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TELEPHONE – AREA CODE 212
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August 2, 1965

SUBJECT: "Cathodic Protection for an Offshore Structure"

To Members of the Lead Industries Association, Inc.:

We have obtained copies of the attached reprint on lead alloy anodes used in "Cathodic Protection for an Offshore Structure", for distribution to members of the chemical construction industry and others concerned with protecting structures against corrosion.

In addition, this reprint will be offered in the "Lead Library" listing in LEAD magazine, which is sent to about 11,000 design engineers and almost 2,000 chemical engineers.

Members may obtain 25 copies of this reprint free of charge, and larger quantities at our cost of $10.00 per 100.

Very truly yours,

Robert Travis

Robert Travis

RT:bd
Attachment

Look Ahead with Lead

N 2339

Cathodic Protection for an Offshore Structure

lead alloy anodes replace graphite

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SUMMARY

Describes graphite anode cathodic protection system installed on a large offshore structure used in mining of sulfur. Graphite anodes in groundbeds had an impressed current from rectifiers. This system proved inadequate because of damage from boat anchors, extensive fishing in the area, and hurricanes. Lead alloy anodes were substituted. These were suspended from the structure so that they could be pulled up during bad weather.

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by

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Cathodic Protection for an Offshore Structure*

lead alloy anodes replace graphite

WHEN Freeport Sulphur Company planned to construct the world's largest offshore platform at Grand Isle, Louisiana, it followed, naturally, that the world's largest offshore cathodic protection system would be required if corrosion was to be controlled. A thorough investigation was made of weather and water conditions so that this information could be given to the cathodic protection firms who would be asked to bid on the project.

What has been found, after working offshore for four years, is that the best laid plans do not guarantee success. This article describes the events that lead to the complete revision of the offshore cathodic protection system from a buried graphite anode system to a suspended lead anode system.

History of the Structure

Construction of the main offshore **platform** was begun in 1958. An underwater sulfur line was laid in 1959 and an extension of the main platform was set in 1962.

Figure 1 shows an aerial photograph of the structure, including power plant, living quarters, heliport, production platforms, and bleedwater platform.

The platform is located in 50 feet of water, seven miles offshore from Grand Isle, Louisiana. The total area under cathodic protection is approximately 765,000 square feet of which 355,000 square feet is in the water zone and 410,000 square feet is in the mud below the Gulf bottom.

Based on an initial current requirement of three milliamps per square foot, the structure would require a cathodic protection system capable of delivering 2295 amps. The coated underground sulfur line, the piling in the mud zone, and polarization of the structure templates in the water zone would decrease the current requirements. On the other hand, turbulence of the Gulf bottom and increased heat on the well equipment would increase current requirements. Rather than attempt to balance the factors, it was decided that they would nullify one another.

Design of Original System

At the outset it was decided that an impressed current system would be installed instead of a galvanic system. The reasons were first, that an adequate power supply would be available, and second, that control of current output to maintain protective potentials would be easier.

The number of anodes to be used would afford a 5-year life. This would minimize replacement because offshore labor is particularly expensive. Cylindrical rectifier cases were considered desirable to reduce space requirements and to have more stability in high winds. Although rectifier materials were not specified, there was a preference for silicon instead of selenium for several reasons: (1) longer anticipated life because of superior aging characteristics, (2) smaller stacks, and (3) higher power efficiency.

Other than these specifications and preferences, the only requirement was the -0.85 volt steel-to-water potential using a copper-copper sulfate half cell as a reference.

Installation of System

The cathodic protection design, which was accepted from one of the cathodic protection companies bidding on the project, incorporated the above items.

The over-all design divided the structure into several projects. Each project would have its own separate cathodic protection system. In this way, each system could be installed immediately after that section of the platform was erected. Another advantage of the sectionalizing would afford full or partial cathodic protection in the event of failure of one system.

Table 1 shows the division of cathodic protection system into projects, rectifier quantity and rating, and other pertinent information.

* Revision of paper titled "Development of a Cathodic Protection System for an Offshore Structure," presented at the 1963 Annual Conference, National Association of Corrosion Engineers, March 11-15, 1963, New York, N.Y.

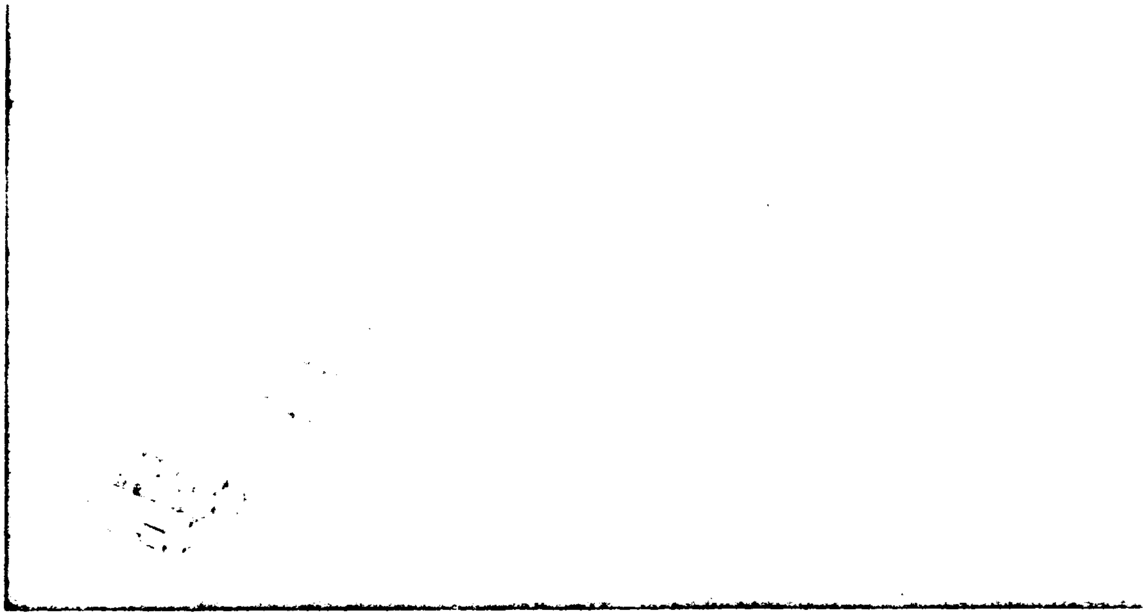

Figure 1—Configuration of offshore structure used to mine sulfur. Entire structure was cathodically protected with impressed current on graphite anodes in groundbeds. This system proved inadequate and was changed to lead alloy anodes suspended from the structure.

Potentials taken in July, 1959, two weeks after all systems had been energized, showed steel-to-water potentials of 0.90 to 1.15 volt with a copper-copper sulfate half cell as reference. At that time, the system was considered entirely satisfactory. For the next five or six years all that would have to be done was take periodic potentials.

Two Factors Overlooked

Complacency came to an abrupt end before the end of August, 1959. It was evident that two factors had been overlooked. One was the efficiency of construction barges in dragging anchors and, in general, completely cutting up the Gulf bottom. This condition, thankfully, was only temporary.

Of a much more serious nature was the problem of fishermen. Grand Isle is one of the most popular deep sea fishing areas in the country. Because fish feed around offshore piling, the Freeport Platform is one of the most popular fishing rigs.

These two factors resulted in fish hooks puncturing anode lead wires and header cables. Another unexpected incident was the sinking of a dump boat off Freeport's Platform which destroyed two anode strings.

Damage was extensive, but with partial replacement of anode beds the safety factor in the overall system made it possible to maintain protective potentials over the entire platform.

Hurricane's Coup de Grace

In September, 1961, Hurricane Carla delivered a coupe de grace to the cathodic protection system. High winds and waves destroyed every cathodic protection system except one, on Production Platform No. 1. This system was destroyed March, 1962, when fire completely razed this part of the structure.

Some of the systems were obviously damaged at the water line, where parted conduit had either scarred the cable insulation or cut the cable. The damage to other systems could not be seen and, because the rectifiers were working properly, it was evident that the damage was underwater, in the form of cable failure or anode damage.

Efforts were made to repair the various cathodic protection systems in December, 1961. These efforts proved unsuccessful because the anodes and cables were so completely fouled.

Study of Lead Anodes

At this time, investigation of lead anodes developed in England in the early 1950's was started. An article

TABLE 1—Division of Cathodic Protection System, by Projects

Project No.	Structure	Rectifier Quantity and Rating	Number 3" × 60" Graphite (No. of groups, No. of anodes)	Approx. Area to be Protected (sq ft)	Current (amps) Requirement Based on 1 ma/sq ft
1	Tower No. 1 [illegible]	[illegible]	2 4	[illegible]	31
	Tower No. 2 [illegible]		1 3	[illegible]	20
	Tower No. 3		1 3	[illegible]	20
2	Tower No. 4	[illegible]	1 3	[illegible]	31
	Tower No. 5 [illegible]		1 3	[illegible]	20
	Tower No. 6		1 3	[illegible]	22
3	Prod. Platform	[illegible]	11 3	[illegible]	135
4	[illegible]	[illegible]	1 3	[illegible]	[illegible]
	[illegible]		6 30	[illegible]	[illegible]
5	Power Plant	[illegible]	6 [illegible]	[illegible]	[illegible]
6	[illegible] Platform	[illegible]	6 3	[illegible]	[illegible]

[illegible] indicated that a lead anode had very promising possibilities for protecting offshore structures.

Because of the necessity of getting the platform under cathodic protection, and because repair of the [illegible] buried graphite system would be relatively expensive, companies involved in offshore cathodic protection were contacted to get more details regarding the installation, operation, experience data available and cost of silvered lead anodes.

Test Made with Lead Alloy Anodes

In January, 1962 four 3-inch diameter, 15-inch long lead anodes (93% Pb, 6% Sb, 1% Ag) were suspended from the platform ten feet above the Gulf bottom (30 to 40 feet below the water line). The anodes were encased in a PVC shield through which ¾-inch diameter holes and ¾-inch by 3-inch slots were cut. Lead wires were No. 4 cable with high density polyethylene insulation. The assembly was suspended by ¾-inch diameter polypropylene rope, with the lead wire spiralled around the plastic rope.

The anodes were suspended between Towers 1 and 2, and 2 and 3. These anodes were tied into the rectifier on Tower No. 2. At the maximum transformer settings on the rectifier, maximum output was 11 amps, 7 volts. The results indicated that anode-to-water resistance was too high to get satisfactory current output.

The fault lay in two areas: 1. there was not enough anode surface area and 2. tying each anode lead wire directly into the rectifier was a waster of unnecessarily high resistance.

To correct the problem, two changes were made. A 3-inch diameter by 30-inch anode was added to increase anode surface area by 100%. And a No. 2/0 header cable was strung along the underside of the walkway, and each anode lead wire was tied to it at the point of anode suspension.

After these changes were made, the rectifier output was increased to 100 amps [illegible]. [illegible] of the four [illegible] [illegible] 17 amps [illegible] and the 20-inch lead anode was [illegible] 33 amps. [illegible] potentials were above [illegible] on Towers 1, 2 and [illegible] which were part of the rectifier system. Partial protection was given the adjacent structures.

Lead Anodes Replace Graphite Anodes

In May, 1962 results continued to be satisfactory, and it was decided to completely replace the buried graphite system with suspended lead anodes.

One 3-inch by 30-inch lead alloy anode (90 lb) replaced each graphite anode group of five. At an average anode current output of 15 amps per square foot and an anode consumption rate of 0.5 lb per ampere-year, the anode life is expected to be approximately six years. This compares with a graphite anode bed (five anodes) anticipated life of five years.

Advantages of Lead Anode System

The lead anode system has several important advantages over the graphite system:

1. Lead anodes are easier to install, requiring no diver or boat.

2. The system is much less expensive to install because of fewer anodes and all work can be done from the platform.

3. Maintenance and trouble shooting are greatly simplified because of the fewer anodes and greater accessibility of the lead wires and anodes.

4. There are no underwater splices.

5. Recovery of most of the anodes can be made if a hurricane or other extremely bad weather is imminent.

6. Higher current densities and longer life are anticipated from each 3- by 30-inch lead anode compared with a five anode grouping of 3-inch by 80-inch graphite anodes. At the present time, suspended lead anode systems have been installed in place of all [illegible] graphite anode beds [illegible] [illegible] rectifier and buried graphite anodes at each terminal.

The cost of the suspended lead anode system was approximately half of the [illegible] buried graphite system. All installations were made by [illegible] personnel. Anodes suspended off walkways are free swinging; anodes suspended off platforms are weighted with concrete blocks.

Sixty-mile an hour winds have been experienced with no detrimental effect on installations of the lead anodes.

At present, all cathodic protection systems are operating properly and all potentials taken on the platform have exceeded the 0.85 volt minimum requirement. Steel test plates have been installed electrically bonded and insulated on the platform. These will be inspected periodically to determine the effectiveness of the cathodic protection system.

References

1. [illegible]
2. [illegible]

Other Articles of Interest

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