ENCARDIO RITE

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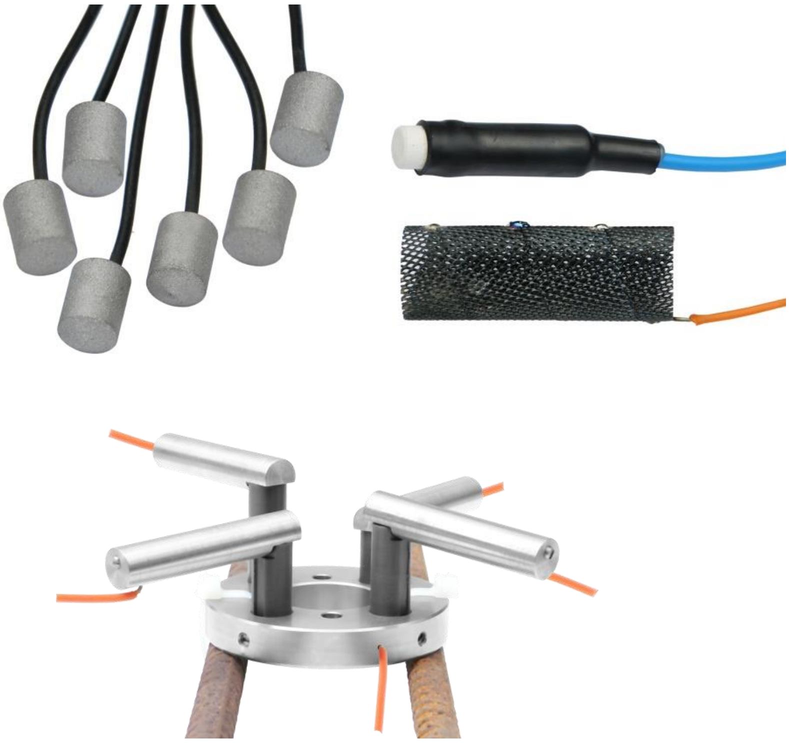
Over 50 years of excellence through ingenuity

USERS' MANUAL

CORROSION MONITORING SYSTEM

MODEL ECS-101



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1 INTRODUCTION

1.1 Why corrosion monitoring is essential

Corrosion of reinforcement is a major factor causing premature deterioration of large scale concrete infrastructure Worldwide. Early failures of structure due to premature reinforcement corrosion may result in damage to people and assets. To prevent degradation as well as to maintain the structure, an effective monitoring solution is needed to assess the corrosion in reinforced concrete.

Reinforced steel bars embedded in good quality concrete should not generally corrode. Concrete has typically a high alkalinity of around pH 12 which passivates the steel surface reducing its dissolution rate to a very low value of around 0.1 µm/year.

Concrete is however porous and moisture can penetrate very easily into it. Chloride penetration can also attack the steel reinforced bars and wire mesh that is used for reinforcement of the concrete.

Around 60 – 65 % of cement is constituted of lime (calcium oxide or calcium hydroxide). Concrete degradation generally takes place by:

- Carbonation i.e. reaction of the calcium compound with atmospheric CO_2
- De-passivation of the reinforced steel bars by ingress of active ions like chlorides in coastal areas due to brackish water or in high mountains/colder climates where de-icing salts are used. Chlorides reduce electrical resistance of concrete allowing corrosion current to flow more easily.

These affect the alkaline condition of the concrete resulting in possible corrosion. When carbonation depth exceeds concrete cover or when chloride ions penetrate in concrete more than the threshold value, it initiates the corrosion. Once initiated, corrosion of the steel reinforcement is self-sustaining. The dissolution rate of steel may go up to10 µm/year. The volume of the corrosion product is more than that of the corroded steel leading to cracking, delamination and then spalling of concrete from the reinforcement. This results in further ingress of CO_2, water, oxygen and chlorides etc. which may finally result in eventual failure. The rate of corrosion affects the remaining service life of structures.

Corrosion of reinforcement steel concrete structures affects safety and durability as follows:

- Steel cross section is reduced, weakening the structure.
- Concrete cracks due to the volume increase in rust.
- Cracking and spalling reduce steel to concrete bond.

Quality control, maintenance and planning for the restoration of these structures need non-destructive inspections and monitoring techniques that detect the corrosion at an early stage. Corrosion loss consumes considerable portion of the budget of the country by way of either restoration measures or reconstruction. There have been a large number of investigations on the problems of deterioration of concrete and the consequent corrosion of steel in concrete.

Properly monitoring the structures for corrosion performance and taking suitable measures at the appropriate time could affect enormous saving. Moreover, the repair operation themselves are quite complex and require special treatments of the cracked zone, and in most instances the life expectancy of the repair is limited. Accordingly, corrosion monitoring can give complete information of changing condition of a structure in time.

1.2 ECS-101 Corrosion monitoring system

Encardio-rite offers a cost-effective reliable corrosion monitoring solution for existing as well as to be constructed structures. The system can be used without the limitations imposed by carbonization and exposure to chlorides in the surrounding environment.

The corrosion monitoring system basically consists of different probes (anodes and combi-electrode) embedded in concrete, data processing nodes and a datalogger to monitor the current corrosion state as well as rate of corrosion of the reinforcement.

A humidity cum temperature sensor can be used for better evaluation of data.

All the above sensors are connected to measurement nodes that transmit data through a single digital bus cable connected to a controller/datalogger.

Model ECS-101 corrosion monitoring system is a scalable system. Various solutions are available for small as well as large structures. Please contact factory for an optimized cost effective solution to suit project requirement.

1.3 Applications

Encardio-rite ECS-101 is a system for measuring current corrosion state of the structure under monitoring and its corrosion rate. It can be used to monitor corrosion in:

- Bridge decks and underground parking garages heavily influenced by de-icing salt
- Structural elements in public swimming pools, amusement parks
- Inaccessible areas e.g. in tunnels and bridges in the corrosive marine environment
- Structures under influence of acid rain, e.g. chimneys, funnels, and smokestacks etc.

One of the main advantages of this solution is its simple and rugged design which makes it suitable for long-term deployment in harsh conditions. The reference electrode used in the system is very stable and can be used for a very long time.

It's capable of working in standalone mode; however it's generally used at a number of locations on the structure to be monitored, as it gives a better idea of concrete health of the entire structure and provides critical information about corrosion and serves as an early warning system that is necessary for structural health of the installation.

1.4 Conventions used in this manual

WARNING! Warning messages calls attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

CAUTION: Caution messages calls attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

NOTE: Note contains important information and is set off from regular text to draw the users' attention.

This users' manual is intended to provide you with sufficient information for making optimum use of corrosion monitoring in your applications.

To make this manual more useful we invite your valuable comments and suggestions regarding any additions or enhancements. We also request you to please let us know of any errors that you may find while going through this manual.

1.5 How to use this manual

The manual is divided into a number of sections. Each section contains a specific type of information. The list given below tells you where to look for in this manual if you need some specific information.

For operating principle See § 2 'Operating principle".
For essential tools and accessories: See § 3 'Tools and accessories required for installation".
For installation of Corrosion Monitoring System See § 4 *'Installation procedure'*
For recording readings from Corrosion Monitoring System: See § 5 *'Measurement and recording'.*

2 CORROSION MONITORING SYSTEM

2.1 Description

Model ECS-101 corrosion monitoring system provides an accurate and easy-to-use online monitoring solution to assist in detecting and reporting the occurrence of corrosion over time and take preventive action in time. With embedded sensors, accurate information about the in-situ durability parameters of concrete structures, such as corrosion current density, concrete resistivity, temperature and concentration of chloride ions, can be monitored and diagnostic information provided. An early warning on structural durability can then be given to prepare maintenance strategies and to introduce corrosion control measures.

To evaluate corrosion activity and for its long term monitoring, Encardio-rite offers a **corrosion monitoring system** based on the following electro-chemical methods:

- Potential measurement using Force Technology ERE 20 reference electrode.
- Corrosion rate monitoring by means of linear polarization measurement.

The corrosion monitoring system basically consists of different probes (anodes and combi-electrode) embedded in concrete, data processing nodes and a datalogger to monitor the current corrosion state as well as rate of corrosion of the reinforcement. A typical installation of the reference electrodes and metallic anodes (4 to 6 numbers) is illustrated in the schematic shown in figure 2-1. The combi-electrode consists of a reference electrode (ERE 20) and a titanium mesh cathode. A humidity cum temperature sensor can be used for better evaluation of data.

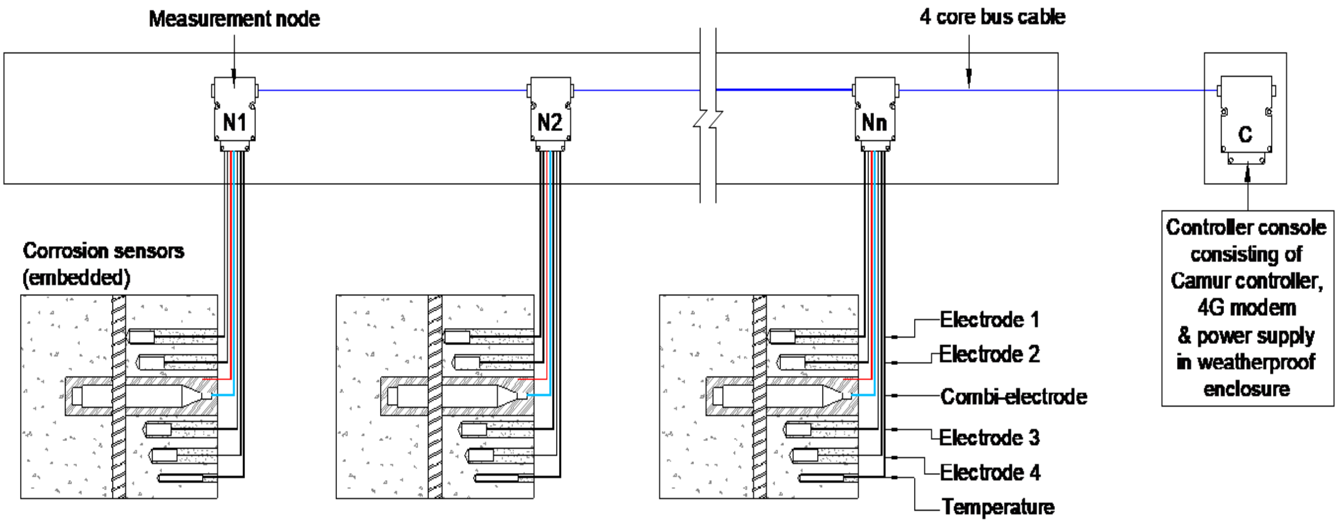


Figure 2-1: Encardio-rite Corrosion Monitoring Solution - typical layout for installation at multiple locations in a concrete structure

All the sensors are connected to measurement node that transmit data through a single digital bus cable connected to a controller/datalogger. Model ECS-101 corrosion monitoring system is a scalable system. Various solutions are available for small as well as large structures. Please contact factory for an optimized cost-effective solution to suit project requirement.

2.2 Corrosion system components

Following items are required at each installation location (quantity to be multiplied by number of installation location):

Item	Qty
Metallic anodes to identify/warn future corrosion risks - embedded during construction or installed later (ECS-101/01N for new structure, ECS-101/01E for existing structure).	4 or 6 no.
Reference electrodes (ERE 20)	1 no.
Titanium mesh cathode	1 no.
Temperature Probe	1 no.
Humidity Probe – optional	1 or 2 no.
Measurement Node for metallic anodes - can connect up to 6 anodes, 1 reference electrode and 1 Titanium mesh cathode	1 no.
Humidity Node for humidity sensor – optional – used when Humidity probe is being used	1 no.

Following items are required in control room/data acquisition location (one set per project).

Item	Qty
Camur III Controller with 4G modem, power supply and weather proof enclosure	1 no.
Bus cable (connects all installed nodes in series; is terminated to the controller)	As req.

All the measurement nodes, from each installation location, are connected to a single digital bus cable (in series) and terminated to the Controller console. The distance between the measurement nodes and controller can be up to 1.2 km. In case the distance is more than 1.2 km, a bus repeater (at additional cost) can be used.

2.2.1 Reference electrode – ECS-101/02R

Encardio-rite uses ECS-101/02R, a long life reference electrode. It provides a stable voltage for more than 30 years It is embedded in the concrete structures to monitor the correct operation of cathodic protection and to monitor the corrosion condition in reinforced steel.

The reference electrode can be installed in both new and existing structures. Based on well-known battery technology, the reference electrode is a half-cell using manganese dioxide in a very alkaline electrolyte, placed in a stainless-steel case and with an ionic membrane of cement mortar ensuring good affinity to the concrete.

Figure 2-2: Reference Electrode – ECS-101/02R

2.2.2 Mesh cathode – ECS-101/02M

Mesh cathode is embedded along with reference electrode in the concrete structure. Together,they are referred to as combi-electrode. The cathode is installed at the center of all the metallic anodes embedded at different depths in the structure. This provide corrosion rate by means of linear polarization measurement.

Figure 2-3:Mesh Cathode – ECS-101/02M

2.2.3 Metallic anode for existing structures - ECS-101/01E

These probes/anodes are installed in the concrete coverof existing structure, between the surface and the outermost layer of reinforcement. They can be retrofitted in any completed structure. Theanodes are preferably made of the same material as thatof the reinforcement. A group of 4 to 6 anodes are mountedat well-defined depths of the concrete cover layers in acircular arrangement in 12 mm Φ drilled holes as shown inthe schematic before.

Figure 2-4: Metallic Anode Probes – ECS-101/01E

2.2.4 Embeddable probe/anode - ECS-101/01N

This probe is designed to be installation during construction. A typical probe is illustrated in the picture in the next column. It consists of a multi-sensory arrangement, which in the standard version consists offour steel anodes and one noble metal cathode. It is castduring construction into the cover of concrete structures. The steel anodes are positioned at various distances between the concrete surface and the reinforcement.

Figure 2-5: Embeddable probe/anode – ECS-101/01N

2.2.5 Temperature probe – ECS-101/03T

Corrosion measurement is affected by temperature. To record temperature measurements in the concrete structure, at the time of corrosion measurement, a temperature sensor can be embedment near anodes and connected to same measurement node with anodes.

Figure 2-6: Temperature Probe – ECS-101/03T

2.2.6 Humidity probe (optional) – ECS-101/04H

Corrosion measurement is affected by temperature and humidity. A temperature cum humidity sensor is available for embedment near the anodes, to monitor temperature and humidity in the concrete structure at the time of corrosion measurement.

Figure 2-7: Humidity Probe – ECS-101/04H

2.2.7 Measurement node - ECS-101MN

The measurement node is a small unit, placed near each monitoring location. It contains an A/D converter, a microprocessor, galvanic separation between analogue and digital side. The measurement node automatically monitors Linear Polarization Resistance (LPR), AC-resistance, potential, current and temperature. The node supports 4-6 anode sensors. Data is transferred from node to Controller console through a single digital bus cable.

Figure 2-8: Measurement Node – ECS-101MN

2.2.8 Humidity node – ECS-101HN

Humidity node is an optional unit typically used with relative humidity sensors. It has a built- in power supply and can monitor sensor output in the range 0-5 V. The input channels are galvanically separated from the bus side.

Figure 2-9: Humidity Node – ECS-101HN

2.2.9 Controller Console – ECS-101C

Controller console is essential for configuring and monitoring sensors, and optionally controlling a cathodic protection system. It collects, stores, and transfers all data from the system. It has built-in controller software to control it, communicate with nodes and transfer data to remote servers.

The controller is housed inside a weatherproof enclosure with 4G modem, power supply and other accessories.

Figure 2-10: Controller console – ECS-101C

2.3 Operating principle

The corrosion monitoring system acts as an early warning system to track and predict the initial stages of corrosion in concrete structures. The system can measure most of the relevant corrosion parameters.

Four to six anodes (ECS-101/01E for existing structures or ECS-101/01N for new structures) are placed in varying, but defined depths from the exposed concrete surface. The depth of anodes is flexible and can be adjusted according to the concrete cover thickness. These monitor the progress of chloride or carbonation corrosion fronts through the concrete cover of structures.

Reference electrode is a long life manganese dioxide reference electrode that is used to monitor corrosion state of reinforcement and also to control cathodic protection systems.

To predict when the reinforcement will start corroding, the LPR technique is used for measurement. In LPR measurements, Titanium mesh cathode is embedded with the reference electrode. The reinforcing steel material's anode is perturbed by a small amount from its equilibrium potential. This can be accomplished potentiostatically by changing the potential of the anode by a fixed amount, ΔE with respect to the potential of the true reference electrode, and monitoring the current, ΔI through the titanium mesh cathode/noble cathode, after a fixed time. The conditions are selected such that the change in potential, ΔE falls within the linear Stern–Geary range of 10–30 mV. The polarization resistance, Rp of the steel is then calculated from the equation:

$$Rp = \frac{\Delta E}{\Delta I} \qquad (1)$$

From which the corrosion rate, through Icorr, canthen be calculated

$$Icorr = \frac{B}{Rp} \qquad (2)$$

Where, B is the Stern–Geary constant. A value of 25 mV has been adopted for active steel and 50 mV for passivesteel. In order to determine the corrosion current density *icorr*, the surface area, A, of anode that has been polarized needs to be accurately known:

$$icorr = \frac{Icorr}{A} \qquad (3)$$

The present residual strength and by extrapolation, the remaining service life of the structure can then be estimated by the value of icorr.

Corrosion current (*Icorr*)	**Corrosion Rate**
Icorr < 0.1 µA/cm2	Passive condition
Icorr 0.1 - 0.5 µA/cm2	Low to medium corrosion
Icorr 0.5 - 1.0 µA/cm2	Medium to high corrosion
Icorr > 1.0 µA/cm2	High corrosion rate

The corrosion measurements are affected by temperatureand humidity, so the conditions at the time of measurementaffect the interpretation of the limits defined above. Hence,it is advised that humidity and temperature of the concretestructure needs to be monitored as well.

When interfaced with the datalogging system, thesystem can either continuously measure potentials to provide corrosion information or can perform scheduledpotential decay measurements which will indicate the proper operation of potential measurement.

With the anode probes and reference electrode, initial corrosion is discovered when threshold values of the potentials or current have been exceeded. The potential ofthe equilibrium is measured between the combi-electrodeand the individual electrodes in the concrete cover.

3 TOOLS & ACCESSORIES REQUIRED FOR INSTALLATION

The following tools and accessories are required for installation of Corrosion Monitoring System

S. No.	Description	Qty.
	Supplied by ER:	
1.	Bus Cable	As required
2.	Hilti fastener M8X75	16 no.
3.	Fischer anchor FSL-10/39	16 no.
4.	Loctite 3463 Caulking Compound	01 no.
5.	Cable tie	100 no.
6.	Anode PushIn Tool	1 no.
	To be arranged by client:	
7.	Allen key set SS	01 no.
8.	PVC tape	02 no.
9.	Metal detector	01 no.
10.	Extension board	01 no.
11.	Impact drill machine	01 no.
12.	Drill bit 6 mm, 8 mm, 12 mm, 28 mm	01 no. each
13.	Air blower	01 no.
14.	Depth gage	01 no.
15.	1/2" GI Pipe, Sockets for 1/2" GI Pipe, Pipe clamp for 1/2" GI Pipe, Screws and Plastic gully (for cable routing/clamping – customer scope)	As required

4 INSTALLATION PROCEDURE

4.1 Site visit and establishing the installation location

An initial site visit is conducted to direct attention to the most probable locations for corrosion. A typical initial visit would include:

- Noting the type and number of anodes that would be required for corrosion monitoring. Different types of anodes are used for existing structures (model ECS-101/01E) and new structures (model ECS-101/01N).
- Collecting information on the material used in the rebar and concrete composition. Collecting sample of rebar used in construction.
- Investigating access to utilities for possible permanent installation
- Noting site characteristics such as interaction of structure with atmosphere, ingression of water, presence of specific chemicals at site etc.

4.2 Installing the probes

4.2.1 ECS-101/01N probes installation in new structure

- Check that the probe has not been damaged during shipment. The anodes must not be corroded. The cable must show no signs of damage from squeezing etc.
- Depending on site requirement, four to six ECS-101/01N anodes are used. The anodes are placed on the outermost reinforcement layer, at varying but defined depths, from the exposed concrete surface. The depth of anodes is flexible and can be adjusted according to the concrete cover thickness - the anodes must be at equidistance, spanned between the reinforcement and concrete outer surface.
- A jig is provided with different steps, with heights marked. Adjust the anode height of anodes as per requirement (depends on distance between outermost reinforcement & concrete outer surface + number of anodes used), as shown in figure below.

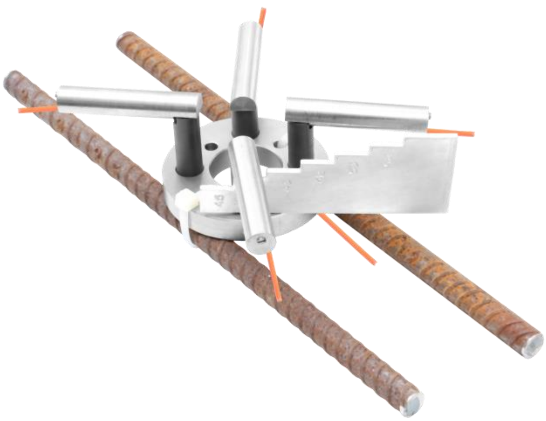


Figure 4-1 Anode height being set with the help of jig

- To avoid rust formation on the anodes, the mounting of the ECS-101/01N probe should be performed as close to the casting time as possible. By use of plastic strips, the ECS-101/01N probe is fixed to the outermost reinforcement net.

NOTE: Ensure that the anodes face the future concrete surface (to be poured). The sensor probes must be placed parallel to the future concrete surface. It is important that the sensor is firmly mounted, so that anodes do not move during casting process or come in contact with reinforcement rod or nearby mounted sensor.

- The reference-electrode is mounted close to the ECS-101/01N probes as shown in figure 4-2 below.
- Once the ECS-101 corrosion system is installed, the location of anodes, reference electrodes, titanium mesh cathode should be documented (including the perpendicular distance from the outermost concrete layer to the outermost anode), for future reference.

NOTE: Ensure that anodes and the titanium mesh cathode must not be in any metal contact with the reinforcement.

Figure 4-2: Anode probes (set of 4 and set of 6 anodes) installed before concrete casting.

4.2.2 ECS-101/01E probes installation in existing structure

Evaluate the corrosion conditions and mark suitable locations where the probes are to be placed. Check the reinforcement location and collect info on the concrete (cover) layer.

The ECS-101/01E electrodes are placed between the outermost reinforcement bar location and the concrete outer surface. Anodes are installed at four (or six) different depths, equidistant, spanned between the reinforcement and concrete outer surface. A typical installation schematic is shown in figure below.

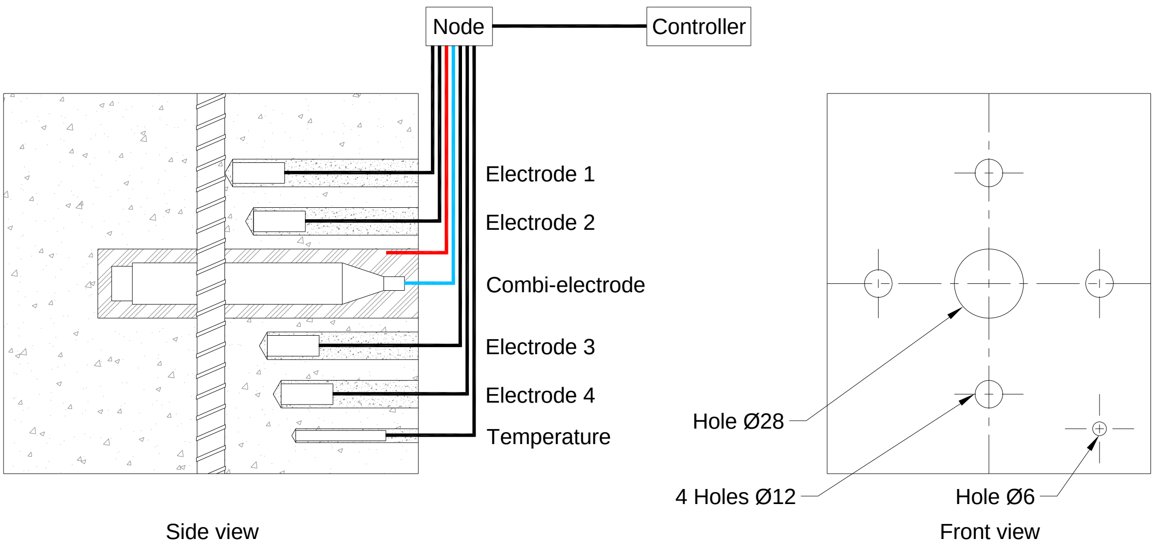


Figure 4-3: Installation schematic for ECS-101/01E electrodes in existing structure

NOTE: Ensure that combi-electrode and measuring anodes do not touch the reinforcement.

CAUTION: To avoid rust formation, the bags with electrodes and desiccant sachet should not be opened until just before mounting.

- Use the template (provided with supply) onto the desired surface and mark the location of holes to be drilled. Please refer the Appendix I & II for template of 4 anode and 6 anode respectively.
- First drill pilot holes on the marked points using 6 mm bit then use 12 mm bit for drilling, to desired depth for respective ECS-101/01E electrode.
- For combi–electrode, a 28 mm drill bit is used to drill the hole to desired depth. A pilot hole is drilled using 12 mm bit first.
- Clean all the holes using air blower and measure their exact depths using suitable depth gage.
- Use the disposable gloves to take out the electrodes from the bags and place the anode into the cylindrical rod type tool to push the anode inside the hole provided with supply into the thread on anode. A groove is provided in the tool for routing cable through it, to prevent any cable damage while hammering.
- Place the anodes in the hole and push it inside, until it reaches the end of hole, using hammer as shown in figure below.

Figure 4-4 Using Anode PushIn Tool to install anode

- Fix the anode with compound and then fill the entire hole with mortar (mortar mixture 1:2, or similar to the cement mixture used in construction).
- Make a mortar mixture and pour the mesh cathode in it then insert the titanium mesh cathode inside the hole. Now place the reference electrode (poured in the mortar mixture) into the titanium mesh cathode with concentric and do not touch each other. Once ensured that these are placed correctly, fill the remaining hole with mortar.

4.2.3 Temperature probe

Corrosion measurement is affected by temperature. To record temperature measurements in the concrete structure, at the time of corrosion measurement, a temperature sensor can be embedment near anodes and connected to same measurement node with anodes.

Figure 4-5: Temperature Probe- ECS-101/03T

4.2.4 Installation of Humidity probe (optional)

The humidity probe is sealed in a housing at the factory. This helps in getting correct humidity data at specific depth.

- Drill a 12 mm dia x 55 mm deep hole at the sensor installation location.
- Place the probe in the hole and fix it in place using Loctite PC3463 caulking compound or equivalent.

Figure 4-5 Humidity probe – ECS-101/04H

4.3 Installation of measurement nodes

- Measurement node for electrodes along with Humidity Node for humidity probe (if required) are mounted in suitable enclosure. The enclosure is installed near the installed sensor probes in a way such that direct sunlight and rain does not affect it.
- Depending on the size of enclosure supplied, mark the location for mounting holes. Drill 8 mm dia x 55 deep holes at marked locations. Fix the enclosure using Hilti HPS-1 M8*55 impact anchors.
- Connect the sensor cables to measurement node after drawing the cables through cable glands.

4.4 Cable routing

- Cables from probes are bunched together using cable ties. We recommend that the cables are protected by a lattice as shown in figure 4-5.
- Cables are routed through conduits to the respective measurement nodes (nodes for electrodes and Humidity Node for Humidity probe). Connection details are mentioned in the table below.
- It is important to mark the cables so that no doubt arises as to which probe each cable belongs to. Clamp the conduit securely to the wall at regular intervals.
- In case multiple corrosion monitoring systems are installed on a structure, a single bus cable is routed, connecting all the measurement nodes in series. The bus cable is finally terminated on the controller console in control room.

Connector Terminal	Connection Detail
Measurement node (for electrodes)	
A1-A4	Working electrodes (anodes) 1 ... 4
A5	Optional connection to reinforcement bar in case of 4 anode sensors
A5-A6	Additional working electrodes for 6 anode sensors
BAR	Optional connection to reinforcement bar in case of 6 anode sensors
CE	Counter electrode (cathode)
RE	Reference electrode
P1+	Supply Voltage for Pt 1000
P2-	Supply Voltage for Pt 1000
P1	Measuring sense for Pt 1000
P2	Measuring sense for Pt 1000
Bus Connections	
+	24V
-	0V

Connector Terminal	Connection Detail
H	D+
L	D-
Humidity node	
1+	Input (RH standard)
+	Power out 5 V
G	Power out 0V

Table 1 Cable connection detail

4.5 Installing Controller Console

The controller, power supply and 4G modem unit are mounted inside a weatherproof enclosure.

At the chosen installation location, mark the locations of mounting holes, depending on the size of enclosure. Drill the 8 mm dia x 75 mm deep holes. Fix the enclosure using Hilti Anchor HST-M8x75/10. Typical installation scheme is shown in figure below.

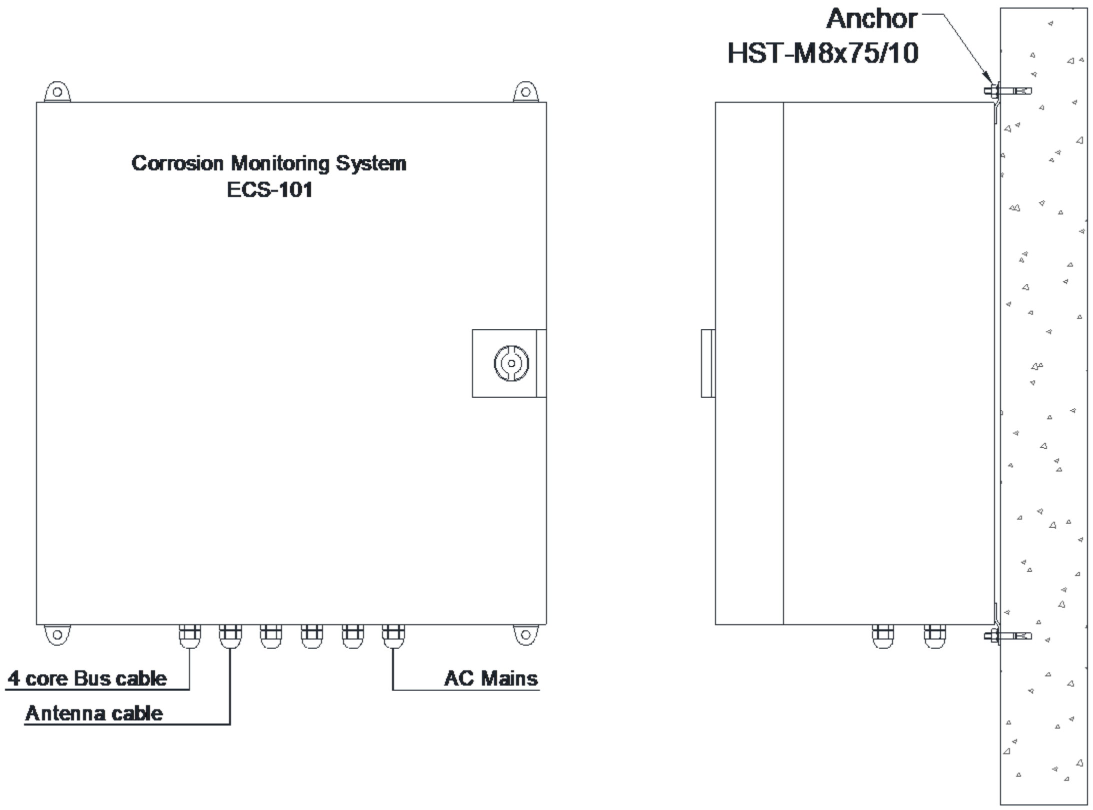


Figure 4-6: Installation of controller enclosure – ECS-101C

5 MEASUREMENT AND RECORDING

Controller console is used for measurement and recording of corrosion data from the measurement nodes. The measurement nodes are bussed together and the bus cable (four core) is connected to the controller. A maximum of 100 measurement nodes can be connected to a single controller.

The controller has the facility to collect, store and push recorded data to remote cloud server.

Each reading is stamped with date and time at which the measurement was taken. It has non-volatile flash memory.

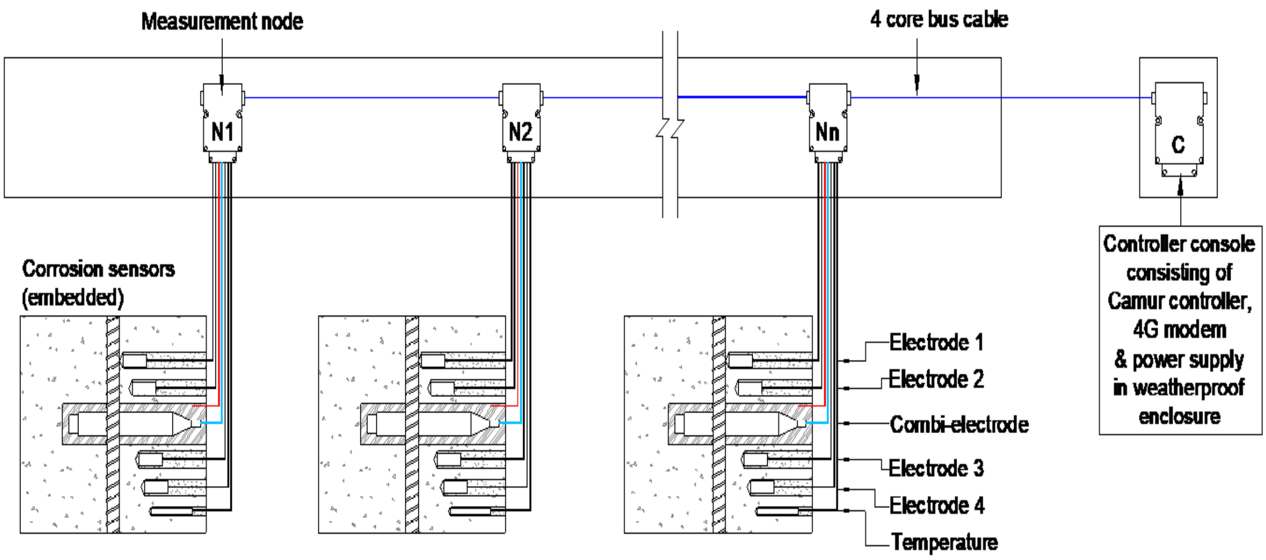


Figure 5-1: Measurement System

5.1 Controller configuration

- Check the wiring in the controller enclosure to ensure there is no loose connection.
- The four-core bus cable is drawn from measurement nodes and connected to the controller. Connection details are mentioned in table below.
- Power supply is turned on to switch on the controller and modem.
- Recording configuration is done by ER personnel as per client's requirement
- Data is transmitted to Drishti Cloud Server where it can be viewed by authorized users.

Connection Detail	Color on Cable	Terminal on Connector
I/P+	Red	+
I/P-	Black	-
Data+	Blue	H
Data-	White	L

Table 2

6 DATA ON DRISHTI

Once the installation is complete and the recording scheduled is configured and Drishti site configuration is done. The recorded data is available on Drishti website. Corrosion monitoring can done by authorized user from anywhere in the world on a device with an active internet connection. Following graphs are plotted for corrosion monitoring:

6.1 OCP (Open Circuit Potential)

This is the potential of installed anodes with respect to the reference electrode.

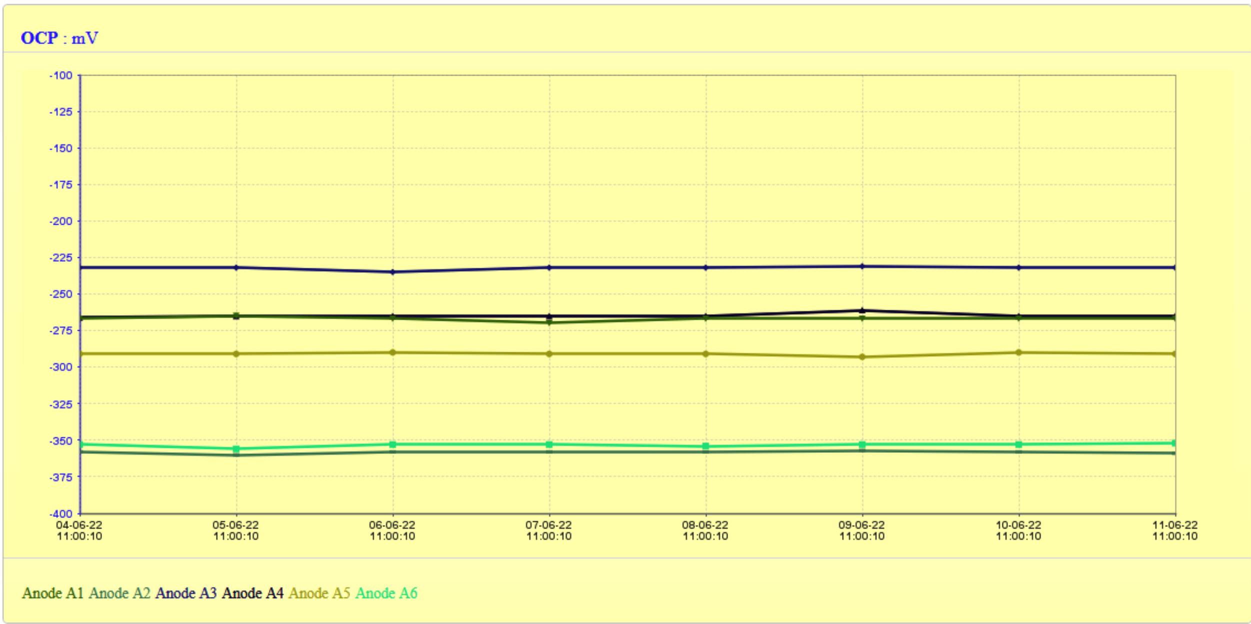


Figure 6-1: OCP of Anodes

6.2 Resistance Measurement

This is the resistance measured between the adjacent anode pairs e.g. between anode pair 1 and 2, between pair 2 and3 etc.

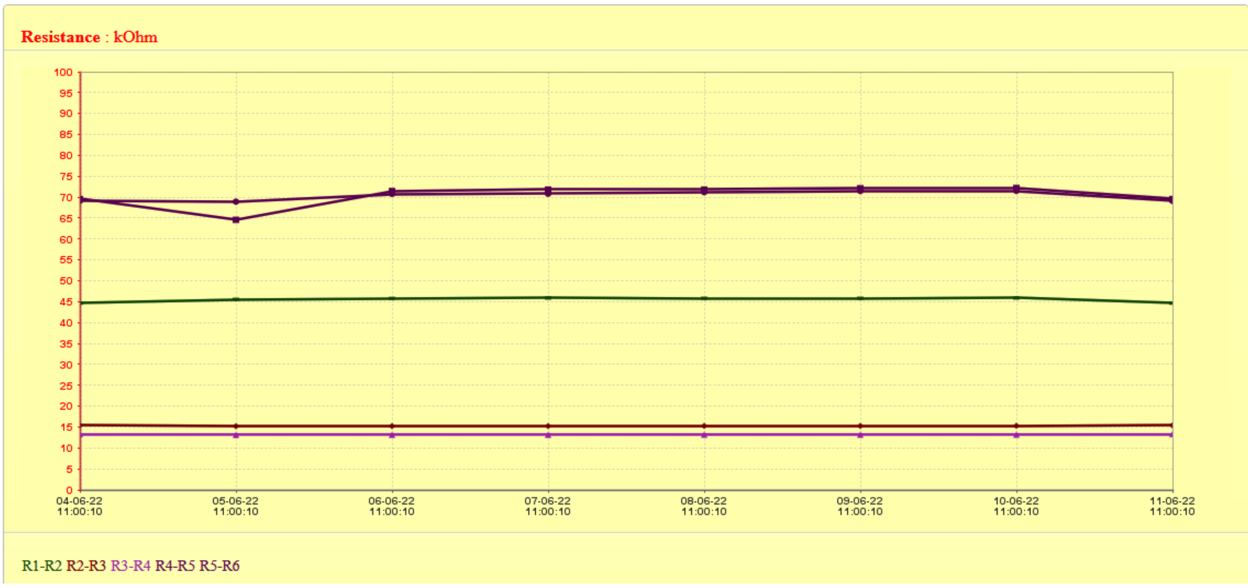


Figure 6-2: Resistance Measured between Anode pairs

6.3 Corrosion Current

This is a parameter which is calculated after the Linear Polarization Resistance Measurement and is indicative of current corrosion state of the monitored site.

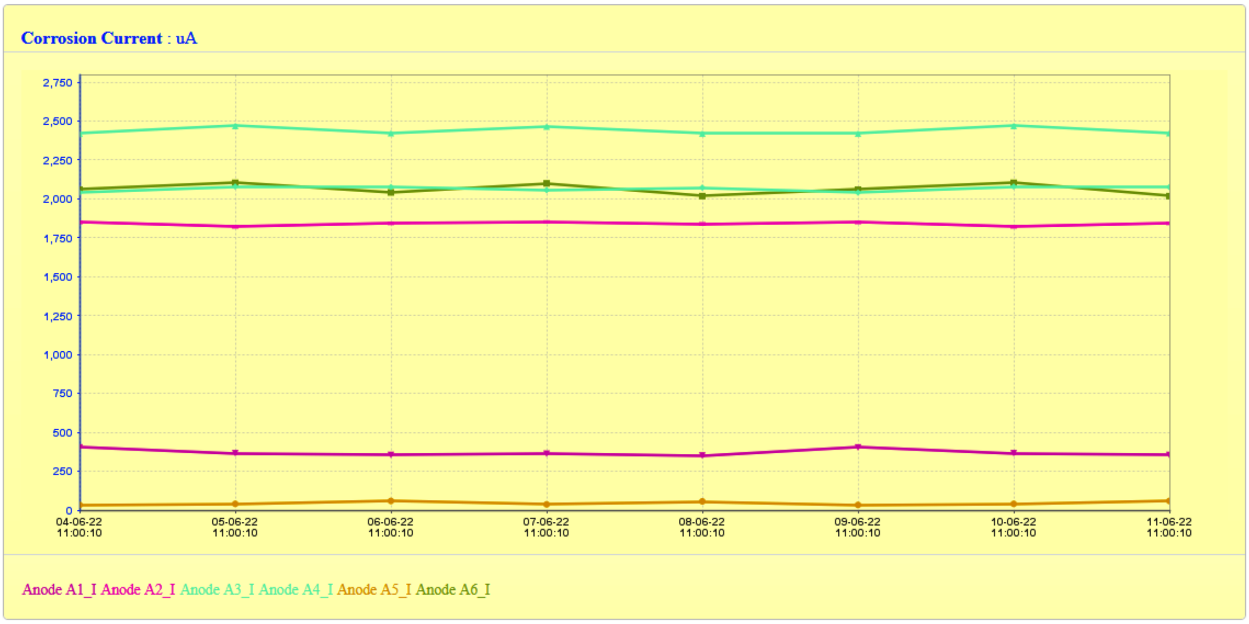


Figure 6-3: Corrosion Current

6.4 LPR (Linear Polarization Resistance)

This is a parameter which is calculated after the Linear Polarization Resistance Measurement and is indicative of current corrosion rate of the monitored site.

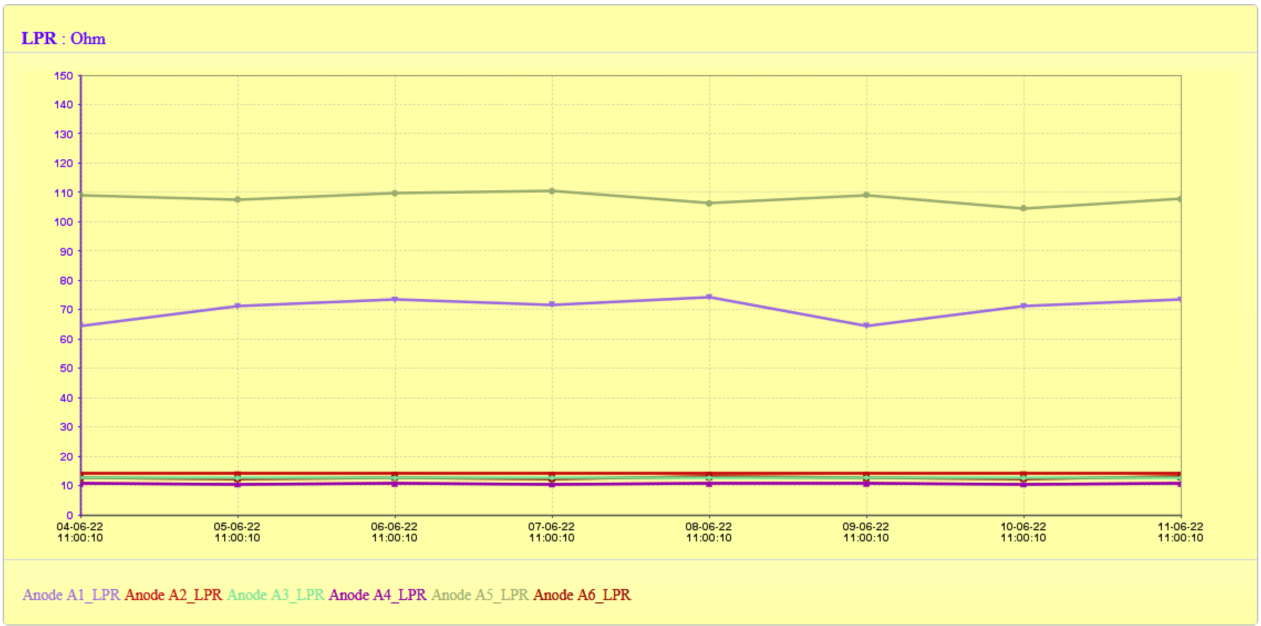


Figure 6-4: Linear Polarization Resistance

6.5 Temperature

This is the concrete temperature measured along with other corrosion parameters, for studying its relation and effects on corrosion rate.

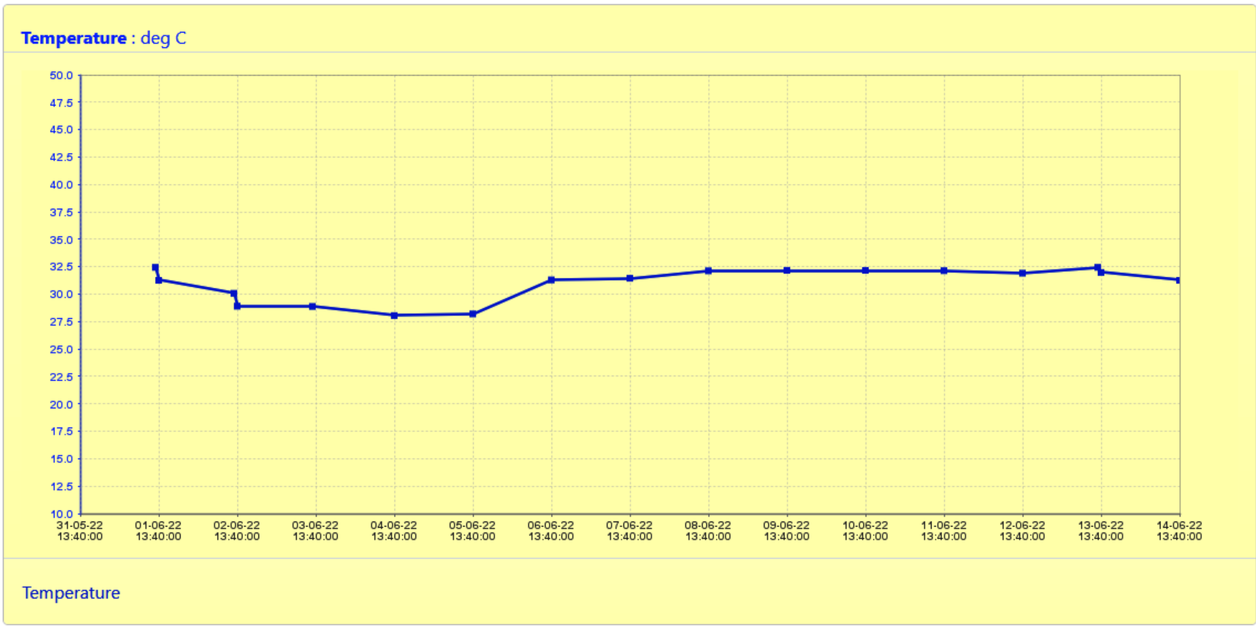


Figure 6-5: Concrete Temperature

7 WARRANTY

The Company warrants its products against defective workmanship or material for a period of 12 months from date of receipt or 13 months from date of dispatch from the factory, whichever is earlier. The warranty is however void in case the product shows evidence of being tampered with or shows evidence of damage due to excessive heat, moisture, corrosion, vibration or improper use, application, specifications or other operating conditions not in control of Encardio-Rite. The warranty is limited to free repair/replacement of the product/parts with manufacturing defects only and does not cover products/parts worn out due to normal wear and tear or damaged due to mishandling or improper installation. This includes fuses and batteries.

If any of the products does not function or functions improperly, it should be returned freight prepaid to the factory for our evaluation. In case it is found defective, it will be replaced/repaired free of cost.

A range of technical/scientific instruments are manufactured by Encardio-rite, the improper use of which is potentially dangerous. Only qualified personnel should install or use the instruments. Installation personnel must have a background of good installation practices as intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

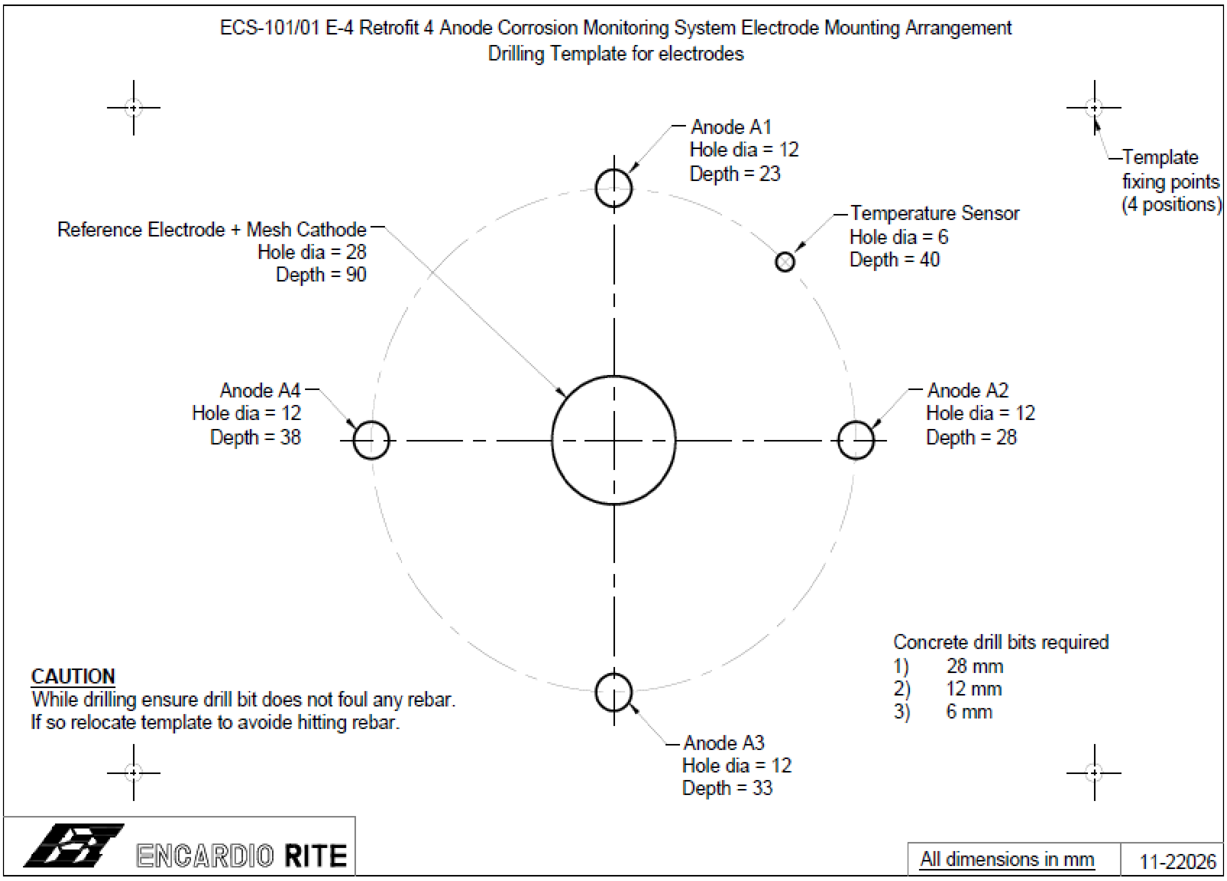
The warranty is limited to as stated herein. Encardio-rite is not responsible for any consequential damages experienced by the user. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Encardio-rite is not responsible for any direct, indirect, incidental, special or consequential damage or loss caused to other equipment or people that the purchaser may experience as a result of installation or use of the product. The buyer's sole remedy for any breach of this agreement or any warranty by Encardio-rite shall not exceed the purchase price paid by the purchaser to Encardio-rite. Under no circumstances will Encardio-rite reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

A lot of effort has been made and precaution for accuracy taken in preparing instruction manuals and software. However best of instruction manuals and software cannot provide for each and every condition in field that may affect performance of the product. Encardio-rite neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damage or loss that results from use of Encardio-rite products in accordance with the information contained in the manuals or software.

Products described in Encardio-rite's catalogues are subject to modification and improvement as dictated by subsequent developments. Encardio-rite reserves the right to modify, change or improve products, to discontinue them or to add new ones without notice.

8 APPENDIX I

The following template shall be use for the installation of 4 anode corrosion monitoring system.



9 APPENDIX II

The following template shall be use for the installation of 6 anode corrosion monitoring system.