



DC VOLTAGE GRADIENT SURVEYS

Frequently Asked Questions

[1.0 What is DCVG Used for?](#)

[2.0 How is the Technique Applied?](#)

[3.0 How Accurate is the Technique?](#)

[4.0 How is the Signal Injected?](#)

[5.0 What Are the Advantages and Disadvantages of DCVG?](#)

[6.0 What Advantages Does the WM3000 Have?](#)

[7.0 What Do You Get with A Full Set of WM3000 Equipment?](#)

[8.0 At What Rate Can the Survey Be Performed?](#)

[9.0 Is the DCVG Survey Difficult to Perform?](#)

[10.0 Why is the DCVG Not Computerised?](#)

[11.0 How Are Defects Marked?](#)

[12.0 What Experience does CORRSTOP have with DCVG?](#)

DC voltage gradient surveys are used along buried pipelines to:

- Accurately locate coating defects
- Estimate defect sizes
- Identify priorities for excavation and repair
- Provide data for cathodic protection adjustment/upgrading
- Enable future coating deterioration to be monitored
- Can be used to estimate levels of cathodic protection at defects when used in conjunction with potential surveys
- Confirms electrical continuity along the pipeline and can often identify shorts to other structures

2.0 How is the Technique Applied?

A summary of the technique and how it is applied is contained

3.0 How Accurate is the Technique?

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



The DCVG is the most accurate technique available in the world for location of defects along buried pipelines. Pin holes can be identified and the epicentre established to within a few millimetres. CORRSTOP surveyed pipelines buried in a built up area and located defects beneath the roads.

The incorporation of our GPS technology has resulted in both speeding up the inspection and improving on our repeatability and accuracy of relocating pipeline coating defects.

4.0 How is the Signal Injected?

The technique is a DC method and normally existing cathodic protection systems are used to inject a signal by the insertion of a 1 Hz cycle current interrupter. It is normally best to isolate away any other bonded pipelines from the pipe under test. If more than one pipe requires testing and they are all bonded together being buried in the close vicinity of one another, then they can all be tested simultaneously as defects can normally be detected several metres distant.

If the pipeline is protected by sacrificial anodes then it is normal to use, say, a 12V battery which is put in circuit to add a boost to the signal and this increased output is interrupted for the survey.

If the pipeline is not cathodically protected then temporary ground beds have to be established in order to inject a signal. The pipeline under test should wherever possible be isolated from foreign structures to minimise signal loss. Higher signals should be used when testing in built up areas or in dry/desert conditions in order to provide reasonable signals to be detected through the higher resistance ground contact points.

5.0 What Are the Advantages of DCVG?

The DCVG method is often compared to CIPS. It is important to clearly understand the differences between the two techniques.

The **DCVG** technique is specifically designed for location of coating defects and to act as a delineation technique for coating refurbishment in order to balance the coating quality with cathodic protection. It is a particularly useful corrosion management tool. Its capabilities include:

- Can be used in all situations e.g. built up areas, across mountains, across deserts, etc.
- Unaffected by induced AC signals.
- Unaffected by stray DC traction currents.
- Can be used to plan future maintenance work without additional surveying.
- Only minimal data is collected relevant to actual defects identified.
- Can be undertaken by one surveyor.
- The technique is extremely rapid and relatively low cost.
- Has been successful in detecting disbonded coating.

12.0 What Experience does CORRSTOP have with DCVG?

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



CORRSTOP personnel were instrumental in 1980 in the development of the technique which was originally being used by Telstra Australia for location of deterioration on underground lead sheathed cables. Trial sets of equipment were produced at that stage for testing of pipelines, Thus, CORRSTOP:

- Have accumulated 16 years of experience with the technique and to date has surveyed over 50,000 km of pipeline in all corners of the world.
- CORRSTOP has the largest group of professional corrosion specialists in the Asia Pacific region providing expert advice, support and field crews.
- The currently available and upgraded model is WM3000 series.

DCVG limitations. The DCVG technique, like all survey techniques, has limitations and built-in errors that must be understood and allowed for in order to get the best results (Table 1).

In the DCVG technique a direct current, typically from the pipe line CP system, is interrupted at a one-Hz frequency. [4] The electrical current flow through the soil to the exposed metal at a coating fault creates a voltage gradient in the soil. This gradient is more concentrated near the coating defect. The pulsing voltage gradient is detected by measuring on a special meter the out of balance between two probe reference electrodes placed on the soil surface. Because the interrupter pulse is irregular, the direction of current flow through the soil can be determined. As the current flows from the CP source to the coating fault, the DCVG meter "points" the surveyor in the direction of the current flow and toward the defect location.

The exact defect location is determined by positioning the electrodes in the vicinity of the defect until a "null" or no pulse is registered. With no voltage difference, the probe tips are located on the same equi-potential line and the defect must then lie midway between the probe tips.

This process is performed down the length of the pipe line and at 90 degrees. Where the center lines of each detection cross is the voltage gradient epicenter, the defect location.

There is always a coating fault where the technique indicates a defect location. The location is reproducible and accurate to within centimeters. However, inexperienced surveyors often confuse a

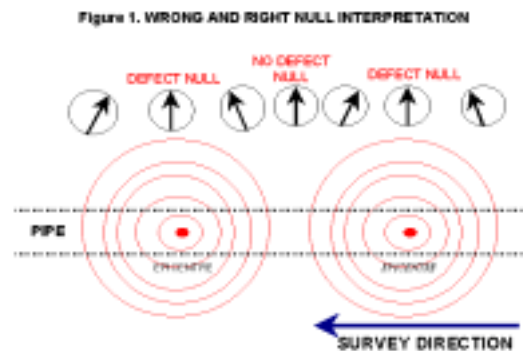
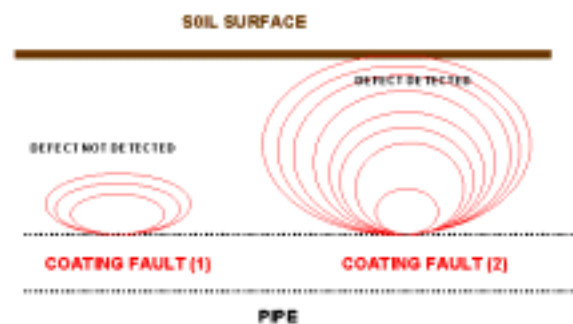


FIGURE 2. COATING FAULTS NOT DETECTED BECAUSE OF INSUFFICIENT DCVG SIGNAL AMPLITUDE



黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

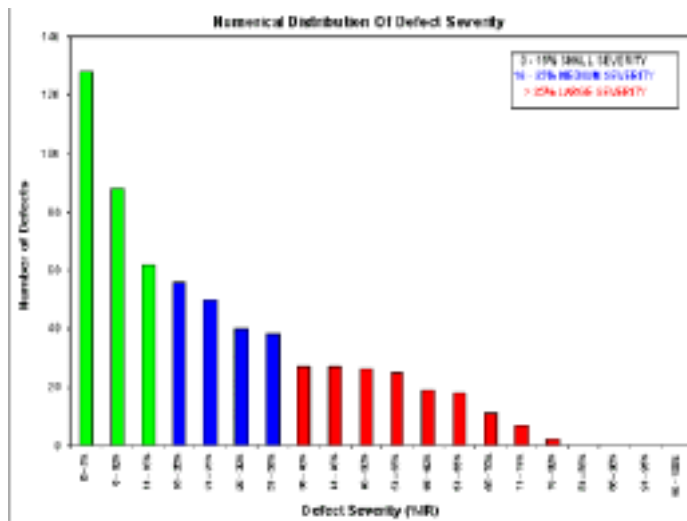
e-mail: hcfeng@CorrStop.Com



defect null with a second null (not a defect location) that occurs in the changeover from the voltage gradient of one defect to another (Fig. 1). Adequate surveyor training can prevent such fundamental errors. A DCVG accreditation scheme is available. [5]

Fig. 3. Frequency distribution of coating defects of different severity.

The ability to detect a coating fault depends upon there being enough DC current flow to the defect to generate a sufficiently large voltage gradient that can be detected at the soil surface. Too small a voltage gradient and the defect will not be seen (Fig. 2). For any pipe line, the severity of defects has the typical logarithmic distribution (Fig. 3). A careless survey, insensitive instrumentation or insufficient DCVG signal means small-severity defects will not be delineated.



If operated correctly, the DCVG technique will detect with 100% certainty a fingernail-size defect buried 6.0 ft down. For this degree of sensitivity, a minimum signal strength is required and the DCVG survey meter should have a 10 mV range.

To ensure a good survey, the DCVG pulse amplitude to remote earth on the pipe line should be measured at tests posts on either side of the pipe line section to be surveyed. If the signal amplitude is small, then the transformer-rectifier (T/R) output should be increased, additional temporary systems should be installed, or the meter's sensitivity must be increased.

Any change in T/R output or use of temporary systems means the survey will measure abnormal operating conditions. This significantly reduces the value of the findings in evaluating the importance of individual defects, because the data no longer represent what is happening under actual operating conditions.

Another value of DCVG signal-amplitude measurement is that it represents CP's availability, or strength, at a coating fault. DCVG signal amplitude indicates the CP T/R's effective range more effectively than pipe-to-soil potential measurement (Fig. 4). A defect will get its total CP from several CP power sources. By interrupting each T/R in turn, the DCVG survey identifies the percentage of CP received from each source.

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



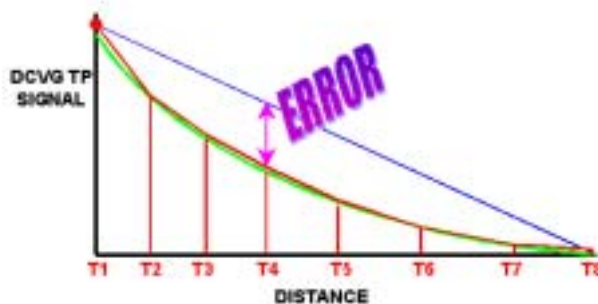
Under normal DCVG surveying, only one CP system is interrupted at a time because the interrupter is moved from one T/R to the next as the survey progresses. This method imposes some limitations on the survey because not all the CP at a defect is being switched when measurements are taken.

An alternative survey method is to synchronously interrupt all T/Rs affecting the pipe line section being surveyed. However, this means each T/R's effective range is not readily observable. There is a tradeoff, depending on which method is used.

Once pinpointed, the defect severity is determined. The term "severity" is preferred over "size" because, although related to the coating damage (size), the electrical measurements taken, determined by the CP current flowing to individual coating faults, are dominated by the nature and type of films on the exposed steel surface. [3]

Defect severity is expressed as a percentage (%IR) of the available CP (DCVG signal amplitude) applied to the pipe line at the defect. [4]

FIGURE 5. ERROR IN TAKING DCVG SIGNAL AMPLITUDE MEASUREMENTS TOO FAR APART AT TEST POSTS



too far apart can be visualized in Fig. 5, with the error dependent on the rate of attenuation of the DCVG signal. The effect is easily seen if the signal strengths at either end of a complete section of pipe line are used rather than measurements taken at closer-spaced test posts in between.

The magnitude of the observed gradient around a defect used to calculate severity depends on many factors, the most significant being defect size (exposed bare metal), surface film integrity, depth of burial and soil resistivity. The gradient around a defect in low-resistivity soils is less evident than for the same geometric sized defect

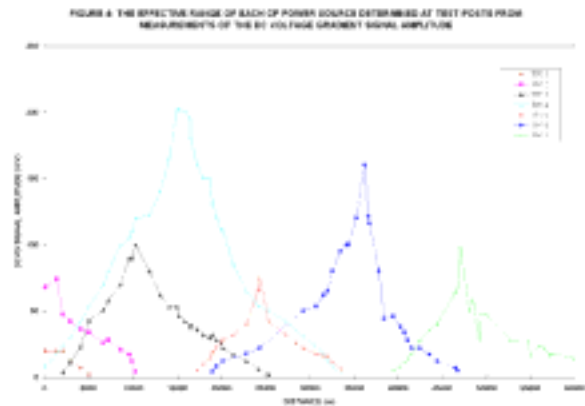
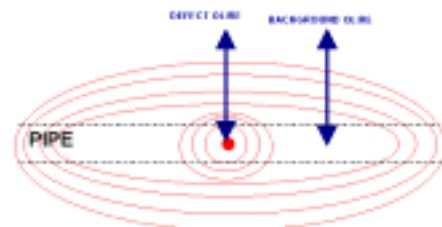


FIGURE 6. DCVG DEFECT EPICENTERS TO REMOTE EARTH (OLRE) SIGNAL AMPLITUDE LIMITATIONS. OLRE OF DEFECT SWAMPED BY BACKGROUND FROM MANY SMALL DEFECTS



黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



receiving the same current in high resistivity soils. The effect of changes in soil resistivity is not linear. High soil resistivities (300,000 ohm/cm) tend to over exaggerate by more than 100% the %IR severity value of defects. The correction to be applied depends on the relative resistance drops across surface films and through the soil to remote earth. In high-resistance soils, the position of remote earth can be a considerable distance from the pipe line. All DCVG data corrections described above are carried out in a data analysis program called PRIMAS, the only known source of such corrections.

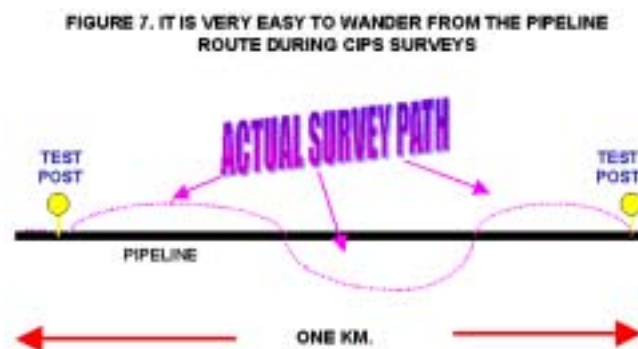
Ruffling (rippling) is a major failure mode of tape coating. It produces a sausage-shaped DCVG isopotential profile in the soil, derived from many small defects in close proximity. Other coating failures, such as coal-tar crown cracking and FBE blistering, also produce the sausage-shaped gradient profile. Within such a profile, it is possible to clearly identify a larger individual coating fault. Epicenter-to-remote-earth potential at these larger individual defects will be dominated by the voltage gradient of the many surrounding small defects (Fig 6). Therefore, the %IR severity of the individual defect can be exaggerated.

For all DCVG electrical measurements, it is important that the T/R output remain constant throughout the day. Another common problem lies with the type of DCVG equipment used. It is important that all DCVG equipment has retained its sensitivity (calibration), that all equipment is of similar sensitivity, and that the same measuring set is used throughout the survey.

CIPS limitations. The Close Interval Interrupted Pipe-to-Soil Potential Survey (CIPS) is a technique claimed to provide a detailed potential profile. It is widely used to assess the overall effectiveness of CP, indicating problem areas such as coating faults or interference at crossing pipe lines. The technique records measurements of the pipe-to-soil voltage gradient profiles down the length of the pipe line at close spacing, typically 6.0 to 10 ft. They are the same voltage gradients used by the DCVG technique. Many CIPS data points are never used in any evaluation process. The CIPS data that is really needed is the pipe-to-soil potential at the DCVG coating fault voltage gradient epicenter because:

- The epicenter (coating fault location) shows the least protected potential and is the location where any coating problem will exist. If the coating is good, why take any CIPS measurements? Good coating is not going to be excavated for repair.
- The defect epicenter is usually the location that will show metal loss.
- Information at defect epicenters from many different surveys allows each defect's importance to be assessed and prioritized for repair.

Combine the surveys. CIPS surveys need to be conducted in a different way from current practice by first using DCVG technology to accurately locate coating faults and then using CIPS to take the epicenter potential readings.



黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



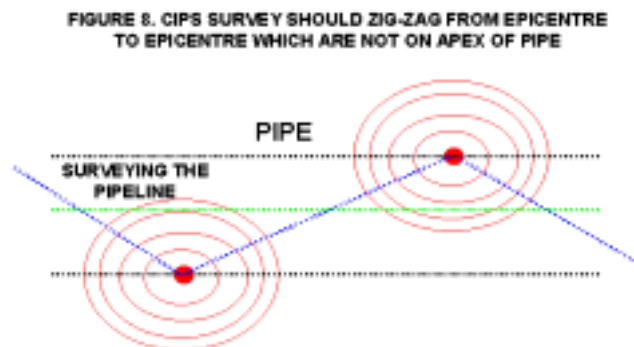
DCVG and CIPS can be run at the same time using a one-Hz pulse to obtain sensible potentials, bearing in mind the significant errors that exist in CIPS potentials, some of which are identified below.

[7.8.9.15] Key items in setting up and conducting a CIPS are listed in Table 2.

It is fundamentally wrong to do the CIPS first, followed by DCVG only at low CP potential areas. The problem indicated by CIPS can be down or upstream from the areas showing low potentials. [14] Further, a typical CIPS takes readings totally at random with respect to coating faults and even pipe location, so the least-protected potentials on the pipe usually are not observed.

Major CIPS errors. The major errors inherent in CIPS are: [7.8.9]

- Unless a pipe locator is used, the CIPS surveyor will significantly wander from the pipe line (Fig. 7). Unlike DCVG technology, there is no indication from CIPS technology to identify the exact pipe location. The surveyor should zigzag because the voltage gradient epicenter will fluctuate from side to side of the pipe, depending on the circumferential orientation of coating faults (Fig. 8). This effect is more noticeable in large-diameter pipe.



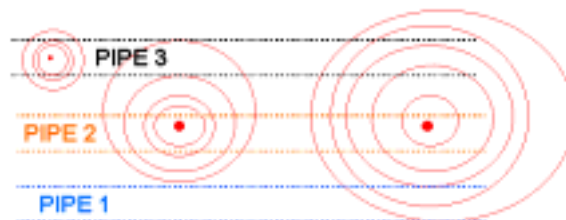
- The common, but important, sausage-shape isopotential profile is not easily recognized, so CIPS can miss significant defect locations. [8]

- On parallel lines, with overlapping voltage gradients, CIPS will give a result which is a mixture of influences from all pipe lines (Fig. 9).

- When the CIPS trailing wire is moved from one test post to the next, a significant CP attenuation error occurs. The observed potentials can either over or under estimate the protection level. The results of correcting for this error, requiring extra measurements and careful thought as to how the survey was performed, are shown in Figs. 10 and 11.

- There is uncertainty as to what constitutes the correct potential for protection. In some soils, protection can be achieved at -600 mV Cu/CuSO₄. In others, -1,100 mV is required. [10] Soil corrosivity variations along a pipe line route are usually not known.

FIGURE 9. OVERLAPPING VOLTAGE GRADIENTS FROM DEFECTS ON PARALLEL PIPELINES AFFECTS CIPS DATA.



- Inability to synchronously switch all DC influences such as DC traction, tellurics, long-line currents. Some DC sources cannot be switched.

- Equipment problems by not

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



synchronizing the voltage recording with the T/R switching.

Another major CIPS limitation is determined by CP amount and coating quality. The limitations can be summarized as:

a) Good coating, small amount of CP, then CIPS represents more the change in ground potential than a change in pipe-to-soil potential. CIPS surveys are limited and results should be treated with caution.

b) Adequate coating, adequate CP. Ideal for CIPS surveys.

c) Poor coating, poor CP, then the ON and OFF graphs coalesce, making nonsense of CIPS readings. CIPS surveys are not recommended. [9]

d) Poor coating, plenty of CP, then large steps occur in both ON and OFF graphs to which a correction must be applied. Otherwise, the data is difficult to interpret properly (Figs. 10 and 11).

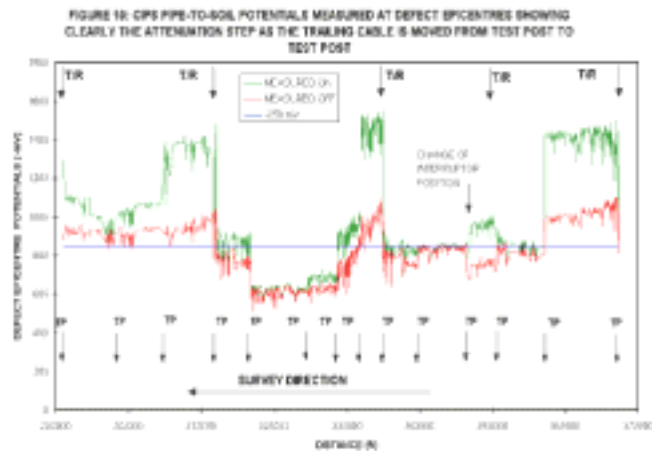
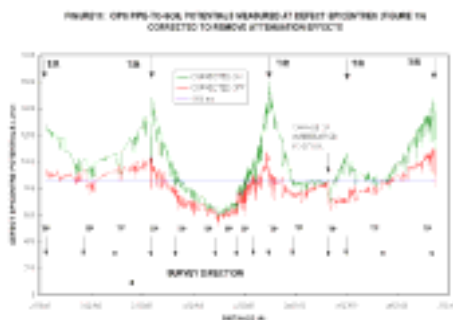


Fig. 10 is a typical CIPS graph for a pipe line with a bad coating to which a lot of CP has been applied. The big vertical steps in both the ON and OFF graphs can be seen as the trailing wire is moved from test post

to test post. These big steps confuse any interpretation to determine if the pipe is adequately protected. Applying the PRIMAS data correction formula to data in Fig. 10, produces an improved presentation in Fig. 11. All CIPS data should be corrected for the attenuation step. However, this does not happen in practice. Therefore, virtually all CIPS surveys are devalued by the inherent inaccuracies in the data collected.



In cases a) and c) above, it is a waste to conduct CIPS surveys on such pipe lines. This also applies to case d), unless data is corrected using a computer program such as PRIMAS. Another precaution, the meaning and usefulness of CIPS data is questionable when temporary CP systems have been set up for a CIPS survey on a line where no CP is usually applied.

Table 1. For a good-quality direct-current voltage gradient (DCVG) survey, these are the key set-up

steps and procedures [11]

- DCVG equipment must have suitable ranges to at least 10mV full-scale deflection.
- There must be adequate DCVG signal amplitude on the pipe, matched to the instrument's sensitivity.

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



A 10-mV instrument will adequately work with a 50-mV DCVG signal. A 50-mV minimum range instrument requires a minimum DCVG signal of 200 mV.

- All instruments on a survey must have equal sensitivity. The same instrument must be used for all DCVG signal amplitude measurements.
- DCVG signal strength should be checked at test posts on either side of the pipe segment to be surveyed to ensure adequate signal strength and confidence in the results. The measuring points should be as close together as possible. The signal-strength measurements also are useful in planning the CIPS.
- GPS coordinates for all features, such as test posts, fences, roads, valves and pig-signaler magnets should be recorded, along with all DCVG locations, for later correlation and relocation.
- Place DCVG probes carefully to ensure that they are not too far apart. Make lateral checks every third step to ensure the survey is on top of the pipe line. Look for the sausage-shape voltage profile which has a strong lateral gradient.
- If there are few defects, a pipe locator will be needed to prevent wandering from the pipe route. This is particularly important when surveying pipe coated with two or three-layer extruded polyethylene.
- All signal amplitudes should be measured to remote earth which will vary in distance from the pipe line as a function of soil resistivity and amount of current flow to a defect. Remote earth typically is the location where two DCVG signal readings, taken 6.0 ft apart, are similar, or very small.
- Temporary CP systems should be monitored to ensure they give constant current during the survey.
- Coating fault severity %IR values should be corrected for soil resistivity to a standard value, corrected for depth of burial effects, and corrected for closeness to the T/R. PRIMAS software handles these corrections.
- Complete DCVG data should be taken at each defect or test post to determine severity, corrosion status and defect orientation.
- The DCVG survey should be conducted only in one direction to avoid confusion.
- The survey should start and finish at a test post each day.
- Comments relating to the survey, route and DCVG measurements should carefully be recorded for future reference. At least two years can elapse between a survey and any excavation. Therefore, detailed comments are useful for relocation purposes.
- If a DCVG signal-amplitude survey is conducted for each T/R before starting a detailed survey, each T/R's effective range can be identified. This identifies which T/Rs to synchronously switch.
- All influencing T/Rs must be synchronously switched, with the switching sequence matched to the data logger's monitoring ability.
- CIPS data must be taken at DCVG epicenters. This eliminates the potential for errors in half-cell placement relative to the pipe. It also fixes the distance measurement because GPS coordinates for each coating fault are logged during DCVG. When running CIPS at the same time as DCVG, a pipe locator is not needed unless there are few coating faults.
- At each test post or monitoring point, the following measurements must be taken to correct attenuation steps (Fig. 12):

1. ON potential at test post No. 2

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



2. OFF potential at test post No. 2
 3. ON potential at test post No. 2 down the trailing cable to the last test post No. 1
 4. OFF potential at test post No. 2 down the trailing cable to the last test post No. 1
 5. Voltage drop from test post No. 2 up the pipe line to the first test post No. 1 and back through the trailing cable to test post No. 2, measured directly with a millivoltmeter, but no half-cell, in the circuit.
- To facilitate data interpretation, all readings must be corrected for the attenuation step as in PRIMAS.
 - All surveys must be taken in one direction only. Survey direction should be noted.
 - All readings should record the environmental conditions at the time of survey.
- Fig. 1. Correct and incorrect DC-voltage-gradient null interpretation.
- Fig. 2. Coating faults not detected because of insufficient DCVG signal amplitude.
- Fig. 3. Frequency distribution of coating defects of different severity.
- Fig. 4. Effective range of cathodic protection power sources determined at tests posts from measurements of the DC-voltage-gradient signal's amplitude.
- Fig. 5. Error in taking DCVG signal amplitude measurements at test posts that are too far apart.
- Fig. 6. Signal amplitude ratio between a DCVG defect epicenter and remote earth (OL/RE) can be swamped by the signal from many small defects.
- Fig. 7. It is easy for the surveyor to wander from the pipe line route during a CIPS because, unlike DCVG technology, there is no indication from CIPS to identify the exact pipe location.
- Fig. 8. The CIPS surveyor should zigzag from defect epicenter to epicenter because the defects are not all on the pipe crown.
- Fig. 9. Overlapping voltage gradients from defects on parallel pipe lines affects CIPS data.
- Fig. 10. CIPS pipe-to-soil potentials measured at defect epicenters clearly showing the attenuation step as the trailing cable is moved from one test post to the next.
- Fig. 11. CIPS pipe-to-soil potentials measured at defect epicenters in Fig. 10 corrected to remove attenuation effects.
- Fig. 12. Voltage and pipe-to-soil potential measurements required at every test post during CIPS.

Traditional CIPS aboveground survey collects unneeded data

Operators urged to shift philosophy to a simpler, more informative approach to coating assessment

While the close-interval-potential survey (CIPS) technique is widely used to

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



determine cathodic protection (CP) system adequacy on buried pipe lines, it is subject to substantial errors that can be reduced by changing operator philosophy and adopting a simpler technique.

Good, meaningful results can be gathered by taking measurements with DC voltage gradient (DCVG) equipment to locate coating defects and then gauging the pipe-to-soil potential and direction of current flow at the defect epicenter with a simple voltmeter while the CP system is switched ON/OFF at the frequency used by the DCVG technique. Measuring pipe-to-soil potential is the standard method to control a pipe line's cathodic protection and to determine the protection level. However, the limitations of taking isolated potential readings at test posts at 0.6 to 1.2-mile intervals are well documented in that the measurements provide little information about the protection level applied between test posts.

A desire to fill in this gap spawned the concept of continuous potential measurements along the pipe line, commonly called close-interval-potential survey (CIPS). CIPS uses a long trailing cable attached to a test post to connect the voltmeter to the pipe line. This allows pipe-to-soil potential measurements to be taken at close spacing along the line's whole length.

The original concept has merit, which probably is why the technique is now widely used. CIPS was first applied almost simultaneously in the UK and the U.S. However, an exhaustive search of published literature has failed to identify any original work and only little subsequent work to establish limitations or inherent inaccuracies in the technique. The only conclusions that can be derived from this is that either no proper investigation has been done, or, if it was done, it was not published because of commercial interests. In the practical application of CIPS, most companies and, in particular, their technicians who conduct the surveys, have little knowledge of the technique's limitations or inaccuracies. There are no written specifications on how a CIPS should be conducted, and how the effect of the inaccuracies may be limited. Also important is that there is no accreditation method or approved training for surveyors by which clients can judge the quality of the personnel and be more assured of a competent survey.

CIPS concept. The technique's general concept is to measure pipe-to-soil potential along the whole pipe line by taking readings at regular intervals. Such potentials then are interpreted according to general criteria originating largely from NACE International as to what constitutes the potential divide between protection and underprotection.¹

For a coated pipe line, any potential measurements taken where the coating is good are of little use in deciding what to repair. The most important pipe-to-soil potential is the potential that occurs at the epicenter of the voltage gradient generated by the CP current flow to steel exposed at a coating fault. The epicenter location will indicate the least protected potential. Only those potentials are of any use in the rehabilitation decision making process. However, such potentials still are subject to error and must be corrected for attenuation profiles.

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



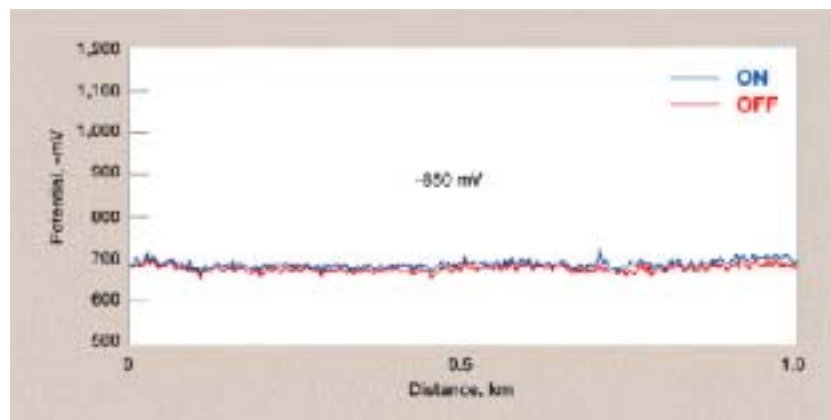
Unfortunately, the way a CIPS typically is conducted pays no attention to coating-defect epicenter locations, which usually are not located prior to a CIPS. It is purely a matter of luck when the CIPS halfcell is placed at the defect epicenter. Also, it is not common to first locate and stake-out the pipe line to ensure CIPS measurements are actually taken over the line.

Any potentials taken at locations other than the defect epicenter, and this usually is most readings, always indicate better protection. Wandering away from directly on top of the pipe also adds to the indication of better protection. Unless a pipe route is well indicated, wandering from the line by 15 ft or more is common.

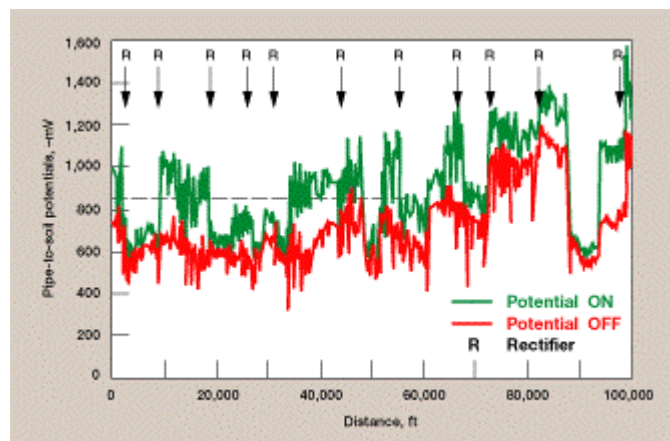
If a pipe line has a near-perfect coating, with low CP-current demand, such as three-layer polyethylene systems, then virtually all pipe-to-soil potential measurements are meaningless. With a near-perfect coating, the measurements observed reflect changes

in ground currents caused by tellurics, DC traction and CP to other pipe lines, rather than genuine changes in pipe-to-soil potential.

If a pipe line has a poor coating and a resulting poor CP level, the ON and



OFF potential readings coalesce (Fig. 1). Fig. 2 is typical of CIPS data where the coating is poor and large amounts of CP are applied, approximately 400 A in 20 miles. The



attenuation steps are very apparent. In CIPS graphs, it generally is the ON potential graph that better indicates coating damage, with the difference between the ON and OFF graph reflecting more the coating's resistance. These differences are poorly defined for a bad coating. Hence, CIPS does not give meaningful data to study protection levels and to

indicate the presence of coating damage on a badly coated pipe.

The potential reading at the second test post resulting from the connection all the way

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



back through the trailing cable to the first test post

The potential reading at the second test post.

Because the voltmeter has many megohms of resistance, the attenuation is not caused by the trailing cable, but is a phenomenon caused by the way the measurements are taken, in particular the relative positions of the connection point and the halfcell location to include the voltage drop in the pipe line between halfcell and trailing wire connection test post. Depending on whether the surveyor is walking away from or towards a rectifier, the pipe-to-soil potential will respectively indicate either better protection, or less protection than the true value. Survey reports should always indicate the direction in which readings were taken.

This built-in error in CIPS readings is industry wide and never corrected for. It is obvious that the error complicates interpretation of the potentials.

There is a standard potential attenuation formula that can be applied to correct for the attenuation error, giving a more realistic value of pipe-to-soil potential for interpretation. However, the formula generally is not applied, because the task of correcting thousands of readings is overwhelming. It is worth applying to defect epicenter potentials, because these are the monitoring points that really matter.

Halfcell location. CIPS errors can occur because of halfcell location. The technique monitors changes in pipe-to-soil potential caused by current flowing through the soil at defect locations. The ON potential reflects more the potential changes due to the coating's resistance and the soil's voltage drop. These are called IR errors. CP current flow through the soil generates a voltage gradient and the shape of this voltage gradient iso-potential profile changes with:

Shape of the bare steel exposed at the coating fault

Nature and density of protective films on the surface of the exposed steel

Orientation of the defect location around the pipe circumference

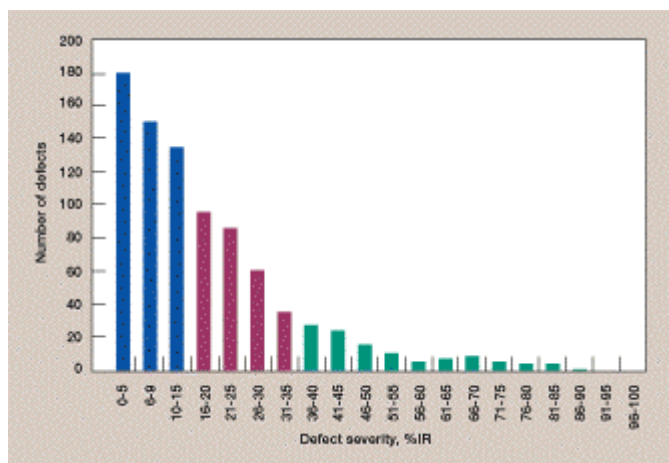
Defect size and whether there are many small defects in close proximity

Soil resistivity and how it varies

Soil pH which strongly influences the nature of any films on the exposed steel surface

Burial depth of the pipe line.

Voltage gradients from defects can stretch some distance; 15 to 60 ft is common, but profiles have been observed that stretch more than 300 ft. This is effectively saying that



黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



observed pipe-to-soil potentials are dominated by voltage gradients from coating defects whose influence can be observed at quite long distances from the actual defect location. This fact raises the question: Why take any measurements where there are no defects, because such measurements reflect not so much pipe-to-soil potential but more the actual change in ground potential?

Coatings fail by a variety of mechanisms. The typical defect-severity distribution is shown in Fig. 3. There usually are many small defects and a decreasing number of defects as severity increases. It is well known that the CIPS technique does not recognize small defects.³ Personal work indicates that most defects of less than 5 to 7% severity in Fig. 3 would not be identified. Typically, this is 50% of all pipe line defects. The number of small-severity defects can be a problem in that the "throw" of CP from the drain point and the value of CP potential are influenced by many small defects and can have the same overall effect as a few big defects.

In any rehabilitation activity, it is necessary to know of all coating faults, irrespective of whether they are repaired, particularly now that the science has reached the stage of trying the model the interaction between CP and coating before and after any proposed rehabilitation process.

The most common iso-potential plot on a pipe line has a sausage shape, oriented longitudinally with the pipe axis. This profile can result from coating failure mechanisms, such as crown cracking in coal tar or, more common, the result of the coalescing of the iso-potential plots of many small coating faults in close proximity, such as occurs in the wrinkling of tape coatings or FBE blistering.

Because the sausage-shaped profile extends along the pipe axis, there is only a change in pipe-to-soil potential at either end. There is no change in pipe-to-soil potential within the profile unless there exists within the many small defects one whose individual iso-potential profile allows it to be recognized as an discrete defect.

The danger in the general scenario above is that conventional CIPS cannot identify the sausage-shape. Therefore, such a large defective area can go unrecognized. This insensitivity is exacerbated the farther the CIPS halfcell location is from the epicenter of the sausage-shaped profile. Wandering away from the actual pipe location can dramatically influence the CIPS technique's accuracy.

There is a further problem. The defect epicenter location will vary from the apex centerline depending on the defect's orientation around the pipe circumference. A defect on the bottom or side, which is where most coating defects occur, will have an epicenter to one side. This problem is exacerbated on larger diameter pipe. Therefore, the best CIPS halfcell location is not always directly on top of the pipe line but in a zig zag through the epicenters on either side of the line. CIPS measurements taken at the crown of a pipe with a defect on the side or bottom would indicate better protection than actually exists. Further problems occur as pipe diameter increases. Results are meaningless on very large, 12 to 30-ft diameter, pipe where the typical pipe apex iso-

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



potential plot is a continuous sausage shape, producing an over-estimation of protection.

ON/OFF potentials. What is actually being measured with CIPS ON and OFF potentials? In the CIPS technique, to measure true pipe-to-soil potential, free from IR error, all DC influencing the area under investigation should be switched synchronously.

In practice, this never can be achieved as it is not possible to switch ON/OFF DC influences, such as DC traction, longline currents and telluric effects, and it may be politically difficult to interrupt CP systems on adjacent lines owned by others.

The magnitude of some of these influences and their variability in most cases is unknown. What value, then, is the OFF pipe-to-soil potential? If it is borderline to accepted interpretation potentials (-850 mV), then it is not possible to conclusively determine if the pipe is protected. If the potentials are at, say, -600 mV, then underprotection can be concluded. Similarly, if potentials are greater than 1,000 mV, protection probably can be assumed.

As the interpretation is relatively crude, why spend thousands of dollars on sophisticated synchronized equipment when the degree of accuracy is limited by outside factors that cannot be influenced or controlled? A simple maximum / minimum voltmeter will give results just as good. Expensive synchronized equipment is not needed for ON potentials, and it is from ON potentials that most information is obtained about:

Problem location, such as coating faults and interfering structures

CP availability as a function of distance from the rectifier

Other interfering DC influences, particularly third-party CP systems and DC traction.

As it is impossible to switch all DC influences at the same time, the situation often exists where specifically designed, expensive equipment is purchased to monitor a parameter, the OFF potential, whose value will always be suspect. The real situation is even more suspect. Synchronized timers are used to switch the rectifiers. Most of those rely on crystals that are well-known to drift, frequently more than claimed. Many units will not remain synchronized for more than four hours. The more modern satellite interrupters are sensitive to overhead power lines, metal fences, trees, anything that blocks the satellite's line of sight.

The problem with interrupters goes deeper. There really is no satisfactory DC-operated solid state switch to carry more than 30 - 40 A. There are many CP rectifiers whose output exceeds 40 A and slave units are used to switch such rectifiers. These essentially are relays. All relays give noisy and uneven pulses.

When a DC source is interrupted, in some cases an anodic spike is observed whose amplitude and duration can be significant.⁴ The anodic spike is a characteristic of the pipe line and its coating. When the rectifier is switched ON, a cathodic spike much larger in amplitude and duration also occurs. The cathodic spike is a function of the CP rectifier, but the cathodic spike's magnitude can be two or more times the typical rectifier output that determines the controlling limitation with solid-state switches. These limitations

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



raise questions:

If there are difficulties in switching, the switching is noisy and there are anodic and cathodic spikes, as well as limitations with the synchronization of interrupters, at which time after switching OFF is the right time to take the OFF pipe-to-soil potential readings? What value is the potential measurement if not all DC influences can be interrupted? All CIPS equipment is subject to these effects, so what is the logic of investing thousands of dollars in unnecessarily sophisticated equipment, which can never properly measure the true pipe-to-soil potential?

Correct potential. What is the correct pipe-to-soil potential for interpretation? Normally, CIPS potentials are interpreted to NACE criteria.¹ In particular, the OFF potential is required to be more negative than -850 mV in order to assume protection.

In practice, the criteria are inadequate. In some soils, protection is achieved at potentials as much as 200 mV less negative than -850 mV. In other soils, potentials more negative by as much as 200 mV than -850 mV are required to achieve protection.⁵ In other words, the criterion for interpreting the OFF potential will vary with soil type, and, as this will vary along a pipe line, the criterion for interpretation must be varied. A single potential is not valid for the entire line. Most operators need to improve their knowledge of the soil corrosivity variations along a pipe line route and how that corrosivity is related to the protection potential. Soil corrosivity is more complex than indicated by the widely used correlation to soil resistivity.

OFF potentials are a dubious measurement and their interpretation is suspect. Potential measurements are best supported by measuring the direction of current flow. Net current flow to a defect indicates protection, irrespective of the defect's epicenter pipe-to-soil potential. This is also a NACE criterion and is easy to assess using DC voltage gradient technology.

Revise the philosophy. The philosophy under which CIPS is used to monitor and control pipe-to-soil potentials, and hence determine rehabilitation requirements, needs drastic revision.

The way surveys are carried out is wrong and most of the information collected is of little value because of the random way the information is collected. The determining factor in all pipe-to-soil potential measurements is the presence and influence of coating faults. Faults will determine:

Effective CP-system range

CP level

Pipe-to-soil potential which CIPS is used to measure.

The way CIPS is universally used today should be reversed. The correct approach is:

Locate the coating fault voltage gradient epicenter

Measure the pipe-to-soil potential only at the epicenter, correcting the potentials for attenuation.

Measuring potentials at other than epicenters is not required. These regions are

黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



protected because they have a better coating.

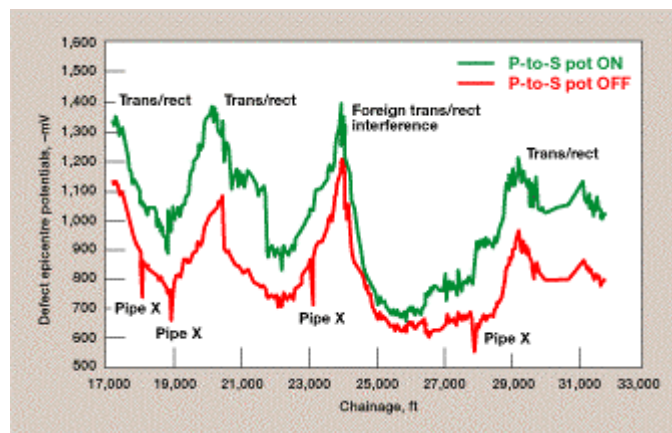
Most CIPS information comes from the ON potentials. Measuring this at epicenters does not require sophisticated equipment. A simple voltmeter, such as Fluke 27, is adequate. OFF potential measurements never will be exact. At best, they only crudely approximate the true OFF potential. As this is the case, the same simple voltmeter, used in its "Min" mode, will provide an adequate measurement. Equipment cost then declines to less than \$1,000, compared to \$15,000 for the sophisticated equipment, excluding interrupters.

Using a simple voltmeter for CIPS measurement, it is possible to record the defect epicenter's pipe-to-soil ON and OFF potential at the same time as DC voltage gradient equipment is used to locate defects and measure the direction of current flow to

indicate protection and correlate with measured potentials.

Using the same interrupter switching frequency as used for the DC voltage gradient equipment – faster than normal CIPS switching – gives data like that shown in Fig. 4.

Only defect epicenter potentials were measured. The location and effective range of the



rectifiers can clearly be seen. The effect of an interfering CP system from a parallel "foreign" pipe line can clearly be observed. The interfering effect had not previously been reported, although conventional CIPS had been carried out over the last 10 years. More interesting are the positive spikes in the OFF potential at locations where the subject pipe line crossed the foreign line and its interfering CP system. Aboveground measurements using DC voltage gradient technology at these locations predicted current leaving the subject pipe line which could result in perforation. Excavation of the pipe line at the crossing point identified the problem as a below-ground, previously unknown, poorly insulated crossbond, draining current back to the foreign pipe line.

With this study, 80% of the relevant information was gathered with little extra effort, using simple equipment. What extra information that could add to the interpretation could have been gathered using more sophisticated and expensive equipment? Very little. Undoubtedly, the potentials could have been "polished" to make them a little more accurate to the true value, but it is doubtful if any additional improvement to the interpretation would be added using sophisticated equipment.

Why, then, expend 80% of the effort / cost to gather / "polish" the residual 20% of information, adding nothing extra to the interpretation? Because of careful halfcell placement, the data given in Fig. 4 are probably more accurate and better represent the

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



true potentials than those potentials gathered using sophisticated, expensive equipment with the halfcell placed at random locations relative to the pipe and any coating faults. Accurate distance measurement is an added problem, common to all aboveground survey techniques. After an exhaustive examination of techniques, the conclusion is that no technique is ideal, but the most accurate are GPS, optical or laser methods. Least accurate are the CIPS cable dispensing and surveyor's wheel measurement techniques, although they are widely used.

Conclusions. Twenty years of examining aboveground pipe line cathodic protection (CP) system diagnostic techniques, leads to these conclusions:

The close-interval-potential survey (CIPS) technique is subject to a number of errors which can be reduced by observing pipe-to-soil potentials at coating-defect epicenters only and correcting the readings for CP attenuation

Good, meaningful results can be achieved by taking measurements at defect epicenters, using simple, inexpensive equipment. Sophisticated equipment is not an indication of a good CIPS survey

The criteria for interpreting pipe-to-soil potentials leave much to be desired because of variations of the criteria with soil corrosivity variations.

C-SCAN Detector Unit

- The Detector Unit is housed in a weatherproof plastic case.



- The front tube contains the antenna system, and the keyboard and LCD display are mounted on the top of the tube. The base compartment contains the main computer, the batteries and connectors.
- The antenna consists of a number of large diameter air cored coils.
- In operation, the computer calculates the vector sum of the field strengths measured by the coils over the length of the instrument. The LCD indicates to the operator that it has 'ACQUIRED' the signal radiating from the buried pipe. The LCD gives an indication of field strength and guides the operator towards the pipe. A comparison of the field strengths at the antenna with the strength of the field measured by the vertical axis, is

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



used to tell the operator when he is 'CLOSE' to the pipeline. When the field measured by the vertical axis coil falls below a threshold value, the instrument display changes to a moving bar display, guiding the operator to 'STOP' once he is 'OVERHEAD'.

- When the instrument is stationary in the 'OVERHEAD' position for a few seconds, it will automatically collect a sample of over 400 readings of the field strength values measured by the antenna over a period of approximately six seconds. Provided the standard deviation of the sample is below a threshold value, the computer will then calculate the depth of the pipe (below the bottom of the unit to the centre line of the pipeline) and the strength of the residual signal current on the pipe.
- The 'DEPTH' and 'CURRENT' values (in metres or feet and mA) are shown on the LCD for a few seconds, and if the operator takes no action, the instrument will repeat the sample and calculation routine.
- Using the keyboard, and following the prompts appearing on the display, the operator can store the displayed data (which is automatically given a reference number), and request the computer to calculate the logarithmic attenuation of the signal from any previous location stored in its memory. This information is displayed on the LCD and is also stored. The computer can store up to 100 complete sets of data (location reference number, depth of pipe, strength of signal current, distance from a previous location reference, and logarithmic attenuation of the signal, in millibels per metre, between the two points). At the beginning of each survey, the computer will also note automatically the time and date using the internal clock, and this information will also appear on the subsequent printout. Current readings obtained in the course of a close interval survey to locate specific faults, are not stored for printout, as they are unlikely to be relevant to subsequent surveys. These readings are generally noted down for plotting purposes by the operator during the course of the operation.
- At the end of a survey (or whenever required) the Detector Unit may be plugged into a standard computer printer (with parallel Centronics type interface, or RS232 serial interface) and the survey report can be printed out in full. Alternatively, the data can be displayed on a computer monitor or stored on disk or tape for further analysis.



- The Detector Unit is powered by a nickel/cadmium rechargeable power pack which will normally provide enough power to run the instrument continuously for over 20 hours. There is, in addition, a built-in lithium power source to maintain the data stored in the memory and the operation of the clock, when the power pack has been exhausted. This has an estimated life of ten years.
- The C-SCAN System is not immune to electromagnetic interference but it incorporates a number of features which are designed to keep such interference to an absolute minimum. Briefly these features include: the generation of a pure sine wave so that no complex harmonics are produced, the use of a carefully selected frequency with virtually no harmonics in common with other frequencies in general use, the narrow bandwidth of the filters in the Detector Unit, and the collection of over 400 signal 'samples' over a period of approximately 6 seconds to eliminate transient interference. The instrument can usually be used in the presence of 'mains' AC current and is not affected by any residual 'ripple' in operating DC (rectified) Cathodic Protection systems.

C-SCAN Generator Unit

- The generator has a built-in re-chargeable power supply of three sealed lead-acid batteries, each producing 12 volts and having a nominal capacity of 7 ampere/hours. The nominal output voltage is 50 volts peak-to-peak (theoretical maximum 60 volts), which is 18 volts rms. An external 12 volt battery (Car battery etc.) can be connected using the cable supplied. This will extend the usable time to the capacity of the external battery. Note: the external battery must be charged separately.
- The generator is charged by an external power unit which will accept mains power at 120 volts or 240 volts and at frequencies of 50 Hz or 60 Hz automatically. A full charge should last for two to three days of normal survey work (depending on level of signal current). The batteries should not be allowed to discharge completely. If possible, the generator should be put on charge at the end of each day's survey. This will extend the life of the batteries.



- Selecting the Signal Injection Points -
- It should be remembered that the signal will travel in both directions from the Signal Injection Point, and that the Detector can operate moving towards the Generator (when attenuation values will be negative) as well as away from it. Thus a signal injection point (CP Test Post, etc) in the middle of the section to be surveyed will probably give better overall results (because of the higher average signal level) than one at the end of the section. Other points to consider when selecting the signal injection point are availability of a good EARTH, and the fact that a section of line 10-15 metres either side of the injection point cannot be surveyed because of mutual interference between the fields radiating from the EARTH LEAD and the pipe. Thus if it is intended to survey a road crossing, it is better not to use the CP Test Posts either side of the road to be checked.
- Connection to pipe -
- The fully charged Signal Generator should be placed close to the selected CP Test Post (or other selected signal injection point), and connected to it using one of the short leads, plugged into the PIPE CONNECTION socket. The other short lead should be plugged into the GROUND CONNECTION socket.
- Once the Signal Current has been set, it will remain constant until the batteries are exhausted. Any changes in operating conditions during the survey (e.g. changes in resistance at the EARTH SPIKE due to rain or capillary action) will be automatically compensated for. If conditions change dramatically such that the unit is unable to maintain the correct current, the unit will cycle the output between zero and maximum. This will be picked up by the surveyor (the detector operator) as alternating 'NO SIGNAL' 'CLOSE' etc.



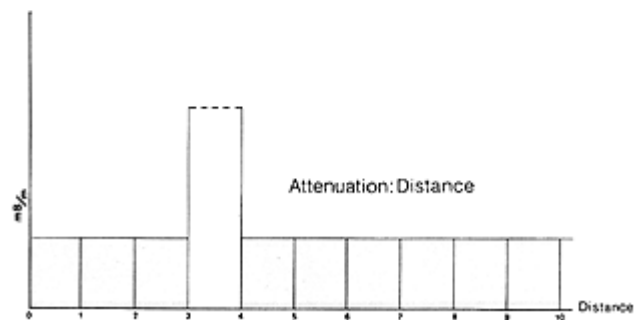
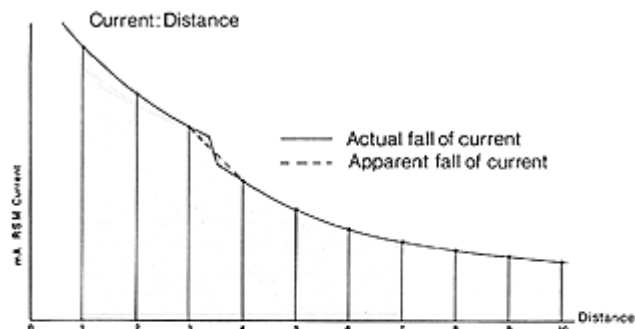


DCAPP

(Data Capture, Archive and Print Program)

- Dynalog supplies the DCAPP program as standard. This is currently available to two forms - DCAPP for DOS which is a stand alone program for DOS PC's - and DCAPP for Excel which runs as a macro in Excel (Excel 97 only - currently in BETA release stage). The program allows a C-SCAN detector unit to download all survey data into the PC and to produce a report, with plots, automatically.
- The C-SCAN detector unit is connected to the PC via an RS232 serial link. Data is downloaded by using the print facility.
- By using the 'front panel' that appears in the Excel screen (shown above) various functions can be selected - these are as follows:
- Initiate the fully automatic download and format procedure. This produces the report *automatically* complete with graphical plots of DEPTH, CURRENT and ATTENUATION. If GPS data is present, a positional plot of each survey point is produced as offsets in metres from the survey start point (not available in DOS version).
- Recall and display of 'old' DCAPP for DOS files, displayed in the new report format
- Manipulation of the source data for corrections, with a re-format function.

Single fault in wrap



黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

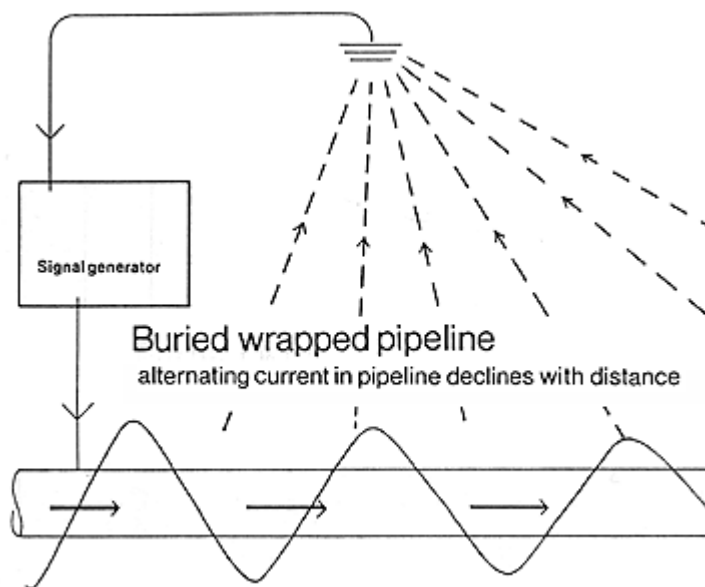
e-mail: hcfeng@CorrStop.Com



- Add pipeline data such as reference points, features CP points etc.
- Click on the thumbnails below for full screen printouts
DCAPP for Excel requires Hyperterminal and Wordpad or Word to be installed.
Excel, Hyperterminal, Wordpad and Word copyright Microsoft corp.

Attenuation surveys ... What are they?

- An electrical current applied to a well wrapped buried metal pipeline will decrease gradually with increasing distance from the current injection point, as the current escapes to earth through the wrapping.
- If the wrap has a uniform thickness and separates the pipe from the surrounding soil at all points, the strength of the signal current on the pipe will decline logarithmically. The rate of decline will be dependant primarily on the electrical resistivity of the wrap or coating in use, and the area of wrap in contact with the soil per unit length of pipe (i.e. for a given coating, the decline is proportional to the circumference of the pipe). [Note: because of the relative magnitude of the resistances involved, local changes in soil resistance can usually be ignored].
- If there is a low resistance electrical path from the pipe direct to the soil at any point, there will be a substantial local increase in



黄骅市科普防腐材料有限公司（廊坊）

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



the rate of loss of signal current. Such a low resistance path could arise from: incorrectly applied wrapping, mechanical damage to the wrap before, during or after installation, decay of the wrap due to soil conditions, disbonding of the wrap from the pipe (provided that ground water has penetrated into the gap to provide an electrical path to earth), or a leak in the pipe itself causing the wrap to fail at the leak point.

- Because the resistance of such a path is likely to be several orders of magnitude less than the resistance of the undamaged wrap, the resultant loss of current, even from a single small fault of a few square millimetres, can usually be detected by a significant increase in the apparent rate of current decline over quite a long length of pipe.
- In practice, the existence of one or two small faults on a section of pipeline several hundred metres in length can usually be tolerated because the Cathodic Protection System can be expected to prevent serious corrosion developing quickly. In this case it may not be necessary to locate the specific faults immediately but the rate of logarithmic decline of current between two specific points can be logged for future reference so that any deterioration of the condition of the pipeline can be monitored. [Note: the logarithmic rate of decline of the current (attenuation) measured in millibels per metre, is effectively independent of the applied current and is only marginally affected by seasonal changes in soil resistivity, so that it is virtually an absolute indication of the average condition of the wrap between two given points at the date of the survey].

NEW FEATURES

- The graphic below shows a representation of the C-SCAN 2000 detector unit display during a survey.

The display is divided into 3 sections.

1. survey status in English
2. survey status in alternate language
3. Positional information

- Sections 1 and 2 will be familiar to existing C-SCAN users. These

黄骅市科普防腐材料有限公司 (廊坊)

河北省廊坊市和平路文体中心

电话(Tel) : 0316-2235133; 13903168421 传真(Fax) : 0316-2232326

Home page: www.Corrstop.com

e-mail: hcfeng@CorrStop.Com



sections show the status of the signal strength of the received signal:

- NO SIGNAL indicates that there is no signal or that the detector unit is too far from the pipeline to pick up the signal.
- ACQUIRED indicates that the detector unit has picked up the signal but is still a long way from the pipeline. The number indicates the relative signal strength
- CLOSE indicates that the detector unit is close to the pipeline (usually within the pipeline depth - horizontally, i.e. 2m distant for a pipeline at 2m depth)
- OVERHEAD indicates that the detector unit is very close to the overhead position. The '>-<' signs indicate the exact overhead position. When they are as close as possible (they may not touch) then the detector unit is directly over the pipeline.
- When the unit has been overhead for a few seconds, it takes over 400 samples and displays CALCULATING. During this time it is important that the unit is not moved.
- After the calculation has been done, DEPTH and CURRENT information is displayed.
- After this point, the user is asked to enter the distance between the present point and the last point surveyed (or any previous point stored in memory). An attenuation figure is given and the result can be stored.
- Section 3 is a new feature to existing users.
- Sections 3 is a new feature and adds positional information to C-SCAN display.
- The position is displayed in two forms: Pipeline position and detector position.



Pipeline position

- The direction and distance of the pipeline from the detector position is displayed as a 'radar' display and distance respectively. The above graphic display shows the direction as a line centered in a box. The centre of the box represents the detector position and the line 'points' towards the pipeline. The figure on the right of the box refers to the horizontal distance to the pipeline, rounded up to the nearest metre. When the detector is close to overhead, both displays blank and the normal OVERHEAD display is used.

GPS Positional data

- The position of the detector in latitude and longitude is displayed underneath the 'radar' box. This requires an EXTERNAL GPS (Global Positioning System) receiver to be connected to the C-SCAN's serial port. The external GPS unit must be capable of send NMEA compatible data over a RS422 or RS232 serial link. The PDOP (Positional Dilution Of Precision) number is displayed against the the 'GPS OK' label. If the external GPS unit is a differential unit (DGPS) then the increased accuracy is reflected in the display. The longitude and latitude data is stored with DEPTH, CURRENT, DISTANCE, LOCATION NUMBER and ATTENUATION. All data stored may be printed out or downloaded to a computer for analysis or graphic presentation, including pipeline position, using the proprietary software DCAPP.