New Techniques Help Win the Corrosion Battle

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A few years ago the word "corrosion" was not used with familiarity by most of those people charged with the maintenance of underground plant facilities.

→ Rusting usually manifested itself in "red water" problems.

→ Pitting in boilers was recognized as a treatment inadequacy.

→ Leaking in underground piping was thought to be due to a peculiar set of circumstances involving the metallurgy of the pipe and some unique and, hoped for isolated soil condition.

But recent and continuing studies on economic losses due directly and indirectly to corrosion have pointed up the importance of corrosion mitigation. Organizations such as The National Association of Corrosion Engineers have done much to educate the public on both the economic advantages of corrosion protection and the modern techniques being used today in this continuing battle.

The word corrosion encompasses all those processes which degrade a metal by combining it with some element in its environment to produce a corrosion product that has not retained the useful properties of the original material.

The corrosion process is electrochemical in nature and always proceeds in such a direction that the energy contained in the corroding system is reduced. Energy is put into metals when they are produced from their ores by the various smelting and electro-metallurgical processes. Some metals contain more energy than others and have, therefore, a greater tendency to corrode, while others with less energy resist corrosion. In general, copper has better corrosion resistance than iron due to the fact that copper has a lower free energy level than iron.

All aqueous corrosion takes place in individual corrosion cells in which there is an anode or corroding element and a cathode or non-corroding element. For corrosion to proceed there must be a metallic path between these two elements for the exchange of electrons and an aqueous or electrolytic path for the movement of charged metal atoms or ions. Processes involving oxygen at the cathode (the non corroding element) usually determine the rate of the corrosion reaction.

These cells can be set up by coupling together two different metals having different energy levels and burying them in the soil, or by different surface conditions at different locations on the same buried metal structure. Differences in soil composition arising from the mixture of different soil strata or chemical contamination can also result in the setting up of corrosion cells. This makes it apparent that corrosion of metals in the soil is a natural process and that peculiar circumstances would pertain if corrosion did not take place.

Corrosion problems involving plant service piping sometimes remain unrecognized for extended periods of time. Cast iron drains, if undisturbed, will function even though severely graphitized and leaks in water piping are difficult to detect unless they are very large. Corrosion is discovered on these systems only when they are excavated for reasons other than repair such as main extension, etc. during plant expansion programs.

Process piping contains many chemicals not normally found in the soil and even small leaks are usually noticed even though their location is sometimes difficult. These pipes often operate at relatively high pressures and sometimes above ground ambient temperatures. If the pipes contain hazardous materials it is usually necessary to shut down a process to effect repairs. Since heat accelerates most chemical reactions, warm pipes can be expected to corrode more rapidly than cold pipes in the same environment. Cooling water return, condensate return, and heavy fuel oil lines are known to have a short life underground.

Corrosion of underground systems in industrial areas is bound to accelerate. The increased complication of piping systems over large areas, the variety of materials used in these systems, and even the different ages of the systems tend to set up large corrosion cells with watermains, electrical neutrals, and interplant piping serving to provide the necessary electronic connection between these various corroding elements. Soil contamination due to sanitary landfill, industrial waste, and air pollutants brought down by rain set up the conditions necessary for rapid deterioration of buried piping.

Modern practice dictates that all piping systems installed in the soil should be coated and wrapped. Since the gas and oil industry have established excellent coating practices it would be wise to coat to specifications established by these industries. Pipe can be obtained yard wrapped to these specifications using hot applied pipeline enamels, polyethylene, and P.V.C, tapes, and extruded plastic coatings. These coated systems must be electrically insulated from all other piping in the ground and supplied with an electrical system called cathodic protection to supplement the coating.

Cathodic protection is achieved by forcing a direct current onto a metal surface from the soil to reverse the current flowing in the corrosion cells. It is possible to completely stop corrosion by this process alone but for economic and engineering reasons it is usual to rely on a coating system to protect most of the buried metal with the cathodic protection system being relied upon to look after the unavoidable pinholes, backfilling, and construction damage. It can be seen that the interconnection of a well coated system under cathodic protection with an old bare system would completely negate a cathodic protection scheme designed to look after a few square feet of bare area.

On well coated, isolated systems it is often possible to supply sufficient cathodic protection current from magnesium anodes installed in the soil near the pipe and connected to the pipe by means of a copper conductor. This anode sets up a corrosion cell in which the pipe is the cathode or non corroding member due to the higher free energy contained in the magnesium. These anodes are usually designed to last for 15 or 20 years after which they require replacement.

If higher levels of protective current are required, rectifiers which force current into the ground through specially prepared graphite or Duriron ground beds may be used. It is possible to determine the level of protection obtained by taking structure-to-soil potentials, using a high resistance voltmeter and a suitable reference electrode.

Existing underground piping and tank systems are amenable to cathodic protection techniques at considerably increased cost. When this cost is related to costs for replacement, downtime, lost product, hazard, etc., it usually proves to be highly desirable from an economic viewpoint. For example, a 10 in. products line when faced with an exponentially rising leak curve resorted to a cathodic protection program at a cost of $5,000/mile when it was found that line reconditioning would cost $40,000/mile.

Corrosion mitigative programs on existing systems should give priority to all lines or tanks operating above ground ambient. It does not usually matter whether or not these are coated or placed in special backfill. Corrosion will concentrate at coating imperfections and since permeable backfills are infiltrated with soil waters they do not prevent corrosion.

Owing to the depth of the excavation necessary to bury large, heavy fuel oil tanks some portion of these tanks usually remains below the water table. If placed in a heavy soil and sand backfilled a virtual “bath tub” is produced in which the tank sits. Little care is taken in coating these tanks, one or two coats of a cutback asphalt with a thickness of 2 mils is typical. If this coating is compared to a modern pipe line coating of 100 mils of hot applied, reinforced asphalt or coal tar, its adequacy is clearly evident. In many cases these tanks are placed under loading aprons of asphalt or concrete making inspection or repairs a costly item.

Before cathodic protection can be considered electrical isolation of the system to be treated is a prerequisite. This sometimes proves very difficult or impossible due to accidental contacts with other underground piping or contact with reinforcing rods at building entries. If isolation can be achieved, cathodic protection can usually be applied at a price much below tank or pipe replacement costs.

Some large refineries have recently embarked upon programs designed to cathodically protect their entire underground plants at costs of up to $200,000 since their studies have convinced them of the value of the application of this important corrosion prevention measure.

When steam lines are placed underground they are either installed in tunnels or some proprietary type of steam conduit is used which consists of the steam pipe surrounded by thermal insulation and encased in a conduit made of a relatively thin gauged corrugated metal. When these conduits are initially installed they have excellent thermal characteristics but, nevertheless, the surface of the conduit remains above ground ambient.

As with most other underground structures installed in the past, the coatings on many of these conduits have been inadequate, and many existing systems have been perforated in many places due to corrosion. If the conduit remains above the water table this damage is seldom evident. However, if the water table rises and water enters the conduit, serious internal corrosion of the conduit can occur which is further accelerated by the breakdown of the thermal insulation.

In some types of steam conduit the steam carrier pipe and condensate return pipes are supported by metal brackets which promote the leakage of heat from the carrier pipe to the outer conduit at each support location causing accelerated corrosion at these locations. Lack of internal insulation in manholes and valve pits is often responsible for sufficiently high heat losses to raise the temperature of the ground surrounding the manhole, resulting also in accelerated corrosion of these conduits in the vicinity of the manholes.

As with the underground tanks, high quality coatings (preferably a coating that is insensitive to occasional high temperatures), electrical isolation, and cathodic protection are mandatory for new systems. On existing system, electrical isolation may be impossible due to contacts between the conduit and building reinforcing steel at building entries. In this case, corrosion damage can be lessened if the conduit can be kept dry internally so that thermal losses and the consequent high surface temperatures in contact with the soil can be reduced.

Sometimes this can be accomplished by improving drainage in the manholes, improving thermal insulation of the manholes and the installation of the drains along the conduit runs to keep the water table below the level of the conduit. Supplementary cathodic protection can be installed on these portions of the conduit run that are remote from other plant piping.

Since corrosion is a natural process it will occur unless specific measures are taken to combat it. Industry is becoming educated in corrosion mitigation practices and has proved to its satisfaction that coatings and cathodic protection, used in combination, can result in substantial maintenance savings.