**Formula 1:** \( A = \pi L \frac{D}{12} \)

Where

\( A = \) area in sq. ft.
\( L = \) length in ft.
\( D = \) diameter in inches.

**Formula 2:** \( I_R = \frac{Sd(1-q)}{1000} \)

Where

\( I_R = \) current requirement in amps
\( S = \) surface area in sq.ft.
\( d = \) current density in mA/sq.ft.
\( q = \) coating quality as a decimal

**Formula 3a:** \( L = \frac{WCU}{8760I} \)

**Formula 3b:** \( W = \frac{8760LI}{CU} \)

Where

\( L = \) years of life
\( W = \) anode weight in lbs.
\( C = \) energy capability in amp-hrs per lb.
\( I = \) current output in Amps.
\( U = \) Utilization factor as a decimal

\( 8760 = \) hours in 365 days

Note: Energy capability is based on an efficiency of 50% for magnesium

\( C = \) (theoretical amp-hrs per lb.)(current efficiency)

For magnesium \( C = 500 \)

\( U = 0.85 \)

**Formula 4a:** **Groundbed Resistance for a Single Vertical Anode**

(Dwight’s Formula)

\[ R = \left( \frac{0.00521 \rho}{L} \right) \ln \left( \frac{8L}{d} \right) - 1 \]

Where

\( R = \) resistance in ohms
\( L = \) anode length (package length) in feet
\( d = \) anode diameter (package diameter) in feet
\( \rho = \) resistivity in ohm-cm

\( \ln \) is the natural logarithm function
**Formula 4b:** Groundbed Resistance for Multiple Vertical Anodes in Parallel (Sunde’s Formula)

\[
R = \left(\frac{0.00521\rho}{NL}\right) \left(\ln\left(\frac{8L}{d}\right) - 1 + \left(\frac{2L}{S}\right)\ln(0.656N)\right)
\]

Where
- \( R \) = resistance in ohms
- \( L \) = anode length (package length) in feet
- \( N \) = number of anodes
- \( S \) = anode spacing in feet
- \( d \) = anode diameter (package diameter) in feet
- \( \rho \) = resistivity in ohm-cm
- \( \ln \) is the natural logarithm function

**Formula 4c:** Groundbed Resistance for a Single Horizontal Anode (Sunde’s Formula)

\[
R = \left(\frac{0.00521\rho}{L}\right) \left[\ln\left(\frac{4L^2 + 4L\sqrt{S^2 + L^2}}{dS}\right) + \frac{S}{L} - \frac{\sqrt{S^2 + L^2}}{L} - 1\right]
\]

Where
- \( R \) = resistance in ohms
- \( L \) = anode (package length) in feet
- \( S \) = twice the anode depth in feet
- \( d \) = anode diameter (package diameter) in feet
- \( \rho \) = resistivity in ohm-cm
- \( \ln \) is the natural logarithm function

**Formula 5a:** Driving Voltage and Life

\[
V_d = \frac{0.0485WaNR_{gb}}{L_f}
\]

Where
- \( V_d \) is driving voltage in volts
- \( W_a \) is the weight of one anode in lbs.
- \( N \) is the number of anodes
- \( R_{gb} \) is the groundbed resistance in ohms
- \( L_f \) is the life of the system in years

**Formula 5b:** Driving Voltage and Polarized Potential

\[
V_d = P_a - P_c
\]

Where
- \( V_d \) is driving voltage in volts
- \( P_a \) is the open circuit potential of the anode
- \( P_{oc} \) is the standard potential magnesium (1.55V for Standard Potential Magnesium)
- \( P_{hc} \) is the high potential magnesium (1.75V for High Potential Magnesium)
P_c is the potential of the cathode in volts. (polarized potential of the pipe)

**Formula 5c: Driving Voltage and Sunde’s Formula**

\[ V_d = \left( \frac{0.00025268W_a \rho}{L_f L} \right) \left[ \ln \left( \frac{8L}{d} \right) - 1 + \left( \frac{2L}{S} \right) \ln(0.656N) \right] \]

Where

- \( V_d \) is driving voltage in volts
- \( W_a \) is the weight of one anode in lbs.
- \( N \) is the number of anodes
- \( L \) is the length of the anode (package) in ft.
- \( d \) is the diameter of the anode (package) in ft.
- \( S \) is the spacing between anodes in ft.
- \( L_f \) is the life of the system in years
- \( \ln \) is the natural logarithm

**Formula 6: Groundbed Current Output**

\[ I = \frac{P_a - P_c}{R_{gb}} = \frac{V_d}{R_{gb}} \]

Where

- \( I \) = Output current in amps
- \( P_a \) = Anode potential in volts
  - (1.55V for Standard Potential Magnesium)
  - (1.75V for High Potential Magnesium)
- \( P_c \) = Cathode potential in volts
  - (potential to which the pipe is to be polarized)
- \( R_{gb} \) = Groundbed resistance in ohms
- \( V_d \) = Driving voltage

**Formula 7: Current Output for One Anode**

\[ I_1 = \frac{(P_a - P_c)}{R_{gb}} \]

Where

- \( I_1 \) is the current output of one anode
- \( P_a \) is the anode potential
  - (1.55V for Standard Potential Magnesium)
  - (1.75V for High Potential Magnesium)
- \( P_c \) is the cathode potential (0.85V)
- \( R_{gb} \) is the groundbed resistance for a single anode (from Dwight’s formula)