Designation: G 102 – 89 (Reapproved 1999)

Standard Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements[1]

This standard is issued under the fixed designation G 102; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice is intended to provide guidance in converting the results of electrochemical measurements to rates of uniform corrosion. Calculation methods for converting corrosion current density values to either mass loss rates or average penetration rates are given for most engineering alloys. In addition, some guidelines for converting polarization resistance values to corrosion rates are provided.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2776 Test Methods for Corrosivity of Water in the Absence of Heat Transfer (Electrical Methods)[2]

G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens[3]

G 5 Reference Test Method for Making Potentiostatic and Potentiodynamic Anodic Polarization Measurements[3]

G 59 Practice for Conducting Potentiodynamic Polarization Resistance Measurements[3]

3. Significance and Use

3.1 Electrochemical corrosion rate measurements often provide results in terms of electrical current. Although the conversion of these current values into mass loss rates or penetration rates is based on Faraday's Law, the calculations can be complicated for alloys and metals with elements having multiple valence values. This practice is intended to provide guidance in calculating mass loss and penetration rates for such alloys. Some typical values of equivalent weights for a variety of metals and alloys are provided.

3.2 Electrochemical corrosion rate measurements may provide results in terms of electrical resistance. The conversion of these results to either mass loss or penetration rates requires additional electrochemical information. Some approaches for estimating this information are given.

3.3 Use of this practice will aid in producing more consistent corrosion rate data from electrochemical results. This will make results from different studies more comparable and minimize calculation errors that may occur in transforming electrochemical results to corrosion rate values.

4. Corrosion Current Density

4.1 Corrosion current values may be obtained from galvanic cells and polarization measurements, including Tafel extrapolations or polarization resistance measurements. (See Reference Test Method G 5 and Practice G 59 for examples.) The first step is to convert the measured or estimated current value to current density. This is accomplished by dividing the total current by the geometric area of the electrode exposed to the solution. It is assumed that the current distributes uniformly across the area used in this calculation. In the case of galvanic couples, the exposed area of the anodic specimen should be used. This calculation may be expressed as follows:

$$i_{cor} = \frac{I_{cor}}{A} \tag{1}$$

where:

i_{cor} = corrosion current density, μA/cm^2,
I_{cor} = total anodic current, μA, and
A = exposed specimen area, cm^2.

Other units may be used in this calculation. In some computerized polarization equipment, this calculation is made automatically after the specimen area is programmed into the computer. A sample calculation is given in Appendix X1.

4.2 *Equivalent Weight*—Equivalent weight, EW, may be thought of as the mass of metal in grams that will be oxidized by the passage of one Faraday (96 489 ± 2 C (amp-sec)) of electric charge.

NOTE 1—The value of EW is not dependent on the unit system chosen and so may be considered dimensionless.

For pure elements, the equivalent weight is given by:

$$EW = \frac{W}{n} \tag{2}$$

where:

W = the atomic weight of the element, and
n = the number of electrons required to oxidize an atom of the element in the corrosion process, that is, the valence of the element.

4.3 For alloys, the equivalent weight is more complex. It is usually assumed that the process of oxidation is uniform and

---

[1] This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metalsand is the direct responsibility of Subcommittee G01.11 on Electrochemical Measurements in Corrosion Testing.

Current edition approved Feb. 24, 1989. Published May 1989. Originally published as G 102– 89. Last previous edition G 102– 89 (1994)$^{\epsilon 1}$.

[2] *Discontinued*—See *1990 Annual Book of ASTM Standards,* Vol 03.02.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

does not occur selectively to any component of the alloy. If this is not true, then the calculation approach will need to be adjusted to reflect the observed mechanism. In addition, some rationale must be adopted for assigning values of *n* to the elements in the alloy because many elements exhibit more than one valence value.

4.4 To calculate the alloy equivalent weight, the following approach may be used. Consider a unit mass of alloy oxidized. The electron equivalent for 1 g of an alloy, *Q* is then:

$$Q = \Sigma \frac{\mathrm{nifi}}{\mathrm{Wi}} \tag{3}$$

where:
fi = the mass fraction of the i^{th} element in the alloy,
Wi = the atomic weight of the i^{th} element in the alloy, and
ni = the valence of the i^{th} element of the alloy.

Therefore, the alloy equivalent weight, *EW*, is the reciprocal of this quantity:

$$EW = \frac{1}{\Sigma \frac{\mathrm{nifi}}{\mathrm{Wi}}} \tag{4}$$

Normally only elements above 1 mass percent in the alloy are included in the calculation. In cases where the actual analysis of an alloy is not available, it is conventional to use the mid-range of the composition specification for each element, unless a better basis is available. A sample calculation is given in Appendix X2 **(1)**.[4]

4.5 Valence assignments for elements that exhibit multiple valences can create uncertainty. It is best if an independent technique can be used to establish the proper valence for each alloying element. Sometimes it is possible to analyze the corrosion products and use those results to establish the proper valence. Another approach is to measure or estimate the electrode potential of the corroding surface. Equilibrium diagrams showing regions of stability of various phases as a function of potential and pH may be created from thermodynamic data. These diagrams are known as Potential-pH (Pourbaix) diagrams and have been published by several authors **(2, 3)**. The appropriate diagrams for the various alloying elements can be consulted to estimate the stable valence of each element at the temperature, potential, and pH of the contacting electrolyte that existed during the test.

NOTE 2—Some of the older publications used inaccurate thermodynamic data to construct the diagrams and consequently they are in error.

4.6 Some typical values of EW for a variety of metals and alloys are given in Table 1.

TABLE 1 Equivalent Weight Values for a Variety of Metals and Alloys

Common Designation	UNS	Elements w/Constant Valence	Lowest		Second		Third		Fourth	
			Variable Valence	Equivalent Weight	Variable Valence	Equivalent Weight	Element/ Valence	Equivalent Weight	Element/ Valence	Equivalent Weight
Aluminum Alloys:										
AA1100[A]	A91100	Al/3		8.99						
AA2024	A92024	Al/3, Mg/2	Cu/1	9.38	Cu/2	9.32				
AA2219	A92219	Al/3	Cu/1	9.51	Cu/2	9.42				
AA3003	A93003	Al/3	Mn/2	9.07	Mn/4	9.03	Mn 7	8.98		
AA3004	A93004	Al/3, Mg/2	Mn/2	9.09	Mn/4	9.06	Mn 7	9.00		
AA5005	A95005	Al/3, Mg/2		9.01						
AA5050	A95050	Al/3, Mg/2		9.03						
AA5052	A95052	Al/3, Mg/2		9.05						
AA5083	A95083	Al/3, Mg/2		9.09						
AA5086	A95086	Al/3, Mg/2		9.09						
AA5154	A95154	Al/3, Mg/2		9.08						
AA5454	A95454	Al/3, Mg/2		9.06						
AA5456	A95456	Al/3, Mg/2		9.11						
AA6061	A96061	Al/3, Mg/2		9.01						
AA6070	A96070	Al/3, Mg/2, Si/4		8.98						
AA6101	A96161	Al/3		8.99						
AA7072	A97072	Al/3, Zn/2		9.06						
AA7075	A97075	Al/3, Zn/2, Mg/2	Cu/1	9.58	Cu/2	9.55				
AA7079	A97079	Al/3, Zn/2, Mg/2		9.37						
AA7178	A97178	Al/3, Zn/2, Mg/2	Cu/1	9.71	Cu/2	9.68				
Copper Alloys:										
CDA110	C11000		Cu/1	63.55	Cu/2	31.77				
CDA220	C22000	Zn/2	Cu/1	58.07	Cu/2	31.86				
CDA230	C23000	Zn/2	Cu/1	55.65	Cu/2	31.91				
CDA260	C26000	Zn/2	Cu/1	49.51	Cu/2	32.04				
CDA280	C28000	Zn/2	Cu/1	46.44	Cu/2	32.11				
CDA444	C44300	Zn/2	Cu/1, Sn/2	50.42	Cu/1, Sn/4	50.00	Cu/2, Sn/4	32.00		
CDA687	C68700	Zn/2, Al/3	Cu/1	48.03	Cu/2	30.29				
CDA608	C60800	Al/3	Cu/1	47.114	Cu/2	27.76				
CDA510	C51000		Cu/1, Sn/2	63.32	Cu/1, Sn/4	60.11	Cu/2, Sn/4	31.66		
CDA524	C52400		Cu/1, Sn/2	63.10	Cu/1, Sn/4	57.04	Cu/2, Sn/4	31.55		

---

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

TABLE 1 *Continued*

Common Designation	UNS	Elements w/Constant Valence	Lowest		Second		Third		Fourth	
			Variable Valence	Equivalent Weight	Variable Valence	Equivalent Weight	Element/ Valence	Equivalent Weight	Element/ Valence	Equivalent Weight
CDA655	C65500	Si/4	Cu/1	50.21	Cu/2	28.51				
CDA706	C70600	Ni/2	Cu/1	56.92	Cu/2	31.51				
CDA715	C71500	Ni/2	Cu/1	46.69	Cu/2	30.98				
CDA752	C75200	Ni/2, Zn/2	Cu/1	46.38	Cu/2	31.46				
Stainless Steels:										
304	S30400	Ni/2	Fe/2, Cr/3	25.12	Fe/3, Cr/3	18.99	Fe/3, Cr/6	15.72		
321	S32100	Ni/2	Fe/2, Cr/3	25.13	Fe/3, Cr/3	19.08	Fe/3, Cr/6	15.78		
309	S30900	Ni/2	Fe/2, Cr/3	24.62	Fe/3, Cr/3	19.24	Fe/3, Cr/6	15.33		
310	S31000	Ni/2	Fe/2, Cr/3	24.44	Fe/3, Cr/3	19.73	Fe/3, Cr/6	15.36		
316	S31600	Ni/2	Fe/2, Cr/3, Mo/3	25.50	Fe/2, Cr/3, Mo/4	25.33	Fe/3, Cr/6, Mo/6	19.14	Fe/3, Cr/6, Mo/6	16.111
317	S31700	Ni/2	Fe/2, Cr/3, Mo/3	25.26	Fe/2, Cr/3, Mo/4	25.03	Fe/3, Cr/3, Mo/6	19.15	Fe/3, Cr/6, Mo/6	15.82
410	S41000		Fe/2, Cr/3	25.94	Fe/3, Cr/3	18.45	Fe/3, Cr/6	16.28		
430	S43000		Fe/2, Cr/3	25.30	Fe/3, Cr/3	18.38	Fe/3, Cr/6	15.58		
446	S44600		Fe/2, Cr/3	24.22	Fe/3, Cr/3	18.28	Fe/3, Cr/6	14.46		
20CB3[A]	N08020	Ni/2	Fe/2, Cr/3, Mo/3, Cu/1	23.98	Fe/2, Cr/3, Mo/ 4, Cu/1	23.83	Fe/3, Cr/3, Mo/ 6, Cu/2	18.88	Fe/3, Cr/6, Mo/6, Cu/2	15.50
Nickel Alloys:										
200	N02200		NI/2	29.36	Ni/3	19.57				
400	N04400	Ni/2	Cu/1	35.82	Cu/2	30.12				
600	N06600	Ni/2	Fe/2, Cr/3	26.41	Fe/3, Cr/3	25.44	Fe/3, Cr/6	20.73		
800	N08800	Ni/2	Fe/2, Cr/3	25.10	Fe/3, Cr/3	20.76	Fe/3, Cr/6	16.59		
825	N08825	Ni/2	Fe/2, Cr/3, Mo/3, Cu/1	25.52	Fe/2, Cr/3, Mo/ 4, Cu/1	25.32	Fe/3, Cr/3, Mo/ 6, Cu/2	21.70	Fe/3, Cr/6, Mo/6, Cu/2	17.10
B	N10001	Ni/2	Mo/3, Fe/2	30.05	Mo/4, Fe/2	27.50	Mo/6, Fe/2	23.52	Mo/6, Fe/3	23.23
C-22[B]	N06022	Ni/2	Fe/2, Cr/3, Mo/3, W/4	26.04	Fe/2, Cr/3, Mo/ 4, W/4	25.12	Fe/2, Cr/3, Mo/ 6, W/6	23.28	Fe/3, Cr/6, Mo/6, W/6	17.88
C-276	N10276	Ni/2	Fe/2, Cr/3, Mo/3, W/4	27.09	Cr/3, Mo/4	25.90	Fe/2, Cr/3, Mo/ 6, W/6	23.63	Fe/3, Cr/6, Mo/6, W/6	19.14
G	N06007	Ni/2	(1)	25.46	(2)	22.22	(3)	22.04	(4)	17.03
Carbon Steel:			Fe/2	27.92	Fe/3	18.62				
(1) = Fe/2, Cr/3, Mo/3, Cu/1, Nb/4, Mn/2			(3) = Fe/3, Cr/3, Mo/6, Cu/2, Nb/5, Mn/2							
(2) = Fe/2, Cr/3, Mo/4, Cu/2, Nb/5, Mn/2			(4) = Fe/3, Cr/6, Mo/6, Cu/2, Nb/5, Mn/4							
Other Metals:										
Mg	M14142	Mg/2		12.15						
Mo	R03600		Mo/3	31.98	Mo/4	23.98	Mo/6	15.99		
Ag	P07016		Ag/1	107.87	Ag/2	53.93				
Ta	R05210	Ta/5		36.19						
Sn	L13002		Sn/2	59.34	Sn/4	29.67				
Ti	R50400		Ti/2	23.95	Ti/3	15.97	Ti/4	11.98		
Zn	Z19001	Zn/2		32.68						
Zr	R60701	Zr/4		22.80						
Pb	L50045		Pb/2	103.59	Pb/4	51.80				

[A] Registered trademark Carpenter Technology.

[B] Registered trademark Haynes International.

NOTE 1—Alloying elements at concentrations below 1 % by mass were not included in the calculation, for example, they were considered part of the basis metal.

NOTE 2—Mid-range values were assumed for concentrations of alloying elements.

NOTE 3—Only consistent valence groupings were used.

NOTE 4—(Eq 4) was used to make these calculations.

4.7 *Calculation of Corrosion Rate*—Faraday's Law can be used to calculate the corrosion rate, either in terms of penetration rate (CR) or mass loss rate (MR) **(4)**:

$$CR = K_1 \frac{i_{cor}}{\rho} EW \tag{5}$$

$$MR = K_2 \, i_{cor} \, EW \tag{6}$$

where:

CR is given in mm/yr, i_{cor} in µA/cm^2,

K_1 = 3.27×10^{-3}, mm g/µA cm yr (Note 3),
ρ = density in g/cm^3, (see Practice G 1 for density values for many metals and alloys used in corrosion testing),
MR = g/m^{2}d, and
K_2 = 8.954×10^{-3}, g cm^2/µA m^2 d (Note 3).

NOTE 3—*EW* is considered dimensionless in these calculations.

Other values for K_1 and K_2 for different unit systems are given in Table 2.

4.8 Errors that may arise from this procedure are discussed below.

4.8.1 Assignment of incorrect valence values may cause serious errors **(5)**.

4.8.2 The calculation of penetration or mass loss from electrochemical measurements, as described in this standard, assumes that uniform corrosion is occurring. In cases where non-uniform corrosion processes are occurring, the use of these

TABLE 2 Values of Constants for Use in Faraday's Equation Rate

A

Penetration Rate Unit (CR)	I_{cor} Unit	ρ Unit	K_1	Units of K_1[A]
mpy	μA/cm^2	g/cm^3	0.1288	mpy g/μA cm
mm/yr[B]	A/m^2[B]	kg/m^3[B]	327.2	mm kg/A m y
mm/yr[B]	μA/cm^2	g/cm^3	3.27×10^{-3}	mm g/μA cm y

B

Mass Loss Rate Unit	I_{cor} Unit	K_2	Units of K_2[A]
g/m^{2}d[B]	A/m^2[B]	0.8953	g/Ad
mg/dm^{2}d (mdd)	μA/cm^2	0.0895	mg cm^2/μA dm^2 d
mg/dm^{2}d (mdd)	A/m^2[B]	8.953×10^{-3}	mg m^2/A dm^2 d

[A] EW is assumed to be dimensionless.

[B] SI unit.

methods may result in a substantial underestimation of the true values.

4.8.3 Alloys that include large quantities of metalloids or oxidized materials may not be able to be treated by the above procedure.

4.8.4 Corrosion rates calculated by the method above where abrasion or erosion is a significant contributor to the metal loss process may yield significant underestimation of the metal loss rate.

5. Polarization Resistance

5.1 Polarization resistance values may be approximated from either potentiodynamic measurements near the corrosion potential (see Practice G 59) or stepwise potentiostatic polarization using a single small potential step, ΔE, usually either 10 mV or − 10 mV, (see Test Method D 2776). Values of ±5 and ±20 mV are also commonly used. In this case, the specimen current, ΔI, is measured after steady state occurs, and $\Delta E/\Delta I$ is calculated. Potentiodynamic measurements yield curves of I versus E and the reciprocal of the slope of the curve (dE/dI) at the corrosion potential is measured. In most programmable potentiodynamic polarization equipment, the current is converted to current density automatically and the resulting plot is of i versus E. In this case, the polarization resistance is given by dE/di at the corrosion potential and 5.2 is not applicable.

5.2 It is necessary to multiply the dE/dI or ΔE/ΔI value calculated above by the exposed specimen geometric area to obtain the polarization resistance. This is equivalent to the calculation shown in 4.1 for current density.

5.3 The Stern-Geary constant B must be estimated or calculated to convert polarization resistance values to corrosion current density **(6, 8)**.

5.3.1 Calculate Stern-Geary constants from known Tafel slopes where both cathodic and anodic reactions are activation controlled, that is, there are distinct linear regions near the corrosion potential on an E log i plot:

$$B = \frac{ba\, bc}{2.303\,(ba + bc)} \tag{7}$$

where:

ba = slope of the anodic Tafel reaction, when plotted on base 10 logarithmic paper in V/decade,

bc = slope of the cathodic Tafel reaction when plotted on base 10 logarithmic paper in V/decade, and

B = Stern-Geary constant, V.

5.3.2 In cases where one of the reactions is purely diffusion controlled, the Stern-Geary constant may be calculated:

$$B = \frac{b}{2.303} \tag{8}$$

where:

b = the activation controlled Tafel slope in V/decade.

5.3.3 It should be noted in this case that the corrosion current density will be equal to the diffusion limited current density. A sample calculation is given in Appendix X4.

5.3.4 Cases where both activation and diffusion effects are similar in magnitude are known as mixed control. The reaction under mixed control will have an apparently larger b value than predicted for an activation control, and a plot of E versus log I will tend to curve to an asymptote parallel to the potential axis. The estimation of a B value for situations involving mixed control requires more information in general and is beyond the scope of this standard. In general, Eq 7 and Eq 8 may be used, and the corrosion rate calculated by these two approximations may be used as lower and upper limits of the true rate.

NOTE 4—Electrodes exhibiting stable passivity will behave as if the anodic reaction were diffusion limited, except that the passive current density is not affected by agitation.

5.3.5 It is possible to estimate b_a and b_c from the deviation from linearity of polarization curves in the 20–50 mV region around the corrosion potential. Several approaches have been proposed based on analyses of electrode kinetic models. See Refs **(9-11)** for more information.

5.3.6 In cases where the reaction mechanism is known in detail, the Tafel slopes may be estimated from the rate controlling step in the mechanism of the reaction. In general, Tafel slopes are given by **(12)**:

$$b = \frac{KRT}{nF} \tag{9}$$

where:

K = a constant,

R = the perfect gas constant,

T = the absolute temperature,

n = the number of electrons involved in the reaction step, and

F = Faraday's constant.

At 25°C, ($\frac{RT}{2.303\,F}$) is 59.2 mV/decade. For simple one electron reactions, K is usually found to be 2.0.

5.3.7 In cases where the Tafel slopes cannot be obtained from any of the methods described above, it may be necessary to determine the Stern-Geary constant experimentally by measuring mass loss and polarization resistance values.

5.4 The corrosion current density may be calculated from the polarization resistance and the Stern-Geary constant as follows:

$$i_{cor} = \frac{B}{R_p} \tag{10}$$

The corrosion rate may then be calculated from the corrosion current, as described in Section 4. A sample calculation is given in Appendix X5.

5.5 There are several sources of errors in polarization resistance measurements:

5.5.1 Solution resistivity effects increase the apparent polarization resistance, whether measured by the potentiostatic or potentiodynamic methods **(13)**. The effect of solution resistance is a function of the cell geometry, but the following expression may be used to approximate its magnitude.

$$R_p = R_a - \rho l \tag{11}$$

where:

R_a = the apparent polarization resistance, ohm cm^2,
ρ = the electrolyte resistivity in ohm cm,
l = the distance between the specimen electrode and the Luggin probe tip, or the reference electrode in cm, and
R_p = the true polarization resistance in ohm cm^2.

Significant solution resistivity effects cause the corrosion rate to be underestimated. A sample calculation is given in Appendix X6.

5.5.2 Potentiodynamic techniques introduce an additional error from capacitative charging effects. In this case, the magnitude of the error is proportional to scan rate. The error is illustrated by (Eq 12):

$$I_{\text{total}} = I_f + c\left(\frac{dV}{dt}\right) \tag{12}$$

where:

I_{total} = the cell current,
I_f = the Faradaic current associated with anodic and cathodic processes,
c = the electrode capacitance, and
dV/dt = the scan rate.

The capacitance charging effect will cause the calculated polarization resistance to be in error. Generally, this error is small with modest scan rates **(14)**.

5.5.3 Corroding electrodes may be the site for other electrochemical reactions. In cases where the corrosion potential is within 50 to 100 mV of the reversible potential of the corroding electrode, the electrochemical reactions will occur simultaneously on the electrode surface. This will cause either the anodic or cathodic *b* value to appear smaller than the corrosion reaction above. Consequently, the Stern-Geary constant *B* will be inflated and the predicted corrosion current will be overestimated **(15)**. In this case, the concentration of the corroding electrode ions is generally of the same magnitude or higher than other ions participating in the corrosion process in the electrolyte surrounding the electrode. Other redox couples that do not necessarily participate in the corrosion reaction may have similar effects. This is especially true for metals exhibiting passive behavior.

6. Keywords

6.1 corrosion current; corrosion rate; electrochemical; equivalent weight; polarization resistance; Tafel slopes

APPENDIXES

(Nonmandatory Information)

X1. SAMPLE CALCULATION—CORROSION CURRENT DENSITY

X1.1 *Data:*

X1.1.1 *Corrosion Current*—27.0 µA.
X1.1.2 *Specimen Size*—round anode area exposed.
X1.1.3 *Diameter*—1.30 cm.

X1.2 *Calculation*—See (Eq 1) in text:

$$i_{\text{cor}} = \frac{27.0}{(1.30)^2 \frac{\pi}{4}} = \frac{27.0}{1.32} = 20.3\ \mu A/\text{cm}^2 \tag{X1.1}$$

X2. SAMPLE CALCULATION—ALLOY EQUIVALENT WEIGHT

X2.1 *Data:*

X2.1.1 *Alloy*—UNS S31600, actual composition not available.

X2.1.2 *Corrosion Potential*—300 mV versus SCE 1N sulfuric acid.

X2.2 *Assumptions:*

X2.2.1 *Composition:*
X2.2.1.1 *Chromium*16–18 %—mid range 17 %.
X2.2.1.2 *Nickel*—10–14 %—mid range 12 %.
X2.2.1.3 *Molybdenum*—2–3 %—mid range 2.5 %.
X2.2.1.4 *Iron*—Balance (ignore minor elements).

$$17 + 12 + 2.5 = 31.5 \tag{X2.1}$$

X2.2.1.5 Iron = 100 − 31.5 = 68.5 %.
X2.2.2 Valence values from Ref **(2)**.

Chromium—+3
Nickel—+2
Molybdenum—+3
Iron—+2

X2.3 *Calculations*—For simplicity, assume 100 g of alloy dissolved. Therefore, the gram equivalents of the dissolved components are given by (Eq 3).

$$Q = \frac{17}{51.996} \times 3 + \frac{12}{58.71} \times 2 + \frac{2.5}{95.94} \times 3 + \frac{68.5}{55.847} \times 2 \tag{X2.2}$$

$$= 0.981 + 0.409 + 0.078 + 2.453 = 3.921\ g \text{ equivalents}$$

The alloy equivalent weight is therefore $^{100}/_{3.921}$ = 25.50.

X3. SAMPLE CALCULATION FOR CORROSION RATE FROM CORROSION CURRENT

X3.1 Data and requirements—See X1 and X2.

X3.1.1 Corrosion rate in mm/yr.

X3.1.2 Density 8.02 g/cm^3.

X3.2 Calculations—See (Eq 5).

$$K_1 = 3.27 \times 10^{-3} \tag{X3.1}$$

$$CR = \frac{3.27 \times 10^{-3} \times 20.3 \times 25.50}{8.02} = 0.211\ \text{mm/yr}$$

X4. SAMPLE CALCULATION FOR STERN-GEARY CONSTANT

X4.1 Case 1 Data—Tafel slopes polarization diagram,

$$ba = 58.2\ \text{mV/decade, and} \tag{X4.1}$$

$$bc = 114.3\ \text{mV/decade.} \tag{X4.1}$$

X4.2 Calculation in accordance with (Eq 7).

$$B = \frac{58.2 \times 114.3}{2.303\,(58.2 + 114.3)} = 16.74\ \text{mV or } 0.01674\ V \tag{X4.2}$$

X4.3 *Case 2*—Cathodic reaction is diffusion controlled

$$ba = 58.2\ \text{mV/decade} \tag{X4.3}$$

X4.4 *Calculation*—(Eq 8):

$$B = \frac{58.2}{2.303} = 25.31\ \text{mV} \tag{X4.4}$$

X5. SAMPLE CALCULATION—CORROSION CURRENT FROM POLARIZATION RESISTANCE DATA

X5.1 Data—Polarization: 10 mV from corrosion potential.

X5.1.1 *Current measured*—17.1 µA.

X5.1.2 *Specimen Size*—14.2 mm diameter masked circular area.

X5.1.3 Tafel slope values given in X4.

X5.2 *Calculations:*

X5.2.1 Current density (see X4):

$$\frac{17.1}{(1.42)^{2}\frac{\pi}{4}} = 10.80\ \mu A/\text{cm}^{2} \tag{X5.1}$$

X5.2.2 Polarization resistance calculation:

$$Rp = \frac{Ep}{\text{i}} = \frac{10\ \text{mV}}{10.80\ \mu A/\text{cm}^{2}} = 926\ \text{ohm cm}^{2} \tag{X5.2}$$

X5.2.3 Corrosion current—(Eq 10)

$$i_{\text{cor}} = \frac{B}{Rp} = \frac{25.31\ \text{mV}}{926\ \text{ohm cm}^{2}} = 27.33\ \mu A/\text{cm}^{2} \tag{X5.3}$$

X6. SAMPLE CALCULATION—SOLUTION RESISTIVITY EFFECTS

X6.1 *Data:*

X6.1.1 *Solution Resistivity*—4000 ohm cm.

X6.1.2 *Distance Between Luggin Tip and Specimen*—5 mm.

X6.1.3 *Measured Polarization Resistance*—9926 ohm cm^2.

X6.2 *Calculation from (Eq 11):*

$$Rp = Ra - \rho 1 \tag{X6.1}$$

$$Rp = 9926 - 0.5 \times 4000$$

$$Rp = 9926 - 2000 = 7926\ \text{ohm cm}^{2}$$

NOTE X6.1—The solution resistivity effect causes the corrosion rate to be underestimated by about 25 % in this case.

REFERENCES

(**1**) Dean, S. W., *Materials Performance*, Vol 26, 1987, pp. 51–52.

(**2**) Pourbaix, M., "Atlas of Electrochemical Equilibrium in Aqueous Solutions," National Association of Corrosion Engineers, Houston, TX, 1974.

(**3**) Silverman, D. C., *Corrosion*, Vol 37, 1981, pp. 546–548.

(**4**) Dean, S. W., Jr., W. D. France, Jr., and S. J. Ketcham, "Electrochemical Methods," *Handbook on Corrosion Testing and Evaluation*, W. H. Ailor, Ed., John Wiley, New York, 1971, pp. 173–174.

(**5**) Dean, S. W., Jr., "Electrochemical Methods of Corrosion Testing," *Electrochemical Techniques for Corrosion*, R. Baboian, Ed., National Association of Corrosion Engineers, Houston, TX, 1977, pp. 52–53.

(**6**) Stern, M. and Roth, R. M., *Journal of the Electrochemical Society*, Vol 105, 1957, p. 390.

(**7**) Stern, M., *Corrosion*, Vol 14, 1958, p. 440t.

(**8**) Mansfeld, F., "The Polarization Resistance Technique for Measuring Corrosion Currents," *Corrosion Science and Technology*, Plenum Press, New York, Vol IV, 1976, p. 163.

(**9**) Barnartt, S., *Electrochemical Nature of Corrosion, Electrochemical Techniques for Corrosion*, R. Baboian, Ed., National Association of Corrosion Engineers, Houston, TX, pp. 1–10, 1977.

(**10**) Oldham, K. B. and Mansfeld, F., "Corrosion Rates from Polarization Curves-A New Method," *Corrosion Science*, Vol 13, No. 70, p. 813 (1973).

(**11**) Mansfeld, F.," Tafel Slopes and Corrosion Rates from Polarization Resistance Measurements," *Corrosion*, Vol 29, p. 10 (1972).

(**12**) Glasstone, S., Laidler, K. J., and Eyring, H., "The Theory of Rate Processes," McGraw Hill, New York, 1941, pp. 552–599.

(**13**) Mansfeld, F., "The Effect of Uncompensated Resistance on True Scan Rate in Potentiodynamic Experiments," *Corrosion*, Vol 38, No. 10, pp. 556–559 (1982).

(**14**) Mansfeld, F., and Kendig, M., "Concerning the Choice of Scan Rate in Polarization Measurements," *Corrosion*, Vol 37, No. 9, pp. 545–546 (1981).

(**15**) Mansfeld, F., and Oldham, K. L., "A Modification of the Stern-Geary Linear Polarization Equation," *Corrosion Science*, 1971, Vol 11, pp. 787–796.