Close Interval Potential Survey (CIPS) Training

- Close Interval Potential Survey (CIPS) are one of several tools used in assessing the effectiveness of cathodic protection (CP) systems used on buried pipelines.
- CIPS are sometimes referred to as pipe-to-soil and potential gradient surveys.
- CIPS are used to measure the potential (voltage) difference between buried pipes with earthen cover and their surrounding soil.
- Where the pipe is located under concrete or asphalt, precautions must be taken to ensure good electrical contact with the soil surrounding the pipeline. This is typically accomplished by boring holes through the concrete or asphalt to allow contact with the soil.

Applications of CIPS:

- Close Interval Potential Survey (CIPS) are used to assess the performance of installed CP systems on underground pipelines.
- CIPS can also be used to detect some coating holidays (defects). CIPS is not effective for detecting very small coating defects.
- CIPS is not effective if pipeline is located under frozen ground, where the pipe coating is disbonded resulting in a non-continuous electrical path to the soil, where the pipe is enclosed in a casing, where the pipeline is located in a rocky terrain or where the pipe is located under a paved road. In these cases, another assessment tool should be considered.
Types of CIPS:

There are three basic types of CIPS:

- “On/off” potential survey measure the potential difference between the pipe and the ground surface as the cathodic protection is switched on and off. On-off surveys are used to evaluate the performance of the CP system against system performance criteria and can be used to detect some coating anomalies.
- “Depolarized” potential surveys measure the potential difference between the pipe and the ground surface after the cathodic protection current has been switched off long enough for the pipe-to-soil potential to stabilize. Depolarized potential is used to evaluate CP system effectiveness by measuring polarization decay.
- “on” potential surveys measure the potential difference between the pipe and the ground surface at regular intervals while the Cathodic protection is operating in its normal mode. “On” potential surveys are used when cathodic protection current sources cannot be interrupted.

BASIC CONCEPTS

The widely practiced technique to monitor pipe to soil potentials of a buried pipeline is to take measurements using a saturated copper/copper sulphate electrode and a high resistance voltmeter, making electrical contact to the pipeline at test posts that are usually spaced at regularly one to two Km intervals along the pipeline route. The problem with such measurements is that they reflect only what is happening one or two meters either side of the test post. Hence what happens to the pipe to soil potentials between test posts are largely unknown.

Further, local influencing factors such as a significant coating fault within a short distance of a test post can dominate the test post reading giving rise to limited information as to the true nature of the level of protection on a pipeline. To overcome the limitations of test post readings, led more than 45 years ago, to the development of the Close Interval Potential Survey (CIPS) technique. In CIPS a long trailing cable is used to make contact to the pipeline via the test post and pipe to soil potentials are measured at regular short intervals along the whole pipeline route thus providing a more intimate view of the level of protection along the whole pipeline. The conventional voltmeter is usually replaced by a data logging voltmeter to gather the large quantity of measurements made. The technique is claimed to provide a detailed potential profile and the results are widely used to assess the overall effectiveness of the pipeline Cathodic Protection. The usual practice in
CIPS is to determine the pipe to soil potential with all recognized DC sources (transformer rectifiers) operational (ON POTENTIAL) and then with all the DC sources interrupted (OFF POTENTIAL). The latter measurement, the OFF potential is now regarded world wide as the most important potential, and is thought to largely eliminate the IR voltage drop errors present in ON readings that are caused by current flow through the soil and films of corrosion product on the pipe surface. The concept of ON/OFF potentials as a technique is based on the principle that when the CP is switched OFF, the IR component in the potential measurements decays almost instantaneously but the pipe to soil interface polarization decays very slowly over hours/days depending upon the soil composition. This allows what is considered to be a more correct pipe to soil potential (the OFF Potential) and hence a better assessment of the level of protection to be measured (free from the IR error).

There is no industry standard identifying the switching frequency and the time after switching that the ON and OFF potentials should be measured. Each vendor of equipment has chosen their own time sequences which depends upon synchronization method (and drift of Synchronization) and accuracy not only of the interrupters used but also the synchronization of the Data Logger with the Interrupters.

DCVG Ltd have designed and have commercially available after thorough testing Quantum CIPS equipment, Satellite controlled and capable of operating at variable ON/OFF sequences and in particular at the DCVG pulse frequency of 0.45 ON/0.8 OFF so two types of survey, true analogue DCVG and CIPS can be run independently but as a one pass survey as required by the ECDA concept.
**DC VOLTAGE GRADIENT TECHNOLOGY & SUPPLY LTD**

MARKET LEADERS IN ECDA SURVEY EQUIPMENT + SOFTWARE & CATHODIC PROTECTION RESEARCH

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**DCVG/ CIPS Current Interrupters**

Four different types of CP Current Interrupters are available.

**Variation 1**

Stand alone unsynchronized Interrupter for simple Analogue DCVG Surveys. DCVG Pulse Frequency only. Not for use with CIPS equipment.

**Variation 2**

Satellite Synchronized Interrupter for one pass combined DCVG Equipment. Operated at DCVG Pulse Frequency only. (0.45 sec

**Variation 3**

Satellite Synchronized Interrupter for DCVG/CIPS Surveys. Operated at any of five ON/OFF switching sequences.

A) For straight DCVG or combined DCVG/CIPS 0.45 seconds ON, 0.8 seconds OFF (1.25 seconds)
B) DCVG (reverse) 0.8 seconds ON, 0.45 seconds OFF (1.25 seconds)
C) DCVG (reverse) 1.6 seconds ON, 0.9 seconds OFF (2.5 seconds)
D) Conventional CIPS 3 seconds ON, 2 seconds OFF (5 seconds), or
E) Conventional CIPS 4 seconds ON, 1 second OFF (5 seconds)

**Variation 4 – Coming Soon.**

Satellite Synchronized Interrupter for DCVG/CIPS Surveys. Operated at the same selected ON/OFF switching sequences as Variation 3 but with a 3 channel built in Data Logging capability to record all satellite information, time, location, current (T/R output), switching sequence local pipe to soil potentials etc. This type of Interrupter is able to provide detailed data capable of being used to study interference and to settle any timing disputes that arise with CIPS equipment that is currently ignored or remains unresolved at present by all technique operators.
To be able to carry out proper surveys and to take all measurements you require the following minimum items per set:

**A Comparison of the Items Making up a FULL or BASIC Close Interval Potential Survey – CIPS Or CIS Set**

<table>
<thead>
<tr>
<th>List Number</th>
<th>FULL CIPS SET – ITEM</th>
<th>Full Set Quantity</th>
<th>Basic Set Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment Carry Cases with Blue Insert.</td>
<td>2</td>
<td>NONE</td>
</tr>
<tr>
<td>2</td>
<td>Quantum CIPS Data Logger with Leather Straps</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Quantum Satellite Aerial</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>50 Amp or 125 Amp Satellite Interrupter</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Interrupter Satellite Aerial</td>
<td>3</td>
<td>2</td>
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<tr>
<td>6</td>
<td>Power Cable to External 12 Volt Battery</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Single Connector Probe Handle</td>
<td>2</td>
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<tr>
<td>8</td>
<td>Double Connector Probe Handle</td>
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<tr>
<td>9</td>
<td>120/240 Volt Battery Charger</td>
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<tr>
<td>10</td>
<td>3-Way Battery Charger Adaptor</td>
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<tr>
<td>11</td>
<td>Right Hand Connection Lead</td>
<td>2</td>
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<tr>
<td>12</td>
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<td>13</td>
<td>Copper Sulphate Crystal</td>
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<td>14</td>
<td>Probe Filler Bottle</td>
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<tr>
<td>15</td>
<td>Probe Tip</td>
<td>10</td>
<td>5</td>
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<tr>
<td>16</td>
<td>Probe Tip Washer</td>
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<td>5</td>
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<tr>
<td>17</td>
<td>Probe Tip Holder</td>
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<td>18</td>
<td>PTFE Sealing Tape</td>
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<td>19</td>
<td>Reference Probes - CIPS</td>
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<td>2</td>
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<td>Reference Probe Carry Case</td>
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<td>21</td>
<td>Shorting Out Lead</td>
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<tr>
<td>22</td>
<td>Quantum to RS232 Download Cable</td>
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<th></th>
<th>Description</th>
<th>Quantity</th>
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<tr>
<td>23</td>
<td>15M Remote Earth Cable</td>
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<td>24</td>
<td>Backpack to Quantum Signal Cable</td>
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<tr>
<td>25</td>
<td>Probe to Probe Connection Cable</td>
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<td>26</td>
<td>Quantum Download CD</td>
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<td>RS232 to USB Adaptor &amp; CD</td>
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<td>28</td>
<td>Wire Dispenser Backpack with Battery</td>
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<td>29</td>
<td>Empty DIN 125 Wire Reel</td>
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<td>30</td>
<td>Wire Winding Spindle</td>
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<tr>
<td>31</td>
<td>Backpack Battery Charger</td>
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<td>1</td>
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<td>32</td>
<td>Backpack Battery to Quantum Cable</td>
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<tr>
<td>33</td>
<td>Quantum User Manual</td>
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<tr>
<td>34</td>
<td>Quantum Cable Connection and Backpack Users Guide</td>
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<tr>
<td>35</td>
<td>Backpack Wire Winding Guide</td>
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<td>36</td>
<td>Quantum Data Processing Manual</td>
<td>1</td>
<td>1</td>
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<td>37</td>
<td>Interrupters Users Manual – 50 OR 125 amp Satellite Interrupter</td>
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<td>38</td>
<td>Combined DCVG &amp; CIPS Method Statement</td>
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<td>39</td>
<td>Certificate of Origins in Documents Folder</td>
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<td>40</td>
<td>Certificate of Calibration &amp; Testing in Documents Folder</td>
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<td>41</td>
<td>Guarantee</td>
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<td>42</td>
<td>Certificate of Conformity &amp; Traceability in Documents Folder</td>
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<tr>
<td>43</td>
<td>Certificate of Quality &amp; Quantity in Documents Folder</td>
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</tr>
</tbody>
</table>

A Full Set of CIPS Must Contain All the Above 43 Items or A Basic CIPS Set Must Contain All 40 Items.
Combined DCVG/CIPS Survey

The correct combined DCVG/CIPS procedures are as follows:-

1. Locate coating faults with the analogue DCVG Meter and mark epicentres with a flag. This is fast and accurate.
2. Using a synchronised CIPS data logger working at the DCVG ON/OFF pulse to take the CIPS and DCVG readings at the fault epicentres. The epicentre is the exact location for the best measurements. All DCVG readings taken with respect to remote earth.
3. If big distance between faults take CIPS readings in between to identify any interference effects etc.
4. As much information of all types such as status of test posts, trees, fences roads etc as possible should be collected during a survey. It is easy to collect then throw away rather than have to remobilise to site.

Detailed Method Statement for combining Analogue DCVG with Quantum CIPS is available from DCVG Ltd.

The only way the correct DCVG and CIPS procedures can be run simultaneously at the DCVG frequency is for the synchronisation of DCVG/CIPS Interrupters and CIPS Data Logger to be very accurate and stable. This is achieved by employing the one second pulses from the NAVSTAR satellite system and high quality electronics.

To ensure CIPS measurements do not include the anodic and cathodic spike errors caused by switching CP systems ON/OFF, the Quantum CIPS readings are taken at the correct positions of the ON/OFF pulse. The NAVSTAR pulse used to control both Interrupters and Quantum Data Logger controls these positions through accurate timing relative to the ON/OFF switching.

The information gathered by this combination of techniques is as follows:-

1. Fault Location GPS Coordinates.
2. GPS Distance Measurement.
3. Coating Fault Severity. Techniques and DCVG instrument used must identify small anodic/anodic faults thought to be the orifices of disbonded coatings.
4. Coating Fault Anodic/Cathodic Corrosion Status. (Level of Protection of individual faults.)
5. Coating Fault CP current demand to identify big current consumers.
6. Effective range of individual CP rectifiers from DCVG test post Measurements.
7. CIPS ON measurement.
8. CIPS OFF measurement. Both ON and OFF measurements supplement the more accurate DCVG Corrosion Status of Faults.
10. Status of repair of Pipeline CP installed equipment (a pipeline furniture audit).
11. High Consequence areas can be identified and coordinates recorded to assist concentrating excavation and repair efforts into the more vulnerable sections of the pipeline.

In addition to the above it is strongly recommended that soil resistivity profiles of the pipeline right of way be obtained using the fast Electromagnetic technique. This type of survey which can only be done when the CP is not pulsing is a quick and accurate measure of the corrosivity of soil surrounding a pipeline. Such measurements are an important input into the decision of what coating faults are most likely to have corrosion and hence candidates for repair.
SURVEYOR TRAINING

The quality of above ground surveys to inspect the Cathodic Protection and the Protective Coating on a buried pipeline depends upon the training, understanding and diligence of the people carrying out the work. This is very important to meet the basic concepts of the ECDA process for Pipeline Integrity. Unfortunately at present there exists no specific assessment as to the “fitness to survey” of the personnel who actually walk the pipeline to gather the data. The client has little knowledge of the authenticity and quality of the results from such surveys and upon which multi million dollar rehabilitation decisions are made. Bad data into the decision making process will result, as has already happened, in the wrong pipeline or wrong location being excavated for repair with budget over runs or less effective rehabilitation for the money spent, being common.

Recognizing the importance of Surveyor Education and skills has led to D C Voltage Gradient Technology and Supply Ltd. taking the lead by the introduction of a Surveyors Accreditation Scheme. Based on 4 levels of competence initially for the application of the D C Voltage Gradient Survey Technique.

- **Level 1:-** Basic training with 5 day Theoretical and Practical course.
- **Level 2:-** Intermediate - with survey work under supervision as part of a team.
- **Level 3:-** Advanced - as a Project Engineer leading a team and carrying out full project data analysis and reporting to the client.
- **Level 4:-** Expert - capable of training others and having extensive project supervision etc. - (typically 10,000 Km of survey).

The basis of the Accreditation is the appraisal by a panel of experts, headed by Dr J. M. Leeds, of the level of competence in DC Voltage Gradient Technology, the overall contribution to the advancement of the Technology and client satisfaction rather than Km surveyed. Over 200 Engineers from many different countries have attended the Basic Training to reach Level 1.
Training Course Content

Session 1 - Day 1: Fundamental Electrochemistry

1. The requirements for Corrosion.
2. The Pourbaix Diagram.
3. Cathodic Electrochemical processes.
5. Organic and Inorganic Coatings.

Session 2 - Day 1: Practical Electrochemistry

6. Pipe to Soil Potential- measurement and limitations.
7. The relationship between Coatings and CP.
8. The limitations of CP.
9. CP current demands for different coating quality.

Session 3 - Day 2: CIPS Survey Techniques

10. Pipe to Soil Potential measurement.
12. Limitations of the CIPS technique.
13. Combining CIPS & DCVG Techniques

Session 8 - Day 3: Organizing a Field Survey

14. What information do I need from Records?
15. Setting Up the Interrupter.
17. Combining CIPS & DCVG equipment together.
18. Starting the survey.
19. What and how to record data.
20. Distance measurement techniques.
21. Preparing the data for analysis.
Session 9 - Day 4: Understanding CIPS Equipment

22. Equipment usage.
23. What Measurements are taken
25. Data Analysis techniques.
26. General Discussion.
27. Revision and Question Time.

Session 10 - Day 5 Afternoon: Written Examination

28. Question and answer session before examination.
29. A 90 minute, 100 question written examination.
30. General Discussion.