Technical paper 1.10
Metrication

The UK Weighing Federation
The UK's definitive voice on all weighing related matters

Introduction

Weights and measures systems date back 1000's of years. At the heart of any system are the fundamental units of measurement including mass length and time. The international unit of mass is the **kilogram** and is defined as the mass of the International Prototype Kilogram, which is held at the International Bureau of Weights and Measures (**B.I.P.M**). Note that the kilogram is now the only physical artefact used for establishing a fundamental unit and investigations are being carried out to link it to a more theoretical basis. A number of authorized copies of the prototype are held by laboratories around the world (the UK holds number 18 and the US number 20). From these, **reference** and working kilogram **standards** are held by Weights and Measures authorities.

Weight versus Mass

Nothing in weights and measures causes more confusion than the definitions of weight and mass, even though engineers might like to believe that this subject is clearly defined. You would think it was simple - the definition for mass states: "**The mass of any object represents the quantity of the material it contains; it is independent of physical changes such as gravity, air buoyancy, temperature etc**."

Unfortunately through common misuse, standards of mass are regularly referred to as 'weights'.

The term 'weight' is ambiguous and in common parlance is used to describe both mass and force. Although the SI system of units clearly differentiates between mass and force, (with no reference to the term weight), weighing has, through common usage, become the accepted term for the determination of mass in all walks of life. One possible reason is that 'mass' is a noun whereas 'weight' is derived from the verb 'to weigh' giving it far more flexibility in use. In fact weighing determines the apparent mass of an object, ignoring the effects of air buoyancy. (Technically speaking we should have a Masses and Measures system and we should know what our mass is rather than our weight. Interestingly and rather strangely, we refer to body mass indicators (BMI) rather than body weight indicators)

Unlike mass, weight varies with geographic location due to changes in the value of g. Gravity is greater at the poles than at the equator and decreases with increase in altitude. The effect of gravity g at any given location can be calculated using the following formula.

$$g = 9.806\,32 - (0.025\,86 \times \cos 2ø) + (0.000\,03 \times \cos 4ø) - (0.000\,002\,93 \times h)\ \text{m sec}^{-2}$$

where ø = degrees latitude and h = height in metres above sea level.

Therefore scales which work by measuring the gravitational force on an object rather than comparing one mass with another (equal arm balance) are technically only correct if calibrated and used at the same location. A legal for trade weighing instrument would be regarded as being sensitive to variations in gravity if, as a result of a change in location, a change of greater than the absolute value of the maximum permissible error (applicable on verification) occurred for any load applied.

For example, a Class III instrument having 3000 scale divisions (e), verified in London and subsequently moved to Edinburgh, will exhibit an additional error in the performance of the instrument due to the incremental increase in the value for gravity.

This error (assuming no change in altitude) is approximately equal to 1.1 e at maximum capacity

The consequence of the change due to gravity is that the instrument will have used up more than a third of the positive error allowance in relation to the 'in service' allowance.

The change due to gravity is proportional; therefore the error at 500 e would be approximately 0.18 e and at 2000 e approximately 0.74 e.

If the instrument already had a significant linearity or hysteresis error on initial verification then the instrument might be close to being outside the error allowance at the m.p.e change points i.e. 500 e and 2000 e, although still within the in-service allowance.

Do things weigh less on the moon?

Yes and no!

If a scale which measures weight is calibrated on earth and transported to the moon, then a 1 kg mass placed on the scale on the moon's surface will appear to weigh approximately 160 g due to the reduced gravitational pull.

However, if this same scale is now calibrated on the moon's surface then, when 1 kg is placed on the scale, the scale will register 1 kg. As clear as moon dust!

Metrication in the UK

Despite the misguided efforts of the media and a few 'libraphiles', the UK has become metricated, except for certain well known exceptions. (The pint is still legal for dispensing draught beer and cider. It can also be used for selling pre-packed milk in returnable containers - bottles to you and me. And of course the mile has survived at least for the time being.)

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 the Council Directive of December 20th 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 use 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 use only metric units for trade purposes. At first the enforcement of this compulsory metrication was patchy at best and a number of high profile court cases challenging the legality of this clouded the issue. Finally, however, on February 3rd 2004, the European Court of Human Rights issued a judgement 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 effectively ended any opposition and since then enforcement of metrication has gone ahead quietly and generally quite efficiently.

However, one area which still causes some confusion is related to a concession negotiated in 1999. Under this concession, pre-packaged goods marked with the contents in metric units can also carry a 'supplementary indication' in other units such as the pound (lb) or ounce (oz). (As an aside it should be noted that if the unit sign for pounds is used it should always be lb, never lbs. The unit derives from the Latin word libra). This was agreed to allow packers to dual mark products destined for the US where prepacks must carry contents in imperial units. This concession for supplementary indications also means that it is possible for weighing instruments that indicate quantity in both metric and imperial units **at the same time** to be Type approved and then 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. Note: the phrase '**at the same time**' is very important here. Weighing instruments that primarily indicate in metric units, but can, by means of a push button or other auxiliary command, indicate in imperial units as an alternative, do not fulfil the supplementary indication criteria and as such cannot be Type Approved or verified.

*Note: The information contained in these web documents is for guidance only and is given in good faith. It is deemed to be correct at time of posting.