APPENDIX I

REFERENCE TABLES AND CURVES

ATOMIC WEIGHTS OF THE MORE COMMON ELEMENTS

Element	Symbol	Atomic Weight	Valence
Aluminum	Al	26.98	3
Barium	Ba	137.36	2
Boron	B	10.82	3
Bromine	Br	79.916	1, 3, 5, 7
Cadmium	Cd	112.41	2
Calcium	Ca	40.08	2
Carbon	C	12.011	2, 4
Chlorine	Cl	35.457	1, 3, 5, 7
Chromium	Cr	52.01	2, 3, 6
Cobalt	Co	58.94	2, 3
Copper	Cu	63.54	1, 2
Fluorine	F	19.00	1
Hydrogen	H	1.0080	1
Iodine	I	126.91	1, 3, 5, 7
Iron	Fe	55.85	2, 3
Lead	Pb	207.21	2, 4
Magnesium	Mg	24.32	2
Manganese	Mn	54.94	2, 3, 4, 6, 7
Mercury	Hg	200.61	1, 2
Molybdenum	Mo	95.95	3, 4, 6
Nickel	Ni	58.71	2, 3
Nitrogen	N	14.008	3, 5
Oxygen	O	16.000	2
Phosphorus	P	30.975	3, 5
Potassium	K	39.100	1
Silicon	Si	28.09	4
Silver	Ag	107.880	1
Sodium	Na	22.991	1
Sulfur	S	32.066	2, 4, 6
Tin	Sn	118.70	2, 4
Zinc	Zn	65.38	2

CHEMICAL CONVERSION FACTORS: RESIDUE TO PERTINENT ELEMENT OR RADICAL

Weighed	Sought	Factor
Al_2O_3	Al	0.529
$BaSO_4$	Ba	0.588
$BaSO_4$	SO_4	0.412
CaO	Ca	0.715
CdS	S	0.778
CO_2	CO_3	1.364
CuO	Cu	0.799
Fe_2O_3	Fe	0.699
$KMnO_4$	Mn	0.348
$Mg_2P_2O_7$	Mg	0.219
$Mg_2P_2O_7$	PO_4	0.853
$Mn_2P_2O_7$	Mn	0.387
$(NH_4)_3PO_4 \cdot 12MoO_3$	P	0.0022
Ni-glyoxime	Ni	0.203
PbO_2	Pb	0.866
SnO_2	Sn	0.788
TiO_2	Ti	0.60
ZnO	Zn	0.803

DISSOLVED OXYGEN (SATURATION VALUES)

Temperature, deg Cent	ppm, by weight
10	11.33
15	10.15
20	9.17
25	8.38
30	7.63
35	7.1
40	6.6
45	6.1
50	5.6

DENSITY AND VISCOSITY OF WATER

Temperature, deg Cent	Density, lb per cu ft	Viscosity, centipoises
10	62.40960	1.3077
15	62.37205	1.1404
20	62.31640	1.0050
25	62.24414	0.8937
30	62.15676	0.8007
35	62.05585	0.7225

IONIC EQUIVALENT CONDUCTANCE AT 25 C

Ion	λ_0[a]
K^+	73.52
Na^+	50.11
H^+	349.82
NH_4^+	73.4
½ Ca^{++}	59.5
½ Mg^{++}	53.06
Cl^-	76.34
NO_3^-	71.44
½ SO_4^{--}	79.8
OH^-	198
HCO_3^-	44.48
½ CO_2^{--}	83
HS^-	72
HSO_3^-	71
½ SO_3^{--}	80
$H_2PO_4^-$	29
½ HPO_4^{--}	60
⅓ PO_4^{---}	78

[a] λ_0 = Ionic equivalent conductance at infinite dilution.

TEMPERATURE CONVERSION FORMULAS

Deg Cent = 5/9 (deg Fahr − 32)
Deg Fahr = 9/5 deg Cent + 32

BICARBONATE, CARBONATE, AND HYDROXIDE RELATIONSHIPS

	Bicarbonate	Carbonate	Hydroxide
$P = 0$	M	0	0
$P < \frac{1}{2} M$	$M - 2P$	$2P$	0
$P = \frac{1}{2} M$	0	$2P$	0
$P > \frac{1}{2} M$	0	$2(M - P)$	$2P - M$
$P = M$	0	0	M

M = Methyl orange alkalinity.
P = Phenolphthalein alkalinity.

Multiply	By	To Obtain
Acres	43,560	square feet
Acre-feet	325,851	gallons
Centimeters	0.394	inches
Centimeters	0.01	meters
Centimeters	10	millimeters
Cubic feet	1728	cubic inches
Cubic feet	7.48	gallons
Cubic feet	28.32	liters
Cubic feet per minute	62.43	pounds of water per minute
Cubic feet per second	0.646	million gallons per day
Cubic feet per second	448.83	gallons per minute
Cubic inches	16.39	cubic centimeters
Feet	30.48	centimeters
Feet of water	0.8826	inches of mercury
Feet of water	62.43	pounds per square foot
Feet of water	0.4335	pounds per square inch
Gallons	3785	cubic centimeters
Gallons	0.1337	cubic feet
Gallons	231	cubic inches
Gallons	3.785	liters
Gallons, Imperial	1.2	gallons, U. S.
Gallons of water	8.345	pounds of water
Grains	0.0648	grams
Grains per gallon	17.12	parts per million
Grains per gallon	142.86	pounds per million gallons
Grams	15.43	grains
Grams	0.001	kilograms
Grams	1000	milligrams
Grams	0.0021	pounds
Grams per liter	58.42	grains per gallon
Grams per liter	8.345	pounds per 1000 gallons
Grams per liter	1000	parts per million
Inches	2.54	centimeters
Inches of mercury	1.133	feet of water
Inches of mercury	0.4912	pounds per square inch
Inches of water	0.0736	inches of mercury
Inches of water	0.036	pounds per square inch
Kilograms	2.205	pounds
Kilograms	1000	grams
Kilometers	3281	feet
Kilometers	0.6214	miles
Liters	1000	cubic centimeters
Liters	0.0353	cubic feet
Liters	61.02	cubic inches
Liters	0.2642	gallons
Meters	100	centimeters
Meters	3.281	feet
Meters	39.37	inches
Milligrams	0.001	grams
Milliliters	0.001	liters
Milligrams per liter	1	parts per million
Million gallons per day	1.547	cubic feet per second
Ounces	437.5	grains
Ounces	28.35	grams
Parts per million	0.0584	grains per gallon
Parts per million	8.345	pounds per million gallons
Pounds	7000	grains
Pounds	453.6	grams
Pounds per cubic foot	0.016	grams per cubic centimeter
Pounds per square inch	2.31	feet of water
Pounds per square inch	2.036	inches of mercury
Square miles	640	acres
Tons, long	2240	pounds
Tons, metric	2205	pounds
Tons, short	2000	pounds

TABLE I.—ANALYSES OF TYPICAL PUBLIC WATER SUPPLIES IN THE UNITED STATES.

(From U. S. Geological Survey Water-Supply Papers 1299 and 1300.)

Water Supply[a]	1	2	3	4	5	6	7	8
Date of Collection	4/9/52	5/12/49	6/4/52	2/6/52	6/30/52	2/11/52	Average 1950 to 51 Year	June 1949
Silica (SiO_2), ppm	2.1	...	2.5	8.6	6.6	17	12	7.5
Iron (Fe), ppm	0.21	0.0	0.03	0.24	0.00	0.0	...	0.02
Manganese (Mn), ppm	0.00	...	0.00	...	...	0.00	...	0
Calcium (Ca), ppm	36	67	5.3	23	31	12	31	13
Magnesium (Mg), ppm	10	26	1.7	9.2	6.1	3.6	12	5.6
Sodium (Na), ppm	3.4	14	1.4	2.7	8.0	139	189	11
Potassium (K), ppm	0.7		0.6			0.4	3	...
Bicarbonate (HCO_3), ppm	135	163	10	25	79	317	121	66
Carbonate (CO_3), ppm	0	...	0	0	0	0	12	0
Sulfate (SO_4), ppm	17	137	11	64	39	5.6	290	13
Chloride (Cl), ppm	6.3	20	2.6	6.6	7.0	56	83	10
Fluoride (F), ppm	0.1	...	0.1	0.0	1.0	0.8	0.4	0.1
Nitrate (NO_3), ppm	...	...	0.3	5.9	2.6	0.0	0.2	0.0
Dissolved solids, ppm	150	461	34	147	156	388	692	93
Hardness as $CaCO_3$, ppm	131	274	20	95	102	45	315	54
Noncarbonate hardness as $CaCO_3$, ppm	20	140	6	75	38	0	197	1
Specific conductance, micromhos at 25 C	225	...	53.4	228	236	660	1040	152
pH	8.2	7.4	6.9	8.1	7.5	7.8	8.4	7.9
Color	3	...	1	5	3	10	...	...
Turbidity	14	...	1.9	...	...	...	...	...
Temperature, deg Fahr	37	...	54	50	...	...	...	...

[a] Water supplies are identified as follows:

1. Chicago, Ill. Lake Michigan: Chicago Avenue pumping station.
2. Jacksonville, Fla. Well supply (finished).
3. New York, N. Y. Catskill supply (finished).
4. Philadelphia, Pa. Schuylkill River supply (finished).
5. Washington, D. C. Potomac River (finished).
6. Houston, Tex. Scott Street well 4; depth, 1756 ft.
7. Los Angeles, Metropolitan District of Southern California. Colorado River (finished).
8. San Francisco, Calif. Crystal Spring lines (finished).

TABLE II.—ANALYSES BY U. S. GEOLOGICAL SURVEY OF TYPICAL SURFACE WATERS OF THE UNITED STATES.

Surface Waters[a]	1			2			3			4		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Date of Collection	Oct. 1 to 9, 1953	May 11 to 20, 1954	1953 to 1954	Jan. 1 to 10, 1954	May 1 to 10, 1954	1953 to 1954	Aug. 1 to 3, 5 to 10, 1955	March 1 to 10, 1955	1954 to 1955	Jan. 4 to 14, 1953	June 10 to 13, 1953	1952 to 1953
Silica (SiO_2), ppm	4.9	5.4	5.8	1.3	0.3	3.6	5.1	6.2	6.7	...	...	...
Iron (Fe), ppm	0.03	0.02	0.03	0.01	0.03	0.02	0.01	0.48	0.08	...	...	...
Manganese (Mn), ppm	...	...	...	...	...	...	0.00	0.32	0.18	...	...	...
Calcium (Ca), ppm	25	8.7	15	26	18	20	62	20	40	80	56	62
Magnesium (Mg), ppm	9.8	1.5	4.6	5.0	2.7	3.4	15	4.9	10	26	12	18
Sodium (Na), ppm	6.8 (Na + K)	5.9 (Na + K)	5.7 (Na + K)	9.5	3.6	5.0	43	4.9	21	73	39	59
Potassium (K), ppm				1.5	1.0	1.1	4.1	1.6	2.6	...	...	...
Bicarbonate (HCO_3), ppm	68	22	38	84	57	66	29	26	26	265	167	191
Carbonate (CO_3), ppm	0	0	0	0	0	0	0	0	0	0	0	0
Sulfate (SO_4), ppm	38	16	24	15	11	11	201	48	120	211	119	177
Chloride (Cl), ppm	12	3.0	7.2	16	4.4	7.8	52	8.0	29	26	9.5	16
Fluoride (F), ppm	0.2	0.1	0.1	0.2	0.2	0.2	0.5	0.1	0.3	...	...	...
Nitrate (NO_3), ppm	5.8	1.8	3.3	0.4	1.7	1.3	3.8	4.5	3.3	3.7	3.8	3.3
Dissolved solids, ppm	156	55	97	121	74	90	409	120	259	589	348	462
Hardness as $CaCO_3$, ppm	103	28	58	86	55	64	219	69	141	306	189	229
Noncarbonate hardness as $CaCO_3$, ppm	47	10	26	17	9	10	195	49	20	89	52	72
Specific conductance, micromhos at 25 C	251	94.0	158	214	129	153	648	185	408	878	538	697
pH	7.6	7.2	...	7.2	7.2	...	6.9	6.8	...	7.9	7.4	...
Color	9	3	4	5	2	9	3	27	...	...	...	...
Temperature, deg Fahr	...	...	...	...	...	...	85	45	...	...	...	...

Surface Waters[a]	5			6			7			8		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Date of Collection	Oct. 5, 1953	May 29, 1954	1953 to 1954	Nov. 7, 1953	July 31, 1954	1953 to 1954	Sept. 21 to 30, 1953	June 21 to 30, 1953	1952 to 1953	March 11 to 20, 1952	June 11 to 20, 1952	1951 to 1952
Silica (SiO_2), ppm	...	...	...	28	6.4	15	11	14	15	15	9.6	13
Iron (Fe), ppm	...	...	...	...	...	...	0.12	0.23	0.14	0.14	0.03	0.06
Manganese (Mn), ppm	...	...	...	...	...	...	...	...	...	...	...	...
Calcium (Ca), ppm	137	38	94	70	...	34	144	64	95	26	17	20
Magnesium (Mg), ppm	40	5.4	24	13	...	4.7	57	15	31	8.1	4.4	6.0
Sodium (Na), ppm	810	45	340	628	...	75	208	28	101	10	4.9	6.9
Potassium (K), ppm	...	...	...				12	4.6	6.8	1.8	1.7	1.9
Bicarbonate (HCO_3), ppm	235	121	209	216	41	105	260	212	243	106	69	85
Carbonate (CO_3), ppm	5	0	...	0	0	...	0	0	0	0	0	0
Sulfate (SO_4), ppm	280	30	180	136	...	40	553	79	262	23	12	15
Chloride (Cl), ppm	1280	62	497	892	21	95	194	24	86	5.8	2.0	3.9
Fluoride (F), ppm	...	...	...	...	...	...	0.5	0.3	0.4	0.4	0.2	0.3
Nitrate (NO_3), ppm	11	5.2	6.8	22	2.8	4.0	3.4	1.4	2.7	1.3	1.1	1.1
Dissolved solids, ppm	2770	285	1300	1900	82	342	1310	335	719	147	91	111
Hardness as $CaCO_3$, ppm	505	117	333	228	36	104	594	221	364	98	60	75
Noncarbonate hardness as $CaCO_3$, ppm	304	18	162	51	2	18	381	48	166	11	4	5
Specific conductance, micromhos at 25 C	4720	470	2230	3170	154	568	1930	541	1100	234	147	177
pH	8.3	8.2	...	8.2	7.6	...	7.5	7.5	...	7.7	7.3	...
Color	...	...	...	...	...	...	...	...	...	15	25	...

[a] Surface waters are identified as follows:

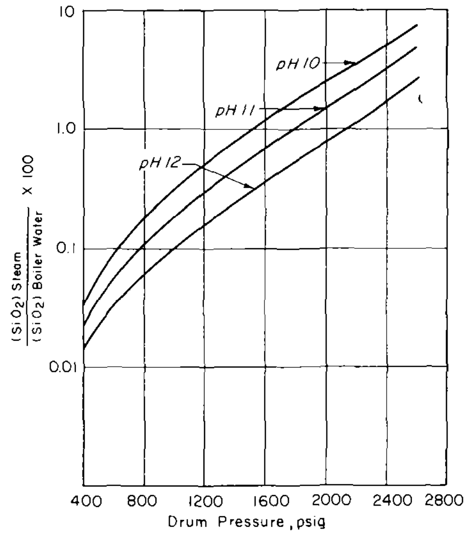
1. Delaware River at Trenton, N. J.
2. Tennessee River at Kentucky Dam, near Paducah, Ky. (WSP-1350).
3. Ohio River at Ravenswood, W. Va. (Water Quality and Flow Variations in the Ohio River 1951–55. Ohio River Valley Sanitation Commission.)
4. Missouri River at Nebraska City, Nebr. (WSP-1291).
5. Arkansas River at Arkansas City, Kans. (WSP-1352).
6. Trinity River at Romayor, Tex. (WSP-1352).
7. Colorado River near Grand Canyon, Ariz. (WSP-1293).
8. Columbia River at Maryhill Ferry near Rufus, Ore. (WSP-1253).

TABLE III.—ANALYSES OF GROUND WATER FROM REPRESENTATIVE AQUIFERS IN THE UNITED STATES.

(From U. S. Geological Survey Water-Supply Papers 1299 and 1300.)

Aquifers[a]	1	2	3	4	5	6	7	8
Date of Collection	1/16/52	10/20/51	4/2/51	1/17/52	5/24/51	5/14/52	1/29/49	10/4/48
Silica (SiO_2), ppm	7.0	11	13	12	21	14	19	27
Iron (Fe), ppm	0.09	0.19	0.43	0.80	1.6	0.00	...	G
Manganese (Mn), ppm	...	0.00	0.0	0.13	...	0.00	0	0
Calcium (Ca), ppm	49	3.0	8.2	72	62	62	56	12
Magnesium (Mg), ppm	9.1	0.8	4.6	28	11	17	12	7.7
Sodium (Na), ppm	9.6	104	17	5.5	56	7.1	71	9.4
Potassium (K), ppm		1.4	1.7	1.0	2.1	1.2	...	...
Bicarbonate (HCO_3), ppm	165	211	85	294	255	244	243	56
Carbonate (CO_3), ppm	0	9	0	0	0	0	0	...
Sulfate (SO_4), ppm	31	9.3	3.7	65	54	15	67	8.9
Chloride (Cl), ppm	9.0	28	2.5	8.0	36	12	51	9.5
Fluoride (F), ppm	0.1	0.9	0.1	0.1	0.3	0.2	...	0
Nitrate (NO_3), ppm	0.2	1.1	0.4	0.7	1.8	5.4	3.5	17
Dissolved solids, ppm	197	274	94	340	370	259	399	115
Hardness as $CaCO_3$, ppm	160	11	39	295	200	225	189	61
Noncarbonate hardness as $CaCO_3$, ppm	24	0	0	54	0	25	0	16
Specific conductance, micromhos at 25 C	342	443	137	565	595	449	...	...
pH	7.7	8.6	6.9	7.6	7.3	7.6	7.7	7.1
Color	2	3	7	2	0	0	...	0
Turbidity	...	2	2	...	...	0	...	...
Temperature, deg Fahr	...	68	...	52	...	78	...	...
Depth, ft	58 to 71	636	400 to 600	108	90 to 265	avg 900	180 to 640	378

[a] Aquifers are identified as follows:
1. Schenectady, N. Y. Wells.
2. Montgomery, Ala. Well 31.
3. Memphis, Tenn. Parkway well field.
4. South Bend, Ind. Well 2, North Station.
5. Wichita, Kans. Wells.
6. San Antonio, Tex. Brackenridge Park well field.
7. Glendale, Calif. Grandview wells.
8. Tacoma, Wash. Well 5A.



Cyrus Wm. Rice & Co., Pittsburgh, Pa.

FIG. 1.—Percentage of Silica in Steam *versus* Boiler Drum Pressure at Selected Boiler Water pH.

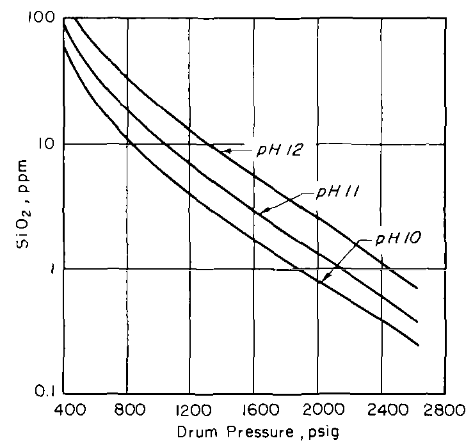


FIG. 2.—Maximum Boiler Water Silica Concentration *versus* Drum Pressure at Selected Boiler Water pH. (Based on maintaining 0.02 ppm SiO_2 maximum in steam.)

TABLE IV.—INDUSTRIAL WATER REQUIREMENTS.

The amounts of water or steam required per unit of product in many industrial operations are tabulated below. All cited sources for the values are listed together at the end of the table.

	Water	Steam
Acetic acid from carbide		7300 lb per ton HAc (3)
Acetic acid from pyroligneous acid	100,000 gal per ton HAc (3)[a]	15,700 lb per ton HAc (3)
Acetic acid from pyroligneous liquor	240 M gal per ton HAc (3)	64,000 to 74,000 lb per ton HAc (3)
Acetic acid, direct (Othmer process)		54,200 lb per ton HAc (3)
Alcohol, industrial	120 gal per gal 100 proof alcohol (5) 52 gal per gal 190 proof alcohol (3) 100 gal per gal alcohol (2) 20,000 gal per ton grain (1) 600,000 gal per 1000 bu grain mashed (5)	 50 lb per gal 190 proof alcohol (3)
Alumina (Bayer process)	6300 gal per ton $Al_2O_3 \cdot 3H_2O$ (3)	15,000 lb per ton $Al_2O_3 \cdot 3H_2O$ (3)
Ammonia, synthetic	31,000 gal per ton liquid NH_3 (1, 3)	
Ammoniated superphosphate	27 to 30 gal per ton ammoniated superphosphate (3)	
Ammonium sulfate	200,000 gal per ton salt (1)	
Buna S	173,000,000 gal per day for 100,000 tons Buna S per year (3)	
Butadiene	320,000 gal per ton butadiene (2)	
Calcium metaphosphate	4000 gal per ton $Ca(PO_3)_2$	
Carbon dioxide	23,000 gal per ton CO_2 (1) 20,000 gal per ton solid CO_2 from 18 per cent flue gas (3)	 20,000 lb per ton solid CO_2 from 18 per cent flue gas (3)
Casein (grain-curd process)		2400 lb per ton casein
Caustic soda (lime-soda process)	18,000 lb per ton NaOH in 11 per cent solution (3) 21,000 gal per ton NaOH in 11 per cent solution (1)	2700 lb per ton NaOH in 11 per cent solution (3)
Caustic soda (electrolytic)		20,000 lb per ton 76 per cent NaOH (3)
Cellulose nitrate	50 gal per lb cellulose nitrate (3) 10,000 gal per ton cellulose nitrate (1)	
Charcoal and wood chemicals	65,000 gal per ton crude $CaAc_2$ (3)	64,000 lb per ton crude $CaAc_2$ (3)
Cottonseed oil	20 gal per gal oil (3) 0.6 gal per gal hardened oil (3)	15 lb per gal oil (3) 0.5 lb per gal hardened oil (3)
Coumarin (synthetic)		3000 lb per ton coumarin or 0.75 ton salicylaldehyde (3)
Cuprammonium rayon	90,000 to 160,000 gal per ton 11 per cent moisture rayon (3)	
Fatty acid refining, continuous		1390 lb per ton stock charged (3)
Gelatin		400 lb per ton gelatin (3)
Glycerine	1100 gal per ton glycerine (1)	8000 lb per ton glycerine (3)
Gunpowder	200,000 gal per ton gunpowder (1) or explosives (2)	
Hydrochloric acid (salt process)	2900 gal per ton 20 Bé HCl (3)	
Hydrochloric acid (synthetic process)	500 to 1000 gal per ton 20 Bé HCl (3)	
Hydrogen	660,000 gal per ton H_2 (1)	
Lactose (milk sugar)	200,000 to 220,000 gal per ton lactose (1, 3)	80,000 lb per ton lactose (3)
Magnesium carbonate, basic	4320 gal per ton basic $MgCO_3$ (3) 39,000 gal per ton $MgCO_3$ (1)	18,000 lb per ton basic $MgCO_3$ (3)
Magnesium hydroxide from sea water and dolomite	Sea water 58,000 gal and fresh water 500 gal per ton $Mg(OH)_2$ (3)	800 lb per ton $Mg(OH)_2$ (3)
Oxygen, liquid	2000 gal per 1000 cu ft O_2 (3)	
Phenol, synthetic		4000 lb per ton phenol (3)
Phosphoric acid (blast furnace)	75,000 gal per ton 100 per cent H_3PO_4 (3)	
Phosphoric acid (Dorr strong-acid process)	7500 gal per ton 35 per cent P_2O_5 acid (1, 3)	780 lb per ton 35 per cent P_2O_5 acid (3)
Potassium chloride from Sylvinite	40,000 to 50,000 gal per ton KCl (3)	2500 lb per ton KCl (3)
Soap, laundry	230 gal per ton soap (3) 500 gal per ton soap (2)	4000 lb per ton soap (3)
Soda ash (ammonia-soda process)	15,000 to 18,000 gal per ton 58 per cent soda ash (1, 3)	
Sodium bichromate		6000 lb per ton sodium bichromate (3)
Sodium chlorate	60,000 gal per ton sodium chlorate (3)	11,000 lb per ton sodium chlorate (3)
Sodium silicate	160 gal per ton 40 Bé water glass (3)	1040 lb per ton 40 Bé water glass (3)
Sodium sulfate, natural		3650 lb per ton anhydrous Na_2SO_4 (95 + per cent) (3)
Stearic acid and red oil		18,000 lb per ton stearic acid (3)
Sulfur dioxide, liquid	18,000 gal per ton liquid SO_2 (3)	6800 lb per ton liquid SO_2 (3)
Sulfuric acid (chamber process)	2500 gal per ton 100 per cent H_2SO_4 (3)	

[a] The boldface numbers in parentheses refer to the list of references appended to this section of the appendix.

	Water	Steam
Sulfuric acid (contact process)	4000 gal per ton 100 per cent H_2SO_4 (3) 5000 gal per ton H_2SO_4 (2)	
Trisodium orthophosphate		150 lb per ton $Na_3PO_4 \cdot 12H_2O$ (3)
Vanillin (synthetic)		30,800 lb per ton vanillin (3)
Viscose rayon	180,000 to 200,000 gal per ton viscose yarn (3)	140,000 lb per ton viscose yarn (3)
	FOOD INDUSTRY	
Bread	500 to 1000 gal per ton bread (4)	600 to 1000 lb per ton bread (4)
Brewing		
Beer	470 gal per bbl beer (5)	
Whiskey	80 gal per gal whiskey (5)	
Canning		
Apricots	8000 gal per 100 cases No. 2 cans (5)	
Asparagus	7000 gal per 100 cases No. 2 cans (1, 5)	
Beans		
Green	3500 gal per 100 cases No. 2 cans (1, 5)	
Lima	25,000 gal per 100 cases No. 2 cans (1, 5)	
Pork and beans	3500 gal per 100 cases No. 2 cans (1)	
Beets	2500 gal per 100 cases No. 2 cans (5)	
Corn	2500 gal per 100 cases No. 2 cans (5)	
Cream or whole	4000 gal per 100 cases No. 2 cans (1)	
Peas	3000 gal per 100 cases No. 2 cans (1)	
Sauerkraut	300 gal per 100 cases No. 2 cans (1, 5)	
Spinach	16,000 gal per 100 cases No. 2 cans (1, 5)	
Succotash	12,500 gal per 100 cases No. 2 cans (5)	
Tomatoes		
Products	7000 gal per 100 cases No. 2 cans (1)	
Whole	750 gal per 100 cases No. 2 cans (1)	
Corn refining	333 gal per ton corn (1)	
Edible gelatin	13,200 to 20,000 gal per ton gelatin (4)	
Edible oil	22 gal per gal oil (3)	
Meat packing		
Packing house	55,000 gal per 100 hog units (1, 5)	
Poultry	4400 gal per ton live weight (1)	
Slaughter house	16,000 gal per 100 hog units (1, 5)	
Stockyards	160 gal per acre (5)	
Milk and milk products		
Butter	5000 gal per ton butter (1)	
Cheese	4000 gal per ton cheese (1, 5)	
Dairies	3 gal per qt milk (2)	
Receiving and bottling	450 gal per 100 gal milk (1, 5)	
Creamery	220 gal per ton raw (5)	
Restaurants	0.5 to 4.0 gal per meal (2, 5)	
Sugar		
Beet	2160 gal per ton refined sugar (3) 20,000 to 25,000 gal per ton sugar (1) 2600 to 3200 gal per ton beets (1)	
Refined cane	1000 gal per ton sugar (2) Condensing 4800 to 8400 gal per ton (3) Pure water 1400 gal per ton refined sugar	3500 lb per ton refined sugar (3)
Vegetable dehydration		
Beets	37,400 gal per ton product (1)	
Cabbage	15,000 gal per ton product (1)	
Carrots	31,600 gal per ton product (1)	
Potatoes	11,200 to 25,000 gal per ton product (1)	
Rutabagas	30,400 gal per ton product (1)	
Sweet potatoes	18,000 gal per ton product (1)	
	TEXTILE INDUSTRY	
Cotton		
Bleaching	25 to 38 gal per yd (2)	
Dyeing	1000 to 2000 gal per 100 lb goods (1)	
Finishing	10 to 15 gal per yd (2)	
Processing	3800 gal per 100 lb goods (1)	
Knit goods, bleaching	16,000 gal per ton goods (2)	
Linen	200,000 gal per ton goods (1)	
Rayon		
Cuprammonium yarn	160,000 gal per ton yarn (1)	
Dissolving pulp	190,000 gal per ton pulp (1)	
Viscose yarn	200,000 gal per ton yarn (1)	
Silk, hosiery dyeing	6000 to 8000 gal per ton goods (2)	
Wool		
Scouring	2000 to 15,000 gal per 100 lb raw wool (1)	
Scouring and bleaching	40,000 gal per ton goods (2)	
	MISCELLANEOUS INDUSTRIES	
Air conditioning	6000 to 15,000 gal per person per season (1)	
Aluminum	1,920,000 gal per ton aluminum (2)	
Buildings, office	27 to 45 gal per day per capita (2, 5)	
Cement, portland	750 gal per ton cement (2, 3)	
Cement rock, beneficiation	720 gal per ton raw rock (3)	

	Water	Steam
Coal		
By-product coke	1430 to 2860 gal per ton coke (3)	570 to 860 lb per ton coke (3)
Carbonizing	3500 gal per ton coal carbonized (1)	
Washing	125 gal per ton coal (1)	
Electricity	80 gal per kw electricity (2, 5) 120,000 gal per ton coal burned (1)	
Hospitals	135 to 350 gal per day per bed (2, 5)	
Hotels	300 to 525 gal per day per guest room (2, 5)	
Laundries		
Commercial	8600 to 11,400 gal per ton "work" (2, 5)	
Institutional	6000 gal per ton "work" (2, 5)	
Leather tannery	375 gal per ton vegetable tan (3) 600 gal per ton chrome tan (3) 6000 to 16,000 gal per ton leather (2) 16,000 gal per ton hides (1)	
Petroleum		
Airplane engine (to test)	125,000 gal per airplane engine (2)	
Gasoline	7 to 10 gal per gal gasoline (2)	
Gasoline, aviation	25 gal per gal aviation gasoline (2)	
Gasoline, natural	20 gal per gal gasoline (3) and 2000 cu ft stripped gas at 150 lb pressure	6 lb per gal gasoline (3) and 2000 cu ft stripped gas at 150 lb pressure
Gasoline, polymerization	34 gal per gal polymer gasoline (3)	2.7 lb per gal polymer gasoline (3)
Oil, Fischer-Tropsch synthesis	150,000 gal per 100 bbl oil (7)	
Oil fields	18,000 gal per 100 bbl crude oil (1)	
Oil refinery	77,000 gal per 100 bbl crude oil (1)	
Pulp and paper mills	50,000 to 150,000 gal per ton pulp (2)	
De-inking paper	38,000 gal per ton paper (1)	
Paper board	14,000 gal per ton paper board (1)	
Soda pulp		13,000 lb per ton dried soda pulp (3)
Strawboard	26,000 gal per ton strawboard (1)	
Sulfate pulp (Kraft)		10,000 lb per ton dried sulfate pulp (3)
Sulfate pulp bleaching	60,224 gal to bleach 1 ton (3) dry pulp of 80 to 85 G.E. brightness	3120 lb to bleach 1 ton (3) dry pulp of 80 to 85 G.E. brightness
Sulfate pulp		5000 to 7000 lb per ton dried pulp (3)
Rock wool	4000 to 5000 gal per ton rock wool (1, 3)	3000 lb per ton rock wool (3)
Rubber (auto tire)		120 lb per auto tire (3)
Steel plant	20,000 to 35,000 gal per ton steel (1)	
Fabricated steel	42,000 gal per ton steel (2)	
Ingot steel	18,000 gal per ton steel (2)	
Pig iron	4000 gal per ton pig iron (1)	
Sulfur mining	3000 gal per ton sulfur (1)	

REFERENCES

(1) G. E. Symons, "Treatment of Industrial Wastes," *Water and Sewage*, Vol. 82, No. 11, November, 1944, p. 44.
(2) *Journal*, Am. Water Works Assn., Vol. 37, No. 9, September, 1945, p. 4.
(3) Chemical and Metallurgical Engineering Flow Sheets, 4th Ed. (1944).
(4) Food Industries Flow Sheets of the Food Producing Industry, 2nd Ed. (1947).
(5) H. E. Jordan, "Industrial Requirements for Water," *The Johnson National Drillers' Journal*, July–August, 1948, p. 7.
(6) W. L. Faith, "Plant Location in Agricultural Process Industries," *Chemical Engineering Progress*, Vol. 45, May, 1949, p. 313.
(7) W. C. Schroeder, "Comparison of Major Processes for Synthetic Liquid Fuels," *Chemical Industries*, Vol. 62, No. 4 p. 577 (1948).
(8) S. T. Powell and L. G. von Lossberg, "Relation of Water Supply to Chemical Plant Location," *Chemical Engineering Progress*, Vol. 45, May, 1949, pp. 289–300.

APPENDIX II

GLOSSARY

Technical terms not in ordinary use, and words used in the Manual in a special sense, are defined below. Definitions given in Standard D 1129[1] are not repeated here.

Absorption—Assimilation of molecules of other substances into the physical structure of a liquid or solid without chemical reaction.

Absorption, radiation—1. The process whereby the number of particles or photons emerging from a body is reduced relative to the number entering, as a result of interactions of the particles with the body.

2. The process whereby part or all of the energy of a particle or of electromagnetic radiation is lost while traversing a body of matter.

Absorption tower—A vertical structure for carrying out an absorption process.

Acid—A compound which dissociates in water solution to furnish hydrogen ions.

Acid anhydride—An oxide which will form an acid when united with water.

Acid mine drainage—Acidic drainage from bituminous coal mines, containing a high concentration of acidic sulfates, especially ferrous sulfate.

Acid radical—The anion in equilibrium with the hydrogen ion of an acid.

Acidify—To make acidic by the addition of acid or acid salt.

Acidimetry—The art of determining the acidity of aqueous solutions.

Activation—The process of inducing radioactivity in a material through nuclear bombardment, especially by neutrons.

Activation analysis—A method of chemical analysis, especially for trace quantities, based on the detection of characteristic radionuclides following nuclear bombardment.

Adsorption—Physical adhesion of molecules to the surfaces of solids without chemical reaction.

Aerobic—Living only in the presence of free oxygen.

[1] See p. 392.

Agglomerate—To gather together into a larger mass or cluster; to coalesce.

Albuminoid—Any of a number of substances resembling the true proteins such as collagen and keratin. A protein in its broad sense.

Algae—Simple forms of aquatic plant life which multiply only by division, but contain chlorophyll and use sunlight for photosynthesis.

Aliquot—A measured fraction of the known total volume of a solution.

Amorphous—Structure without crystalline components; having no determinate shape.

Amperometrically—Determined by measurement of electric current flowing or generated, rather than by voltage measurement.

Anaerobic—Living in the absence of free oxygen.

Analysis, chemical—Determination of the chemical elements or constituents of a compound or mixture. Also a statement of the results of such a determination.

Angstrom unit—A measurement of length usually applied to light or other radiation wavelengths—0.0001 μ, cm/10^8.

Anion—A negatively charged ion resulting from dissociation of molecules in aqueous solution.

Anode—The positive pole in an electrolytic cell which attracts negatively charged particles or ions (anions).

Anthrax—A malignant infectious disease of cattle, sheep, and other animals, and of man, caused by *Bacillus anthracis*.

Arc, visible—An electrical discharge in which radiation of wavelengths discernible by the normal human eye is produced.

Arthropods—Animals with articulate body and limbs.

Ascarite—A proprietary absorbent for carbon dioxide consisting of asbestos fibers impregnated with dehydrated sodium hydroxide.

Aspirator—A type of suction pump operated from a laboratory water tap.

Autotrophs—Microorganisms which utilize inorganic materials for energy and obtain carbon from the carbon dioxide of the atmosphere.

Background, instrument—Undesired counts or responses due to cosmic rays, local contaminating radioactivity, electronic noise, and the like. Background is sometimes used to refer to the radiation causing the undesired response.

Backwash—Reversed flow of liquid for cleaning or the discharge from such an operation.

Bacteria—One-celled microscopic organisms.

Bacteria, iron—Bacteria which assimilate iron and excrete its compounds in their life processes, thereby contributing to corrosion.

Bacteria, non-pathogenic—Bacteria which do not induce disease in man or the higher animals.

Bacteria, pathogenic—Microorganisms that produce disease.

Bacteria, sulfate-reducing—Bacteria which assimilate oxygen from sulfate compounds, thereby reducing them to sulfides.

Bacteriophage—A viral agent that dissolves specific bacterial cells.

Balance, water—A material account of the weight of water entering and leaving an industrial installation or process.

Basic—Alkaline.

Beam trap—A device on an X-ray-diffraction camera for absorbing the undiffracted primary X-ray beam after it has passed through the sample.

Biota, stream—The collective animal and plant life of a stream.

Birefringence—The difference between the maximum and minimum index of refraction of a crystal.

Blanket—A layer of material outside the core of a reactor in which fissionable materials are produced through neutron activation.

Blowdown—Draining off a portion of the liquid in a vessel, usually to reduce the concentration of the remaining liquid.

BOD—Biochemical oxygen demand of a water—the oxygen required for oxidation of the soluble organic matter by bacterial action in the presence of oxygen.

Bovine tuberculosis—An infectious disease affecting any of various tissues of the body due to the tubercle bacillus and characterized by the production of tubercles.

Brine—Concentrated solution, especially of chloride salts.

Bromination—Chemical treatment with bromine.

Brucellosis—Infection with bacteria of the Brucella group, frequently causing abortions in animals and undulant fever in man.

Buffer—A substance which tends to resist changes in pH of a solution.

Buffered water—Water containing dissolved or suspended material which resists changes in the pH of the water.

Calibration—The process of standardizing.

Carbonate hardness—That hardness in a water caused by bicarbonates and carbonates of calcium and magnesium.

Carryover—Entrainment of liquid or solid particles from the boiling liquid in the evolved vapor; also the particles so entrained.

Cathode—The negative pole of an electrolytic cell which attracts positively charged particles or ions (cations); the negative electrode of a vacuum tube.

Cathodic protection—Reduction or prevention of corrosion of a metal surface by making it cathodic by use of sacrificial anodes or impressed currents.

Cation—A positively charged ion resulting from dissociation of molecules in solution.

Cavitation—The formation of cavities in a liquid by rapid movement over confining or impelling surfaces and the subsequent collapse of these cavities; the destruction of metal surfaces as a result of cavitation in the liquid.

Centrifuge—A device for separating the lighter and heavier portions of a fluid by centrifugal force.

Chamber, ionization—An instrument whose response to radiation is due only to collection of the ions formed by the interaction of the radiation with the chamber materials.

Chelating agents—Chemical compounds which have the property of withdrawing ions into soluble complexes.

Chlorinator—A machine for feeding either liquid or gaseous chlorine to a stream of water.

Coagulation—The coalescence of fine particles to form larger particles.

Collimator tube—A device for defining the path of rays, such as light or X-rays.

Colloidal—Matter of very fine particle size, usually in the range of 10^{-5} to 10^{-7} cm in diameter.

Colorimeter—A device for measuring or comparing colors or colored solutions.

Colorimeter, photoelectric - cell — A colorimeter which measures the light transmitted through a solution by the response of a photoelectric cell.

Colorimetric determination—An analytical procedure based on measurement, or comparison with standards, of color naturally present in samples or developed therein by addition of reagents.

Combinations, molecular—Possible mutual arrangements of the known proportions of anions and cations present in a mixture.

Combinations, probable—The most likely manner, in the judgment of the analyst, in which the ions of a solution or the constituents of a deposit are combined into compounds in the original sample.

Combining weight—The relative or equivalent weight of an element or compound which enters into combination with another element or compound.

Comparator—A device for comparing colored or turbid solutions against standard solutions' light filters under favorable lighting conditions.

Complexes—Compounds formed by the union of two or more simple salts.

Composition, elemental—Describing a substance in terms of atoms of which it is composed.

Concentration—The process of increasing the dissolved solids per unit volume of solution, usually by evaporation of the liquid; the amount of material dissolved in a unit volume of solution.

Concentration, maximum permissible—The concentration of a specific radionuclide, or a mixture of radionuclides, allowed in an environmental medium, such as air or water.

Condensate—Liquid (water) obtained by evaporation and subsequent condensation.

Condenser—An apparatus for removing heat from a gas (steam) so as to cause the gas to revert to the liquid state (water).

Cooling coil—A coil of pipe or tubing to contain a flowing stream of hot liquid which is cooled by heat transfer to a cold liquid outside.

Cooling tower—Hollow, vertical structure with internal baffles to break up falling water so that it is cooled by upward-flowing air and evaporation from the extended surface of the water.

Corrosion—Chemical attack, as of metals, by which the metal is converted to a compound and thus deteriorated.

Corrosion, electrochemical—Corrosion resulting from the flow of an imposed or self-induced electric current.

Counter, proportional—An instrument whose response to radiation is based upon the collection of the ions formed by the interaction of the radiation with the counter materials, *plus* a proportionate number of secondary ions formed by gas amplification.

Cross-section—The probability, per unit flux and per unit time, that a given nuclear reaction will occur.

Crustaceae—Aquatic animals having a shell.

Culture—Any organic growth which has been intentionally developed by use of a suitable food and environment.

Culture medium—A food substance for growing organic life for study.

Curie—The unit of quantity of radioactive material, defined as that quantity of a nuclide in which the number of disintegrations is 3.7×10^{10} per second.

Deaeration—The process of removing air from a liquid in which it is dissolved.

Decantation—Separation of a liquid from solids, or from a higher density liquid, by carefully pouring off the upper layer after the heavier material has settled.

Decay, heat—The heat produced in or by radioactive material through absorption of the disintegration energy.

Decay, radioactive—Radioactive disintegration.

Decompose—To separate into simpler substances or to change the form or quality of a substance by chemical action; to decay or rot.

Degas—To remove a gas from a liquid or solid.

Dehydrated—Freed from, or lacking, water.

Dehydration—Process of removing water, such as roasting, desiccation, etc.

Dendrite—A tree-like crystalline structure within a solid material.

Density—Weight per unit volume.

Deposit, water-formed—Material formed or deposited on the walls of a water-containing vessel.

Descale—To remove a solid scale layer from its supporting surface.

Desuperheating—Removing sensible heat from a gas (steam) to reduce its temperature.

Detergent—A cleansing and dispersing agent which, like soap, removes a film from its supporting structure by other means than solvent or chemical action.

Diaphragm—A flexible partition between two chambers.

Diatom—Single-celled marine animal having a coating or sheath consisting principally of silica.

Diatomaceous—Made up of the skeletal remains of diatoms.

Diatomaceous earth—A fine, siliceous earth consisting mainly of the cell walls of diatoms.

Diffraction—Bending a beam of light, and so separating it into its colored components, by passing it through a medium of different density or by grazing it across a grating.

Diffraction, angle of—The angle through which a beam of light is bent as it passes through a substance of different density.

Diffractor—A prism or grating which will cause light rays to bend.

Digestion—Prolonged solution of, or reaction with, a solid by a liquid.

Dilution—The addition of more solvent to a solution.

Disintegration, radioactive—A spontaneous nuclear transformation characterized by the emission of energy from the nucleus.

Dissolved matter—The material in solution in a liquid.

Dolomitic lime—Lime containing 30 to 50 per cent magnesium and 70 to 50 per cent calcium oxide as contrasted with a lime containing 95 to 98 per cent calcium oxide.

Dose—A measure of the amount of radiation energy absorbed per unit mass.

Dosimeter—Any instrument which measures radiation dose, especially a small ionization chamber in which accumulated electrical charge, rather than current or events, is measured.

Dry pipe—The horizontal pipe within a boiler through which generated steam is discharged. By multiple changes in direction of steam flow, it serves to separate water droplets from the steam.

Eductor—A mechanical device combining a high-velocity fluid jet, a venturi, and a side arm for pumping gas or liquid in through the side arm and discharging it with the effluent jet; frequently used as a vacuum pump.

Efficiency, detector—A measure of the probability that an event will be recorded when a radiated particle or photon passes into a detector. It is usually measured by the fraction or per cent recorded.

Efficiency, over-all—The response of a detector to a radiation source, defined as the fraction of emitted radiation particles or quanta recorded by the detector.

Effluent—A liquid, solid, or gaseous product, frequently waste, discharged or emerging from a process.

Electrolyte—A substance which dissociates into two or more ions when it is dissolved in water.

Electrolyze—To decompose a compound, either liquid, molten, or in solution, by an electric current.

Embrittlement, caustic—Intergranular failure of boiler steel resulting from the combination of a stress beyond the yield point of the steel and attack by a concentrated caustic solution.

Encrusting—Capable of forming a hard coating or scale.

Encrusting solids—Dissolved solids which, when concentrated by evaporation, will precipitate as a hard coating or scale on heat-transfer surfaces.

End point—The stage in a titration when equivalence is attained as revealed by a change that can be observed or measured such as color development, formation of precipitate, or attainment of specified pH.

End point, electrometric—The stage in a titration when equivalence is reached as revealed by attainment of a specified pH or change in current flow measured by a glass electrode.

End point, methyl-orange—The stage in an acid-base titration when equivalence is attained as revealed by change in color of methyl-orange indicator.

End point, phenolphthalein—The stage in an acid-base titration when equivalence is attained as revealed by change in color of phenolphthalein indicator.

Energy, disintegration—The energy released in radioactive decay.

Entrainment—The carrying over of drops of liquid from an evaporator or boiler due to the vapor velocity being greater than the rate of settling of the drops.

Enzyme—A catalyst produced by living cells.

Equalizing basin—A holding basin in which, by retention, variations in flow and composition of a liquid are averaged out.

Equivalent, chemical—The weight in grams of a substance which combines with or displaces one gram of hydrogen, obtained by dividing the formula weight by the valence.

Erosion—The wearing away of a solid substance by repeated impact action of a solid, liquid, or gas.

Etiologic agent—Causative agent, such as a bacterium which induces a specific disease.

Evaporated—A liquid converted to its vapor by the application of heat or reduced pressure.

Evaporator—An apparatus in which a solution is converted to a vapor and a more concentrated solution, the relatively pure vapor usually being condensed for re-use.

Evaporator, single-effect—An evaporator in which the liquid is subjected to only one evaporating step.

Evaporator, multiple-effect—A series of single-effect evaporators so connected that the vapor from one effect is the heating medium for the next.

Evaporator salines—The concentrated solution effluent from evaporators; also the salts in such a solution.

Evapotranspiration—Transfer of moisture to the atmosphere by plant life, occurring as a result of the processes of evaporation and photosynthesis.

Evolution—The escape or liberation of a gas.

Excited—Stimulated, by applied energy, into an unstable or metastable state, such as in the formation of ions from neutral atoms.

Extraction—The process of dissolving and separating out specific constituents of a sample by treatment with solvents specific for those constituents.

Eyepiece—The lens or lens system to which an observer applies his eye in using an optical instrument.

Fallout—Radioactive débris, usually from a nuclear detonation, which has been deposited on the earth after having been air-borne. Special forms of fallout are "dry fallout" (or "dust-out"), "rainout," and "snowout."

Fauna—Animals, or animal life.
Ferrobacillus ferrooxidans—An autotrophic bacterium which oxidizes ferrous iron under acid conditions.
Filamentous—Having the shape of a fine thread-like body or structure.
Film badge—An appropriately packaged photographic film for detecting radiation exposure of personnel.
Filter plant—The portion of a plant containing the equipment employed to strain water for the removal of suspended solids.
Filtrate—The liquid which has passed through a filter.
Filtration—The process of separating solids from a liquid by means of a porous substance through which only the liquid passes.
Fission—The splitting of a nucleus into two more or less equal fragments, usually as a result of the capture of a bombarding particle, especially a neutron. In addition to the two fragments, neutrons and gamma rays are usually emitted during fission.
Fission products—The nuclides produced by the fission of a heavy element nuclide such as uranium-233, uranium-235, or plutonium-239.
Flame photometer—Apparatus for giving a reproducible amount of emitted light for a given concentration of element in the test solution, and for determining the intensity of such emission as a function of concentration of the element without excessive interference from other emitted light.
Flashing—The conversion of a portion of a hot liquid under pressure to its vapor by release of the pressure.
Floc—A felted mass formed in a liquid medium by the aggregation of a number of fine suspended particles.
Flora—Plants, or plant life.
Flow cells—A sensing element or combination of elements, such as electrodes, immersed in a flowing liquid or gas for the purpose of measuring continuously some property of the fluid, such as electrical conductivity.
Flow diagram—The diagrammatic representation of a works process, showing the sequence and interdependence of the successive stages.
Flumed—The transportation of solids by suspension or flotation in flowing water.
Fluorescence—The absorption of radiation at one wavelength or range of wavelengths and its re-emission as radiation of longer, visible wavelengths.
Flux—The number of particles or photons passing through a surface per unit time; for electromagnetic radiation, the energy passing through a surface per unit time.
Fluxing—Addition of a low-melting compound to a substance to decrease fusion temperature of the mixture.
Geiger-Mueller tube—A gas-filled chamber with electrodes operated at a voltage such that a discharge triggered by a primary ionization event will increase until stopped by reduction of the electric field. The size of the response is independent of the unit amount of primary ionization.
Geometry—The average solid angle at the source subtended by the aperture or sensitive volume of a detector, divided by 4π. Geometry is frequently (but loosely) used to denote over-all counting efficiency.
Glass electrode—An electrode consisting of a thin glass membrane separating solutions of known and unknown pH value, the potential difference between the two sides being measured for determining the pH of the unknown.
Grain per gallon—A measure of solution concentration—17.1 ppm.
Grating—A band of equidistant, parallel, straight lines ruled on a suitable surface for systematically dispersing polychromatic light into its separate wavelength components.
Gravimetric—Measured by weight.
Ground water—Water derived from wells or springs, not surface water from lakes or streams.
Gases, half-bound—Gases, such as carbon dioxide, which are evolved by decomposition of unstable ions upon heating.
Half-life—The average time required to reduce the amount of a particular radionuclide to half its original value through radioactive disintegration.
Heat exchanger—A mechanical device by which heat is transferred from a flowing fluid within tubes to another outside the tubes.
Heat transfer—The process of removing heat from a hot body or fluid to another, usually through an intervening wall.
Heater, feedwater—A heat exchanger for raising the temperature of feedwater.
Heterotrophs—Microorganisms which must obtain carbon from organic compounds.
Homogeneous—Of uniform composition throughout.
Hot-well, condenser—Reservoir at the bottom of a condenser shell for collecting condensed water.
Humidity—The concentration of water vapor in an atmosphere.
Hydrazine—An ammonium compound, N_2H_4, which is used as an oxygen scavenger in boiler water.
Hydrometer—A buoyant instrument with graduated stem for measuring the specific gravity of liquids.

Hydroponics—Growth of plants in nutrient solution rather than in earth.

Hygroscopic—Tending to absorb moisture from the atmosphere.

Hypochlorite solution—Bleaching or sterilizing solution containing $(O\ Cl)^-$ ion.

Incubation—Maintenance of viable organisms in nutrient solution at constant temperature for controlled growth or reproduction.

Index of refraction—Ratio of the velocity of light in the substance in question to the velocity of light in a vacuum.

Indicator—Substance which gives a visible change, usually of color, at a desired point in a chemical reaction.

Inoculate—To introduce a small amount of substance into a solution for observation of its effect such as growth or crystal formation.

Intensity, line-spectra—Intensity of the characteristic lines in the spectrum of an excited element.

Interfering substances—Materials which restrict or prevent a desired reaction, or contaminate the product.

Iodimetry—Measurement by consumption or reaction of iodine, usually in solution.

Ion—An atom or radical in solution carrying an integral electrical charge either positive (cation) or negative (anion).

Ion exchange—A process by which certain ions of given charge may be absorbed from solution and replaced in the solution by other ions of similar charge from the absorbent.

Isotropic—Having the same optical properties in all directions.

Kjeldahl determination—The chemical determination of nitrogen by which organic material is decomposed and its nitrogen converted to ammonia.

Latent energy—The energy (heat) required for a change of state at constant temperature, as the thawing of ice into water or the evaporation of water into steam.

Lattice—The uniform, three-dimensional arrangement of atoms or ion groups in a crystal.

Leach—To dissolve certain constituents from a larger mass by a slow washing operation.

Lignin—The major non-cellulose constituent of wood.

Macro—Large, as compared with micro (small).

Macro sample—One large enough to be weighed accurately on an analytical balance.

Macrochemical—On a normal scale of weights and volumes, as opposed to microchemical.

Membrane, porous—A barrier, usually thin, which permits the passage only of particles up to a certain size or of special nature.

Metabolism—The process by which food is used and wastes are formed in living matter.

Methemoglobinemia—Condition resulting from intake of excessive quantities of nitrate (blue babies).

Microbiological—Pertaining to very small living matter and its processes.

Microbiota—Microscopic plants and animals.

Microchemical—Chemical reactions on a very small scale.

Microorganism—Minute living matter.

Microscopic—Minute, very small; pertaining to a microscope.

Microscopy, chemical—Identification by microscopic observation of both chemical reactions and optical properties.

Moderator—Material used in a nuclear reactor to slow neutrons from the high energies at which they are released. Moderators are usually materials of high scattering cross-section, low atomic weight, and low absorption cross-section.

Molds—Filamentous fungi composed of many cells.

Monitoring, radioactive—Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in any area, as a safety measure for health protection.

Mother liquor—A solution substantially freed from undissolved material by filtration, decantation, or centrifuging.

MPC—Maximum permissible concentration. See Concentration, maximum permissible.

Nephelometry—Measurement of the light scattered by turbid liquids.

Nessler tubes—Matched cylinders with strain-free, clear-glass bottoms for comparing color density or opacity.

Nesslerization—A process for determining ammonia by its reaction with a mercury complex in alkaline solution.

Neutralization—Reaction of acid or alkali with the opposite reagent until the hydrogen ions are approximately equal to the hydroxyl ions in the solution.

Neutron activation analysis—Activation analysis using neutrons as the bombarding particle.

Nitrobacter—A genus of bacteria that oxidize nitrite to nitrate.

Nitrogen, organic—Nitrogen combined in organic molecules such as proteins, amines, and amino acids.

Nitrosomonas—A genus of bacteria that oxidize ammonia to nitrite.

Noncarbonate hardness—Hardness in water caused by chlorides, sulfates, and nitrates of calcium and magnesium.

Non-condensable—Gaseous matter not liquefied or dissolved under the existing conditions.

Non-referee—A method of test featuring speed and practical usefulness rather than high accuracy, which is used for process control and general information rather than in settlement of disputed test results.

Nuclide—A species of atoms with a given nuclear constitution, described by the number of protons Z, the total number of nucleons (protons plus neutrons) A, and (if necessary) the energy state. Usually only atoms capable of existing for a time of the order of 10^{-10} seconds or longer are considered to be nuclides.

Nutrient—Food.

Objective—The lens, or set of lenses, opposite the eyepiece in a microscope, which forms an image of the specimen.

Occlusion—An absorption process in which one material adheres strongly to another, usually a solid.

Opacity—The ratio of transmitted to incident light.

Orientation—The relative position of particles with respect to one another or to a reference point.

Orientation, crystal—The geometric relationship between the optical axes and an external reference.

Orifice—A restricted opening of known dimensions, usually for limitation or measurement of fluid flow.

Oxidation—Reaction of a substance with oxygen; loss of electrons by one element to another element.

Oxide—A chemical compound of a metal, or group of elements which act in common as a metal, with oxygen.

Oxide, basic—An oxide which forms hydroxide on reaction with water.

Oxygen demand—Oxygen required for oxidation of inorganic matter, or for stabilization of decomposable organic matter by aerobic bacterial action.

Pathogenic—Causing disease.

Pathogens—Pathogenic or disease-producing organisms.

Photometer—An instrument which measures the intensity of light or degree of light absorption.

Photon—The smallest unit of electromagnetic radiation. The term *photon* is most commonly used in reference to the particulate aspect of electromagnetic radiation. A photon of radiation frequency ν has an energy $h\nu$ and a momentum $h\nu/c$, where c is the velocity of light *in vacuo*.

Photosynthesis—Formation of chemical compounds in chlorophyll-containing tissues of plants exposed to light.

Physical tests—Determinations based on observation or measurement of physical properties.

Pollution—The result of discharging normally foreign material into ground or surface water.

Polyphosphate—Molecularly dehydrated orthophosphate.

Precipitate—An insoluble compound formed by chemical reaction between two or more normally soluble compounds in solution.

Priming—A carry-over of water with a sudden generation of steam, like the bumping which sometimes occurs when water is boiled in an open vessel.

Process, hot-flow—Addition of chemicals to hot water (200–212 F) passing slowly through a reaction tank.

Proliferation—The growth or production by multiplication of parts as in budding or cell division.

Protozoa—Microscopic, one-celled animals.

Purity, steam—An inverse measure of the nonwater (salts, solids, oil) constituents of steam.

Quality, steam—An inverse measure of the entrained, unevaporated moisture in steam.

Qualitative—Pertaining to the nature of component parts rather than to the amount of such components present.

Quench—To cool a material suddenly; halt abruptly a process or reaction.

Radiation—The emission and propagation of energy through space or through a material medium; also the energy so propagated.

Radioactivity—Spontaneous nuclear disintegration with emission of particulate or electromagnetic radiations.

Radionuclide—A radioactive nuclide.

Radiotracer—A tracer which is detected by means of its radioactivity.

Rainout—See Fallout.

Reactant—A substance which undergoes chemical change in contact with another substance.

Reactor—An assembly capable of sustaining a fission chain reaction.

Reconstitution—The restoration of the original characteristics of a specific water.

Recycled—Having flowed more than once through the same series of processes, pipes, or vessels.

Referee method—A method of test, usually of the highest accuracy available, which is used by mutual consent of contracting parties for establishing an acceptable value or quality in settlement of disputed test results.

Refractory—Heat-resistant; fusible with difficulty.

Regeneration—Restoration of water-treating power to an ion exchanger.

Rehydration—Recombination of water with a molecule of a chemical compound.

Reprecipitation—Dissolving a precipitate and then re-forming it by repetition of the previous procedure. (Used as a purification step in analysis.)

Residue—That which remains after a part has been separated or otherwise treated.

Resolving power—Capacity of an optical system to distinguish adjacent images.

Riparian—Of, pertaining to, or situated, or dwelling on the bank of a river or other body of water.

Rotifera—Minute, many-celled aquatic animals.

Runoff—Water flowing to a stream as a result of rainfall or melting snow.

Saprophytic organism—Any organism living on dead or decaying matter.

Scintillation—The production of light photons by the interaction of radiation with a suitable material.

Sedimentation—Gravitational settling of solid particles in a liquid system.

Self-absorption—The absorption of radiation particles or photons in the source itself.

Sequester—To form a stable, water-soluble complex.

Settling basin—Reservoir receiving water after chemical mixing to permit settling of the floc.

Shielding—Material used to prevent or reduce the passage of radiation particles or photons.

Slimes—Substances of viscous organic nature, frequently derived from microbiological growth.

Sludge blanket—A horizontal layer of solids hydrodynamically suspended within an enclosed body of water.

Softener, base-exchange—Water softener using an ion-exchange material.

Softener, lime-soda—Water softener using calcium hydrate and sodium carbonate as the reacting chemicals.

Solubility—Degree to which a substance will dissolve in a particular solvent.

Solutes—Substances which are dissolved in a liquid.

Solid solution—Mixture of two or more isomorphous substances in a single crystal form.

Species—A classification group having only minor details of difference among themselves.

Specific gravity—Ratio of the weight of any volume of a substance to the weight of an equal volume of water at 4 C.

Spectrograph—Instrument used for photographing a spectrum.

Spectrophotometry—Quantitative measurement with a photometer of the quantity of light of any particular wavelength absorbed by a colored solution, or emitted by a sample subjected to some form of excitation such as a flame, arc, or spark.

Spectroscope—Instrument used to view spectra emitted by bodies or substances.

Spectroscopy—Application of spectroscope to investigation of chemical composition.

Spore—A minute resistant body within bacteria, considered as a resting stage of bacteria.

Spray ponds—Ponds or basins in which cooling water is pumped and sprayed through nozzles, thereby reducing the water temperature by evaporation.

Stage, mechanical—The device used to manipulate a specimen under the lens of a microscope for examination.

Standardization—The manipulations necessary to bring a preparation to an established or known quality; for example, the preparation and adjustment of a standard solution in volumetric analysis.

Staphylococci—A genus of sphere-shaped, pus-forming bacteria.

Statistical uncertainty—That portion of the uncertainty of a radioactivity determination due to the random variation in the disintegration process.

Stoichiometric—The fixed weight ratios in which elements combine into chemical compounds.

Streptococci—A genus of sphere-shaped bacteria forming chains of cells; produce pus.

Strongly basic acid absorber—An ion-exchange resin in which the hydroxyl ion exhibits a very low exchange potential.

Sulfuritic material—Compounds of sulfur and iron represented by the formula FeS_2.

Superheater—A heat exchanger in which steam is heated above the equilibrium temperature corresponding to the operating pressure.

Supernatant—The liquid standing above a sediment or precipitate.

Survey meter—A portable instrument for detecting and measuring radiation under varied physical conditions.

Thermal shock—A stress-strain condition set up by a sudden change in temperature.

Titration—The determination of a constituent in a solution by the measured addition of a reactive, standard solution of known strength until the reaction is completed.

Titer—The concentration of a dissolved substance as determined by titration.

Tracer—A foreign substance mixed with or attached to a given substance to enable the distribution or location of the latter to be determined subsequently.

Tritium—A radioactive hydrogen isotope of atomic weight 3.

Tube bank—A large number of metal tubes set parallel and close together, as in a boiler.

Tube failure—Leakage or bursting of tubes resulting from corrosion, overheating, etc.

Tuberculation—A type of corrosion in which the corrosion products form blisters or nodules.

Turbidimeter—Instrument for determining the quantity of matter, in the form of fine suspended particles, in a liquid.

Turbidity—The reduction of transparency of a liquid due to the scattering of light by suspended particles.

Undulant fever—An irregular, relapsing fever, with swelling of joints, spleen, and rheumatic pains caused by Brucella organisms.

Vacuum deaeration—Equipment operating under vacuum to remove dissolved gases from water in the cold.

Vacuum-return system—A system whereby a vacuum is applied to the return pipes to facilitate the flow of condensate back to the boiler.

Viable—Living and potentially reproductive.

Virus—Submicroscopic infectious agent.

Volatile—Capable of being readily evaporated at relatively low temperature.

Volatilize—To convert into a gas or vapor.

Volumetric—Pertaining to measurement by volume, as opposed to gravimetric.

Waste—Any material which is of no further utility to the particular process involved.

Water of crystallization—Water which is an integral constituent of crystals or hydrated salts.

Water hammer—A sharp, hammer-like blow caused by the sudden stoppage of water flow in a long pressure conduit due to the rapid closing of valves. It may also be caused by the sudden collapse of steam bubbles upon entering cold water.

Weakly basic acid absorber—An ion-exchange resin in which the hydroxyl ion exhibits an exceedingly high exchange potential.

Weir boxes—Dams over which, or through a notch in which, the liquid carried by a horizontal open channel is constrained to flow for measurement.

Westphal—A type of weighing balance for determining the specific gravity of liquids and solids.

X-ray diffraction—A method of identifying crystalline substances by means of the scattering of X-rays by the constituent atoms to form characteristic patterns.

Yeasts—Broad group of fungal microorganisms causing fermentation.

Zeolite—A group of hydrated aluminum complex silicates, either natural or synthetic, with cation-exchange properties.

Zeolite, regenerating—A zeolite capable of being regenerated or converted to its original form by brine treatment.

Zeolite softeners—Equipment containing zeolite for softening water.

APPENDIX III

LIST OF ASTM SYMPOSIUMS AND TECHNICAL PAPERS ON INDUSTRIAL WATER

Committee D-19 has sponsored many symposia and discussions of various phases of the use of industrial water. The resulting papers have been published at several times and different places. For convenience in locating this literature relating to the subject of this Manual, a complete listing is given below.

1934

M. C. SCHWARTZ AND W. B. GURNEY, "The Determination of Traces of Dissolved Oxygen by the Winkler Method," *Proceedings*, Vol. 34, Part II, p. 796 (1934).

SHEPPARD T. POWELL, "Water as an Engineering and Industrial Material," ninth Edgar Marburg Lecture, presented at 1934 Annual Meeting of A.S.T.M. in Atlantic City, N. J., June, 1934; *Proceedings*, Vol. 34, Part II, p. 3 (1934).

1936

ALFRED H. WHITE, CLAUDE H. LELAND, AND DALE W. BUTTON, "Determination of Dissolved Oxygen in Boiler Feed Water," *Proceedings*, Vol. 36, Part II, p. 697 (1936).

W. C. SCHROEDER, A. A. BERK, AND EVERETT P. PARTRIDGE, "Effect of Solution Composition on the Failure of Boiler Steel Under Static Stress at 250 C.," *Proceedings*, Vol. 36, Part II, p. 721 (1936).

R. M. HITCHENS AND R. W. TOWNE, "The Rate of Reaction of Sodium Sulfite with Oxygen Dissolved in Water," *Proceedings*, Vol. 36, Part II, p. 687 (1936).

W. C. SCHROEDER, A. A. BERK, AND EVERETT P. PARTRIDGE, "The Use of Solubility Data to Control the Deposition of Sodium Sulfate or Its Complex Salts in Boiler Waters," *Proceedings*, Vol. 36, Part II, p. 755 (1936).

1937

R. T. SHEEN AND C. A. NOLL, "Determination of Hardness in Water by Direct Titration." *Proceedings*, Vol. 37, Part II, p. 609 (1937).

EVERETT P. PARTRIDGE, "Some Applications of the Polarizing Microscope to Water-Conditioning Problems," *Proceedings*, Vol. 37, Part II, p. 600 (1937).

T. H. DAUGHERTY, "Technique in the Determination of Dissolved Oxygen," *Proceedings*, Vol. 37, Part II, p. 615 (1937).

1938

BAKER WINGFIELD, W. H. GOSS, WALTER J. HAMER, AND S. F. ACREE, "The Need for pH Standards," ASTM BULLETIN, No. 90, January, p. 15 (1938).

FREDERICK G. STRAUB AND T. A. BRADBURY, "A Method for the Embrittlement Testing of Boiler Waters," *Proceedings*, Vol. 38, Part II, p. 602 (1938).

J. B. ROMER, W. W. CERNA, AND H. F. HANNUM, "The Estimation of Sodium in Water Supplies by an Indirect Method," *Proceedings*, Vol. 38, Part II, p. 638 (1938).

P. G. BIRD, "Removal of Dissolved Salts from Water by Exchange Filters," *Proceedings*, Vol. 38, Part II, p. 631 (1938).

1939

R. C. ULMER, "Determination by the Evaporation Method of Small Amounts of Dissolved Solids in Water Such as Condensed Steam from Boilers," *Proceedings*, Vol. 39, p. 1221 (1939).

A. M. AMOROSI AND J. R. MCDERMET, "The Calculation of the Distribution of Carbon Dioxide Between Water and Steam," *Proceedings*, Vol. 39, p. 1204 (1939).

D. S. MCKINNEY, "The Calculation of Equilibria in Dilute Water Solutions," *Proceedings*, Vol. 39, p. 1191 (1939).

RICHARD C. COREY AND THOMAS J. FINNEGAN, "The pH Dissolved Iron Concentration and Solid Product Resulting from the Reaction Between Iron and Pure Water at Room Temperature," *Proceedings*, Vol. 39, p. 1242 (1939).

1940

Symposium on Problems in the Classification of Natural Water Intended for Industrial Use, *Proceedings*, Vol. 40, pp. 1305 to 1353 (1940):

Robert C. Adams, "Reporting the Results of Water Analysis."

V. V. Kendall, "A Review of Data on the Relationship of Corrosivity of Water to Its Chemical Analysis."

Everett P. Partridge and G. B. Hatch, "Measuring the Scale-Forming and Corrosive Tendencies of Water by Short-Time Tests."

J. H. Walker, "A Method of Measuring Corrosiveness."

1941

Boiler Feedwater Studies. Report of Joint Research Committee, ASTM BULLETIN, No. 111, August, p. 56 (1941).

45-1

Symposium on Problems and Practice in Determining Steam Purity by Conductivity Methods, *Proceedings*, Vol. 41, pp. 1261 to 1338 (1941):

A. R. Belyea and A. H. Moody, "The Sampling of Steam and Boiler Water."

S. F. Whirl and W. A. Lower, "Experimental Methods for Determining Conductivity Corrections for Dissolved Gases in Steam Condensate."

D. S. McKinney, "Calculation of Corrections to Conductivity Measurements for Dissolved Gases."

P. B. Place, "The Degasification of Steam Samples for Conductivity Tests."

A. R. Mumford, "A New Type of Conductivity Apparatus for Use with Boiler Waters and Steam Samples."

C. E. Kaufman, "Conductivity Cells and Electrical Measuring Instruments."

1942

Round-Table Discussion on the Solvent Action of Water Vapor at High Temperature and Pressure, *Proceedings*, Vol. 42, pp. 977 to 1020 (1942):

George W. Morey, "Solubility of Solids in Water Vapor."

1943

ROBERT C. ADAMS, ROBERT E. BARNETT and DANIEL E. KELLER, JR., "Field and Laboratory Determination of Dissolved Oxygen," *Proceedings*, Vol. 43, p. 1240 (1943).

R. C. ULMER, J. M. REYNAR, AND J. M. DECKER, "Applicability of the Schwartz-Gurney Method for Determining Dissolved Oxygen in Boiler Feedwater and Modification of the Method to Make It Especially Applicable in the Presence of Such Impurities as Are Encountered in Power Plants," *Proceedings* Vol. 43, p. 1258 (1943).

Symposium on the Identification of Water-Formed Deposits, Scales, and Corrosion Products by Physico-Chemical Methods, *Proceedings*, Vol. 43, pp. 1269 to 1308 (1943):

C. E. Imhoff and L. A. Burkardt, "X-ray Diffraction Methods in the Study of Power Plant Deposits."

Everett P. Partridge, R. K. Scott, and P. H. Morrison, "Diagnosis of Water Problems at Limbo Station."

J. A. Holmes and A. O. Walker, "The Interpretation of Analyses and Problems Encountered in Water Deposits."

1944

Boiler Feedwater Studies Joint Research Committee, *Proceedings*, Vol. 44, p. 504 (1944).

Round-Table Discussion on Organizing the Classification of Industrial Waters, *Proceedings*, Vol. 44, pp. 1051 to 1082 (1944):

W. D. Collins, "Typical Water Analyses for Classification with Reference to Industrial Use."

Lewis B. Miller, "The Use of Selected Waters in Pulp and Paper Manufacture."

R. E. Hall, "Treatment of Various Types of Waters for Operating Pressures Above 400 psi."

J. A. Holmes, "Classification of Feedwater for Boilers Operating Between 100–400 psi."

1947

Round Table Discussion on Water-Formed Deposits, *Proceedings*, Vol. 47, pp. 1088 to 1117 (1947):

Michael Fleischer, "Some Problems in Nomenclature in Mineralogy and Inorganic Chemistry."

Alton Gabriel, Howard Jaffe, and Maurice Peterson, "Use of the Spectroscope in the Determination of the Constituents of Boiler Scale and Related Compounds."

J. F. SEBALD, "An Evaluation of Test Methods for the Oxygen in Deaerated Boiler Feedwater, "*Proceedings*, Vol. 47, p. 1121 (1947).

1948

Panel Discussion on Corrosion of Pressure Vessels, *Proceedings*, Vol. 48, pp. 897 to 926 (1948):

R. B. Donworth, "Station Design and Composition of Materials as Factors in Boiler Corrosion."

Richard C. Corey, "Corrosion of High-Pressure Steam Generators: Status of Our Knowledge of the Effect of Copper and Iron Oxide Deposits in Steam Generating Tubes."

1949

Round Table Discussion on Standards for Water-Borne Wastes, ASTM BULLETIN, No. 16, December (1949):

George D. Beal and S. A. Braley, "Analysis of Water-Borne Industrial Wastes: The Need for Uniformity in Methods of Analysis and Reporting."

Charles F. Hauck, "Gaging and Sampling Water-Borne Industrial Wastes."

1950

Max Hecht, "Industrial Water and Water-Borne Industrial Waste," ASTM BULLETIN, No. 168, September, p. 31 (1950).

1951

Symposium on Flame Photometry, STP 116, Am. Soc. Testing Mats. (1951): R. K. Scott, W. M. Marcy, and J. J. Hronas, "The Flame Photometer in the Analysis of Water and Water-Formed Deposits."

1952

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water, *STP 130*, Am. Soc. Testing Mats. (1952):

M. F. Madarasz, "Automatic Sampling of Industrial Water and Industrial Waste Water."

Robert Rosenthal, "Some Practical Aspects of the Measurement of pH, Electrical Con-

ductivity and Oxidation-Reduction Potential of Industrial Water."

A. E. Griffin, "Continuous Recording of Chlorine Residuals and Determination of Chlorine Demand."

F. C. Staats, "Measurement of Color, Turbidity, Hardness, and Silica in Industrial Waters."

J. K. Rummel, "Continuous Measurement of Dissolved Gases in Water."

1955

Symposium on High-Purity Water Corrosion, *STP 179*, Am. Soc. Testing Mats. (1955):

F. N. Alquist, "The Preparation and Maintenance of High-Purity Water."

H. W. Huntley and S. Untermyer, "The Use of Water in Atomic Reactors."

Donald M. Wroughton, James M. Seamon, and Paul E. Brown, "Influence of Water Composition on Corrosion in High-Temperature, High-Purity Water."

A. H. Roebuck, "Effect of Material Composition in High-Temperature Water Corrosion."

R. U. Blaser and J. J. Owens, "Special Corrosion Study of Carbon and Low Alloy Steels."

1956

Symposium on Steam Quality, *STP 192*, Am. Soc. Testing Mats. (1956):

W. B. Gurney, "Measurement and Purification of Steam to 0.01 ppm Total Dissolved Solids."

E. E. Coulter and T. M. Campbell, Jr., "Steam Purity Determination by Tracer Techniques."

R. O. Parker and R. J. Ziobro, "Comments on Corrections to Steam Conductivity Measurements."

A. B. Sisson, F. G. Straub, and R. W. Lane, "Construction and Operation of Larson-Lane Steam Purity and Condensate Analyzers."

Symposium on Industrial Water and Industrial Waste Water, *STP 207*, Am. Soc. Testing Mats (1956):

Claude K. Rice, "Three is a Vital Number." (The relations of the Public, Government and Industry in the measurement and abatement of stream pollution.)

T. C. Wilson, "Industrial Waste Problems in Southern California."

Carl B. Johnston, "Water Pollution Control in the Los Angeles Area."

Robert C. Adams, "Committee D-19: The First Quarter Century."

O. M. Elliott, "Sea Water Purification."

J. K. Rice, "The Use of Organic Flocculants and Flocculating Aids in the Treatment of Industrial Water and Industrial Waste Water."

1957

Everett P. Partridge, "Your Most Important Raw Material—Water," thirty-first Edgar Marburg Lecture, presented at 1957 Annual Meeting of ASTM in Atlantic City, N. J., June, 1957.

Symposium on Determination of Dissolved Oxygen in Water, *STP 219*, Am. Soc. Testing Mats. (1957):

K. G. Stoffer, "A Study of the Accuracy of Methods of Testing for Dissolved Oxygen in High-Purity Water."

W. W. Eckenfelder, Jr. and Conrad T. Burris, "Polarographic Measurement of Dissolved Oxygen."

Thomas Finnegan and Ross C. Tucker, "The Beckman Dissolved Oxygen Analyzer."

A. J. Ristaino and A.A. Dominick, "Evaluation of Hartmann and Braun Dissolved Oxygen Recorder for Boiler Feedwater."

H. A. Grabowski, "Determination of Dissolved Oxygen by Means of a Cambridge Analyzer."

1958

Symposium on Radioactivity in Industrial Water and Industrial Waste Water, *STP 235*, Am. Soc. Testing Mats. (1958):

A. R. Belyea, "Introduction."

A. Louis Medin, "Radioactivity and Purity Control of APPR Primary Water."

S. F. Whirl and J. A. Tash, "Radioactive Waste Processing Control, Shippingport Atomic Power Station."

C. J. Munter, "Test Methods for Radioactivity Hazards in Industrial Waters."

B. Kahn, D. W. Moeller, T. H. Handley, and S. A. Reynolds, "Analysis for Radionuclides in Aqueous Wastes from an "Atomic" Plant."

D. L. Reid, "Analysis of Environmental Samples for Radionuclides."

L. R. Setter, G. R. Hagee, and C. P. Straub, "Analysis of Radioactivity in Surface Waters."

J. M. Seamon, "Summation."

L. R. Setter, G. R. Hagee, and C. P. Straub, "Analysis of Radioactivity in Surface Waters," ASTM BULLETIN, No. 227, January, p. 35 (1958).

1959

Symposium on Identification of Water-Formed Deposits, *STP 256*, Am. Soc. Testing Mats. (1959):

J. K. Rice, "Deposit Identification—First Step Toward Understanding a Water Problem."

C. H. Anderson, "The Application of Emission Spectroscopy to the Analysis of Water-Formed Deposits."

C. M. Maddin and R. B. Rosene, "Identification by Instrumental Methods of Chemical Compounds in Water-Formed Deposits."

E. A. Gulbransen and T. P. Copan, "Electron Microscopy and Electron Diffraction Studies of Oxide Films on Iron in Water and Oxygen Atmospheres."

J. V. Smith, "Correlation of Elemental Analysis and Phase Identification as Viewed by a Mineralogist."

R. K. Scott, "Summary."