KEY INDUSTRIAL SUPPLIES LIMITED

#75 Union Road, Marabella, Trinidad, West Indies,
Mailing Address: P.O. Box 4221 Claxton Bay,
Tel: (868) 6580021 / 658-0028 Fax: (868) 658-2354
Email: ryanl@keyindustrial.biz / shauntellep@keyindustrial.biz

ANODES: Zinc, Aluminum & Magnesium

Galvanic Corrosion is created when metals of different potentials are attached to each other and submerged in water or any solution that carries electrical current. Since different metals corrode at different rates, a current flow will be created from the faster corroding metal (anode) to the slower corroding metal (cathode). A reliable anode must be capable of continuously supplying electrical current throughout its life. HARBOR anodes are made from high purity base metals before being alloyed with controlled amounts of additives to enhance electrochemical properties and to offset the small amount of impurities that detract from current output. Improper or unalloyed anodes start off with a high current output which tapers off over time, thus providing insufficient current for long term protection.

The three main metal alloys used as galvanic anodes are Zinc, Aluminum and Magnesium. Each alloy has both advantages and disadvantages, dependant on many variable situations. Care should be taken to determine which type of anode is installed

Magnesium has the most negative electro potential of the three and is more suitable for areas where the electrolyte (soil or water) resistivity is higher. This is usually on-shore pipelines and other buried structures, although it is also used on boats in fresh water and in water heaters.

Zinc is considered a reliable material, but is not suitable for use at higher temperatures, as it tends to passivate (becomes less negative); if this happens, current may cease to flow and the anode stops working. Zinc has a relatively low driving voltage, which means in higher-resistivity soils or water it may not be able to provide sufficient current.

Aluminum anodes have several advantages, such as a lighter weight, and much higher capacity than zinc. However, their electrochemical behavior is not considered as reliable as zinc, and greater care must be taken in how they are used.

Zinc and Aluminum are generally used in salt water, where the resistivity is generally lower. Typical uses are for the hulls of ships and boats, offshore pipelines and production platforms, in salt-water-cooled marine engines, on small boat propellers and rudders, and for the internal surface of storage tanks.

PHYSICAL PROPERTIES

	ZINC		ALUMINUM		MAGNESIUM				
	TYPICAL "HARBOR" ANODES	MIL SPEC A-18001K	TYPICAL "HARBALUM" ANODES	MIL SPEC A-24779	H-1			HIGH POTENTIAL	GALVOROD
COMPOSITION					GRADE A	GRADE B	GRADE C		
Aluminum	0.25	.1 - .5	Balance	Balance	5.3 - 6.7	5.3 - 6.7	5.3 - 6.7	0.01 max	2.5 - 3.5
Cadmium	0.05	.025 - .07	-	-	-	-	-	-	-
Iron	0.001	.005 max	.06	.09 max	.003 max	.003 max	.003 max	0.03 max	.002 max
Copper	0.001	.005 max	.003	.004 max	0.02 max	0.05 max	0.1 max	0.02 max	0.01 max
Lead	0.002	.006 max	-	-	-	-	-	-	-
Zinc	Balance	Balance	6.0	4.0 - 6.5	2.3 - 3.5	2.3 - 3.5	2.3 - 3.5	.	0.7 - 1.3
Indium	-	-	0.017	.014 - .020					
Silicon	-	-	0.15	.08 - .20	0.1 max	0.2 max	0.3 max	0.05 max	.05 max
Mercury	-	-	-	.001 max	-	-	-	-	-
Tin	-	-	-	.001 max	-	-	-	-	-
Manganese	-	-	-	-	.15 min	.15 min	.15 min	0.50 - 1.30	.20 min
Nickel	-	-	-	-	0.002 max	0.003 max	0.003 max	0.001 max	0.001 max
Magnesium	-	-	-	-	Balance	Balance	Balance	Balance	Balance
Other Imp	-	-	-	.020 max	.20 max	.20 max	.30 max	0.30 max	.30 max

ELECTROCHEMICAL PROPERTIES

	ZINC	ALUMINUM	MAGNESIUM	
	ZINC HARBOR MIL-A-18001	ALUMINUM HARBALUM MIL-A-24779	MAGNESIUM	
			H-1	HIGH POTENTAIL
Theoretical ampere-hours per pound	372	1352	-	-
Current Efficiency (percent)	95	85	50 - 54	50 - 55
Actual ampere-hours per pound	354	1150	500 - 540	500 - 550
Consumption, pounds per ampere year	24.8	7.62	17	17
Potential (reference Cu/Cu/SO4)	-1100m/v	-1150m/v	-	-
Closed Circuit Potential (Cu/Cu/SO4)	-	-	-1.45 to -1.55v	-1.50 to -1.75v
Open circuit Potential (Cu/Cu/SO4)	-	-	-1.50 to -1.60v	-1.70 to -1.75v

Differences between ZINC – ALUMINUM – MAGNESIUM Anodes

Zinc Anodes work well in salt and the upper saline levels of brackish waters. In lower levels of brackish and fresh waters, zinc doesn't have the current output to fully protect, however, partial protection occurs.

Aluminum Anodes work well in salt and the upper saline levels of brackish waters. In lower levels of brackish and fresh waters, aluminum anodes can film over by not sloughing its consumed metal which causes passivation and the possibility of a total loss of galvanic protection.

Magnesium Anodes work well in salt, brackish and fresh waters. Fresh water use is more prevalent due to the possible "over-protection" that may occur in the less resistant environments of salt and upper saline level of brackish waters.

Summary: There are several factors that play into which type of anode to use on any given structure or vessel. These include water salinity, water temperature, water speed, metals to be protected, required anode life span, etc. For vessel protection, typical speed and how often the vessel is used can make a difference in choosing the proper protection. Changing habits in a vessel's use can also change the type of anode required for protection. Since electrical currents change every time a vessel travels into different environments (waters), there is no absolute value to the corrosion rates of metals so each vessel (or structure) must be looked at individually for the proper protection.

ZINC Reference Cell "Interpretation Readings"

Protected Steel: CuCu/So4 @ -.85v

Protected Steel: Zinc Reference Cell @ -.25v

METAL	NATURAL READINGS	PROTECTED READINGS
Magnesium	-.350 to -.550	-.550 to -.750
Zinc	+.050 to -.150	-.150 to -.350
Aluminum	+.050 to -.150	-.150 to -.350
Cadmium	+.050 to -.150	-.150 to -.350
Steel	+.350 to +.550	+.150 to +.350
Cast Iron	+.350 to +.550	+.150 to +.350
Aluminum Bronze	+.400 to +.600	+.200 to +.400
Tin	+.400 to +.600	+.200 to +.400
Copper	+.400 to +.600	+.200 to +.400
Tin/Lead Solder	+.450 to +.650	+.250 to +.450
Brass	+.450 to +.650	+.250 to +.450
Manganese Bronze	+.450 to +.650	+.250 to +.450
Silicon Bronze	+.500 to +.750	+.300 to +.550
Copper/Nickel	+.500 to +.750	+.300 to +.550
Lead	+.650 to +.850	+.450 to +.650
Silver	+.650 to +.850	+.450 to +.650
Titanium	+.700 to +.900	+.500 to +.700
Platinum	+.950 to +1.150	+.750 to +.950
Graphite	+1.05 to +1.250	+.850 to +1.050