Cathodic Corrosion Protection of earthburied Pipelines
Corrosion Problems?

Earthburried pipelines are usually expensive investments. In order to defend against the threat of corrosion they are protected by coatings and coverings. However, the smallest damage of the coating or any cracks in the covering steadily lead to the feared pitting corrosion.

Corrosion causes an electrochemical reaction which leads to loss of metal. As a result pipelines become leaky and can cause enormous damage to property and environment.

Conservation of Value

The expected lifespan of a pipeline network is, depending on the transport medium, a minimum of 50 years. However, a pipeline should be functional for up to 100 years. Cathodic corrosion protection offers an optimum of safety and efficiency because with a cathodic protection system pipelines can be operated even in critical soils reliably.

Cathodic Corrosion Protection - the Solution

Cathodic corrosion protection (CCP) belongs to the oldest protection methods at all. V&C has been working in the field of cathodic protection of earthburried structures since 1971. Today it is one of the leading suppliers in Central Europe.

CCP as an active protection method attacks corrosion - in contrast to passive protection methods - at its roots. It is based on the connection between the potential of steel and the corrosion rate. Through installation of a negative protection current the electrochemical potential of the pipeline is brought to a stable passive state and the corrosion process is stopped.

The high-quality-work of cathodic corrosion protection is regulated by numerous standards, guidelines and recommendations. Besides V&C collaborates actively with professional associations such as the Austrian Association for Gas and Water (OVGW) or the German Gas Association (DVGW). Furthermore V&C has been working according to the quality managementsystem ISO 9001 as well as the safety and environmental managementsystem SCC (Safety Certificate Contractors) for many years.
Basics of Cathodic Corrosion Protection

Corrosion is always due to differences of potential between metallic materials (e.g. pipelines) and its environment. It is an electrochemical process that leads to destruction of material on the metallic surface. The oxidation process can be described by the following formula:

\[ \text{Fe (metal)} \rightarrow \text{Fe}^{2+} \text{(soil)} + 2e^- \]

The base anode decomposes whereas the noble cathode stays free of corrosion.

This process can be changed by applying electrical voltage between metal and ground. The following illustration shows how the electrochemical potential between metal and ground influences the corrosion rate. The graphs represent the different soil types.

It is clearly indicated that the corrosion rate lessens with increasing electrochemical potential, whereas a corrosion rate of 10µm per year is technically regarded as negligible.

In order to minimize loss of pipeline material it is necessary to have a pipe-soil-potential of -0.75 to -0.95 V (versus a copper/coppersulfat reference electrode).
**Highest Economic Efficiency**

Through application of a cathodic corrosion protection system the costs of maintenance for pipeline networks can be clearly reduced. A lower vulnerability of the plants allows longer maintenance cycles and as a consequence the upkeep can be cut in half.

The specific costs of cathodic corrosion protection depend on several factors. So it is not only the lengths of the pipeline or the network that is crucial but also the age of the net and whether the pipeline has already been renewed or not.

In principle the costs for a cathodic protection system run up to 4 - 15% of the total amount of the building costs for a pipeline system. This amount, however, bears no relation to the costs of any repair works or loss of production.

The economic efficiency of cathodic corrosion protection is illustrated in the figure above. It shows that even an afterwards installed protection system at existing pipelines leads to a reduction of the costs of maintenance. A cathodic protection system improves the operation of the network which results in a greater safety and an avoidance of a supply gap. Furthermore the lifespan of a pipeline network can be doubled by using cathodic corrosion protection.
Macrocell Corrosion

Macrocell corrosion is caused similar to corrosion of aeration cell by different resting potentials at different places. In contrast to aeration cells the differences of potential at macrocells are not due to different grounds but to different metallic materials.

Everywhere where reinforced concrete structures are in conjunction with metal pipelines macrocell corrosion can occur.

Causes of Corrosion

Pipelines are corrosion-endangerd by an interplay of influences like aggressive substances in the soil, galvanic connectors or sulphate-reducing bacteria in the ground. Basically it can be distinguished between four main causes that lead to corrosion of metallic structures.

Aeration Cell Corrosion

The resting potential of steel in aerated soils (e.g. sand) does not differ much from those in unaerated soils (e.g. clay). But is there any vacancy in the covering or coating of the pipeline which is in contact with different soil types, a voltage gradient occurs. This voltage gradient causes a corrosion current in the ground. At vacancies in unaerated areas corrosion can appear at a speed of up to more than one-tenth of a millimeter per year.

Steel in concrete has a potential that is several 100 mV more positive than those of earthburried pipelines. Due to the big surface difference of the reinforced concrete structure and the small pipeline vacancies severe corrosion damages can occur within few years. Ablation rates of up to one millimeter per year are possible.
Stray Current Corrosion

Railway tracks are connected electrically conductive with the ground by the roadbed. As a consequence part of the current which flows back in the rails streams as stray current into the soil.

For the simple reason that current always takes the path of the least resistance, it uses metal installations, such as pipelines or tubings, concrete reinforcement and cables on its way through the ground.

Due to the polarity of the railway feeding-in (positive pole at overhead electrical line and negative pole at track) stray current leaves mainly close to transformer substations and causes there a loss of material that leads soon to pitting corrosion.

Alternating Current Corrosion

Pipelines, that are led due to local conditions (e.g. mountains, densely built-up areas) underneath or close to high-voltage overhead lines, are greatly influenced by alternating currents.

Those induced alternating currents can not only cause enormous corrosion damages at pipelines but also dangerous high contact voltages that require special safety and protection measures.

Both in the case of stray current corrosion and alternating current corrosion it is necessary to install not only an active cathodic corrosion protection system but also a polarisation cell, that shunts hazardous voltages to ground. Only in this way any danger for man and material can be avoided.
The principle of CCP

There are two possibilities for designing an active corrosion protection system of earthburried pipelines: Cathodic protection with impressed current or galvanic anodes.

V&C offers both methods, however, it prefers working with an impressed current protection system for earthburried structures.

Cathodic protection with an impressed current protection system

An impressed current system uses - in comparison to a galvanic anode system - current which is produced by a rectifier and transmitted by foreign current anodes to the earthburied object to be protected.

The advantage of this method lies primarily in the possibility that the output voltage can be regulated depending on the soil resistance and the protecting current requirements of the pipeline. Furthermore cathodic corrosion protection with an impressed current system enables automatic recording of the state of the pipeline and thereby possible irregularities can be immediately recognised and remedied.

The anodes which are used for the protective current supply can be built horizontally or vertically in the ground. Depending on the local surrounding conditions there are primarily FeSi anodes used, either single or pre-finished as canister anode with backfill.

The effectiveness of the cathodic protection system is monitored through potential mapping.
Galvanic anodes have a livetime of maximum 20 years and have to be changed at the end of this time. However, in contrast to impressed current systems galvanic anode systems are less expensive.

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Cathodic corrosion protection with a galvanic anode system

For smaller objects or those where a power supply with rectifier is difficult (e.g. in less conductive grounds) cathodic protection with galvanic anodes is used. The method is based on the difference between the anode material and the object to be protected. As the anode material is not as precious as the metal of the pipeline, current flows automatically from the anode to the pipeline because of the voltage gradient.

The required number and size of anodes depend on the size of the object to be protected, the specific soil resistance and the planned term of protection.
V&C Rectifiers

The rectifiers of V&C are custom-build and in conformity to international norms and safety standards. They range from a simple, manually adjustable protection rectifier up to a fully automatic regulating rectifier station with remote control for the monitoring of several or complex objects.

Maintenance and Monitoring

The performance of a cathodic corrosion protection system is proven through adherence to standards and guidelines of prewritten criteria. In addition cathodic protection plants have to be monitored regularly. A complete monitoring system consists of reference electrodes, measuring devices, measuring points or a wireless remote data transmission system.

V&C offers its customers the maintenance of corrosion protection systems with wireless data transmission and remote recording of the data. The data are transferred via GSM network and can then be evaluated comfortably in the office. In this way a permanent monitoring of the protection plants is guaranteed and possible failures can be removed immediately.

Example of an automatic regulating protection rectifier with remote control

In addition V&C has a well-skilled and experienced staff team who can carry out commissioning and maintenance measurements on site.

Remote monitoring system via GSM network
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