§ 86.344–79 Humidity calculations.

(a) The following abbreviations (and units) are used in this section:

$BARO$ = barometric pressure (Pa)
H = specific humidity, (gm H_2O/gm of dry air)
K = 0.6220 gm H_2O/gm dry air
M_{air} = Molecular weight of air = 28.9645
M_{H2O} = Molecular weight of water = 18.01534
P_{DB} = Saturation vapor pressure of water at the dry bulb temperature (Pa)
P_{DP} = saturation vapor pressure of water at the dewpoint temperature (Pa)
P_v = partial pressure of water vapor (Pa)
P_{WB} = saturation vapor pressure of water at the wet bulb temperature (pa)
T_{DB} = Dry bulb temperature (°K)
T_{WB} = Wet bulb temperature (°K)
Y = Water-vapor volume concentration

(b) The specific humidity on a dry basis of the intake air (H) is defined by equation (1).

$$H = \frac{(K)\,(P_v)}{BARO - P_v} \qquad (1)$$

(c) The partial pressure of water vapor may be determined in two manners:

(1) A dew point device may be used. In that case:

$P_v = P_{DP}$

(2) A wet-bulb, dry-bulb method may be used. In that case "Ferrels equation" (eq. (2)) is used.

$$P_v = P_{WB} - 0.000660\,(T_{DB} - T_{WB})\,BARO[1 + 0.00115(T_{WB} - 273.15)] \qquad (2)$$

(d)(1) The saturation vapor pressure (P_{WB}) of water at the wet-bulb temperature is defined by equation (3) (Ref. Wexler and Greenspan, equation (23), National Bureau of Standards).

$$P_{WB} = \exp\left[B \text{ in } T_{WB} + \sum_{i=0}^{9} F_i T_{WB}^{i-2} \right] \qquad (3)$$

where:

P_{WB} is in Pascals (Pa)
T_{WB} = Web-bulb temperature (°K)
B = − 12.150799
F_0 = − 8.49922(10)^3
F_1 = − 7.4231865(10)^3
F_2 = 96.1635147
F_3 = 2.4917646(10) $^{-2}$
F_4 = − 1.3160119(10) $^{-5}$
F_5 = − 1.1460454(10) $^{-8}$
F_6 = 2.1701289(10) $^{-11}$
F_7 = − 3.610258(10) $^{-15}$
F_8 = 3.8504519(10) $^{-18}$
F_9 = − 1.4317(10) $^{-21}$

(2) The table in Figure D79–5 may be used in lieu of equation (3).

(e) The saturated vapor pressure of water at the dry-bulb temperature (P_{DB}) is found (if required) by using dry-bulb absolute temperature (°K) in equation (3).

(f) The percent of relative humidity (RH) (if required) is defined by equation (4).

$$RH = \frac{P_n}{P_{DB}}(100) \qquad (4)$$

(g) The water-vapor volume concentration on a dry basis of the engine intake air (Y) is defined by equation (5).

$$Y = \frac{(H)(M_{air})}{(M_{H2O})} - \frac{P_v}{BARO - P_v} \qquad (5)$$

FIGURE D79–5—SATURATION VAPOR PRESSURE OVER WATER (PASCALS)

Temperature °C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	610.752	615.207	619.690	624.203	628.744	633.315	637.916	642.545	647.205	651.894
1	656.614	661.364	666.144	670.955	675.796	680.669	685.572	690.507	695.473	700.471
2	705.500	710.562	715.655	720.781	725.939	731.130	736.354	741.611	746.901	752.224
3	757.581	762.971	768.396	773.854	779.347	784.874	790.436	796.033	801.664	807.331
4	813.034	818.771	824.545	830.355	836.200	842.082	848.001	853.956	859.948	865.978
5	872.045	878.149	884.291	890.470	896.688	902.945	909.239	915.573	921.945	928.357
6	934.808	941.298	947.828	954.399	961.009	967.660	974.351	981.083	987.856	994.670
7	1001.53	1008.42	1015.36	1022.34	1029.37	1036.43	1043.54	1050.70	1057.89	1065.13
8	1072.41	1079.74	1087.11	1094.52	1101.98	1109.48	1117.03	1124.63	1132.27	1139.95
9	1147.68	1155.46	1163.28	1171.15	1179.07	1187.04	1195.05	1203.11	1211.21	1219.37
10	1227.57	1235.83	1244.13	1252.48	1260.88	1269.32	1277.82	1286.37	1294.97	1303.62
11	1312.32	1321.07	1329.87	1338.73	1347.63	1356.59	1365.60	1374.67	1383.78	1392.95

FIGURE D79–5—SATURATION VAPOR PRESSURE OVER WATER (PASCALS)—Continued

Temperature °C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
12	1402.17	1411.45	1420.78	1430.16	1439.60	1449.10	1458.64	1468.25	1477.91	1487.62
13	1497.39	1507.22	1517.11	1527.05	1537.04	1547.10	1557.21	1567.39	1577.62	1587.90
14	1598.25	1608.66	1619.12	1629.65	1640.24	1650.88	1661.59	1672.36	1683.18	1694.08
15	1705.03	1716.04	1727.12	1738.26	1749.46	1760.73	1772.06	1783.45	1794.91	1806.43
16	1818.01	1829.67	1841.38	1853.17	1865.02	1876.93	1888.91	1900.96	1913.08	1925.27
17	1937.52	1949.84	1962.23	1974.69	1987.21	1999.81	2012.48	2025.21	2038.02	2050.90
18	2063.85	2076.87	2089.97	2103.13	2116.37	2129.68	2143.07	2156.53	2170.06	2183.66
19	2197.34	2211.10	2224.93	2238.84	2252.82	2266.88	2281.02	2295.23	2309.52	2323.89
20	2338.34	2352.86	2367.47	2382.15	2396.91	2411.76	2426.68	2441.68	2456.77	2471.93
21	2487.18	2502.51	2517.93	2533.42	2549.00	2564.66	2580.41	2596.24	2612.16	2628.16
22	2644.25	2660.42	2676.68	2693.02	2709.46	2725.98	2742.59	2759.28	2776.07	2792.94
23	2809.91	2826.96	2844.11	2861.34	2878.67	2896.09	2913.60	2931.20	2948.89	2966.68
24	2984.56	3002.54	3020.61	3038.77	3057.03	3075.39	3093.84	3112.39	3131.03	3149.78
25	3168.62	3187.55	3206.59	3225.73	3244.96	3264.30	3283.73	3303.27	3322.91	3242.65
26	3362.49	3382.43	3402.48	3422.63	3442.89	3463.24	3483.71	3504.28	3524.95	3545.73
27	3566.62	3587.62	3608.72	3629.93	3651.25	3672.67	3694.21	3715.86	3737.61	3759.48
28	3781.46	3803.55	3825.75	3848.07	3870.50	3893.04	3915.70	3938.47	3961.36	3984.36
29	4007.48	4030.71	4054.06	4077.53	4101.12	4124.83	4148.65	4172.59	4196.66	4220.84
30	4245.15	4269.58	4294.13	4318.80	4343.60	4368.52	4393.56	4418.73	4444.02	4469.44

§ 86.345–79 Emission calculations.

(a) The following abbreviations (and units) are used in this section.

α = atomic hydrogen/carbon ratio of the fuel
φ = dry fuel-air ratio (measured)/fuel-air ratio (stoichiometric)
BARO = Barometric pressure (in. *H* g*A*)
BHP = Brake horsepower
BSCO = Brake specific carbon monoxide emissions, (gm/*BHP-HR)*
BSFC = Brake specific fuel consumption (lb/*BHP-HR*)
BSHC = Brake specific hydrocarbon emissions (gm/*BHP-HR*)
$BSNO_X$ = Brake specific oxides of nitrogen emissions (gm/*BHP-HR*)
DCO = CO volume concentration in exhaust, ppm (dry)
DCO_2 = CO_2 volume concentration in exhaust, percent (dry)
DHC = HC volume carbon concentration in exhaust, ppmC (dry)
DKNO = NO volume concentration in exhaust, in ppm (dry and humidity corrected)
EIP = engine intake pressure (in. *H* g*A*) = *BARO* − inlet depression
f/a = measured dry fuel-air ratio
G = humidity of the inlet air in grains of water per pound of dry air = (453.59/0.0648) *H,* (see § 86.344)
K = water − gas equilibrium constant = 3.5
K_{NOx} = Humidity correction factor for oxides of nitrogen
K_w = Wet to dry correction factor
M_C = Atomic weight of carbon
(M_C + M_H) = mean molecular weight of the fuel per carbon atom
M_{CO} = Molecular weight of CO
M_F = Mass flow-rate of fuel used in the engine in lb/hr = W_f/453.59
M_H = Atomic weight of hydrogen
$M_{NO}2$ = Molecular weight of nitrogen dioxide (NO_2)
T = Temperature of inlet air (°F)
W_{CO} = Mass rate of CO in exhaust, grams/hr
W_f = Mass flow-rate of fuel used in the engine, in grams/hr = (453.59)×(W_f lbs/hr)
WHC = HC volume concentration in exhaust, ppm *C*(wet)
W_{HC} = Mass rate of HC in exhaust, grams/hr
W_{NOx} = Mass rate of NO_X in exhaust, grams/hr
Y = H_2O volume concentration of intake air (See § 86.344)

(b) Determine the exhaust species volume concentration for each mode.

(c)(1) Convert wet basis measurements to a dry basis by the following:

Dry concentrations = $1/K_W$×wet concentrations. K^W is defined by the equation in Figure D79–6.

(2) For Diesel engines, for each mode use the measured engine (*f/a*) entering the combustion chamber when calculating φ. If applicable bleed air, etc. must be subtracted from the measured air flow (see § 86.313).

(3) For gasoline-fueled engines, optional for Diesel engines, calculate φ for each mode by substituting *WHC* for *DHC* in the (*f/a*) equations in paragraph (d) of this section.

(4) Calculate a *Y* value for each gasoline-fueled engine test from the pretest data. Apply the *Y* value to the K_W equation for the entire test.

(5) Calculate a separate *Y* value for each Diesel test segment from the pretest-segment data. Apply the *Y* value to the K_W equation for the entire test-segment.