AC Mitigation - Part No. 2

What can be done to avoid stray currents?

Methods & Equipment

Electricity plays a vital part in our daily life. To Imagine life without it is unthinkable today.

In certain cases, electric current can stray away from its intended path and can flow in unintended circuits and materials. This flow of stray current causes the electrochemical deterioration of metallic surfaces, which is known as ***stray current corrosion.***

The magnitude of the deterioration is directly related to the extent of unintended current flowing in the structure. Localized faults in insulation and connections can result in localized stray currents causing localized corrosion damage. Structures in the surrounding area of high-voltage equipment and conductors attract stray voltages, even during normal fault-free operation of a high-voltage circuit.

❖ Some of the commonly occurring sources of stray currents are:

- Grounded direct current (DC) power systems distributing and transmitting power to consumers
- Electrically operated rapid transit systems
- Corrosion protection systems designed with cathodic protection (CP)
- Electrical welding equipment

❖ The minimization of the stray currents and voltages involves:

- Detecting and measuring stray current as well as the source of the voltage and its path
- Mitigation of defects and insulation failures
- Repairing defective connections

❖ Why does stray current occur?

Stray current occurs because of induced or leaked voltage, which is the unintended presence of a voltage difference between two objects, this is increasingly common as infrastructure of differing nature share servitude and right of ways. Ideally, these should have zero voltage difference between them. Even grounded objects at differing locations may have a voltage difference existing between them, and stray current may flow between them **as a result.** The presence of induced voltage due to the proximity of high-tension cables along with inductance or capacitance in the circuit is one of the causes of the problem. Current leakage due to insulation failure or defective connections can be another cause of stray currents. This can affect equipment enclosures, which are normally connected to ground. (For more on this topic, see Corrosion and Electrical Interference in Buried Metallic Structures.) Persons coming into contact with the stray voltage may not necessarily sense the current flow, as the current flow may be small.

❖ Detecting Stray Voltage

A number of electricity distributors and major users conduct regular tests for stray voltage to ensure public safety and prevent corrosion. The instruments used to sense and detect stray voltage can vary, but some of the common devices are electrical voltage tester and electric field sensors. Confirmatory testing is done with a low-impedance voltage meter. Electrical volt testers are handheld devices that visually indicate a contact with an energized surface.

Then the verification of existence of voltage is done by a low-impedance voltmeter. Electric field detectors sense the electric field in relation to the person's body. It is done by sensing and detecting the gradient of an electric field at a distance, without having to make a direct contact.

Stray current cannot be heard, seen or smelled, there is no easy method to know when a significant stray current exists. Regular system inspection and testing is important, but a serious condition or failure can develop suddenly without any discernible warning.

The corrosion of the stray current is observed as localized pits at points where the current leaves the pipes and structures. Initially, this effect is not visible to the naked eye. The detection is done by measuring metal-structure-to-soil-potential difference. Current-mapping devices use radio detectors. Different instruments are used to detect DC and AC stray currents.

❖ Prevention of Stray Current Corrosion

The minimization of stray current corrosion is achieved by manipulating the design parameters. The goal is to reduce the flow of stray current, which is accomplished by increasing the overall circuit resistance in various ways.

Cathodic protection with an impressed current system are used to offset the effect of stray current.

In this method, the metallic structure that becomes damaged due to stray current is efficiently connected to the negative terminal of the DC source with a low-resistance connector. The connection is designed as unidirectional, so that stray current can flow from the buried metallic structure to the negative terminal of the power source.

Basic Categories –

Pipeline surge protection systems fall into three basic categories:

- ❖ SSD – Solid State Decouplers
- ❖ PCR - Polarization Cell Replacement
- ❖ Spark gaps / Surge Arrester

Some or all of the above devices can be combined to form surge and steady state mitigation systems to best suit a particular pipeline associated application.

The need for solid state de-couplers arises from mitigating induced voltages on pipelines near overhead power lines. These de-couplers are installed for safety reasons as well as maintaining required DC voltages for protecting the integrity of pipelines.

❖ SSD – Solid State Decouplers

Are devices that upon a predetermined voltage threshold begin to conduct forming a near short circuit across the circuit it is connected to? Once the fault has passed or been subdued and the voltage falls below the pre-determined device threshold, the device commutates (switches) to the "off" state.

These types of devices do not fully comply with NFPA 70 guidelines when they are in conduction mode. Both cathodic protection applied DC and Induced AC present on the operating circuit (Insulated coated Pipe) is short circuited (to Ground).

These types of devices can have AC mitigation circuits in parallel to decouple AC steady state interference from overhead powerlines on the pipe to cater for AC voltage below the cathodic protection DC fault threshold level. Once **"on"**, current flowing through the device can maintain these devices in the conducting state even when the voltage fault threshold has fallen below the level set.

Economical and relatively small in size are some advantages but disadvantages are that their application can result in surging of cathodic protection power supplies and as mentioned above do not fully meet NFP 70 requirements and Eskom guidelines. Typical current discharge limits are 1,2kA and 3,7kA. Greater discharge limits are available but are generally by special request.

❖ PCR - Polarization Cell Replacement

Are those devices which conduct once a predetermined voltage has been attained? Once conducting, they maintain the predetermined volt drop across the device. The voltage clamping devices will "soft turn on" as the threshold approaches and have a partial turn on bleeding more and more current off of the pipeline as the voltage threshold is approached. Once at predetermined threshold, the voltage will be clamped whilst the conduction will be at maximum. The Voltage clamping devices truly comply with NFPA 70 guidelines as they do not "Short Circuit" both the current as well as the voltage off of the pipeline. These types of devices can have AC mitigation circuits in parallel to decouple AC steady state interference from overhead powerlines on the pipe to cater for AC voltage below the cathodic protection DC fault threshold level. Once "on" current flowing through the device will not keep the device conducting if the voltage falls below the predetermined threshold.

Clamping devices are heat generation (ignition temperatures in Hazardous zones) and relative physical size whilst they fully comply with NFP 70 and Eskom guidelines.

❖ Spark gaps / Surge Arrester

This device forms an arc in an altered (gas filled) closed environment when a preset voltage threshold is reached. Significant current and voltage relative to the conduction threshold is required to maintain the arc. It therefore stands to reason that if the device is not hermetically sealed the characteristics of the device will fluctuate with climatic changes.

Gas discharge devices cannot accommodate an indefinite number of discharges. The maximum number of events discharge devices can only cope with is 1 (one) 100kA discharge before the characteristics of the device is irreversibly altered.

❖ Other areas of attention:

Sections of pipeline influenced by AC induction and accessible to the public require special attention as a member of the public may inadvertently provide a current path to ground when touching the exposed section of pipeline.

Typical appurtenance's that are necessary for long term maintenance of the pipeline are the general culprits in this regard. As one cannot do away with the test facility or chamber, special attention needs to be applied at these locations and can take the form of Insulation, ensuring an equipotential plane or both.

Crushed stone or Asphalt surrounds around the exposed facility will insulate the feet of the public so upon touching the facility the person is effectively insulated from providing a current path from the pipeline to ground. The surround must be of sufficient width that the person intending to touch the facility's exposed point, cannot do so, unless they are fully on the insulating surround. Crushed stone unfortunately is not all that viable as it tends to be repurposed for informal building projects.

Equipotential planes are generally the most effective as they are sections of bare metal buried around the exposed facility raising the surrounding soils in which they are buried, to the same potential level as the pipeline. As voltage/ potential is the precursor to current flow, without there being a potential difference between the AC influenced pipeline and the soil at the exposed facility, current would not flow through the fiddling public.

Similar treatment needs to be applied to pipe racks, insulating flanges and well insulated above ground pipes, to ensure that the unindenting public does not provide an inadvertent current path to ground.

End of pipelines at reservoirs, pump stations, off takes etc. generally have isolating flanges installed. The close proximity of the "live" and earthed sections around the isolating flange demand the "Live" section to be fitted with a voltage clamping device to Ground to ensure that hazardous levels are not reached and excess voltages are decoupled to ground without affecting the required Cathodic Protection current.

The attending consultant should provide a maintenance plan with regards to the AC mitigation system to ensure continued operation of the installed safety equipment. The equipment deployed to protect casual contact does not, and cannot withstand an infinite number of surge events and will require maintenance from time to time.

AC Mitigation is not just protecting your assets, but gives you peace of mind knowing that your staff are protected too.