The working life of an impressed current anode may be defined by the number of ampere-years of service that it to be transferred through the earth to protect a structure.

Ampere-Years = (Gross Weight x Utilization Factor) / Consumption Rate.

Example: For a 69 lb HSCI tubular anode of Utilization Factor 85% and Consumption Rate 0.75 lb/A-yr,
Ampere Years (Life) = 78.2

Utilization: The percentage of the original weight of anode material that may be reasonably expected to discharge current before operation ceases.

Utilization factors of 65% for stick anodes, and 85% for tubular anodes, are often used for design of High Silicon Cast Iron (HSCI) groundbeds. Field and testing experience indicates that the 65% and 85% utilization values are reasonable and conservative, providing that the anode and the cable connection do not fail prematurely due to manufacturing defects or installation problems

For impressed-current anodes in coke breeze operating at published nominal discharge current, full utilization occurs when, due to consumption of nearly all the anode mass, either the cable connection fails, or the anode-to-soil resistance limits out the rectifier. When an anode has been fully utilized, the material remaining is insufficient to maintain a reasonable percentage of the anode's original current output. A well-made, well-designed anode in a high quality groundbed will be accorded a high utilization value, relative to poor quality anodes of ineffective design in backfill of marginal or low quality.

Because impressed current anodes are consumed preferentially from the ends, end-connected stick anodes exhibit lower utilization than center connected tubular anodes. Accordingly, utilization values appropriate for end-connected solid sticks are lower than those for centrally connected tubular anodes.

Selected Experience Reports: High Silicon Cast Iron Anode Utilization

- In 1979, DurIron reported 87% utilization, at 3.5 Amps/sqf current density, from centrifugally cast tubular anodes that had been almost fully consumed in synthetic seawater in laboratory Tests [(L38)].
- In 1998 a specimen Anotec chill cast 2" x 60" EHA stick anode was recovered from natural seawater by West Coast Corrosion after 24 Amp Years of service at 4.86 Amps (average)[(L34)]. The specimen, without failing in service, weighed 13.75lb as recovered. Inspection indicated that an additional 4 to 5 pounds could be utilized; which indicated 75% full utilization. The 65% utilization factor often assumed for ground bed design seems conservative.

  Figure 1 shows the as-recovered anode beside a new 44 lb equivalent.

Figure 1: Type EHA 2 x 60" 44lb anodes before and after consumption

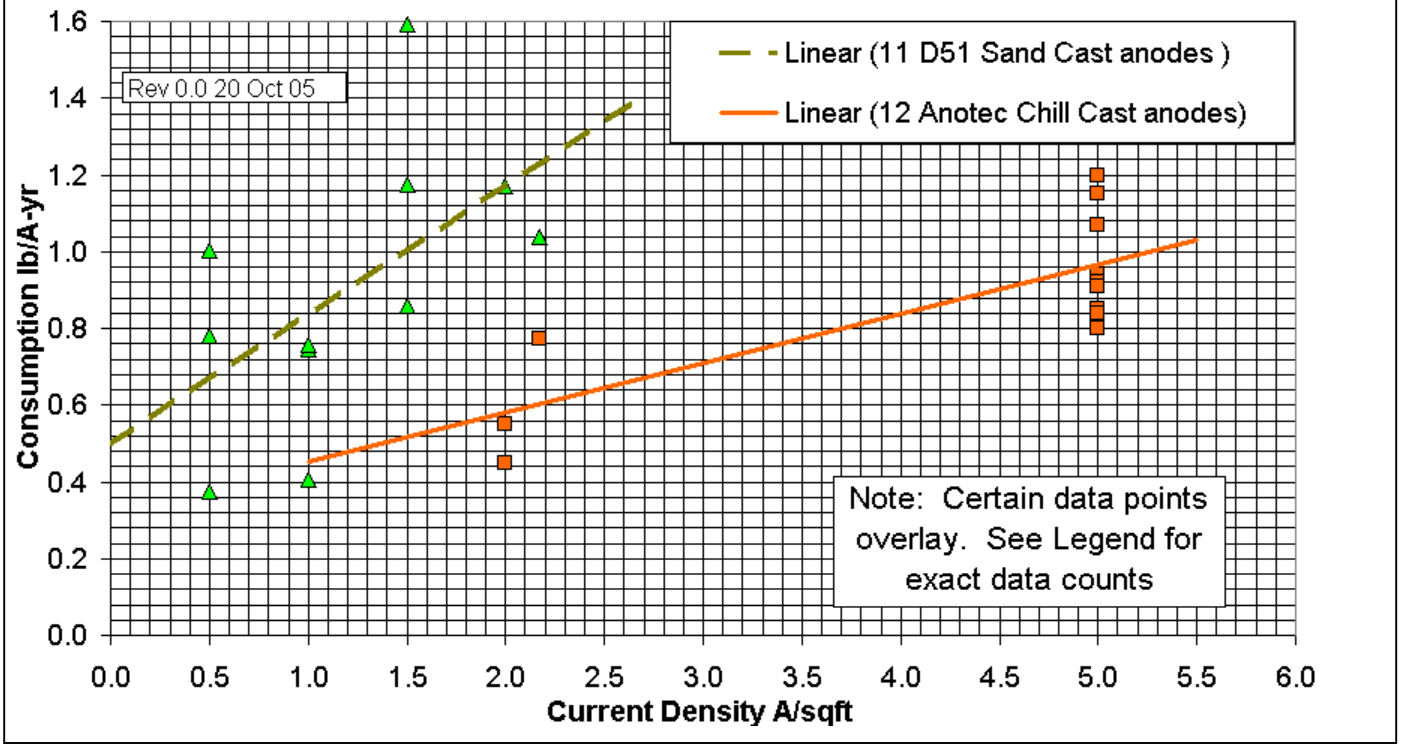
Consumption Rate: The rate at which the anode material is consumed by the passage of Impressed Current. For designing HSCI groundbeds in natural soils and waters, Consumption Rates of 0.5 to 1 lb/A-yr have been widely used, in conjunction with the appropriate Utilization Factor for the type of anodes involved,

The Consumption Rate of a material can be determined by testing. A controlled current is discharged from an anode into a specified environment for a period of time. Weight Loss divided by Ampere Years represents the "instantaneous" consumption rate for the material and environment involved: Consumption defined in this way must be modified by Utilization in order to be useful for groundbed design. Alternatively, if a consumption rate calculation is based on the original gross weight divided by ampere-years to failure, a Utilization Factor is not applicable. Obviously, for design purposes, it is important to know whether a published consumption rate is "Instantaneous" or "Utilizable".

Instantaneous Consumption Rates for High Silicon Cast Iron. Although the consumption rate of High Silicon Cast Iron is fairly consistent within normal applications, variations may be experienced.

Figure 2 shows Consumption Rate gradually increasing with Current Density for both Sand Cast Anodes (D51) and Chill Cast Anodes (Anotec). Specimens were bedded in sand with 2% Sulphate solution.

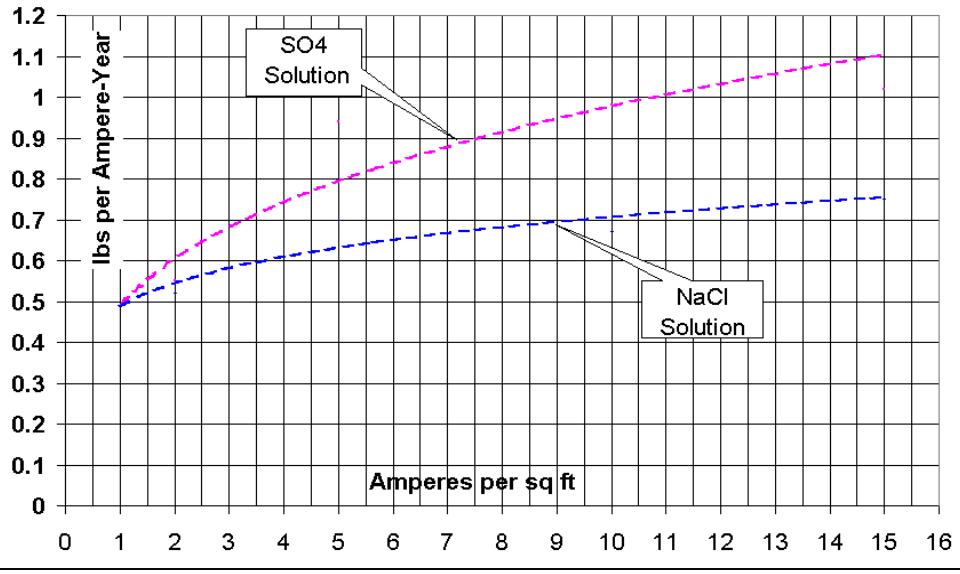
FIGURE 2: Consumption Rate relative to Current Density : Chill Cast vs Sand Cast, in Sand Bed with SO4
ref: Groundbeds / Literature Review Oct 05.xls



In Figure 2, the wide dispersion of points and steeper trend-line for Sand Cast anodes may be due to inconsistencies of metallurgical structure causing mechanical loss compared to Chill Cast equivalents.

Figure 3 compares consumption rates for Chill Cast HSCI anodes bedded in sulphide and chloride solutions in accelerated testing. Figure 3 charts consumption at current discharge densities up to 15 A/sqft (160A.sqM). Occasionally drying sensitivity in natural soils with clay content will limit sustainable current discharge to much lower levels, ie, 0.5 to 0.75 A /sqft from anode to coke breeze

FIGURE 3: Consumption Rate and Current Density
1F9 anodes in sand bed w salt solution 80 days



Refer to Application Basics and Groundbed Drying for information about Current Density Limitations.