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PIPE LINES – EXTERNAL CORROSION

BY

DAN BABOR

Abstract. Two areas of corrosion occur in pipe lines: corrosion from the medium carried inside the pipes; corrosion attack upon the outside of the pipes (underground corrosion. Electrolytic processes are also involved in underground corrosion. Here the moisture content of the soil acts as an electrolyte, and the ions required to conduct the current are supplied by water-soluble salts (chlorides, sulfates, etc.) present in the soil. The nature and amount of these soluble materials can vary within a wide range, which is seen from the varying electrical conductivity and pH (varies between 3 and 10). Therefore the characteristics of a soil will be an important factor in under-ground corrosion.

Key words: corrosion, electrolytic, pipe line.

1. Introduction

On buried pipe lines the following principal types of corrosion will occur.

2. Corrosion Resulting from Oxygen Content.

Oxygen from the atmosphere or from oxidizing salts tends to form oxides with metals. If these oxides are soluble the corrosion attack is greatly accelerated, if these corrosion products are insoluble, they may reduce corrosion by forming a protective layer; on the other hand they will increase the corrosion attack if they are nobler than the bare metal. Corrosion also may be promoted by oxygen concentration cells when a pipe line passes through soils of different oxygen content.

3. Corrosion Resulting from Passing through Soils of Different Mineral Content.

The potential along a pipe line depends to some extent on the soluble salt content of the soil. It is found that sections of a pipe line passing through soil of high salt content are anodic to sections about which the alt content of the soil is lower (Fig.1).

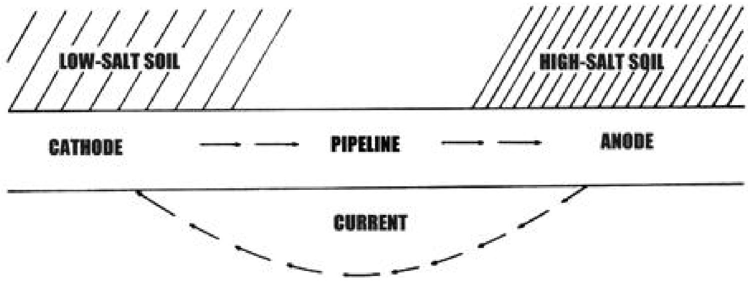

Fig. 1. – Pipe line corrosion in different soils.

4. Corrosion Due to Contact of Dissimilar Metals, Particularly at Valves.

This is a typical galvanic corrosion.

5. Stray Current Corrosion (Electrolysis).

It arises in the following way: electric current from a D.C. power station or other source of supply reaches the consumer (for example a locomotive) through a rail or suspended wire. The current through the consumer is completed by a return rail connected to earth (Fig. 2).

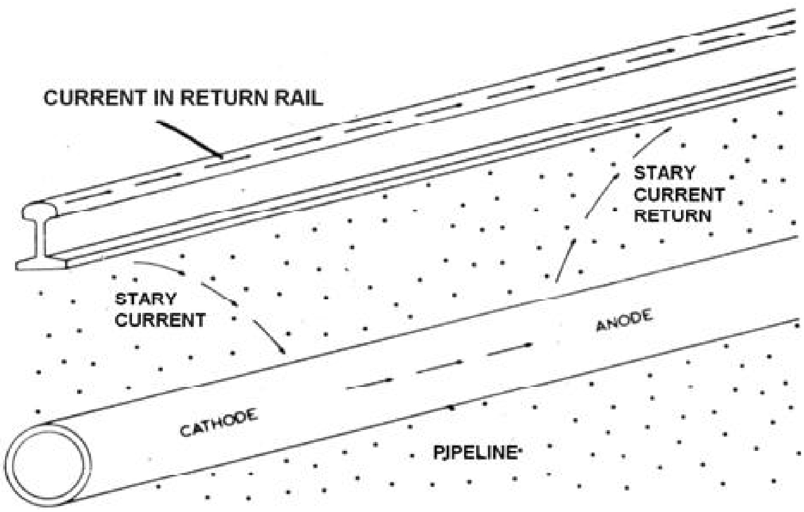

Fig. 2. – Stray current corrosion.

While the conductivity of the rail is much higher than that of the earth, a portion of the return current is still diverted into the earth. This current, through the earth, will readily pass through any metallic conductor, such as a pipe, in its path. Where the electron flow begins in the pipe-line an anodic reaction (corrosion) takes place, and where the electron flow ends in the pipe and the electrical conduction is resumed by the earth there is a cathodic (protective) reaction.

6. Corrosion Supported by Bacteria.

Corrosion is also observed in absence of oxygen when sulfate-reducing bacteria are present. These bacteria are found in soils, deep wells, and seawater. By their metabolic processes they are capable of depolarizing cathodic areas. Corrosion attacks initiated by such bacteria may rapidly lead to destruction of piping.

In cast iron pipes a type of corrosion is occasionally observed which is called graphitization. Herein a great part of the metallic matrix is removed from the affected zones, leaving behind a black porous structure, which may retain the shape of the original, metal but lacks its strength. The graphite embedded in the metallic matrix acts as a cathode, and the metal as an anode. This phenomenon is seldom observed except in highly aggressive soils and is a result of stray currents or electrical currents due to the potential differences set up in soils of varying properties through which the pipe line happens to pass (see below).

The relative corrosion resistance of a large number of metals commonly used for piping, buried for protracted lengths of time in a number of soils over the country. The corrosivity of various soils differs greatly, and because of the scatter of results caused by many factors (for which the references cited should be studied) only the roughest generalization can be made in a limited space.

It has been demonstrated that none of the commonly used ferrous metals (such as open-hearth steel, wrought iron, Bessemer steel, plain carbon steel, pit cast iron and centrifugally cast iron) are immune to corrosion in all of the soils, and that in the same soil these materials corrode at nearly the same rate.

In low-alloy steels, as compared with plain steels, the initial rate of weight loss is lower, but the initial rate of pitting is higher. Except the very poorly aerated and reducing group of soils, the rate of pitting diminishes with time more rapidly for the alloy steels than for plain steels.

Higher alloy steels with high chromium content are observed to have deeper pits than plain steel in most of the soils. The tendency of high concentrations of chromium to accelerate pitting appears to be neutralized by adding sufficient nickel to produce austenitic steels (such as type 302), which are found to be wholly resistant to corrosion. Also austenitic cast irons are considerably more resistant to corrosion than plain cast iron.

Pipe specimens of copper and copper alloys exposed up to 14 years in a wide variety of soils indicate that tough-pitch copper, deoxidized copper and copper containing up to 3% Si with and without addition of tin, and red brass (containing 15% Zn) all behave essentially alike.

Galvanizing substantially improves the corrosion resistance of buried steel. A zinc coat of 2 oz./sq. ft. was sufficient to protect the underlying steel exposed for 14 years in inorganic oxidizing soils, but in inorganic reducing and highly reducing organic soils thick coatings are required.

Rubber and rubber-like coatings afford complete protection. The same is true in steel pipes coated with porcelain enamel.

7. Protection of Underground Pipe Lines

In highly aggressive soils it is recommended to apply special coatings to the pipes or employ other methods of corrosion prevention. Before about 1930 underground pipe lines were protected from corrosion almost exclusively by the application of coatings, usually bituminous. Later this was displaced by the application of cathodic protection, frequently together with a protective coating. In this case the cathodic protection consists of impressing an electromotive force on an underground pipe line or structure to keep it cathodic with respect to the ground. Where a convenient D. C. source is not available, anodes of aluminum, magnesium, or zinc are used.

Coatings used to provide corrosion protection to underground pipe lines show different resistance to microbiological deterioration.

Whereas the corrosion inside the pipes must always be considered, an appreciable outside attack is rarely found except in subterranean pipe lines buried in aggressive soils.

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"Gheorghe Asachi" Technical University, Jassy
Department of Concrete, Materials, Technology and Organization

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COROZIUNEA EXTERNĂ A CONDUCTELOR METALICE

(Rezumat)

Conductele sunt afectate de două fenomene distincte de coroziune, coroziunea datorată fluidului transportat prin conductă şi coroziunea cauzată de agenți externi (cunoscută şi sub denumirea de coroziune subterană). Acest proces de coroziune (subpământeană) este, printre altele, favorizat şi de anumite fenomene electrolitice. În acest caz, umiditatea din sol joacă rolul de electrolit iar ionii care realizează transportul de curent sunt generați de dizolvarea sărurilor prezente în sol (cloruri, sulfuri, etc.). Tipul şi cantitatea acestor săruri pot varia foarte mult, lucru ce se poate observa din încadrarea măsurătorilor privind conductivitatea şi pH-ul (între 3 şi 10) intr-o plajă largă de valori. Se poate concluziona că natura şi proprietățile solului sunt factori importanți în ceea ce priveşte coroziunea subterană.