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12.3 CONVERTING BETWEEN MASS AND WEIGHT

As the difference is equal to the weight of the volume of air displaced by the object being weighed, high density materials will displace less air than low density materials; therefore, the difference between weight in air and weight in vacuum varies with density and will have the greatest impact on low density materials. While this difference is not large, it is measurable and typically impacts the third and fourth decimal place of the density, by an amount shown in the table below.

Table 5 – Mass to Weight Density Corrections

Density Range (kg/m^3)	Density Correction (kg/m^3)
Less than 996.6	1.1
996.6 – 1,663.5	1.0
Greater than 1,6635	0.9

The majority of petroleum based materials are in the density range of 600.0 to 996.6 kg/m^3, therefore, the most common correction is 1.1; however, densities above 996.6 kg/m^3 are not uncommon, especially in the chemical industry. When adjusting a density in vacuum to its corresponding density in air, the correction is subtracted. When adjusting a density in air to its corresponding density in vacuum, the correction is added.

While the use of Table 5 to adjust densities for mass to weight calculations and vice versa is convenient and quick, especially for field applications, API *MPMS* Chapter 11.5.3 specifies a formula for making this conversion, which is reproduced below.

The following equation expresses the relationship between Density in Vacuum in kg/m^3 at 15°C and Density in Air at 15°C in kg/m^3

$$D_a^{15} \text{ in } kg/m^3 = 1.000149926\, D^{15} - 1.199407795$$

Where: D_a^{15} = Density in Air

D^{15} = Density in Vacuum

In the event of a dispute or when greater discrimination is required than is provided for by Table 5, the formula specified in API *MPMS* Chapter 11.5.3 shall be used.

Whether quantities are reported in weight (air) or mass (vacuum) is a commercial decision to be determined by agreement of the commercial parties involved.

16.2 INTERRELATION OF UNITS

It is frequently necessary to convert from one type of unit to another using a conversion factor. These conversion factors are found in API *MPMS* Chapter 11.5 of which there are three subchapters:

- Chapter 11.5.1 - Conversions of API Gravity at 60°F
- Chapter 11.5.2 - Conversions for Relative Density (60/60°F)
- Chapter 11.5.3 - Conversions for Density in vacuum at 15°C

These three standards replace the Density/Weight/Volume Intraconversion tables formerly located in API *MPMS* Chapter 11.1, Volumes XI/XII. There are separate conversion factors for mass and weight, depending upon which one is required.

Due to the complexity of these interrelations there is frequently more than one way of performing these conversions and this standard does not attempt to define any specific routines for converting from one unit to another; however, the user should be guided by the following:

- Conversion units that are “exact by definition” are to be considered primary and shall be used whenever possible
- Conversion processes shall not produce a result that contradicts an “exact by definition” value
- The use of multiple conversion factors should be avoided if possible. If this cannot be avoided the process that uses the least number of conversion factors shall be used.

The conversion factors specified in API MPMS Chapter 11.5, when used in chain calculations should be used to the full discrimination allowed by the computing hardware or the maximum number of decimal places specified by Chapter 11.5, whichever is the greater; however, it is recognized that there are applications where chain calculations are not practical or where the conversion factor must be specified and in such cases the following discrimination levels should be used.

Table 6 – Discrimination levels for Conversion Factors

Factor	Decimal Places
Pounds per US gallon @ 60°F	x.xxx
US Gallons @ 60°F Per Pound	x.xxxxx
Tons[1] per 1000 gallons @ 60°F	x.xxxxx
Tons[1] per 1000 liters @ 15°C	x.xxxxx
Gallons @ 60°F per Ton[1]	xxx.xxx
Tons[1] per barrel @ 60°F	x.xxxxx
Barrels @ 60°F per Ton[1]	x.xxxxx
Cubic meters @ 15°C per Ton[1]	x.xxxxx
US gallons @ 60°F to liters @ 15°C	x.xxxxx
Barrels @ 60°F to liters @ 15°C	xxx.xxx
Liters @ 15°C to US gallons @ 60°F	x.xxxxx
Cubic meters @ 15°C to barrels @ 60°F	x.xxxxx

Note 1: tons applies to short tons, metric tons and long tons