11.2 PHYSICS AND FORMULAS

PSIG to PSIA

PSIA = PSIG + 14.7
Round up to the next whole number.

PSIA to PSIG

PSIG = PSIA – 14.7
Round up to the next whole number.

Depth (fsw) to PSIG

PSIG = Depth x .445
Round up to next whole number.

PSIG to Depth (fsw)

Depth = PSIG divided by .445
Round up to next whole number.

PSIG to Atmosphere Absolute (ATA)

$$\text{ATA} = \frac{(\text{PSIG} + 14.7)}{14.7}$$

Carry two decimal places.

Atmospheres Absolute (ATA) to PSIG

(ATA – 1) x 14.7 = PSIG

Depth (fsw) to Atmospheres Absolute (ATA)

$$\text{ATA} = \frac{\text{Depth} + 33}{33}$$

Carry two decimal places.

ATA to Depth (fsw)

ATA – 1 x 33 = Depth (fsw)
Round up to next whole number.

Dalton's Law ("T" Formula)

$$\frac{PP}{ATA \quad \% \text{ of Gas}}$$

PP = Partial Pressure
% = Percent by Volume of the Identified Gas
ATA = Atmospheres Absolute

Gay-Lussac's Law

$$P2 = \frac{P1 \times T2}{T1}$$

Volume is constant.
T1 = Initial Temperature (absolute)
T2 = Final Temperature (absolute)
P1 = Initial Pressure (absolute)
P2 = Final Pressure (absolute)

Charles' Law

$$V2 = \frac{V1 \times T2}{T1}$$

Pressure is constant.
T1 = Initial Temperature (absolute)
T2 = Final Temperature (absolute)
V1 = Initial Volume (absolute)
V2 = Final Volume (absolute)

Boyles' Law (Pressure/Volume Relationship)

$$\frac{DL + 33}{DA + 33} \times OV = NV$$

DL= Depth Left
DA = Depth Arrived
OV = Original Volume
NV = New Volume

Henry's Law

(The Law of Gas Absorption and Solubility) EXPLANATION:

- "The amount of any given gas that will dissolve in a liquid at a given temperature is directly proportional to the partial pressure of that gas."
- Gas diffuses and dissolves in blood, because of the difference in partial pressure, between inhaled and exhaled air.
- The inert gas in the breathing media (nitrogen or helium) will be dissolved into the diver's body tissues as the diver is descending and during the time spent on bottom.
- Whatever gasses that have been dissolved in a diver's body tissues, at a given depth and pressure, will remain in the tissues, as long as the depth is maintained. As the diver starts to ascend, more and more of the dissolved gas will come out of his or her tissues. If his ascent is controlled, as through the use of the decompression table, the dissolved gas will be carried to the lungs and exhaled before it accumulates sufficiently to form significant bubbles in the blood or tissues.

General Gas Law (Pressure/Volume/Temperature Relationship)

$$(P1 \times V1) \div T1 = (P2 \times V2) \div T2$$

Degrees Fahrenheit to Rankine

$$R^{o} = F^{o} + 460^{o}$$

Degrees Celsius to Absolute

$$C^{o} + 273^{o} = \text{Degrees Kelvin}$$

Degrees Fahrenheit to Celsius

$$5 \times (F^{o} - 32^{o}) \div 9 = \text{Celsius (carry 1 decimal place)}$$

Degrees Celsius to Fahrenheit

$$(9 \times C^{o}) \div 5 = 32^{o} = \text{Fahrenheit (carry 1 decimal place)}$$

Gas Volume Requirement Formula if Using an LP Compressor

$$SCFM = ATA \times ACFM \times N$$

Gas Volume Requirement Formula if Using an HP Gas Bank

$$SCF = ATA \times ACFM \times N \times T$$

SCFM = Standard Cubic Feet per Minute
SCF = Standard Cubic Feet
ATA = Atmospheres Absolute
ACFM = Actual Cubic Feet per Minute
N = Number of Divers
T = Time (always expressed in minutes)

Minimum Manifold Pressure

MMP = D x .445 + Over Bottom Pressure
(OBP is established by company or a set standard used.)
Round up to next whole number.

Average Gas Consumption Based Upon Moderate

Free-flow Type Hat (Desco, MK V)	4.5 ACFM
Demand Type Hat (Superlite/Miller)	1.4 ACFM
Built-in Breathing System (BIBS)	0.3 ACFM

Treatment Gas Mixtures (O_2/HeO_2/N_2O_2)

Depth (fsw)	Gas Mixture	PPO_2
0 – 60 fsw	100 % O_2	1.00 – 2.81 ATA
61 – 165 fsw	50/50% HeO_2 or N_2O_2	1.42 – 3.00 ATA
166 – 225 fsw	64/36% HeO_2	2.17 – 2.80 ATA

Example of Calculating Surface Interval

Reached surface (RS) @ 2305 hrs.
Left surface (LS) @ 0317 hrs. (carry over 24-hr. clock)
0317 hrs. could be expressed, ONLY FOR THE PURPOSE OF CALCULATION, as 2717 hrs. 2717 minus (-) 2305 = 4:12
4 hrs. and 12 min.

Calculating In-water Travel Time

1. Depth left (ft/m) minus (-) depth arrived (ft/m) = distance traveled (ft/m).
2. Distance traveled divided (÷) by ascent/descent rate = minutes (and/or percentage of a minute in decimal.
3. Whole number is minute(s). Decimal is percentage of minute. Take decimal and multiply (x) by 60 (number of seconds in a minute). Decimal will then convert to actual seconds.

EXAMPLE:

215 fsw – 87 fsw = 128 fsw Ascent rate: 30 fpm
128 fsw ÷ 30 fpm = 4.26 (4 minutes and .26 or 26% of a minute)
26 x 60 = 15.6 seconds (round up to next whole second) = 16 seconds
4 minutes and 16 seconds is your travel time from 215' to 87'

FORMULA DEFINITIONS

ACF	Actual Cubic Feet
ACFM	Actual Cubic Feet per Minute
ATA	Atmospheres Absolute
ATM	Atmospheres
CFM	Cubic Feet per Minute
D	Diameter
FFW	Feet of Fresh Water
FSW	Feet of Sea Water
FV	Floodable Volume
HP	High Pressure
LP	Low Pressure
MFW	Meters of Fresh Water
MSW	Meters of Sea Water
MWP	Maximum Working Pressure
PP	Partial Pressure
$PP0^2$	Partial Pressure of Oxygen
PPM	Parts Per Million
PSIG	Pounds per Square Inch Gauge
PSIA	Pounds per Square Inch Absolute
SCF	Standard Cubic Feet
SCFM	Standard Cubic Feet per Minute
V	Volume
W	Weight
WP	Working Pressure

11.3 ENGLISH METRIC EQUIVALENTS

PRESSURE EQUIVALENTS				
Atmosphere	**Bars**	**Pounds Per Square Inch (PSIG)**	**Columns of Mercury at 0°C**	**Columns of Water at 15°C**
1	1.01325	14.696	.76 meters / 29.92 inches	10.33 MSW / 33.06 FSW
0.986923	1	14.50	.75 meters / 29.59 inches	10.20 MSW / 32.63 FSW
0.967841	.98066	14.22	.73 meters / 28.95 inches	10.00 MSW / 32.00 FSW
.068046	.068947	1	.05 meters /2.03 inches	.70 MSW / 2.25 FSW
1.31579	1.33322	19.33	1 meters / 39.37 inches	13.60 MSW / 43.50 FSW
.0334211	.0338639	.4911	.0254 meters / 1 inch	.345 MSW / 1.10 FSW
.09674	.09798	1.421	.0735 meters / 2.89 inches	1 MSW / 3.19 FSW
.002456	.002489	.0360	.0018 meters / .0735 inches	.025 MSW / .0812 FSW
.029487	.029877	.4333	.0224 meters / .8822 inches	.304 MSW / .975 FSW
.030242	.03064271	.4444	.0229 meters / .9048 inches	.3126 MSW / 1 FSW

MASS EQUIVALENTS

Kilograms	Grams	Ounces	Pounds	Tons (short)	Tons (long)	Tons (metric)
1	1000	35.274	2.20462	1.1023×10^{-3}	9.942×10^{-4}	0.001
0.001	1	0.035274	2.2046×10^{-3}	1.1023×10^{-6}	9.842×10^{-7}	0.000001
6.479×10^{-5}	0.6047989	2.2857×10^{-3}	1.4286×10^{-4}	7.1429×10^{-8}	6.3776×10^{-8}	6.4799×10^{-8}
0.0283495	28.3495	1	0.0625	3.125×10^{-5}	2.790×10^{-5}	2.835×10^{-5}
0.453592	453.592	16	1	0.0005	4.4543×10^{-4}	4.5359×10^{-4}
907.185	907185	32000	2000	1	0.892857	0.907185
1016.05	1.016×10^{6}	35840	2240	1.12	1	1.01605
1000	10^{6}	35274	2204.62	1.10231	0.984206	1

LENGTH EQUIVALENTS

Centimeters	Meters	Kilometers	Inches	Feet	Yards	Fathom	Miles	Nautical Mi.
1	0.01	0.00001	.3937	.0328	.0109	.005468	6.21×10^{-5}	5.36×10^{-6}
2.54	0.025	2540×10^{-5}	1	.0833	.0277	.01388	1.57×10^{-5}	1.37×10^{-5}
30.48	0.3048	3048×10^{-4}	12	1	.3333	.16666	1.89×10^{-4}	1.64×10^{-4}
91.44	0.9144	9.14×10^{-4}	36	3	1	.5	5.68×10^{-4}	4.93×10^{-4}
100	1	0.001	39.37	3.28	1.093	.5468	6.21×10^{-4}	5.39×10^{-4}
182.88	1.828	.000182	72	6	2	1	.00113	9.86×10^{-4}
100,000	1,000	1	39,370	3,280.83	1,093.61	546.8	.6213	.5395
160,935	1609.35	1.609	63,360	5,280	1,760	880	1	.8683
185,325	1853.25	1.853	72,962.4	6,080.4	2,026.73	1,013.36	1.1515	1

VOLUME AND CAPACITY EQUIVALENTS

Cubic Centimeters	Milliliter	Liter	Cubic Inches	Cubic Feet	Cubic Yards	Pint	Quart	Gallon
1	.99997	9.99×10^{-4}	.061023	3.53×10^{-5}	1.30×10^{-6}	2.113×10^{-3}	1.056×10^{-3}	2.641×10^{-4}
16.387	16.387	.016386	1	5.78x10-4	2.14x10-3	.034632	.017316	4.329×10^{-3}
28,317	28,316.2	28317	1728	1	.037037	59.84448	29.9221	7.48052
764,559	764,559	764.53	46,656	27	1	1615.79	807.896	201.974
1.00	1	.001	.061025	3.53×10^{-5}	1.308×10^{-6}	2.11×10^{-3}	1.056×10^{-3}	2.641×10^{-4}
1000.03	1,000	1	61.0251	.0353154	1.308×10^{-3}	2.11342	1.05671	.264178
473.179	473.166	.47316	28.875	.0167101	6.188×10^{-4}	1	0.5	.125
946.359	946.359	.9463	57.75	.0334201	1.237×10^{-3}	2	1	.25
3,785	3,785	3.785	231	.133681	49511×10^{-3}	8	4	1