Editors note: see also “Instrument” from (2)

Non-automatic weighing **machine**
(1) **weighing** equipment that includes a machine which accomplishes a **weighing** operation and which requires the intervention of an operator during the **weighing** process, especially to deposit loads on, or remove loads from, the load receptor and also to determine the result of the **weighing** process, and for the purposes of these **Regulations** shall include an **automatic** catchweight **weighing** machine;

Non-automatic zero-setting device
(3) Device for setting the indication to zero by an operator.

Number of verification scale intervals (single-interval instrument)
(3) Quotient of the maximum capacity and the verification scale interval: n = Max/e

Pre-set tare device
(3) Device for subtracting a pre-set tare value from a gross or net weight value and indicating the result of the calculation. The weighing range for net loads is reduced accordingly.

Pre-set tare value (PT)
(3) Numerical value, representing a weight, which is introduced into the instrument. "Introduced" includes procedures such as: keying in, recalling from data storage, or inserting via an interface.

Price-computing instrument
(3) Instrument that calculates the price to pay on the basis of the indicated mass and the unit price.

Price-labelling instrument
(3) Price-computing instrument that prints the weight value, unit price and price to pay for pre-packages.

Reduction ratio R
(3) The reduction ratio of a load transmitting device is: R = FM/FL where: FM: force acting on the load measuring device, FL: force acting on the load receptor.

Reference conditions
(3) A set of specified values of influence factors fixed to ensure valid inter-comparison of the results of measurements.

Repeatability
(3) Ability of an instrument to provide results that agree one with the other when the same load is deposited several times and in a practically identical way on the load receptor under reasonably constant test conditions.

Rounding error
(1) the difference between the indicated or printed digital value and the result the machine would give if it were analogue;

Rounding error of digital indication
(3) Difference between the indication and the result the instrument would give with analogue indication.

Scale interval
(1) the value, expressed in units of measurement of mass, equal to –

(a) in the case of a machine with an analogue indicating device, the smallest subdivision of the scale; or
(b) in the case of a machine with a digital indicating or printing device, the smallest difference between two consecutive indicated or printed values;

Schedule 3 application
(2) in relation to an instrument, means an application described in Schedule 3;

Self indicating machine
(1) a machine in which the position of equilibrium is obtained without the intervention of the operator;

Self service weighing **machine**
(1) a **non**-**automatic weighing** machine which, in accordance with section 7(1) and (4)(a) of the Act, is made available for use for trade by any prospective buyer of goods so that the weight and price of goods selected by him is determined and made known to him;

Self-indicating instrument
(3) Instrument in which the position of equilibrium is obtained without the intervention of an operator.

Self-service instrument
(3) Instrument that is intended to be operated by the customer.

Semi-automatic zero-setting device
(3) Device for setting the indication to zero automatically following a manual command.

Semi-self indicating machine
(1) a machine in which the operator only intervenes above a certain range of self indication or printing, in order to re-establish the function of self indication or printing;

Semi-self-indicating instrument
(3) Instrument with a self-indication weighing range, in which the operator intervenes to alter the limits of this range.

Sensitivity
(3) For a given value of the measured mass, the quotient of the change of the observed variable ℓ and the corresponding change of the measured mass M: $k = \Delta\ell/\Delta M$

Significant fault
(3) A fault greater than e. Note: For a multi-interval instrument, the value of e is that appropriate to the partial weighing range.

The following are not considered to be significant faults, even when they exceed e: faults arising from simultaneous and mutually independent causes in the instrument, faults implying the impossibility to perform any measurement, faults being so serious that they are bound to be noticed by all those interested in the result of measurement, transitory faults being momentary variations in the indication which cannot be interpreted, memorized or transmitted as a measuring result.

Span stability
(3) The capability of an instrument to maintain the difference between the indication of weight at maximum capacity and the indication at zero over a period of use within specified limits.

Sticker
(2) except in references to disqualification sticker and re-qualification sticker, means a green sticker measuring at least 12.5 mm by 12.5 mm square bearing a capital letter M printed in black and referred to in paragraph 1 of Annex IV to the NAWI Directive; and

Subtractive tare device
(1) a tare device which intrudes on the **weighing** range of any weight indicating and printing device with which it is associated;

Tare device
(1) a device for –

(a) resetting the weight indicating and weight printing devices to zero when a load is on the associated load receptor, or
(b) subtracting a pre-set value of weight from the weight indicating or printing device;

Tare device
(3) Device for setting the indication to zero when a load is on the load receptor: without altering the weighing range for net loads (additive tare device), or reducing the weighing range for net loads (subtractive tare device). It may function as: a non-automatic device (load balanced by an operator), a semi-automatic device (load balanced automatically following a single manual command), and an automatic device (load balanced automatically without the intervention of an operator).

Tare value (T)
(3) The weight value of a load, determined by a tare weighing device.

Vehicle check weighing **machine**
(1) a **non**-**automatic weighing** machine which, in accordance with section 7(4)(a) of the Act, is made available for use for trade only for the purpose of checking compliance with statutory provisions regarding the weight and axle weight of road vehicles;

Verification scale interval
(1) the metrologically significant value of the scale interval for the verification of the machine which is determined from Schedule 1 to these **Regulations**;

Verification scale interval (e)
(3) Value, expressed in units of mass, used for the classification and verification of an instrument.

Weighing **range**
(1) the range between the maximum capacity and –

(a) the approved minimum load, or
(b) in a case where there is no approved minimum load marking, the lowest value of weight which can be indicated or printed;

Weighing range
(3) Range between the minimum and maximum capacities.

Weight receptor
(1) in relation to a machine where equilibrium is obtained totally or partially by means of weights, means a live part of the machine on which the weights are placed for a **weighing** operation;

Zero setting device
(1) a device by which a machine may be balanced, set to indicate zero, or set to a datum position when the load receptor is empty.

Zero-setting device
(3) Device for setting the indication to zero when there is no load on the load receptor.

Zero-tracking device
(3) Device for maintaining the zero indication within certain limits automatically.

Sources:

(1) The Weighing Equipment (Non-automatic Weighing Machines) Regulations 2000
(2) The Non-automatic Weighing Instruments Regulations 2000
(3) OIML R76-1 Non-automatic weighing instruments Part 1: Metrological and technical requirements - Tests