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WEIGHTS AND MEASURES USED IN THE LEAD INDUSTRY

by Michael Gill and William Harvey

INTRODUCTION

The wide variety of weights and measures used in the British lead industry is a constant source of frustration and, as Nicholson wrote, they were the “*most confusing ... of the many confused mediæval weights*”.¹ Despite legislative attempts at standardisation, many units were far from standard and seemingly familiar weights were different from those recognised today. This situation persisted until well into the 19th century and the following review of the subject is, therefore, intended to clarify some points and highlight the pitfalls which catch the unwary.

The origin of the weights and measures used in the lead industry has been, and will remain, a source of speculation, with some favouring the survival of systems used by the Romans. Blanchard, however, has proposed that a vestigial feature of weights used by an early mediæval silver/lead/tin industry was the piece weighing 168 lbs.²

VOLUMETRIC MEASURES FOR ORE

Although steelyard-type weighing machines were developed in early Egypt, most minerals (e.g. coal and the ores of lead, tin and copper) were measured by volume.³ Lead ore was measured by volume from at least the 12th century, and from the 15th century onwards it was measured in units which related to the Winchester bushel. The latter unit, which, as the Struck bushel, is still used in the USA, was 3.106% smaller than the Imperial bushel, which replaced it by an Act of Parliament in 1824.⁴ The Winchester bushel held 64 pints, dry measure, each of 33.6 cubic inches.

THE DISH

The dish was the basic volumetric unit for lead ore, but extreme caution must be exercised when using this unit because its size and, therefore, the weight of ore held, varied from place to place. For example, Willies notes that, depending on the liberty in which the ore was being measured, a dish could contain approximately 14, 15 or 16 pints.⁵ The dish of 16 pints is equal to the Peck, which was a quarter of a Winchester bushel. In all cases, however, nine dishes equalled one load of ore.

The dish was most widely used in Derbyshire where, in the Low Peak, the volume of the standard dish, dating from 1513 and preserved at the Moot Hall in Wirksworth, is 14 Winchester pints. The Derbyshire Mining Customs and Mineral Courts Act, passed in 1852, made provision for adjusting the weight of the Wirksworth dish to 15 pints should the standard of 1513 ever be lost.⁶ It held around 65 lbs of lead ore, which is equal to 4.623 lbs per pint, and hence a rough guide to the weight of ore held by this and the other dishes is:-

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Pints	Lbs	
14	65	Low Peak
15	70	High Peak
16	74	

Nevertheless, the precise weight of ore held by any given dish depended on the size of ore granules and any interstices, the moisture content, how cleanly the ore had been dressed and what proportion of other minerals, such as zinc blende, were intimately mixed with it.⁷

Two wooden dishes, which appear to have been kept at Millclose Mine, were recorded by Willies.⁸ One, marked 'GR1770', had a volume of 449.238 cubic inches or 13.4 pints, and the other, marked 'VR1858', had a volume of 476.633 cubic inches or 14.2 pints. Neither had been much used and they may have been kept as standards to which other measures were referred. William Bray, who toured parts of Derbyshire in the 1770s, agreed that the "*Dish or hopper was 16 pints in the High Peak and 14 in the Low*", but Hooson's *Miners Dictionary* did not.⁹ Interestingly, Hooson felt that "*The brazen dish is ... exactly eight quarts [16 pints] of water in the Low Peak, but in the High Peak we always reckon and esteem it to be one-eighth part bigger*" [18 pints?].¹⁰

Hooson and others also give some indication of the variation in the weight of ore in a dish. The former states that if "... *the ore be good, as one dish to weigh five stone and a half, ... that three loads five dishes, will be full enough to make up one ton.*" Assuming 12 lbs to the stone (as used for lead) gives the weight per dish as 66 lbs, which is reasonable, but three loads five dishes is only 2112 lbs or 18.8 cwts. A note on one set of mill accounts in the Bagshaw MSS tells us: "*1 dish of 12 Meer Oare weighs 62 pounds*", whilst another gives: "*1 dish of good ore = 60 lbs*".^{11,12} Finally, Stokes wrote: "*In the Castleton district, the ore is sometimes sold at a price for a load of ore [nine dishes] of 60 lbs per dish as the standard*".

The Barmaster used a round, wooden dish, which had been correlated to the standard, to measure the ore. The dish was filled with ore and, in the High Peak, the surface of the ore was made level with the top of the dish by using a wooden strickle to strike off any excess. In the Wirksworth area, the ore was strickled using a hand.

Volumetric measurement was not so widely used outside Derbyshire or, at least, it did not persist for anywhere near as long. For example, in 1304/5 the accounts of a small lead mine at Baxenden, near Burnley, record: "*91 loads 6½ dishes of ore brought from the miners. 9 dishes make one load*".¹³ By the 1630s, however, the overseers of the Thieveley lead mine, also near Burnley, had fixed the dish's weight at 56 lbs. They also used hundredweights and tons.¹⁴

BURDEN

This unit, used by Derbyshire miners from at least 1236, was equal to three dishes of ore.¹⁵

THE PIGGIN, HOPPITT and POKE

Miners in Swaledale, Arkengarthdale and Lunedale, in Yorkshire, used a system which probably originated as a volumetric one, but which had become weight-based by the late 17th century. This was as follows:-^{16, 17, 18}

One piggin	=	56 lbs
Two piggins	=	one hoppitt or one poke (112 lbs).
Two hoppitts	=	one horse (load) (224 lbs)
Four horse (loads)	=	one Bing (896 lbs)
17 horse (loads)	=	one fother of lead ore (3808 lbs)

The fother (or fodder) was normally used as a weight (see below) of metallic lead, but in the above case it appears to have been used as an estimate of the probable produce of metallic lead, because 18th century ore-hearths yielded around 65 per cent of lead from the ore, which was a Stockton fother.

$$(2240 \div 3808) \times 100 = 64.7\%$$

There is a reference to a three hundredweight horse load in Arkengarthdale, but this may be a transcription error. The horse load is often abbreviated to 'horse' and at two hundredweight could comfortably have been carried by a jagger pony. The horse load mentioned by William Bray as having been used in Derbyshire could not, however. This was "*9 dishes make a load and four of these a horse load*", which was around 2340 lbs in weight!⁹

The gatherers of tithe ore in Arkengarthdale used a hybrid system and collected in horses of 20 stones (2½ cwt) and sometimes converted them to horses of 16 stones (2 cwt) in their accounts.¹⁹ The Rectory of the church of St Mary in Arkengarthdale had, as custom, a tithe due to it on all ore "*as it fell from the point of the pick when it was dug in a mine in the parish of Arkengarthdale and such part as was small enough to pass through the mesh was by custom exempt from tithe.*" The ore was sorted using a riddle with one-inch mesh and one such was kept at each mine.^{20, 21}

BING

Most of the Pennine orefields, from Yorkshire northwards, eventually switched to the bing as the primary measure for ore (see below for Scotland). Ore accounts are, therefore, generally given as follows:-

In the 18th Century	14 lbs	=	1 stone
	16 stones	=	1 horse
	4 horse	=	1 bing

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In the 19th Century	14 lbs	=	1 stone
	8 stones	=	1 hundredweight (cwt)
	8 cwt	=	1 bing

In mining fields such as Central Wales and the Isle of Man, where it was usual to sell ore to distant smelters, the ore appears to have been weighed in tons, hundredweights, stones and pounds. Even here there are potential problems, however, and Moissenet, writing on smelting in Shropshire, reminds us that, “*When the concentrates are weighed at the smelt works, an extra 200 lb. is added to each ton, making the weight of a ‘ton’ at the mine (20 x 112 + 200) = 2440 lbs. The English practice is generally to buy lead concentrates by the ton of 21 cwts (= 2352 lbs), with no allowance for moisture. The excess 88 lbs corresponds to the small loss through transportation and above all hygroscopic water. This normally constitutes around 3½% of the weight of the mineral content ...*”²²

WEIGHTS USED FOR METALLIC LEAD

Once lead was smelted, it was cast into a variety of shapes and sizes, many of the terms for which have become confused. For the purposes of this paper, therefore, the term ingot will be used to cover any size, shape or weight of lead which the smelter has cast ready for market. Lead weights must also be used with caution because, as will be shown, the value applied to them varied both with time and from place to place. A good example of this ambiguity is given in the following account for a small lead mine at Baxenden in Lancashire:-¹³

“9½ fothers 7 pieces 1 stone of lead bought from the same of which 6 stone make a piece, and 25 pieces make a fother”

This may appear simple, but the stone could have been either 12 or 14 lbs and there were at least nine distinct fothers! Hence, if the stone was 12 lbs the piece weighed 72 lbs and the fother was 1800 lbs, but if the stone was 14 lbs the piece weighed 84 lbs and the fother was 2100 lbs, which is nearly 17 per cent heavier. Neither value agrees with a known fother, but the second is that given by Sheppard for a load (see below).²³

FOOT (FOTINEL, FOTMAL, FOTMELL or FORMEL)

This is one of the oldest units for weighing lead. It was in use by the end of the 13th century and apparently survived until around the end of the 16th century.²⁴ In 13th century Scotland, duty on lead was levied on “*quadriga plumbi*” cart loads and “*fotemalis*”.²⁵ It is generally taken to have been 70 lbs, with 24 feet (1680 lbs) to a cart load, but, according to Kiernan, in 16th century Derbyshire “*the sub-unit of the foot was confined to the boles*”, where 30 feet = 1 fother, making 84 lbs per foot.^{26, 27}

CUT

A mediæval lead weight which was one-fourteenth part of a foot or 5 lbs.

WAYE (WEY, WEIGH or WAGHE)

This was a unit for the weight of dry goods. In 1303, the miners of Greenhow Hill in Yorkshire, who were under the control of Fountains Abbey, were using a waye which was defined as being 15 stones of lead, where each stone weighed 12 lbs.²⁸ This was 180 lbs, which was exactly 1/13th part of a Hull Fother (see below).

LOAD (CARATATE)

As noted above, in 13th century Devon the load was 1680 lbs, which was 24 feet (of 70 lbs each) or 15 cwt. Rieuwerts also records a fother (see below) of 1680 lbs being used in Derbyshire until the 13th century. Writing in the 1660s, but citing an earlier source, however, Sheppard held that "*The load of lead doth consist of 30 formells*" where "*a formell was six stone except two pounds & every stone doth consist of 12 lbs ... by which the sum in the formell is 70 lbs*". This made the load 2100 lbs.

FOTHER (FODDER)

It has been suggested that the fother descended from a Roman weight and amounted to a caratate or cart load, and references to "*quadriga plumbi*" and "*fotemalis*" may support this.²⁹ The occasional use of the fother as a measure for ore has been discussed above, but its principal use was as the basic unit by which lead was sold. As appendix I shows, however, its weight varied from place to place. Hooson's *Miners Dictionary* adds confusion by defining the fother as follows: "*Amongst lead-merchants it is nine pieces or pigs of lead, and commonly more weight than a ton by half a hundred; in both the Peaks the merchants deal and sell the lead by foddors*". This would make the fother 2296 lbs, which bears no relationship to known values. There were also adjustments in the size of some fothers, as the following memorandum, by the Duke of Bridgewater's agent, shows:³⁰

"That Grassington mill weight is 20 hundred to ye fother and 120 pounds to ye hundred but in ye year 1711 Mr Myers ye Lord Burlington's Steward has altered ye same and made ye hundred weight 112 and ye fother 22 hundred weight - so that every piece ought to weigh 1cwt or 8 stones - 11 pounds - 5 ounces [= 123.3 lbs] now but ye weight of every piece before at 20 hundred and 120 pounds to ye hundred was 1cwt or 8 stones = 8 pounds = 0 ounces [= 120 lbs] and what Thomas Topham's duty must be reckoned at 12d per fother duty is 7¼d for every piece."

According to William Bray, writing in the 1770s, the fother's weight varied from one place to another to reflect the expense of carriage, which was paid by the seller. The price per fother was the same at all places, but the reduction in weight paid for the cost of moving it to market.⁹ The values given in

appendix I support this claim, but, whilst it may once have been true, by the early 18th century mining agents had elaborate ready-reckoners which allowed them to calculate the price of lead in local markets for every sixpence (6d) that the price moved in London.³¹ It is likely that the system had worked whilst the price of lead and cost of carriage remained fairly stable, but, if either moved significantly, it would encourage a shift to settlement of accounts in cash.

Not all areas used fothers. For example, the returns of lot-lead on the Mendip between 1602 and 1666 are given in tons, hundredweights and pounds.³² The same units were also used by the overseers of the Thieveley lead mine, near Burnley, in 1630/31.¹⁴ By the mid 19th century, lead merchants and smelters were increasingly dealing in tons and hundredweights, with the latter weight being used for pieces.

PIGS and PIECES

These terms are often used interchangeably (see Hooson above) for a range of sizes and shapes of ingots. As will be shown, however, a pig was strictly twice the weight of a piece. Smelters at Leadhills and Wanlockhead, in Scotland, produced pieces, which they called 'Bars', containing under eight stones (Amsterdam) or over eight stones and six pounds of smelted lead.

Derbyshire smelters produced a range of large ingots for which, as yet, there is little evidence elsewhere. In the 16th century, for example, the most commonly used weight when casting ingots at Derbyshire boles was 10¾ cwt, which was half a Bawtry fother. The change to the ore-hearth around 1580 brought a shift to smaller ingots such as Whetstone lead, which weighed about one hundredweight and was shaped like a small, round grindstone. More usually, Kiernan tells us: "*Ore-hearth lead was cast into pigs - ingots with rounded ends - weighing around 22½ stones (315 lbs) or half pigs, which were usually called pieces, weighing 11¼ stones (157½ lbs). Pigs of slag lead had the same weight, but were cast into square-ended ingots.*"²⁹

Willies confirms that two pieces of lead made one pig, but notes that their weights varied. He goes on to say that they were often made as close as possible to 176¼ lbs so that 16 of them (or eight great pigs) made one mill fother (fodder) of 2820 lbs.⁵ Nevertheless, ingots of other weights were made and in 1687 Daniel Wigfall and Francis Gell sent 17568 great pigs and 12164 little pigs to London. One such great pig was found in the bed of a gravel pit on the line of the former course of the River Trent. It was 'boat' shaped, being elliptical in plan with a carinated cross section and weighed 295 lbs. Allowing for a slight over-weight, eight such pigs made a Hull fother (8 x 292.25 lbs = 2340 lbs).³³ Great pigs fell from use in the 18th century, in favour of the little pig or piece. Gabriel Jars gave the weight of a piece in Derbyshire as 150 lbs.³⁴

Clearly matters are not as simple as writers on Derbyshire would have us believe. They have favoured the explanation that these other weights were made to suit other fothers, perhaps depending on the destination of the lead - for example red lead mills. Whilst that may be true for those ingots at either end of the weight range, it is more likely that Derbyshire smelters conformed to the practice used elsewhere (and discussed below) of having a weight per piece which, in the immediate area at least, was unique to that mill.

The weight chosen for these pieces was often a whole-fraction of a fother, which gave a rule of thumb measure of fothers by quantity. It would also serve to make the pieces readily identifiable, even if the mill marks (see below) were defaced. For example, a piece of lead from the Allen Mill, near Hexham, recently discovered on the sea bed near the Turks and Caicos Islands, weighed 164 lbs, and 15 of them would weigh just 4 lbs short of a Stockton (on Tees) fother.³⁵ When the lead was sold, however, it was weighed precisely and its value calculated to the nearest pound weight, with the bill being adjusted for any over or under weight.

It is common to see something like the following memorandum in smelting accounts “... *smelted to the end of X at the end of last week ... now on with Y*”. This another way in which smelters kept track of their output. Called the mill mark, it had 400 pieces (a unit called a mark) stamped with the same letter or number and then changed for the next in sequence. Even here, one must be cautious, however, because the Surrender Mine, in Swaledale, was using a mark of 500 pieces from 1798 to at least 1801.³⁶

In the case of some pieces of *Greenside* (near Patterdale in Cumbria) lead discovered on the wreck of an American Civil War blockade runner off Charlestown, South Carolina, it was possible to find the mill mark in the smelting ledgers and thus date their production to within a few days. It was also possible to identify the merchant to whom they had been sold.³⁷

SCOTTISH WEIGHTS

THE STONE AMSTERDAM

Until the 1830s, the ‘Amsterdam’, or ‘Dutch’, system of weights was used at the Leadhills and Wanlockhead mines. It had been established as the Scottish standard in 1617, when it superseded a system called the Tron, and it acknowledged Scotland’s considerable trade with continental Europe at that time and the need for a common measure. For example, Glasgow had a set of standard weights provided by the Conservator of Privileges of Dort.

The weights were also known as ‘French Troye’. This seems to have had nothing to do with the Troy system, but to have referred to the town of Troyes, a centre for mediæval trade. There were also Dutch weights called ‘Trois or Troish’, all of which emphasises the need for caution when interpreting old records.

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The Amsterdam weights were based on a stone of 16 pounds, and a pound of 17 ounces and $6^{15}/_{16}$ drams Avoirdupois. In practice, the latter figure was rounded to 7 drams. Comparative figures then are:

$$\begin{aligned} 1 \text{ stone Amsterdam} &= 1.25 \text{ stone Avoirdupois.}^{38} \\ &= 17.43 \text{ pounds Avoirdupois} \\ 1 \text{ pound Amsterdam} &= 1.09 \text{ pounds Avoirdupois} \end{aligned}$$

The system apparently did not include for a ton, but at Leadhills and Wanlockhead a ton of '136¼ stones Amsterdam' was used as a measure of output. This is equivalent to the ton of 2000 lbs Av.

The Union of 1707 decreed that Scotland should use the avoirdupois system, but this ruling was largely ignored. It was not until 1826 that any effort was made to bring Scottish weights into line with England, and it was the 1830s before the lead mines moved away from the 'Amsterdam Measure'.

THE SCOTTISH BING

The Scottish Bing also differed from its English counterpart and in 1745 it was recorded as follows:

*"The English bing of ore is 64 stones of 14 pounds weight to the stone. Our bing is 72 stones Amsterdam."*³⁹

This meant that the English bing was 896 lbs Av., and the Scottish 1253 lbs. Av., a very considerable difference.

UNITS OF LENGTH

FATHOM

Records of surveys, or diallings, of the workings show that the fathom, of six feet, was the principal unit of measurement for the depths of shafts and lengths of levels. It might be used with a fraction, for example:

"The branch measures 47 and one sixth fathoms"

or it could include feet and inches, as follows:-

*"William Adamson and partners... employed at £6 per fathom have driven 5 fths 2 ft and 3 ins".*³⁸

YARD

Three feet or half a fathom, this is more commonly used at coal mines.

MEER

This was the variable unit of length used for setting out grants of mining ground along the line of a vein. A distance of one quarter of a meer, called the Quarter Cord, was allowed on either side of the vein's centre-line, in which miners could sink shafts, dump waste rock, dress their ore, have buildings and work any branches or out-fliers from the vein.

In Derbyshire the meer varied between 29 yards in the High Peak area and 32 yards in the Low Peak, but some liberties used 27, 28 or 30 yards. A square meer, of 14 yard sides, was used for pipeworks. In much of Yorkshire the meer was 30 yards, but at Conistone, in Wharfedale, and at Greenhow Hill it was 32 yards. Until the late 17th century, when it was replaced by the 30 yard meer, the Grassington mines used a 21 yard meer.⁴⁰ A 16th century lease of mines at Carperby gives the meer as 42 yards. An example of a square meer is given in a 1676 agreement on the working of Copperthwaite Vein, and its associated flats, at Marrick. This had sides which were 25 yard in length.⁴¹

APPENDIX I**EXAMPLES OF FOTHERS**

	Cwt	lbs	lbs
London	19½	112	2184
Hull	19½	120	2340
Newcastle	21	112	2352
Bawtry	21½	112	2408
Craven	20	123	2460
Stockton	22	112	2464
York	19½	128½	2506
Derbyshire	22½	112	2520

(weights taken from Yorke MSS at Leeds Archives)³¹

Surrender Mine	25	112	2800
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(weight taken from Warwick Record Office – CR1248/21/R16)

Wales			2400
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(weight taken from W.J. Lewis)⁴²

Chester			2400
Liverpool			2400
Bristol			2400

(weights taken from R. Hunt)⁴³

Bristol			2240
Thorne			2408
Stockwith			2408

(weight taken from A.H. Stokes and L. Willies)^{44,45}

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APPENDIX II

PIECES MADE AT YORKSHIRE SMELT MILLS 1657-1890

Examination of accounts show that the average weight of the pieces, from batch to batch, seldom varied by more than a few pounds.

MILL	PERIOD	AV WTNO. PER TON or PIECE STOCKTON FDR	Lbs
AD	1683	130.4	19 fdr
AD	1735-1756	145.1	17 fdr
AD (Surrender)	1798-1801	175	16 fdr (2800 lbs)
AD (Stonesdale mine)	1857-1858	140.3	16 ton
AD	1859-1878	113.2	20 ton
Arkengarthdale (Clints mill)	1657-1658	129.4	19 fdr
Arkengarthdale	1783-1798	147.3	17 fdr
Arkengarthdale	1871-1890	114.7	20 ton
Grinton	1775-1801	153.5	16 fdr
Grinton	1809-1817	162.3	15 fdr
Grinton	1841-1852	171.6	13 ton
Marrick	1657-1727	133.1	18½ fdr
Marrick	1862-1871	114.0	20 ton
Grassington	1735-1849	123.0	20 fdr
Cockhill	1839-1844	170.0	13 ton
Heathfield	1870-1872	113.3	20 ton
Prosperous	1839-1844	171.0	13 ton

The above average weights fall into four distinct groups, each with an average weight of:-

lbs. suggesting they were centred on	lbs	giving per Stockton fother
114	112	22
129	130	19
146½	144	17
169	164	15

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37. Lead ingots marked 'Greenside' discovered off Charlestown, South Carolina - John Hodgkins pers. comm.
38. Harvey, W.S. "Weights and Measures used at the mines of Leadhills and Wanlockhead in the late Eighteenth Century" *Memoirs of the Northern Cavern & Mine Research Society*, Vol.2 No.3 (1973), pp.139-143. NB. On page 139 the value of the stone Amsterdam was erroneously given as 1.05 instead of 1.25 stoness Av.
39. Williams, J. (ed) "A Leadhills Diary for 1745" *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society*, Vol.LIV (1979) p.107.
40. Gill, M.C. *The Grassington Mines* (Keighley: British Mining No.46, 1993).
41. Tyson, L.O. *A history of the manor and lead mines of Marrick, Swaledale* (Sheffield: British Mining No.38, 1989).
42. Lewis W.J. *Lead Mining in Wales* (Cardiff: University of Wales Press, 1967).
43. Hunt, R. *A Historical Sketch of British Mining* (1887).
44. Stokes, p.48 - gives the Bristol fother as 2240 lbs, but those of Chester and Liverpool as 2400 lbs. He also lumps the Thorne, Stockwith and Bawtry fothers together as a "Trent Fother".
45. Willies, "... Price of Lead" Also gives a mill fother of 2820 lbs, which is confirmed by Stokes (p.37).

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