Use of MOSCAD RTUs for Cathodic Corrosion Monitoring and Protection of Oil and Gas Distribution Pipelines

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1. Problem Description

Cathodic corrosion of metal pipes and storage tanks is a widely known phenomena. It causes damage to the installation, and at a later stage it might result in leakages and financial losses. Leakage of gas causes safety problems to the population, and this itself is a serious concern. Operators of pipelines learned this problem a long time ago and with Cathodic Corrosion Protection (CCP) they found ways to eliminate such corrosion.

When damage occurs along the pipe, due to any reason, the affected area develops "Negative" potential in reference to the ground and in reference to the "healthy" surface of the pipe. The voltage difference between that spot (in the pipe) and the ground results in Cathodic current flowing between that negative "Anodic" spot and the pipe surface. This leads to further corrosion, and eventually causes a hole to form in the pipe. See Figure 1. below.

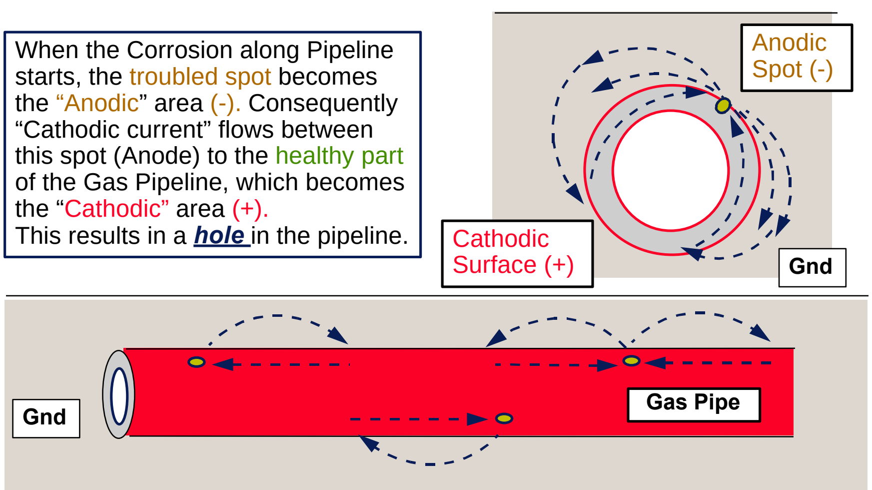

Figure 1. Destructive Corrosion Current

2. Cathodic Protection

A solution to this problem is provided by applying a negative potential to the pipe. This action will make the "healthy" surface of the pipe "more negative" than the affected spot in the pipe, thus eliminating the Cathodic current flowing between that spot and ground.

Creating such "Negative Potential Difference" results in an equally distributed current between the pipeline and ground. This can be achieved by connecting a power supply of 20-100 V between the pipeline and the Ground over a distance of 10-20 kilometers. This power supply unit will inject a DC current for CCP in the range of 20-100 A, which will cause a current flow between the pipeline to the ground. The current level depends on multiple parameters. See Figure 2.

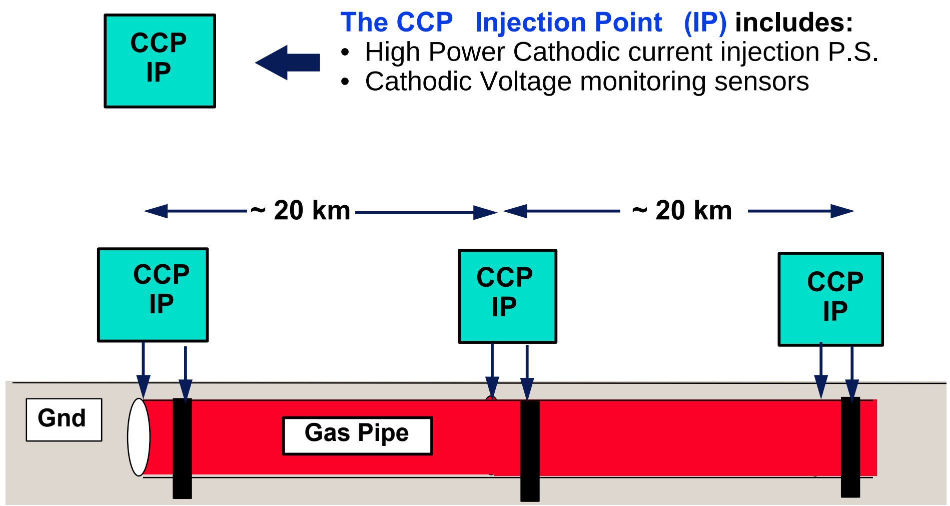

Figure 2. Cathodic Protection Concept.

3. System Operation

Once the CCP voltage is applied to the pipe, the "ground current changes direction and instead of flowing via the troubled spot, it flows through the healthy surface of the pipe in the opposite direction. This suppresses the corrosion process and eliminates more serious damage to the pipeline. If the system works properly a "hole" in the pipe can be eliminated.

The injected voltage/current results in a potential (pipe-to-ground) of -0.95 V to -2.5 V along the pipeline. Such measurement should take place at the CCP site, not far from the connection of the power supply. Figure 3 below shows the difference between the current flow along the pipeline, before and after connection of the CCP system.

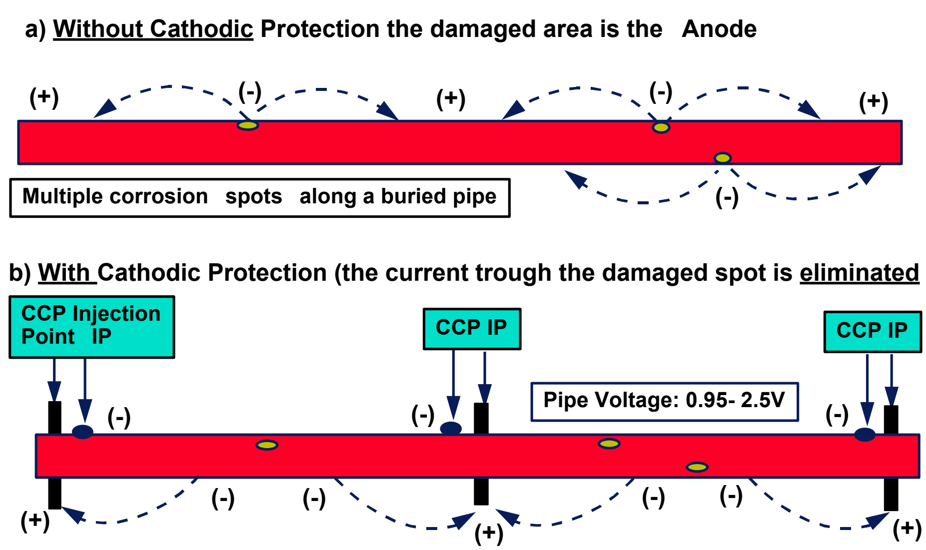

Figure 3. Implementation of Cathodic protection

4. Protection Monitoring

In order to perform monitoring of the CCP system operation, it is necessary to measure the voltage output and the “injected” current levels. Accurate measurement of these parameters is not critical, and one may compromise on an accuracy of +/- 5% (Required: >1 MΩ input).

The injected current level is regulated by a Transformer Tap Changer. In case the applied voltage and the injected current are too low, the protection is not as effective as required. In case the voltage is set for higher than required level, it causes loss of electric energy and results in higher than required operating cost. The current density is about of ~ 2 mA/m$^{2.}$

Selection of the applied voltage is not a straight forward issue, and it depends on the nature and conductivity of the ground. The conclusion is that for optimal operation it is required to periodically adjust the Tap Changer of the transformer. See Fig 4.

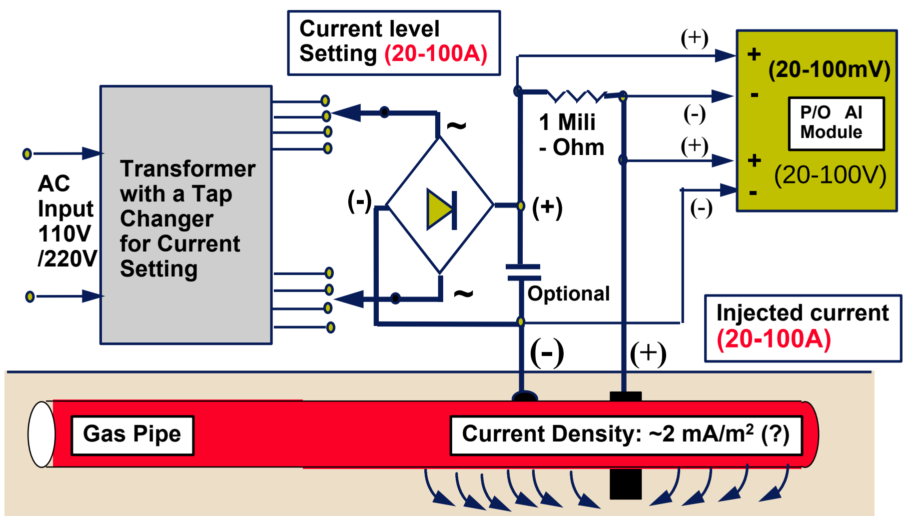

Figure 4. Cathodic Protection system

Communications with the CCP system RTUs helps to resolve certain problems along the pipeline. For example, if one of the DC Voltage injection sites loses power, it is possible via communication to increase the injected current at a nearby site. If the normally injected current at a site is set for 50 A, and a nearby site is out of order, it shall be possible to increase that current to 70-100 A. This allows compensating for that failed power supply.

5. RTU Connections

The role of the RTU in the CCP application is to perform monitoring of the CCP power supply operation as well as monitoring of the actual pipe-to-ground voltage. In a typical CCP site, there may be a number of incoming/outgoing pipes, thus the RTU must have at least 4 analog inputs. Two inputs measure the Power supply voltage (0-100V) and the power supply output current (0-100 mV), which represents 0-100 A. See Figure 5.

The 8 DI inputs may be dry contact type, to allow monitoring of conditions such as: intrusion, fire, gas leakage, etc. The 8 DO output is required to control additional equipment which may be present at the CCP site. In addition it can be used for local signaling.

The RTU should send an alarm to the control center in case of AC outage, power supply failure, or when the measured pipe-to-ground voltage is out of range. The role of the back-up battery supplied with the RTU is to allow sending an alarm signal to the control center about a power fail situation. Thus a low capacity back-up (for about 30 minutes of operation) such as the standard MOSCAD 5Ah battery is suitable for this application.

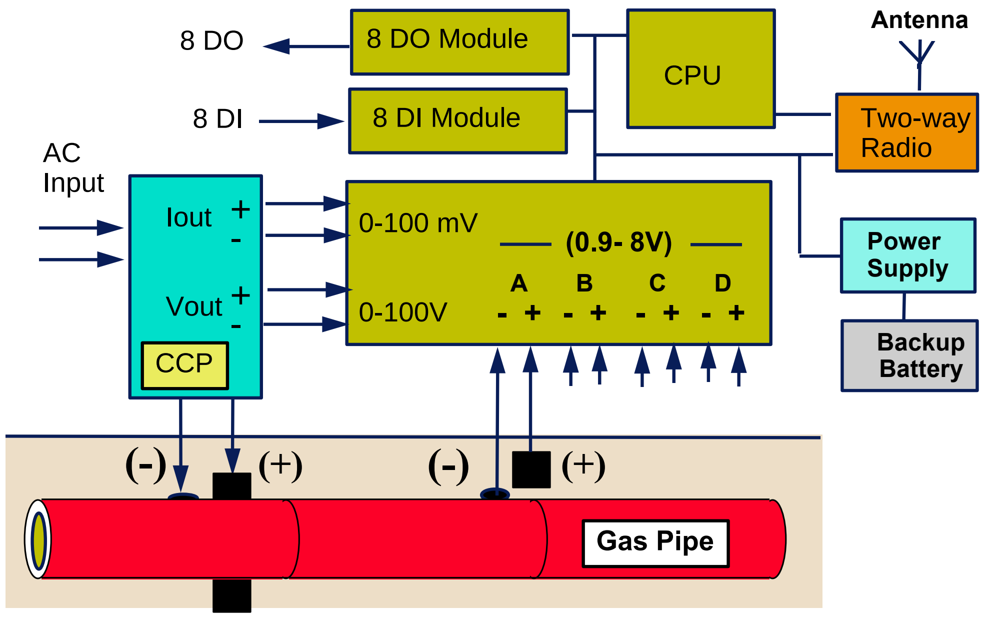

Figure 5. RTU Connection for CCP Monitoring

Note: *The RTU is built into a IP-54 or better NEMA type enclosure, which is suitable for outdoor applications. This requires the RTUs to withstand operating temperature of -30 deg.C to +60 deg.C.*

5. Data Communications

Communication between the RTU sites and the Master Control Center (MCC) is not a simple task. The reason is, that there are quite a large number of RTUs located along a pipeline. As the channel availability (delay time to get a channel) for this application is not critical, one may consider implementing a Store & Forward (S&F) communications scheme utilizing a single RF channel for the entire area. Alternatively it may be possible to use a shared infrastructure (data network, Trunked radio system, etc.). As CCP systems typically include 100-1000 RTU sites, the communication scheme must be carefully and properly resolved.

For the CCP application, the system is expected to operate in infrequent polling and contention modes. Due to nature of the pipeline system RTUs along the pipeline might not hear each other. Thus data collision may occur in case two or more RTUs initiate a transmission simultaneously.

This sometimes requires that RTUs communicating in a S&F be equipped with a high gain omni-directional antenna. Communication to that RTU takes place from both directions. See Figure 6. However, the MOSCAD MDLC protocol overcomes this situation, by repeating the missed part of any transmission at pseudo-random intervals, to avoid “synchronized collisions”.

The communication system is designed in a hierarchical form, in which a group of RTUs report to the Data Concentrator Unit (DCU). In order to communicate with the MCC, the DCUs may also communicate in a separate S&F scheme. Alternately the DCUs may be linked to a wireline, Satelite, fiberoptic, cellular, telephone or a microwave communications networks.

One important benefit of using a conventional or a Trunked radio system is, that this allows re-use of the same RF channels which are used for voice communications.

Gas Distribution Companies which invest in a CCP system may benefit greatly from using the MOSCAD technology. Especially beneficial is the MOSCAD-L RTU which is intended for use with low power radios and low I/O counts. Connection of these RTUs to the CCP Master control center is done via a Front Interface Unit (FIU) using the MODBUS protocol or via a MOSCAD TCP/IP Gateway, using the industry standard. TCP/IP protocol over Ethernet LAN.

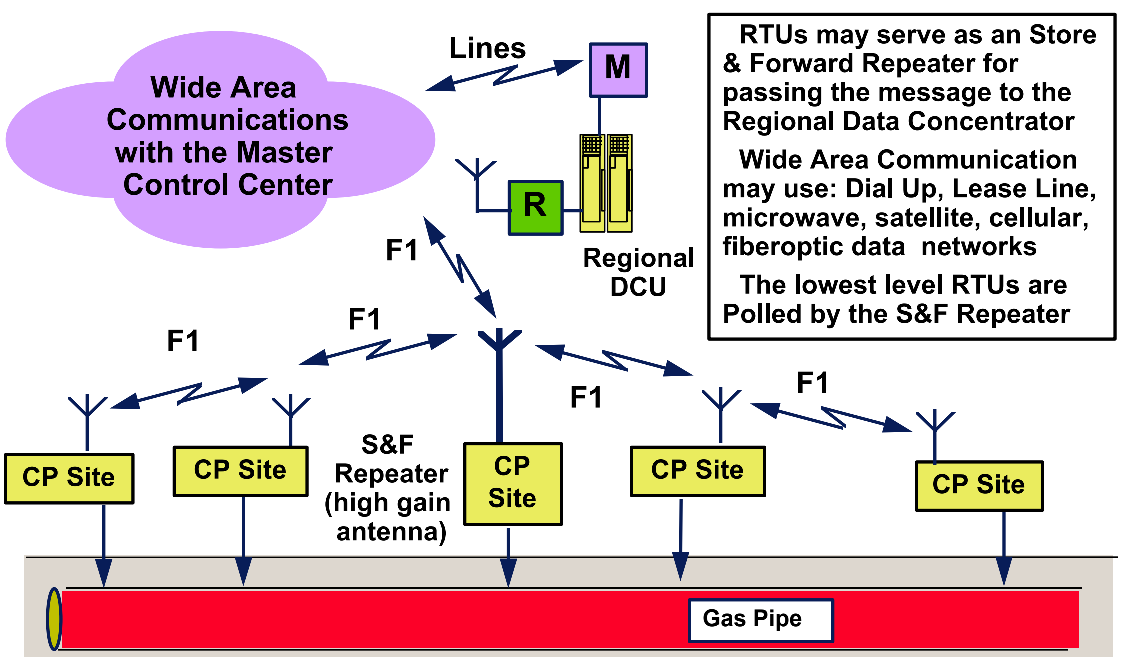

Figure 6. Communications for CCP system

6. Enhanced Monitoring System

Monitoring of the protection scheme solely at the CCP injection sites is sometimes not enough, and it is recommended to perform similar measurements “in-between” these sites. The voltage varies in-between the injected sites, thus it is expected that around the “mid-point” one can measure about -0.95 V (optimal level). As mentioned, higher voltage results in un-necessary loss of energy, while lower voltages result in insufficient protection. See Figure 6.

A critical consideration is, that in the region between the injection points, there is no supply of AC power and the unit must utilize solar panel and battery as the main power source. This requires that the radio based RTUs are designed for maximum power saving.

As this application is not "time critical", it can be programmed for reporting at specific time intervals. This allows the radio to be completely disconnected from the supply of power, when not needed. The RTUs used in-between the injection points need only a Mixed I/O module. It may include two 0-10 V high impedance inputs, 2-8 DI for status and environmental monitoring, and two DOs for connecting the supply to the radio and for local signaling.

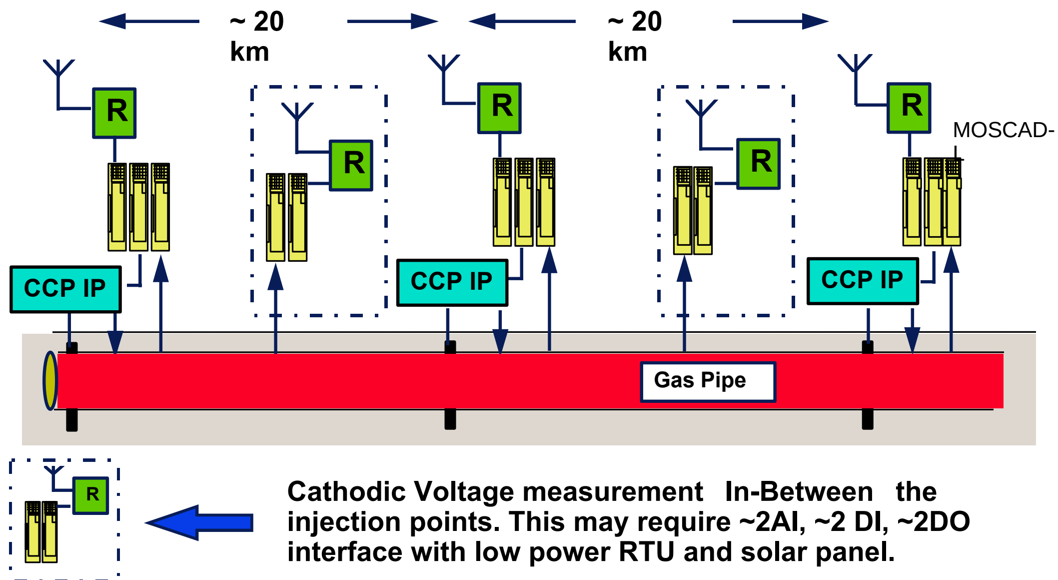

Figure 6. Enhanced measurement along the pipeline

Summary of Benefits

Evaluating the cost benefits provided by remote monitoring of a CCP system is a complex task. The main reason is, that the CCP system itself is doing the job, and monitoring provides additional assurance that it is operating accurately. Among the main benefits of such monitoring system are:

- Reduced damages to the pipeline
- Reduced cost of energy achieved by optimal current setting.
- Reduction of the time required to detect a problem.
- Ability to provide CCP back-up for a site which is out of order.
- Operator is assisted by real-time data to make critical decisions.

MOSCAD RTUs are adaptable to a range of communications media, and this itself creates major operating and cost benefits to the customer. The Programmable Logic Controller (PLC) capabilities of MOSCAD allows expansion of the RTUs serving the CCP application, with innovative functions and new connectivities as may be needed in the future.