CATHODIC PROTECTION

A Symposium

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PREFACE

In December, 1947 in Pittsburgh, Pa., a Joint Symposium on Cathodic Protection was held under the sponsorship of the National Association of Corrosion Engineers and the Electrochemical Society. This constituted a review of the state of development of the basic principles of cathodic protection and their application to the control of corrosion.

The papers presented at this symposium have been assembled here in book form for ready reference and to fill a void in the technical literature.

These collected papers will provide a sound basis for the prevention of corrosion by cathodic protection. They also may indicate some gaps in our knowledge. It is hoped, therefore, that this publication may stimulate additional research to fill such gaps and thus further extend the technical foundation upon which improvements in practice must be based.

The sponsoring organizations wish to express their appreciation to the authors for the time and effort expended in preparing their papers for publication.

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Co-Chairman
Electrochemical Society

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Co-Chairman
National Association of
Corrosion Engineers

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THE USE OF WIND-DRIVEN GENERATORS AS AN EXTERNAL SOURCE OF PROTECTIVE CURRENTS

By M. L. Jacobs*

The use of wind electric generators for the cathodic protection of pipelines is not new. Many hundreds have been in service for more than 10 years, on pipelines of various sizes and with various conditions and types of coatings. The purpose of this article mainly is to bring out and present certain facts concerning the new system of using wind electric generators in combination with magnesium anodes to secure a system of continuous cathodic protection for the pipeline.

It is well known that wind electric plants naturally are subject to periods of low wind and calm in which insufficient current is generated to give the desired protection. In many areas up to 80 percent of the time there is sufficient wind to generate a potential suitable for adequate protection. Different methods of supplying current during calm periods have been tried during the past decade, including storage batteries, but they have not been too successful because of the difficulty of distributing the current and often due to the amount of current required from the auxiliary source during calm periods.

Installations have been made in the last three years using a combination of wind electric plant and magnesium anode to prove and verify certain facts concerning this combination system. It has been learned that when properly placed magnesium anodes are attached to the pipeline in the area being protected by the wind electric plant, considerably fewer anodes are required than would be necessary if anodes alone were used. This apparently is a consequence of the fact that the wind electric plant, in raising a potential somewhat higher than necessary for periods of time, builds up pipe protection which is not immediately reversed when the wind plant gradually drops back to zero output. Anodes placed at low resistance spots automatically set up protective currents at these spots enabling the overall area to remain electrically protected, due to the periodic buildup of the wind electric plant, since the magnesium anodes cease to function in proportion to the pipe-to-soil potential built up by the wind electric plant. Their effective life is increased many times by the fact that the wind electric plant is supplying sufficient current a major portion of the time.

It is because of these two reasons — less anodes and less deterioration of the anodes per year — that the combination system is proving itself to be a very economical and effective method of pipeline protection.

Hardly any two pipelines corrosion problems may be solved by the same economics because of the wide variation in conditions, but as near average condition I submit the following methods of protection, A) with magnesium alone, and B) with magnesium used in conjunction with a wind plant:

*General Manager, Jacobs Wind Electric Company, Minneapolis, Minn.

Estimated cost of protecting 25 miles of poor to fairly well coated 8-inch pipeline under average right-of-way conditions over a period of 15 years.

A. Protected by Magnesium Anodes

Materials per mile (4 anode groups of 4 each)....	$ 91.71
Labor cost per mile..................................	53.60
Transportation, insurance and misc. costs per mile..	15.00
Total installation cost, per mile.........	$160.31

Estimated life of magnesium anodes, 5 years.

Total cost over 15 yr. period: 3x$160.31x25=$11,024.25

B. Protected by Magnesium and Wind Plant

Cost of installing wind plant.......................	$1000.00
Cost of installing magnesium (1 group/mi. no replmts.).......................	1002.00
Maintenance on wind plant ($50 per year).....	750.00
Total cost over 15 yr. period...........	$2752.00

Estimated net saving $11,024.25-$2752.00=$8272.25

This effects a saving of approximately $331.00 per mile.

No engineering costs are included in the cost estimates but this item probably would be practically the same regardless of which method of protection is used. Best results certainly would be afforded by a well-engineered job for the' combination method, but even the magnesium anodes alone could not be effectively installed without a certain amount of engineering.

As a means of comparison I submit below a cost estimate for a rectifier installation for the same conditions as was outlined above:

C. Protected by Rectifier

Cost of installing rectifier.........................	$ 800.00
Maintenance over 15 year period	752.00
Operating cost ($15 per month)	2700.00
Total cost over 15 yr. period	$4252.00

Estimated net saving: $4252-$2752=$1500.00

The combination effects a saving of about $60 per mi. over the rectifier.

This system is undergoing extensive field tests from Montana to Texas, which includes pipe inspection and inspection of anodes, and from engineering data now available which is being supplemented from month to month, the wind electric magnesium anode combination system will have an increasing part to play in the cathodic protection of pipelines, because the wind electric plant as now manufactured has very little annual maintenance, is not affected by weather conditions, does not require frequent attention and produces a large volume of current per month.

DISCUSSION

By O. C. Mudd*

Wind driven generators have been developed to a

*Shell Pipe Line Corp., Houston, Texas.

high degree of dependability. However, the factor of wind continuity still remains a major consideration when wind generators are installed.

Excessive current during high winds may even be detrimental and lack of current during periods of calm may allow corrosion to resume at a normal previous rate or may even occur at an accelerated rate.

Installations have been made where excess current is stored in alkaline storage cells to be utilized during periods of calm. In some installations this has been done without relays in any circuit, others may require relays to prevent current feed back to the wind generator especially where the storage cells exceed 6 volts.

The combination of wind generators and galvanic anodes appear to offer a fairly economical method of improving protection by wind generators and in some degree, resemble the storage cell combination with the advantage of having an assured current supply over extended periods of calm when storage cells might be totally discharged before recurrence of wind velocities to start the generator.

By L. K. Hedding*

Question No. 1 — In commenting upon Mr. Jacobs' paper, O. C. Mudd had described the use of Edison storage batteries in combination with the wind driven generator to supply power during periods of low wind velocity. My question was, "Is the battery connected in multiple with the generator when the generator is supplying power, and if so what provisions are made to prevent over-charging of the battery?"

Answer - By M. L. Jacobs

The battery is connected in multiple with the generator. However, no provision is necessary to prevent overcharging of Edison batteries as they satisfactorily withstand overcharges or discharging completely. Lead-acid type batteries are not satisfactory for this type of service.

By H. A. Robinson**

The installation of magnesium anodes in combination with the wind-driven generator features the use of the anode as a supplementary or stand-by source of current which becomes active only during periods of calm — when the generator is inactive. In service of this type the anodes obviously are subject to a fluctuating or intermittent type of current drain which raises a number of questions relative to the performance of the magnesium anode when used in this way. The general effect of this type of operation can best be appraised by considering the respective effects on: a) anode life, b) anode efficiency and c) the ability of the anode to resume normal operation after a period of idleness.

Anode life definitely will be increased inasmuch as the corrosion rate of the idle anode is markedly lower than that of the anode which is actively supplying current. The extent of the difference can be illustrated by comparing the performance of a 17-pound anode which continuously delivers 90 milliamperes with that of a similar anode in the same environment but on open circuit. In the gypsum-bentonite backfills ordinarily used, the corrosion rate of the idle anode is about one tenth that of the anode supplying 90 milliamperes, and corresponding anode lives are about 100 years and 10 years respectively.

Intermittent or fluctuating anode operation such as described above will, in general, tend to reduce anode efficiency, since some corrosion is occurring during periods when the anode is inactive. An estimate of the amount of decrease in efficiency in any specific instance would require a detailed current-time log, but a general idea as to the size of the effect can be obtained by assuming a simple case of intermittent operation such that the anode supplies current 50 percent of the time and is effectively idle the remainder. If the anode operates at 50 percent efficiency when delivering current, the efficiency realized for the combined on and off time will be about 45 percent.

Exception to the above statements could be taken if anode current were to be reversed during periods when the generator was active. In this case the anodes would receive cathodic protection when idle, and the attendant accumulation of alkali around the anode would have the effect of increasing the over-all efficiency. While this might be desirable from the standpoint of efficiency alone, other considerations make this condition definitely undesirable.

The ability of the anode to resume its normal delivery of current after a period of idleness will not be impaired so long as anode current flow has not been reversed during periods when the generator is active. Prolonged or frequent reversals of anode current flow would produce considerable quantities of alkali at the anode. In addition to inhibiting local corrosion and raising anode efficiency as noted previously, this would also effect polarization of the anode such that the anodes would be slow to pick up the load when the generator became idle. This tendency could be combatted by using backfills rich in soluble chlorides or sulfates, or by addition to the backfill of chemicals, e.g., ammonium salts, which, temporarily at least, would prevent the attainment of pH values above about 10.5. A more practical and effective solution, however, would consist in preventing anode current reversal either by designing the installation carefully so as to avoid excessively high pipe-to-soil potentials or by the use of suitable blocking relays.

By H. C. Van Nouhuys*

An inherent characteristic common to each of the three methods of cathodic protection presented in Mr. Jacobs' example is over-protection in the immediate vicinity of the anode or ground bed. In the case of the wind driven generator, however, this becomes a fortunate factor rather than an economic loss due to pro-

*Union Switch & Signal Co., Swissvale, Penna.

**Metals Protection Laboratory, Dow Chemical Co.

*Electrical Engineer, Southeastern Pipe Line Co.

longing decay of the protective hydrogen film on the pipe surface during periods of calm. In the vicinity of the points on the pipeline where protection falls to zero during periods of calm, galvanic anode groups will be required and as the end of the maximum wind generator spread is approached, anode groups in general will be more closely spaced until at the tip ends of the spread, spacing and deterioration of anodes will reach normal, i.e., the same as for a galvanic anode system alone.

This system is believed ideally suited for areas where soil resistivities do not exceed 5000 ohms per cubic centimeter. The suggestion is made that still higher soil resistivity may be economically allowable by using magnesium in the new ribbon form.

By Oliver Osborn*

In answer to a question asked regarding time required for a pipeline to depolarize after cathodic protection was removed, a specific case was cited as follows:

On well coated pipelines it is believed time required for depolarization may be a matter of several days. In one specific magnesium installation on a 20 mile 12" pipeline located in 500-1000 ohm/cm^3 Gulf Coast soil, from 10 to 14 days were required for the line to depolarize after the magnesium had been disconnected. Average polarized voltage was -1.10 volts ($CuCuSO_4$ Ref.); average depolarized voltage was -0.70 volts.

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*Electrochemical Engr. Dept., Texas Division, The Dow Chemical Company.