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."