Cathodic Protection of Oil Field Lease Equipment

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CORROSION OF STEEL

Corrosion of steel, in contact with the earth, or brine, results from the creation of anodic and cathodic areas caused by differences in the electrolyte, and/or differences in the surface of the metal occurring in manufacture or fabrication.

In the anodic areas current leaves the surface of the structure and enters the electrolyte, causing loss of metal or pitting action. In the cathodic areas, current flows from the electrolyte onto the surface of the structure and no corrosion occurs.

The principal of cathodic protection is based on forcing direct current to flow from the electrolyte onto all exposed surfaces of the structure so that the structure becomes cathodic and in a non-corrosive state.

Another form of corrosion is caused by depolarization of areas along the surface of the metal by action of sulfate reducing anerobic bacteria. Under cathodic protection a highly alkaline film is built up on the cathodic surface which arrests the action of the bacteria.

The application of these principals to the protection of oil lease equipment has made possible considerable savings both in equipment and labor.

Current for applying protection to oil lease equipment is obtained by one of two methods.

1. First, the use of galvanic current furnished by magnesium anodes. In this system the anode is dissipated and must be replaced from time to time.
2. The second method is the use of graphite anodes and rectifiers. This is a more permanent system. However, it requires an external source of power.

Cathodic protection of tanks, treaters, gun barrels, filters and other vessels which contain brine, can offer complete protection of that portion of the vessel which is below the water level. Field tests have shown that protection, even in bacterial environments, is practical from both the economic and operating standpoint.

Protection Of Emulsion Treater

First, I would like to discuss the protection of a typical emulsion treater. The average vertical treater will require the use of five 3 inch x 60 inch anodes. If no power is available, the magnesium type would be used. A 4 inch nipple is welded into each compartment which contains brine, except the burner compartment which requires an anode on each side of the fire tube. The anodes are self supporting and are placed through the nipples and clamped into position by the coupling.

The lead is then connected to the vessel through a shunt and a length of resistance wire. The shunt is used to read the amount of current which is controlled by the length of resistance wire. The resistance wire is adjusted to give 10 ma for each quare foot of exposed steel surface. It should be pointed out that in some areas more current may be required, and only internal measurements of the potential of the steel will indicate complete protection. The anodes will last approximately one year, under average conditions.

For the graphite type, the positive lead of the rectifier is connected to the anode and the negative lead to the vessel. The current to each anode is adjusted at the rectifier. For this type of installation the anode life should be 5 years.

Another vessel which gives considerable trouble is the filter. These vessels may be charged with graphitic ore, sand, and in some cases, anthracite ore. Protection is attained by mounting anode nipples on the top of the tank and forcing the anode into the filter bed. Somewhat higher current densities may be required.

For protection of bolted and welded tanks, many systems of getting anodes in the tanks have been tried. One of the common methods has consisted of placing the anode on concrete blocks or other structures in the vessels. This requires draining the vessel and removing the cleanout hatch. In many cases the labor involved is more costly than the magnesium.

The best method for mounting anodes in these tanks is the use of deck mounts. These mounts are nipples which are welded or flanged into the tanks, a cap with an insulator for hanging the anode and a compression fitting for bringing out the lead wire. The cap is held in position by a victaulic coupling. By this method anodes may be changed very quickly without having to drain the tank or get inside. These mounts are available in two sizes, one for the graphite anode and the large type for the round 51# magnesium anode. In some cases two anodes may be hung from the same mount. Controlling the current output of the magnesium by its size rather than by external resistance gives considerable higher efficiencies. This mounting system is suitable for fresh water tanks also.

Current requirements for protection have been determined by tests run in the field. A typical test run in anerobic bacterial environment gave the following results:

Current Density	Weight Loss in 7 Months
No current applied	30.5 grams
5 ma. square foot	1.9 grams
10 ma. square foot	0.0 grams

Further tests have shown that although most of the protection is attained at a 5 ma. density, complete protection requires a 10 ma. square foot current density. It may be necessary to run this test on the particular vessel for complete protection.

External corrosion of buried injection and flow lines can be a troublesome and expensive problem, expecially when soils, which may or may not be naturally corrosive, are contaminated by oilfield brine, acid, sludge, etc. Where these lines are bare, the most practical method of corrosion control is "hot spot" cathodic protection, using galvanic anodes such as magnesium.

Where coated lines are used, complete protection of the entire system is quite practical, using either magnesium or small rectifiers with graphite anode groundbeds as a source of protective current. In either case, a preliminary investigation by qualified personnel is indispensable to selection of the most practical and economical form of protection.

As cathodic protection of well casings has become more or less generally accepted, it would be well to go into the procedures of installing a system on a West Texas field.

The primary consideration is the nature of the failures because the application of cathodic protection will prevent leaks only on the external surfaces of the casing. In determining whether or not the failures are external or internal the following procedures may be of assistance.

1. Internal caliper surveys. The surveys will show if internal corrosion is present; however, in some instances both internal and external corrosion is present in the same well.
2. Inspection of the tubing. Metal loss on the tubing is often a good indication of internal corrosion of the casing.
3. Correlation of leaks. In many cases in a given area a known sand will be an offender from the standpoint of corrosion. When a number of leaks occur opposite one of these sands, external corrosion will be suspect.
4. Potential profile surveys may show gross anodic areas opposite salt water sands as well as other formations which cause large anodic areas.
5. Casing inspection. The most reliable method is to inspect the casing when it is possible to recover it.

SURVEYS

At the present time, there are two methods which are generally accepted as workable to determine the current required for cathodic protection of oilwell casings. These surveys are:

The Potential Profile Survey

This survey is conducted by contacting the casing internally with a known spacing between two electrodes and measuring the IR drop. This method gives the amount of current flowing in the casing, its direction, and shows the areas where current is leaving the casing. This method is effective where large anodic areas are present but offers little help where small concentrated cells are caused by anerobic bacterial attack. Much of the corrosion in the West Texas area has been found to be of the bacterial type. This method is somewhat expensive in that the tubing must be pulled and the well must be killed with oil as the instrument can not be run in salt water. Great care must be taken when this survey is run to obtain reliable information. Once the anodic areas are located, current is applied to the casing in order to determine the amount which will eliminate the anodes.

Surface Potential Break

This method requires that the well be insulated and a temporary groundbed used to impress current on the well in order to start polarization on the well. Small increments of current are drained for short, accurately timed periods of time. Immediately after the current is interrupted, the potential is measured to a truly remote electrode. The potentials so measured are plotted against the log of the currents drained. The break of the curve so derived is assumed to be the minimum current required to attain polarization of the casing.

The instrumentation for this survey is highly specialized and requires extreme accuracy for reliable results. The location of the electrode for measuring the potentials is very critical and in some cases requires spacing up to one mile. This type of survey has given good results when properly run, and has correlated with the down-the-hole potential profile survey.

This type of survey has proven to be reliable and considerably more economical than the potential profile survey.

Soil Resistivities

In order to design cathodic protection systems for the protection of oil well casings, the resistance of the earth at the anode location is necessary for proper allocation of the number of anodes as well as the voltages required for the rectifier. Although in most cases the groundbed is located in the old mud pit, it is still necessary to measure the soil resistances. The four point system is used for these tests which will give the average resistance to the depth of the anodes. This procedure is required before the economic considerations of the system can be made.

Location Of Foreign Lines

In locating groundbeds it is necessary to find all lines which might be within the field of influence of the anode system. Foreign lines may require relocation of the groundbed or a bonding system.

INSTALLATION

Proper installation of cathodic protection on well casings requires that many factors be considered in order to give trouble free service for long periods of time. In most cases, these installations have a large number of separate systems which must be checked and maintained. For this reason, it becomes almost mandatory that the best and most reliable equipment be used throughout. A few considerations for the different components of these installations will be discussed.

The Rectifiers

These units should be designed to give many years of trouble free service in the particular environment where they are used. In West Texas, the principal considerations are:

a. Cooling - we have recommended oil cooled units for this application.
b. Dust - the oil cooled unit will eliminate this problem.
c. Servicing - the rectifiers should be so designed as to permit easy removal from the cases to permit substitution of replacement units or servicing.
d. Reliability - many of these installations must last for many years and only those units which are made by an established manufacturer, who can supply replacement parts, should be considered. Design of these units should be straight forward and only the best of components used.

Several of the early installations on well casings have not given proper service, and the few dollars saved on the initial installations have led to extremely high operating costs which have amounted to many times the difference in the cost of first class units. There is nothing to be gained in solving one operating problem by creating another. Another consideration for the rectifiers should be case design. The case should be able to deflect small arm bullets. Round cases have been very good in this respect.

The Anodes

The anodes should be specially treated for salt water service. As most groundbed installations will be in the old mud pits, special treatment of the anodes is necessary to prevent chlorine damage.

Groundbed Design

Only the best grades of direct burial should be used. Groundbed design is critical in West Texas and experience in the particular area is almost a must in order to get trouble free groundbeds. West Texas will require groundbeds considerably different from the types used in other parts of the country.

Lightning Protection

Arrestors which have proved successful in the West Texas area should be used. High static potentials, caused by the dust storms, have led to the failure of some rectifiers. The proper selection of arrestors will practically eliminate this problem.

When cathodic protection systems have been properly installed, based on good current requirement surveys, the casing leaks attributed to active external corrosion have been practically eliminated.

Maintenance of Cathodic Protection Systems

As to maintenance of cathodic protection systems, a few general rules are indicated:

1. Regular checks of current outputs.
   This is normally checked by measuring the current drop across a shunt mounted in the anode lead. With rectifier installations the current is measured by the ammeter on the rectifier.
2. Pipe to soil readings
   For line installations, regular stations are made for checking the voltage of the line to a copper/copper sulfate halfcell. This measurement requires a high resistance voltmeter and a copper sulfate electrode. Regular checks are made to see that a pipe-to-soil potential of at least -0.85 volts is maintained. This measurement may be taken in a tank; however, a calomel halfcell is used to prevent dilution of the cell. A voltage of -0.78 volts to calomel is considered protective potential.
3. Inspection of anodes
   In well designed tank installations it is possible to inspect the magnesium anodes from time to time to determine the remaining life.
4. Insulation check
   On lines which are under protection, insulation of the protected portion and other lines should be checked annually or when current or pipe-to-soil readings fall below the protective levels.

Cathodic protection of oil lease equipment is relatively new, and it is fast finding general acceptance. The industry has recognized the considerable savings to be made in this field.