Table 1 Impressed-current anode materials

Material	*Consumption rate or operating current density*	*Notes*
Consumable:		
Scrap iron	~ 9 kg A^{-1} $year^{-1}$	Cheap: suitable for buried or immersed use
Cast iron	<9 kg A^{-1} $year^{-1}$	Cheap; buried or immersed use; carbon skeleton reduces consumption
Semiconsumable:		
Silicon cast iron (Fe–14Si–(3 Mo)	5–50 A m^{-2} (in freshwater or soil)	Buried or immersed use; consumption (<1 kg A^{-1} $year^{-1}$); Mo reduces consumption in seawater
Graphite	2.5–10 A m^{-2}	Consumption rate very much less than steel or cast iron (< 1 kg A^{-1} $year^{-1}$); chloride ions reduce consumption
Nonconsumable:		
Lead alloys:		
1. Pb–6Sb–1Ag	<50–200 A m^{-2} (in seawater)	PbO_2 film restrains consumption
2. Pt-activated	<50–500 A m^{-2} (in seawater)	PbO_2 film protective
Platinized Ti, Ta, or Nb	< 1000 A m^{-2} (consumption)	Discontinuities in Pt coat protected by oxide film on subtrate; sensitive (< 100 Hz) AC ripple in DC or negative current spikes causing electrode consumption; maximum operating potential with Ti substrate: 9 V

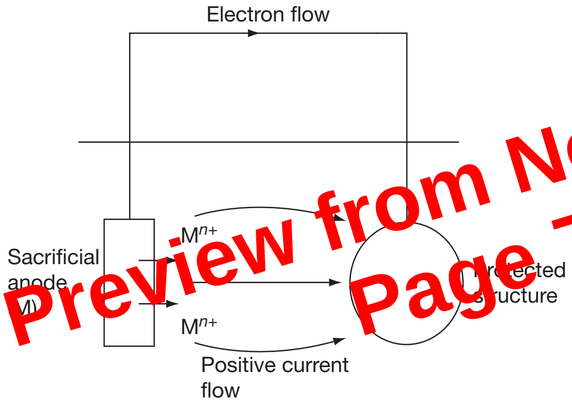

Figure 8 Schematic diagram of cathodic protection using sacrificial anodes. In practice, the anode, which will be mounted on a steel core, can be attached directly to the structure.

is required to keep disadvantageous tramp elements (notably iron and copper) below defined threshold levels. Many anode failures can be attributed to poor production quality control. A guide to minimum quality standards has been produced.[3]

Table 2 gives electrochemical properties for various generic anode types. It will be apparent that the driving voltages that are available from sacrificial anodes are substantially less than those available from power sources. At best, an anode will produce 1 V to steel, whereas an impressed current power source may produce up to 100 V.

A more detailed treatment of cathodic protection by sacrificial anodes is provided elsewhere in this book.

4.18.4 Proof of Protection

4.18.4.1 Steel

Figure 4 demonstrates that the rate of dissolution of iron (or any other metal) decreases as the potential is made more negative. **Figure 6** shows that the current required to reach any given potential below the corrosion potential (E_{corr}) will vary according to the composition of the corrosive solution. Thus **Figure 6** shows that, in the absence of oxygen, the current requirement would be low, but would increase to a value approximating to the limiting current in its presence. Moreover, since the limiting current can be increased by increasing the oxygen concentration or the solution flow rate, the current required for protection will change predictably with change in either of these parameters.[4] It follows that the current required to prevent corrosion completely (i.e., in principle to achieve E_a) will vary according to the environment and the environmental dynamics. As a consequence, there is no single current that will assure protection in all cases. Current supplied is not, therefore, an unequivocal indication of the effectiveness of protection.

By contrast, it appears from **Figures 4** and **6** that a potential measurement would be more reliable: specifically, that E_a (the equilibrium potential for the