LINEAR POLARISATION RESISTANCE (LPR) EQUIPMENT

DATASHEET

LPR METER

Introduction

BAC Corrosion Control Ltd (BAC) has introduced a range of specialist products for monitoring and determining the presence and rate of corrosion to steel reinforcement in concrete structures and buildings.
These products can be used to establish whether Cathodic Protection (CP) is needed on a structure by installing them at the build stage or retro fitting them to existing structures and then analysing the information obtained.

Corrosion monitoring

In steel reinforced concrete structures, corrosion monitoring of the rebar has become increasingly important. The steel reinforcement in concrete structures is susceptible to corrosion when chloride ions enter into the concrete from de-icing salts, or from seawater in marine environments or other chloride rich sources.

The passive film on the reinforcing steel can be broken down by carbonation and the presence of chlorides from de-icing or marine salts resulting in corrosion. Other factors affecting the corrosion rate include Oxygen content, moisture presence and temperature. Corrosion of the steel reinforcement can weaken the structural strength, create cracking, delamination and spalling of the concrete.

Linear Polarisation Resistance

The Linear Polarisation Resistance technique measures corrosion rate continuously in real-time. This electrochemical measurement is based on applying a small potential shift to a corroding metal electrode, the resultant current being proportional to the corrosion rate. LPR instrumentation converts the current measured to corrosion rate readings in µm/yr/100cm2.

Structures of importance

- Road decking, bridges & car parks
- Tunnel walls (monitor seepage from bedrock)
- Water intake structures
- Marine located piers, jetties, docks & caissons
- Nuclear installations & storage facilities
- Buildings in corrosive environments

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Steel in concrete corrosion trend

Corrosion of steel in concrete should normally be looked at as a medium to long term trend and not be interpreted from instant one off readings, although corrosion mapping using the portable LPR probe set can give a general picture when used to map a concrete surface with both potential and corrosion rate.

When concrete is new it will contain significant water volume and the potential (mV) of the steel will be correspondingly negative (not to be confused with corroding potential levels). Similarly the corrosion rate will appear high.
As the concrete cures and dries it would be usual to see a positive increase in the steel potential and a reduction in the corrosion rate. Over time it should become stable.
After a period of stability and assuming that the steel starts to corrode, then the trend will tend to be reversed. Assuming that the concrete has not become waterlogged corrosion potentials and rates should then be relatively easily identified.

ASTM C876 Interpretation of corrosion potentials

Corrosion Potential (Ag/AgCl)	Probability of Corrosion
Less negative than -0.150 V	90% probability of no corrosion
Between -0.150 V and -0.300 V	an increasing probability of corrosion
More negative than -0.300 V	90% probability of corrosion

Interpretation of corrosion rates

Corrosion Rates (µm/yr)	Probability of Corrosion
Less than 1	negligible corrosion rate
Between 1 – 10	low corrosion rate
Between 10 - 100	moderate corrosion rate
Greater than 100	high corrosion rate

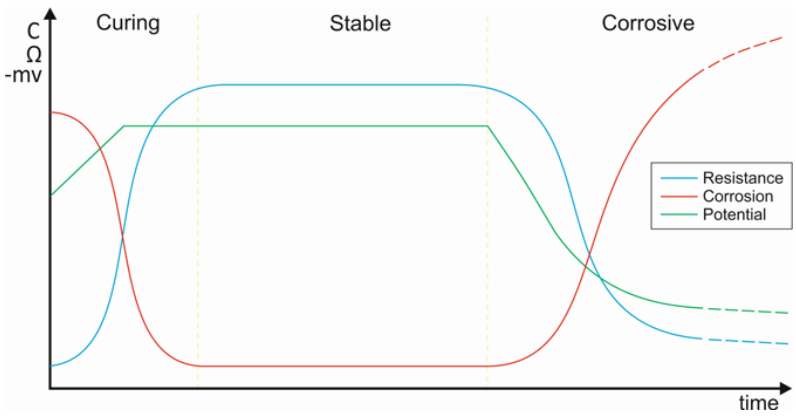

Figure 1 – Graph showing typical long term trends of steel in concrete corrosion The above is a very simplified explanation of what generally happens and whilst use of the LPR equipment is relatively straightforward, the interpretation of the readings is not always so simple and this work should be carried out by a qualified person certified to at least level 2 (R Category) of the EN15257 standard or equivalent.

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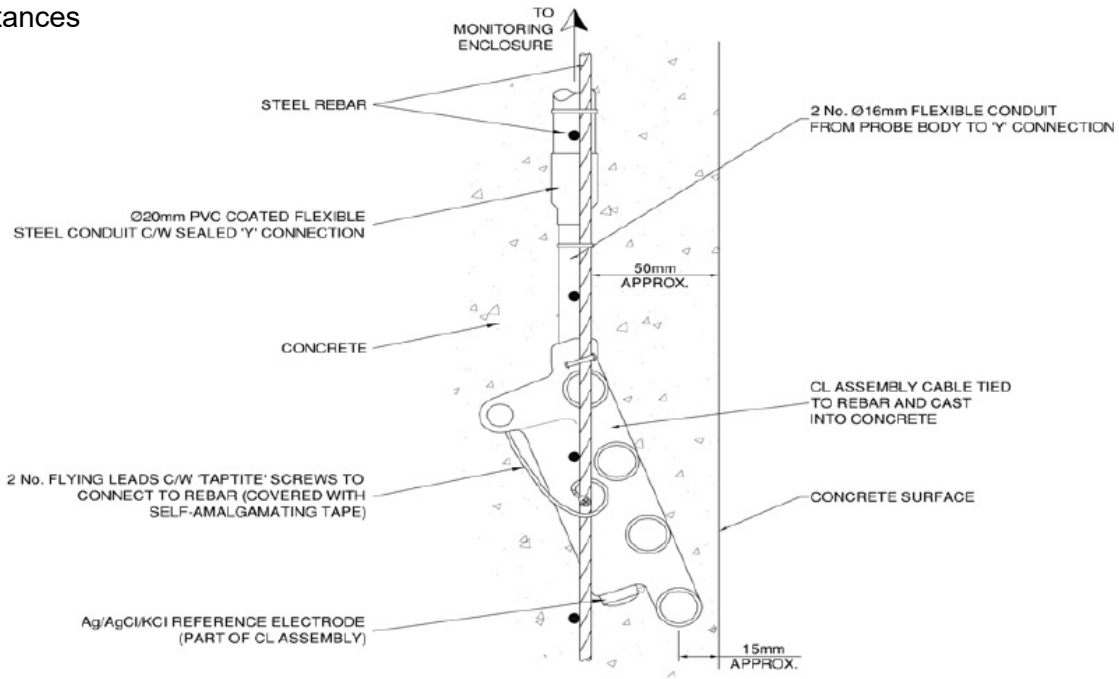
CL Ladder Probes

Corrosion monitoring CL Ladder probes are advanced embeddable corrosion rate probes for use on NEW build structures. The unique design has four independent LPR electrodes at varying levels of concrete cover which allows the determination of a variety of parameters relating to the condition of the structure.

Functions

- Corrosion rate & potential measurements at each of the four electrodes plus main steel
- reinforcement
- Electrical Resistance (between three pairs of electrodes)
- Temperature of probe
- Estimation of rate of ingress of corrosive substances



Operation

The probe is usually installed at an angle to the surface of the concrete as in the diagram. Each of the elements (numbered 1-4) is at increasing distances from the surface; hence any corrosive substances penetrating the concrete arrive at the electrodes sequentially. A sequential increase in corrosion rate over the probe elements 1 to 4 indicates the progressive ingress of corrosive substances.

Concrete electrical resistance can be measured between pairs of adjacent elements. This augments the corrosion rate data to provide an indication of the rate of corrosive substance ingress i.e. chloride ion ingress from seawater exposure. A temperature measuring device is included to allow for temperature related variations in corrosion rate or electrical resistance to be factored out.

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Electrical connections to the rebar allow LPR corrosion rate and corrosion potential to be measured. Initially, after casting, it can be assumed that the corrosion rates of the rebar and the fourth element will be similar.
After casting, initial corrosion rate data can be used to calibrate the probe to account for the differing measured corroding surface area of the rebar and the elements, and as the element area is known accurately, henceforth a more accurate corrosion rate of the rebar can be calculated.

Features

- 25mm diameter Ag/AgCl reference electrode
- Stainless steel auxiliary electrode & pseudo reference electrode
- Approx 180x130x75mm in size (excluding cable)
- Compatible with BAC Corrosion Control Ltd and BGB Projects Ltd's testing instrumentation
- Available with 21-core cable in four different lengths.
- Used for estimating corrosion potential, corrosion rate of steel reinforcement and carbon steel element.
- Robust construction designed for casting into concrete.

CL Ladder Probe

Retrofit Probes

The retrofit LPR probes are designed to be installed into existing steel reinforced concrete structures providing the basis for a corrosion monitoring system.

Common features across the range of probes:

- 15mm diameter Ag/AgCl reference electrode
- MMO-coated Ti auxiliary electrode
- MMO-coated Ti pseudo-reference electrode
- ~30 mm diameter, ~80 mm long

Remote Monitoring Compatible Probe

Stand Alone probe

Additional feature for the stand alone probes:

- Unique 64-bit ID Chip
- IP68 connector

Installation

The probe body should be installed in a hole in the concrete approximately 35mm diameter and 85mm deep, with the probe being properly embedded and fully grouted into the concrete. For the Stand Alone probes (both types) the surface plate should be flush with the concrete surface.

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Stand Alone Probe with Flying Lead

For the remote monitoring compatible probes and the stand alone probe with flying lead, connection to the reinforcement bar at an appropriate location is by means of attaching the flying lead, terminated in a crimp ring connector, by either using a 5mm TaptiteTM screw or direct BAC pin braze.

Negative connection point

For the stand alone probe, connection to the steel is via a negative connection point which will allow connections to be made to multiple probes around the structure for testing with a portable instrument. The negative connection (see below for differing types) point should be fully grouted into the concrete with the surface plate being flush with the concrete surface.

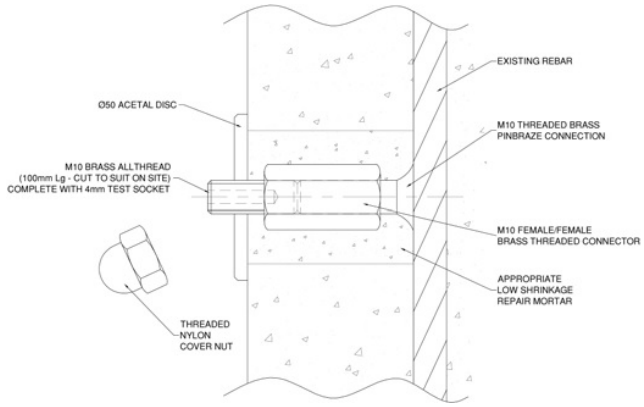

Figure 3 - Negative Connection Point - Pin Braze Type

Negative Connection Point surface plate

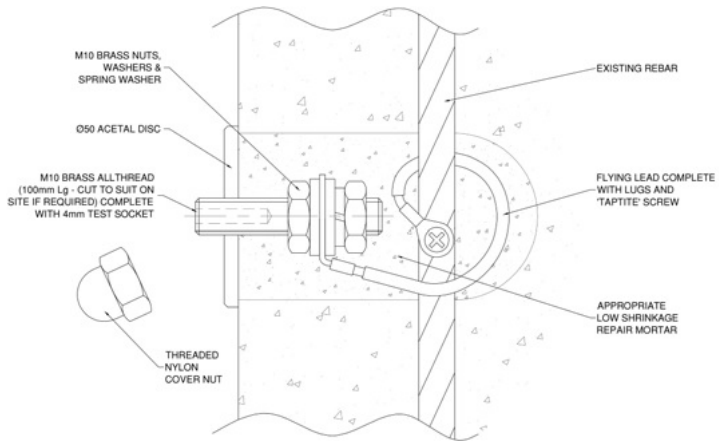

Figure 4 - Negative Connection Point - TaptiteTM type

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Portable LPR Kit

'Bigfoot' and 'Littlefoot' surface mounted probes were developed to provide assessment information on the corrosion condition of steel reinforcement by supplementing traditional surface mapping corrosion potential surveys.

Features

- BigFoot
- Littlefoot
- Resistivity Probe
- Extension pole
- Extension pole brackets
- Connection leads

Resistivity Probe

Ag/AgCl Reference Electrodes

Underside of the 'Bigfoot' probe

Operation

The corrosion rate system using hand held LPR meters and 'Bigfoot' or 'Littlefoot' probes provides potential and corrosion rate simultaneously. Readings taken on a grid formation usually take some 30-90s at each reading site.

With a trailing test lead connected to the electrically continuous steel reinforcement, the probe is held against the concrete surface in a grid formation. The LPR meter carries out testing at each node point, recording the steel corrosion potential (mV or V against Ag/AgCl) and corrosion rate (µm/yr/100cm²). If the surface area of the steel beneath the probe diameter can be estimated, the factor is applied to provide an actual corrosion rate reading.

Portable LPR kit Resistivity

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Resistivity meter

For use with the portable LPR kit, Megger DET4 Series Soil resistivity Meters are available from BAC. The DET4TD2 model is a dry-cell battery powered basic 4-terminal tester, and the DET4TR2 is a rechargeable battery powered tester.

Features

- 2, 3 and 4 point testing
- Stakeless (clamp-on) testing capability
- ART (Attached Rod Technique) capability
- Multiple, user selectable test frequencies
- Resistance measurement range to 200 kΩ
- IP54 rated
- Warning indicators prevent test failure
- Simple one button operation
- Included leads, stakes, calibration certificate and rugged carry case

LPR Meters

The LPR meters are used to carry out measurements of current parameters from the probe sets of steel reinforcement in concrete from embedded ladder probes, retrofit LPR probes and the BAC portable LPR probe set. The portable meters are housed in rugged machined Aluminium cases and the use the LPR corrosion rate measurement technique. It is a self contained battery powered system which provides compatibility with all relevant probes.

Technical data

The corrosion rate range covered by the meters are from 0.2µm to 5mm/year for a 100 square centimetres surface area test electrode with the results being displayed on the meter screen. Both meters are able to identify Unique ID chips contained in the probes where present. The Manual LPR meter is used to read the range of BAC retrofit probes as well as being used with the portable LPR kit. It can also be used to measure limited readings on the CL Ladder probes. The Automatic LPR meter is used to read the BAC LPR ladder probes, and when switched to the manual mode, used to read the BAC retrofit probes and portable LPR kit.

Features

- Enclosure dimensions 160 x 75 x 220mm
- Weight 2.5kg
- Power supply battery Rechargeable batteries
- Temperature Range 0 to 50 deg C
- Corrosion potential -1024 to 1024mV
- Corrosion rate surface 0.2µm to 5mm/year
- Area (Max) 100cm2
- Resolution corrosion potential 0.5mV
- Memory 500 readings
- Clock type Real time

Supplied with

- Universal mains charger
- USB download cable
- Shoulder strap
- CD with utility software

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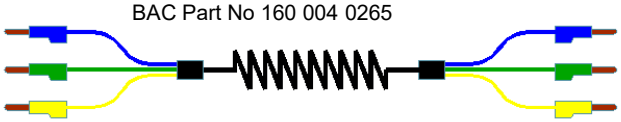
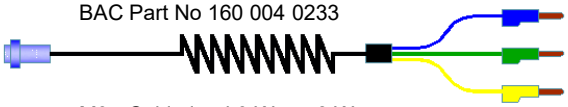
Manual meter leads available

M1 - Cable lead 3 x 4mm plugs - 3 x 4mm plugs
BAC Part No 160 004 0265



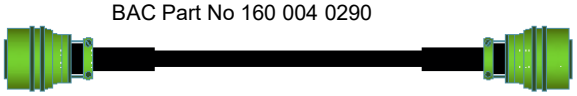
M2 - Cable lead 6 way - 3 x 4mm plugs
BAC Part No 160 004 0233



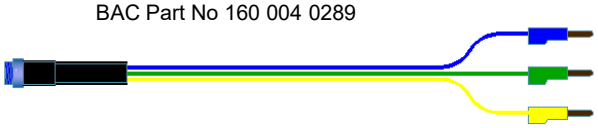
M3 - Cable lead 3 Way - 8 Way
BAC Part No 160 004 0268

Automatic meter leads available

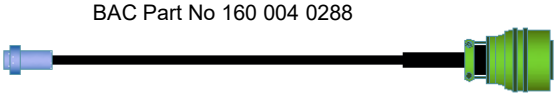
A1 - Cable lead 26 way - 26 way
BAC Part No 160 004 0290



A3 - Cable lead 6 way - 3 x 4mm plugs
BAC Part No 160 004 0289



A2 - Cable lead 26 way - 6 way
BAC Part No 160 004 0288

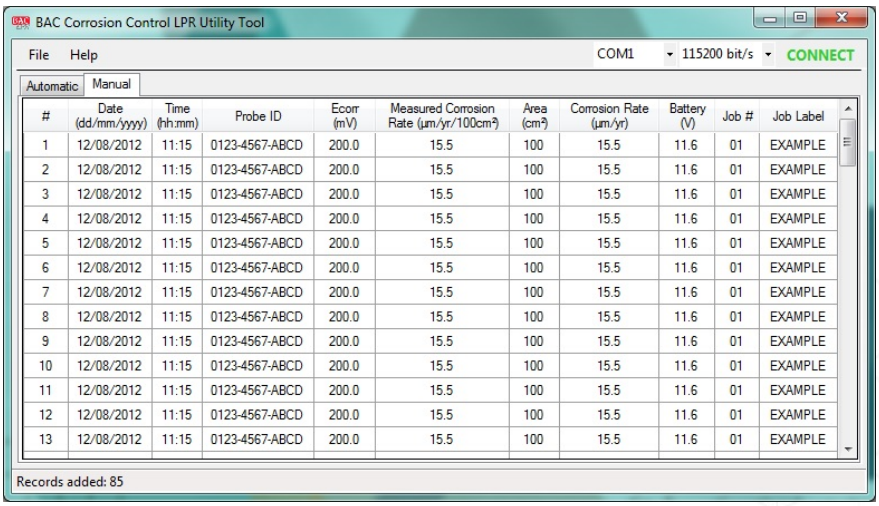


LPR Meter Protective Case

For use with both the manual and automatic LPR meters, protective cases are available to ensure the meter is kept in pristine condition and allows the operator full use of the meter while encased.

Utility software

A free download utility is used to download the data from the meter and save it to a Microsoft Excel spread sheet. The imported data is automatically loaded into a table as shown below. Automatic and Manual readings are filtered and stored in two separate tabs on the form.



#	Date (dd/mm/yyyy)	Time (hh:mm)	Probe ID	Ecorr (mV)	Measured Corrosion Rate (µm/yr/100cm²)	Area (cm²)	Corrosion Rate (µm/yr)	Battery (V)	Job #	Job Label
1	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
2	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
3	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
4	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
5	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
6	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
7	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
8	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
9	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
10	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
11	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
12	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE
13	12/08/2012	11:15	0123-4567-ABCD	200.0	15.5	100	15.5	11.6	01	EXAMPLE

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LPR METER

Parts List

Part No	Description
160 004 0182	Portable LPR Kit (Complete)
160 004 0219	Ladder probe + 5 meters of cable
160 004 0220	Ladder probe + 10 meters of cable
160 004 0221	Ladder probe + 15 meters of cable
160 004 0222	Ladder probe + 20 meters of cable
160 004 0141	Single Probe Terminal Box
160 004 0142	Double probe Terminal Box
160 004 0223	Retrofit Probe (Standalone)
160 004 0232	Retrofit Probe (Standalone) + Flying Lead
160 004 0298	Retrofit Probe (Wired) + 5 meters cable
160 004 0299	Retrofit Probe (Wired) + 10 meters cable
160 004 0151	Retrofit Probe (Wired) + 15 meters cable
160 004 0300	Retrofit Probe (Wired) + 20 meters cable
160 004 0204	Negative Connection Kit - Taptite Type
160 004 0308	Negative Connection Kit - Pin Braze Type
160 004 0276	Manual Handheld Meter Set
160 004 0265	M1 Cable lead - 3x 4mm plugs to 3x 4mm plugs
160 004 0233	M2 Cable lead - 3x 4mm plugs to 6 way IP68 plug
160 004 0268	M3 Cable lead - 8 way plug to 6 way IP68 plug
160 004 0274	Manual Meter Lead Full Set
160 004 0277	Automatic Handheld Meter Set
160 004 0290	A1 Cable lead - 26 way plug to 26 way plug
160 004 0288	A2 Cable lead - 26 way plug to 6 way IP68 plug
160 004 0289	A3 Cable lead - 6 way IP68 plug to 3x 4mm plugs*
160 004 0286	Automatic Meter Lead Full Set
160 004 0224	Attaché Case (Replacement)
160 004 0332	LPR Meter Protective Case
160 004 0225	Spare battery (Replacement)
160 004 0270	Detachable Neck Strap (Replacement)
160 004 0271	230V AC Mains Charger (Replacement)
160 004 0269	USB Cable (Replacement)
160 004 0272	Software CD (Replacement)

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