



Standard Practice for Conversion Units and Factors Relating to Sampling and Analysis of Atmospheres¹

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1. Scope

1.1 This practice provides units and factors useful for members of the air pollution and meteorological communities.

1.2 This practice is used together with [IEEE/ASTM SI-10](#), which discusses SI units and contains selected conversion factors for inter-relation of SI units and some commonly used non-metric units.

2. Referenced Documents

2.1 *ASTM Standards*:²

[D1356 Terminology Relating to Sampling and Analysis of Atmospheres](#)

[E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves](#)

[IEEE/ASTM SI-10 Standard for Use of the International](#)

¹ This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.01 on Quality Control.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

System of Units (SI): The Modern Metric System

3. Significance and Use

3.1 ASTM requires the use of SI units in all its publications and their use in reporting atmospheric measurement data. However, there are historic data and even data currently reported that are based on a variety of units of measurement. This practice tabulates factors that are necessary to convert such data to SI and other units of measurement.

3.2 [IEEE/ASTM SI-10](#) does not list all the conversion factors commonly used in air pollution and meteorological fields. This practice supplements [IEEE/ASTM SI-10](#).

3.3 The values reported here were obtained from a number of standard publications. They were adjusted to five figures and organized in a rational order. All values reflect the latest information from the 16th General Conference on Weights and Measurements held in 1979.

3.4 The factors in [Table 1](#) are provided to change units of measurement from one system to related units in other systems, as well as to smaller or larger units in the same system.

3.5 Values of units in the left column may be converted to values of units in the right column merely by multiplying by the conversion factor provided in the center column.

TABLE 1 Conversion Units

Multiply	By	To Obtain
Temperature		
Degrees Fahrenheit (F) + 459.72	1	Degrees Fahrenheit Absolute or Rankine (R)
Degrees Fahrenheit (F) – 32	5/9	Degrees Celsius (C)
Degrees Celsius (C) + 273.15	1	Kelvins (K)
Degrees Celsius (C) + 17.78	1.8	Degrees Fahrenheit (F)
Degrees Rankine (R) – 459.72	1	Degrees Fahrenheit (F)
Kelvins (K) – 273.15	1	Degrees Celsius (C)
Pressure		
Dynes per square centimetre	1.4504 × 10 ⁻⁵ 10.197 × 10 ⁻⁴ 1 × 10 ⁻⁶ 0.1	Pounds per square inch Grams per square centimetre Bars Pascals
Pounds per square inch absolute (psia)	70.307 51.715 144 1 6894.8	Grams per square centimetre absolute Millimetres of mercury absolute Pounds per square foot absolute Pounds per square inch gage + 14.696 Pascals
Pounds per square inch gage (psig)	70.307 51.715 27.673 1 6894.8	Grams per square centimetre Millimetres of mercury at 0°C Inches of water at 4°C Pounds per square inch absolute – 14.696 Pascals
Inches of water (at 4°C)	0.03614 0.07355 0.57818 25.399 2490.8 249.2	Pounds per square inch Inches of mercury Ounces per square inch Kilograms per square metre Dynes per square centimetre Pascals
Inches of mercury (at 0°C)	0.49116 13.595 345.31 3.3864 × 10 ⁴ 3386.4	Pounds per square inch Inches of water at 4°C Kilograms per square metre Dynes per square centimetre Pascals
Millimetres of mercury (at 0°C)	0.01934 1.3595 1333.2 133.32	Pounds per square inch Grams per square centimetre Dynes per square centimetre Pascals
Centimetres of mercury (at 0°C)	1.3332 × 10 ⁴ 135.95 27.845 1333.2	Dynes per square centimetre Kilograms per square metre Pounds per square foot Pascals
Atmosphere (normal)	760 1.0133 14.696 29.921 1033.2 1.0133 × 10 ⁶ 1.0132 × 10 ⁵	Millimetres of mercury at 0°C Bars Pounds per square inch Inches of mercury at 0°C Grams per square centimetre Dynes per square centimetre Pascals
Bars	14.504 1.0197 × 10 ⁴ 1.000 × 10 ⁶ 750.06 0.98692 10 ⁵	Pounds per square inch Kilograms per square metre Dynes per square centimetre Millimetres of mercury (0°C) Atmospheres Pascals
Pascals	10 1.4504 × 10 ⁻⁴ 4.0128 × 10 ⁻³ 2.9530 × 10 ⁻⁴ 7.5007 × 10 ⁻³ 9.8692 × 10 ⁻⁶ 10 ⁻⁵	Dynes per square centimetre Pounds per square inch absolute Inches of water (at 4°C) Inches of mercury (at 0°C) Millimetre of mercury (at 0°C) Atmosphere (normal) Bars
Density		
Grams per cubic centimetre	1 0.03613 8.3452 62.428	Grams per millilitre Pounds per cubic inch Pounds per gallon (U.S.) Pounds per cubic foot
Pounds per cubic foot	0.01602 5.7870 × 10 ⁻⁴	Grams per cubic centimetre Pounds per cubic inch
Concentration (See also Section 4.)		
<i>Gases in Gas:</i> Parts per million by volume (ppm(v))	1 1 × 10 ⁻⁴	Micromoles of gas per mole of gas Percent by volume

TABLE 1 *Continued*

Multiply	By	To Obtain
	Molecular weight/24 450	Milligrams of substance per litre of air (at 25°C and 101.3 kPa pressure)
	1×10^{-6}	<u>Partial pressure of one constituent</u>
		Total pressure of mixture
Parts per billion by volume (ppb(v))	1×10^{-3}	Parts per million by volume
One percent by volume	10 000	Parts per million by volume
Milligrams per litre	1000	Milligrams per cubic metre
	1×10^6	Micrograms per cubic metre
Milligrams per cubic metre	1×10^{-3}	Milligrams per litre
Micrograms per cubic metre	1×10^{-6}	Milligrams per litre
<i>Liquid and Solid Particles in Gas:</i>		
Milligrams per litre	1×10^3	Milligrams per cubic metre
	1×10^6	Micrograms per cubic metre
Milligrams per cubic metre	1×10^{-3}	Milligrams per litre
Micrograms per cubic metre	1×10^{-6}	Milligrams per litre
Ounces per thousand cubic feet	1.0012	Grams per cubic metre
Grains per cubic foot	2.2883	Grams per cubic metre
Particles per cubic centimetre	2.8317×10^4	Particles per cubic foot
	1×10^6	Particles per cubic metre
Particles per cubic metre	1×10^{-6}	Particles per cubic centimetre
	0.02832	Particles per cubic foot
Millions of particles per cubic foot	35.314	Millions of particles per cubic metre
<i>Gases, Liquids, and Solids in Liquids:</i>		
Gram molecular weight per litre	1	Moles per litre
Parts per million by weight	1	Milligrams per litre (where specific gravity of dispersion medium is 1.00)
	Length	
Angstrom units	1×10^{-10}	Metres
	3.9370×10^{-9}	Inches
	1×10^{-4}	Micrometres
	1×10^{-8}	Centimetres
	0.1	Nanometres
Nanometres	1×10^{-9}	Metres
	1×10^{-7}	Centimetres
	10	Angstrom units
Micrometres	3.9370×10^{-5}	Inches
	1×10^{-6}	Metres
	1×10^{-4}	Centimetres
	1×10^4	Angstrom units
Millimetres	0.03937	Inches (U.S.)
	1000	Micrometres
Centimetres	0.39370	Inches (U.S.)
	1×10^4	Micrometres
	1×10^7	Nanometres
	1×10^8	Angstrom units
Metres	6.2137×10^{-4}	Miles (statute)
	1.0936	Yards (U.S.)
	39.370	Inches (U.S.)
	1×10^9	Nanometres
	1×10^{10}	Angstrom units
Kilometres	0.53961	Miles (nautical)
	0.62137	Miles (statute)
	1093.6	Yards
	3280.8	Feet
Inches (U.S.)	0.02778	Yards
	2.5400	Centimetres
	2.5400×10^3	Angstrom units
Feet (U.S.)	0.30480	Metres
	30.480	Centimetres
Yards (U.S.)	5.6818×10^{-4}	Miles
	0.91440	Metres
	91.440	Centimetres
Miles (nautical)	1.1516	Statute miles
	2026.8	Yards
	1.8533	Kilometres
Miles (U.S. statute)	320	Rods
	0.86836	Nautical miles
	1.6094	Kilometres
	1609.4	Metres
	Area	
Square millimetres	0.00155	Square inches
	1×10^{-6}	Square metres
	0.01	Square centimetres
	1.2732	Circular millimetres
Square centimetres	1.1960×10^{-4}	Square yards

TABLE 1 *Continued*

Multiply	By	To Obtain
Square kilometres	0.00108	Square feet
	0.15500	Square inches
	1×10^{-4}	Square metres
	100	Square millimetres
	0.38610	Square miles (U.S.)
Square inches (U.S.)	1.1960×10^6	Square yards
	1.0764×10^7	Square feet
	1×10^6	Square metres
	247.10	Acres (U.S.)
	0.00694	Square feet
Square feet (U.S.)	0.00077	Square yards
	6.4516×10^{-4}	Square metres
	6.4516	Square centimetres
	645.16	Square millimetres
	3.5870×10^{-8}	Square miles
Square miles	0.11111	Square yards
	144	Square inches
	0.09290	Square metres
	929.03	Square centimetres
	2.2957×10^{-5}	Acres
Cubic millimetres	640	Acres
	3.0976×10^6	Square yards
	2.7878×10^7	Square feet
	2.5900	Square kilometres
	2.5900×10^6	Square metres
Volume		
Cubic millimetres	6.1023×10^{-5}	Cubic inches
	1×10^{-9}	Cubic metres
	0.001	Cubic centimetres
	0.03381	Ounces (fluid, U.S.)
	0.06102	Cubic inches
Millilitres	0.001	Litres
	1	Cubic centimetres
	0.00131	Cubic yards
	0.26418	Gallons (U.S.)
	0.03532	Cubic feet
Litres	33.815	Ounces (fluid, U.S.)
	61.025	Cubic inches
	0.00100	Cubic metres
	1000	Cubic centimetres
	1.3079	Cubic yards (U.S.)
Cubic metres	35.314	Cubic feet (U.S.)
	264.17	Gallons (U.S.)
	6.1023×10^4	Cubic inches
	1000	Litres
	1×10^6	Cubic centimetres
Gallons (U.S.)	1×10^9	Cubic millimetres
	0.00495	Cubic yards
	0.13368	Cubic feet
	128	Ounces (fluid)
	231	Cubic inches
Cubic inches (U.S.)	0.00378	Cubic metres
	3.7854	Litres
	3785.4	Millilitres
	3785.4	Cubic centimetres
	2.1433×10^{-5}	Cubic yards
Cubic feet (U.S.)	5.7870×10^{-4}	Cubic feet
	0.00433	Gallons (U.S.)
	0.55410	Ounces (fluid)
	1.6387×10^{-5}	Cubic metres
	0.01639	Litres
Cubic centimetres	16.387	Millilitres
	16.387	Cubic centimetres
	1.6387×10^4	Cubic millimetres
	0.03704	Cubic yards
	7.4810	Gallons (U.S.)
Cubic feet (U.S.)	1728.0	Cubic inches
	0.02832	Cubic metres
	28.316	Litres
	2.8316×10^4	Cubic centimetres
	1	Millilitres
Cubic centimetres	1.3079×10^{-6}	Cubic yards
	3.5314×10^{-5}	Cubic feet (U.S.)
	2.6417×10^{-4}	Gallons (U.S.)
	0.03381	Ounces (fluid, U.S.)

TABLE 1 *Continued*

Multiply	By	To Obtain
	0.06102	Cubic inches
	1×10^{-6}	Cubic metres
	1000	Cubic millimetres
Time		
Seconds (mean solar)	1.1574×10^{-5}	Days
	2.7778×10^{-4}	Hours
	0.01667	Minutes
Minutes (mean solar)	9.9206×10^{-5}	Weeks
	6.9445×10^{-4}	Days
	0.01667	Hours
Hours (mean solar)	0.00595	Weeks
	0.04167	Days
	3600	Seconds
Days (mean solar)	1440	Minutes
	8.6400×10^4	Seconds
Weeks (mean solar) ^A	168	Hours
	1.0080×10^4	Minutes
	6.0480×10^5	Seconds
Months (mean calendar) ^A	30.42	Days
	730	Hours
	4.3800×10^4	Minutes
Years (calendar) ^A	2.628×10^6	Seconds
	8760	Hours
	5.256×10^5	Minutes
Velocity		
Feet per second	0.01136	Miles per minute
	0.68182	Miles per hour
	1.0973	Kilometres per hour
	18.288	Metres per minute
	30.480	Centimetres per second
Feet per minute	0.00508	Metres per second
	0.01136	Miles per hour
	0.01667	Feet per second
	0.01829	Kilometres per hour
	0.30480	Metres per minute
	0.50800	Centimetres per second
Centimetres per second	3.7282×10^{-4}	Miles per minute
	0.02237	Miles per hour
	0.03281	Feet per second
	0.03600	Kilometres per hour
	0.60000	Metres per minute
	1.9685	Feet per minute
Miles per hour	0.01667	Miles per minute
	1.4667	Feet per second
	1.6093	Kilometres per hour
	26.822	Metres per minute
	44.704	Centimetres per second
	88	Feet per minute
Metres per minute	0.03728	Miles per hour
	0.05468	Feet per second
	0.06	Kilometres per hour
	1.6667	Centimetres per second
	3.2808	Feet per minute
Kilometres per hour	0.27778	Metres per second
	0.62137	Miles per hour
	0.91134	Feet per second
	16.667	Metres per minute
	27.778	Centimetres per second
	54.681	Feet per minute
Mass (or Weight)		
Milligrams	2.2046×10^{-6}	Pounds (avoirdupois)
	3.5274×10^{-5}	Ounces (avoirdupois)
	0.01543	Grains
	1×10^{-6}	Kilograms
Micrograms	1×10^{-6}	Grams
Grams	0.00220	Pounds (avoirdupois)
	0.03527	Ounces (avoirdupois)
	15.432	Grains
	1×10^6	Micrograms
Kilograms	0.00110	Tons (short)
	2.2046	Pounds (avoirdupois)
	35.274	Ounces (avoirdupois)
	1.5432×10^4	Grains
Grains	1.4286×10^{-4}	Pounds (avoirdupois)
	0.00229	Ounces (avoirdupois)

TABLE 1 *Continued*

Multiply	By	To Obtain
Ounces (avoirdupois)	0.06480	Grams
	64.799	Milligrams
	3.1250×10^{-5}	Tons (short)
	0.06250	Pounds (avoirdupois)
	437.50	Grains
Pounds (avoirdupois)	28.350	Grams
	5×10^{-4}	Tons (short)
	16	Ounces (avoirdupois)
	7000	Grains
	0.45359	Kilograms
Tons (short, U.S.)	453.59	Grams
	2000	Pounds (avoirdupois)
	3.200×10^4	Ounces (avoirdupois)
	907.19	Kilograms

^A For specific applications and exceptions, see Terminology **D1356**.

4. Conversion for Gases and Vapors

4.1 To convert concentrations of gases and vapors from parts per million by volume to milligrams per litre and vice versa at any condition of temperature and pressure, the following formulas will be found useful:

$$\text{Concentration, ppm(v)} = \frac{(C_1 \times 24450 \times T \times 101.3)}{(\text{mol wt} \times 298 \times P)} \quad (1)$$

$$\text{Concentration, mg/litre} = \frac{(C_2 \times \text{mol wt} \times 298 \times P)}{(24450 \times T \times 101.3)} \quad (2)$$

where:

- C_1 = concentration, mg/L,
- C_2 = concentration, ppm(v),
- T = absolute temperature, K, and
- P = absolute pressure of the sampled air stream, kPa.

NOTE 1—It is usually necessary to convert the measured air flow to the temperature and pressure of the sampled air stream.

5. Sieve Number versus Particle Size

5.1 The following are excerpts from Specification **E11**. For complete information on this subject, refer to Specification **E11**.

Sieve Number	Sieve Opening in.	μm
80	0.0070	180
100	.0059	150
120	.0049	125
140	.0041	106
170	.0035	90
200	.0029	75
230	.0025	63
270	.0021	53
325	.0017	45
400	.0015	38

6. Keywords

6.1 area; concentration; conversions; density; length; mass; pressure; sieves; temperature; time; units; velocity; volume; weight

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