



Lightning, Surges and Rectifier Protection

Typical rectifier applications often place them in environments where they may be subjected to electrical voltage transients of a destructive nature. In order to protect a rectifier against these possibly fatal surges, an understanding is required of what voltage transients are, and what techniques and devices can be successfully used to suppress them.

Types of Voltage Transients

Voltage transients can be broadly categorized into two basic types:

NATURAL OCCURRING: As the name implies, the over-voltage conditions are due to natural phenomena, primarily lightning, and power system disturbances. These surges are characterized by their random occurrences and create the most difficulty to analyze as to amplitude, duration and energy content. They are also the hardest to deploy corrective measures against.

REPEATABLE TRANSIENTS: These types of transients are the result from the release of electrically stored energy, and are usually man-made. These surges are the direct result of inductive load switching, load faults and circuit commutation by transistors, SCR's, relays and fuses.

Lightning

Lightning phenomena because of its energy levels, combined with the primarily outdoor rural environment of cathodic protection rectifiers, pose the most destructive potential for these cathodic protection rectifiers. Studies done on lightning strokes indicate an average stroke to have a duration of 30 microseconds, with a stroke length of 3 km and a total energy of 3×10^8 joules; the equivalent of 10^{13} watts. There is an average of 4 strokes per lightning flash; each stroke being separated by about 40 milliseconds. It is these successive strokes which are seen by the human eye as a flicker.

We are primarily concerned with cloud-to-ground lightning. It is these strokes which cause direct over-voltage surges and induced voltages on cathodic protection rectifier AC input lines and structure-ground bed installations. Most cloud-to-ground lightning will bring a negative charge to earth. There will be a correspondingly higher percentage of lightning-to-ground strokes in moun-

tainous regions than over flat land. Direct strokes to AC power lines will cause high energy transients to affect cathodic protection rectifiers miles from the actual stroke. In addition, cloud-to-ground strokes produce large ground currents in the vicinity of the stroke. These currents in turn cause either by direct conduction or by induction, transient energy to appear on AC and DC cathodic cables, pipelines and through the grounded installations.

Repeatable Transients

As stated previously, these types of transients are due to the release of stored energy in inductive and capacitive circuits. Although containing lower levels of energy than lightning, they may still pose a serious problem to unprotected solid state rectifiers and their controls. A summary of these repeatable transients are as follows:

Energization of the cathodic protection rectifier transformer primary

Energization of a rectifier transformer will couple the applied input voltage via stray capacitance and the inductance of the secondary winding to generate a transient voltage equal to twice the normal peak secondary voltage. If the interwinding capacitance (Cs) is relatively large, it is conceivable that a substantial portion of the applied AC input voltage could be coupled to the secondary, regardless of the transformer turns ratio.

De-energizing the transformer primary

Interrupting the primary of the rectifier transformer may generate voltage transients in excess of ten times the normal secondary voltage, depending upon the impedance of the transformer secondary. By interrupting the transformer magnetizing current, the resulting collapse of the magnetic flux in the core couples a high voltage transient into the transformer secondary and to the rectifier diodes. This stored energy can amount to approximately 0.06 joules per 1000 volt-amperes of transformer capacity.

Fault with an inductive power source

A short circuit in the load, or internally will cause secondary protective fuses or circuit breakers to operate. The energy from the inductive power

source or efficiency filters will generate a high energy transient across the rectifier diodes and/or SCR's. Interruption of load current will have a similar effect.

Rectifier Susceptibility

Some cathodic protection rectifier components; either by their construction or their position in the electrical circuitry, are more susceptible to voltage transient failure than others. The components most susceptible in the conventional rectifiers are the diodes or selenium cells which comprise the rectifier stack assembly. In addition, automatic rectifiers usually have a number of semiconductor components such as transistors, integrated circuits, signal diodes, etc., which are designed to operate on low voltages, often less than 30 volts DC. Isolation transformers are often on the "front lines" because they are hooked to AC input lines. As components, however, they can withstand relatively high surge voltages; usually greater than 2,000 VAC steady state or 5,000 volts impulse.

Other components may be susceptible to energy transients as well. They include meters, wires and insulation and even surge arrestor devices themselves if the transient energy is too high.

Protection Against Surges

It may seem within this hostile world of multiple sources of potentially lethal voltage transients that a cathodic protection rectifier's life may be short lived. There are, however, installation steps and protective devices which may be applied to nullify these transients. They include:

1. Select a rectifier site which is not on the crest of a hill where lightning would be more apt to strike it.
2. Utilize a good electrical ground, preferably a separate ground rod. Surge arrestors designed to shunt transients to ground will work only if a low ground resistance is achieved.
3. If possible, do not hook the rectifier AC input to power lines which feed surge producing equipment.

4. Apply voltage suppression devices which are sized and installed in the most effective place in the cathodic protection rectifier.