Analog DCVG Holiday Detector

Model EPT- 4000

Survey Instrument

Electronic Pipeline Technology

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1- Theory of operation:

Coating defects cause to create a low resistance with the ground and cause to escape current to the ground. The CP voltage may come down and it is not able to protect the pipeline.

To find the exact location of the coating fault have to install an Interrupter to the rectifier to create ON and OFF signal that discriminate this current form other pipelines or stray current. By using a very sensitive with high input resistance DCVG Holiday Detector operator can survey the pipeline and find exactly where is the current escaping location.

All coating defects that show voltage under the protection level need attention. Adjustment or modify cathodic protection system are indicated at all location where pipe to soil Potential is under the protection level.

Repairing holidays or defects in the coating can result in acceleration corrosion, if enough level of cathodic protection system is not provided. Significant improvement or upgrading of a cathodic protection system can be performed for the cost of one excavation to repair a coating defect or holiday.

The application and maintenance of enough cathodic protection system is a proactive method of corrosion control, whereby dig and repair or replacement of coating is another significant way to prevent of damage to the pipelines.

2- Accessories:

A DCVG Holiday detector is accompanying with the following accessories.

1- Charger that able to work 110 or 220-240 volt AC. This charger has plugs that can work North America or Europe

2- Two Half Cell Electrode RE- 5C

3- One Flexible Pogo stick

4- One pair cable to connect pogo sticks to the unit

5- Manual Instruction

6- Pogo stick with variable offset from +_ 1 volt

Warning

This is sensitive equipment with 20000 Mega ohm inputs that designed to measure very low milivolts max 5000 mV.

Do not connect any voltage more than 15 volts to the input and only in critical very dry condition put the input Impedance on 10000 Mega Ohm. When you finished immediately decrease the input impedance to protect from any external high voltages sources.

Do not use this survey equipment in thunder storm or lightening.

Do not touch the meter that may cause static electricity.

Do not connect pogo sticks to the barn fence that has high voltage and may damage the equipment.

The EPT- 4000:

Charge the Battery: the Battery is the latest generation of rechargeable nickel Metal Hydride batteries. Do not allow the battery to freeze, like wise do not store in a very hot location.
Initially charge the battery for **maximum 6 hours**. Do not charge Battery except the Battery is completely exhausted.
The nominal Battery voltage is 7.2 volt and when charging may show voltage as high as 8.2 volt. The battery is exhausted when the voltage drop to 5 volt. Operator can check the Battery with ON and OFF Switch and in the middle range at number 15 there is a red mark for battery testing. The battery capacity is 1.8 Amp and should run the instrument for several days. You can charge the Battery of extra pogo stick with this charger for two hours. Pogo stick must work for a few months.

Half Cell Care: The Copper Sulphate Half cells supplied are precision measurement electrodes. They should be kept clean and serviced regularly by changing the old copper sulphate solution and refilling with fresh copper sulphate crystals and distilled water. Keep the plastic cap on when not in use to prevent the tip from drying.

Screw the copper sulphate half cells in to half cell extension pogo stick Poles, connect neck strap to the EPT- 4000 and connect the cables between the half cell Pogo sticks and EPT – 4000. The length of the half

cell Pogo stick is adjustable Please adjust for your convenient pogo length for your survey.

The EPT- 4000 Instrument is equipped with the following:

1- Turn ON the instrument using The ON/OFF Battery Test Switch
2- Selected the input Impedance 10M for wet ground, 1000 for dry and 10000 for very dry conditions. The input has a differential input and the number shows are the Impedance of pogo stick to the internal ground. Therefore the real input Impedance between the two pogo sticks is 20 M, 200 M, 2,000 M, and 20,000 Mega Ohm. It is the highest input impedance all over the world for DCVG Holiday Detector.
3- Select the mV range, start with a high value and adjust down observing for voltage gradient pulse.
4- Differential Mode that used to shows the different between ON and OFF in the centre of Meter. When you are in normal operation it shows ON and OFF and green LED is on and when you push the Pogo stick switch it will go to Differential mode and the red LED will illuminate.
5- Charger yellow LED indicator will turn ON when you connect the charger to the unit.

How to start doing the DCVG survey:

To discriminate DC voltage Gradient, from the other sources Pulsed DC current is required. This can be provided by installing two synchronized GPS Current interrupters in the output of Cathodic Protection Rectifiers between to test point of the pipeline that we want to survey.

Using two Synchronized Interrupters will create very high accurate results compare with one Interrupter. If the pipeline is protected by a sacrificial anode system then it will be necessary to install temporary rectifiers and ground bed to provide the necessary DC pulse.

It may be necessary to Increase the output of the rectifiers to achieve sufficient IR drop for voltage gradient Detection.
To Perform a DCVG survey 500- 600 mill volts of differential potential swing shift is required between the Rectifier ON and OFF Potential. It is often necessary to increase the output of the cathodic protection rectifier to provide sufficient IR for DCVG measurement.

To minimize the polarization of the pipeline when the IR drop by increasing the output of rectifier, change the interruption cycle to give a Cycle such as 300 milliseconds ON and 700- milliseconds OFF (1 second cycle). It is possible to select 1 second ON and 1 second OFF (2 seconds cycle).

DCVG Survey Procedure:

To undertake a DCVG survey typically, a minimum differential potential swing of 300- 500 mV is sought and the current sources output of the rectifiers is adjusted accordingly.
The application of a pulsed Current enables coating defect to be distinguish from potential difference between the half- cells that will crear because of the power line, other pipelines or stray current.

The difference between ON and OFF potential must be recorded by the operator at the test point nearest the survey start point and all other test points encountered in the survey. Make sure the range is set to 5000 or 2000 milivolt when making this measurement. Record the rectifier ON and OFF potential, you need this value to calculate the IR drop voltage.
When you survey the pipeline in normal mode put the offset voltage OFF and when you find a coating problem, then operator can use differential mode system for swing voltage or Turn ON the offset voltage in the pogo stick and turn the potentiometer so that the swing voltage goes in the center of meter.

Calculate the % IR of the defects:

The operator traverses the pipeline route using the probes as walking sticks. Both probes must be in contact with ground to measure the voltage gradient. One probe can be on the centerline of the pipeline (pipe connected pogo stick in the unit) and the other maintained a lateral

separation of 1-2 meter (voltage gradient connected pogo stick in the unit) in this situation when you find a defect the meter needle must point out to the fault location on the pipeline. Probes can leapfrog along the centre line.

If no defect is present the needle on the voltmeter shows no movement. As a defect is approached a noticeable fluctuation is observed on the voltmeter at are rate similar to the Interruption cycle.

The amplitude of the fluctuation increase as the defect approached and adjustment of voltmeter sensitivity is made as necessary.

The Differential swing voltage on the voltmeter is directional, providing the probes are maintained in similar orientation parallel to the pipeline.

Thus the defect is centered by detailed maneuver around and the size of the defect estimated by considering differential signal strength at the defect, different between ON and OFF potential at start test point and distance from those points Data obtained.

DCVG Calculations to find % IR on the defect using the following formula

According to the NACE standard (A6.3.5) lateral reading near the defect will yield Maximum voltage difference where gradients are a maximum. Whereas readings at remote earth will indicate Zero to 1 mv. The summation of these reading is commonly referred to as the **Over- the line** to remote earth voltage. The expression “Percentage IR” has been adopted to give an indication of defect size.

Signal Strength at the defect point= mv2 + m2/m1+ m2 (mv1- mv2)

%IR= Over- the line /signal Strength

mv1= Differential Voltage swing at last test station

mV2= Differential voltage swing at nest test station

m1= Distance from the defect point to last test station

m2= Distance to next test station

This percentage IR drop is used to predict the reduction in protection levels ignoring polarization effect.

Potential at defect= adjacent test point ON voltage – (%IR/100 x Differential swing potential)

For example if IR drop is 20% and potential ON in the nearest test point is -950 mV and is assumed that state off potential is -600 mV.

Potential at defect= -950 – (20/100 x (950- 600)) = -880 mV

It shows that a reduction in protection but still protected. If the IR drop is % 50 then the potential in the defect is -775 mV and it is under the protection.

Appendices:

Special for DCVG Holiday Detector Model EPT 4000:

1- Input: It has two differential channels in the input. When a voltage is applied to the input this voltage is divided between two channels

differentially. It doesn't use ground as a one input. If there is some offset in one channel because they are similar the other one has the same amount and the difference will be zero.

2- There are active filters in the input of both channels and will not let to interfere the power line or any other high frequency sources. If any manufacturer does not put a strong filter in the input the output will be change by stray current or noise of power lines and will create offsets.

3- There is very accurate multiplier operation amplifier, which transfer the voltage to the meter. We have two options one is normal and the other one is differential mode that I am going to explain in this regards.

Normal mode is mean that the meter will shows the real voltage and it work exactly as a normal voltmeter and we can measure any DC voltage. In this mode we can measure ON potential and OFF potential of the pipeline. In other word the meter swing between OFF and ON (not in the centre)
We assume that ON potential is A and OFF potential is B, therefore Meter swing between B and A.

By pushing the pogo sticks switches it will go to the differential mode. In this mode the Meter will show the difference between ON and OFF in the centre of Meter or it shows "A-B" when we find a place that current escape as we approached to the holiday The difference "A-B" will going up and in the exact location of defect this Number "A- B" is maximum. In

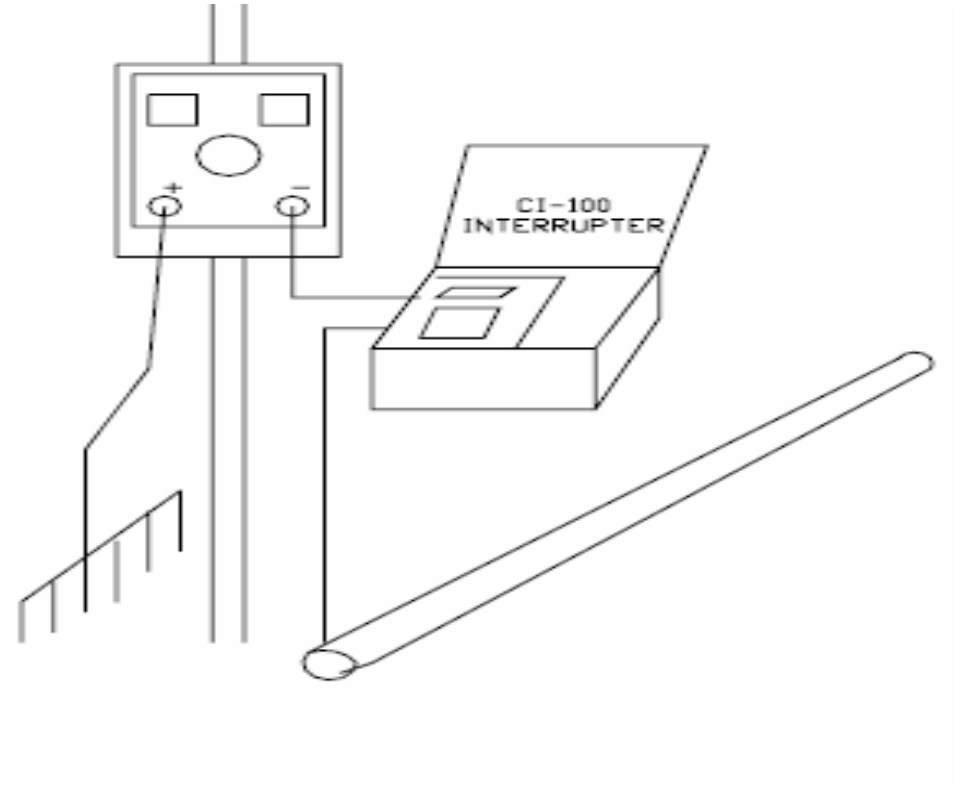
this mode we can not measure a simple DC voltage because ON voltage and OFF voltage are equal and therefore the difference is Zero.

How to start The DCVG Test:

To detect DC voltage Gradients, Pulsed DC current is required. This can be provided by installing a current Interrupter in the output of the Cathodic Protection Rectifier. If the Pipeline is protected by a sacrificial Anode system then it will be necessary to initial a temporary Rectifier and Ground bed to provide the necessary pulsed DC current.

Interrupting the Rectifier:

Installing Current Interrupters may be Hazardous. Only trained personnel should install current Interrupter in the cathodic protection Rectifiers. Turn OFF and lock out the AC supply while the Interrupter is being installed. In this Interrupter there is no difference between two poles.



DC Interruption:

Where possible it is preferable to interrupt the DC output of the rectifier. Put two poles of the interrupter series with Negative Pole of Rectifier and Pipeline connection.

It may be necessary to install a temporary rectifier at the mid point between rectifiers to achieve sufficient IR drop for the Measurement of the DC voltage Gradient.

Where multiple rectifiers must be interrupted to perform the DCVG survey the Interrupters must be synchronized to allow detection of voltage gradient in the soil.

AC Interruption:

Connect the one cable of Interrupter in one leg of the AC supply and the other cable connects to the AC input of Rectifier (series with AC Power).

Millivolt swing shift:

It may necessary to increase the output of the Rectifier to achieve sufficient IR drop (voltage gradient created when there is a defect) for voltage gradient detection. Ensure that the output of the Rectifier does not exceed the capability of the current interrupter being used.

To perform a DCVG Survey 500- 600 millivolts of potential shift is required in the Test points between the Rectifier ON and OFF. It is often necessary to increase the output of the Cathodic Protection Rectifier to provide sufficient IR drop for DCVG measurement. To minimize polarization of the pipeline when the IR drop is increased by increasing the output of Rectifier, Put the interrupter on 1 second Cycle 1 and 500 Milli seconds OFF.

EPT/ CI-100 GPS Current Interrupter

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The difference between ON and OFF potential must be recorded at the test point nearest the starting the survey and all other test points encountered, and the survey commenced.

The Operator traverse the pipeline rout using the probes as walking sticks. Both probes must be in contact with the ground to measure the voltage gradient. One probe can be on the centerline of the pipeline and the other maintained at a lateral separation of 1- 2 meter or probes can leapfrog along the centre line.

“Measuring the Pipe to soil Potential at a Test station “

If no defects are present the needle on the voltmeter registers no movements. As a defect is approached a noticeable fluctuation is observed on the voltmeter at a rate similar to the Interrupter Cycle.

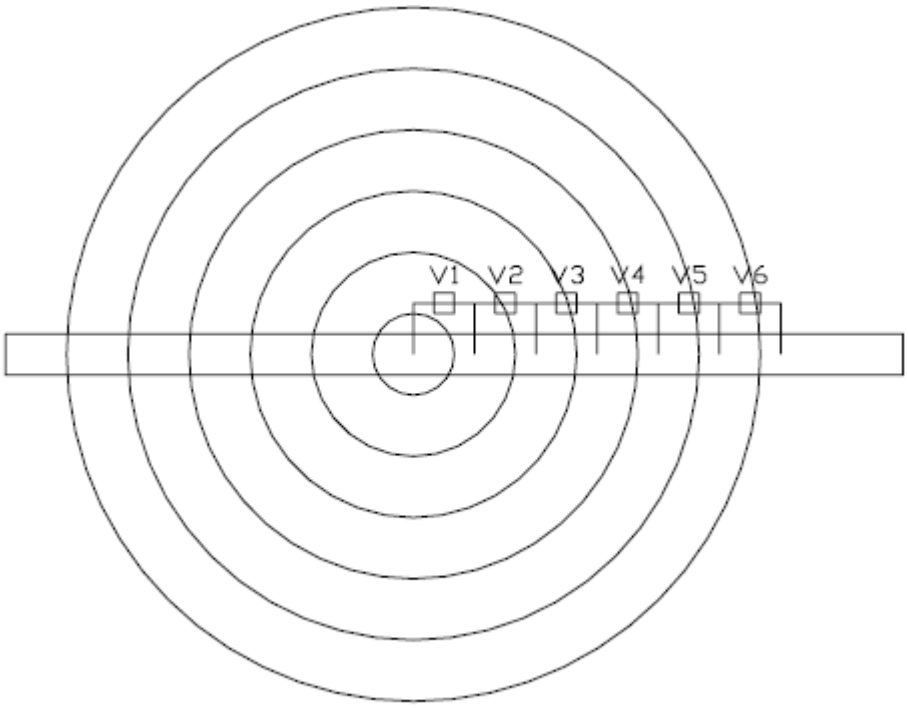
The amplitude of the fluctuation increase as the defect is approached and adjustment of voltmeter sensitivity is made as necessary. The swing on the voltmeter is directional. Providing the probes is maintained in similar orientation parallel to the pipeline.

Thus the defect is centered by detailed maneuver around the epicenter and size of the defect estimated by considering strength at the defect, different between ON and OFF Potential at adjacent test point and distance from those points data obtained.

Over the Line to Remote Earth Voltage Drop

Voltage drop at defect point = V1+ V2+ V3+ V4+ V5+V6+ V…..

The DCVG Survey provides an evaluation of each defect located. The defect can be sized by relating the signal voltage (potential swing) to remote earth to the signal potential voltage (Potential swing) at the defect point.



Voltage Gradient line resulting from different types of defects

DCVG Calculations

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