(Deck)
Knowing the basics eliminates intimidation from AC mitigation

(Deck)
Pipe lines sharing power transmission ROWs need some extra diligence to ensure safety and reliability

Robert F. Allen, ARK Engineering & Technical Services, Inc., Cohasset, Massachusetts

A good grasp of a few options will deflate the sense of intimidation experienced by the pipe line operator who realizes that electrical interference mitigation requires non-routine testing, monitoring and maintenance.

An outline of options and technology for managing electrical interference mitigation systems for pipe lines installed in a power company's right of way is valuable. Monitoring and testing for company policy compliance and human safety can be very confusing and intimidating initially to a pipe line operator. In addition, there are a number of safety precautions that should be understood and adhered to whenever tests are being conducted in joint facility rights-of-way. This article outlines what knowledge and procedures are needed to relieve the tensions of the task.

Electrical interference mitigation systems for pipe lines can be composed of different equipment and materials for reducing induced and conducted electrical voltages and currents on the pipe line.

Electrical interference. The primary method for reducing electrical interference effects on pipe lines close to electric transmission circuits is to reduce the pipe line's resistance to earth. This is accomplished with electrical interference mitigation systems installed at areas of peak AC or DC voltages along the pipe line. Also, in order to maintain safety under fault conditions, gradient control mats will be installed at aboveground appurtenances where contact with the pipe line could be made. However, the lowering of the pipe line's resistance to earth can affect the operation of a cathodic protection system on the pipe line.

Interference mitigation systems. There are several systems available for mitigation of electrical interference on aboveground and buried structures. These include:

- o Zinc ribbon anode material
- o Packaged magnesium anodes
- o Carbon steel, galvanized steel and bare copper wire.

Some of these methods, including the zinc ribbon and the packaged magnesium anodes, can be used for cathodic protection and mitigation of electrical interference on the pipe line.

Use of the other methods for interference mitigation requires the isolation of the pipe line from the grounding system to reduce cathodic protection requirements and maximize current distribution. Isolation devices--such as zinc grounding cells, polarization cells and solid-state isolator-surge protectors--are used to isolate the pipe line from the grounding system and to protect isolated fittings from lightning and other electrical interference damage. These devices are considered a part of these mitigation systems and require monitoring and maintenance.

Electrical interference testing. When testing electrical interference mitigation systems in joint facility corridor rights-of-way, a number of safety and equipment issues are of concern. If these measurements are not conducted correctly, the interaction of a cathodic protection and electrical interference systems can produce field measurement data that are not consistent with data recorded in areas without the influence of high voltage electric transmission lines. These data may indicate that areas of the pipe line system do not comply with minimum state and federal regulatory corrosion control requirements.

These measurements must be taken properly, the appropriate criteria applied and each measurement appropriately evaluated. The activities are performed to maintain public safety and reduce operating costs from electrical interference. Proper training, well-documented measurement procedures and an automated record keeping system can address these challenges. [1]

Once criteria have been selected for use on underground structures, documented testing procedures are required so that evaluation results can be compared to previous and future data with confidence. [1]

Testing and maintenance are also required at meter and regulator stations, valve sites and compressor stations if these facilities are located on, or close to, high voltage transmission corridors. Testing electrical interference mitigation systems in meter and regulator stations and other facilities can be difficult due to the fact that most of these facilities have gradient control mats installed for aboveground pipe runs and other appurtenances. These gradient-control mats are installed to reduce step and touch potentials to personnel.

All procedures associated with monitoring and testing of the cathodic protection system should include the recording of AC voltages and the integrity testing of gradient control mats. Whenever DC current measurements are made for cathodic protection monitoring, AC currents should also be recorded. AC IR drop measurements can be in error due to the impedance of the pipe line. Accurate AC IR drop measurements can be obtained with a large clamp-on ammeter if its use is practical. Two different methods are used to record the AC current measurements:

O An external shunt with a large current capacity

O Pipe line current measurements based on voltage drop measurements at pipe line test stations.

These data can determine the possibility of AC corrosion on the pipe line.

If a galvanic anode system is being used for electrical grounding, a special circuit is required to measure galvanic DC current. This is needed to reduce the AC current magnitude into the shunt resistor path so that DC current can be measured with a clamp-on ammeter or a voltmeter connected across the known shunt resistor. [2] This circuit is outlined in Fig. 1.

Both AC and DC measurements of pipe-to-soil potentials should be recorded at each test station or other aboveground appurtenance of the pipe. If a gradient control mat is buried at these test stations and connected directly to the pipe, the reference electrode must be placed above the pipe but sufficiently remote from the gradient control mat so that the influence of the mat is reduced on the AC and DC potential measurement. [3] A distance of 10 ft from the end of the mat, which is usually 3 ft beyond the test station or aboveground appurtenance, is usually sufficient but this may require experimentation at these test stations to determine a remote location (Fig. 2).

If a close-interval survey is to be conducted on a section of pipe line in a joint facility corridor, the presence of AC voltage on the pipe line during a close-interval survey should be monitored by recording AC measurements at specified intervals to determine if it is safe to continue.

Test equipment. Field test personnel need well-maintained equipment that is adequate for the job. All testing and training should be geared toward minimizing error in field measurements. Voltmeters or multimeters used for cathodic protection measurements--such as voltage, current and resistance--must have an adequately rated AC filter to protect the meter from these induced AC levels.

If a close-interval survey is to be conducted on a section of pipe line in a joint facility corridor, the voltmeters used should have a high AC voltage rejection rate. This high AC voltage rejection rate is needed to reduce the possibility of picking up induced AC voltage on the survey wire while testing along these rights-of-way. This survey wire should be reconnected to the pipe wherever possible to minimize the length of wire along the right-of-way and reduce the induced voltage levels.

Electrical isolation. Electrical isolation of pipe networks is often essential for the effective operation of the cathodic protection system. [2] Prior to interference testing on any pipe line system in a joint facility corridor it is important to know what type or types of electrical isolation is being used for insulated fittings and grounding systems.

Surge protection devices--such as DC decoupling devices, zinc grounding cells and polarization cells--are used to connect across insulated flanges and fittings. These devices can provide an alternative path to steady-state induced AC and fault current. Additional information on these devices is outlined below.

Spark gaps and lightning arresters also have been used in the past in this application. They have been somewhat effective against lightning and small fault currents, but they are also subject to high maintenance and not suitable for draining continuous steady state induced AC currents.

DC decoupling devices. In the past 15 years, solid-state DC Decoupling devices have become available and proved to be successful in providing a low resistance AC path for draining AC interference currents from the pipe line while maintaining a high impedance to DC, thus maintaining the DC cathodic protection voltage levels on the pipe line.

The failure mode of DC decoupling devices is a short circuit condition which is a safe condition for AC hazards but a disadvantage to the cathodic protection system.

Zinc grounding cells. Zinc grounding cells also are frequently used as an electrical isolation device by providing a low-resistance path for both AC and DC. One drawback of these cells is that AC can depolarize the zinc grounding cell allowing more cathodic protection current to pass through the cell. The typical failure mode for zinc grounding cells will be an open circuit thereby creating a possible safety hazard.

Polarization cells. Polarization cells are similar to zinc grounding cells in that as AC depolarizes the internal plates it can lower the back voltage, which may compromise the operation of the cathodic protection system. If the solution in the polarization cell becomes diluted or the solution level is low in the cell, this can cause cell failure. The typical failure mode for polarization cells is an open circuit condition, thereby creating a safety hazard.

There are other issues concerning the testing and maintenance of AC mitigation and cathodic protection systems in joint facility corridors. These include casings and electric power line facilities including towers, electric system grounds and guy anchors.

Casings. Carrier pipe, inside a casing in a joint facility corridor or subject to steady-state induced voltage or fault currents, should be connected to the casing through a surge protector type device to reduce the possibility of failure of the carrier pipe within the casing due to AC corrosion. [2] This connection is outlined in Fig. 3.

Electric power line facilities. Consideration for DC interference on electric power line towers, grounds and guy anchors often is overlooked in designs for an impressed-current system for the pipe line in a joint facility corridor. [2]

An interference survey should be conducted with the electric transmission system operator at regular intervals--such as every two years--to determine the extent of the interference and possible damage to the electric systems' buried facilities from DC interference.

Conclusion. Although electrical interference mitigation systems installed for pipe lines in joint facility corridors can be confusing, with a basic understanding of the systems and personnel safety requirements these systems can be tested and maintained to provide a safe and compliant cathodic protection system and reduce the induced levels of AC voltage on the pipe line to safe levels.

Safe work procedures and safety training should be reviewed prior to any testing of the pipe line system on a joint facility corridor.

-30-

ACKNOWLEDGEMENT

(Editor's query----Does this article need an acknowledgment?)

The author

The author

Robert Allen is vice president of ARK Engineering & Technical Services, Inc., Cohasset, Massachusetts. He is an active member of NACE International and is past chairman of the Greater Boston, Massachusetts, NACE Section. He is a NACE-certified cathodic protection specialist and has more than 16 years experience in corrosion control and AC electrical interference analysis in the pipe line industry. He has written several papers and articles in trade and technical journals on the subjects of electrical interference effects, cathodic protection and electrical grounding. His memberships include NACE International, Institute of Electrical & Electronic Engineers, American Society of Mechanical Engineers and Instrument Society of America.

(sidebar)

Some recommended practices

From NACE Standard RP0177-95

NACE Standard RP0177-95, "Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems" [4] outlines recommended practices in the areas of AC interference mitigation and cathodic protection in joint facility corridors. Some of the main recommendations concerning testing and monitoring of these systems are outlined or quoted below.

Personnel Protection

1. The possibility of hazards to personnel during construction and system operation due to contact with metallic structures exposed to electrical interference and/or lightning effects must be recognized and provisions made to alleviate such hazards. Personnel shall be informed of these hazards and of the safety procedures to follow for testing in areas near high voltage transmission lines.

2. Not more than one device intended to limit AC potentials on the pipe line shall be disconnected at any one time. In all cases, tests to detect these potentials, on the pipe line, should be conducted first and the pipe line treated as a live electrical conductor until proven otherwise. All cathodic protection test records should include AC potential readings taken at these locations also.

3. Safe work procedures must include methods of connecting and disconnecting test instruments. Test leads must be connected to the instrument first and then the structure. Test leads must be removed from the structure and then from the instrument.

4. Tools, instruments, or other implements shall not be handed, at any time, between a person standing over a ground mat or grounding grid and a person who is not over the mat or grid.

5. 15 Volts AC (RMS) open circuit or a source current capacity of 5 mA or more is considered to constitute a shock hazard. Mitigation systems should be designed to reduce and maintain AC voltage potentials below 15 V AC to prevent shock hazards to personnel and the general public.

Equipment Protection

1. The AC Current in the pipe line to be protected may flow to ground through the cathodic protection equipment. Current flowing in the cathodic protection circuits under normal AC power system operating conditions may cause sufficient heating to damage or destroy the equipment. Heating may be significantly reduced by the use of properly designed series inductive reactances and/or shunt capacitive reactances in the cathodic protection circuits.

System Testing

1. If galvanic anodes are used for cathodic protection in an area of AC influence and if test stations are available, the following tests should be conducted during each pipe line corrosion survey using suitable instrumentation: a) Measure and record both the AC & DC currents from the anodes, b) Measure and record the AC & DC pipe-to-soil potentials.

2. Grounding facilities for the purpose of mitigating electrical interference effects should be carefully tested at regular intervals to ascertain the integrity of the grounding system. (end of sidebar)

LITERATURE CITED

1 Davis, K.E., “Evaluation of Cathodic Protection Levels on Natural Gas Distribution Systems”, CORROSION /98, paper no. 665, NACE International, Houston, Texas.

2 Gummow, R.A., “Cathodic Protection Considerations for Pipelines with AC Mitigation Facilities,” PRC International Corrosion Supervisory Committee, American Gas Association, Arlington, Virginia, 1999.

3 Anon., Intermediate Course, Appalachian Underground Corrosion Short Course, West Virginia University, 2000 revision, Chapter 8.

4 Standard Recommended Practice – "Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems", NACE Standard RP0177-95, Houston, Texas, 1995.

Fig. 1. Using shunt capacitor and resistor to facilitate measurement of AC and DC current. [1]

Fig. 2. A distance of 10 ft from the end of the gradient-control mat usually is sufficient to correctly measure AC and DC pipe line potential, but experimentation at test stations may be needed to find a good remote location.

Fig. 3. Electrolytic capacitor with surge voltage protection connected between carrier pipe and casing in a corridor shared by pipe line with power transmission lines.

2, 530 words