ER Probe & Coupon Installation and Commissioning Guidelines
Buried Pipeline Applications

MetriCorr Item Number 101445

Classification: Non-Classified					
Rev	Date	Comments	Author	Review	Approval
100	2018-08-02	Final	LVN		

Contents

1. Scope

The scope of this document is to provide pipeline operators, consultants and service providers guidance in relation to installation and commissioning of ER probes and coupons for monitoring external corrosion and cathodic protection of buried pipelines. Readers are encouraged to use this document as inspiration when preparing own procedures and practices, and to provide MetriCorr with their feedback on impracticalities, experiences, tips and hints to continuously improve the document.

2. References and Related Documents

The below standards and guidelines are useful documents within the above scope.

1. NACE SP0169:2013 - Control of External Corrosion on Underground or Submerged Metallic Piping Systems,
2. NACE TM0497:2012 - Measurements Techniques Related to Cathodic Protection of Underground or Submerged Metallic Piping Systems,
3. NACE SP0177:2014 - Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion,
4. NACE SP0104:2014 - The Use of Coupons for Cathodic Protection Monitoring Applications,
5. NACE SP21424:2018 – Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring.
6. EN 12954:2001 - Cathodic protection of buried or immersed metallic structures - General principles and application for pipelines,
7. EN 13509:2003 - Cathodic protection measurements techniques,
8. EN 50162:2004 - Protection against corrosion by stray current from direct current systems,
9. EN 1580:2013 - Evaluation of AC corrosion likelihood of buried pipelines applicable to cathodically protected pipelines,
10. ISO 15589-1:2015 Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems — Part 1: On-land pipelines,
11. ISO 18086: 2015 - Corrosion of metals and alloys — Determination of AC corrosion — Protection Criteria
12. CeoCor document: Applications of Coupons for Cathodic Protection Monitoring Purposes.
13. Effect of Coating Defect Size, Coating Defect Geometry, and Cathodic Polarization on Spread Resistance - Consequences in relation to AC Corrosion Monitoring; CeoCor paper 2010-05, Lars Vendelbo Nielsen & Michael Berggreen Petersen (MetriCorr, Denmark), Leslie Bortels & Jacques Parlongue (Elsyca, Belgium).
14. Reference electrodes for monitoring cathodic protection on buried pipelines, CeoCor draft document, Working group E, Chaired by Brian Wyatt.

3. Introduction

The application of ER probes or coupons serves mainly either of two purposes:

- Monitoring of adequate cathodic protection and the consequent risk of corrosion, or
- Monitoring of DC or AC interference and the consequent risk of corrosion

The installation of ER probes and coupons should be made in such a manner that the representability of a pipeline coating fault is maintained to the greatest possible extent. The following are points that should be considered in this context:

- The probe should be installed in the same soil or backfill as the pipeline itself.
- The probe size and geometry and consequent spread resistance should reflect the purpose of the monitoring. Reference [13] provides a general basis.
- The probe should not cause or receive any electrical interference from adjacent coupons or coating faults unless this is part of the purpose of monitoring.
- The probe should have and maintain an effective electrical contact to the surrounding soil – unless lack of contact is part of the purpose of monitoring.

4. Selection of installation sites

The selection of the installation sites may include the following issues [12]; discussed below

- General verification of the cathodic protection effectiveness (4.1).
- Verification of the corrosion risk due to DC interference (4.2).
- Verification of the corrosion risk due to AC interference 4.3).

4.1. General verification of CP effectiveness

For general verification, the ER probes or coupons may be installed in locations where the protection criterion can be difficult to obtain, in areas with various soil resistivities, soil chemistry, moisture content, current density, coating condition. Examples of such locations are

- The top of a dry, rocky hill,
- Low points with increased humidity,
- Mid-span between CP current sources,
- Casings.

The probes should be placed in each environment to help identify the effectiveness of the impressed current system in that specific environment. In any case the probes/coupons should be electrically connected to the pipeline. It may be considered whether to install the probe near the upper part of the pipeline or lower part of the pipeline; since the humidity of the soil may differ in those areas. The pipe may act as a drain and humidity accumulate at the lower part. Seasonal variation in ground water level could also be considered.

Further guidance is given in [1, 2, 4, 6, 7, 10, 12]. The effect of the probe area should be taken into consideration [13].

4.2 Verification under DC interference conditions.

For the evaluation of the risk of DC stray current corrosion, the probes should be placed in any location where the criteria for unacceptable DC stray current may be present. Refer to references [1,8]. DC interference may include influence from:

- DC traction systems

- Overhead lines for vehicles
- Trolley bus systems
- DC power systems
- DC equipment at industrial sites
- Cathodic protection systems
- High voltage DC (HVDC) transmission systems
- Wind farm power systems
- Geomagnetic interference
- Tidal fluctuations

4.3 Verification under AC interference conditions.

For the evaluation of AC corrosion likelihood, the probes/coupons should be installed anywhere the criteria for AC corrosion likelihood is evaluated. Refer to [5, 9, 11]. AC interference may include influence from

- Overhead power transmission cables
- Buried power transmission cables
- AC traction systems.

The site selection according to [5] include locations where:

- the AC voltage is shown by calculation or by AC voltage surveys to be significant,
- The soil resistivity is low,
- The CP condition can be excessive e.g. nearby CP current sources,
- The CP condition may be inadequate like at mid points between CP current sources,
- DC interference (anodic or cathodic) is present,
- In line inspection, excavation activities or leak history have shown corrosion activity,

5. Installation Guidelines

5.1 Safety

The safety procedures of the responsible pipeline operator must be followed. These procedures may include (list is not exhaustive):

1. Procedures to avoid damaging the pipeline, the pipeline coating, cables, or test stations etc. during the installation
2. Personal protective clothing requirements, such as hard hat, safety shoes/boots, non-flammable workwear etc.
3. Instructions to protect installation personnel from hazardous Step & Touch voltages, surges, etc. and how to terminate work in severe weather conditions – thunderstorms etc.

5.2 General Pipeline Description

The installation of probes is typically an integral part of monitoring of an entire pipeline, or a pipeline system, in which the probe has been installed in a hot spot or for routine monitoring. The results from the probe/coupon are then viewed in a broader context where information on the entire pipeline system is necessary. This information may include (but is not limited to) the following points:

- Name of pipeline (Identification number)
- Route
- Length
- Diameter
- Coating
    - type,
    - age
    - resistance
- Isolating joints
    - Numbers
    - Locations
- Bonds
    - Numbers
    - Locations
    - Types (rail, foreign pipe, etc.)
- Rectifiers (T/R's)
    - Numbers
    - Positions
    - Current outputs
    - Operational mode (Voltage, Current, Potential, IR free mode)
- Sacrificial anodes
    - Numbers
    - Locations
    - Current outputs
    - Resistance to earth
- Groundings / earthing installation
    - Numbers
    - Locations
    - Types (Zinc, Copper, mitigation wire etc.)
    - Type of AC discharge device (PCR, SSD etc.)
    - Current drain (AC as well as DC)
    - Resistance to earth
- AC interference sources
    - Detailed location
    - Calculations
    - Induced AC voltage and other previous measurements
    - Other relevant studies performed
- DC interference sources
    - Detailed location
    - Calculations
    - Measurements
    - Relevant studies performed
- General cathodic protection level on the pipeline considered
    - Descriptions
    - Measurements
    - ILI findings
- Soil resistivity information

Even though all the above information may not be necessary for the characterization of each individual ER probe or coupon installation, all these parameters will have an impact on the measured output of each local sensor (ER probe or coupon).

5.3 Installation Identification.

Each individual ER probe or coupon installation should be clearly identified by indicators such as:

- Pipeline name / identification
- Chainage
- Tag number
- GPS coordinates
- Location on pipeline (clockwise).

5.4. Site Description

In addition to the installation identification a description of the site can be beneficial. Such a description may include:

- Area description
  - Rural
  - Urban
  - Industrial
  - Farmers land
  - Swamp
  - Desert
  - Coastal
- Soil description
  - Clay
  - Sandy
  - Silt
  - Marine sand
  - Gravel
  - Anaerobic (H_2S smell - MIC)
  - Dry/Wet/humid
  - Other observations
- Soil resistivity measurements
  - Above ground (pin spacing for instance 0.75m, 1.5m, 3m)
  - Soil box measurement of the local resistivity in the soil where the probe is installed.

5.5 Excavation and Installation Methods

5.5.1 General considerations

As mentioned, when installing probes and coupons, good electrical contact must be continuously maintained between the probe/coupon surface and the surrounding environment. During the installation process, the soil around the probe shall be well compacted to prevent settlement and air voids forming around the probe. These voids could result in loss of full contact between the coupon surface and the surrounding soil. The possible loss of contact because of soil movement caused by freezing or subsidence of the backfill material around the coupon shall be considered and minimized during installation [4].

Probes and coupons may be installed by different methods, including:

- Complete excavation (whether heavy construction excavators or shoveling)
  - Installation of the probes during the pipeline construction
  - Later excavation due to routine pipeline integrity inspection or repairs
  - Excavation with the sole purpose of installing the probe or coupon.
- Local dig
  - Hand digging
  - Auguring
  - Air vacuum excavation

NOTE: Hydrovac installation must be avoided as it results in the introduction of a chemical environment that differs from the original state.

Hand digging using a dedicated set of specialized shovels and tools.

Local digging - air vacuum procedure involving high-pressure- and mechanical tool for soil release and a vacuum suction hose for removing the soil. (Photos with kind permission of Kantex).

Hand-dig in the desert – full pipe excavation.

5.5.2 Considerations in case of complete excavation

When completely excavating the pipeline, the probe may be arranged very close to the pipe itself – "flush" with the pipe wall – making an optimal condition for providing the same soil and humidity as experienced by the pipe itself. The probe can be arranged in a sleeve/adaptor such as that shown below.

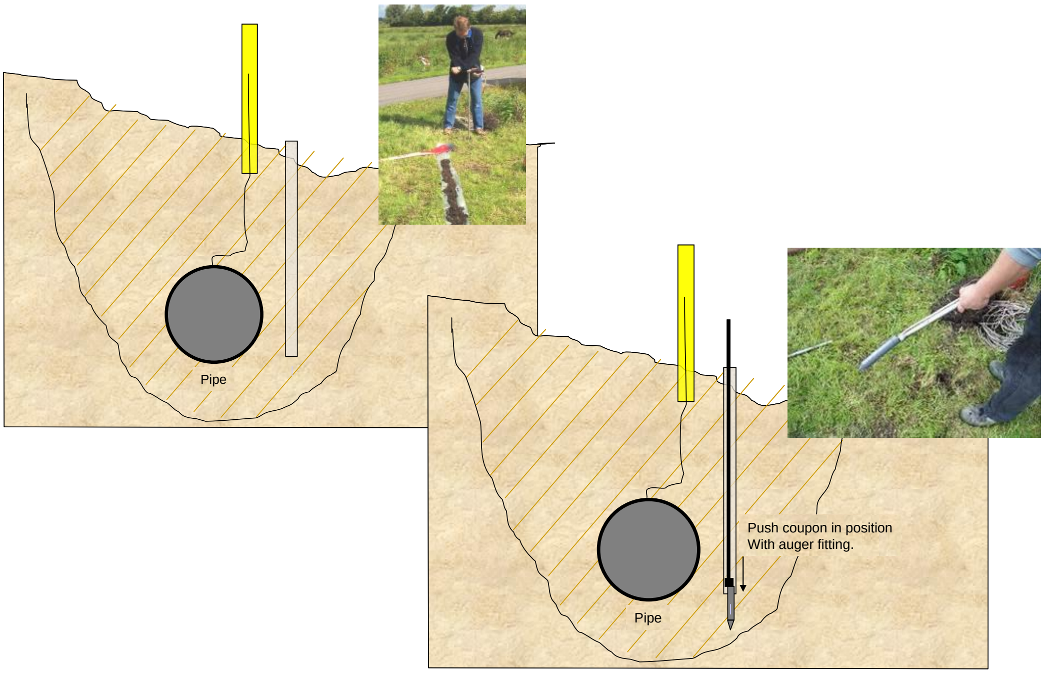
Ensure that the probe is embedded in the same soil as the pipeline and not just arbitrary soil from the excavation. The probe surface should point away from the pipeline. See suggested procedures for local digs.

Rod type ER probe embedded in sleeve for providing a better integration with a pipe surface.

5.5.3 Considerations for local digs

Consider the following steps for a local-dig procedure.

1. Locate and mark all buried structures including piping, tanks, and cabling prior to the installation.
2. Select a point to dig - take proper precautions so as not to damage the coating or structure when auguring/digging.
3. Auger, shovel or use the air vacuum technique to produce the hole almost to desired depth. Make sure to keep track of the excavated soil to be able to fill back in the same layers as before excavation. This may be a particularly challenging when applying air vacuum.
4. For characterization of the soil, it is advised to use some excavated soil to perform resistance test in a soil box, to observe humidity, perform an acid droplet test for presence of calcium carbonate or to sample for further analysis back in laboratory. Collect this soil from the depth where the probe is going to be installed. Keep a strict record of the sampled soil.
5. Push the coupon in position using an auger fitting (can be supplied by MetriCorr). The probe surface should point away from the pipeline.
    a. If the soil is soft / sandy push the coupon an additional probe length down through the undisturbed native soil/backfill. In this case, the soil usually fills out and compacts around the probe providing good electrical connection. Back fill the excavation in the same row as uncovered compacting regularly.



Push coupon in position with auger fitting or the like

    b. If the soil is harder, it may be necessary to form a cake of soil from the desired coupon depth and form a "cake" around the artificial coating defect of the coupon – mixed with a bit of distilled water prior to positioning in the soil. Fill back the soil in the drilled hole in the same row as uncovered compacting regularly.
6. Arrange the ER coupon test leads in the test station or junction box.
7. Coil up any excess ER probe cable and bury next to the installation.
8. Install the reference cell. It is recommended NOT to place the reference cell adjacent to the probe surface, as leak of ions from the reference cell electrolyte is common and will change the soil

chemistry. The reference cell should be arranged at least 50 cm from the surface of the probe, bearing in mind that most of the IR drop occurs within millimeters from the probe surface and cannot be compensated in practice by placing the reference electrode close to the surface of the probe.

5.6. Installed Items

During the installation, note the type and serial numbers of installed equipment (ER probes, reference electrodes, ICL dataloggers, remote monitoring units), their position relative to a fixed point and make a sketch of the installation that outlines the situation plan. Record GPS coordinates.

6. Commissioning

6.1 Conventional checking

The following points should form part of a commissioning process:

1. The installed reference electrode should be calibrated against a calibrated master working reference electrode (MWRE – a reference electrode for practical on-site calibration of reference electrodes [14]). Values should be noted.
2. The remote monitoring system should be tested – i.e. the connectivity and reporting of the first data should be verified.
3. The programming of the datalogger and remote monitoring unit (sample intervals and transmission intervals).
4. First measurement results. While present on site (and before backfilling) the first measurement results from the installation should have a sanity check.
    a. ER probe thickness – is it close to certificate values?
    b. DC potential - check against a measurement using a portable reference electrode and multimeter.
    c. AC voltage – as above (turn multimeter in AC mode).
    d. DC current density – a cathodically polarized structure will show a negative sign.
    e. AC current density – see below
    f. Spread resistance. Should be close to U_{AC}/J_{AC}. See below.

6.2 A special note on spread resistance

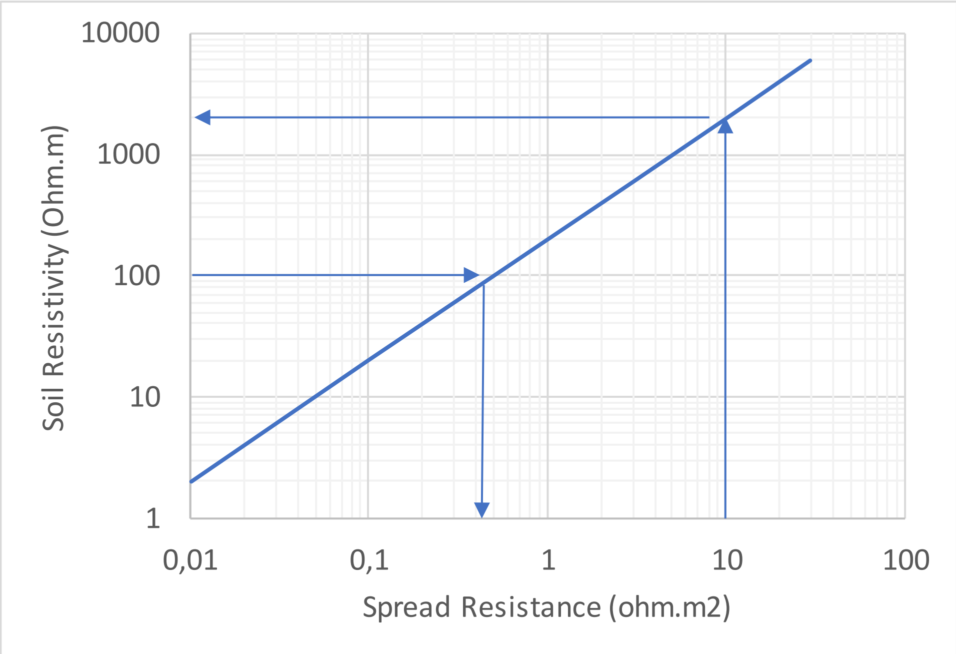
The spread resistance may be very low (0.01 Ohm.m2) or very high (+10 Ohm.m2) or in the interval in between. I.e. it is defined within an interval of +4 decades.
The spread resistance relating to a coating defect with diameter (d) and area (A) is usually described by

$$R_{spread}(ohm.m^2) = \frac{R_{soil}(ohm.m) \cdot A(m^2)}{2 \cdot d\ (m)}$$

To be a true indication, the measured soil resistivity must be valid VERY CLOSE to the surface of the probe. When polarizing a coupon or probe, the CP current will significantly change the soil resistivity at the probe surface over the following days or weeks (it can increase or decrease very significantly).

If the soil resistivity is measured in a soil box using soil from the excavation exactly where the probe is intended to be installed (in the same spot after excavation), and then compare to the initially measured spread resistance immediately after installation, a fair correlation given by the above formula may be observed.

For a MetriCorr 1 cm2 ER probe the below graph is a good approximation.



Example:

If a soil resistivity (soil box) around 100 ohm.m is measured – it would be expected that the initial spread resistance would be around 0.5 Ohm.m^2. If the measured initial spread resistance is 10 Ohm.m^2, then the probe may not have a full contact to the soil, and the positioning of the probe must be re-done, because this corresponds to a soil resistivity of 2000 Ohm.m. There should be a reasonably good agreement for the INITIAL spread resistance (factor of 2). Later, as mentioned, this correlation will cease because the CP process takes over the local soil resistivity.

Do this check before covering the excavation or local dig completely.

Appendix – Installation report and commissioning document (example)

ER probe installation & commissioning

MetriCorr

1. Date

Installation date	2018.08.02	
Commissioning date	same	

(commissioning should be made immediately after installation)

2. Installation Id.

Pipeline	MC Pipeline 24-76	
Chainage	KP 34+876	
Tag	Test station 45	
GPS		
	Latitude	55.695043
	Longitude	12.430163

3. Safety procedures

All applicable safety procedures followed (check √) √

4. General pipeline description

N/A (check √)	☐
According to document:	MetriCorr consultancy report 42123

5. Site description

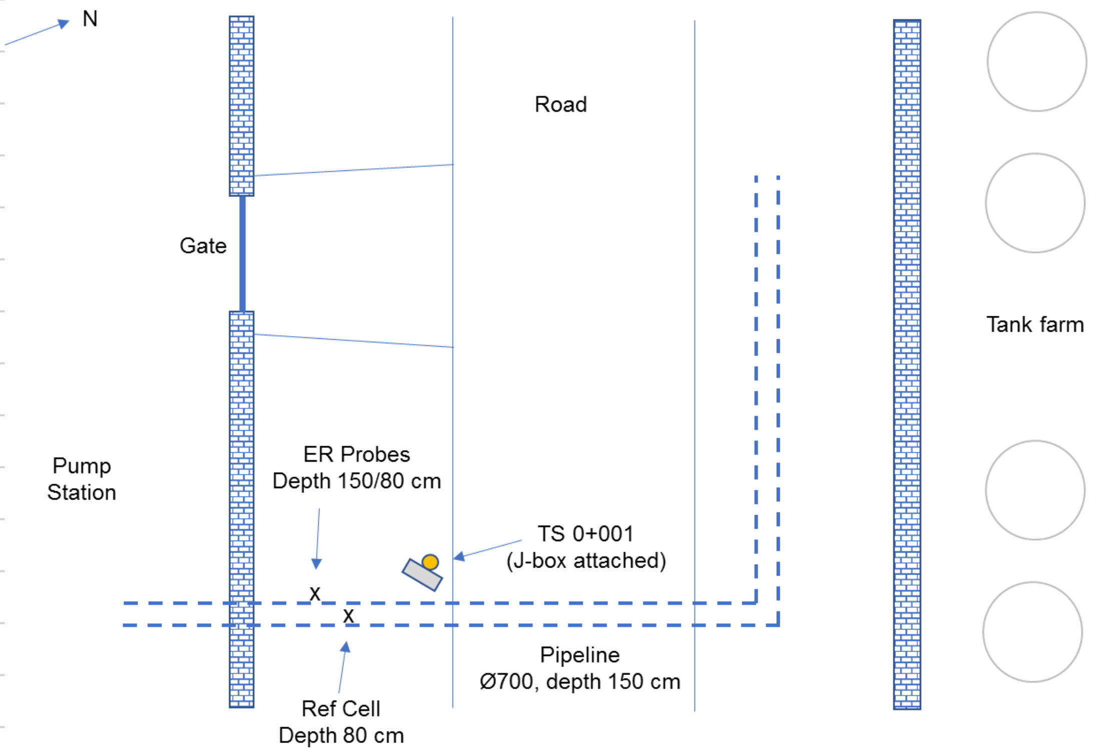
Area (check √)	Rural:	☐	Urban:	☐	Industrial:	√	
	Farmland:	☐	Swamp:	☐	Desert:	☐	
	Other:						
Soil Type (check √)	Clay:	☐	Sandy:	☐	Silt:	√	
	Gravel:	☐	Swampy:	☐	Coastal:	☐	
	Anaerobic:	☐	Dry:	☐	Wet:	√	
	Other:						
Soil Resistivity	0.75 m	Rmeas		Rsoil		Ohm.m	
	1.50 m	Rmeas		Rsoil		Ohm.m	
	2.50 m	Rmeas		Rsoil		Ohm.m	
Local Resistivity (Soil Box)		Rmeas		Rsoil		Ohm.m	

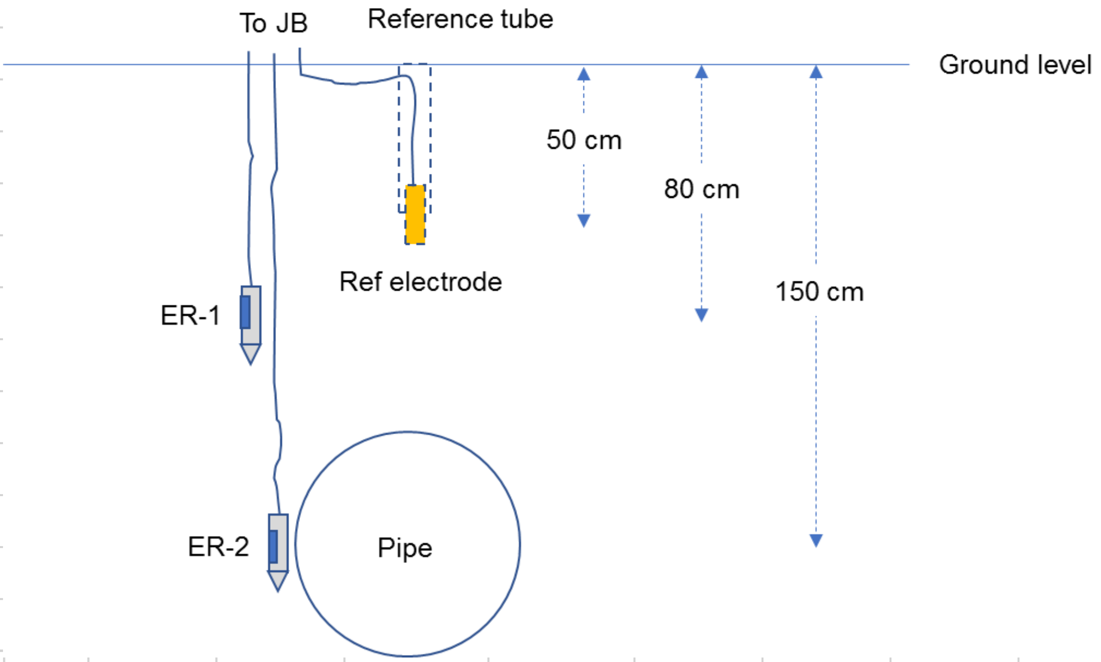
6.	Installation Method (check √)		
	Hand digging		√
	Air vacuum		☐
	Auger		☐
	Complete excavation		√
	During construction		☐
	Other (identify)		

7.	Installed items				
	ER probe 1	S/N	Pi 20304052	Type:	Pi-1-10-12
	ER probe 2	S/N	Pi 20304050	Type:	Pi-1-10-12
	ICL	S/N	AM02789349 (Slimline)		
	Skywave	IMEI	N/A		
	MasterLink		AL02789138		
	Reference electrode		Type XXYY from supplier AAABBB		
	Others				

(Certificates should be attached where applicable)

8. Situation plan (sketch)





9. Commissioning

Reference electrode calibration

mV: 3 (Stationary versus portable Master)

Programming

	Masterlink: 'AL02789138'		
	Request	Latest Registration	
Sleep(OK) hours	12	12	'01-Aug-2018 19:16:14 (UTC)'
Sleep(Fail) hours	4	4	'01-Aug-2018 19:16:14 (UTC)'
Latitude	Get position: ☐	55.695043	'04-Jul-2018 19:57:34 (UTC)'
Longitude		12.430163	'04-Jul-2018 19:57:34 (UTC)'

	Slimline ICL: 'AM02789349'	
	Request	Latest Registration
Start time, HH:MM (UTC)	Hour: -- , Minute: --	**Next Measurement:** '01-Aug-2018 20:00:00 (UTC)'
Sample interval (min)	60	60 '01-Aug-2018 19:16:14 (UTC)'
Probe 1	Pi20304052 Auto-detected ERv2 probe	Pi20304052 **Mode:** 'Connected' Area: '1 cm2', Initial Thickness: '500 µm'
Probe 2	Pi20304050 Auto-detected ERv2 probe	Pi20304050 **Mode:** 'Connected' Area: '1 cm2', Initial Thickness: '500 µm'

First data measurement

PipeLine	Chainage	Tag (Location)	Sensor S/N	Vcorr µm/y	Thickness µm	Edc V	EirFree V	Jdc A/m2	Uac V	Jac A/m2	Rs Ωm2	Setup	Latest ←
MC-Pipeline 24-76	34.876	Test station 45	Pi20304050	0	494.751	0.000	0.000	0.000	0.001	0.011	0.118	Setup	01-Aug-2018
MC-Pipeline 24-76	34.876	Test station 45	Pi20304052	100	502.556	0.000	0.000	0.000	0.000	0.011	0.046	Setup	01-Aug-2018

RMU connectivity check — Data recieved on WebService

10. Add photos as required

11. Sign off:

Name (print): C.P. Joe

Company: MetriCorr CP Services

Signature: C P