



## **John Mulvany & Dr. John Leeds Experimenting During The Initial Development And Testing Of The DC Voltage Gradient Technique In The Australian Desert In The Early 1980's**

The DCVG technique is one of the two most important inspection tools used in the ECDA concept to inspect buried pipelines. The other is CIPS. Both DCVG and CIPS utilise the pipelines CP system, one of the two corrosion mitigation techniques applied to the outside of pipelines. The NACE SP 0502-2008 which is a virtual reissue of the original 02 document perpetuates gross errors in the way DCVG is classed the same as ACVG. It is NOT the same. See Page 3 for a list of Coating Fault properties and Information Sheet 7 for limitations of AC and EM techniques.

CIPS and DCVG are the only two inspection methods that assess the effectiveness of a pipeline Cathodic Protection system

**NOTE:- ECDA = External Corrosion Direct Assessment from the NACE SP 0502-2008 Document.**

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## **Second To None. Predominant (29 YEARS) Expertise In DCVG Technology – “We Lead Others Copy”**

DCVG was first discovered by **John Mulvany** an Australian ex Telecom Corrosion Engineer, who worked extensively with Dr. Leeds of DCVG Ltd. in developing the technique and its application. This gives **DCVG Ltd. an unparalleled 29 years experience in DCVG Technology.** This expertise backed by the excavation and inspection of several thousand DCVG fault indications, plus the interpretation of DCVG electrical data to what is found during excavation is passed onto users of our DCVG Equipment. Technology transfer is via detailed Training Courses and ongoing e mail Technical Support. Finding coating faults is not difficult but the correct interpretation of survey data to identify what coating faults to cost effectively repair requires experience and the type of expertise that is available from DCVG Ltd.

### **Principle of the DC Voltage Gradient Technique**

In Cathodic Protection when current flows through the resistive soil to the bare steel exposed at faults in the protective coating, a voltage gradient is generated in the soil. The larger the fault the greater the current flow and hence voltage gradient and this is utilised in the technique to prioritise faults for repair. The voltage gradient is observed by measuring the out of balance between two copper sulphate electrodes utilising a specially designed milli-voltmeter. When the two electrodes are placed 1.5 meters apart on the soil in the voltage gradient from a coating fault, one electrode adopts a more positive potential than the other which allows the direction of current flow to be established and fault to be located. To simplify the fault location interpretation, the applied CP is separated from all other DC influences such as Tellurics, DC Traction etc, by pulsing the local CP ON and OFF in an unsymmetrical fashion. The pulsing DC can be from the pipeline CP system itself, or from an independent source such as a portable DC generator or batteries utilising a temporary groundbed and impressed on top of a pipelines existing CP system.

In surveying a pipeline, the operator walks the pipeline route testing for a pulsing voltage gradient at regular intervals. As a fault is approached, the surveyor will observe the milli-voltmeter needle begin to respond to the pulse, pointing in the direction of current flow that is towards the fault.

When the fault is passed the needle direction completely reverses and slowly decreases as the surveyor moves away from the fault. By retracing to the fault, a position of the electrodes can be found where the needle shows no deflection in either direction (a null). The fault is then sited midway between the two electrodes. This procedure is then repeated at right angles to the first set of observations, and where the two midway positions cross is the epicentre of the voltage gradient. This is usually directly above the coating fault.



In order to determine various characteristics about a fault, such as severity, shape, corrosion behaviour, etc, various electrical measurements around the epicentre and from epicentre to earth are made for interpretation.

The beauty of the DCVG technique is that it utilises the existing pipeline CP system at its normal setting wherever possible and hence results reflect the intimate interaction between the protective coating degradation and the effectiveness of CP at individual coating faults. This is very powerful information in the fight against corrosion. No AC or Electromagnetic Technique offers such a direct study capability.

The DCVG Technique can be applied in City Streets, Process Plant and Refineries, across Rivers and Estuaries, Swamps, Parallel Pipeline systems, to Gas, Oil, Chemical and Water Pipelines. Also DCVG can be used to evaluate the protective coating on Telephone and Power Cables.

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The detailed information provided by DCVG Technology when analysed with other information such as Pipe to Soil Potential, Soil Resistivity and Composition, pH, Temperature, Operational History, Inline Inspection Tool Data, etc through a program such as DCVG Ltd's ECDA program enables pipeline rehabilitation requirements for the Steel, Coating and CP to be prioritised for the most cost effective repair.

**BEWARE OF SO CALLED COMBINED DIGITAL DCVG/CIPS. IT IS NOT DCVG TECHNOLOGY AT ALL. IT IS IN FACT LATERAL CIPS THAT IS A VERY CRUDE INACCURATE WAY OF ASSESSING COATING DAMAGE. THOSE OFFERING DIGITAL DCVG AS A TECHNIQUE OBVIOUSLY DO NOT UNDERSTAND TRUE DCVG TECHNOLOGY. See our Information Sheet 11**

## **What Are The Properties Of A Coating Fault That We Should Measure?**

The collection and analysis of the correct information is important to make your Pipeline Integrity Activities both cost and technically effective. Identified in this table in order of priority are the properties of coating faults that need to be measured to provide data for the best subsequent analysis. If you have any suggestions to add to this table please let us know.

<b>Properties of a Coating Fault Required for Proper Fault Analysis</b>		
<b>PRIORITY</b>	<b>PROPERTY</b>	<b>TECHNIQUE USED</b>
1	Fault Cathodic Current	<b>DCVG</b>
2	Fault Anodic Current	DCVG
3	Net Current Flow To/From Fault	DCVG
4	Soil Resistivity	EM
5	CIPS OFF potential	CIPS
6	CIPS ON Potential	CIPS
7	DC Interference	DCVG & CIPS
8	AC Interference	Voltmeter
9	Disbondment	Visual/DCVG/ Coating Type
10	Soil pH	pH Meter
11	Type of Soil	Visual
12	Vegetation / Roots	Visual
13	Fault Severity	DCVG
14	Fault Size	Visual on Excavation
15	Location	DCVG/GPS
16	Closeness to Another Fault	DCVG/GPS
17	Overall Density of Faults	DCVG/GPS
18	Type of Coating	Records
19	Field Joint Coating	Records
20	Age of Coating	Records

See next page for full names of the techniques used in the table.

EM = Electromagnetic Soil Resistivity Measurement.

DCVG = Analogue DC Voltage Gradient Technique. This table does not apply to so called combined digital DCVG/CIPS which is really just lateral CIPS and is a sham technique.

CIPS = Close Interval Potential Survey Technique also known as CIS in North America.

GPS is sub-metre GPS Location and Distance measurement equipment, eg. Trimble Pro XRT.

**In ECDA SP 0502-2008 Table 2 that deals with Tool Selection only two techniques CIPS (Close Interval Potential Survey) and DCVG evaluate a**

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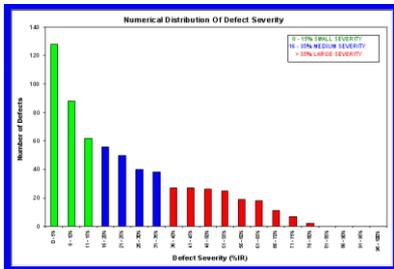
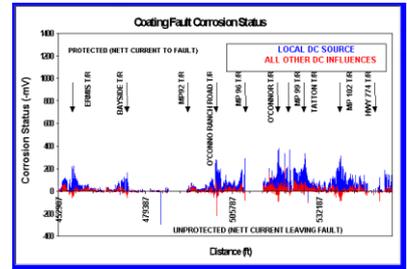
**pipeline's Cathodic Protection, one by Potential the other by Net Current Flow. Both are CP criteria used to determine if the pipeline is adequately protected.**

**All other techniques given in Table 2 are used to locate coating faults.**

**Information Sheet 10 that can be obtained from DCVG Ltd deals extensively with the inaccuracies, limitations and omissions present in the ECDA document SP 0502-2008 and these inadequacies in the document should be considered when attempting an ECDA study.**

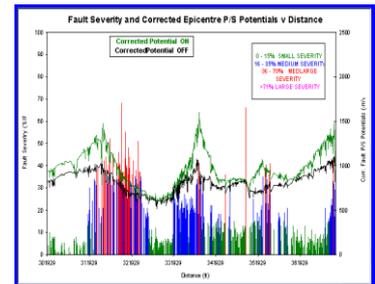
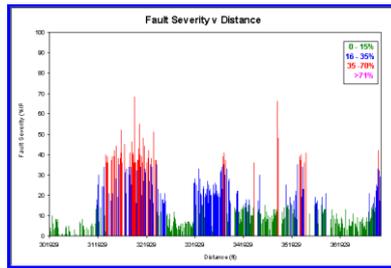
## ECDA Data Analysis

Not every Coating Fault or Metal Loss Location requires repair. In practice, for most pipelines 99+% of all coating faults have no metal loss but there is the potential for metal loss if there is a coating fault with weak CP in soil of low resistivity. Whilst the repair of critical metal loss is important, most pipelines are rehabilitated on the basis of the need to improve the protective coating in order to make the CP more effective.

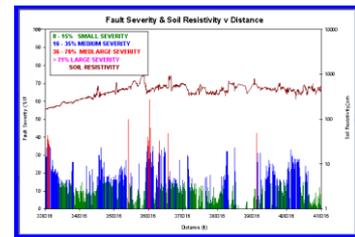


Remember Inline Inspection Tools detect the symptom of the problem, DCVG when combined with potential measurements detect the real cause of the problem that leads to metal loss. This real cause of the problem is a breakdown in corrosion control through coating failure and an inadequate CP system.

There is never enough money to repair all coating faults. Detailed analysis of data is required to identify large current consuming coating faults particularly those in low soil resistivity areas so these faults can be repaired releasing CP that then becomes available to improve protection of those faults not identified for repair.



The DCVG Ltd ECDA Computer software analyses data sets from many different types of survey etc (including Inline Inspection Data) to identify Critical Coating Faults for repair. The ECDA Software handles all four stages of the ECDA Process, from Pre Assessment, Indirect Assessment, Direct Examination to Post Assessment. The DCVG Ltd ECDA program is built by Corrosion Engineers for Corrosion Engineers and is very user friendly and has been well tried and field tested by our Corrosion Engineers on more than 11,000Km of pipeline, with all types of coating systems involving more than 100,000 Coating Faults. Our ECDA program also will estimate the cost of the repair of the Steel, the Coating and the Cathodic Protection system so faults can be prioritised, budgets can be prepared, matching the costs involved to the Companies ability to finance the Rehabilitation work.



## Technical Support.

To assist users to get maximum benefit from our DCVG and CIPS equipment we offer unlimited free technical support via e-mail or communication via Skype. Our Skype address is dcvg-sarah. We also undertake commissions to Analyse and Interpret Clients data or to Audit Sub-Contract survey work carried out for pipeline Operating Companies.

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## **Pipeline Survey Method Specifications**

1. "Specification for the Method of Inspection of the Coating Quality on Buried Pipelines using the DC Voltage Gradient Technique."
2. "Specification for the Method of Inspection of the Coating Quality on Buried Pipelines using the Close Interval Potential Survey (CIPS)."
3. "Specification for the Method of Inspection of the Coating Quality on Buried Pipelines using the analogue DC Voltage Gradient technique combined with a digital Close Interval Potential Survey operated at the DCVG ON/OFF pulse sequence."
4. "Specification for the Method of Inspection of Soil Resistivity surrounding Buried Pipelines using Electromagnetic Techniques."
5. "Specification for the Method of Inspection of Depth of Cover of Buried Pipelines using Electromagnetic Techniques."
6. "Specification for the Method of Inspection of the Coating Quality on Buried Pipelines using the DC Voltage Gradient technique combined with a Close Interval Potential Survey and co-ordinated with in-line metal loss inspection tools."
7. "Technical Specification for Rehabilitation of the Coating on Operating Pipelines."
8. "Technical Specification for Quality Control During Rehabilitation of the Coating of Operating Pipelines."
9. "General Contractual Specification for Rehabilitation of the Coating on Operating Pipelines."

New Method Sheets to cover different applications of DCVG Technology are in preparation, for example, Under City Streets, Parallel Pipelines, Sea Water Crossings etc.

All DCVG Ltd Specifications, Method Sheets, Technical Papers, Equipment and Spares can be shortly purchased on line from our updated web pages [www.dcvg.com](http://www.dcvg.com)

## **DC Voltage Gradient Training Courses. Level 1 and 2**

The detailed Training Courses prepares Surveyors for ECDA Inspection work by teaching how to survey properly including running DCVG, CIPS and Pipe Location simultaneously, how to match multiple data sets including ILI information, interpret data and be aware of technique strengths, weaknesses and any possible errors in Surveying and Data Analysis. (All techniques have limitations and errors which in many survey techniques are ignored.) To carry out an effective ECDA Process gathering Quality data is essential. The Level 1 course is five days long and by preference is held at customers premises with the practical work carried out on actual customers pipelines. The emphasis is to achieve maximum technology transfer hence the course is split into classroom and field activities. After initial 2 days training, operators use equipment to find faults, take electrical measurements, and analyse data for interpretation into actual refurbishment requirements. Level 2 is a 3 day course and goes into Survey Organisation, Complex Surveys and Data Analysis in detail besides reviewing students survey work that they have done. Accompanying the training course is a very detailed instruction manual, which covers every aspect of DCVG Technology. This manual is only available to attendees of the training course. In addition DCVG Technology and Supply Ltd have available to customers the largest collection of published technical papers on the principles and applications of DCVG Technology. This coupled with ongoing research into the technology and other coating survey methods emphasises our leadership of the market place in the inspection of coatings on buried pipelines. Remember, the corrosion of steel exposed at coating faults is recognised as one of the major causes of pipeline failure. A coating fault is also necessary for the development of Stress Corrosion Cracking, a most insidious form of pipeline failure.

Students must pass Level 1 before progressing to Level 2.

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# DCVG TRAINING COURSE CONTENTS

LEVEL 1	LEVEL 2
<p><b>Session 1. Course Introduction and Organisation. Fundamental Electrochemistry.</b></p> <ol style="list-style-type: none"> <li>1. The requirements for Corrosion.</li> <li>2. The Pourbaix Diagram.</li> <li>3. Cathodic Electrochemical processes.</li> <li>4. Cathodic Protection and Cathode Films.</li> <li>5. Organic and Inorganic Coatings.</li> </ol> <p><b>Session 2. Practical Electrochemistry</b></p> <ol style="list-style-type: none"> <li>6. Pipe to Soil Potential- measurement and limitations</li> <li>7. The relationship between Coatings and CP.</li> <li>8. The limitations of CP.</li> <li>9. Typical CP current demands for different coating quality.</li> <li>10. Pipeline Failure through Metal Loss, Stress Corrosion Cracking etc.</li> </ol> <p><b>Session 3. Coating Failure Mechanisms</b></p> <ol style="list-style-type: none"> <li>11. General Discussion.</li> <li>12. Tape Coatings.</li> <li>13. Asphalt and Coal Tar.</li> <li>14. Thin Film coatings (FBE).</li> <li>15. Other Coating systems.</li> </ol> <p><b>Session 4. The DC Voltage Gradient Technique</b></p> <ol style="list-style-type: none"> <li>16. Fundamentals of the DCVG technique.</li> <li>17. Detailed explanation of DC Voltage Gradient equipment</li> <li>18. The DCVG Pulse (Meter Indications). Practical Class demo.</li> <li>19. DCVG Signal electrical circuit</li> <li>20. DCVG Coating Fault detection method</li> </ol> <p><b>Session 5. DCVG Electrical Measurements.</b></p> <ol style="list-style-type: none"> <li>21. Understanding the DCVG Signal Amplitude.</li> <li>22. Taking Electrical Measurements to determine the Severity of Coating Defects</li> <li>23. Defining the Coating Fault shape using iso-potential plots.</li> <li>24. Determining the Corrosion Behaviour of Faults.</li> <li>25. Determining where Faults get their CP from</li> <li>26. DC Traction and other Interference effects.</li> <li>27. Typical DCVG results</li> </ol> <p><b>Session 6. Special uses for DCVG Technology.</b></p> <ol style="list-style-type: none"> <li>28. Surveying parallel pipelines</li> <li>29. Complex pipeline networks</li> <li>30. Using DCVG to investigate CP systems</li> <li>31. Test Posts, Insulating Flanges, Cased Crossings</li> <li>32. The use of DCVG to control Cathodic Protection</li> </ol> <p><b>Session 7. Other Survey Techniques</b></p> <ol style="list-style-type: none"> <li>33. Pipe to Soil Potential measurement.</li> <li>34. Close Interval Potential Survey technique.</li> <li>35. Limitations of the CIPS technique.</li> <li>36. Limitations of the DCVG technique.</li> </ol> <p><b>Session 8. Organising a Field Survey.</b></p> <ol style="list-style-type: none"> <li>37. What information do I need from Records?</li> <li>38. Setting Up the Interrupter.</li> <li>39. What Initial DCVG Signal Amplitudes to measure?</li> <li>40. Starting the survey and how to locate</li> <li>41. What data to record? How should data be recorded?</li> <li>42. Distance measurement techniques to use and their limitations.</li> <li>43. Preparing the data for analysis.</li> </ol> <p><b>Session 9. Field Work. Locating Coating Faults</b></p> <ol style="list-style-type: none"> <li>44. Setting up conditions for a DCVG Survey.</li> <li>45. Measurement of the DCVG Signal Amplitude.</li> <li>46. Location of Coating Faults.</li> </ol> <p><b>Session 10. Electrical Measurements at Coating Faults.</b></p> <ol style="list-style-type: none"> <li>47. Anodic/Cathodic Corrosion Behaviour.</li> <li>48. Electrical measurements and Fault Severity.</li> </ol> <p><b>Session 11. DCVG Data Analysis.</b></p> <ol style="list-style-type: none"> <li>49. Calculation of Fault Severity.</li> <li>50. Assessment of results obtained.</li> <li>51. Effect of Depth of Burial and Soil Resistivity on Fault Severity.</li> <li>52. What Faults to repair.</li> <li>53. Computerised Data Analysis techniques using the DCVG Ltd ECDA program.</li> <li>54. General Discussion.</li> </ol>	<p><b>Session 1. Course Introduction and Organisation</b></p> <ol style="list-style-type: none"> <li>1. Review and Critique of any Student Survey Work Carried Out. Discussion of Student Problems.</li> <li>2. Client Education and Contracts.</li> <li>3. Preliminary look at ECDA Specifications.</li> <li>4. Detailed DCVG Survey Specification. Client Education. What does the Client want.</li> </ol> <p><b>Session 2.</b></p> <ol style="list-style-type: none"> <li>5. Survey Team Composition.</li> <li>6. Surveyor Selection and Education.</li> <li>7. Equipment Required and Plans to Handle Field Work and Data Analysis.</li> <li>8. Planning a Survey.</li> <li>9. Managing your Survey Team. Multiple Teams.</li> </ol> <p><b>Session 3.</b></p> <ol style="list-style-type: none"> <li>10. Survey Set up and Methodology, Gathering Field Data. Auditing CP Hardware and ROW.</li> <li>11. Discussion on Rectifiers and Temporary CP Systems, Problems and Limitations.</li> <li>12. Surveying. Permits, Land Owner Co-operation, Client Co-operation.</li> </ol> <p><b>Session 4.</b></p> <ol style="list-style-type: none"> <li>13. Survey Problems. Fences, Electric Fences, Streams, Rivers, City Streets. No Test Posts.</li> <li>14. Parallel Pipelines, Complex Pipeline Networks.</li> <li>15. Client Reporting, Daily, Weekly, Monthly. Use of e-mail for Reporting.</li> <li>16. Errors and Limitations of DCVG Surveys. Equipment Problems and Maintenance.</li> </ol> <p><b>Session 5.</b></p> <ol style="list-style-type: none"> <li>17. Review of Type of Data Collected During a Survey.</li> <li>18. Distance Measurement Techniques Including GPS.</li> <li>19. Data Transfer From Field to Office.</li> <li>20. Error Correction and Avoidance.</li> <li>21. Other Methods for Above Ground Surveys.</li> </ol> <p><b>Session 6.</b></p> <ol style="list-style-type: none"> <li>22. The CIPS Technique. Different types of CIPS Equipment and Methodology.</li> <li>23. CIPS Set Up, Errors and Limitations of the Technique.</li> <li>24. Combined Surveys, DCVG and CIPS. What Type of Data is Collected. ECDA Requirements.</li> </ol> <p><b>Session 7.</b></p> <ol style="list-style-type: none"> <li>25. Organisation of Combined Survey and Data Collection.</li> <li>26. Co-ordination in Field of Different Types of Surveys including Soil Resistivity, Inline Inspection Pigs for Metal Loss, Guided Wave Ultrasonic Inspection, Acoustic Emission.</li> <li>27. Importance of Soil Resistivity.</li> </ol> <p><b>Session 8.</b></p> <ol style="list-style-type: none"> <li>28. Matching Survey Data Sets. DCVG/CIPS/Soil Resistivity/Metal Loss etc. Correlation Points.</li> <li>29. Coating Fault Specific and Non Specific Data. The Usefulness of Different Types of Data.</li> </ol> <p><b>Session 9.</b></p> <ol style="list-style-type: none"> <li>30. Data Analysis. What do you want from the Analysis to meet Client Requirements?</li> </ol> <p><b>Session 10.</b></p> <ol style="list-style-type: none"> <li>31. Current American External Corrosion Direct Assessment (ECDA) Techniques and its Limitations. A Close Look at Type of Data Input to the ECDA Process.</li> <li>32. How Poor Data can Defeat the ECDA Process.</li> </ol> <p><b>Session 11.</b></p> <ol style="list-style-type: none"> <li>33. Data Analysis Programs and How they Work.</li> <li>34. Advanced Applications of DCVG Technology. SCC Studies.</li> <li>35. Detailed look at Sham DCVG Techniques.</li> <li>36. DC vs AC Techniques. Errors and Limitations.</li> </ol> <p><b>Session 12.</b></p> <ol style="list-style-type: none"> <li>37. Converting ECDA Analysis into a Rehabilitation Program.</li> <li>38. Defining Pipeline Rehabilitation Requirements, Metal Loss, Coating and Cathodic Protection.</li> <li>39. Pipeline Rehabilitation Techniques including Relocation</li> </ol>

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55. Revision and Question Time. <b>Session 12. Written Examination.</b> 56. A 90 minute, 10 question written examination 57. General Discussion. 58. Assessment of the DCVG Training Seminar.	of Fault Areas. 40. Review of Course Contents, Discussions on Application of ECDA and Repeat Surveys. 41. Review of Student Critiques of Sample Survey Report - Limitation Report Problem Discussion
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## D.C.Voltage Gradient Equipment. Full or Basic Sets.

Equipment can be purchased as a FULL set or as a BASIC Set. All of DC Voltage Gradient Equipment Sets come with spares and is manufactured in UK to military specifications. A FULL set comes complete with everything except a DC power source needed to survey a buried pipeline. The equipment which is a direct descendant from the original work carried out in Australia is packed into protective carry cases and has two main components, the Interrupter and the Survey Meter. During manufacture maximum emphasis has been placed on simplicity, quality and robustness of construction with the equipment kept as flexible as possible to use. Although the equipment comes with an instruction booklet, a very comprehensive training course is available to ensure operators know how to gather data and to use and interpret results in order to gain maximum benefit from the technology transfer process. The BASIC set consists of the same quality components but the minimum components required to do DCVG surveys. There are no carry cases or spares in a BASIC set.

<b><u>BASIC DCVG SET</u></b>		<b><u>FULL DCVG SET</u></b>	
DCVG Survey T/R Interrupter	1	DCVG Survey T/R Interrupter	1
DCVG Survey Meter	1	DCVG Survey Meter	1
Probe Handles (Bias)	2	Probe Handles (Bias)	2
Copper Sulphate Reference Probes	2	Copper Sulphate Reference Probes	2
Right Hand Connection Leads	1	Right Hand Connection Leads	1
Left Hand Connection Leads	1	Left Hand Connection Leads	1
Reference Probe Tip Holders	2	Reference Probe Tip Holders	2
Probe Tip Washers	2	Probe Tip Washers	4
Wooden Probe Tips	4	Wooden Probe Tips	4
PTFE Sealing Tape	1	PTFE Sealing Tape	1
120/240 Volt Battery Charger	1	120/240 Volt Battery Charger	1
Battery Charger Adapter Lead	1	Battery Charger Adaptor Lead	1
DCVG Instruction Manual	1	DCVG Instruction Manual	1
<b>No Carry cases are provided.</b>		Equipment Carry Case	1
		Probe Carry Case	1
		DCVG Method Statement	1

In all sets of DCVG Equipment the Stand Alone Interrupter can be replaced by a Satellite Interrupter that is fully compatible with our Quantum CIPS Equipment. Interrupters can be either 50 or 125 Amp Capacity. For pipelines with multiple Rectifiers we recommend the purchase of Satellite Controlled Synchronous Interrupters so all rectifiers are switching ON/OFF at same time.

### **Equipment Spares**

A full range of spares for DC Voltage Gradient Equipment is available ex stock together with many extras to extend equipment application to complicated or



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cold weather applications. DCVG spares are fully compatible with earlier models produced over the last 30 years. Also a number of the DCVG spares are fully compatible with our Quantum CIPS data logging equipment. A full spares catalogue is available on request and they can also be seen and purchased directly from our [www.dcvg.com](http://www.dcvg.com) web site.

DCVG Ltd also offer a service of repairing, upgrading, recalibrating etc all different parts of the DCVG and CIPS equipment sets.



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