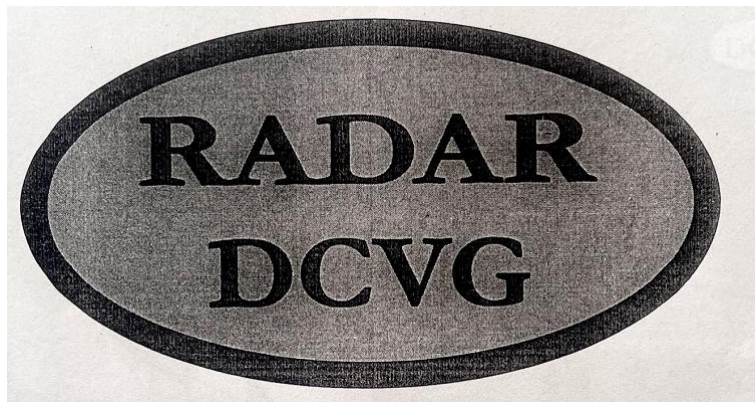


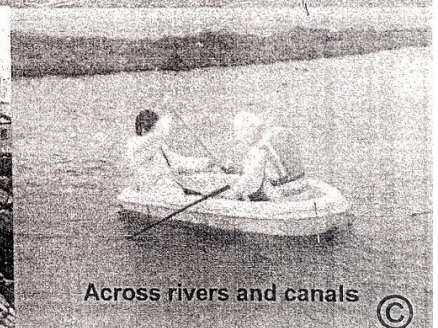
RADAR PIPE COATING SURVEY (R.P.C.S)

**Guide to checking the status of underground pipelines with DIRECT
CURRENT VOLTAGE GRADIENT (DCVG) device**



The DCVG Technique Is Very Flexible And Offers The Operator The Ability To "Go Anywhere"

100% Of Pipeline Can Be Surveyed: (Except Casing)



Across rivers and canals



In the name of Allah, the most Merciful, the most Compassionate

We are proud to witness a new development and a product different from the past in Radar Engineering Company with the grace and favor of Almighty God and with continuous efforts based on the latest international standards.

Radar Engineering Company with its expert and experienced staff has been able to provide great services to the industries of our country by designing and producing all kinds of electronic devices and precision instrument systems.

And now, in line with the realization of the construction goals of our dear country, with the benefit of all electronic systems similar to foreign ones and with the design and production of DIRECT CURRENT VOLTAGE GRADIENT, we hope that we can take a positive step towards the advancement of our country's industries with DCVG coating defect finder device that determines the defective points of the pipes and cables coating buried in the soil with very high accuracy.

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INTRODUCTION

The increase in the consumption of petroleum materials and chemical compounds, etc., due to the one-way and uneconomical transportation of these materials on a large scale by trucks from the production areas to the places of consumption, requires the use of pipelines to transport these materials. Since the pipes and other facilities that are built for this purpose are mostly metal, the problem of corrosion in such a system is extremely important and cannot be ignored. Otherwise, corrosion will cause many human and financial losses. To prevent corrosion in such a system, it is very important to choose the correct coating material for the pipeline, and if a mistake occurs in this case, it will cause irreparable damage.

Despite the primary care of the pipe coating insulation during transportation, including laying the pipe inside the canal, during piping, which must be done to prevent injury to the pipe coating, but also due to many other factors, corrosion, and spoilage of the coating happens that some of these factors are as follows:

1. The holes that exist in the coating layer.
2. Fractures that are caused by mechanical and thermal stresses.
3. Tensile that are caused by tension (caused by soils that have dried and contracted quickly) which in this case will damage the pipe coating.
4. Perforation by plant roots
5. The effect of bacteria in the soil around the pipe
6. Increasing the cathodic protection current will not necessarily provide the necessary protection, but it will cause the loss of adhesion and strength of the coating as a result of creating hydrogen increasing the alkalinity of the environment, and intensifying the damage.

Considering the above, it is necessary to prevent the influence of some factors with great care and careful inspection. For this purpose, cathodic protection systems are used to support the coating and prevent pipe corrosion, although it is the most

effective method for protecting very small defects, so due to the increase in the number of defects, this system cannot be the answer to protecting the pipes.

According to the experiences obtained, pipes whose cathodic protection current needs to reach a maximum of 200 microamps per square surface (for normal soils) can be effectively protected. On the other hand, the process of gradual deterioration of the coatings after passing the above-mentioned limit is very fast and the increase in the current required for cathodic protection becomes exponential and causes other negative aspects such as the coatings adhesion loss.

The occurrence of pitting corrosion in underground pipes is one of the most important and serious risks that occur due to the disruption of the above-mentioned balance and as a result of the protection system's ineffectiveness, and in this sense, the issue of timely notification of even small damage to the coating is important.

The most important and common method to know the coating condition and cathodic protection efficiency is to measure the potential at one-kilometer intervals. The efficiency of this method is average and at the same time that it determines the general condition of the cathodic protection level, it cannot detect the breakdowns and defects of the coating at distances far from the measurement points and knowing the existence of the issues and problems of specific points of the coating is not possible with this method, until the occurrence of leaks and holes in the pipe. Therefore, in the case of old pipelines or lines whose coating condition is not satisfactory, in addition to the above method, OVER THE LINE inspection methods should be used to determine the coating condition. Among the advanced methods that are used to determine the defective points of the coating, the following can be mentioned:

1. PEARSON SURVEY
2. CLOSE ORDER POTENTIAL SURVEY (COPS)
3. C-SCAN

4. DC VOLTAGE CHANGES METHOD

which can be called the DCVG (DIRECT CURRENT VOLTAGE GRADIENT) device as the most complete and simplest method for determining coating defects.

Before any action, the dear operator who owns this device is requested to use it practically as much as possible by creating artificial points on a cable buried in the ground or a pipe, until after mastering it, to be able to use the device in different situations and get the desired result.

DEFINITION AND SPECIFICATIONS

In general, the DCVG device includes one millivolt with high apparent resistance two electrodes, and a cut-off and cut-off current set up to 0.9 seconds.

The DCVG device, which is used to check coating defects, is a technique that is completed as follows.

- The input resistance (INPUT IMPEDANCE) is increased up to 10/12 ohms, which has increased the device capacity.

The AC adapter is connected to the INTERRUPTER METER PROBES at the same time and is used to charge the batteries of the device (all of which are rechargeable).

Even though working with the DCVG device is very simple, the optimal use of the device can only be achieved by an operator who has sufficient experience. Although, a summary of the DCVG device description and a guide on how to use it, is provided below so that it can be helpful.

THE DEVICE COMPONENTS PROVIDED TO YOU

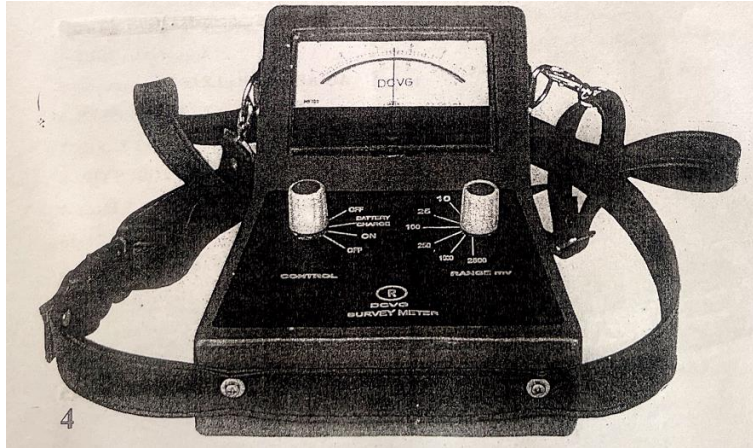
1. METER device (receiver)
2. INTERRUPTER device (transmitter)
3. HANDLE
4. LEADS and AC ADAPTER connector wires
5. HALF-CELL PROBES



6. COPPER SULPHATE container
7. PROBES TIP
8. METER device HOLDER strap (receiver)
9. Device charger
10. Carrying bag for DCVG device
11. HALF-CELL PROBES carrying case
12. Device usage guide
13. 3-year warranty card

THE RECEIVING DEVICE SPECIFICATIONS (METER)

- With 10/12 OHMS-INPUT IMPEDANCE
- With a key with 2500MV, 1000MV, 250MV, 100MV, 25MV, 10MV states. which provides the possibility of checking and measuring almost all potential changes in different environmental conditions.
- The device's internal battery is charged only when the key is OFF.
- The light built into the meter (light emitting diode) indicates yellow when the battery is charging, and to know whether the battery is charged or not, you can charge the battery by placing the key in the BATTERY CHECK position and figuring it out by the pointer going through the whole screen. A normal check is possible by placing the key in the ON position.
- There are two plugs on the front of the device, which are for connecting HANDLES, and one plug is on the right side, which is for charging.
- LIGHT IN NIGHT system: It is used to light the meter in low-light environments.
- Its circuit is designed to prevent extra sounds. It prevents sudden input excess voltage and by controlling it, it gives a limited current to the device. In addition, it is resistant to water and allows the operator to use it in rainy weather.



THE TRANSMITTER DEVICE SPECIFICATIONS (INTERRUPTER)

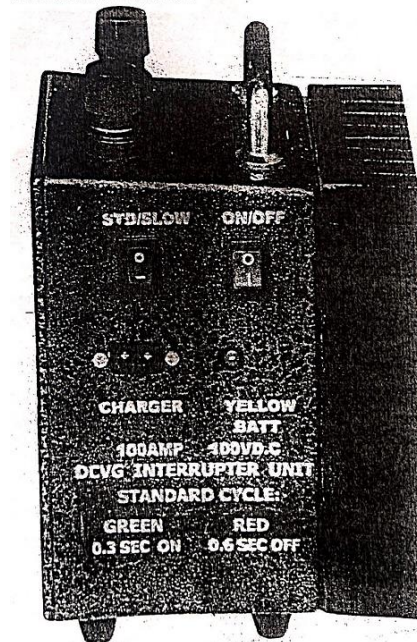
- Its capacity is 100 volts and 100 amperes DC.
- Its battery is of LEAD ACID type, which works continuously for seven days, and its capacity is 12 volts and 2.5-amp hours. The connection and disconnection speed in normal mode is 0.3 seconds ON and 0.6 seconds OFF, and the connection and disconnection speed in slow time is 0.6 seconds ON and 1.2 seconds OFF.
- When the light is green, it indicates that the device is in ON mode.
- When the light is red, it indicates that the device is in OFF mode.
- When the light is yellow, it indicates that the batteries are weak, and when the battery is weak, the device will automatically turn off.

The status of the warning light is as follows:

GREEN = ON

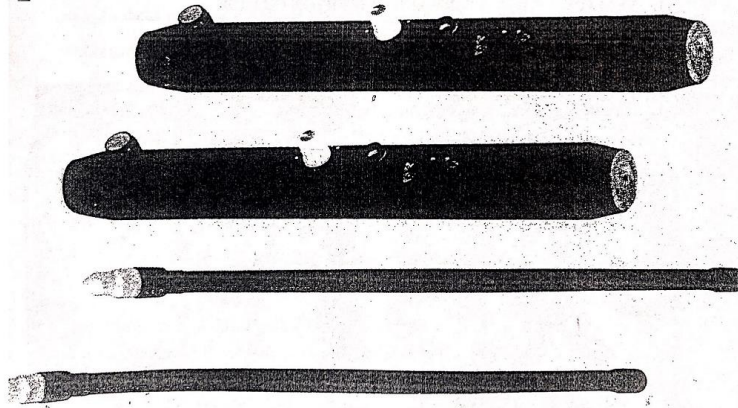
RED = ON

YELLOW = LOW BATTERY AND BATTERY ON CHARGE



PROBES SPECIFICATIONS (HANDLES AND HALF-CELL PROBES)

- HALF-CELL PROBES are made of standard COPPER SULPHATE, and the half-cell is made of fiberglass, which is lightweight and long. In the half-cell holder (HANDLE) several control keys work up to 1.2 volts, which should be noted when working with two half-cells, only one of these two keys should be ON and the other one should be OFF. Each of the two half-cells contains a copper rod like the length of the half-cell with a 2 mm diameter.
- Its battery is nickel-cadmium and rechargeable, which works up to 30 days after charging.
- The battery charger works with 120/240V input and 16-18V output.
- The tip of half-cells is made of wood in different types, suitable for working on all surfaces.



PREPARING EQUIPMENT FOR THE SURVEY

1. BATTERY CHARGING

It is possible to charge all components together. However, two METER and INTERRUPTER devices need charging more than the handles. If the batteries are completely discharged, each of them individually needs two days of full charge. If the device is not used for a week or more, it should be charged overnight or 24 hours. When we want to use the device for a long time, we must charge the METER device and the INTERRUPTER device every night.

2. HALF-CELL PROBES

The wooden tip of the probes should be fixed to the head of the half-cells and placed in water for a few hours before use. In conditions where the ground is dry and its resistance is high, sharp tips should be used, and when the surface of the ground is covered with cement, it is better to use tips that have a flat surface which provides the possibility of more contact with concrete. When filling half-cells with copper sulfate solution, the upper part of half-cells (handles) should be removed. In addition, copper sulfate solution can be prepared in different concentrations, which depends on the type of use. For example, when half-cells are used to measure the pipe-to-soil potential, the solution should be saturated and the crystals should be

suspended in the half-cell, in normal tests where only %10 defect is desired, distilled water should be used for the solution.

When checking, it is better to have spare tips with you so that they can be used when they are lost.

3. INTERRUPTER

We put the INTERRUPTER device in the circuit and we know that the potential difference signal measured from the TEST POINT (T.P) during ON and OFF time is a cathodic system.

The established current may be supplied from a permanent or temporary source. The cable that is used to connect the circuit must be chosen so that it can be used in different situations and as much as possible, their cross-sectional area should be 10 square millimeters to lower the circuit resistance.

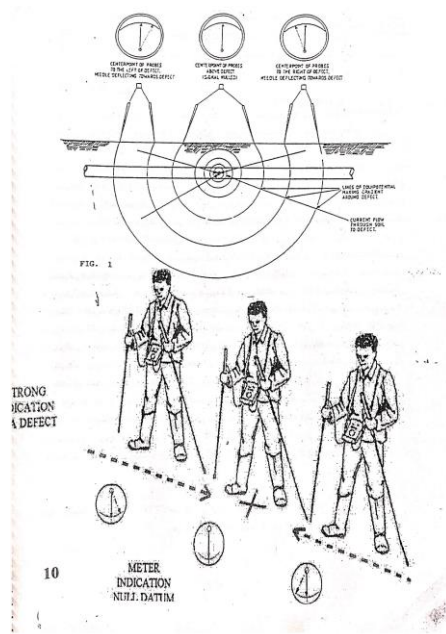
INTERRUPTER can be placed both in the way of the positive cable and in the way of the negative cable. Care must be taken to correctly determine the cable connection marks, for example, the negative terminal of the device (black) should be connected to the negative pole of the rectifier device, and the positive terminal of the device (red) should be connected to the cable that is connected to the pipe. If the wrong connections are made, the MOSFET will fail, and damage to the device will not occur, unless the output current is high. It should be noted that the OUTPUT of the rectifier device is selected at its lowest level, and then the rectifier is turned off, and after placing the INTERRUPTER in the circuit and turning it ON, select the normal speed, and the switch of the rectifier device is set to the ON position, and the output load of the rectifier device is gradually increased to achieve the desired signal value. It may be necessary to increase the rectifier in several steps for an OUTPUT check to achieve, for example, 400-500mV. Of course, it is possible to work with a 100-millivolt signal, but it is possible that small defective points will remain neglected and hidden (especially in low soil resistance) and the work will become a bit boring.

The amount of signal that is injected into the line at the point where the cable connects to the TEST POINT (T.P.), is connected like measuring the potential of the pipe to the soil.

HOW TO WORK WITH DCVG

This method requires a direct DC, which is applied to the line by placing an INTERRUPTER in its path with an ON time of 0.3 seconds and an OFF time of 0.6 seconds.

This direct current can be a cathodic system, a temporary system that includes a generator and a portable rectifier device, a high-capacity battery, or from an anode substrate or a piece of pipe that is buried in the ground at a distance from the pipeline, used as a substrate. The output current leaves the anode or any other item that is used as a substrate and reaches the pipe surface through the ground to the points where the coating is damaged and the pipe is in contact with the ground. The passage of current from the ground towards the pipe causes changes in the soil potential (due to the current passage through different parts of the soil that do not have uniform resistances) and the closer it is to the location of the coating defect, the greater this number of changes with each turning ON and OFF. The pointer of the device brings the operator closer to the defect location, and when we reach the defect location, the complete stop of the pointer movement indicates the defect location, and when the pointer does not move between ON and OFF, it means that there is no potential difference between the two half-cells and both half-cells are placed in an equal line of potential, so the defect must be between these two half-cells. (Figure 1 of the booklet)



START WORKING TO FIND A DEFECT IN THE LINE

- Prepare the devices.
- Fill the half-cells with the desired solution.
- Attach the handles to the half-cells.
- Connect the connecting cables to the device firmly put the device in ON mode and close the retaining straps.
- Set the METER switch to ON and then set the voltage adjustment switch to 1000 millivolts. Turn the key of the left handle clockwise to 2 or 3 and connect the wire of the meter (left side) to the left handle.

Move to the T.P. where you want to start the measurement and place the tip of the left half-cell on the ground preferably on the pipe.

Connect the tip of the right half-cell with the T.P. metal rod, then adjust the BIAS half-cell key on the left so that the meter pointer goes through the whole scaled screen.

Place the key on one of the positions to read the correct digit. For example, if the setting switch of the device is on 1000 mV and the pointer of the device stops at 150

mV when it is OFF and 700 mV when it is ON, the actual signal in that T.P. at the measurement location (150-700) means it is 550 millivolts.

If you consider the right half-cell with BIAS CONTROL and connect the tip of the left half-cell to T.P., then the direction of movement of the pointer will be from 700 mV in the OFF state to 150 mV in the ON state. In any case, the signal is still the same at 550 millivolts.

If the pipe or other metal structure is connected with the pipe under investigation, they will receive the same signal or less depending on the connection resistance. If the mentioned structures are not electrically connected to the pipe under investigation, if they are in the vicinity of the pipeline, due to being in the induction field, they will be affected by the field and will receive some of these currents and be forced to discharge from other points of the field where the meter pointer shows this opposition. (The interference amount depends on the current that is applied to the line) If the signal measured at the T.P. location is less than 400 millivolts, try to increase the rectifier output load to this level, and if it is not possible, continue with the existing signal otherwise, use a temporary system in place of T.P.

Important: Note down the signal value measured at each distance from T.P. The signal value measured at each T.P. or connection point should be noted down and the beginning and end of each survey should be noted because they are used when calculating the potential relative to the ground.

FINDING A DEFECT

Set the voltage selection switch of the meter device to 100 millivolts and make sure that the BIAS switch of one of the handles is in the ON position and on 2 or 3. If this is your first check, move on the line and the state of the half-cells is such that one of them is in front and the other is behind the head and keep a little distance from your side for your comfort. Place the half-cells 1.5-2 meters apart on the ground, then turn the BIAS CONTROL knob to make sure the pointer on the screen moves. Try to

keep the pointer on the screen the whole time the half-cells are in contact with the ground. This action makes you aware of your contact with the ground when you reach a defect.

Lift the half-cells and move away from the T.P. After three steps, touch the half-cell to the ground again and bring the pointer to the screen to see if you have any changes. If no change is observed, lift the half-cells move forward three more steps, and bring the pointer back to the screen with the BIAS CONTROL key. If you see the range of changes, try to remember the movement direction of the pointer, and if you are not sure what the direction of movement of the pointer is, you will reach the exact location of the defect with a forward or backward movement.

Remember that when the key is in the OFF position, it is longer than the ON time, and when the device is in the ON position, the current is directed through the ground to the defect location, which depends on the movement range of the indicator.

If you see a change in the movement of the indicator, move the half-cell that is closer to the defect location, for example, A, 1 meter closer to the front, and place half-cell B in the previous location of A. The closer you get to the defect location, the more the indicator range changes and you may need to change the meter adjustment key to a higher level.

As soon as you move away from the defect point, the movement direction of the indicator will return and gradually the change amount in its range will decrease. In this case, go back and try to stand in the place where NULL is obtained and open your hands in the place of the defect by observing the indicator movement, if the movement is from the left to the right, bring the left half-cell closer to you until make the indicator stop moving and stand in the NULL state and place the mark on the ground with your foot in the middle of the two half-cells, if the movement of the indicator is from right to left, do the same as before. What you have done is nullify the indicator of the device by placing two half-cells on the same potential circuit

around the defect. By referring to Figure 1 of the booklet, whenever half-cells are placed on a circuit of the same potential, there is no potential between the two half-cells, so the indicator should not move.

Now, with a 90-degree angle, change your location and the half-cell to the line stand in front of the mark you previously placed on the ground, and try to bring the indicator to NULL like the first step, then again put a mark that interrupts the previous mark, return from the first point you left by changing your position (90 degrees) and stand in front of the mark you left in the second step and try to make the indicator NULL and leave the third mark and exactly this sign must cross the second sign, which is exactly the place of the defect and is called the EPICENTER. If the first mark is placed exactly on the pipe, it coincides with the third point you placed, and if the first point is not exactly on the pipe, but on both sides of the pipe, then the second and third points are selected for the EPICENTER and for the last step of confirming the defect location, one of the half-cells can be placed at the defect location and the other half-cell at a distance of 1.5 meters in the four directions (compass directions). The indicator of the device should show the shape of the current side passing towards the defect location in all four cases, and if not so, it is clear that the EPICENTER location has not been chosen accurately, or that the coating defect is in the form of a long or microscopic gap.

SIZING THE DEFECT

Place one of the half-cells on the EPICENTER point and the other half-cell at a 90-degree angle to the line. If necessary, adjust the meter and try to have the pointer on the screen with the BIAS key. Then write down the millivolts value, for example, if the meter adjustment key is set to 250 millivolts and the indicator movement changes from 25 millivolts in the OFF state to 110 millivolts in the ON state. The actual value will be $110-25=85$ millivolts, which should be noted down. Then move the half-cell B to location A move away from that point at the same angle and note down the

millivolts reading with each movement. Until the indicator stops at zero and does not move, then add the millivolts values read together and use them to calculate OL/RE. The point where the indicator no longer moves is the remote earth point and you are far from the VOLTAGE GRADIENT. You must remember to keep the indicator on the screen with the BIAS key at all times. The sum of the potential drop readings you noted down is used to determine OL/RE and to determine DEFECT IR (Figure 2 of the booklet) and should be noted in front of each defect. The value size of the defect shape depends on the percentage value of the measured signal that you have measured from the nearest T.P., which is described by referring to Figure 3 of the booklet on how to measure the signal between two T.P.s. After all the specifications related to a defect are recorded, refer to the next point, when you move away from a defect, choose the distance of half-cells, 1 meter from each other until you are completely away from the GRADIENT location and the device indicator is at a steady state.

In addition, one or more defects may be found very close to the first defect.

THE DEFECT VALUE RATIO OF A DEFECT

The defect ratio or defect size is determined by the %IR value of the signal applied to the line. The potential difference signal between ON and OFF time obtained from the nearest T.P. is calculated. To calculate between two T.Ps while checking if we have the distance between two T.Ps, we use the following formula:

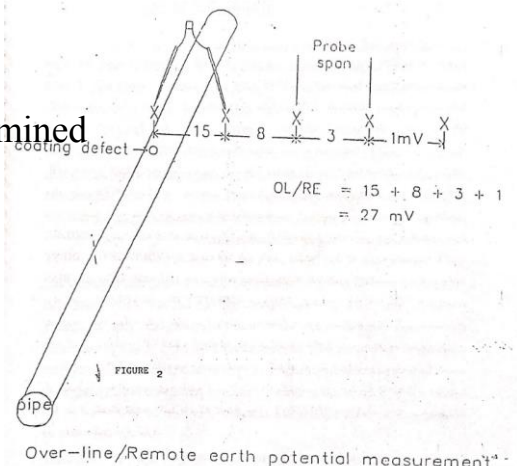
$$P/RE = S1 - \frac{DX(S1-S2)}{d2-d1}$$

Then by putting in this formula, the %IR value is determined

$$\text{DEFECT SIZE (\%IR)} = D \frac{\text{EFFECT IR OR OL/RE (MV)}}{\text{APPLIED SIGNAL (MV)}}$$

For example:

The signal at T.P. 1



S1=800 MV

The signal at T.P. 2

S2=300 MV

Distance between T.P. 1 and defect location

DX=400 M

Distance from T.P. 1

d1=0000 M

The distance between T.P. 1 and T.P. 2

d2=1000M

Refer to Figure 1

$$P/RE = S1 - \frac{DX(S1-S2)}{d2-d1} = 800 - \frac{400(800-300)}{1000-0} = 600 \text{ MV}$$

$$\text{DEFECT SIZE} = \frac{OL/RE}{\text{APPLIED SIGNAL}} = \frac{27}{600} = \%IR$$

previously calculated according to Figure 2

$$OL/RE = 15 + 8 + 3 + 1 = 27 \text{ MV}$$

The magnetic field amount around a defect location depends on many factors, the most important of which is soil resistance. The potential changes amount around a defect with low soil resistance is less than the changes amount of the same amount from a defect with high resistance, which is because the distances of the fields are closer to each other in low resistances and large distances in high resistances.

CALCULATION OF PIPE TO REMOTE EARTH POTENTIAL BETWEEN TEST POINTS.

Calculating the P/RE potential value is very important as it should be used in the %IR calculation. Of course, this is practical if you have the distance between the two T.P.s and the distance between the defect site and the starting point.

The far potential value is obtained from the following relationship:

$$P/RE = S1 - \frac{DX(S1-S2)}{d2-d1}$$

Current measured at T.P. 1

S1=800 MV

Current measured at T.P. 2

S1=300 MV

Defect distance to T.P. 1

DX=400 M

The distance between two T.Ps

d2 =1000 M

The starting distance of the measurement from the T.P. location

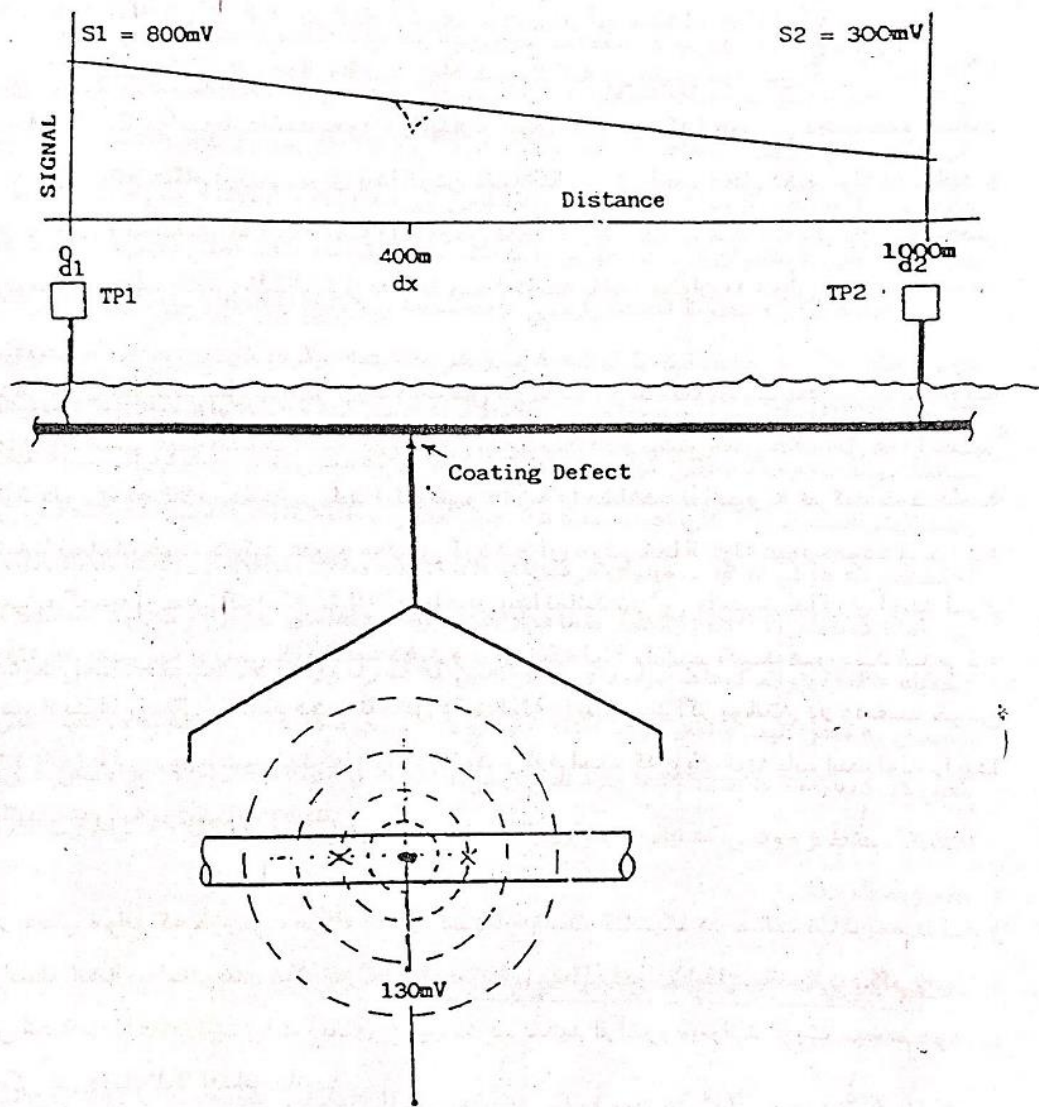
d1=0

$$P/RE=S1-\frac{DX(S2-S1)}{d2-d1}=800-\frac{400(800-300)}{1000-0}=600 \text{ MV}$$

Figure number 3

If the distance from the defect location to T.P. is not known, use the map and anything else that can help, otherwise, by putting an approximate number in the formula, obtain the approximate damage amount.

Fig. 3 RELATIVE SIZING OF COATING DEFECTS



Method of estimating pipe to remote earth potential and hence calculating %IR for sizing defect.

ADDITIONAL INFORMATION

The GRADIENT around a T.P. affects the signal measurement at that point and the signal value: The measured value will be less than the actual value, in such cases, if the GRADIENT insists, it should be noted and added to the distance measurements

you make. In some cases, when checking to find a problem, you may not know the exact location of the pipe and there are no signs to indicate the existence of the pipe. In such cases, if the coating is weak and there are problems in the line, you can act as follows:

Move by placing one half-cell in front and one half-cell in back. The movement direction of the indicator will lead you to the defect. After three or more steps, change the location of the half-cells so that it changes 90 degrees, then observe the indicator change and continue moving until the indicator direction is reversed and then you have passed the pipe, go back and try to find NULL with the meter. In this case, you are standing on the pipe, then continue your investigation, and in order not to lose the pipe, do these actions every few steps you take to find the exact location of the pipe. If the coating is in good condition, you cannot find the pipe and it is necessary to find the pipe first with a pipe finder and then investigate.

In some cases, when the rectifier output of the cathodic system is at its maximum, and due to the connection of other structures to the pipeline, it does not allow you to check, and if you want to disconnect these connections, you have to spend a lot of time, therefore, you can use a temporary auxiliary system in T.P. location.

MARKING THE DEFECTIVE POINTS

Marking the defective points, whether temporary or permanent, should be specified. Temporary marking is easy, but installing signs permanently is not easy, especially if the defect is in a busy traffic area or a cattle crossing, in such a situation, the signs will be destroyed, and natural disasters may also cause them to be destroyed. In the city's vicinity, you can use spray paint or marking by auxiliary points. In addition, if the city map and the lines under investigation are in hand, the exact location of the defect can be used as a REFERENCE according to references such as buildings or the corner of the park and any other available feature, and in the case of the main pipelines that pass-through deserts and outside the city, due to the presence of

mountainous areas or places that may be covered with many plants, it is better to use T.Ps installed on the route as REFERENCE. But in terms of saving time, you can use the GLOBAL POSITIONING SYSTEM (GPS) device that is provided to you along with the DCVG device (with two Persian and Latin guides). The GPS device can be carried by the operator or an assistant who moves with the operator, and upon reaching the defect location and using GPS, the signals in the space are recorded in the device according to the physical location of the location, which is entered into a PC device at the end of each day, the information is saved and when drilling is needed, the exact location of the defect is obtained by getting information from GPS.

DECIDING WHICH POINTS TO DRILL

Since the %IR value of a defect depends on the applied current value of the soil resistance, it cannot be said that, for example, %10 IR is a defect in another place where the soil conditions are different. For this purpose, it is suggested to drill different forms of %IR so that you can closely observe the appearance and the damage amount, which will give you useful information and help in evaluating the defective points.

As a guide, it can be said that three IR modes have been investigated in conditions where the soil has a resistance of 1000 ohms to 5000 ohms.

When we have 0 to %15IR, if the cathodic system works well and there are no other defective points near the defect, we can skip the repair of that point.

In cases where IR is %15 up to %35, the defective points should be repaired within 1-2 years.

When IR is %35 up to %50 or higher, the defective points must be drilled and repaired immediately.

DETECTION OF INTERFERENCE

The effects of stray currents on external installations and vice versa are determined by checking with the DCVG device. Just as the defect points of the coating are

determined by receiving current to these points during this inspection, the points where the current exits from these points due to the electric currents interference (stray) when the operator moves away from these points, the indicator of the device taps (flips) this and indicated the phenomenon. At the same time, this condition is repeated at the points where the anode is also connected to the pipe.

PROPER USE OF THE BIAS RANGES

There are different degrees on the handles, and the best conditions for choosing it depend on the following two factors:

1. The physical condition of the land where the line is checked.
2. Selection of the voltage adjustment switch state in the METER.

If we can have the indicator on the whole screen, the best position of the key is when it is placed at its lowest level, because in a situation where the ground resistance increases, it allows the operator to increase the position of the keys to a higher level. Usually, in places where the ground resistance is between 1000 and 10000 Ohm cm, even if the switch is in the 25 millivolt position, it is possible to have the indicator on the entire screen and there is no need to change the switch position, but if the ground conditions change and the resistance between 10,000 and 200,000 Ohm cm, the operator has to change the key status every time the half-cells are moved, even if it is necessary to put the key in 100 millivolt mode so that he can have the indicator on the screen.

MEASURING OL/RE POTENTIAL NEAR PHYSICAL OBSTRUCTION

During the survey, you may come across several obstacles such as concrete walls or metal structures and environments that have thorns, which will make it difficult to continue the survey for measuring OL/RE (measurement of remote potential) if you want to perform this measurement outside these environments, you must be far away from the defect location and your measurement value will have a significant difference with its actual value or that point should be neglected. In such cases, it is

suggested to use a companion as an assistant and measure as follows: Your companion needs a copper sulfate half-cell that is equipped with 30 meters of wire and a 4mm plug that can be connected to the handle. When the operator reaches the coating defect, removes one of the half-cells from service and connects the assistant's half-cell, which is equipped with a 30-meter wire to the device, after crossing the mentioned obstacles, the assistant stands in a place and places his half-cell on the ground. The operator then notes the changes of the indicator on the device (millivolts read) and then loudly announces that he should move 2 to 3 meters away from the place where he stands, by doing this, the operator wants to make sure that if there is an increase in potential change or not if no increase change is observed, the operator notices that an assistant is located in the remote earth environment and writes down the same number as the OL/RE potential in the notebook. Although the above operation is tedious, it is required to achieve a true OL/RE potential.

IS STEEL AS A COATING DEFECT CORRODING?

With the DCVG method, the aforementioned very important issue can also be investigated. Determining whether the flow path is towards the pipe or vice versa when the cathodic system is OFF or ON, and therefore the pipe is exposed to corrosion or not?

Therefore, the existing method indicates the presence or absence of corrosion and does not say much about the severity and weakness of corrosion. In this regard, to obtain more definitive results by using the cathodic protection rectifier device, it is necessary to adjust the output signal so that we can have a normal potential of 1000 to 900 millivolts at the desired location and then proceed as follows: First, at the specified location of the defect, the two tips of the half-cell are brought together a little far from the defect location (about 2 meters) so that the indicator is set in the middle position, then the operator places one of the half-cells at the exact location of the coating defect and places the other half-cell far from the defect, enough to

fully open the other hand, in such a situation, one of the four states of Figure 4 may be observed, with the explanation that the continuous lines indicate the initial state of the indicator in the disconnected state of the protection signal is OFF and the dotted lines are the reaction of the hand to the re-establishment of the protection signal ON.

From the four situations in Figure 4, it can be concluded that the most dangerous is the fourth situation, where the pipe is naturally in a corrosion state, and at the same time, despite the presence of the cathodic system, this part is not protected. The coating repair in the mentioned place is the priority. Also, in the second situation, caution should be taken and the coating should be repaired. Due to changes in the cathodic protection station efficiency or seasonal changes, the protection current may drop and the pipe may be exposed to corrosion.

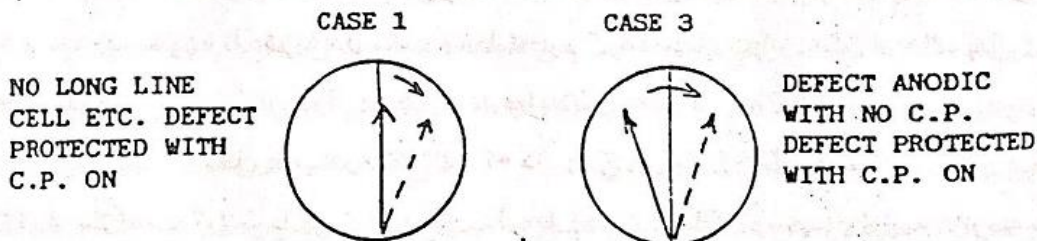
FIGURE 4

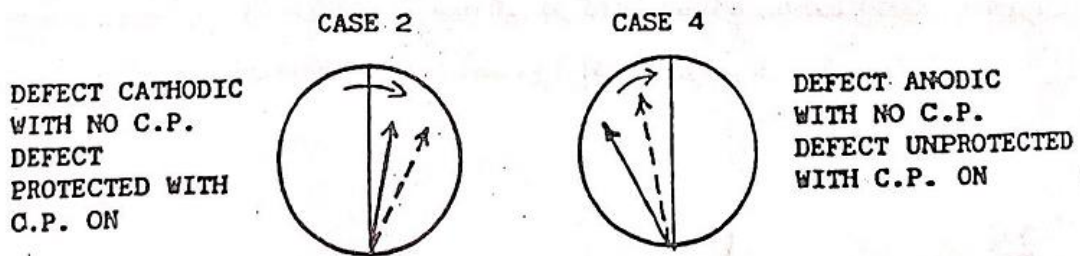
Use of DCVG Equipment to determine if active corrosion is taking place on a buried pipeline. Place one probe on Epicentre and one probe remote from Epicentre.

Two movements of meter needle.

- a) Initial shift from center position (solid lines).
- b) Response of millivoltmeter to impressed DC signal (dotted line).

Cases 3 & 4 are likely to give rise to corrosion.





DEFECT SIZE, SHAPE, AND LOCATION ON PIPE

From the severity of the weakness and the positions of the voltage lines (gradient), the shape and position of the coating damage can be estimated before drilling (Figure No. 5). For example, small point defects on the upper surfaces of the pipe usually have circular voltage lines and the voltage lines related to the defects located on the lateral surfaces are located on one side and are oval.

Longitudinal defects have continuous and long lines.

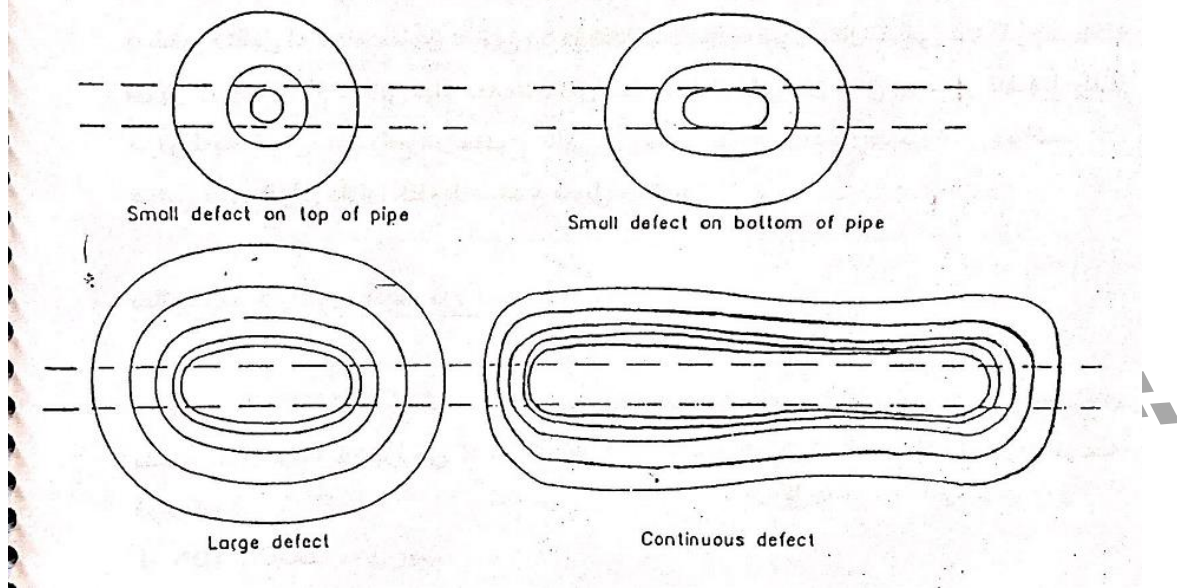
A FEW TIPS ABOUT PERFORMING THE SURVEY

Useful information about the condition of underground pipelines can be obtained with the DCVG method, and one or more of the following goals should be taken into account in each investigation.

1. LOCATION
2. SIZE or %IR size of the defect
3. SHAPE
4. CORROSION

In most studies, only the location of the damage and its size, and sometimes, in the case of large damage, the anodic and cathodic conditions are specified. Due to the time-consuming nature of the investigations, determining the shape and location of the damage is usually neglected, so the speed of conducting tests in the first stage depends on the variety of investigations and in the next stage on the complexity of the pipe status and the damage amount.

Fig. 5 Uni-potential line plots above typical defects



For the guidance of the dear operator, an example with figures and numbers to comply with items 1 to 4 is done as follows:

SIGNAL=640 MV

SIGNAL=646 MV

1. LOCATION is specified

$$\%IR = \frac{OL}{SIGNAL}$$

2. SIZE or %IR

$$\%IR = S + \frac{DX}{X} (S - S)$$

$$\%IR = OL$$

$$640 + \frac{DX}{245} (646 - 640)$$

According to the relationship, OL=2 is already obtained

DEFECT NO.1 %IR=

DEFECT NO.2 %IR=

DEFECT NO.3 %IR=

Stages 1 and 2 are determined out of four stages. Now, for the third step, that is, SHAPE (the defect form), we will proceed as follows:

We place one half-cell at the defect location and change the other half-cell 1.5 meters from the defect location in four directions and note the voltage amount changes.

N=15 MV

S=14 MV

E=15 MV

W=16 MV

ISOLATE DEFECT: The defect of the coating is single and located in the upper part of the pipe.

Now that the third stage, i.e. The defect location is identified, we go to the fourth stage (the last stage) to determine whether the coating defect location is subject to corrosion or not.

We move two meters away from the defect site bring the two ends of the half-cell closer together and try to bring the pointer to zero, then we return to the defect site put one half-cell in the damaged place, and put the other one in one of the four main states and we observe the changes in the movement of the indicator and should it be one of the four states that are exposed to corrosion or not?

Now, we will fully implement the following table for the example of the number we entered and examine the conditions that have arisen.

DISTANCE		NO REPAIR	SIZE	SHAPE	CORROSION	
					OFF Cathodic	ON Cathodic
1)	4.9m	NO REPAIR	0.3%	ISOLATED	C	C (NO CORROSION)
2)	9.4m	NO REPAIR	3.7%	ISOLATED	A	C (NO Corrosion with c.p on) (Corrosion with c.p off)
3)	23.5m	REPAIR 1-2years	15.5%	ISOLATED	A	C (NO Corrosion with c.p on) (Corrosion with c.p off)

Note: The obtained %IR value can be interpreted as follows.

% 0-15	%15-35	%35-100
1) NO REPAIR	2) REPAIR 1-2YEARS	3)REPAIR IMMEDIATELY

1. Due to the smallness of the defect, it is protected by C.P.
2. Repairing the defect between 1-2 years later.
3. Repair the defect as soon as possible.



Example of a 30" pipeline inspection by RADAR DCVG device