

Evaluation of Corrosion in Reinforced Concrete (RC) Structures



FORCE Technology has been deeply involved with the problems of corrosion of steel and other metals cast in concrete since the 1970s. The ever-increasing rise in the amount of corrosion related damage to concrete structures has resulted in continual and expanding development by FORCE Technology in this area.

FORCE Technology offers a wide range of special and advanced techniques for most aspects of concrete condition assessment backed up by decades of experience in different sectors of industry such as bridges, tunnels, nuclear power plants, off-shore, housing, harbour structures etc. In this respect the spectrum of technology offered by FORCE Technology is quite unique.

Services for evaluating corrosion activity in RC structures:

- Electro-chemical methods for assessment of the corrosion condition of reinforcing including Half-Cell Potential measurements (HCP) and Galvanostatic measurements (GPM)
- Permanent monitoring of reinforcement
- Corrosion by means of embedded sensors
- Evaluation of condition and potential durability of concrete structures and preparation of suitable strategies for maintenance and repair
- Laboratory analysis of concrete pore water, measurement of chloride distribution and threshold chloride concentration for initiation of corrosion.

GalvaPulse™

Half-Cell Potential, Electrical Resistance and Corrosion Rate



The GalvaPulse™: Hand held computer and electrode

Principle

The GalvaPulse™ (GPM) is a rapid “non-destructive” polarization instrument used to estimate the corrosion rate of reinforcement in concrete, based on the galvanostatic pulse method. Access to the reinforcement is required. In addition, the half-cell potential and the electrical resistance of the cover layer are measured, all in one operation.

A short duration anodic current pulse is induced into the reinforcement galvanostatically from a counter electrode placed on the concrete surface together with a reference electrode. The applied current is normally in the range of 5 to 400 mA, and the typical pulse duration is 5 to 10 seconds.

To be able to measure the corrosion rate the electrode of the GalvaPulse™ has a “Guard Ring” to confine the current to an area equivalent to the central counter electrode, See figure 1.

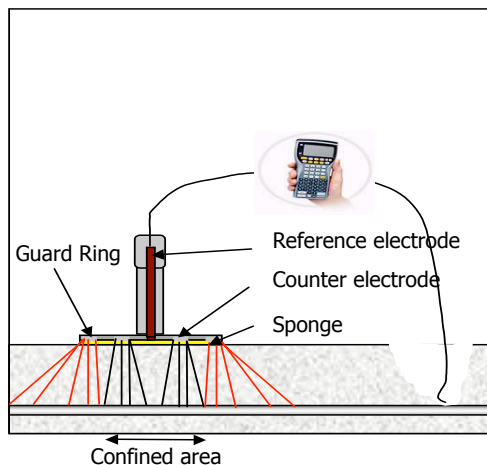


Figure 1. Sketch of GalvaPulse™ electrode

Without the Guard Ring the area of the counter electrode would be much smaller than that of the working electrode (the reinforcement) and the electrical signal would have a tendency to vanish with increasing distance (cover).

Therefore the Guard Ring is indispensable for the system to be able to measure the effective polarization resistance and convert this to a corrosion rate.

Example

Swimming pool structures are often inspected using the GPM. Where there is a high concentration of chlorides present and also humid and warm air.

In figure 2 typical corrosion rate values are shown for a swimming pool wall.

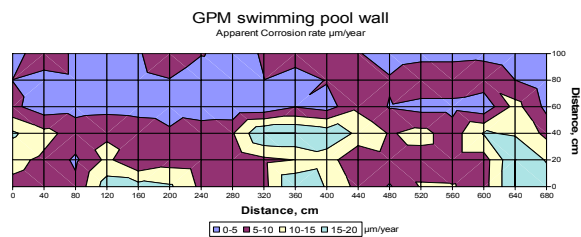


Figure 2. Presentation of the corrosion rate

Features

- Estimation of the reinforcement corrosion rate is made in less than 10 seconds
- Reliable evaluation of reinforcement corrosion in e.g. anaerobic concrete
- Half-cell potential along with the electrical resistance of the cover layer
- Lightweight electrode / hand held computer and easy to operate software
- Durable Guard Ring system for focusing the current field to the reinforcement
- Measurement on uneven and curved surfaces.

CorroWatch Multisensor

Early Warning System for Initial Stages of Corrosion



The CorroWatch attached to the reinforcement

Principle

The CorroWatch acts as an early warning system to predict the initial stages of corrosion in concrete structures. It is cast into the cover concrete, normally in newly cast concrete structures. The sensor can measure most of the relevant corrosion parameters.

The CorroWatch is a multisensor, which in the standard version consists of four black steel anodes and one noble metal cathode. The anodes are placed in varying, but defined distances from the exposed concrete surface. The height of the anodes is flexible and can be adjusted according to the concrete cover thickness.

To predict when the reinforcement will start corroding, the current between the single anodes and the cathode is measured, either with an ampere meter or a specially designed data logger. When corrosion starts, the current will increase significantly.

The CorroWatch can easily be attached to a logger for monitoring of data. Remote monitoring by modem is also possible.

Example

The photo shown above shows the CorroWatch attached to the reinforcement prior to casting. The cover layer for each anode is noted and used for later service life calculations.

In figure 3 an example from a laboratory test is shown indicating when the corrosion initiates at each of the 4 anodes.

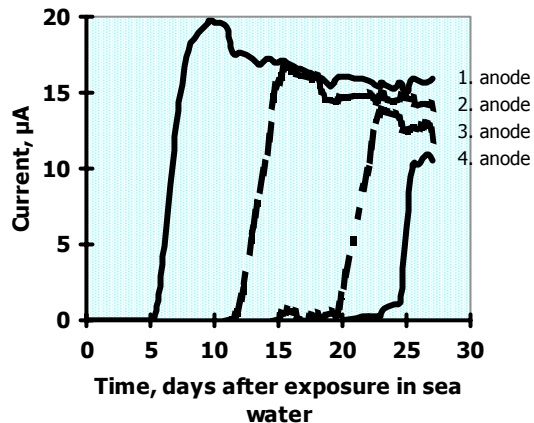
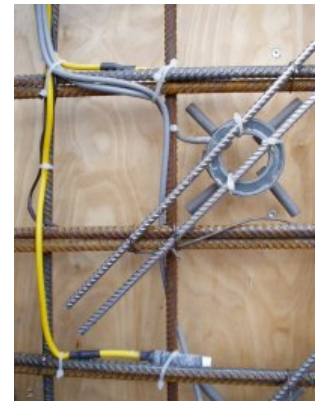


Figure 3. Increase in current in the 4 anodes

The CorroWatch can be used without any additional electrodes. But as an additional back-up the ERE 20 sensor (described on the next page) can be installed together with the CorroWatch as a reference electrode. See adjacent photo.



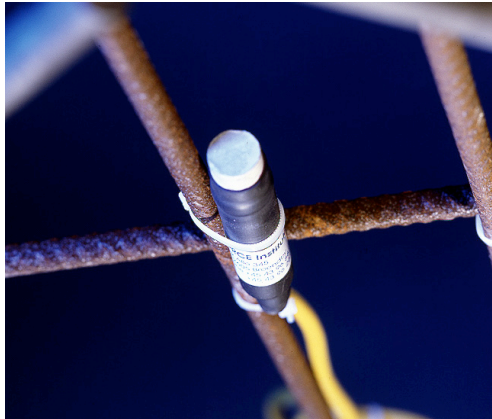
The potentials measured with the ERE 20 are compared with the current measured with the CorroWatch to check the readings of the CorroWatch multisensor.

Features

- Areas difficult to access, e.g. tunnels
- Bridges in marine environments
- Splash zones, e.g. pillars in sea water
- De-icing areas, e.g. parking floors/decks
- Structures heavily affected by acid rain, e.g. chimneys.

ERE20

Embeddable Reference Electrode



The ERE 20 attached to the reinforcement

Principle

The ERE 20 is a true, long life Reference Electrode, which can be cast into the cover concrete, normally in newly cast concrete structures, to check the cathodic protection and to monitor the corrosion state of reinforcing steel.

The potential of ERE 20 is nearly independent of changes in the chemical properties of the concrete. It can, therefore, be used in wet or dry concrete, whether exposed to chlorides or to carbonation.

Based on proven battery technology, the ERE 20 is a true half-cell using a manganese dioxide electrode in steel housing with an alkaline, chloride-free gel. The steel housing is made of a corrosion resistant material. The pH of the gel corresponds to that of pore water in normal concrete, so errors due to diffusion of ions through the porous plug are eliminated.

The ERE 20 can easily be attached to a logger in order to monitor data. Remote monitoring by modem is also possible.

Example

The ERE 20 is used to check the correct operation of the cathodic protection in structures.

Figure 4 shows a typical curve showing the potentials found on checking a CP-system.

In this example the current is turned off after 18 hours and the potentials are found to shift 100 mV within 4 hours. Thus, one of the criteria for correct function of the cathodic protection is seen to be fulfilled.

According to EN 12696 the Polarisation Decay should be met within 24 hours.

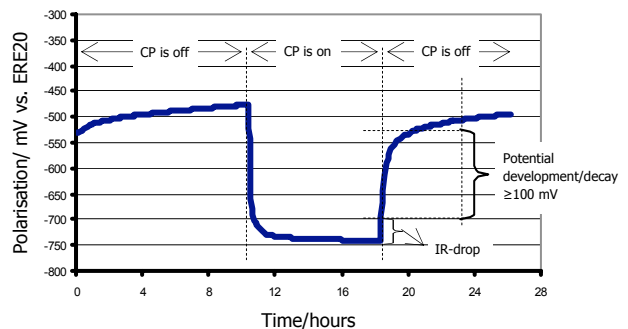


Figure 4. Polarisation curve from CP system

Features

- Control of cathodic protection
- For potential measurements in wet and dry concrete
- Can be exposed to chloride or carbonation
- Does not induce corrosion in steel
- Does not change potential of steel.



Further information:

Oskar Klinghoffer, tel. (direct) +45 43 26 72 55, osk@force.dk

Subject to changes without notice

FORCE Technology Netherlands B.V.
Tel. +31 71 523 5212
FORCE Technology Rusland LLC
Tel. +7(812) 326 80 92

FORCE Technology USA Inc.
Tel. +1 713 975 8300
FORCE Technology Brazil Ltda.
Tel. +55 21 2610 7400

FORCE Technology Norway AS
Claude Monets allé 5
1338 Sandvika, Norway
Tel. +47 64 00 35 00
Fax +47 64 00 35 01
info@forcetechnology.no
www.forcetechnology.no

FORCE Technology Sweden AB
Tallmätargatan 7
721 34 Västerås, Sweden
Tel. +46 (0)21 490 3000
Fax +46 (0)21 490 3001
info@forcetechnology.se
www.forcetechnology.se

FORCE Technology
Headquarters
Park Allé 345
2605 Brøndby, Denmark
Tel. +45 43 26 70 00
Fax +45 43 26 70 11
force@force.dk
www.forcetechnology.com