Brance-Krachy Co., Inc.
Quality and Service Since 1932

HOUSTON BEAUMONT MIDLAND SULPHUR

Cathodic Protection Equipment for Heat Exchangers and Condensers

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CATHODIC PROTECTION OF
CONDENSER AND HEAT EXCHANGER COMPONENTS

There are four general methods available to attack a specific corrosion problem.

1. The selection of a more resistant alloy for the corroding part.
2. Treatment of the electrolyte to make it less aggressive.
3. The application of a coating to separate the surface from the electrolyte.
4. Cathodic Protection.

Cathodic protection when used in conjunction with other methods can be beneficial in mitigating corrosion problems in heat exchanger tube sheets and heads.

I. THE GALVANIC SERIES

A. The galvanic series should be considered when choosing materials for use in equipment which is to be submerged in water or buried in soil, to determine the compatibility of certain metals when connected to form a galvanic couple.

GALVANIC SERIES OF METALS AND ALLOYS

MATERIAL	Potential Reference $Cu-CuSo_4$, Half Cell
Magnesium (Glavomag)	1.750
Magnesium (H-I Alloy)	1.550
Zinc	1.106
Cast Iron	.686
Carbon Steel	.686
Yellow Brass	.436
Muntz Metal	.436
Aluminum Bronze	.406
Aluminum Brass	.396
Composition 'G' 88% Copper, 10% Tin, 2% Zinc	.386
Admiralty	.366
90:10 Cu-Ni + .82 Fe	.356
Monel	.151

B. It can be seen from this table that admiralty condenser tubes when used on a carbon steel tube sheet will cause a of 320 mv. (.686-.366=.320) potential to exist between them. This potential will cause a current to flow from the tube sheet to the tube ends. The tube sheet will be galvanically attacked, most severely around the tubes. If a magnesium anode is introduced into the system, a current would flow from the magnesium anode to all other components, thereby preventing corrosion on all elements except the magnesium anode. The use of cathodic protection therefor allows more extensive use of steel as tube sheets and header material.

II. GALVANIC CORROSION DESIGN FACTORS.

If, in the design of condensers and heat exchangers, consideration is given to the magnitude of the galvanic action produced by various dissimilar metals, a many of the serious corrosion problems would be minimized. Some of the more predominant design factors are:

1. Area Effect.

   a) A small area of less noble metal should never be exposed to a large area of a more noble metal. This greatly increases the galvanic activity and rapidly corrodes the less noble metal.

   b) Conversely, if a small area of noble metal is coupled to a large area of less noble metal it would not present a serious corrosion condition because of the large difference in area. The corrosion of the less noble metal would be less severe.

2. Compatibility of Metals

   a) If a choice of two metals exists, try to choose those that are close to each other in the galvanic series.

   b) If the more noble metal has the smaller area, satisfactory results can be expected.

3. Space for Cathodic Protection.

   It is suggested that sufficient space be made available when new heat exchangers are designed to accommodate and 8”x8”x4” anode.

III. CATHODIC PROTECTION DESIGN FACTORS.

A. Anode Selection

1. 15S 8” x 8” x 4” 15 pound magnesium anode.
2. 7.5S 8” x 8” x 2”   7.5 pound magnesium anode.

3. 2R5 5” dia x 2” 2 pound magnesium anode.
4. E2 4” dia x 2” 2 pound magnesium condenser anode.
5. Zinc condenser anodes, 1” thick and from 3” to 12” dia.
6. Magnesium and zinc pencil anodes.
7. Impressed current systems.

B. Anode Calculation

1. Compute the surface area of the compartment to be protected (in square feet). Keep in mind that protection cannot be afforded the inner surface area of the tubes.

2. Determine the largest anode that space limitations will permit.

3. The required current density for protection varies with water resistivity, velocity and temperature. This value is usually determined from experience in the specific situation. A figure of 50 ma/SqFt may be used as a starting point for fresh water exchangers and 100+ for salt water.

4. Determine the resistivity of the water.

5. Read from the chart the current output that the suitable anode will produce at the electrolyte resistivity. Divide this current into the total current required for the chamber to obtain the number of anodes that must be installed.

6. Read the expected life from the chart.

7. Anodes, which are installed in pairs, will have a reduced output per anode due to the current interference produced by both anodes attempting to use the same current path though the water. This feature is desirable for longer life when less current is required from an anode installation.

8. Unless scheduled sooner, the condenser should be opened for inspection after approximately half the estimated anode life has pasted. The anode consumption can then be estimated by visual inspection or weighing. A revised estimate of life as well as an approximation of the actual current output can be made.

9. In some cases, such as large turbine condensers, standard magnesium hull anodes can be used. The advantage of such an installation, where space is available, is increased life due to the small surface area per pound of magnesium afforded by this anode. Impressed current systems may be a reasonable choice for these large installations.

C. Anode Installation

1. To protect a heat exchanger water box, a anode must be installed in all compartments of both ends of the heat exchanger.

2. The surface of the anode must remain bare (free of all paint or grease) in order to supply the protective current.

3. A monel or stainless steel securing stud is recommended for attaching anodes to a condenser cover plate. The reason for this selection is to avoid damage to the securing stud due to corrosion should the condenser be continued in service after the anodes have been dissipated. Galvanic corrosion between the stud and other metals will not take place so long as the anode is in operation.

4. To prevent excessive current flow to the adjacent surface a rubber sheet or polyethylene box is placed under the anode.

5. If the electrolyte resistivity is very low, for example with seawater, a resistance washer can be reduce the current output of the anode.

IV. POLARIZATION EFFECTS

A white calcareous coating will often forma on the protected surfaces. This coating should not be removed as it is very beneficial in reducing the current requirements for full protection.

EXAMPLE

TWO PASS EXCHANGER
4 FT DIAMETER
1 FOOT BETWEEN HEAT AND TUBE SHEET
WATER RESISTIVITY – 200 OHM CM
<u>ASSUMED</u> CURRENT REQUIREMENT 25 MA/Ft^2

STEP 1

CALCULATE SURFACE AREA

INLET AND OUTLET CHAMBER

HEAD	$nr^2/2 = 6.3\ Ft^2$
SHEET	$nr^2/2 = 6.3\ Ft^2$
SHELL	$nDL/2 = 6.3\ Ft^2$
DIVIDER	$DL = 4.0\ Ft^2$
TOTAL	$22.9\ Ft^2$ EACH

RETURN CHAMBER

HEAD	nr^2 – 12. Ft^2
SHEET	nr^2 – 12.6 Ft^2
SHELL	nr^2 – 12.6 Ft^2
TOTAL	37.8 Ft^2

STEP 2

CALCULATE CURRENT NEEDED

INPUT & OUTPUT CHAMBERS

22.9 Ft^2 *.025 A/Ft^2 = 0.58 A

RETURN CHAMBER

37.8 FT^2 *.025 A/Ft^2 = .95A

STEP 3

DETERMINE OUTPUT AND LIFE FROM GRAPH

15S	. 3 A @ 30 MONTH LIFE	- 8 REQUIRED
7.5S	. 2 A @ 20 MONTH LIFE	- 11 REQUIRED
2#	. 1 A @ 9 MONTH LIFE	- 20 REQUIRED

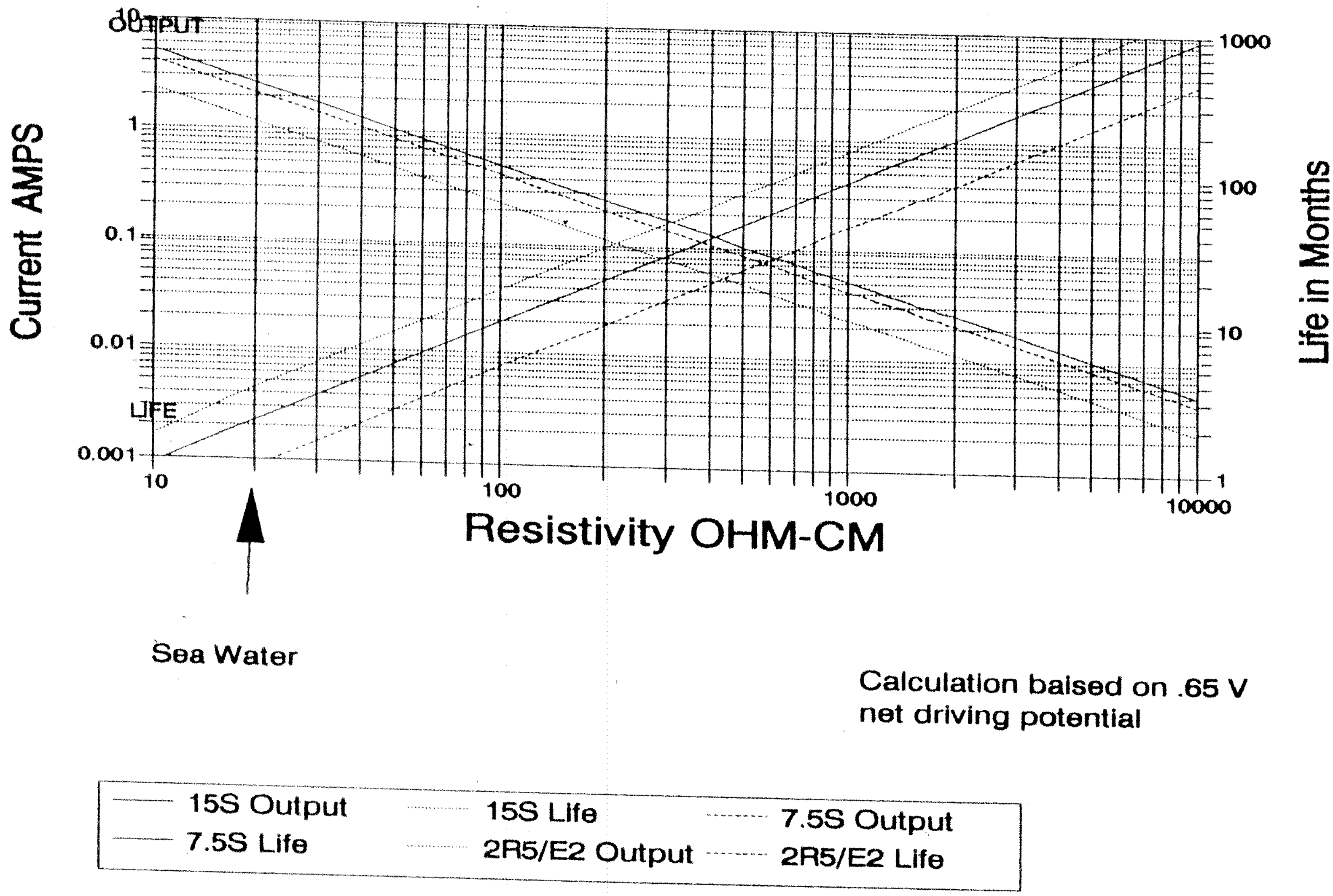
STEP 4

CHOSE THE BEST ANODE

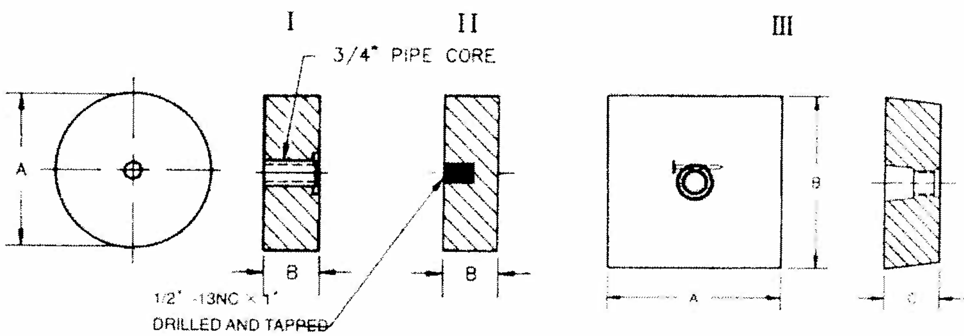
SINCE THERE IS SUFFICIENT SPACE EITHER THE 15S OR THE 7.5S WOULD BE A GOOD CHOICE DEPENDING ON THE INSPECTION SCHEDULE. THIS IS IF ALL ASSUMPTIONS ARE CORRECT AND CONDITIONS REMAIN STABLE.

IF UNSURE – USE AS MANY OF THE BIGGEST THAT WILL FIT.

Magnesium Condenser Anode
Resistivity vs Output & Life



Magnesium Condenser Anodes



Type	Figure	Nominal Dimensions (in.) A	B	C	Weight (lb.)
BK1R375 1/2" PIPE CORE	I	3 3/4	1	-	1
BK2R3	I	3	2	-	1
BK2R5	I	5	2	-	2
BKE2	II	4 3/4	2	-	2
BKE1	II	4 3/4	1	-	1
BK4S1	III	4	4	1	1
BK4S2	III	4	4	2	2
BK4S4	III	4	4	2	4
BK15S	III	8	8	4	15
BK7.5S	III	8	8	2	7.5
BK6SX3	III	8	4	3	6

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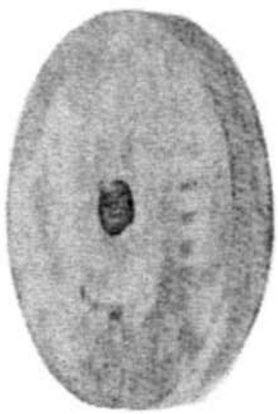
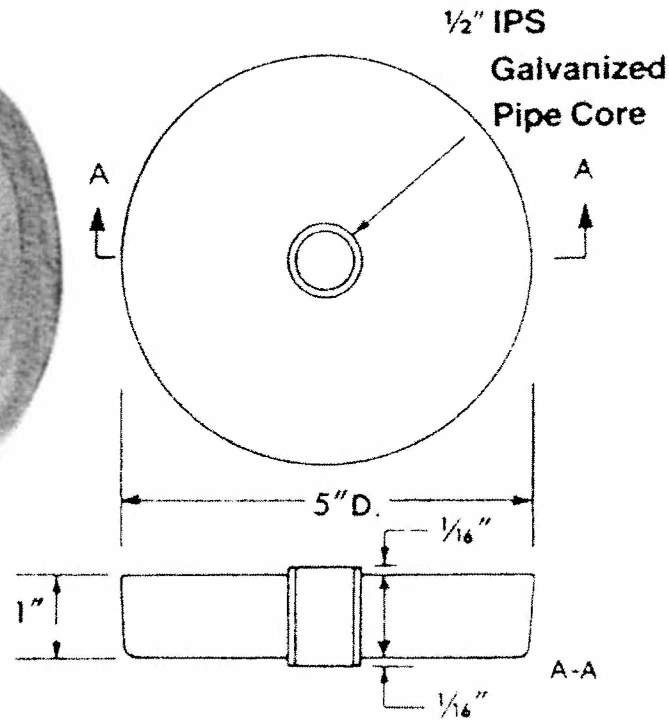
Zinc Condenser Anodes





Type	Weight (lb.)	Diameter	Cores
BKCZ-2	1	2"	1
BKCZ-3	2	3	1
BKCZ-4	3	4	1
BKCZ-5	5	5	1
BKCZ-6	7	6	1
BKCZ-9	16	9	2 on 3 1/2 " centers
BKCZ-11	24	11	2 on 3 1/2 " centers

Cathodic Protection & Power Transmission Equipment
BK
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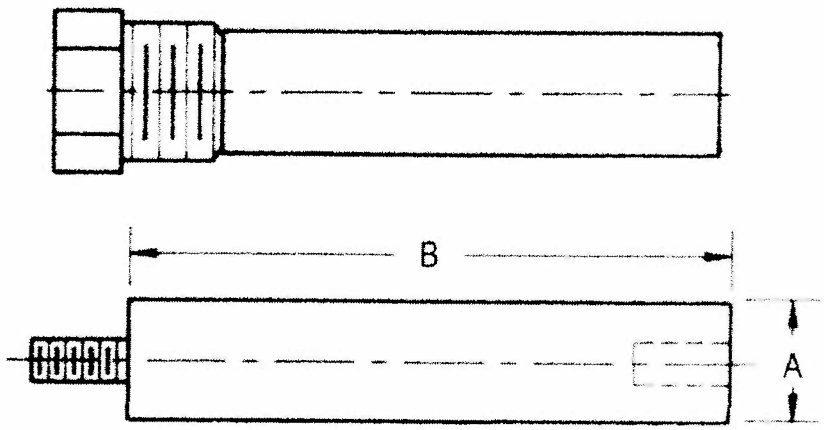
Magnesium Pencil Anodes



Anode Part No.	Pencil Dimensions (in.) A	B	Anode Thread	Plug NPT Size	Plug Part No.
BKMP500	.550	1"-24"	3/8-16 NC	3/8"	BKPP375-B
BKMP750	.750	1"-24"	5/8-11 NC	3/4"	BKPP750-B
BKMP840	.840	1"-24"	5/8-11 NC	3/4"	BKPP750-B
BKMP1050	1.05	1"-24"	3/4-10 NC	1"	BKPP1000-B
BKMP1315	1.315	1"-24"	3/4-10 NC	1 1/4"	BKPP1250-B

Other sizes available on a custom basis.

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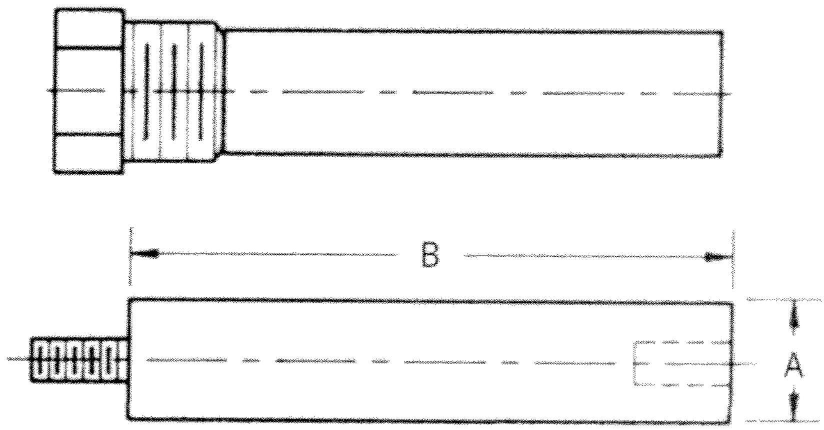
Zinc Pencil Anodes



Anode Part No.	Pencil Dimensions (in.) A	B	Anode Thread	Plug NPT Size	Plug Part No.
BKP375	.375	1"-6"	3/8-16 NC	1/4"	BKPP250-B
BKP500	.500	1"-6"	3/8-16 NC	3/8"	BKPP375-B
BKP625	.625	1"-6"	3/8-16 NC	1/2"	BKPP500-B
BKP750	.750	1"-6"	5/8-11 NC	3/4"	BKPP750-B
BKP840	.840	1"-6"	5/8-11 NC	3/4"	BKPP750-B
BKP1050	1.05	1"-6"	3/4-10 NC	1"	BKPP1000-B

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