Speech presented to the National Association of Corrosion Engineers on February 12, 1954
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EXPERIENCES IN CORROSION CONTROL ON A PRODUCTS PIPE LINE

The subject of Corrosion, or loss of iron and steel and other metal products due to electro-chemical action is of vital interest to everyone. This loss on a continent - wide basis runs into billions of dollars annually. The theoretical and technical aspects of corrosion and its control have been covered in many excellent papers. This afternoon I wish to deal in an informal manner with some experiences and practical aspects of corrosion control, on one particular type of plant subject to its evils - namely, the refined products pipe line.

The Sarnia Products Pipe Line consists of about 188 miles of 12 and 10 inch pipe and about 12 miles of 6 inch spur line. Since a major part of a very large investment was to be put in the ground, cathodic protection of the line was included in the design from the outset.

Reviewing very briefly for a moment, the principles of corrosion protection by means of cathodic protection, we recall that the corrosion or rusting of steel or iron is an electro-chemical process. In this process we have a chemical action accompanied by the flow of an electric current. This current is usually thought of as the so called direct current and by the standard convention flows from the anode through the electrolyte to the cathode. It is where the current leaves the anode and enters the electrolyte that corrosion occurs, except in a few special cases. In the cathodic protection technique the structure to be protected is forced into being the cathode by means of externally applied potentials, thus transferring the corrosion to some expendable structure which is forced into being the anode. All cathodic protection systems work on this principle.

The amount of current required to force the pipe or other structure into behaving as a cathode is a function of many variables. Two of the most important are the resistivity or resistence per unit volume of the soil, and the degree of insulation between the structure and the soil.

By considering ohms law, it can be seen that the better the insulation between the pipe and the soil, the less current that will be required to attain an adequate pipe to soil potential. This brings us to the subject of pipe coating. Our Sarnia Products pipe line is wrapped and coated throughout its length. This coating consists of a layer of coal tar, enamel applied hot to a depth of about 3/32" into which is wrapped a fibreglass cheesecloth-like mat for tensile strength. A layer of felt paper is then applied over the coating, as protection against damage while the pipe is being laid and during and after the backfilling operation. The coating is checked for insulation leaks by means of a "Holiday" detector or Jeep. This little instrument applies high voltage pulses across the coating and will detect even tiny pinholes in the coating. The voltage applied is about 10 KV, but the pulse width is small enough so that there is not enough energy to burn or damage the coating.

We now have about 200 miles of very valuable steel pipe buried in the ground with a coating which is as perfect as can be made at the present time. One might wonder why we need bother with any further protection. Consider for a moment a very small hole in the coating. Under certain conditions this portion of the pipe may be subject to a potential such as to cause currents to flow out into the soil electrolyte at this hole in the coating. The small area of pipe under the hole will be the anode and rapid corrosion will take place at this one point. The actual loss of metal will be small, but it takes only a very small hole to make a sizeable leak in such a pipe line.

For the above reasons, we believe that the best solution in the long run is a pipe with as good a coating as possible, followed by a systematic application of cathodic protection. With a good coating, one current source can protect about 30 to 40 miles of pipe. In Ontario where electric power is readily available, the obvious choice of a current source is a small selenium rectifier. Having decided on the current source, two problems remained - the size of the current source and the number and distribution along the pipe line, with perhaps the third problem of the type of structure to use as an anode at each rectifier site.

As we pointed out before the amount of current, and therefore, the rating of the rectifier, is a function of the coating and the soil resistivity. Accordingly, a preliminary survey was carried out in the early planning stages to sample the soil resistivity at various points along the line. At this point we enter upon the practical aspects of corrosion control - barbed wire fences, wet boots, irate farmers and their legendary daughters, broken automobile springs, etc. One of our members here present helped carry out much of this preliminary work and will bear me out on some of these sidelights, I am sure.

Now having obtained a fairly complete set of measurements, and armed with some curves of pipe coating performance under various conditions, we were able to make a reasonably accurate calculation of current requirements and current source spacing. After applying a generous safety factor for coating deterioration and the probability that parallel structures would eventually be bonded to our pipe, we standardized on 10 ampere, 25 volt selenium rectifiers, with a tap adjustment for rectifier stack input voltage and therefore current output. The required number of such units was still somewhat nebulous, since the pipe was not yet in the ground.

In order to facilitate analysis and test of our cathodic protection equipment, we decided to install test leads at one mile intervals along the line. These leads consist of #8 type TW wire, thermite welded to the pipe and brought up to a small weatherproof terminal box for easy access. At certain points two test leads were installed, with the points of connection about 150' apart to permit measurement of the direction and magnitude of currents on the pipe.

Following the installation of the test leads, another survey was performed. This time pipe to soil potentials at various points were measured, and an attenuation curve was plotted from these results. This curve was a valuable aid in deciding the number and location of the rectifiers. Inspection of the curve indicated that rectifiers could be spaced evenly along the line at approximate 30 mile intervals. It thus began to look as if we would require six rectifier sites, each unit covering a section of line 15 miles each side of the site.

The choice of the rectifier sites was the final problem (we thought). Six points were first marked on the map at equal intervals along the line. A field trip was then made and the general area around each point was inspected and checked for

(1) Availability of power
(2) Good road access
(3) Soil resistivity
(4) Required property right-of-way

The actual resolution of the above factors proved more difficult than one might at first imagine. Anyone familiar with Ontario's sideroads knows that they are not laid out in a very logical manner. In some cases the points on the map had to be moved east or west as much as 10 miles in order to get a site that had a reasonably good road and available power.

In some cases, the ideal locations from the standpoint of low soil resistivity were inaccessible, had no power, or suffered from both maladies. The choice was thus a compromise, and six locations were chosen which seemed about the best under the circumstances. These sites were inspected with an eye towards the installation of the ground beds, the necessary cable trenches and the amount of property for which it would be necessary to obtain an easement.

Preliminary overtures were then made to the landowners involved, and this proved to be a most enlightening experience! It is very hard to convince a farmer that electric apparatus is not necessarily lethal. Also we found that at one of our pet locations, situated miles from anywhere, the land was valued like gold as a large industrial development site, and no structure, underground or otherwise, could be erected on it. However, with considerable rearrangement, moving of locations and relocation of ground beds, we were finally able to obtain the necessary easements. The location of every site which we had originally decided upon was different, but on the whole the system appeared to be workable.

At this point I might mention that we had decided to use 10 graphite anodes for each ground bed, these were to be located about 500' from the pipeline connected together with 15' spacing. Each rod would be centred in a hole about 10" in diameter and 12' deep with coke breeze or carbon granule backfill, to increase the effective area of the anode, and thus result in long life and low maintenance. It was also decided that the holes would be made by means of a power driven auger. The ground bed would be connected to the rectifier by means of a #8 TW cable with double thick insulation, and the rectifier would be connected to the pipeline with a similar cable.

Construction started at the Sarnia end in the midst of a blinding rainstorm, and close on the heels of the disastrous tornado. Several large items of debris, among these the twisted remains of a farm windmill were moved to one side to allow the backhoe operator to complete his trench. The first installation was completed to the best textbook standards, however, and measurements indicated a very satisfactory job.

The first job was the exception which proves the rule as they say. On the next site we encountered the old practical aspect again. This time it appeared in two forms - one was solid rock at about four feet, and the other was the landowner's wife at about 212 degrees.

As a result of these two unforeseen variables, it appeared that:

(A) We would have to revise our technique of vertical anode placement and

(B) We would have to change the configuration of our ground bed or be sued for being off our prearranged easement.

Accordingly, 10 trenches the length of an anode were made with a backhoe and a smaller trench about a foot deep was made in the main trench. This small trench was filled about half way with carbon backfill and the anode laid in place. Backfill was then placed to a depth of about a foot above the anode and the remainder of the trench was filled with clean gravel. The completed ground bed was very satisfactory and the same technique was used on several other sites where rock conditions made it impossible to install the vertical type of bed.

On one other location we encountered a condition that was even more difficult to overcome than the rock. This was quicksand about three feet below the surface. The presence of the watery sand made the value of the carbon backfill rather doubtful, and in this case the anodes were installed without the powdered carbon. The completed bed proved satisfactory, but we anticipate a much more rapid deterioration of the graphite anodes.

Following the installation of the rectifiers, a survey was started from the Sarnia end, and the rectifiers were turned on, one by one, and spot checks were made of pipe to soil potential, and the rectifiers were adjusted to give a minimum of 850 millivolts as measured with a bridge voltmeter and a copper sulphate electrode.

A point to point survey was then performed, with a pipe to soil reading made every mile. From this information, a curve of pipe to soil potential on a pipeline mileage base was prepared. This curve was surprisingly uniform, with potentials averaging about a volt with rectifier current outputs averaging less than 2 amperes. These results show that preliminary surveys, and good initial engineering pays dividends, even though plans may be somewhat upset by unforeseen field conditions. The low rectifier currents also serve to show that a good coating job is well worth the investment, since it reduces to a minimum the chance of interfering with other buried structures, and cuts down on operating power costs.

The lower Don Valley portion of our Products Pipe Line has not as yet been thoroughly checked, and the protection technique has not been decided upon. However, due to the complex arrangement of underground plant in this area, it appears that perhaps the best solution would be magnesium anode beds placed at intervals. This would give good protection, and would cause little or no interference with other buried structures.

In closing, I might say that one of our greatest problems in the corrosion field is the protection of the buried pipe and conduit at our pump stations and terminals. This is a difficult one since all the equipment is grounded to banks of copper ground rods. We are working for a satisfactory solution to this problem since we know from inspection that some of our plant is already being subjected to severe corrosion.

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April 6/54.