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