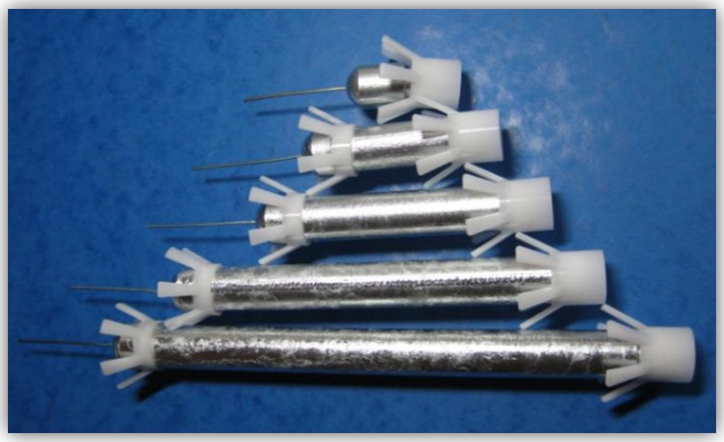
The DuoGuard™ Hybrid Anode™ Range Installation Guidelines



Concrete Preservation Technologies Ltd

IMPORTANT: This installation methodology is an outline – modifications will be made for local site requirements and will be identified in the final specification.

1.0 Preliminaries

The structure should be assessed prior to application of the DuoGuard Hybrid Anode range technology as follows;

1. **Review of records:** All available drawings and recorded information should be reviewed for information relating to location, quantity, nature and continuity of reinforcement and to concrete quality.

2. **The reinforcement continuity** shall be proven on site by measuring the electrical resistance between reinforcing bars in mutually remote locations across the structure and between reinforcing bars exposed during concrete repairs or other works following the method and acceptance criteria as specified in EN 12696:2000, clause 7.1. These measurements shall include the following:

3. **The continuity between elements of the structure**.

4. **The continuity of metallic items**, other than reinforcement. Any external metallic items shall be electrically bonded during the initial impressed current phase of treatment.

5. **Reinforcement location/concrete cover**: Steel reinforcement size and location should be established to confirm details in the drawings.

6. **Concrete cover of the area to be protected** should be determined to ensure a minimum cover of at least 20 mm for the purposes of installation of the DuoGuard anode system.

   Confirm depth of surface to be treated is 150 mm or greater prior to installation.

7. **Stray currents**: The structure should be assessed for the presence of AC or DC stray currents. If stray currents are evident, remedial action must be undertaken under the auspices of a competent electrical/corrosion engineer.

2.0 Installation

1. Confirm steel continuity in areas to be treated.

2. Undertake a reinforcing steel survey as follows:

a) Mark steel locations on concrete surface in conjunction with drawings

b) Mark locations for DuoGuard units on concrete surface in conjunction with drawings

c) Mark locations for saw cuts in conjunction with drawings

d) Mark locations for reference probes (if used)

e) Mark locations for the DuoGuard anodes surrounding the reference probes in the test areas, if utilised

f) Mark position of the monitoring/connection boxes if used.

g) Mark position for the temporary power supplies

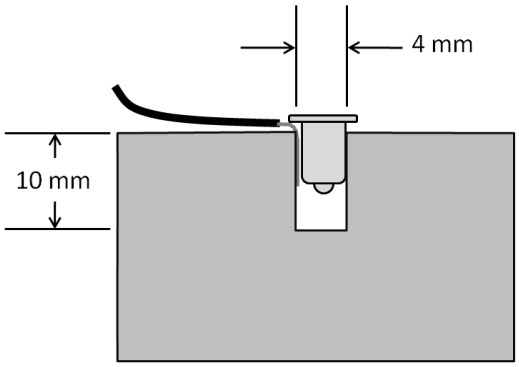
3. Drill 30 mm diameter holes at the locations identified in the drawings and 2(ii) above.

4. Cut chases as identified in 2(iii) above, 4 mm wide x 15 mm deep, between holes for location of titanium feeder wires. Ensure that no reinforcing steel is exposed as this has the potential to cause electrical shorts.

Cut chases for the additional titanium wire connections as identified in 2(iii) above.

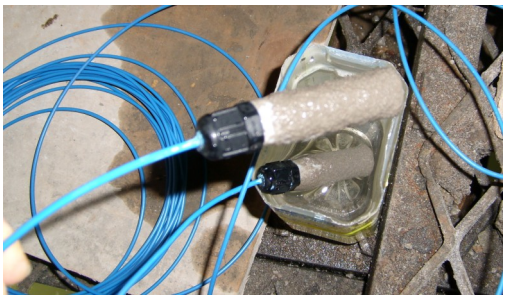
Cut chases for the copper cables as identified in 2(iii) above.

All holes and saw cuts shall be fully cleaned out prior to application of the DuoCrete SD mortar and concrete repair mortar.

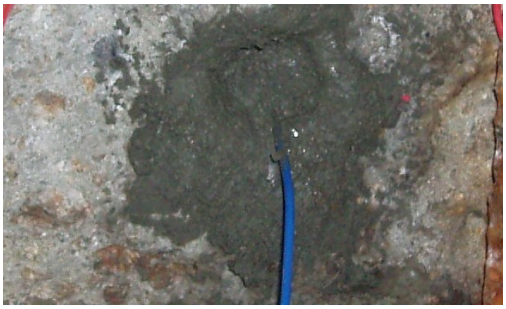


5. Make electrical connections to the reinforcing steel by first exposing the steel, drilling a 4 mm hole and riveting a titanium wire connection with a 3.2 mm diameter stainless steel rivet (grip range 3.2 - 4.8 mm). At least two steel connections per zone of anodes shall be made.

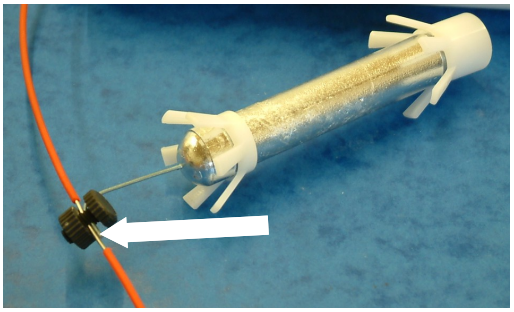
6. Position temporary power supplies.



7. Identify the locations for reference electrodes (if required) and install in 105 mm deep x 30 mm diameter drilled holes into the concrete deck. Run the cabling back in 20 mm deep x 7 mm wide saw cuts to the appropriate enclosure. Fill the saw cuts with a low shrink repair mortar.



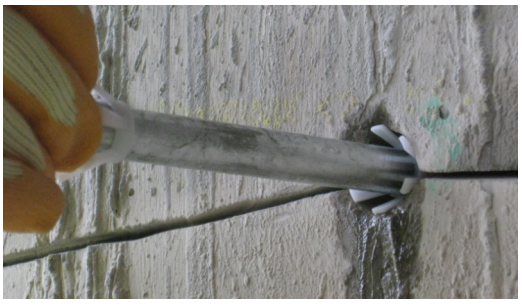
8. Strip the coating from the titanium wire using wire strippers, only in the location where the anodes are to be fixed. Electrically pre-connect the individual DuoGuard units to the titanium feeder wire using the plastic screw connectors, with the DuoGuard units positioned in the holes. Twist the excess wire from the DuoGuard units around the titanium feeder wire to ensure electrical continuity. The screw connectors should be hand tight – electrical resistance between the primary titanium anode wire and the individual DuoGuard units should be checked to ensure electrical continuity.



9. With the DuoGuard units now fixed onto the titanium feeder wire, they should be removed from the holes prior to application of the DuoCrete SD mortar.

10. Using a spray bottle or other suitable method, wet out the holes ensuring that any excess water is removed prior to application of the SD mortar.

11. Using a sealant gun and a rubber hose extension (e.g. 5/8 inch automotive hose) to allow access to the base of the hole, apply DuoCrete SD mortar into the pre-drilled holes to an initial depth of ~50 mm from the concrete surface by slowly retracting the hose from the base of the hole. Insert the individual DuoGuard units into the mortar – the mortar should flow to ~20 mm from the concrete surface. Ensure that any trapped air is removed and that the plastic screw connector is below the concrete surface. The DuoGuard units should be applied immediately after injection of the SD mortar.



12. The installation is checked for electrical shorts by measuring the electrical potential between the reinforcing steel and the DuoGuard units using a high impedance voltmeter during installation. The potential difference should be greater than 300 mV and stable.

13. The remaining void at the top of the anode hole should be filled with a low shrink repair mortar within 2 hours of installation. The installation should continue to be checked for electrical shorts as detailed in section 10. Any electrical shorts should be rectified immediately. The chases within which the titanium wire is situated, and excavations where steel connections have been made, can also be filled with the low shrink concrete repair mortar at this stage.

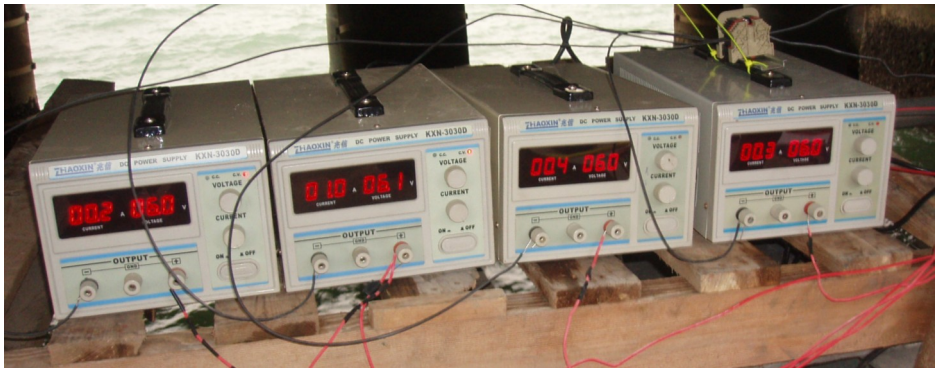
14. The installed DuoGuard units in each zone are connected to a 12V temporary power supply. **The titanium feeder wire from the DuoGuard units is connected to the positive terminal; the wire from the steel is connected to the negative terminal**. This should be completed within 2 hours of installation of the units. Also ensure that any bare titanium wires outside of the concrete, which can possibly short, are insulated using insulation tape.

15. Undertake a polarity check and record the data. The steel potential must shift more negative relative to the reference electrode. If the potential moves to a more positive potential relative to the reference electrode then the current should be disconnected immediately and professional advice sought. A method statement must be provided by the contractor.

Polarity check data will be recorded for all zones of DuoGuard application. Record number of tests undertaken and detail any areas which fail the test prior to rectification.

Note – A method of obtaining a polarity check is to place a surface reference electrode adjacent to a DuoGuard unit and observe the change in potential registered as the impressed current is applied. Ensure that the reference electrode is in the COM terminal for polarity checks.

** **Note** – the DuoCrete SD mortar should only be applied and cured at a temperature greater than 5ºC and rising.



16. Activate the power supply for 1 week. If batteries are used, exchange battery power units on a daily basis or as necessary to maintain charge capacity in excess of 50% (ensure that replacement batteries are kept fully charged). The voltage and current output for each zone shall be recorded on a daily basis. A method statement must be provided by the contractor.

Each treated zone is logged as follows***;

Zone	**Date connected to power supply**	**Date power supply disconnected**	**Daily Voltage (V)**	**Daily current (mA)**													
				1	2	3	4	5	6	7	1	2	3	4	5	6	7

*****A copy of this information is to be forwarded to the client and CPT.**

Note: To determine the voltage of the battery or power supply, use a voltmeter to direct read from the terminals of the battery.

A typical method of measuring the current delivered from the power supply is to measure the voltage drop across a 0.1 Ω resistor placed in series with the circuit.

After 1 week disconnect the wires from the positive and negative terminals of the 12V power supply and connect them together within the connection box.

17. The DuoGuard units are now operating in galvanic mode.

18. The feeder wires are buried in the chases using repair mortar or pourable compound as specified which is allowed to cure according to the manufacturer's instructions.

19. Clean the treatment area.

20. The installation phase is now complete.

3.0 Additional Information

Any unusual site details should be discussed with the engineer/CPT prior to installation of the system.

Process Monitoring

- **Visual inspection**

Before the DuoGuard hybrid anode system is connected to the power supply for the impressed current, the installation and all its component parts shall be subjected to a complete visual inspection to check they are installed correctly, labelled and protected from environmental, human and animal damage.

- **Routine inspection and maintenance**

Routine inspection shall be carried out at least once a day. The following checks shall be carried out and the data recorded:

Phase 1 – Impressed current

1) Confirmation that the battery power supplies are functioning correctly and have sufficient charge capacity for the impressed current treatment.
2) Measurement of current delivery to each treatment zone.
3) Visual checks of cable insulation and anode connections, to confirm their proper function.

Phase 2 – Galvanic protection current

Confirmation of galvanic activity after the 1st phase impressed current treatment may be undertaken by measuring current between the DuoGuard anodes and the reinforcing steel after a period of 2 hours after disconnection of the power supply. A protective current will be observed from the DuoGuard anodes.

Acceptance Criteria

The immediate and continued effectiveness of the DuoGuard system shall be assessed using steel corrosion rate measurement.

b) Steel Corrosion Rate Measurement

This method uses the applied current density of a segment of the anode system and the steel potential shift achieved from application of the galvanic current to calculate the open circuit steel corrosion rate. The rest of the DuoGuard system should remain connected in sacrificial anode mode to act as a guard ring to the DuoGuard anode group to be tested. Small or large perturbation techniques can be utilised in measuring steel corrosion rates, the former identified with the polarisation resistance method and the latter using larger potential perturbations as detailed elsewhere (G.K.Glass, A.C.Roberts and N.Davison, 'Criteria for novel electrochemical treatments of steel in concrete', Proceedings of the 7th International Conference on Concrete in Hot and Aggressive Environments, Volume 2, p.477-492, 13-15 October 2003).

Corrosion rates less than 1-2 mA/m^2 (less than -2µm of steel section loss per year) are in general deemed to be negligible rates obtained on passive steel. (See Corrosion, vol 55, 1999, pg 286).

