



History of Weights and Measures

PREFACE

Weights and Measures has always been an important subject to humankind. Since the dawn of civilization, there was a need for standardization of weights and measures so that trade and important construction works can be carried out with widespread agreement.

One of the earliest civilizations, the inhabitants of the Indus Valley Civilization (3000–1500 B.C.E.), developed a sophisticated procedure of standardization, using weights and measures, evident by the excavations made at the Indus valley sites. This technical standardization enabled gauging devices to be effectively used in angular measurement and measurement for construction. Calibration was also found in measuring devices along with multiple subdivisions in case of some devices. Many other civilizations employ their own system of weights and measures.

One of the most widely used system before the Metric system was the British Imperial system.

THE IMPERIAL SYSTEM

The system of imperial units or the imperial system (also known as British Imperial) is the system of units first defined in the British Weights and Measures Act of 1824. Before the introduction of that Act, many different standards were used in different parts of UK and the surrounding world, they might have the same name, but the measure was different.

With the expansion of the British Empire during the 19th century, this system gained foothold in many Commonwealth countries. Most countries in the world had now changed to the using of metric system, only USA, Myanmar and Liberia (a country in West Africa) remain using their own system of weights and measures.

The three most important measures for the Imperial system are length, weight and volume. A brief account of the origin of these measures is appended below.

LENGTH

As early as the middle of the tenth century it is believed that the Saxon King Edgar kept a "yardstick" at Winchester as the official standard of measurement. A traditional tale tells the story of Henry I (1100-1135) who decreed that the yard should be "the distance from the tip of the King's nose to the end of his outstretched thumb".

In 1588 Queen Elizabeth I issued a new standard yard which remained the legal British yard for over 300 years until 1824, when it was superseded by an Act of Parliament under George IV. This Act attempted to introduce systems of measures more widely into British society and remove inaccuracies associated with measurement.

The new yard became the first imperial standard and was actually a standard that had been commissioned by the Royal Society in 1742, which in turn had been based on an earlier Elizabethan standard.

In fact this yard had a very short official life (9 years and 198 days) as in 1834 it was damaged in a fire that burned down both Houses of Parliament. A new standard was eventually legalised in 1855 and was based on unofficial standards that had been compared to the Imperial Yard before it was damaged.

MASS

There were four different weighing systems in the UK before Queen Elizabeth I --- the Troy, London, Merchant, and Tower pound. Each of them agreed on the basic unit of grain. This grain was legally defined as the weight of a grain seed from the middle of an ear of barley, equal to 64.79891 milligrams. Each system however defined its pound and other weighing units to be of a different number of grains.

Merchants were complaining to Queen Elizabeth I, "that the weights being used throughout this realm are uncertain and varying one from another to the great

slander of the same Our realm and decency of many, both buyers and sellers". It was then declared that the Avoirdupois weight system would be the only one that was legal for all purposes.

The avoirdupois pound, also known as the wool pound, first came into general use c. 1300. It was initially equal to 6992 troy grains. The pound avoirdupois was divided into 16 ounces. During the reign of Queen Elizabeth, the avoirdupois pound was redefined as 7,000 troy grains. Since then, the grain has often been an integral part of the avoirdupois system. By 1758, two Elizabethan Exchequer standard weights for the avoirdupois pound existed, and when measured in troy grains they were found to be of 7,002 grains and 6,999 grains. The 7000 grain standard continued to become the Imperial Standard Pound, still in use in the United States today.

The Weights and Measures Act of 1878 marked a major overhaul of the British system of weights and measures, and the definition of the pound given there remained in force until the 1960s. The pound was defined thus (Section 4) 'The ... platinum weight ... deposited in the Standards department of the Board of Trade ... shall continue to be the imperial standard of ... weight ... and the said platinum weight shall continue to be the Imperial Standard for determining the Imperial Standard Pound for the United Kingdom'. Paragraph 13 states that the weight of this standard in vacuum shall be called the Imperial Standard Pound, and that all other weights mentioned in the Act and permissible for commerce shall be ascertained from it alone. The First Schedule of the Act gave more details of the standard pound:- It is a platinum cylinder nearly 1.35 inches high, and 1.15 inches diameter, and the edges are carefully rounded off. It was constructed following the destruction of the Houses of Parliament by fire in 1834, and was stamped P.S. 1844, 1 lb (P.S. stands for 'Parliamentary Standard'). This definition of the Imperial pound remains unchanged.

VOLUME

In 1824, Britain adopted a close approximation to the ale gallon known as the imperial gallon and abolished all other gallons in favour of it. Inspired by the kilogram-litre relationship, the imperial gallon was based on the volume of 10 pounds of distilled water weighed in air with brass weights with the barometer standing at 30 inches of mercury and at a temperature of 62°F (17 °C). In 1963, this definition was refined as the space occupied by 10 pounds of distilled water of density 0.998859 g/mL weighed in air of density 0.001217 g/mL against weights of density 8.136 g/mL. This works out at approximately 4.5460903 L (277.41945 cu in). The metric definition of exactly 4.54609 cubic decimetres (also 4.54609 L after the litre was redefined in 1964, = 277.419433 cu in) was adopted shortly afterwards in Canada, but from 1976 the conventional value of 4.546092 L was used in the United Kingdom until the Canadian convention was adopted in 1985.

Historically gallons of various sizes were used in many parts of Western Europe. The table appended to the left shows the various comparisons of the gallons and the two Imperial standards described above are highlighted.

COMPARISON OF HISTORIC GALLONS		
VOLUME	DEFINITIONS	
cu in	L or dm ³	
216	≈ 3.5396	Roman con gius
224	≈ 3.6707	preserved at the Guildhall, London (old UK wine gallon)
231	3.785411784	statute of 5th of Queen Anne (UK wine gallon, standard US gallon)
264.8		ancient Rumford quart (1228)
265.5	≈ 4.3508	Exchequer Henry VII, 1497, with rim)
266.25	≈ 4.3631	
268.8025	4.40488377086	Winchester, statute 13 + 14 by William III (corn gallon, old US dry gallon)
271	≈ 4.4409	Exchequer (1601, E.) (old corn gallon)
272	≈ 4.4573	corn gallon (1688)
277.18	≈ 4.5422	statute 12 of Anne (coal gallon) = 33/32 corn gallons
277.274	4.543460	Imperial Gallon (1824) as originally evaluated.
277.419433 (ca.)	4.54609	standard imperial gallon (metric) (1964 Canada gallon, 1985 UK gallon)
≈277.419555	4.546092	Imperial gallon (1895) Re-determined in 1895, as defined in 1963.
278	≈ 4.5556	Exchequer (Henry VII, with copper rim)
278.4	≈ 4.5622	Exchequer (1601 and 1602 pints)
280	≈ 4.5884	Exchequer (1601 quart)

Presented by



馬來亞秤私人有限公司
MALAYAN DACHING CO PTE LTD

www.malayandaching.com



History of Weights and Measures

THE METRIC SYSTEM

Since the Metre Convention in France in 1875, the metric system has been coordinated by three international bodies, all established by the Convention:

- International Bureau of Weights and Measures
- International Committee for Weights and Measures
- General Conference on Weights and Measures (CGPM)

The task of the International Bureau of Weights and Measures is to ensure worldwide uniformity of measurements and their traceability to the International System of Units (SI).

The International Bureau of Weights and Measures works under the supervision of The International Committee for Weights and Measures which in turn comes under the authority of The General Conference on Weights and Measures.

The rationality of the metric system is briefly described below:

LENGTH

DEFINITIONS OF THE METRE SINCE 1795 BASIS OF DEFINITION	DATE	ABSOLUTE UNCERTAINTY	RELATIVE UNCERTAINTY
1/10,000,000 part of the quarter of a meridian, measurement by Delambre and Mechain	1795	0.5–0.1 mm	10 ⁻⁴
First prototype Metre des Archives platinum bar standard	1799	0.05–0.01 mm	10 ⁻⁵
Platinum-iridium bar at melting point of ice (1st CGPM)	1889	0.2–0.1 µm	10 ⁻⁷
Platinum-iridium bar at melting point of ice, atmospheric pressure, supported by two rollers (7th CGPM)	1927	n.a.	n.a.
1,650,763.73 wavelengths of light from a specified transition in krypton-86 (11th CGPM)	1960	0.01–0.005 µm	10 ⁻⁸
Length of the path travelled by light in a vacuum in 1/299,792,458 of a second (17th CGPM)	1983	0.1 nm	10 ⁻¹⁰

The construction of the international prototype metre and the copies which would be national standards was at the limits of the technology of its time. The bars were to be made of a special alloy, 90% platinum and 10% iridium, which is significantly harder than pure platinum, and have a special X-shaped cross section (a "Tresca section", named after French engineer Henri Tresca) to minimise the effects of torsional strain during length comparisons. The first castings proved unsatisfactory, and the job was given to the London firm of Johnson Matthey who succeeded in producing thirty bars to the required specification: one of these (No. 6) was determined to be identical in length to the metre des Archives, and was consecrated as the international prototype metre at the first meeting of the CGPM in 1889. The other bars, duly calibrated against the international prototype, were distributed to the signatory nations of the Metre Convention for use as national standards: for example, the United States received No. 27 with a calibrated length of 0.999 9984 m ± 0.2 µm (1.6 µm short of the international prototype).

The first (and only) follow-up comparison of the national standards with the international prototype was carried out between 1921 and 1936, and indicated that the definition of the metre was preserved to within 0.2 µm. At this time, it was decided that a more formal definition of the metre was required (the 1889 decision had said merely that the "prototype, at the temperature of melting ice, shall henceforth represent the metric unit of length"), and this was agreed at the 7th CGPM in 1927.

VOLUME

The SI unit for volume is the litre. A box of 10cm by 10cm by 10cm is a litre. As volume is a derived quantity from length, there should be no problem defining it as long as the length is well defined and the box well measured.

MASS

Since 1889 the magnitude of the kilogram has been defined as the mass of an object called the international prototype kilogram, often referred to in the professional metrology world as the "IPK". There was no change since then. The initial motivation was to have the weight of one litre of water. Nowadays there is discussion to redefine the kilogram in terms of either the Planck constant or the Avogadro Number. The Planck constant is a fundamental constant of nature and if this definition is fixed, the kilogramme would depend on the definition of the metre, second and speed of light. The Avogadro number is the number of atoms or molecules in one mole of material. A mole of material would have its atomic weight in grams. For instance, one mole of pure water weights 18g (1+1+16).

WEIGHTS & MEASURES LEGISLATIONS IN SINGAPORE

Imperial System was implemented in Singapore following a report by the Committee of Weights and Measures in 1886. The report stated that there were various standards for weights in Singapore and recommended an Ordinance to be enacted to standardize them. In the same year, an Ordinance on Weights and Measures (Ordinance No. 37) was passed and that marked the beginning of weights and measurements legislations in Singapore.

The regulating body, the Weight and Measure Office (WMO) was set up in the Police Force of the Straits Settlements in 1889. They offered free verification and stamping of weighing machines until 1st January 1890.

Five years after Singapore became independent, WMO was transferred from the Police Force to the Trade Division of the Ministry of Finance in 1970. Later in April 2000, WMO was transferred from the Ministry of Trade and Industry to SPRING Singapore.

SPRING stands for Standards, Productivity and Innovation for Growth. SPRING Singapore, is a statutory board under the Ministry of Trade and Industry, with the mission of raising productivity to enhance Singapore's competitiveness and economic growth.

The predecessor of SPRING was the Productivity and Standards Board (PSB) which in turn was formed by the merger of the National Productivity Board (NPB) and the Singapore Institute of Standards and Industrial Research (SISIR) in April 1996. The merger aimed at bringing together the soft skills of productivity handled by NPB and the technical aspects handled by SISIR. In April 2000, PSB was renamed SPRING Singapore to signify the shift towards an innovation-driven economy, and therefore its new role in promoting creativity to sustain growth for Singapore.

As the national authority on metrology, SPRING is custodian of Singapore's reference standards for measurements related to mass, length, time, temperature, luminous intensity, and electrical current, and for chemical measurements.

The role of the WMO is to ensure that a uniform and accurate system of weights and measures is used in Singapore. It also protects the interest of both the consumers and traders by regulating the use of weighing and measuring instruments used for sale or trade.

CONVERTING FROM IMPERIAL TO METRIC SYSTEM

Prior to 1970, several systems of measurement were used in Singapore. The Imperial system was widely used in the public sector, commercial areas and major shopping centres, while customary measurements such as the "gantangs and chupaks", and the "katis" and "tahils", were used for certain commodity and retail trading. In the late 1960s, the Metric system had begun to gain acceptance in many countries, and several of Singapore's major trading partners had decided to go metric. In December 1968, the Singapore government indicated its intention to switch to the Metric system and the Ministry of Science and Technology was tasked to study the impact of the change. In response, the Ministry tabled a White Paper titled A report on a study of the proposed conversion to the metric system in Singapore to the Singapore Parliament in November 1970. The paper recommended the implementation of the Metric system in phases, starting with the public sector and expanding to the private sector. In addition, two Bills, the Metrication Bill, which introduced the International System (SI) of weights and measures, and the Weights and Measures (Amendment) Bill, which legalised the use of SI units in trade, were also passed by Parliament and came into force on 15 February 1971.

The Weights and Measures (Sale of Goods in Metric Units) Order was introduced in 1981 as the standard for measurements. However, with the widespread use of metric units, the Metrication Order was repealed in 2006. Allowances were, however, made for the use of traditional Chinese weights in Chinese medical halls.



Presented by



馬來亞秤私人有限公司
MALAYAN DACHING CO PTE LTD

www.malayandaching.com



Chinese daching used in medicinal shops during 1880s.

Straits Settlements Beam Scale - 1912.



Spring Hanging Scale - 1950s.

Spring Dial Scale - 1950s.



Counter weight scale - 1950s.

Automatic Weighing Scales used in the Pharmaceutical industry in the 1970s.



Digital weigh scales used in 1980s.

Analytical Balances used since 1990s.



The gallery is open for free viewing by appointment only, please contact us at:

Malayan Daching Co Pte Ltd

5 Tanjong Penjurong Crescent

Singapore 608970

Tel: +65 6763 4545

Fax: +65 6763 6656

Email: sales@malayandaching.com

www.malayandaching.com

The Heritage Gallery



WINDOW TO THE PAST

Weights and measures of the past and present

Presented by

 馬來亞秤私人有限公司
MALAYAN DACHING CO PTE LTD

MDC Heritage Gallery

MDC started in 1955 as a manufacturer and service provider of mechanical scales. From that humble beginning, MDC has since expanded its business activities to include Process Automation, Building & Construction, Chemical Packaging & Trading, and Surface Treatment services.

In February 2012, MDC relocated its operations to the current premises at 5 Tanjong Pagar Crescent. Shortly thereafter, a heritage corner was set up to trace the developmental path of the company and to honour its origin. Among the items on display are traditional Chinese dachings, old balances, weighing machines, weights and measures used in Singapore during different periods --- the very products that MDC had handled over all these years.

In September 2013, MDC was very fortunate to receive from SPRING Singapore a large quantity of weights and measures artefacts. Some of these artefacts were the standards used by Weights & Measures Office (WMO) in the managing of the Weights & Measures Programme in Singapore. The oldest piece of these artefacts is dated back to 1884 when Singapore was still part of the Straits Settlements.

With the enlarged collection, the MDC Heritage Gallery was established.

We hope that all visitors would enjoy viewing the precious artefacts on display. For those with inquisitive minds, they could even trace the development of Weights and Measures Legislations in Singapore.

Weights & Measures Office

Singapore's Weights and Measures Legislations can be dated back to 1889 when a Weights and Measures Office (WMO) was set up in the Police Force of the Straits Settlements following the first Ordinance on Weights and Measures passed in 1886.

Five years after Singapore achieved independence, WMO was transferred from the Police to the Trade Division of the Ministry of Finance in 1970. Later in April 2000, WMO was transferred from the Ministry of Trade and Industry to SPRING Singapore.

Today, SPRING Singapore, a member of the Asia Pacific Legal Metrology Forum and a Corresponding Member of the International Legal Metrology Organisation manages the Weights and Measures Programme for trade transactions in Singapore involving weights and measures.



TOP ROW
Standard liquid measures used in the 1950s to verify liquid measures.

BOTTOM ROW
Imperial standard weights used in the 1880s to 1950s.

Straits settlements imperial beam scales used in the 1910s for the calibration of pound weights.



Standard liquid measures used in the 1950s to verify liquid measures.

Two-pan, three-knife-edge balance used in the 1970s for the calibration of standard weights.



Various counter-weight and mechanical weighing scales used in the 1950s to present for many different trades in Singapore.