P h o s p h - 8
Distribution of Phosphate Species, version 2.0, (C) 2004, 2006

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Phosph-8 uses calculations found in the literature to determine the various phosphate equilibria that are useful for operating a high-pressure boiler using a phosphate treatment program. It should be recognized that striving to get a specific Na to PO4 ratio can actually be harmful to the operation of a boiler. The control of a phosphate program must put a major effort to ensuring that the concentration of phosphate in the boiler is kept below the point where hideout and the ensuing problems become serious issues.

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Instructions:

Single Ratio This page calculates the Na to PO4 ratio from the water analysis. Enter the concentration of phosphate in mag/L (ppm) and the pH in the two cells marked in blue. It is assumed this is a boiler sample and the measurements are made after cooling the sample to 25°C. The position of the sample is marked on the graph. The graph axes can be adjusted to fit the required by clicking on one of the numbers on the x-axis scale and selecting "Format Axis".

Na_PO4   This page gives the hard numbers from the calculations across the different Na to PO4 ratios.

Species   This page shows how the relative composition of the three ions mono, di and trisodium phosphate vary with pH. Curves are available in steps for 0, 25, 50, 100, 150, 200, 250 and 300 °C.

Constants   This table lists the constants used for the calculations.

Sodium-to-Phosphate Ratio

INPUTS

mg/L	10.00
pH	9.63

RATIO

Na:PO4	2.40

DETAILS

H+	2.37E-10
OH-	4.23E-05
H2PO4-	3.93E-07
HPO4--	1.05E-04
PO4---	2.22E-07
MSP	3.93E-07
DSP	6.24E-05
TSP	4.25E-05
Na	2.53E-04

pH vs. Phosphate Diagram

pH (y-axis), Phosphate (mg/L) (x-axis)

Legend:
- 3.0
- 2.8
- 2.6
- 2.4
- 2.2
- 2.0
- 1.8
- ■

pH vs. Concentration of Phosphate for Varying Sodium-Phosphate Ratios
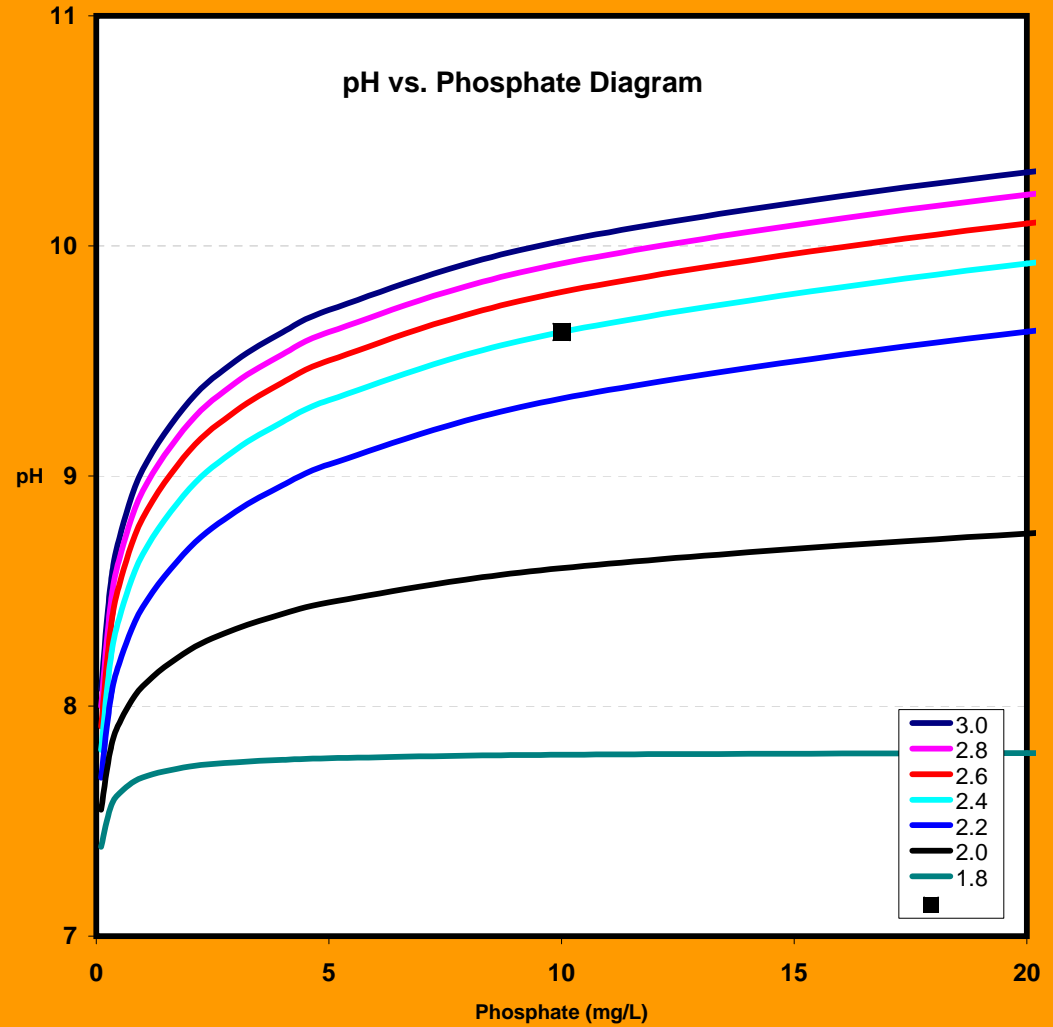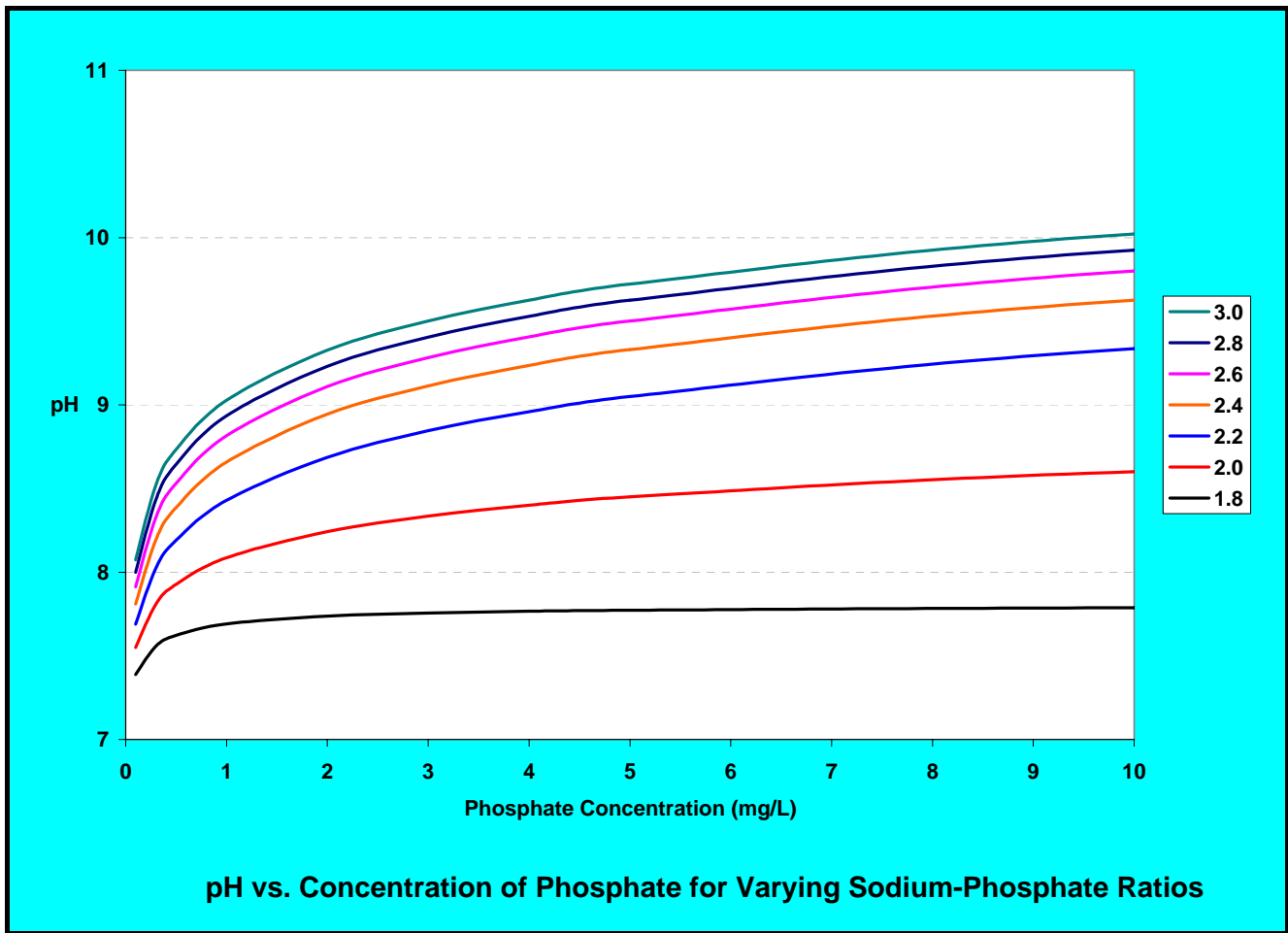
ppm		0.1	0.3	0.5	1	2	3	4	5	10	20	30	50	100
	3.0	8.07	8.52	8.73	9.03	9.33	9.50	9.63	9.72	10.02	10.32	10.49	10.71	11.00
	2.8	8.00	8.43	8.64	8.94	9.23	9.41	9.53	9.63	9.92	10.22	10.40	10.61	10.90
	2.6	7.91	8.33	8.53	8.82	9.11	9.28	9.41	9.50	9.80	10.10	10.27	10.49	10.78
Ratio	2.4	7.81	8.19	8.39	8.66	8.94	9.11	9.24	9.33	9.63	9.92	10.10	10.31	10.60
	2.2	7.69	8.02	8.19	8.43	8.69	8.85	8.96	9.05	9.34	9.63	9.80	10.01	10.30
	2.0	7.55	7.81	7.93	8.09	8.24	8.34	8.40	8.45	8.60	8.75	8.84	8.95	9.10
	1.8	7.39	7.56	7.62	7.69	7.74	7.76	7.77	7.77	7.79	7.80	7.80	7.80	7.80

Distribution of Phosphate Species at T = 150°C
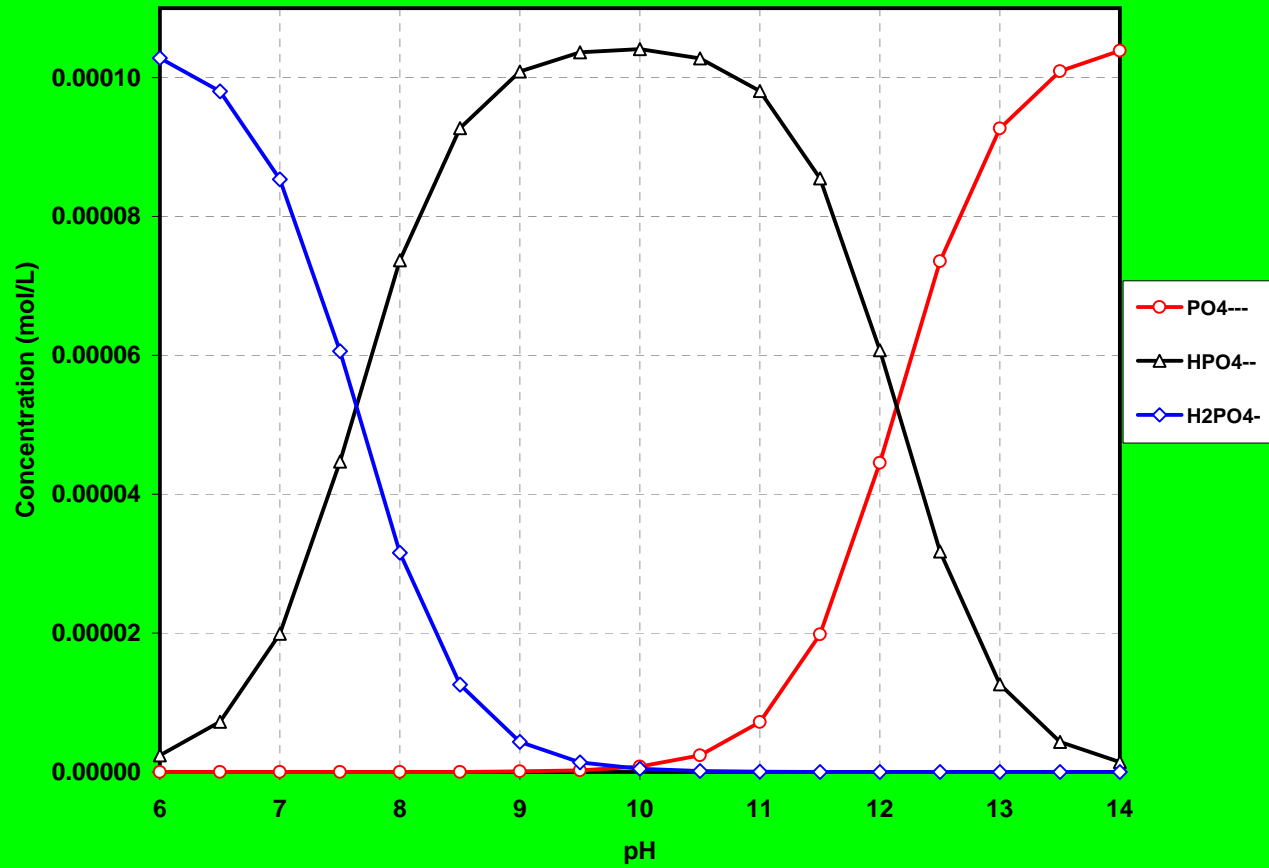
pK1 = -3.02
pK2 = -7.63
pK3 = -12.13
pKw = 11.70

pH	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0
PO4---	1.8E-12	1.7E-11	1.5E-10	1.0E-09	5.4E-09	2.1E-08	7.4E-08	2.4E-07	7.6E-07	2.4E-06	7.2E-06	2.0E-05	4.5E-05	7.4E-05	9.3E-05	1.0E-04	1.0E-04
HPO4--	2.4E-06	7.2E-06	2.0E-05	4.5E-05	7.4E-05	9.3E-05	1.0E-04	1.0E-04	1.0E-04	1.0E-04	9.8E-05	8.5E-05	6.1E-05	3.2E-05	1.3E-05	4.4E-06	1.4E-06
H2PO4-	1.0E-04	9.8E-05	8.5E-05	6.1E-05	3.2E-05	1.3E-05	4.3E-06	1.4E-06	4.5E-07	1.4E-07	4.2E-08	1.2E-08	2.6E-09	4.3E-10	5.4E-11	5.9E-12	6.1E-13

CONSTANTS FOR CALCULATING PHOSPHATE EQUILIBRIA

Temp	pKw	Kw	pK1	K1	pK2	K2	pK3	K3
0	14.95	1.12E-15	-2.07	8.59E-03	-7.32	4.80E-08	-11.97	1.07E-12
25	14.00	1.00E-14	-2.15	7.05E-03	-7.20	6.25E-08	-11.83	1.48E-12
50	13.27	5.37E-14	-2.29	5.16E-03	-7.19	6.44E-08	-11.78	1.65E-12
100	12.27	5.37E-13	-2.62	2.38E-03	-7.34	4.60E-08	-11.87	1.34E-12
150	11.70	2.00E-12	-3.02	9.57E-04	-7.63	2.33E-08	-12.13	7.33E-13
200	11.44	3.63E-12	-3.49	3.27E-04	-8.05	8.91E-09	-12.53	2.94E-13
250	11.39	4.07E-12	-4.01	9.77E-05	-8.56	2.79E-09	-13.01	9.71E-14
300	11.49	3.24E-12	-4.59	2.58E-05	-9.14	7.33E-10	-13.55	2.81E-14