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CORROSION AND CONSERVATION OF BURIED METAL STRUCTURES

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Corrosion of metal is its disintegration, due to chemical action. In the case of buried metal structures it is caused by the action of chemicals in the soils, soil waters and other materials that are in contact with the buried metal. However, no appreciable corrosion can occur in the absence of moisture. A steel pipe may safely be buried in dry chemicals for an indefinite period, but if moisture is added, severe corrosion may result. Pure water will not corrode metal, but if a small amount of corrosive chemicals is dissolved in the water, it will become corrosive. Two major factors must therefore be considered in connection with corrosion: chemicals and moisture. In the presence of large amounts of chemicals that we know will attack metal when moist, moisture will be the controlling factor, but if the metal is constantly wet, the amount and character of the chemicals will control the severity of the corrosive action. There are also other factors that often tend to influence corrosive action to some degree, and in rare cases do exert a powerful influence. Among these may be mentioned: temperature, physical characteristics of soil, differences in potential, and stray currents.

Temperature will affect the rate of a chemical reaction, and more corrosion will result from a warm solution than from a cold one. The physical characteristics of the soil will affect the rate of percolation of soil waters and will determine

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the character of contact between the metal and surrounding materials. Heterogeneity of soils may lead to differences in potential within the soil itself and also between the soil and the buried metal. Differences in potential will probably accelerate corrosion to a degree proportionate to the current flow. Stray current electrolysis is an example of this type of action.

If a pipe line is the underground structure under consideration, we shall find that these principles can be applied in practice. It has been found that there is little difference in the rate of corrosion of iron and steel. Iron pipe is usually quite thick, and as the pitting rate tends to decrease with the depth of the pits, a considerable service life is usually realized from iron pipe, even in corrosive soils. However, the results of the Bureau of Standards soil corrosion studies show that the service lives of iron and steel pipe of the same thickness may be expected to be equal, if used under the same conditions.

If we intend to place a pipe in soil, and wish to obtain an idea as to the length of service life that may be expected from it, we must know what chemicals are present in the soil and also the amount and character of the soil waters. In most cases we can safely assume that most of the available water will percolate through the soil from the surface down to the depth at which the bottom of the pipe will rest, but we must also consider that certain waters may be present that have traveled a considerable distance underground and, therefore, may have entirely different characteristics.

If a soil sample is taken by means of an auger from the surface down to the depth of the bottom of the ditch, we will obtain a cross section of soil through which surface waters will penetrate to reach the bottom of the pipe, and if we seal this sample immediately, we will be able to retain all of the natural contained moisture. A chemical analysis of the soil and the waters, or water extract, will disclose the presence and amount of all chemicals that we know to be corrosive, non-corrosive, accelerators or inhibitors of corrosion. We shall then be able to give the soil a chemical and physical rating in the scale of corrosiveness and this, when correlated with a study of the topography in the neighborhood of the test, with particular consideration to the drainage, exposure, and use of surface, will enable us to decide, with a reasonable degree of accuracy, whether the pipe will serve for a considerable period without any protection or whether the use of an expensive coating is justified.

It has been found that the same characteristics frequently obtain in a soil over considerable areas, and close sampling need not be resorted to. However, if a decided change, either in the nature or amount of chemicals, is found in adjacent samples, it is necessary to take additional samples in order that the point of change may be located.

This method also has applications other than determining the relative corrosiveness of unknown soils. It has been used in the City of Denver to determine the dividing line between a decidedly corrosive and a comparatively non-corrosive area. It was found that on one side of the line the soil contained considerable amounts of soluble chlorides and sulphates, while on the other side very small amounts of these chemicals were present. The dividing line followed a contour line rather closely, and could be accurately traced on a map of the gas distribution system. This line was then extended beyond the present distribution system in order that corrosive areas would be known when the system was extended. A corrosion survey was made of the City of Pueblo for the Pueblo Gas & Fuel Company, in order that the nature of the chemicals causing very severe corrosion in certain parts of the town could be determined and a means of protection suggested.

In conducting a survey of this nature it is well to keep in mind the fact that, regardless of the apparent dryness of the location, moisture is sure to reach the pipe at certain times. The amount and character of annual precipitation should be considered, and also the probability that the trench will provide a drainage way for all excess moisture, both from rainfall and melting snow, also for any ditches that may be near and above its bottom level. It is probable that the soil around the bottom of the pipe will always contain more moisture than will be found in the soil sample above it.

As we know that at least a certain amount of moisture will be available for chemical reaction, we must consider the chemicals in the soil and soil waters as most important factors to corrosion. In rating them as to their relative importance, it is well to remember that any chemical that will attack steel on the laboratory bench will attack steel in the ground. Strong alkalies are usually destructive, but the chlorides and sulphates seem to be the most harmful. Sulphides are dangerous because they may contact with the pipe and because they are apt to become oxidized to sulphates at some future time. Calcium carbonate, or limestone, is not only non-corrosive but seems to have an inhibiting action when corrosive chemicals also are present. All soil acids must be considered corrosive until some practical means is evolved for the separation of the various organic acids and the determination of those that are most destructive.

Mountainous regions are usually alkaline, and in arid regions the soils adjacent to them and extending for several hundred miles from the foot-hills are usually alkaline. As we get farther from the hills and into a region of increased rainfall, the alkalies are less strong, a considerable amount having been removed by leaching. In a region of abundant vegetation, we find that the soils are mostly acid, probably due to an abundance of organic acids generated by decayed plants.

It is of little use to determine when and where we may expect corrosion, unless we have some means of combating it successfully, or at least of modifying its destructive action. We know that no appreciable corrosion can occur to dry metal, and therefore we may safely conclude that any material that is capable of excluding soil waters will prevent serious corrosion to underground structures. A film of any thickness that would be impermeable to all soil waters for an indefinite period would be an ideal coating, provided that it had the necessary properties to resist the stresses and abrasions of underground service. Until a material has been discovered that will provide such a film, we shall be forced to depend upon a thick coat to protect the metal for any considerable time.

There can be no protection unless a continuous coat of the protecting material covers all parts of the metal. There is little doubt that most coating failures are due to misapplication, but it is also true that many failures are due to a poor choice of coatings. A certain coating giving satisfactory protection in one location may be totally unadapted to serve in another. The chemicals present in the soils must be considered.

Hot coatings, or coatings of materials that have to be heated for application, are often chosen without thought of the conditions under which they are to be used. The melting point is of the utmost importance. A material of high-melting point should be used in a hot climate in order that the coat will not run from the pipe before lowering, but that same material might be brittle and crack if applied to cold pipe and lowered and back-filled in cold weather. The use of a low melting-point material in low temperatures will tend to assure a good coating on the buried pipe without the use of excessive amounts of "flux." High atmospheric temperatures, of course, demand a material of high melting point, which not only prevents sliding, but assures a coating hard enough to resist a considerable amount of abrasion and soil stress.

Wrapped coatings should be used where severe abrasion may be expected. The wrappings themselves usually have little or no resistance to soil waters, as they are seldom thoroughly impregnated with the coating materials, but where properly applied they protect the coating beneath from being removed by abrasion.

Paints containing vegetable oils should not be used in alkaline soils, as the oils are apt to saponify. Concrete is subject to attack by certain chemicals found in soils. Thin coatings of any nature should not be used in extremely corrosive conditions. The addition of an inhibitor to any coating material may increase its efficiency by retarding corrosion if soil waters should penetrate to the metal.

The economics of protection must be considered in the following manner:

1. If metal is to be buried in a soil, will that soil destroy the metal in such a short time that some form of protection seems advisable?
2. Is it possible to obtain some form of protection that will prolong the service life of the structure?
3. Will the additional service life obtained assure an adequate return on the investment in protection?

It has been estimated that over half of the coatings applied to pipe lines in the past might have been saved if some knowledge of the corrosiveness of the locations had been obtained beforehand. We are probably safe in estimating that half of the remainder were either misapplied or gave underprotection, and a considerable amount were not adapted to meet the existing conditions. Engineers and chemists are now devoting a great deal of time to the subject and are making rapid strides that will, undoubtedly, save millions of dollars through preventing the use of unnecessary protection, but at the same time assuring adequate protection to service and investment.