

Logarithmic Expression of Total Alkalinity and Ca-Hardness

KHALID MAHMOOD ZIA, HAQ NAWAZ†, SHAHID IQBAL AND AMERA IFTIKHAR‡

Chemical Section, Gas Turbine Power Station, ‡Steam Power Station, WAPDA, Faisalabad and †Department of Chemistry, University of Agriculture, Faisalabad-38040, Pakistan

ABSTRACT

This research was conducted to express the logarithmic values of total alkalinity and Ca-hardness. The p-Alkalinity values for selected concentrations (0.10 to 10.00 ppm) were arranged in tabular form which decreased as concentration increased. The p-Alkalinity values for higher concentrations were determined by observing the derived formula. The required p-Alkalinity values were compared with the pre-calculated values and found to be the same. The p-Ca and p-Alkalinity relationship was examined. For the same concentration the p-Ca value (+0.30) was larger than p-Alkalinity value. An interpretation of the logarithmic values of total alkalinity and Ca-hardness was checked.

Key Words: Alkalinity; Ca-hardness; Concentration; Logarithmic expression; Saturometry

INTRODUCTION

In circulating cooling water systems, alkalinity and calcium hardness are the important factors considered in predicting the tendency of water to develop calcium carbonate scale. Langelier (1936) developed a saturation index chart from which the saturation pH (pH_s) can be calculated by applying the equation $\text{pH}_s = (\text{pK}_2 - \text{pK}_s) + \text{pCa} + \text{pAlk}$, when values of Ca-hardness, total alkalinity etc. are known and described in ppm as CaCO_3 . An interpretation of water analyses for saturometry determinations utilizes logarithmic expression of the calcium hardness and total alkalinity (Anonymous, 1990). Alkalinity of water is its acid neutralizing capacity. It is the sum of all the titrable bases. Alkalinity is a measure of an aggregate property of water and can be interpreted in terms of specific substance only when the chemical composition of the sample is known (Jenkins & Moore, 1977). A simple method of saturometry determination was introduced by arranging the (pK₂-pK_s) and p-Alkalinity values in tabular form (Zia *et al.*, 1999). These values were determined without the use of Langelier chart and only by calculation with the help of derived formula. The p-Alkalinity and p-Ca relationship was also developed.

MATERIALS AND METHODS

This practical approach for plant operators was conducted in Chemical Section, Gas Turbine Power Station (WAPDA), Faisalabad, Pakistan. The parameters like total alkalinity (carbonates, bicarbonates and hydroxides alkalinity) and Ca-hardness was determined by applying standard methods of analyses (Arnold *et al.*, 1992; BETLZ, 1967). The p-Alkalinity values for selected concentrations (0.10 to 10.00 ppm) were

arranged in tabular form (Table I). The values for higher concentrations of alkalinity were determined by the derived equation

$$\text{RpAlk} = \text{TpAlk} - n \quad \text{I}$$

Where

RpAlk = p-Alkalinity values for some concentration.

TpAlk = Tested p-Alkalinity values given in Table I

n = Represents the exponents of concentrations term written scientifically (Concentration $\times 10^n$)

The values obtained by applying equation I were compared with the values of p-Alkalinity values at various concentration, (Table II) as observed by Zia *et al.* (1999). The pCa was calculated by applying the following relation for the same concentration of total alkalinity and Ca-hardness.

$$\text{pCa} = \text{pAlk} + 0.3 \quad \text{II}$$

Where

pCa = Negative log. factor of Ca-hardness expressed in ppm as CaCO_3 .

pAlk = Negative log. factor of total alkalinity expressed in ppm as CaCO_3 .

RESULTS AND DISCUSSION

Alkalinity and Ca-hardness measurements are used in the interpretation and control of water and wastewater treatment processes.

Alkalinity. Alkalinity is primarily a function of CO_3^{2-} , HCO_3^- and OH^- ions. It is taken as indicator of the concentration of these ions (Thomas & Lynch, 1960). The p-Alkalinity values for selected concentration (0.10 to 10.00 ppm) are arranged in more precise and convenient form (Table I). The values for higher concentration was calculated by applying eq. I which was observed during the research work of this project.

Table I. p-Alkalinity values at (0.10 to 10.0ppm) concentrations

Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk	Conc. (ppm)	p-Alk
0.10	5.70	1.10	4.67	2.10	4.38	3.10	4.19	4.10	4.09	5.10	3.99	6.10	3.94	7.10	3.89	8.10	3.82	9.10	3.76
0.20	5.40	1.20	4.64	2.20	4.36	3.20	4.18	4.20	4.08	5.20	3.99	6.20	3.94	7.20	3.88	8.20	3.81	9.20	3.75
0.30	5.20	1.30	4.61	2.30	4.34	3.30	4.17	4.30	4.07	5.30	3.98	6.30	3.93	7.30	3.87	8.30	3.80	9.30	3.75
0.40	5.10	1.40	4.58	2.40	4.32	3.40	4.16	4.40	4.06	5.40	3.98	6.40	3.93	7.40	3.86	8.40	3.80	9.40	3.74
0.50	5.00	1.50	4.55	2.50	4.30	3.50	4.15	4.50	4.05	5.50	3.97	6.50	3.92	7.50	3.85	8.50	3.79	9.50	3.73
0.60	4.95	1.60	4.52	2.60	4.28	3.60	4.14	4.60	4.04	5.60	3.97	6.60	3.92	7.60	3.85	8.60	3.78	9.60	3.73
0.70	4.90	1.70	4.49	2.70	4.26	3.70	4.13	4.70	4.03	5.70	3.96	6.70	3.91	7.70	3.84	8.70	3.78	9.70	3.72
0.80	4.83	1.80	4.46	2.80	4.24	3.80	4.12	4.80	4.02	5.80	3.96	6.80	3.91	7.80	3.84	8.80	3.77	9.80	3.71
0.90	4.76	1.90	4.43	2.90	4.22	3.90	4.11	4.90	4.01	5.90	3.95	6.90	3.90	7.90	3.83	8.90	3.77	9.90	3.71
1.00	4.70	2.00	4.40	3.00	4.20	4.00	4.10	5.00	4.00	6.00	3.95	7.00	3.90	8.00	3.83	9.00	3.76	10.00	3.70

Evaluation. Suppose following results were shown by a circulating cooling water sample.

Total alkalinity (ppm) = 450

Applying scientific notation conc. $\times 10^n = 4.50 \times 10^2$

TpAlk (at 4.50 ppm) = 4.05 (From Table I)

$n = 2$ (by applying scientific notation)

Applying eq. I

$$RpAlk = TpAlk - n \quad \text{I}$$

$$RpAlk = 4.5 \times 10^2 = 4.05 - 2.00$$

$$RpAlk = 2.05 \quad \text{III}$$

The required pAlk values obtained (eq. III) were the same as of table II at 450 ppm concentration and found the same. The results obtained agreed with the findings of Zia *et al.* (1999) who reported that a ten times increase in concentration (ppm) only one (1.00) degree decrease in p-Alkalinity values takes place.

Ca-Hardness. Hardness of water is not a specific constituent but it is a variable and complex mixture of cations and anions. Hardness of water is predominantly due to Ca^{2+} and Mg^{2+} ions although some other polyvalent ions also contribute (Diel *et al.*, 1950). Logarithmic values of Ca-hardness are pre-calculatory values used in the interpretation and are easy control of treatment processes. The pre-determination of pAlkalinity values helps to calculate the pCa values for the same concentration.

Evaluation. Suppose, circulating cooling water sample showed following result

$$Ca\text{-Hardness (ppm)} = 450$$

$$p\text{-Alk (at 450 ppm)} = 2.05 \text{ (from eq. III)}$$

Applying equation II

$$p\text{-Ca} = pAlk + 0.3 \quad \text{II}$$

$$p\text{-Ca} = 2.05 + 0.3 = 2.35$$

Hence for the same concentration pCa values is (+0.30) larger than pAlk values and an interpretation of the logarithmic values of total alkalinity and Ca-hardness was checked and hence found satisfied. These results are in agreement with those of presented by Zia *et al.* (1999).

REFERENCES

Anonymous, 1990. Modern power station-chemistry and metallurgy (Vol.E) 3rd ed., pp: 297–304. Pergamon Press, New York, USA.

Table II. p-Alkalinity values at various concentrations

C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl	C.	pAl
01	4.70	21	3.38	41	3.09	61	2.94	81	2.82	101	2.70	121	2.58	141	2.46	161	2.35	181	2.24
02	4.40	22	3.36	42	3.08	62	2.94	82	2.81	102	2.69	122	2.57	142	2.45	162	2.34	182	2.23
03	4.20	23	3.34	43	3.07	63	2.93	83	2.80	103	2.68	123	2.56	143	2.44	163	2.33	183	2.22
04	4.10	24	3.32	44	3.06	64	2.93	84	2.80	104	2.67	124	2.55	144	2.43	164	2.32	184	2.21
05	4.00	25	3.30	45	3.05	65	2.92	85	2.79	105	2.66	125	2.54	145	2.42	165	2.31	185	2.20
06	3.95	26	3.28	46	3.04	66	2.92	86	2.78	106	2.65	126	2.53	146	2.41	166	2.30	186	2.19
07	3.90	27	3.26	47	3.03	67	2.91	87	2.78	107	2.64	127	2.52	147	2.40	167	2.29	187	2.18
08	3.85	28	3.24	48	3.02	68	2.91	88	2.77	108	2.63	128	2.51	148	2.39	168	2.28	188	2.17
09	3.80	29	3.22	49	3.01	69	2.90	89	2.77	109	2.62	129	2.50	149	2.38	169	2.27	189	2.16
10	3.70	30	3.20	50	3.00	70	2.90	90	2.76	110	2.61	130	2.49	150	2.37	170	2.26	190	2.15
11	3.67	31	3.19	51	3.00	71	2.89	91	2.76	111	2.60	131	2.48	151	2.36	171	2.25	191	2.14
12	3.64	32	3.18	52	2.99	72	2.87	92	2.75	112	2.58	132	2.47	152	2.35	172	2.24	192	2.13
13	3.61	33	3.17	53	2.98	73	2.86	93	2.74	113	2.57	133	2.46	153	2.34	173	2.23	193	2.12
14	3.58	34	3.16	54	2.98	74	2.85	94	2.74	114	2.56	134	2.45	154	2.33	174	2.22	194	2.11
15	3.55	35	3.15	55	2.97	75	2.85	95	2.73	115	2.55	135	2.44	155	2.32	175	2.21	195	2.10
16	3.52	36	3.14	56	2.97	76	2.84	96	2.73	116	2.54	136	2.43	156	2.31	176	2.20	196	2.09
17	3.49	37	3.13	57	2.96	77	2.84	97	2.72	117	2.53	137	2.42	157	2.30	177	2.19	197	2.08
18	3.46	38	3.12	58	2.96	78	2.83	98	2.71	118	2.52	138	2.41	158	2.29	178	2.18	198	2.07
19	3.43	39	3.11	59	2.95	79	2.83	99	2.71	119	2.51	139	2.40	159	2.28	179	2.17	199	2.06
20	3.40	40	3.10	60	2.95	80	2.83	100	2.70	120	2.50	140	2.39	160	2.27	180	2.16	200	2.05

- Arnold, E.G., S.C. Lenore and D.E. Andrew, 1992. Standard Methods for the Examination of Water and Waste Water (18th eds.). APHA Washington, DC.
- BETLZ, 1967. Betz Handbook of Industrial Water Chemistry, 6th ed. Betz Laboratories Inc., USA.
- Diel, H., C.A. Goetz and C.C. Kach, 1950. The versenate titration for total hardness. *J. Amer. Water Works Assoc.*, 42: 49.
- Jenkins, S.R. and R.C. Moore, 1977. A proposed modification to the classical method of calculating alkalinity in natural waters. *J. Amer. Water Works Assoc.*, 69: 56.
- Langelier, W.F., 1936. The analytical control of anticorrosion water treatment. *J. Amer. Water Works Assoc.*, 28: 1500.
- Thomas, J.F.J. and J.J. Lynch., 1960. Determination of carbonate alkalinity in natural waters. *J. Amer. Water Works Assoc.*, 252–9.
- Zia, K.M., M. Iqbal, H. Nawaz and G. Samin, 1999. Langelier calcium carbonate saturometry determination by table values. *Int. J. Agri. Biol.*, 1: 353–5.

(Received 25 March 2000;Accepted 28 April 2000)