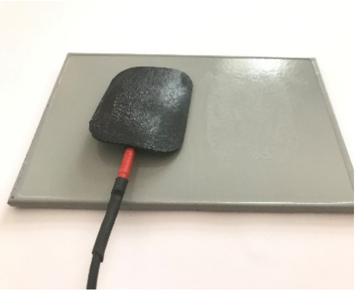
Contents

ELECTROLYTE APPLICATION AND REMOVAL



Apply the paste electrolyte, in a thin layer, onto the entire electrode surface. Press the electrode firmly onto the surface of the coating and check if adherence is complete. The electrode will stick to the surfaces due to the stickiness of the electrolyte paste. After the measurement, gently detach the electrode or electrodes from the coating surface. Proceed with the measurement at another location. Replenish the electrolyte when it no longer evenly covers the electrode surface and/or after it shows loss of adhesion. Thoroughly remove the electrolyte from the coating surface by rinsing it with warm, approximately 40 °C, water and dry with a paper tissue. In the field, the electrolyte may be removed by a cleansing wipe or may be washed out with detergent and cold water.

The paste electrolyte forms a purely ohmic contact between the electrode surface and the coating, therefore not interfering with the coating impedance measurement. For details of the electrolyte composition, its electrochemical characteristics and MSDS, please see the ReCorr® QCQ Paste Electrolyte documents provided with the device or contact us at info@recorrtech.com.

ONE AND TWO-ELECTRODE SETUPS

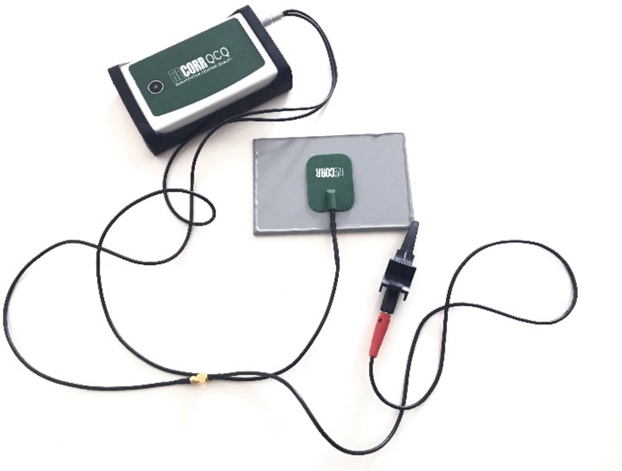
In the one-electrode measurement setup, the black pin electrode is attached to the coating surface and the red pin with a crocodile clip is connected to the exposed part of the substrate (upper figure left). In the two-electrode measurement setup, a pair of electrodes are used, one connected to the red and the other to the black pin cable (upper figure right). For switching between the one and two-electrode setups, part of the cable with a red banana pin, plugged into a crocodile clip, is unscrewed from the cable leading to the instrument. The cable with a red pin plugged into the electrode is screwed on the cable leading to the instrument. **The crocodile clip should have good electrical contact with the substrate. Highly resistant contact, e.g. due to the rust layer or remains at the substrate of the coating will yield falsely high coating impedance.** For details of connecting the instrument to the PC or Android device, adjusting the measurement parameters and running the experiment please see the ReCorr® QCQ Quick Start Leaflet and the ReCorr® QCQ Software documents provided with the device or contact us at info@recorrtech.com.

CHECKING ELECTRODE CONTACTS AND ELECTROLYTE PERFORMANCE

To check the electrode contacts, press the electrodes without the electrolyte firmly together and record the open-circuit potential. The instrument should read the potential equal to zero. To check the performance of the electrolyte, apply a thin layer onto the electrode surface and press the electrodes firmly together leaving them to adhere one to another. Again, the instrument should read the potential equal to zero. Record the impedance spectrum. The result should show zero or very low phase angle ($-20° < \theta < 0$), and the impedance around 200 Ω in the whole frequency range. **Check the contacts at the beginning of a set of measurements, and occasionally during the measurements. Check the conductivity of the electrolyte, especially if it appears dry. Use only the ReCorr® QCQ Paste Electrolyte with the ReCorr® QCQ instrument. The electrolyte to high conductivity, wrong consistency, causing the coating pore clogging or electrode polarization will yield falsely high impedance results and improper shape of the impedance spectra.**

MEASURING SUBSTRATE AND COATED SAMPLE CORROSION POTENTIAL

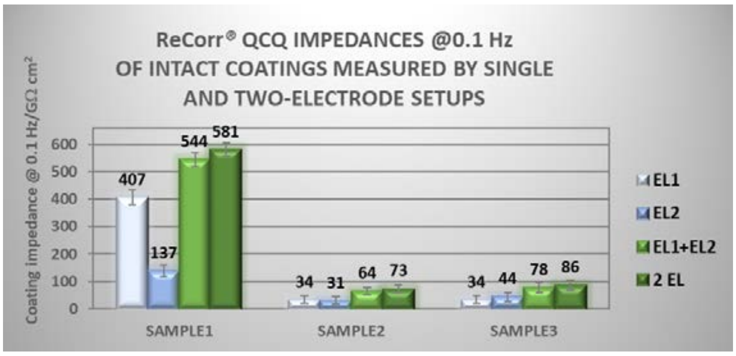
Measurement of the substrate corrosion potential may be done on a bare substrate metal specimen by a one-electrode setup, where the black pin electrode with applied electrolyte is attached to the uncoated substrate and the clip is attached to the substrate metal. Coated electrode corrosion potential is measured in the same manner. Coated electrode potential approaching that of the substrate potential indicates coating degradation. Increasingly more positive corrosion potential of coated samples indicates an increasingly higher degree of substrate insulation from the environment attained by the coating. Highly resistant coatings may give unstable potential due to the lack of electrolytic contact between the electrode and the substrate. **The one-electrode measurement should be done with DC offset potential equal to the substrate corrosion potential while the two-electrode measurement setup assumes that the two electrodes are identical so DC offset the potential for impedance measurements should be set to zero.** For corrosion potentials of common metals and alloys, please see the ReCorr® QCQ Paste Electrolyte documents provided with the device or contact us at info@recorrtech.com.

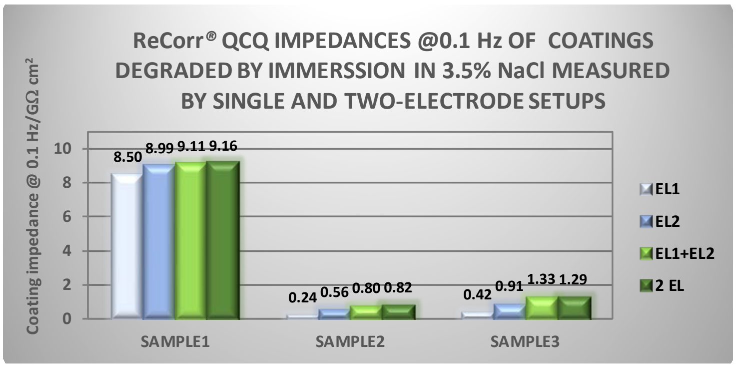


CHECKING FOR SURFACE AND PARRALLEL CONDUCTION

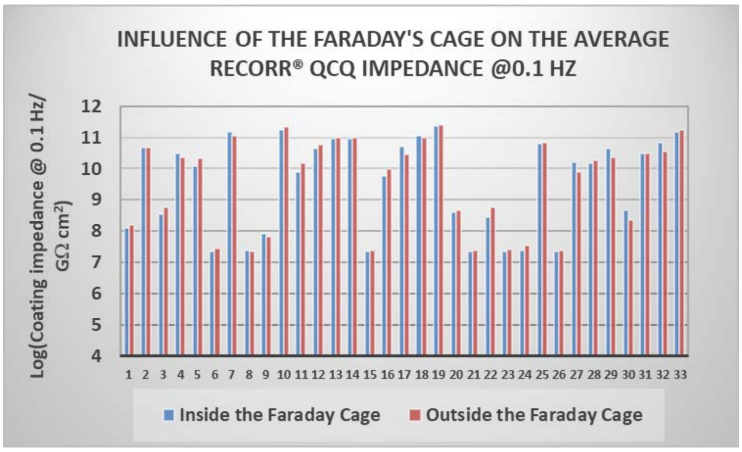
The one-electrode measurement setup assumes that the current passes through the coating immediately below the attached electrode and proceeds through the substrate to the clip. The two-electrode measurement setup assumes the current passes between the electrodes by passing twice through the coating below the electrodes and the substrate between them. A conductive layer (e.g. of grease or water) present at the surface may cause the spread of the current outside the electrode area in the one-electrode setup or surface current between the electrodes, in the two-electrode setup. For proper measurement, the surface of the coating should be clean and dry. If the coating has been exposed to humid conditions or immersed, the surface should be thoroughly dried by firmly rubbing it with a paper towel for c.c.a 15 seconds and letting it dry for minimum 2 and maximum 5 minutes before placing the electrode on the coating surface and performing the measurement. Special care has to be taken not to smear the electrolyte over the surface and short circuit the electrodes. Cleaning or degreasing the electrode with various chemicals may also cause surface conduction. **Surface conduction will result in falsely low coating impedance.** Absorption of water into the coating may also cause spreading of the current in a one-electrode setup and current flowing between the electrodes through the coating in a two-electrode setup, i.e. the so called parallel conduction. However, this effect is unlikely in most cases due to the much shorter current path and much higher cross section area for the flow of current below the electrodes as opposed to that between the electrodes. **The appearance of parallel conduction would indicate a high degree of water absorption into the coating in combination with the high coating adherence to the substrate.**

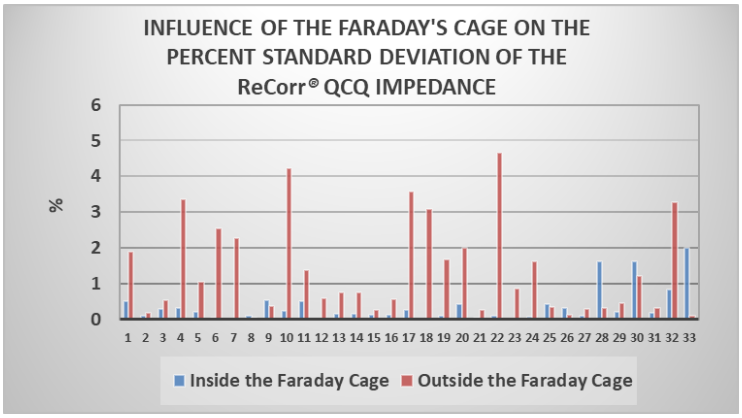
To check for surface or parallel conduction, the electrodes may be placed at a closer or greater distance or opposite to one another. Measurements should be done between the electrodes (two-electrode setup) and between each of the electrodes and the substrate (one-electrode setup). Figures on the right show measurements for three intact and the three coatings degraded by immersion in 3.5% NaCl, demonstrating the results obtained in the absence of surface and parallel conduction. **When no surface or parallel conduction is present, close, distant and oppositely placed electrode setups, providing that the coating is homogeneous, should yield similar results. The impedance measured by the two-electrode setup should approximately equal sum of the impedances of the two electrodes measured by the one-electrode setup, irrespective of the coating homogeneity. On homogeneous coatings, each of the electrodes yields approximately ½ of the impedance obtained by the two-electrode arrangement.**





AVOIDING AC INTERFERENCES





Coating impedance measurements are subject to AC interferences if such influences exist at the location of measurement. This effect may be particularly pronounced for the coatings with impedance >108 W cm2 and at frequencies lower than 10 Hz. The interferences have a much larger effect on the phase angle than on the modulus of impedance. To avoid the influence of AC interferences on the coating assessment, the measurement in the laboratory may be done in the Faraday's cage. Due to the adequate shielding of the instrument and the cables, in many instances, ReCorr® QCQ Device will enable measurements of acceptable quality on high impedance coatings, even outside of the Faraday's cage. Additionally, averaging of up to 10 repeated single frequency measurement @0.1 Hz will increase the precision of measurements. Comparison of the impedances @0.1 Hz for 33 specimens of industrial coating systems measured inside and outside of the Faraday's cage is shown on the upper figure on the right. In the lower figure shows percent standard deviation which equals the maximum 2% in the Faraday's cage and id slightly lower than 5% outside of the cage.

For a detailed strategy of measuring and avoiding of AC interferences in the laboratory and in the field, please see the ReCorr® QCQ Software documents provided with the device or contact us at info.@recorrtech.com.

TEMPERATURE AND HUMIDITY INFLUENCE

A strong influence of the temperature on the coating impedance has been observed in the ISO 16773 glass cell filled with liquid electrolyte and subjected to temperature cycles spanning through dozens of degrees and lasting for 10 hours. Pronounced temperature effect on polymeric coating impedance may be explained by the movement of polymeric chains with the increase in temperature, the increase in the polymer free volume, ingress of the electrolyte into the coating polymer, clustering of water molecules and linking of the water clusters into continuous conductive paths within the coating. In ReCorr® QCQ Test, no liquid electrolyte contacts the coating, and the impedance results reflect the impact of the corrosive environment on the coating without the measuring cell electrolyte uptake interference. The result will, therefore, be predominantly influenced by the temperature and the humidity of the surroundings in which the sample has been conditioned. In the accelerated corrosion tests, the sample is conditioned in the artificial corrosive environment. For the measurement, it is shortly removed from that environment and immediately subjected the ReCorr® QCQ measurement. The fastness of the measurement procedure enables the coating to remain in the conditioned state, and the measurement itself to be greatly insensitive to the laboratory environment. In the case of the field measurements, the impedance depends on the atmospheric conditions that have stabilized the coating. The temperature of the environment, the temperature of the coating surface and the air relative humidity should be recorded along with the ReCorr® QCQ measurements.