

## Appendix 3. The Mendenhall Order of April 5, 1893

This order was published as appendix 6 of the Report for 1893 of the Coast and Geodetic Survey.

### FUNDAMENTAL STANDARDS OF LENGTH AND MASS

While the Constitution of the United States authorizes Congress to "fix the standard of weights and measures," this power has never been definitely exercised, and but little legislation has been enacted upon the subject. Washington regarded the matter of sufficient importance to justify a special reference to it in his first annual message to Congress (January, 1790), and Jefferson, while Secretary of State, prepared a report, at the request of the House of Representatives, in which he proposed (July, 1790) "to reduce every branch to the decimal ratio already established for coins, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide." The consideration of the subject being again urged by Washington, a committee of Congress reported in favor of Jefferson's plan, but no legislation followed. In the meantime the executive branch of the Government found it necessary to procure standards for use in the collection of revenue and other operations in which weights and measures were required, and the Troughton 82-inch brass scale was obtained for the Coast and Geodetic Survey in 1814, a platinum kilogramme and metre, by Gallatin, in 1821, and a troy pound from London in 1827, also by Gallatin. In 1828 the latter was, by act of Congress, made the standard of mass for the Mint of the United States, and, although totally unfit for such purpose, it has since remained the standard for coinage purposes.

In 1830 the Secretary of the Treasury was directed to cause a comparison to be made of the standards of weight and measure used at the principal custom-houses, as a result of which large discrepancies were disclosed in the weights and measures in use. The Treasury Department, being obliged to execute the constitutional provision that all duties, imposts, and excises shall be uniform throughout the United States, adopted the Troughton scale as the standard of length; the avoirdupois pound, to be derived from the troy pound of the Mint, as the unit of mass. At the same time the Department adopted the wine gallon of 231 cubic inches for liquid measure and the Winchester bushel of 2150.42 cubic inches for dry measure. In 1836 the Secretary of the Treasury was authorized to cause a complete set of all weights and measures adopted as standards by the Department for the use of custom-houses and for other purposes to be delivered to the governor of each State in the Union for the use of the States, respectively, the object being to encourage uniformity of weights and measures throughout the Union. At this time several States had adopted standards differing from those used in the Treasury Department, but after a time these were rejected, and finally nearly all the States formally adopted, by act of legislature, the standards which had been put in their hands by the National Government. Thus a good degree of uniformity was secured, although Congress had not adopted a standard of mass or of length, other than for coinage purposes, as already described.

The next and in many respects the most important legislation upon the subject was the act of July 28, 1866, making the use of the metric system lawful throughout the United States and defining the weights and measures in common use in terms of the units of this system. This was the first *general* legislation upon the subject, and the metric system was thus the first, and thus far the only, system made generally legal throughout the country.

In 1875 an international metric convention was agreed upon by seventeen Governments, including the United States, at which it was undertaken to establish and maintain at common expense a permanent international bureau of weights and measures, the first object

of which should be the preparation of a new international standard metre and a new international standard kilogramme, copies of which should be made for distribution among the contributing Governments. Since the organization of the Bureau, the United States has regularly contributed to its support, and in 1889 the copies of the new international prototypes were ready for distribution. This was effected by lot, and the United States received metres Nos. 21 and 27 and kilogrammes Nos. 4 and 20. The metres and kilogrammes are made from the same material, which is an alloy of platinum with 10 per cent of iridium.

On January 2, 1890, the seals which had been placed on metre No. 27 and kilogramme No. 20 at the International Bureau of Weights and Measures, near Paris, were broken in the Cabinet room of the Executive Mansion by the President of the United States in the presence of the Secretary of State and the Secretary of the Treasury, together with a number of invited guests. They were thus adopted as the national prototype metre and kilogramme.

The Troughton scale, which in the early part of the century had been tentatively adopted as a standard of length, has long been recognized as quite unsuitable for such use, owing to its faulty construction and the inferiority of its graduation. For many years, in standardizing length measures, recourse to copies of the imperial yard of Great Britain had been necessary, and to the copies of the metre of the archives in the office of weights and measures. The standard of mass originally selected was likewise unfit for use for similar reasons, and had been practically ignored.

The recent receipt of the very accurate copies of the International Metric Standards, which are constructed in accord with the most advanced conceptions of modern metrology, enables comparisons to be made directly with those standards, as the equations of the national prototypes are accurately known. It has seemed, therefore, that greater stability in weights and measures, as well as much higher accuracy in their comparison, can be secured by accepting the international prototypes as the fundamental standards of length and mass. It was doubtless the intention of Congress that this should be done when the international metric convention was entered into in 1875; otherwise there would be nothing gained from the annual contributions to its support which the Government has constantly made. Such action will also have the great advantage of putting us in direct relation in our weights and measures with all civilized nations, most of which have adopted the metric system for exclusive use. The practical effect upon our customary weights and measures is, of course, nothing. The most careful study of the relation of the yard and the metre has failed thus far to show that the relation as defined by Congress in the act of 1866 is in error. The pound as there defined, in its relation to the kilogramme, differs from the imperial pound of Great Britain by not more than one part in one hundred thousand, an error, if it be so called, which utterly vanishes in comparison with the allowances in all ordinary transactions. Only the most refined scientific research will demand a closer approximation, and in scientific work the kilogramme itself is now universally used, both in this country and in England.\*

\*NOTE.—Reference to the act of 1866 results in the establishment of the following:

$$\begin{aligned} & \text{Equations.} \\ & 1 \text{ yard} = \frac{3600}{3937} \text{ metre.} \\ & 1 \text{ pound avoirdupois} = \frac{1}{2.2046} \text{ kg.} \end{aligned}$$

A more precise value of the English pound avoirdupois is  $\frac{1}{2.20462}$  kg., differing from the above by about one part in one hundred thousand, but the equation established by law is sufficiently accurate for all ordinary conversions.

As already stated, in work of high precision the kilogramme is now all but universally used and no conversion is required.

In view of these facts, and the absence of any material normal standards of customary weights and measures, the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the International Prototype Metre and Kilogramme as fundamental standards, and the customary units—the yard and the pound—will be derived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this Office for several years, but it is considered desirable to make this formal announcement for the information of all interested in the science of metrology or in measurements of precision.

T. C. MENDENHALL,  
*Superintendent of Standard Weights and Measures.*

Approved:  
J. G. CARLBLE,  
*Secretary of the Treasury.*  
APRIL 5, 1893.

[United States Coast and Geodetic Survey.—Office of Standard Weights and Measures—T. C. Mendenhall, Superintendent.]

#### TABLES FOR CONVERTING CUSTOMARY AND METRIC WEIGHTS AND MEASURES.

OFFICE OF STANDARD WEIGHTS AND MEASURES,  
*Washington, D.C., March 21, 1894.*

The yard in use in the United States is equal to  $\frac{3}{4} \frac{6}{10} \frac{0}{10} \frac{0}{10}$  of the metre. The troy pound of the mint is the United States standard weight for coinage. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter and contains 7,000 grains troy. The grain troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound.

2·20462234 pounds avoirdupois = 1 kilogramme.

In Great Britain the legal metric equivalent of the imperial gallon is 4·54346 litres, and of the imperial bushel 36·3477 litres.

The length of a nautical mile, as given below, is that adopted by the United States Coast Survey many years ago, and defined as the length of a minute of arc of a great circle of a sphere whose surface is equal to the surface of the earth (the Clarke spheroid of 1866).

1 foot	=	0·304801 metre, 9·4840158 log.
1 fathom	=	1·829 metres.
1 Gunter's chain	=	20·1168 metres.
1 square statute mile	=	259·000 hectares.
1 nautical mile	=	1853·25 metres.
1 avoirdupois pound	=	453·5924277 grammes.
15432·35639 grains	=	1 kilogramme.

\* \* \* \* \*

By the concurrent action of the principal Governments of the world, an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilogrammes were prepared; from the other a definite number of metre bars. These standards of

weight and length were intercompared without preference, and certain ones were selected as international prototype standards. The others were distributed by lot, in September, 1889, to the different Governments, and are called national prototype standards. Those apportioned to the United States were received in 1890 and are in the keeping of this office.

The metric system was legalized in the United States in 1866.

The International Standard Metre is derived from the Metre des Archives, and its length is defined by the distance between two lines at 0° centigrade on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogramme is a mass of platinum-iridium deposited at the same place, and its weight in vacuo is the same as that of the Kilogramme des Archives.

The litre is equal to a cubic decimetre, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogramme in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimetre.

## Appendix 4. The International Nautical Mile

The following announcement is quoted from the National Bureau of Standards Technical News Bulletin of August 1954.

### Adoption of International Nautical Mile

Beginning on July 1, 1954, the National Bureau of Standards will use the International Nautical Mile in lieu of the U.S. Nautical Mile. This decision, replacing the U.S. Nautical Mile of 1,853,248 meters (6,080.20 feet) by the International Nautical Mile of 1,852 meters (6,076.10333 . . . feet), confirms an official agreement between the Secretary of Commerce and the Secretary of Defense to use the International Nautical Mile within their respective departments.

The use of a mile derived from the length of a degree of the earth's meridian is very old. It is believed that the Chaldean astronomers determined the length of such a unit. Miles of this sort have been variously called meridian miles, geographical miles, sea miles, and nautical miles, and they have differed greatly in magnitude, some of the values providing 10, 12, 15, and 60 miles to a degree. The British and the U.S. nautical miles were each derived by taking 60 nautical miles per degree, but the values adopted were not the same. The nautical mile adopted by the British Admiralty equals 6,080 British feet, while the U.S. nautical mile has had the adopted value of 1,853,248 meters, from which the equivalent 6,080.20 U.S. feet has been derived. The British foot is shorter than the U.S. foot by 1 part in 400,000, an amount which is of no importance in the ordinary transactions of everyday life but which is very important in precise measurements.

In 1929 the International Hydrographic Bureau obtained an agreement from a large number of countries to adopt a value of 1,852 meters for the nautical mile, the unit thus defined to be called the International Nautical Mile. However, at the same time Great Britain, the U.S.S.R., and the United States did not accept this value, each country preferring to retain the nautical mile to which it had been accustomed.

Finally, in 1953 an informal group from the Department of Defense and the Department of Commerce considered a proposal for international standardization of abbreviations for the knot and the mile. At this meeting the general situation regarding the nautical mile