Corrosion Service Company Ltd.

Cathodic Protection of Steel Reinforced Concrete Structures

DAC-Anode® Conductive Coating Anode System Installation and User Guide

This report was prepared exclusively for the purposes, project, and site location(s) outlined in the scope of work. The conclusions and recommendations in this report are based on data obtained and analyzed in accordance with industry practice, on the site conditions and operational status of the system at the time of the survey, and on information provided to us. Corrosion Service Company Limited waives responsibility for any decisions or actions taken as a result of our report, or for any consequential damage resulting from such decisions or actions, should the site conditions change, should the operational status change, and should the information provided to us be in error.

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1 General

1.1 Intent

1.1.1 The intent of this document is to provide a guide for the installation of the DAC-Anode® conductive coating anode system, and includes installation procedures for the effective application of cathodic protection (CP) to the reinforcing steel in concrete structures.

1.2 Definitions and Declarations

1.2.1 The term OWNER shall refer to the executor of the cathodic protection project or its duly appointed representative.

1.2.2 The term CORROSION ENGINEER shall refer to an OWNER approved, registered professional engineer who is accredited as a 'Cathodic Protection Technologist' by NACE International and is experienced in the application of cathodic protection to reinforced concrete structures.

1.2.3 The term CONTRACTOR shall refer to the party awarded the contract to install the cathodic protection system.

1.2.4 The OWNER shall define the scope of work and approve materials to be used. All substitutions shall require the prior approval of the OWNER.

1.2.5 Designation of trade names defines the quality and performance of materials and does not preclude the use of OWNER approved substitutions.

1.3 Pre Commissioning Considerations

1.3.1 Consider all labour, materials, tools, equipment and transportation to complete the work as outlined in the scope of work, technical drawings and as necessary by evidence.

1.3.2 Works are detailed in this user guide.

1.3.3 Works shall include, but not be limited to, the following:

a) A preliminary potential survey of the structure.
b) The installation of reference electrodes.
c) The installation of electrical connections to, and bonds between, the metallic components to be protected.
d) The general preparation and cleaning (i.e., brush blast) of all concrete surfaces where the conductive coating is to be applied.
e) The detection and electrical isolation (i.e., masking) of any metallic components at or near the concrete surface to be coated.
f) The application of DAC-Anode® WB to the prepared concrete surface.
g) The installation of wire anodes on coated surfaces.

h) A second application of DAC-Anode® WB so as to submerge the wire anodes and the plugs holding them in place.
i) The application of a DAC-Anode® OVERCOAT over the conductive coating.
j) The installation of system power supply/control modules.
k) The installation of interconnecting wiring, conduit, cable trays, junction boxes, etc.

1.4 Documents Included

1.4.1 CSCL Product Catalogue Page: DAC-Anode® WB and Overcoat PCP

1.4.2 CSCL DAC-Anode® Installation and User Guide

1.5 Materials Handling and Storage

1.5.1 Materials shall be handled and stored so as to prevent personal injury and to prevent the delay of works.

1.5.2 All materials which can be damaged by exposure to the elements and/or temperature extremes shall be stored in a suitably controlled environment.

1.6 Workmanship

1.6.1 Skilled labour only shall be used for all work.

1.6.2 All work shall be performed under the direction of the OWNER using the most suitable equipment.

2 Materials Specification

2.1 Dac-Anode® WB

2.1.1 DAC-Anode® WB is a single package, electrically conductive coating for application on properly prepared reinforced steel concrete structures. Intended for use as an impressed current cathodic protection system anode, DAC-Anode® WB is designed to distribute direct current to embedded reinforcing steel. Electrical connection to the conductive coating is accomplished by means of small anode wires embedded into the coating.

2.1.2 Dac-Anode® WB characteristics include, but not be limited to, the following:

Technical Data	
Generic Type	Single component water-based acrylic copolymer
Color	Black
Solids by Volume	40% ± 2%
Solids by Weight	54% ± 2%
VOC	103 grams/liter (0.86 lbs./gal.)
Mixing Ratio	Not applicable
Induction Time	Not applicable
Thinner	Not recommended
Clean up	Water
Pot Life	Not applicable
Suggested Primer	Not applicable
Application Methods	Brush, Roll, or Spray
Recommended Thickness Single coat dry film thickness with primary anode wire (platinum clad) @ 10 mA/m^2 anode output and wire/wire spacing of:	**5m (16.4 ft) max:** 750 microns wet – 300 microns DFT (30 mils wet – 12 mils DFT) **2.5m (8.2 ft) max:** 500 microns wet – 200 microns DFT (30 mils wet – 12 mils DFT)
Theoretical Coverage	1.3 m^2/liter @ 300 microns DFT (52.9 ft^2/gal. @ 12 mils DFT)
Coverage (5% Loss)	1.2 m^2/liter @ 300 microns DFT (48.9 ft^2/gal. @ 12 mils DFT)

Technical Data	
Drying Time (at 21ºC) -To Dry Hard -To Recoat	 3-4 Hours 4-6 Hours
Specific Resistivity	0.8 ohm-cm (hard)
Liner Resistance	**<300 OHM:** 7.6 cm x 1.8m x 400 microns DFT (3 in x 5.9 ft x 16 mils DFT) **<400 OHM:** 7.6 cm x 1.8 m x 300 microns DFT (3 in x 5.9 ft x 16 mils DFT)
Packaging	3.78 & 18.9 liters (1 & 5 US gallons)
Shelf Life (at 4 to 38ºC)	Six (6) months in original unopened container.

2.2 Overcoat

2.2.1 DAC-Anode® Overcoat is a single component, acrylic emulsion, water-based finish coat for use as a topcoat over DAC-Anode® WB conductive coating. Easy to apply and cleans up with soap and water. Dries quickly to matte finish, has excellent flexibility and maintains color when exposed to normal weathering and mild industrial environments. Easily recoated after extended periods.

2.2.2 The characteristics of the decorative top coat shall include, but not be limited to, the following:

Technical Data	
Generic Type	Acrylic emulsion
Color	White (Other colors available on request)
Solids by Volume	47%± 2%
V.O.C	150 grams/liter (1.25 lbs./gal.)
Mixing Ratio	Not applicable
Thinner	Not recommended
Clean up	Hot Water
Pot Life	Not applicable
Application Methods	Roller or spray
Number of Coats	1 or 2, depending on substrate

Technical Data	
Recommended Thickness	87-175 microns (3.5 – 7 mils) DFT depending substrate porosity
Theoretical Coverage	5.3 m^2/liter @ 87.5 microns DFT/coat (215.9 ft^2/gal. @ 3.5 mils DFT) 2.65 m^2/liter @ 175 microns DFT (107.9 ft^2/gal. @ 7 mils DFT)
Drying Time @ 21ºC (70°F)	Tack free: 2 Hours Full cure: 4-7 Days
Packaging	3.78 & 18.9 liters (1 & 5 US gallons)
Shelf Life (at 4 to 38ºC)	One (1) year in original container

2.3 DAC-Anode® Wire

2.3.1 The wire anode is a metallurgical clad tri-metal composite used for primary distribution of the protective current to the conductive coating.

2.4 Reference Electrodes

2.4.1 The reference electrodes shall be specifically designed for embedding in concrete and shall be of either graphite, silver-silver chloride, or molybdenum-molybdenum tri-oxide as specified in the design.

2.5 DAC-Anode® Current Controller

2.5.1 Each structure shall have at least one dedicated DC power supply/control circuit capable of operating in either the ‘constant current’, ‘constant voltage’, or ‘potential controlled (i.e., +1500 to -1500 mV)’ mode.

2.5.2 The circuit shall facilitate adjustment of the outputs and ‘set’ potential throughout the entire operating range with a minimum resolution of 1%.

2.5.3 The circuit shall be capable of providing at least 25 mA per square metre of surface to which it is to provide protection at a driving voltage of at least 12V DC.

2.5.4 Terminals shall be provided for each circuit to connect the positive and negative outputs, the AC supply inputs, the structure sense leads and the reference electrode cables.

2.5.5 The DC output and control input terminals shall be DC isolated from the AC supply lines.

2.5.6 The reference electrode inputs shall have a minimum impedance of 10 Mega Ohms.

2.5.7 Provision shall be made for direct monitoring of the individual circuit output voltage and current, as well as, the control ‘set’ and reference feedback potentials via either built-in metering or a portable multimeter.

2.5.8 Each circuit shall incorporate a pilot light which shall indicate that the unit has AC power and is operating within the selected operating range of the selected control mode.

2.5.9 The circuits may either be housed individually or in groups as indicated on the design drawings. The circuit enclosure shall meet or exceed local/project electrical codes or equivalent requirements.

2.5.10 The power input and output of each circuit shall be fused within their respective rating and shall be supplied with transient suppression devices to prevent damage caused by lightning, AC power surges, etc.

2.5.11 Each circuit shall have the capability of operating continuously without damage while the output terminals are directly shorted.

2.5.12 The AC input power required may be either 110 or 220 VAC, at 60 Hz having a power transfer capability corresponding to the requirements of the DC circuits.

2.5.13 The power supply/controllers shall be local power supply/controller board approved for the application.

2.6 Electrical Wiring

2.6.1 With the exception of the reference electrode wiring, all DC wiring shall be soft annealed, seven strand (7 Str), copper, having RWU-90 insulation or equivalent.

2.6.2 The minimum size and colour coding of the DC wiring is tabulated below:

Function	Gauge (AWG)	Colour
Structure Power	#12	Green
Structure Sense	#14	White
Anode Power	#12	Red

2.6.3 The reference electrodes shall be supplied with nylon insulated coaxial cable having an AWG #22 core (minimum) and coloured black.

2.6.4 All AC wiring shall be sized, insulated, and colour coded in accordance with the project's Electrical Code requirements.

2.6.5 Except where installed in grout filled slots in the structure slabs, cables shall either be run in PVC conduit, incorporated in 'Teck' cables, or strapped to horizontal cable trays. The materials and methods employed in this respect shall conform to pertinent electrical codes and municipal by-laws.

3 Installation Procedures

3.1 Preliminary Potential Survey

3.1.1 Prior to the commencement of the installation, a potential survey of the structure shall be performed under the supervision of the CORROSION ENGINEER.

3.1.2 The intent of this survey is to determine the optimum reference electrode and monitoring locations, and to establish a potential data base for future evaluation of the cathodic protection system.

3.1.3 The CORROSION ENGINEER shall submit a written report to the OWNER following the preliminary survey which shall include the survey procedure, all data obtained, an interpretation of the data, recommended reference electrode types and locations, and general recommendations.

3.2 Reference Electrode Installation

3.2.1 At least one reference electrode shall be installed in each structure as specified by the CORROSION ENGINEER.

3.2.2 The reference electrode shall be embedded in the original concrete within 150 mm, but not closer than 50 mm to reinforcing steel.

3.2.3 The concrete removed for the installation of the reference electrodes shall be replaced with an OWNER approved, non-shrink grout.

3.3 Structure Sense Lead Installation

3.3.1 A structure sense lead shall be attached to the reinforcing steel within 450 mm of each reference electrode.

3.3.2 The method of attachment may be either by thermite weld or brazing. All exposed copper shall be completely and permanently sealed with an epoxy coating.

3.3.3 The concrete removed for the installation of the structure sense lead shall be replaced with an OWNER approved, non-shrink grout.

3.4 Structure Power Cable Installation

3.4.1 A structure power cable shall be attached to the reinforcing steel of each structure and be located at least 2000 mm from the structure sense lead connection.

3.4.2 The method of attachment may be either by thermite weld or pin brazing. All exposed copper shall be completely and permanently sealed with an epoxy coating.

3.4.3 The concrete removed for the installation of the structure power lead shall be replaced with an OWNER approved non-shrink grout.

3.5 Surface Preparation

3.5.1 All surfaces to which DAC-Anode® WB conductive coating is to be applied shall be lightly sand blasted to remove all grease, oil, dirt, paint, sealants, and other foreign matter.

3.5.2 All cracks, openings, or construction defects in the concrete surface which may expose rebars, wires or chairs shall be repaired with OWNER approved grout.

3.5.3 It shall be the responsibility of the CONTRACTOR to ensure that the prepared surface is clean, dry, and free of cracks, openings or defects.

3.6 Metal Detection and Masking

3.6.1 Following the preparation of the surface, it shall be thoroughly inspected to detect all metallic components such as rebars, stirrups, tie wires, anchor bolts, chairs, etc. which protrude, or are located within 10 mm of the concrete surface.

3.6.2 All metal detected as a result of the inspection in 3.6.1 shall be suitably masked such that the DAC-Anode® WB conductive coating will not be applied within 40 mm of any metallic component.

3.6.3 All other metal appurtenances such as scuppers, drain pipes, conduit, steel beams and trusses, railings, hangers, etc. shall be completely covered with a suitable masking material which shall extend at least 50 mm outside the concrete surface area to be coated.

3.6.4 In the case of continuous metallic conduit run on the structure, non-metallic spacers shall be inserted to lift the conduit from the concrete surface so that the conductive coating may be applied beneath it.

3.6.5 Masking shall also be provided at all locations specified by the CORROSION ENGINEER which are to be used for future potential monitoring.

3.6.6 It is the responsibility of the CONTRACTOR to ensure that all metal objects are detected and properly masked.

3.7 Application of DAC-Anode® WB Conductive Coating

3.7.1 The conductive coating shall be stored, mixed, and applied as per the manufacturers' recommendations to yield a minimum dry film thickness of 750 microns wet for a 5 m long patch and 500 microns wet for 2.5 m long patch.

3.7.2 The conductive coating shall be applied to all concrete surfaces of the structure, except as otherwise noted on the design drawings.

3.7.3 The only areas of the structure to which the conductive coating shall not be applied, are areas within 50 mm of a metallic appurtenance and measurement windows for future potential monitoring.

3.8 Wire Anode Installation

3.8.1 After the conductive coating has cured to a dry hard surface, and within 48 hours of its application, the wire anodes shall be fixed to the coated surface in the lengths and positions specified in the design.

3.8.2 The wire anodes shall be fixed to the coated surface using plugs to hold the wire in place or OWNER approved alternate method.

3.8.3 The wire anode and plug shall be embedded in another coat of conductive coating having a minimum dry film thickness of 750 microns wet for a 5 m long patch and 500 microns wet for 2.5 m long patch.

3.9 Application of DAC-Anode® Overcoat

3.9.1 The overcoat topcoat shall be stored, mixed, and applied as per the product recommendations to yield a minimum dry film thickness of 87-175 microns.

3.9.2 The overcoat topcoat shall be applied to all concrete surfaces of the structure, except as otherwise noted on the design drawings.

3.10 Installation of Cables and Conduits

3.10.1 All cables shall be installed in conduits or via ‘Teck’ cable wherever possible.

3.10.2 All conduits shall be mounted and secured to the structure in conformance with pertinent electrical codes and municipal by-laws, where they will neither encourage vandalism nor present a public safety hazard.

3.10.3 Where cables are not installed in conduit, they shall be installed in saw slots made in the structural slab which shall extend to within 100 mm of a conduit entry.

3.10.4 Cable saw slots shall not be deeper than 25 mm, shall be sufficiently wide to provide a 5 mm space around each conductor, and shall be filled, level to the surface, with an OWNER approved, latex-modified grout providing at least 12 mm of cover over the cables.

3.10.5 All wire connections shall be either contained in water-tight enclosures or be directly and permanently sealed against moisture penetration.

3.11 Installation of Power Supply/Controllers

3.11.1 The power supply/controller enclosures shall be mounted where they will neither encourage vandalism nor present a public hazard.

3.11.2 The power supply/controller enclosures shall be positively secured where indicated to provide permanent support.

3.11.3 All conduit entries to the power supply/controller enclosures shall be water-tight.

3.12 Provision of AC Power and Inspection Certificate

3.12.1 The CONTRACTOR shall be responsible for securing appropriate AC power supply from the local electrical utility.

3.12.2 The CONTRACTOR shall submit to the OWNER a certificate of inspection from the local electrical utility at the completion of all electrical works.

4 Commissioning

4.1 General

4.1.1 System commissioning shall include the actual energization of the system, an evaluation survey, and a final report.

4.1.2 All stages of the system commissioning shall be performed under the direct supervision of the CORROSION ENGINEER.

4.2 Energization

4.2.1 Prior to the activation of the power supply/controller circuits, all masking shall be removed.

4.2.2 Each power supply/controller circuit shall be set to operate in the ‘constant current’ mode with an output corresponding to 20 mA per square metre of protected surface. After the energization phase is complete the current should be brought down to 2 mA per square metre of protected surface.

4.2.3 The output parameters of each power supply/controller shall be measured and recorded.

4.2.4 Potentials shall be measured from various points on the structural steel of each structure with respect to a single reference electrode to ensure continuity.

4.2.5 Structure potentials shall be measured with respect to the permanent reference electrodes and with respect to a portable copper-copper sulphate reference electrode placed at the measurement ‘windows’ provided.

4.2.6 All structure potential measurements shall be taken while the output current of the corresponding power supply/controller circuit is cyclically interrupted.

4.2.7 The protective current provided by each section of conductive coating shall be measured and, if necessary, the output current of the corresponding power supply/controller shall be reduced to ensure that the coating current density does not exceed 25 mA per square metre.

4.2.8 In the event that a deficiency or fault is detected during the energization procedure, additional testing shall be performed to determine what remedial action is required.

4.2.9 An interim report shall be submitted by the CORROSION ENGINEER to the OWNER including all data obtained and, if necessary, the details of any remedial action required.

4.2.10 Following the completion of any remedial work approved by the OWNER, the energization procedure shall be repeated for the affected section of the structure.

4.3 Evaluation Survey and Report

4.3.1 The evaluation survey shall be performed within the period of 40 to 60 days following energization of the system.

4.3.2 All potential and current measurements performed during the energization procedure shall be repeated during the evaluation survey.

4.3.3 The output parameters and control mode of each power supply/controller circuit shall be adjusted to optimize the operation of the cathodic protection system.

4.3.4 The CORROSION ENGINEER shall submit a final report to the OWNER which shall include the following:

a) A compilation of all data obtained during the preliminary survey, the energization procedure, and the evaluation survey.
b) An interpretation and evaluation of the data collected with regards to the effectiveness and expected service life of the system.
c) Recommendations pertinent to any immediate remedial work required.
d) A system operating manual complete with maintenance procedures and troubleshooting schematics.

5 Inspection

5.1 Contractor's Responsibility

5.1.1 It shall be the responsibility of the CONTRACTOR to ensure that all inspection procedures and requirements are completed before proceeding to the following stage of construction.

5.2 Inspection Procedures

5.2.1 The OWNER shall inspect:

a) All materials prior to their use.
b) All material storage facilities prior to their use.
c) All reference electrode and structure sense lead locations immediately prior to and following their grouting.
d) The surface preparation procedures and resultant quality prior to masking.
e) The metal detection and masking procedures and quality prior to the application of the conductive coating.
f) The equipment employed, the application procedures, and the wet and dry film thickness of the conductive coating as it is applied.
g) The wire anodes before and after they are embedded in the additional layer of conductive coating.
h) The equipment employed, the application procedures, and the wet and dry film thickness of the decorative top coat as it is applied.
i) The proposed placement of all cables and conduit prior to their installation.
j) All cable splices and connections prior to commissioning.
k) The proposed location of the power supply/controller enclosures prior to their placement.
l) The mounting and conduit entry arrangements prior to commissioning.
m) The soffit mounting of other conduits/utilities by other contractors to be properly isolated at each contact point on the soffit.