ACCELERATED CORROSION TESTING OF REINFORCING STEEL EMBEDDED IN CONCRETE

by

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ABSTRACT

Deterioration of reinforced concrete structures resulting from corrosion of the reinforcing steel is a growing and a major worldwide problem. The seriousness of the problem is illustrated by the fact that corrosion costs over $15 billion per year in the United States. In the United Kingdom, approximately US $900 000 is being spent annually on surveying buildings and civil engineering structures suffering from deterioration.

Generally, the deterioration is the result of cracking and spalling of the concrete, which in turn is the result of its property deficiencies, high permeability, low strength, poor durability, sensitivity to freezing and thawing. The intrusion of chlorides into the concrete causes corrosion of the embedded reinforcing steel. Accumulation of corrosion products around the reinforcing bar develops more cracks in the protective concrete cover due to expansion, allowing penetration of additional deleterious materials, thereby accelerating corrosion, causing more spalling, and adversely affecting the structural integrity.

The theoretical part of this thesis reviews the basic corrosion concepts, types of corrosion, the corrosion of

reinforcing steel and the techniques of protection from corrosion. In addition, the various available corrosion testing methods are reviewed.

The second part describes the experimental work carried out at McGill University dealing with accelerated electrochemical corrosion testing of reinforced concrete. The effect of clear concrete cover depth on the corrosion of reinforcing steel and the preventive effects of epoxy coating bars, concrete surface sealant coating used as a protection measures for steel in concrete are studied.

The results of the various test series including the experimental data along with the conclusions and appropriate recommendations are presented.

RÉSUMÉ

La détérioration des structures en béton armé causée par la corrosion de l'acier de l'armature est devenue intéressante de plus en plus, car maintenant elle est un problème d'ordre mondial. L'importance de ce problème est illustré par les dépenses payées aux États-unis d'une valeur de $15 billions chaque année. En Angleterre, chaque année, les travaux de maintenance des structures qui souffrent de problèmes de détérioration, coûtent $900.000.

Généralement, la détérioration est causée par la fissuration du béton, qui, à son tour est la cause des défauts dans les propriétés de béton conventionnel, comme avoir une perméabilité élevée, une faible résistance, une courte durabilité, être sensible à la congélation et la dégélations. L'intrusion de chlorure dans le béton cause la corrosion de l'acier enfoncé dedans. L'accumulation de ces substances corrosives autour de la barre d'acier et dans les fissures cause une expansion du béton et par conséquent l'augmentation du volume et nombre des fissures; permettant la pénétration additionnelle des matières nuisibles, et par la suite l'accélération de la corrosion augmente encore les fissures et affecte l'intégrité de structure.

La partie théorique de cette recherche traite la conception fondamental de la corrosion, les types de corrosion, la corrosion de l'acier de l'armature, les techniques de protection contre la corrosion, en plus des méthodes d'utilisations de différents tests de corrosion ont été étudiés.

La deuxième partie décrit le travail expérimental effectué à l'université McGill qui a traité les tests de corrosion électrochimiques du béton armé, l'effet de l'épaisseur nette de la couverture de béton sur le taux de corrosion de l'acier de l'armature et l'effet des barres d'acier revêtues par l'époxy. Ainsi, la surface de béton revêtue par des matières étanches comme des mesures de protection pour l'acier de l'armature, a été étudiée.

Les résultats des différents séries de tests incluant les résultats expérimentaux et leurs conclusions en plus de quelques et des recommandation appropriées ont été présentés.

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GLOSSARY OF CORROSION TERMS

Active. Freely corroding

Anion. Negatively charged ion, which migrates to the anode of a galvanic or voltaic cell.

Anode. An electrode at which oxidation of the surface or some component of the solution is occurring.

Anodic polarization. That portion of polarization of a cell which occurs at the anode.

Cathode. The electrode of an electrolyte cell at which reduction occurs. In corrosion processes, it is usually the area that is not attacked. Typical cathodic processes are cations taking up electrons and being discharged, oxygen being reduced, and the reduction of an element or group of elements from a higher to a lower valence state.

Cathodic polarization. That portion of the polarization of a cell which occurs at the cathode.

Cation. A positively charged ion of an electrolyte, which migrates toward the cathode in a galvanic or voltaic cell.

Electrode potential. The potential of an electrode as measured against a reference electrode. The electrode potential does not include any resistance loss in potential in solution due to the current passing to or from the electrode.

p. XXI missing

Electrolysis. The chemical change in an electrolyte resulting from the passage of electricity.

Electrolyte. A chemical substance or mixture, usually liquid, containing ions which migrate in an electric field.

Electromotive force series (Emf series).
A list of elements arranged according to their standard electrode potentials, the sign being positive for elements whose potentials are cathodic to hydrogen and negative for those anodic to hydrogen.

Embrittlement. Severe loss of ductility of a metal or alloy.

Film. A thin , but not necessarily visible layer of material.

Galvanic cell. A cell made up of two dissimilar conductors in contact with an electrolyte.

Galvanic Series. A list of metals and alloys arranged according to their relative potentials in a given environment.

Hydrogen embrittlement. Embrittlement caused by entrance of hydrogen into a metal.

Impingement attack. Corrosion associated with turbulent flow of a liquid.

Inhibitor. A chemical substance or mixture which, when added to an environment usually in small concentration, effectively decreases corrosion.

Ion. An electrically charged atom or group of atoms.

Noble metal. A metal which occurs commonly in nature in free state. Also, a metal whose corrosion product are formed with a low-negative or a positive free-energy change.

Oxidation. Loss of electrons by a constituent of chemical reaction.

Passivation. A reduction of the anodic reaction rate of an electrode involved in electrochemical action such as corrosion.

pH value. Measure of acidity or alkalinity. A scale ranging from 0 to 14 is used to express acidity or alkalinity of aqueous solutions. Values ranging from 7 to 0 denote increasing acidity and from 7 to 14 increasing alkalinity.

Polarization. The deviation from the open circuit potential of an electrode resulting from passage of current.

Potential. Electrical state of a body which promotes the exchange of electrons with a second body. The potential difference is measured in volts.

Reduction. An electrochemical reaction which is reverse of oxidation. A chemical change of state in which the substance gains electrons.

Rusting. Corrosion of iron resulting in formation of products on the surface consisting largely of hydrous ferric oxide.

Sacrificial protection / anodes / pieces.
A detailed description is provided in Section 4.4.1

Spalling. The chipping or fragmenting of a surface or surface coating caused, for example, by differential thermal expansion or contraction

CHAPTER 1

INTRODUCTION

1.1 Corrosion

CORROSION, is often mentioned in different fields of sciences, because of the importance of this natural event. The origin of this word comes from the latin word CORRODERE which means "gnawing away". Rusting of iron and steel is the most well known form of corrosion. Similar processes occur in the other metals and also in non metallic materials such as concrete.

Two of the definitions were given to this process by scientists and engineers are:

- Corrosion is an involuntary destruction of substances like metals and mineral building materials by the surrounding media, which are usually liquid. It usually begins at the surface and is caused by chemical, or electrochemical reactions.
- Corrosion is the destructive attack of a metal by chemical or electrochemical reaction with its environment.

From the above two definitions it can concluded that both definitions have the same connotation, that is, it is an attack by the environment causing deterioration in metallic and non-metallic materials.

1.2 IMPORTANCE OF CORROSION

The importance of corrosion studies is twofold. The first is economic, including the reduction of material losses resulting in the wasting away or sudden failure of piping, tanks, concrete and metallic structures.
The second is conservation, applied primarily to metallic resources, whose supply around the world is limited. Also, the wastage of these resources includes the corresponding losses of energy accompanying the production and fabrication of metal and concrete structures. The accompanying conservation and optimization of the human effort required for design and rebuilding of corroded metal equipment, bridges, structures, etc.., is equally important.

Economic losses are divided into (i) direct losses and (ii) indirect losses. The direct losses consist of the cost of replacing the corroded structures and their components such as pipelines, metal roofing or repainting of structures where prevention of rusting is the main objective. The indirect losses are more difficult to assess, but a brief survey of typical losses of this kind leads to the conclusion that they total several billions of dollars more than the direct losses already outlined. Examples of indirect losses are:

1. Shutdown. The replacement of a corroded tube in an oil refinery may cost a few hundred dollars, but a shutdown of the unit while repairs may cost $800 per hour in lost production[20].

2. Loss of product. Losses of oil, gas or water occur through a corroded pipe system until repairs are made.

3. Overdesign. This factor is common in the design of water tanks, bridges, and many important structures. Because corrosion rates are unknown, and because the methods of corrosion control are uncertain, they are often designed significantly larger than that required for normal or applied stresses to ensure a reasonable service life.

With an adequate knowledge of corrosion, more reliable estimates of equipment service life can be made, and construction cost can be reduced in terms of materials and labour.

The economic importance of corrosion and corrosion protection can be shown by the following examples:

It is estimated that roughly 3% of the annual production of steel is lost by corrosion.

The collapse of the Silver Bridge into the Ohio river, (because of stress corrosion) cost 40 lives and million of dollars[11].

A chemical company spends $2 million dollars per year on painting steel to prevent rusting from marine environment. Costs of corrosion will escalate substantially in the next few decades because of the worldwide shortages of construction materials, higher energy costs, aggressive corrosion environments in coal conversion processes, and other factors.

Therefore, it is extremely important to reduce as far as possible the financial loss due to corrosion, which not only affects steel but to some extent all other structural materials as well.

1.3 CORROSION OF CONSTRUCTION MATERIALS

Concrete and steel are the major materials used in the construction industry. Therefore, the following discussion concentrates on these materials.

When concrete corrodes, the corrosive substances are carried to the building materials by means of aqueous solutions (natural and industrial waters, gases dissolved in moisture etc..). New readily soluble compounds can be formed on the surface, causing solution corrosion. Swelling corrosion can take place by the formation of voluminous new compounds produced inside the material.

The factors which cause the destructive reactions affecting construction materials are manifold. The following are the most important:

1.3.1 Physical factors:

Heat

Temperature variation

Frost

Running water

Solar radiation (particularly ultraviolet rays)

Wind

Dust

1.3.2 Chemical factors:

Acids

Alkalis

Salt solution

Organic materials

Flue gases

1.3.3 Biological factors:

Microorganisms

Fungi

Algae

Marine animals

Insects

Worms

Multicellular plants

These factors may act singly, but usually more than one factor are involved, thereby increasing the degree of corrosion. The most important factors causing corrosion of construction materials are generally chemical in nature. In addition, humidity in its various forms (rain, condensation, fog, high atmospheric humidity, ground water, steam, sea water, river water) is always a necessary precondition for corrosion under normal conditions.

1.4 COST OF DAMAGE DUE TO CORROSION

Corrosion of steel reinforcing bars is a problem in many structures (i.e., pier and buildings), but it is a major problem (because of deicing salts) in highway bridges, large parking areas. It is a problem of multibillion dollars in Canada and the United states. One study has estimated that an additional $3 trillion dollars are needed to be spent in the United states during the next decade simply to halt the rate of deterioration. This cost seems to be very large, however, rough estimates and evaluation of the cost of repairing and protecting bridge decks and parking structures shows beyond doubt that this estimate is reasonable.

1.4.1 Bridge Deck Repair Costs

According to data from the National Bridge Inventory file,in the Northeast, Midwest, and Mountain regions in the USA --where deicing salts are used commonly--approximately 60,000 decks less than 20 years old are now in sound condition and potentially vulnerable to chloride contamination from continued salting. On the basis of historical rates of deck deterioration in these salt-using regions, one would expect about 15 percent, or 10,000 of these bridge decks, to become seriously damaged during the next 10 years.

The following rough calculation suggests that about 10,000 decks will become damaged during the next 10 years because of continued salting.

To estimate the average annual cost of repairing these damaged decks, it can be assumed (for simplicity) that about 1 in 10, or 1000, will need to be rehabilitated each year during the 10-year period. The typical surface area of a deck is 7,000 ft^2 (650 m^2).
Multiplying this figure by 1000 damaged decks yields around 7 million ft^2 of deck surface that will need to be rehabilitated each year. According to estimates provided by the California and New York State Highway Departments, the average cost of rehabilitating a concrete deck, wherein the concrete is completely removed and replaced and the

reinforcing steel is cleaned, is between \$20 and \$40/ft^2. This results in a cost of about \$280 million per year to repair deteriorated bridge decks with surface areas around 7 million ft^2 (650300 m^2).

An analysis of the National Bridge Inventory file indicates that between 3,000 and 4,000 new decks are constructed each year in salt-using regions, where deck protection is necessary. Multiplied by the average deck surface area of 7,000 ft^2, the total area of these 3,000 to 4,000 new decks range between 20 million and 30 million ft^2. Hence, given an incremental protection cost of \$4/ft^2, the total annual cost of new deck protection is \$75 million to \$125 million[46,47] (rounded to the nearest \$25 million).

During the next 10 years, the total cost of protecting newly constructed decks and restoring currently sound (and uncontaminated) decks that become damaged by salting will be roughly \$325 million per year.

1.4.2 Parking Structure Repair Costs

There are some 5,000 parking garages in the Northeast and Midwestparts of the USA. Like bridge decks, many older parking garages are critically contaminated with salt and will need to undergo major rehabilitation in the near future. Accordingly, a priority of the parking garage industry is to protect newer garages not already critically contaminated with chloride. During the next ten years, the total cost of protecting new garages ($30 million) and rehabilitating currently sound garages that become damaged by continued salting ($50 million to $150 million) will be roughly $75 million to $175 million per year[50,69,70].

As mentioned before, the huge cost of replacement or rehabilitation of these important structures puts the engineering community on the alert. Time is running out, and this necessitates special attention to the development of new techniques to protect against damages caused by corrosion.

1.5 Scope Of The Thesis

The protection of reinforcing steel embedded in concrete is the main general objective of this research program. This can be achieved by different methods. Evaluating the effect of clear concrete cover depth on the corrosion of reinforcing embedded in concrete is the point of interest in this thesis. This phenomenon will be studied in this research program by running an accelerated electrochemical corrosion experiment with different variables such as improving the quality of concrete cover, using epoxy coated bars and different kinds of surface sealing for different concrete cover depths.

The basic corrosion concepts, which covers the mechanism of corrosion, polarization, passivity, and the various types of corrosion will be reviewed in Chapter 2.

The corrosion of reinforcement steel including the main causes of rebar corrosion, the effect of concrete properties, and the service life of the structures as related to reinforcement corrosion will be the main subject of Chapter Three.

Chapter 4 outlines the techniques and the methods used in protecting the reinforcement steel from corrosion.

Chapter 5 presents the various corrosion testing methods that can be used to predict the likelihood of corrosion taking place, and identify the areas of structure which are of a higher risk.

The description of the experiment set-up, the details of the research program carried out at McGill University during the year 1992-1993 and the results of the tests will be presented in Chapter 6.

Analyzing of the results obtained from the various test series, the effect of using the epoxy coated bars, the effect of surface sealing, and the effect of concrete quality on corrosion are discussed in Chapter 7. In addition, the summary and the conclusions of this test program are presented.

It is hoped that this further informations on the corrosion phenomenon and the results obtained from the various test series will prove to be of value in the quest to provide practical solutions to the problem.

CHAPTER 2

BASIC CORROSION CONCEPTS

2.1 INTRODUCTION

Knowledge of fundamental concepts of corrosion is necessary to understand the corrosion process. Because of its broad scope, this chapter deals only with the basic principles involved in the corrosion process, The parameters that affect the corrosion process are defined and classified. Corrosion is divided into two categories: wet corrosion and dry corrosion. This chapter deals primarily with wet corrosion and covers the corrosion mechanism forms and the effects of environmental factors, The basic components of a corrosion cell are explained. The principles of polarization, and the rate of corrosion are reviewed. Examples are used throughout the chapter to illustrate applications of the various principles. Forms of corrosion such as uniform and pitting attack are presented. The environmental influences discussed include biological corrosion, and stray currents.

Within the corrosion theory one can distinguish concepts which are of fundamental importance. Furthermore, one can divide the subject area in various ways, according to the corrosion type, corrosive medium, the method of corrosion protection, the type of material or field of application, etc.

2.2 CORROSION MECHANISM

Corrosion occurs by chemical or electrochemical reactions. An example of a chemical reaction is the dissolving of a metal by an acid. An electrochemical reaction involves metals, chemicals, and water that combine to form cells capable of generating electricity. Through the action of these cells, metals revert back to their native compounds by using electricity as a source of energy.
According to the International Standards ISO 8044[23], "corrosion was defined as a physicochemical interaction between a metal and its environment which results in changes in the properties of the metal and which may often lead to impairment of the function of the metal, the environment or the technical system of which these form a part".
This interaction is usually of an electrochemical nature.

2.3 ELECTROCHEMICAL CORROSION

All metals are thermodynamically unstable and tend to react with their environment to produce compounds such as oxides or carbonates. This reaction involves the movement of electrons and is called the electrochemical reaction.

The most common forms of metallic corrosion are caused by electrochemical reactions, wherein two metallic phases (e.g. iron oxide and iron) react in the presence of electrolytic solutions.

2.3.1 Electrochemical Reactions

An electrochemical reaction is characterized by the fact that it takes place with donation and receiving of electrons. Such a reaction can be schematically represented:

$$Ox + n\bar{e} \underset{oxidation}{\overset{reduction}{\rightleftharpoons}} RED, \quad \text{(Eq. 1)}$$

where red is a reducing agent (electron donor), Ox is an oxidizing agent (electron acceptor) and n is the number of electrons(e-), taking part in the reaction.

When a reaction takes place with the emission of electrons, (i.e. when it goes to the left in Equation 1), it is termed oxidation. If it takes place with consumption of electrons, (i.e. it goes to the right in Equation 1), then it is termed reduction. A reducing agent and an oxidation agent associated as indicated by the formula are often called a redox pair and the reaction a redox reaction. Electrons cannot exist free in a solution in any significant concentration. The electrons emitted in an oxidation reaction must therefore be used up in a simultaneous reduction reaction. It is possible that the reactions take place by contact between an oxidizing agent and a reducing agent, both of which are in the solution, for example:

Oxidation:	$2Fe^{2+} \longrightarrow 2Fe^{3+} + 2e^-$	(Eq. 2)
Reduction:	$\frac{1}{2} O_2 + H_2O + 2e^- \longrightarrow 2OH^-$	(Eq. 3)

Total reaction: $2FE^{2+} + \frac{1}{2}O_2 + H_2O \longrightarrow 2FE^{3+} + 2OH^-$

Alternatively, the reaction can take place in an electrochemical cell (Fig. 2.1).

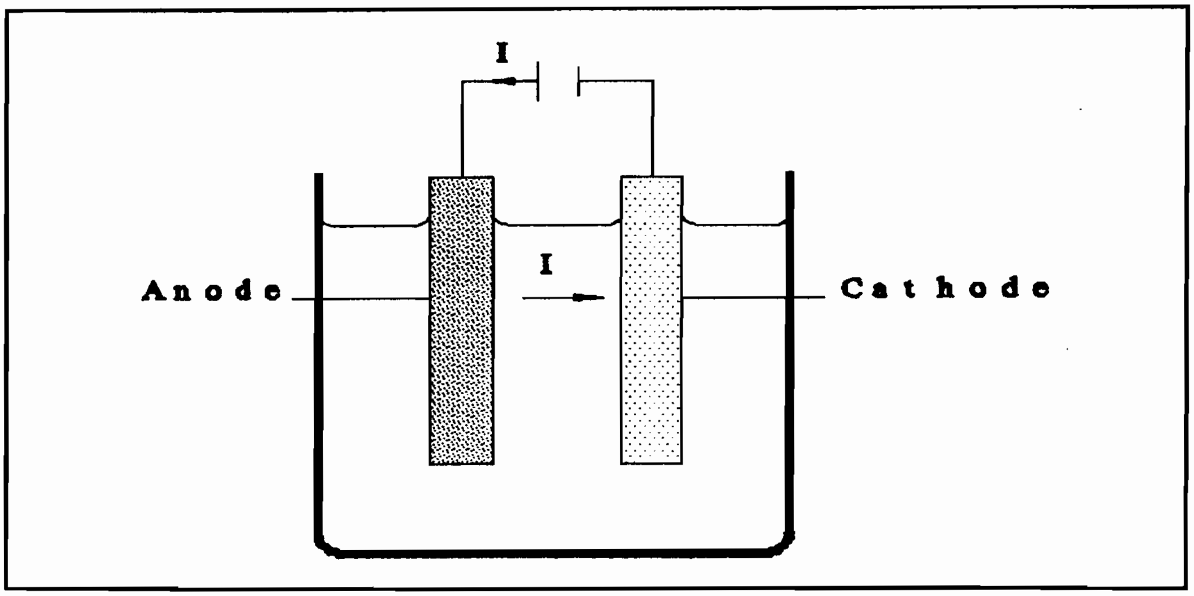

Figure 2.1 Electrochemical cell; the arrows show the direction of the electric current (I)

An ordinary electrochemical cell consists of two electrodes connected by an electrolyte. The electrodes are made of an electron conductor, e.g. a metal which is in contact with an electrolyte.

The electrolyte is often an aqueous solution having the ability to conduct electricity. The current is conducted through the electrolyte by ions. The electrode from which the positive electric current enters the electrolyte is called the anode. The other electrode, through which the electric current leaves the electrolyte, is called the cathode.

When the electric current passes through an electrode surface in one direction or the other, an electrochemical reaction always takes place. This is called an electrode reaction, The electrode reaction at the anode, i.e. the anodic reaction, is always an oxidation reaction. Similarly, the cathodic reaction which occurs at the cathode is always a reduction reaction .

An electrochemical cell, in which the current flow is forced by an external source, is called an electrolytic cell. An electrochemical cell, which can itself produce an electric current, is called a galvanic cell.

2.3.2 Faraday's Law

The current entry into and exit from an electrolyte are always associated with electrode reactions which are manifested as change in the electrode materials or the environment. The quantities converted during electrode reactions are proportional to the amount of current which passes through the electrode surface. This is governed by **Faraday's law**, according to which it requires 96,500 Coulombs (ampere-seconds) or 26.8 Ah(ampere-hours) for a conversion including one mole of electrode (e^-).

The current efficiency for a given electrode reaction gives the proportion of current through the electrode surface, which is required for that reaction. The remainder of the current is consumed by other electrode reactions which take place simultaneously at the electrode surface.

2.3.3 The Concept Of Electrode Potential

If a piece of metal, Fe, is surrounded by an aqueous solution containing ions of the metal, Fe^{n+} ,then electrode reactions take place at the surface of the metal until equilibrium is reached:

$$Fe^{n+} + ne^{-} \rightleftharpoons Fe. \qquad \text{(Eq. 4)}$$

These reactions lead as a rule to an <u>electrical double layer</u> being established in the interface region (Fig.2-2).

The existence of this electrical double layer means that the piece of metal now has another electrical potential, that is, the so-called Galvanic potential (ϕ_1) compared with the solution potential (ϕ_2).

The difference in Galvanic potential, (ϕ_1-ϕ_2), cannot as a rule be determined by direct measurement but a relative value can be

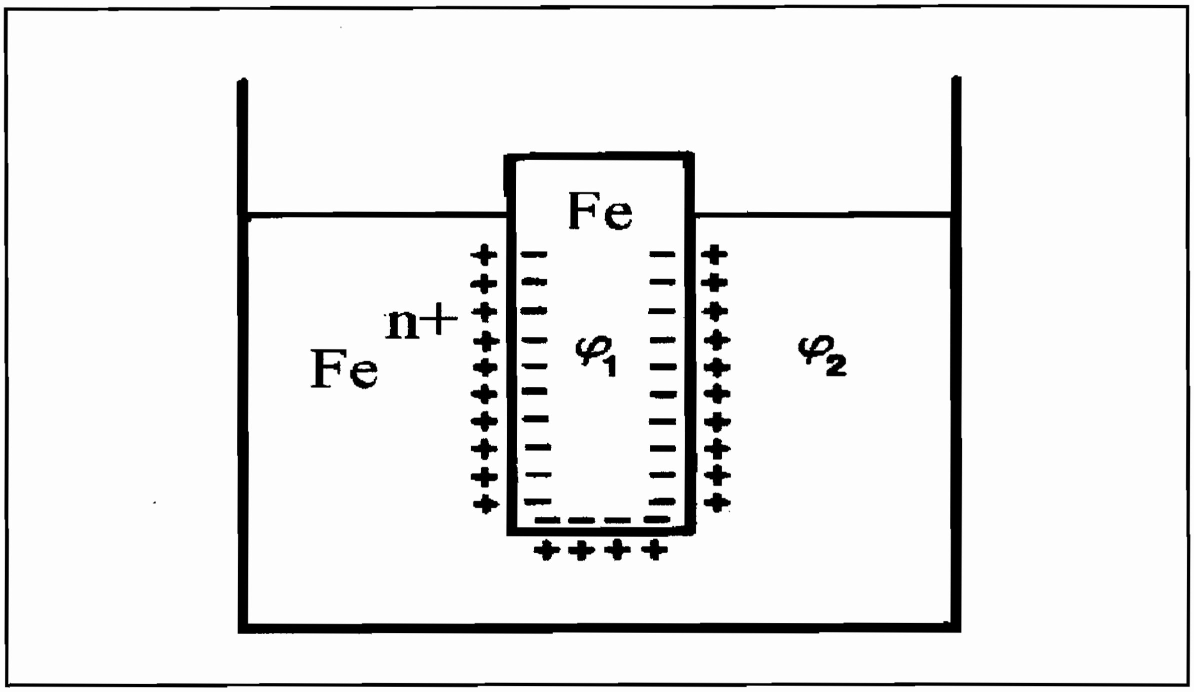

Figure 2-2 Metal (Fe) in an aqueous solution containing the metal ions, Fe^{n+}; an electrical double layer has formed.

measured in comparison with the Galvanic potential difference of a so-called reference electrode. This measurable relative value is called the electrode potential and is designated by the symbol E.

2.3.4 The Galvanic Cell

It was mentioned before that an electrochemical cell having the ability to produce electric current itself, is called a galvanic cell (Fig. 2.3). If the electrodes of such a galvanic cell are coupled using an external metal conductor, an electric current will flow from one electrode (positive pole) to the other (negative pole). On the other hand, in the electrolyte the current will flow in the opposite direction, as indicated in (Fig. 2.3). Therefore, the positive pole acts as the cathode and the negative pole as an

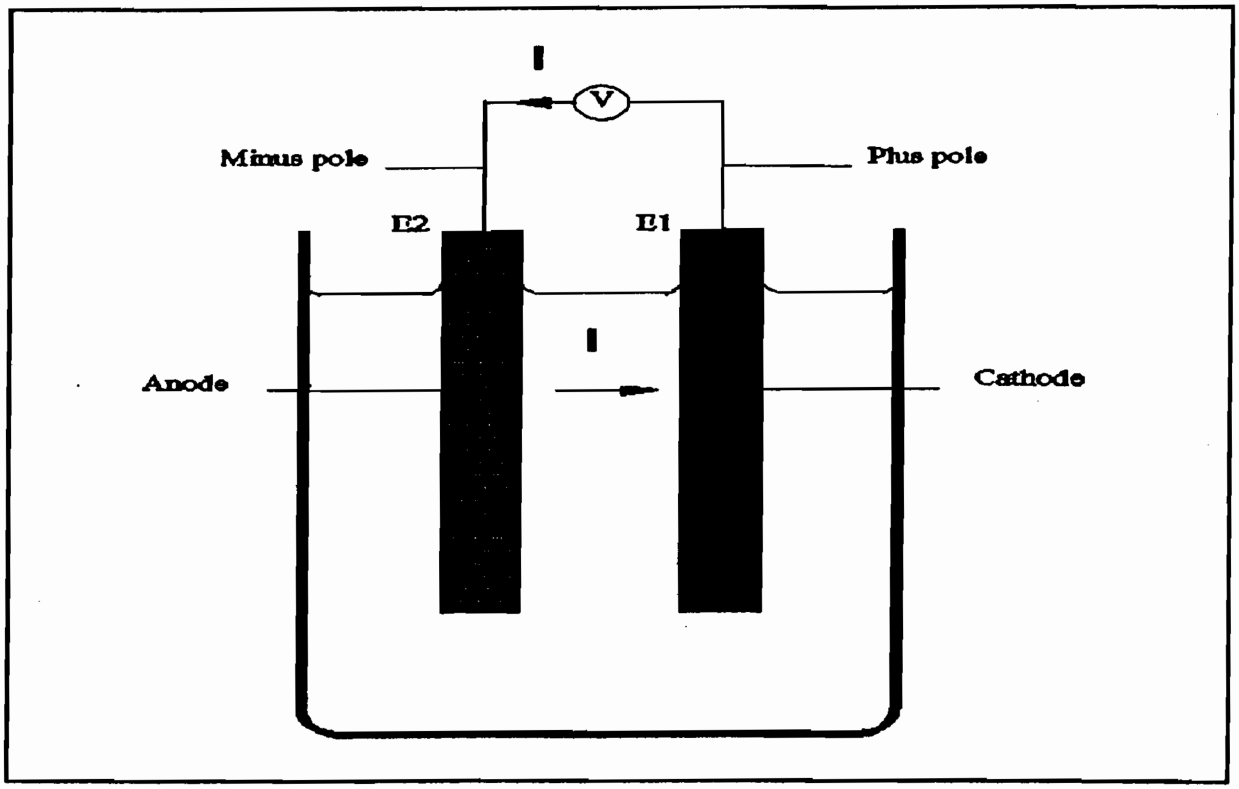

Figure 2-3 : Galvanic cell with voltmeter

anode. The electrical potential difference between the electrodes, which can be measured with a voltmeter is called the terminal voltage. The terminal voltage measured when the galvanic cell is not producing current is called the electromotive force, or the e.m.f. The electromotive force is a measure of the driving force of the chemical reaction that takes place in the cell, when the electrodes are connected by a metal conductor. The electromotive force (ΔE) can be calculated from the potentials(E_1 and E_2) of the electrodes making up the cell:

$$\Delta E = E_1 - E_2 .$$

Each electrode with its surrounding electrolyte is called a half cell.

2.3.5 Reference Electrodes

The potential of an electrode has an absolute value, the Galvanic potential difference, but this is difficult to measure experimentally. The interest is usually centered on the reaction which occurs at one electrode only. Measurements are made by using an electrode which has a relatively fixed value of potential, regardless of the environment in which it is used, called a reference electrode. Therefore any change occurring in the emf is the result of change in the potential of the electrode under observation and not of the reference electrode. Examples of reference electrodes are:

- The standard hydrogen electrode (SHE) consisting of a platinum wire platinized by electrolysis, which is surrounded by a solution having a H^+ ion activity of 1 and bathed in hydrogen gas at 1 atmospheric pressure.

- The calomel electrode, which consist of mercury in equilibrium with Hg_2^{++} , its activity is determined by the solubility of Hg_2Cl_2 (mercurous chloride or calomel).

In technical experimental work it is normal to make measurements with the saturated calomel electrode SCE .

2.3.6 Polarization

An electrode is no longer in electrical equilibrium when a net current flows to or from its surface. The measured potential of such an electrode is altered to an extent depending on the magnitude of the external current and its direction. The direction of potential change is always such as to oppose the shift from equilibrium and hence to oppose the flow of current, whether the current is impressed externally, or it is of galvanic origin. When current flows in a galvanic cell for example, the anode always becomes more cathodic in potential and the cathode always becomes more anodic, with the difference of potential decreasing.
The extent of potential change caused by net current to or from an electrode, measured in volts, is called polarization.
Polarization can be divided into two main components:

- Concentration polarization, caused by the difference in concentration between the layer of electrolyte nearest the electrode surface and the bulk of electrolyte.

- Activation polarization, caused by a retardation of the electrode reaction.

The polarization of an anode is always positive and that of a cathode is always negative (Fig.2-4).

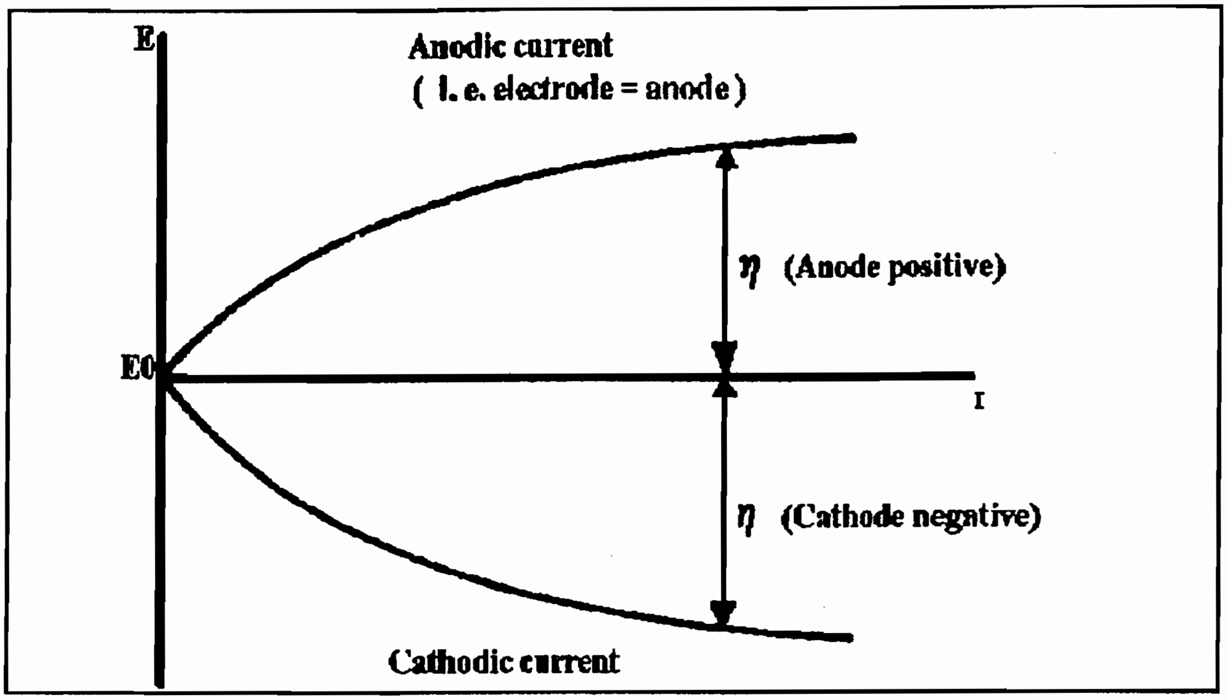

Figure 2-4 : Anodic and cathodic polarization curves; E=electrode potential, i=current density, η=polarization

Polarization reduces the terminal voltage of a galvanic cell, as the current drawn from the cell increases. When current is passed through an electrolytic cell from an external source, the polarization produced will lead to the need for a higher applied voltage.

2.3.7 Electrolytic Conductance

The flow of current in an electrolyte solution takes place via the movement of ions;anions (negatively charged) and cations (positively charged) (Fig.2.5). Cations migrate in the direction of the current and anions against it. In some parts of the solution,

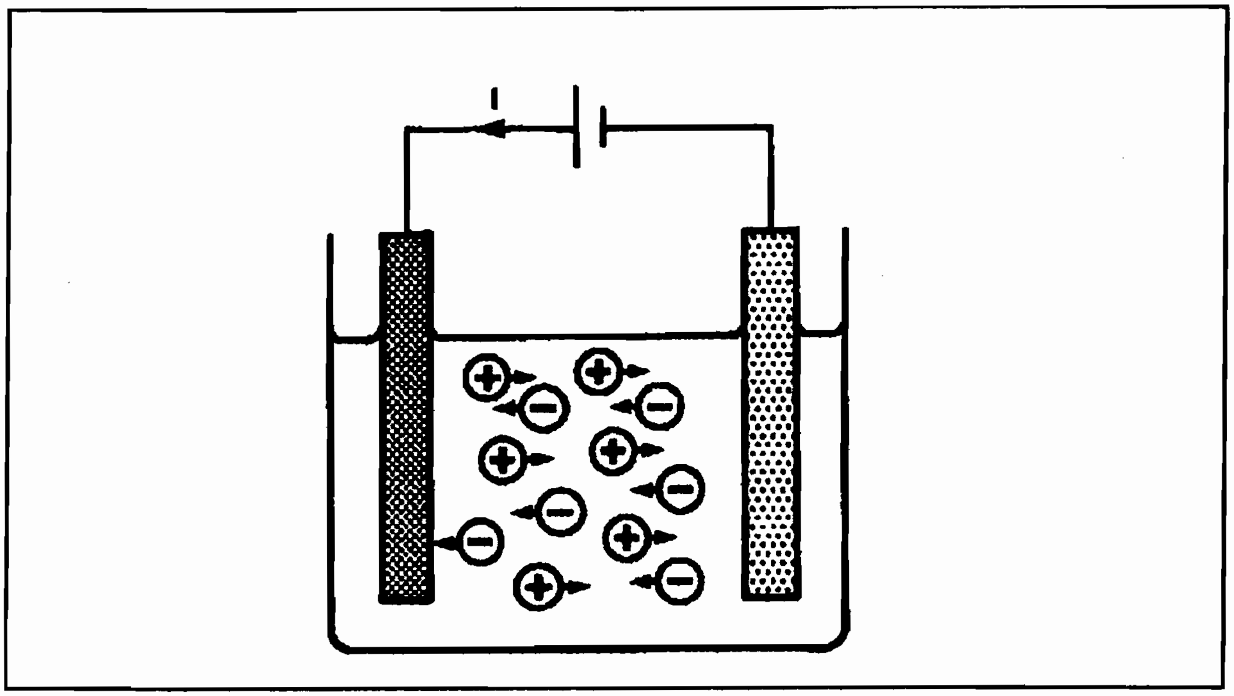

Figure 2-5 : Transport of electric current through electrolyte.

there is always electro-neutrality which means that the anions and cations balance each other.

Ohm's law applies for transportation of current through the electrolyte solution:

$$U = I.R \, , \qquad \text{(Eq. 5)}$$

where **I** is the current strength in amperes, **U** is the potential difference between the electrodes in volts and **R** is the resistance of the electrolyte in ohms.

Further:

$$\frac{1}{R}=L \, , \qquad \text{(Eq. 6)}$$

where **L** is the conductance of the electrolyte in $ohms^{-1}$.

2.3.8 The Rate Of Corrosion

If a thermodynamic driving force* exists for a corrosion process, then it will take place. The rate of corrosion can, however, vary within wide limits. In certain cases, it can be large and it can cause serious damage to the material. In other cases, it can be small and of little practical importance; This is a result of inhibition of one or more of the electrode reactions.
The extent of corrosion can be expressed in a variety of ways, such as the change in weight of the material, the depth of the surface zone which has been corroded away, the number or quantity of pits formed, the amount of corrosion product, changes in the ultimate strength, yield strength or rupture strain of the metal, etc. The changes in magnitude of these phenomenological entities per unit of time is a measure of the corrosion rate. Another measure is the density of the corrosion current. In Table 2.1, some of the most frequently encountered units of corrosion rate are given.

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* The driving force of corrosion : In general it is a 'return' to the ore composition which takes place when a metal corrodes. An example is the rusting of steel.

Table 2.1 - Various units of corrosion rates

Corrosion effect	Unit
Weight change	g/m^2 /year
	mg/m^2 /day
Increase in corrosion depth	μm/year
	$\mu m/year=10^{-3}$ mm/year
	inch per year=25.4mm/year
	mil per year=mpy=10^{-3} ipy =25.4 μm/year
Corrosion current	mA/cm^2
Decrease in ultimate strength strength or rupture strain	per cent/year (of the yield initial value)

If the corrosion rate is expressed as the corrosion current density then a retardation of the reaction will become apparent in the form of polarization. The polarization curves displaying this effect for the electrode reactions in the corrosion process can be shown on an Evans diagram (Fig.2-6).

In the Evans diagram[9,10], the polarization curves have been drawn for both the anodic metal oxidation, and for the cathodic reduction process. The intersection of these two curves provides information about the corroding electrode. I is the corrosion current and E is the mixed potential, called the free corrosion potential, which can

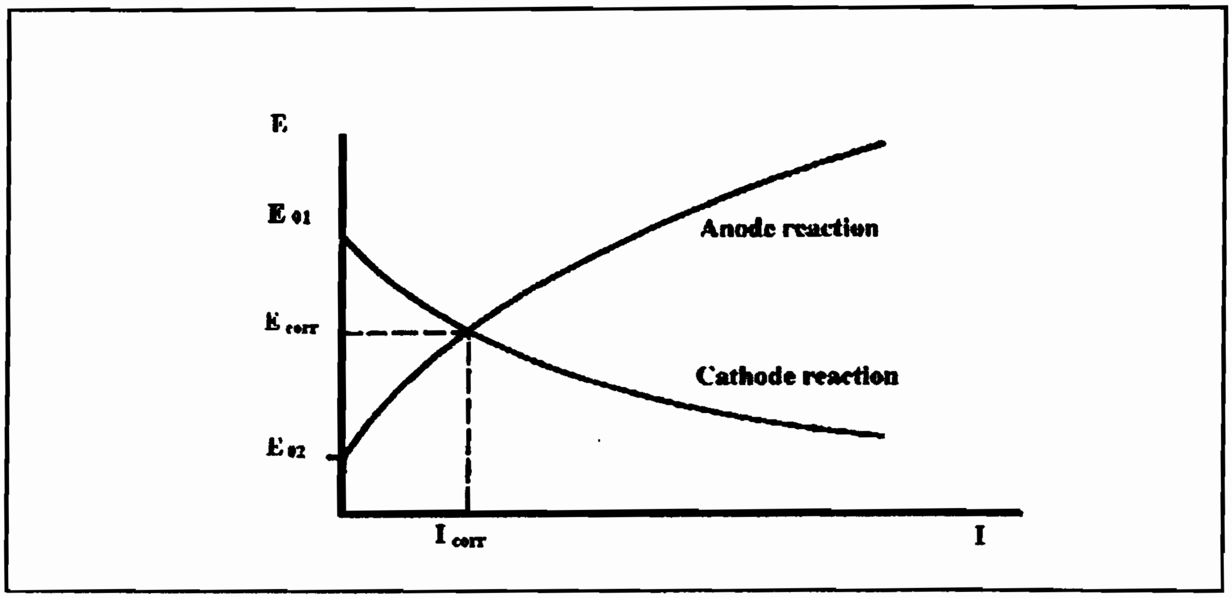


Figure 2-6 : Evans diagram; E=electrode potential, I=current.

be measured for the corroding electrode.

As can be seen from the Evans diagram, the position of the intersection of the two curves and thereby the magnitude of the corrosion current is determined by the form of the polarization curve. When there is a high cathodic polarization (Fig.2-7), the corrosion process is said to be under a <u>cathodic control</u>. Alternatively, if the anodic polarization is dominant (Fig.2-8), the corrosion process is termed to be under <u>anodic control</u>. In cases where the anodic and the cathodic polarization are of the same order of magnitude, the control is mixed (Fig.2.6).

The Evans diagram is applicable in many other similar cases for the schematic description of the polarization curves of corrosion cells.

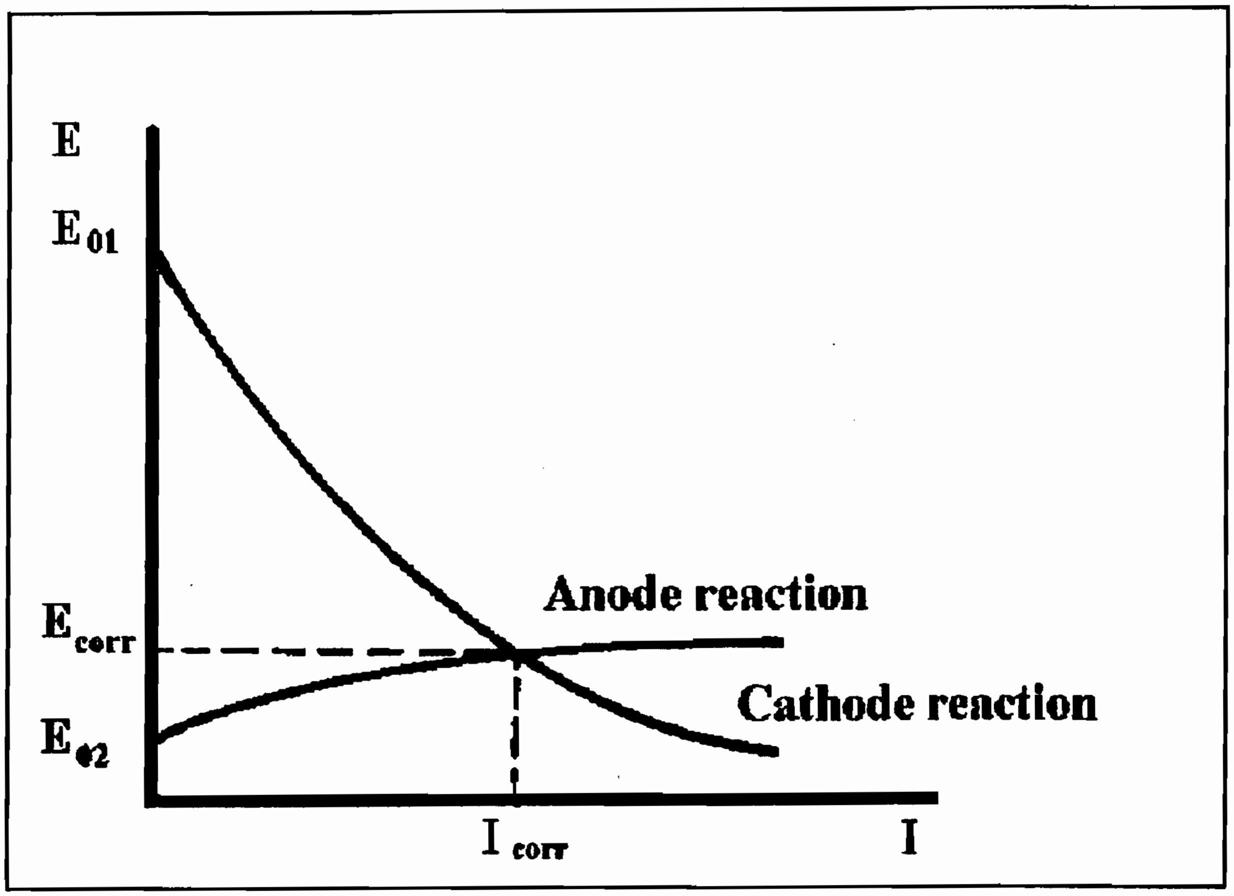


Figure 2-7 : Cathodic control; E=electrode potential, I=current

2.3.9 Passivity

A metal which is thermodynamically unstable in a given electrolytic solution is said to be passive when it remains visibly unchanged for a prolonged period.

It was observed that iron reacts rapidly in dilute HNO_3, but it is visibly unattacked by concentrated HNO_3. Upon removing the iron from concentrated acid and immersing it into dilute acid, a temporary state of corrosion resistance persists.

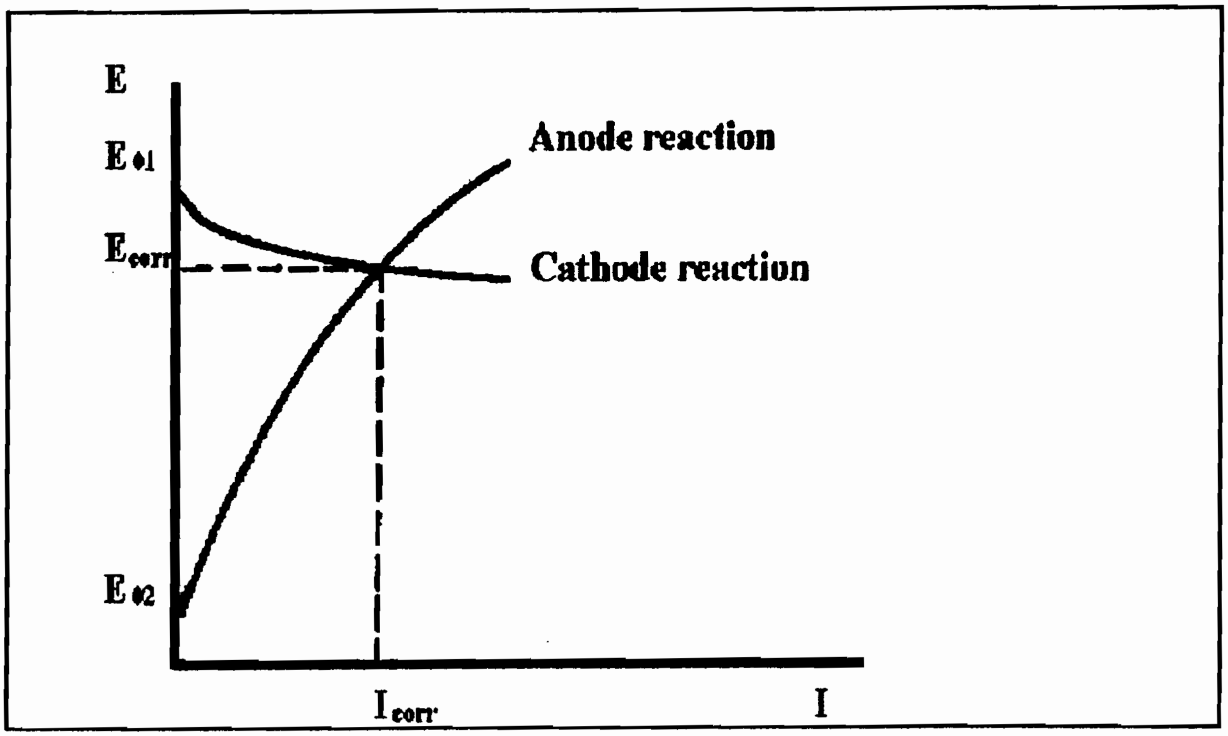


Figure 2-8 : Anodic control; E=electrode potential, I=current

The phenomenon itself is rather difficult to define because of its complex nature and the specific conditions under which it occurs. Essentially, passivity refers to the loss of chemical reactivity experienced by certain metals and alloys under particular environmental conditions. That is, certain metals become essentially inert and act as if they were noble metals such as platinum and gold. Fortunately, from an engineering standpoint, the metals most susceptible to this kind of behaviour are the common engineering and structural materials.

Two scientific definitions were given to this phenomena[18]

Definition 1. A metal active in the Emf Series, or an alloy composed of such metals, is considered passive when its electrochemical behaviour becomes that of an appreciably less active or noble metal.

Definition 2. A metal or alloy is passive if it resists corrosion substantially in an environment where thermodynamically there is a large free energy decrease associated with its passage from the metallic state to appropriate corrosion products.

Passivity can be quantitatively described by characterizing the behaviour of metals which show this unusual effect.

Figure 2.9 illustrates the typical behaviour of a metal that demonstrates passivity effects[11]. The behaviour of this metal can be conveniently divided into three regions: active, passive, and transpassive. In the active region the behaviour of this material is identical to that of a normal metal. Slight increases in the oxidizing power of the solution cause a corresponding rapid increase in the corrosion rate. If more oxidizing agent is added, the corrosion rate shows a sudden decrease. This corresponds to the beginning of the passive region. Further increases in oxidizing agents produce little change in the corrosion rate of the material. Finally, at very high concentrations of oxidizers or in the presence of very powerful oxidizers, the corrosion rate again increases with increasing oxidizer power. This region is termed the transpassive region.

It is important to note that during the transition from the active to the passive region, a reduction of 10^3 to 10^6 is usually

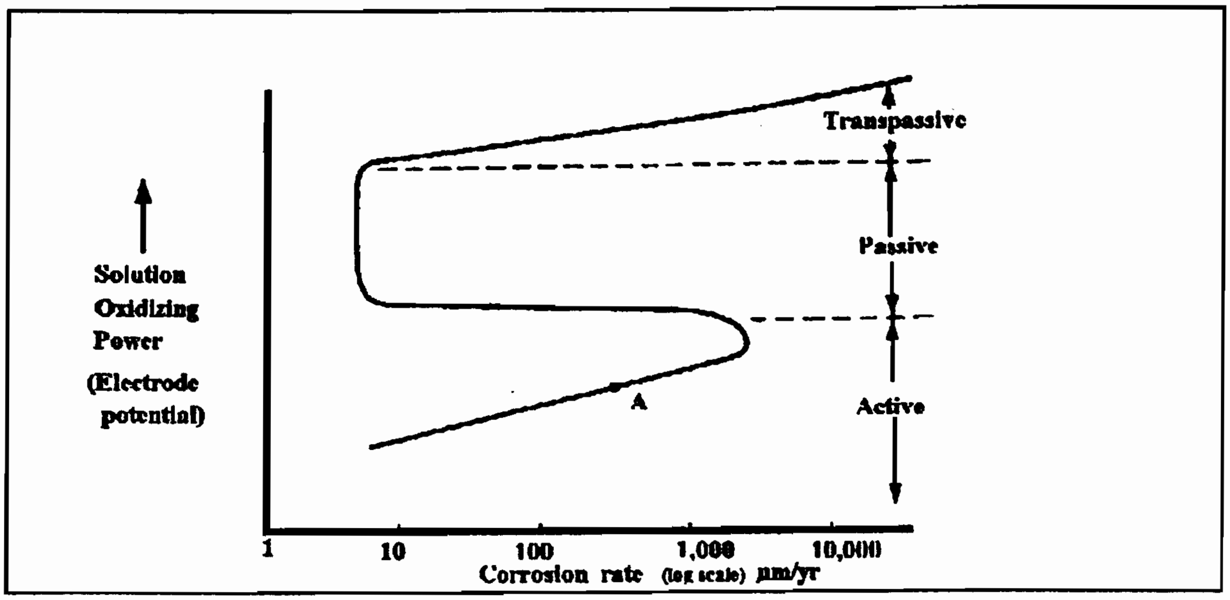


Figure 2-9: Corrosion characteristics of an active-passive metal as a function of solution oxidizing power (electrode potential).

observed in the corrosion rate . The precise cause for this unusual active-passive-transpassive transition is not completely understood. It is a special case of activation polarization due to the formation of a surface film or protective barrier that is stable over a considerable range of oxidizing power and is eventually destroyed in strong oxidizing solutions. The exact nature of this barrier is not understood. However, for the purposes of engineering application, it is not necessary to understand the mechanism of this unusual effect completely since it can be readily characterized by data such as are shown in (Fig. 2-9).

To summarize, metals that possess an active-passive transition become passive or very corrosion resistant in moderate to strong oxidizing environments. Under extremely strong oxidizing conditions, these materials lose their corrosion resistance properties.

Passivity offers a unique possibility for reducing corrosion, but it must be used with caution because of the possibility of a transition from the passive to the active state.

2.4 TYPES OF CORROSION

2.4.1 Introduction

Industry still does not fully realise the situation; more and more corrosive effluent is being emitted in a self-poisoning circle, resulting in increasing corrosiveness of atmosphere, soil and natural waters.

Until a decade ago, various generalisations were the substance of discussions about corrosion. One was supposed to avoid a particular metal or to treat its surface carefully. Data were tabulated to indicate compatibilities between dissimilar metals that should not be placed together or in ionic contact in an electrolytic solution. These generalisations are still valid but at present one must regard them as being superficial. Any corrosion process is chemically complex; it is not just a simple case of one material being oxidised to an ionic state and the other reduced through a gain of electrons. One must consider the surface effects which initiate a corrosion process along with the cumulative effect of the individual corrosion attacks.

2.4.2 Scope

This section lays the groundwork to the basic information about the more common forms of corrosion, by considering the different causes of corrosion and their mechanisms as well as the appearance of the attack.

2.4.3 Uniform Corrosion (General corrosion)

2.4.3.1 Definition

Uniform corrosion is a chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface to the corrosive environment. There are no distinguishable areas of the metal surface which are solely anodic or cathodic, i.e. anodes and cathodes are inseparable (Figure.2-10).

2.4.3.2 Cause

This corrosion is characterised by a general wasting away of the surface and will normally be found where a metal is in contact with an acid or a solution. However, the presence of an acid in a solution is not essential, e.g., high temperature oxidisation is a

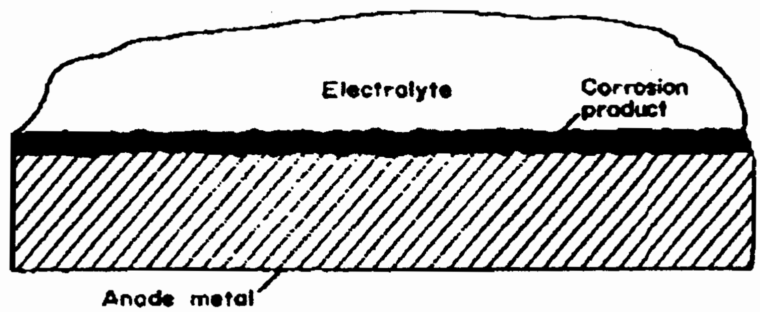


Figure 2-10 : Uniform corrosion (general corrosion)

form of uniform attack which occurs in a relatively dry atmosphere. The corrosion product may either form a protective layer on the metal and slow down further corrosion or, the corroded material may dissolve in the corrosive environment, as in the case with a direct chemical attack.

2.4.4 Cavitation Corrosion

2.4.4.1 Definition

Cavitation corrosion involves conjoint action of corrosion and cavitation. When vapour bubbles formed under reduced pressure collapse, the resulting shock wave can cause material damage. (Figure. 2-11)

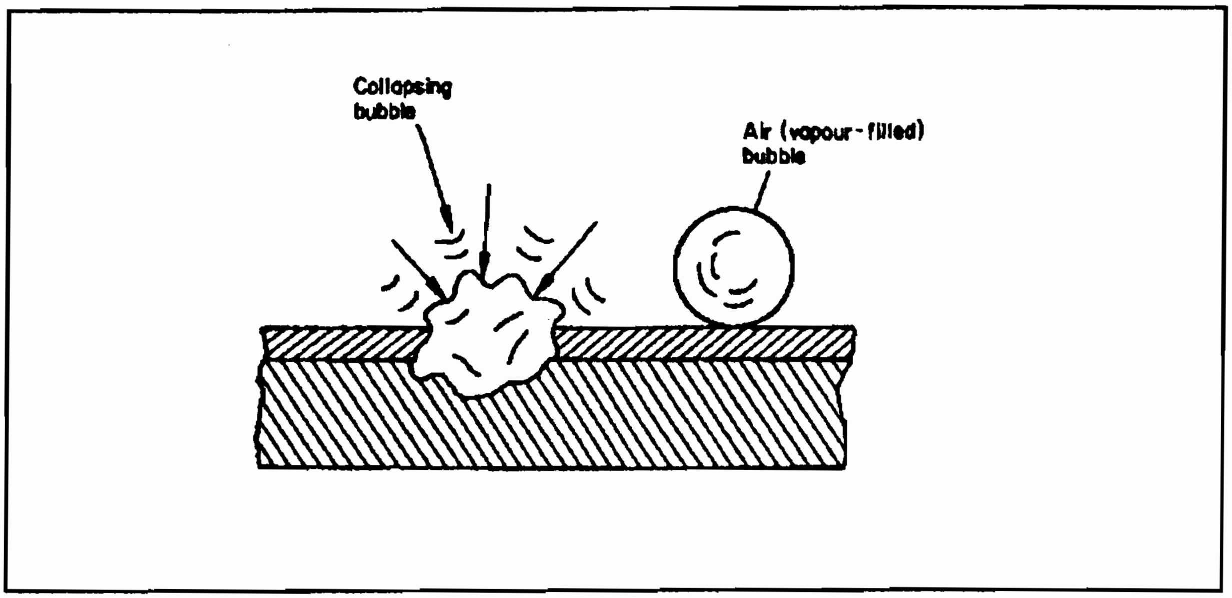


Figure 2-11 : Cavitation damage

2.4.4.2 Cause

Repeated collapse of vapour bubbles on a metal surface can cause mild physical damage to the protective films (cavitation corrosion), resulting in severe deformation and fracture of surface (cavitation deformation) or fatigue of metal surface (cavitation fatigue). The low pressure regions are created by flow divergence, water rotation, and restrictions met on lines, or by vibration.

<u>2.4.5 Concentration Cell</u>

2.4.5.1 Definitions

<u>Concentration cell</u> is a galvanic cell in which the emf is due to the difference in the concentration of one or more reactive constituents of the electrolyte solution (Figure 2-12).

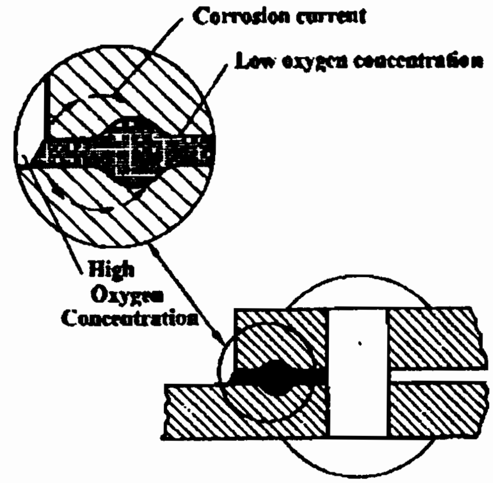


Figure 2-12 : Concentration cell

Crevice corrosion consists of localised corrosion resulting from a crevice formed between two surfaces, at least one of which is a metal.

2.4.5.2 Cause

Oxygen concentration cells are present in crevices, and also in water lines, adherent deposits and deep recesses, which hinder the diffusion of oxygen and set up differences in solution concentration. The low oxygen areas are anodic and thus corrosion prone.

Metal ion concentration cells, much like their oxygen counterparts, strive to balance out concentration differences. Thus, when the solution over a metal contains more metal ions at one point compared with another, the metal goes into solution where ion concentration is low.

2.4.6 Corrosion-Erosion

2.4.6.1 Definitions

Corrosion-erosion is a corrosion reaction accelerated by velocity and abrasion, usually accelerated also by presence of solid particles (Figure 2-13).

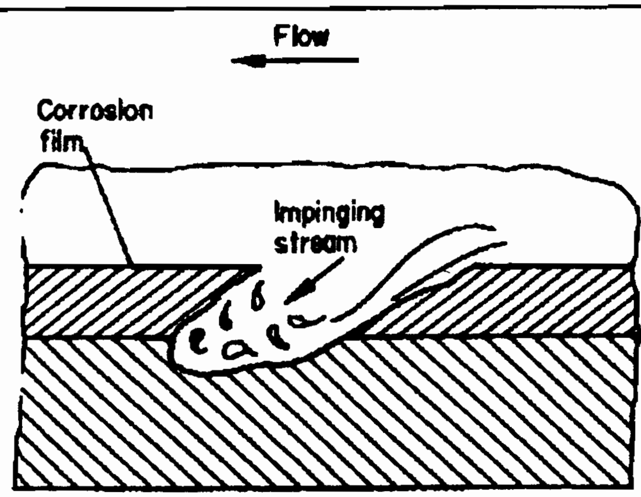


Figure 2-13 : Corrosion-erosion

Impingement attack consists of localised corrosion resulting from the action and/or erosion (separately or conjoint) when liquids impinge on a surface.

Wire drawing consists of corrosion attack promoted by high velocity wet steam at a speed of over 60 m/s (200 ft/s).

2.4.6.2 Cause

Impingement corrosion is caused by an impinging water stream breaking through corrosion scale and dissolving the metal; the cause of wire drawing is high velocity wet steam. The effect depends mainly on liquid speed and the amount of air or solids contained in it and other factors which affect the rate of formation of protective films.

2.4.7 Corrosion Fatigue

2.4.7.1 Definition

Corrosion fatigue is manifested by failure through cracking resulting from the action of alternating stresses in the presence of a corrosive environment (Figure.2-14).

2.4.7.2 Cause

In much the same way as static stresses link up with corrosion to produce stress corrosion cracking, cyclic loads combine with corrosion to cause corrosion fatigue. This results in metal failure occurring substantially below the fatigue limit for non-corrosive conditions. The combined deteriorating effect of these two phenomena -corrosion and fatigue- is greater than the sum of the damage caused by the two individual phenomena.

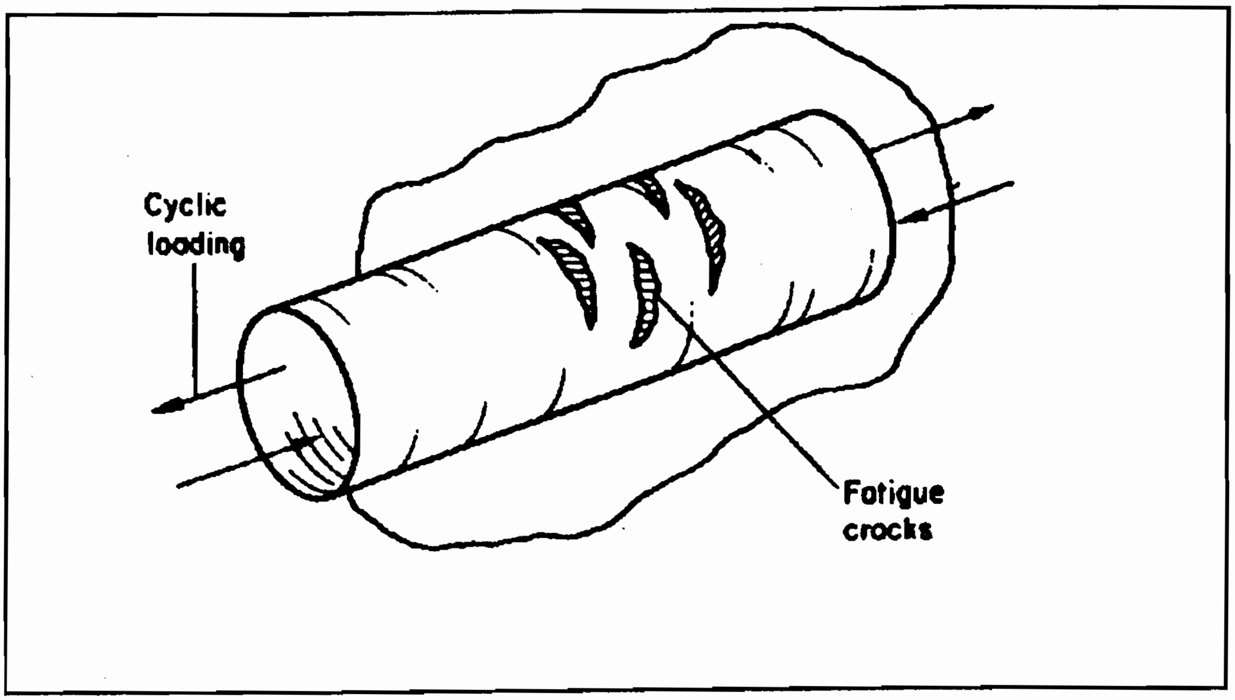


Figure 2-14 : Corrosion fatigue

2.4.8 Fretting Corrosion

2.4.8.1 Definition

Fretting corrosion consists of localised deterioration at the interface between two contacting surfaces, accelerated by relative motion of sufficient amplitude between them to produce slip (Figure 2-15).

2.4.8.2 Cause

This corrosion occurs between surfaces in close contact, usually under a fairly heavy load and subjected to very slight relative movement (e.g. minute slippages caused by high frequency

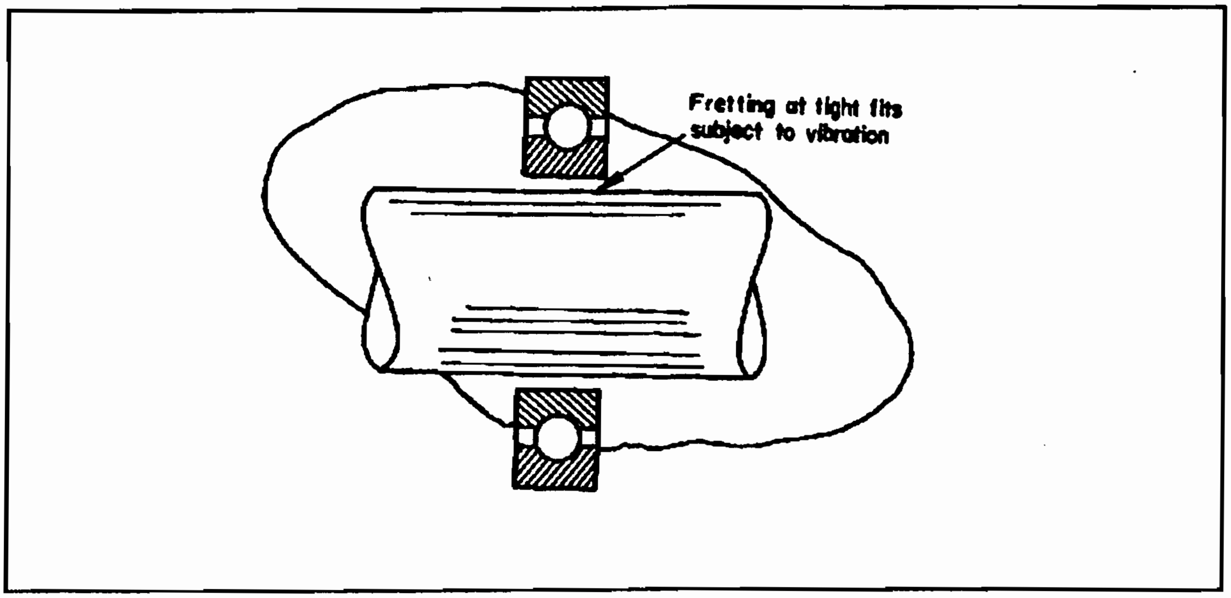


Figure 2-15 : Fretting corrosion

vibrations). Differences in elastic strain between surfaces may be sufficient to cause fretting corrosion, which appears to be due to welding of contacting high spots and their subsequent rupture. Local attack may start fatigue cracks, especially at locations where there is stress concentration, and the mating areas are pitted. Wearing away of surface protective films can initiate galvanic or concentration cell corrosion.

2.4.9 Galvanic Corrosion

2.4.9.1 Definition

Galvanic corrosion is associated with the current resulting from the coupling of dissimilar electrodes in an electrolyte (Figure 2-16).

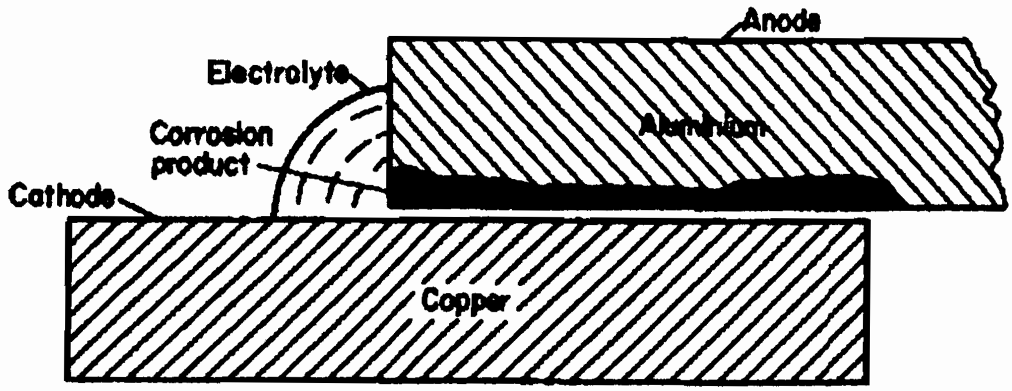


Figure 2-16 : Galvanic corrosion

2.4.9.2 Cause

When two dissimilar metals exposed to an electrically conductive environment are in direct contact, connected electrically by a conductor or by a conductive medium, preferential attack on one, the anodic metal, occurs while corrosion on the other, the cathodic metal, slows down or ceases.

2.4.10 High Temperature Corrosion

2.4.10.1 Definition

Corrosion results from the effects of atmospheric conditions, various gases, molten metals and salts at high temperatures (Figure 2-17) .

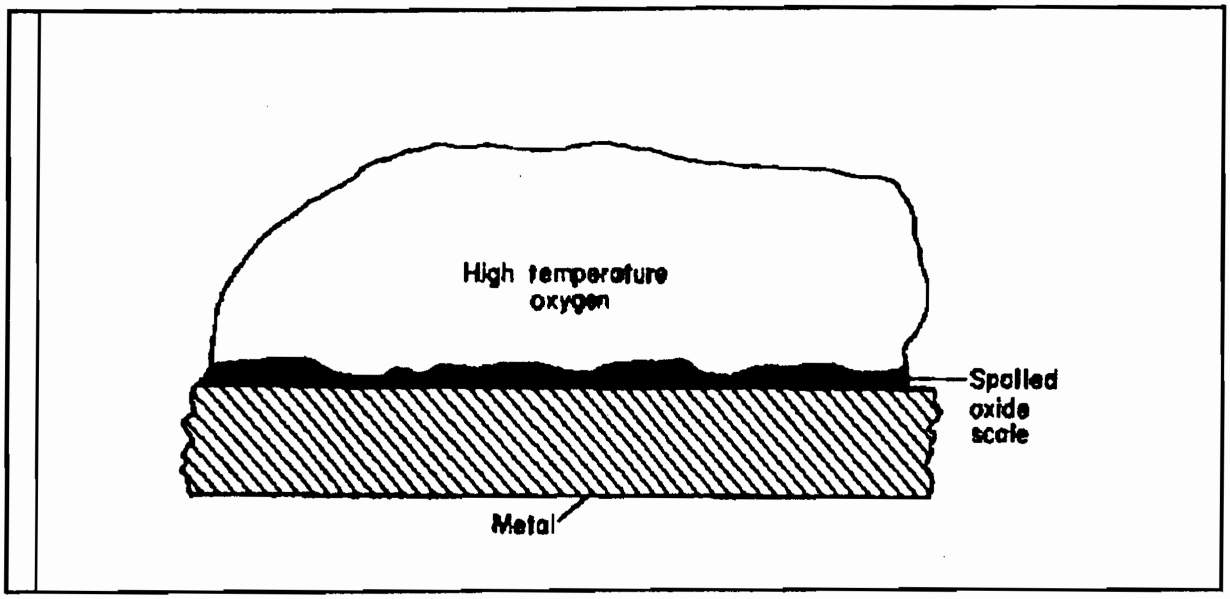


Figure 2-17 : High temperature corrosion

2.4.10.2 Cause

This form of corrosion is caused by high temperatures and it depends on the composition of the basic metals, composition of the environmental atmosphere, gases, salts or deposited metals, the temperature and the exposure time. It varies considerably. Light metals (those lighter than their oxides) form a non-protective layer that gets thicker with passage of time. This layer forms, spalls and re-forms. Other forms of high temperature corrosion include sulphidation, carburisation and decarburization.

2.4.11 Hydrogen damage

2.4.11.1 Definition

Hydrogen damage causes reduction of the load-carrying capability by admission of hydrogen into the metal (Figure.2-18).

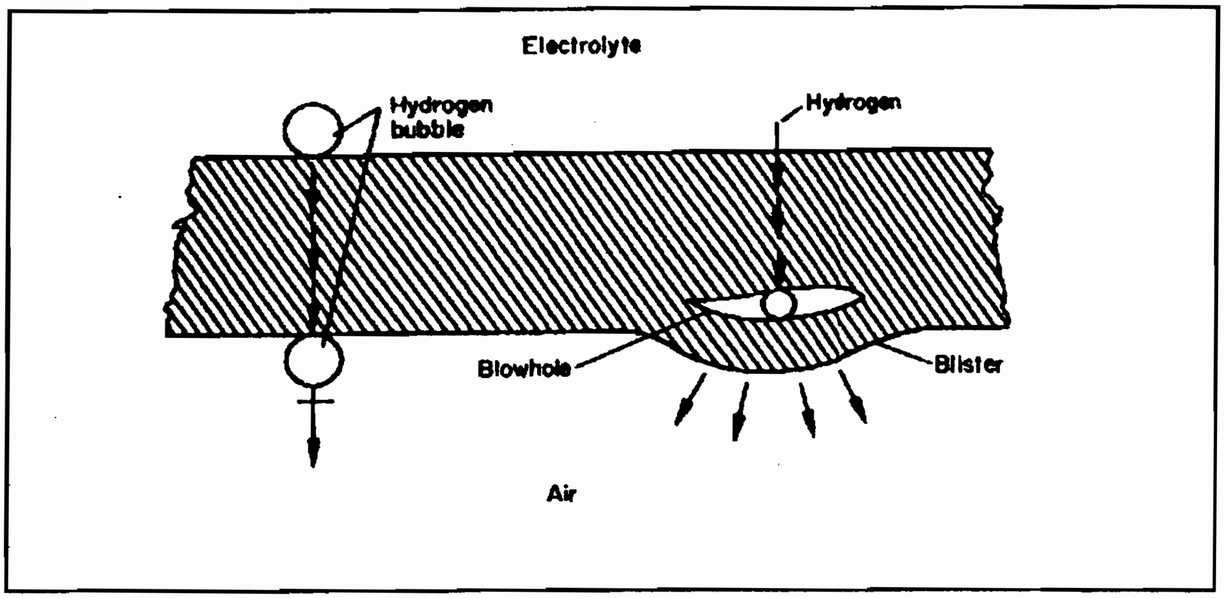


Figure 2-18 : Hydrogen damage

2.4.11.2 Cause

Mechanical damage of a metal is caused by the presence of hydrogen, or interaction with it. Hydrogen blistering and hydrogen embrittlement are caused by penetration of atomic hydrogen into metal. Decarburization is caused by moist hydrogen at high temperatures. Hydrogen attack is a disintegration of oxygen-containing metal in the presence of hydrogen. The origin of hydrogen can be found in the cleaning, pickling, cathodic protection, welding, treatment and operation.

2.4.12 Intergranular Corrosion

2.4.12.1 Definition

Intergranular corrosion consists of preferential corrosion at grain boundaries of a metal or an alloy (Figure.2-19) .

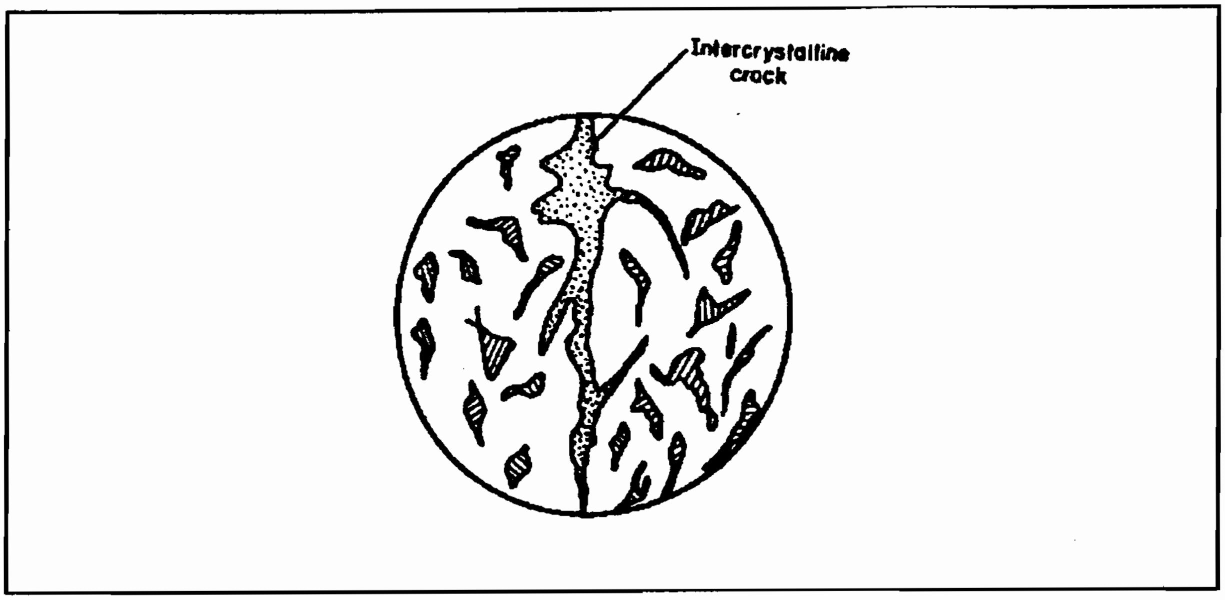


Figure 2-19 : Intergranular corrosion

2.4.12.2 Cause

Intergranular corrosion can be caused by impurities at the grain boundaries, enrichment of an element, or depletion of one of these elements in the grain boundary areas. Therefore, the grain boundary becomes anodic to the surrounding grains. As a result, the alloy at the grain boundary corrodes and may also lose its strength. Stainless steels that are improperly heat treated and do not contain special stabilizing alloying additions are susceptible to intergranular corrosion. Intergranular corrosion can be recognized by crack patterns along the grain boundaries.

2.4.13 Microbial Corrosion

2.4.13.1 Definition

Microbial corrosion is manifested as deterioration of materials caused directly or indirectly by bacteria, moulds or fungi singly or in combination.

2.4.13.2 Cause

Using the term corrosion in its broadest sense, the microbes (bacteria, moulds or fungi) may cause corrosion by:

(a) Chemical attack of metals, concrete and other materials by the by-products of microbial life, namely acids (e.g. sulphuric, carbonic or other organic acids), hydrogen sulphide or ammonia.

(b) Microbial attack of organic materials (e.g. organic paint coatings,plastic fittings and linings), some natural inorganic materials (e.g. sulphur), or inhibitors.

(c) Depassivation of metal surfaces and induction of corrosion cells.

(d) Attack of metal by a process in which microbes and the metal cooperate to sustain the corrosion reaction.

(e) Attack due to a combination of bacteria.

2.4.14 Pitting Corrosion

2.4.14.1 Definition

Pitting corrosion consists a localised corrosion with appreciable penetration into the metal, resulting in the formation of cavities (Figure. 2-20).

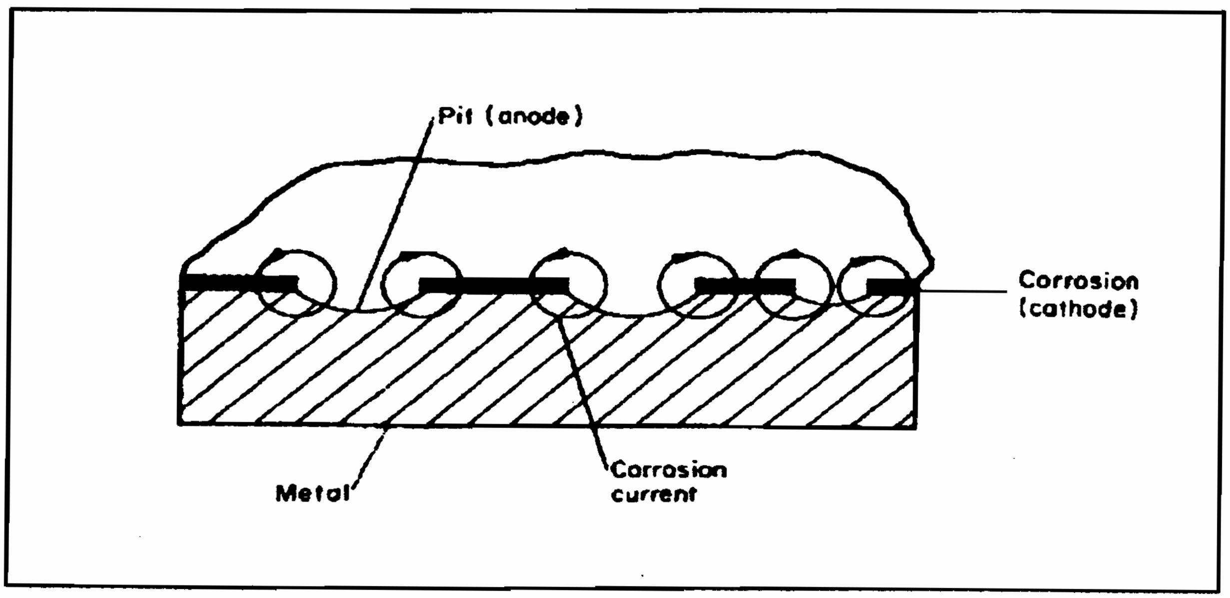


Figure 2-20 : Pitting corrosion

2.4.14.2 Cause

When protective film, or layers of corrosion product break down, localised corrosion (pitting) occurs. An anode forms where the film has broken, and the unbroken film (or corrosion product) acts as a cathode. The pits form starting points for stress concentration that can cause, or accelerate, stress corrosion or corrosion fatigue attack.

2.4.15 Selective Attack (Leaching)

2.4.15.1 Definition

Selective attack is the process of extraction of a soluble component from an alloy with an insoluble component, by percolation of the alloy with a solvent--usually water (Figure.2-21).

2.4.15.2 Cause

Basically, one element of a metal or alloy is singled out for corrosion attack. The most well known example of selective corrosion is the dezincification of brass. upon dezincification, the zinc is dissolved selectively, while the copper is left as a porous mass having poor structural strength. Dealuminification of aluminium bronze is a similar corrosion processes.
Graphitic corrosion in grey cast-iron provides another example of

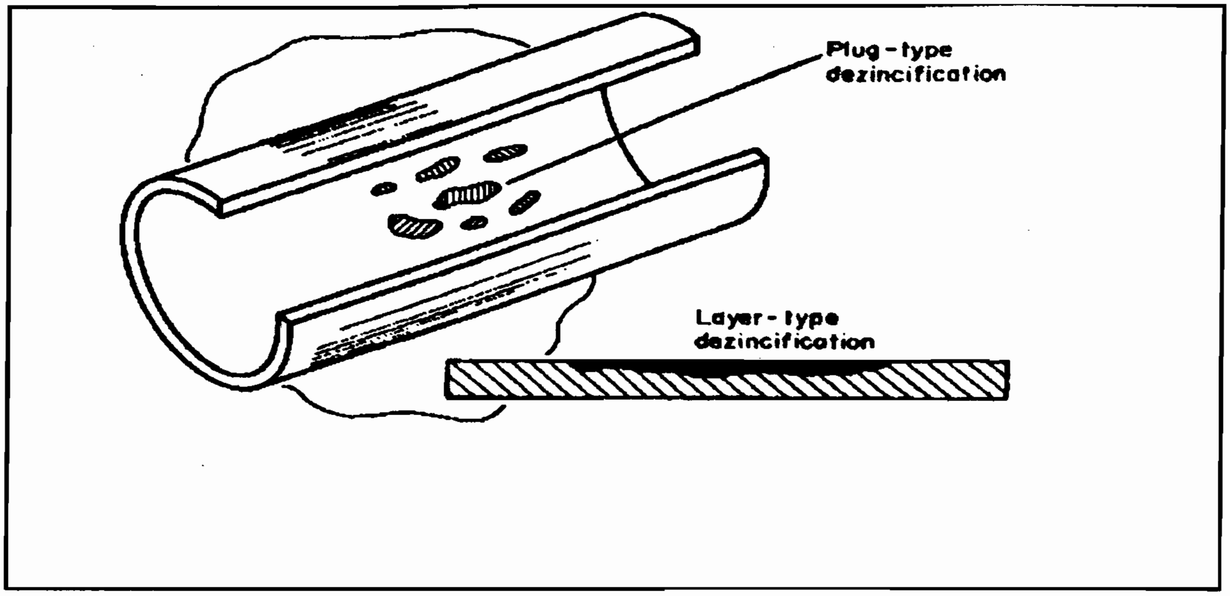


Figure 2-21 : Selective attack (leaching)

selective corrosion where the metallic constituents of the iron are removed. The remaining graphite allows the object concerned to maintain its shape but its strength and weight are severely reduced.

2.4.16 Stray Current Corrosion (Electrolysis)

2.4.16.1 Definition

This form of corrosion results usually from direct current flow through paths other than the intended circuit (Figure.2-22).

2.4.16.2 Cause

Electrolytic corrosion due to uncontrolled electrical currents (mostly dc or hvdc) from extraneous sources through unintended

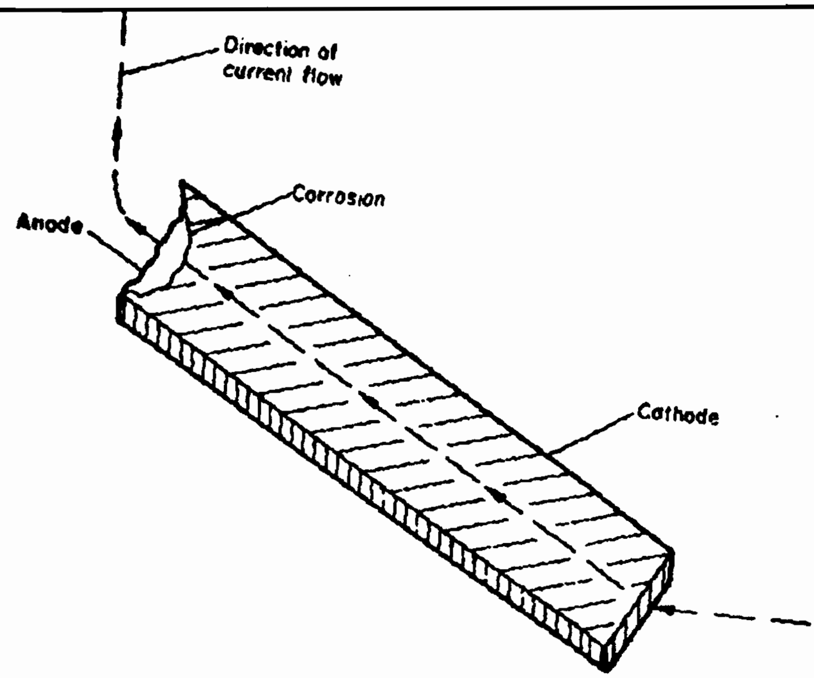


Figure 2-22 : Stray current corrosion

paths. In general, it is only direct current which gives rise to stray current corrosion in iron and steel. Stray current likely to cause damage can originate from, for example, direct current driven tramcars or underground trains, direct current of welding equipment through metal structures causing connected structures to corrode.

2.4.17 Thermogalvanic Corrosion

2.4.17.1 Definition

Thermogalvanic corrosion results from a galvanic cell caused by a thermal gradient (Figure. 2-23).

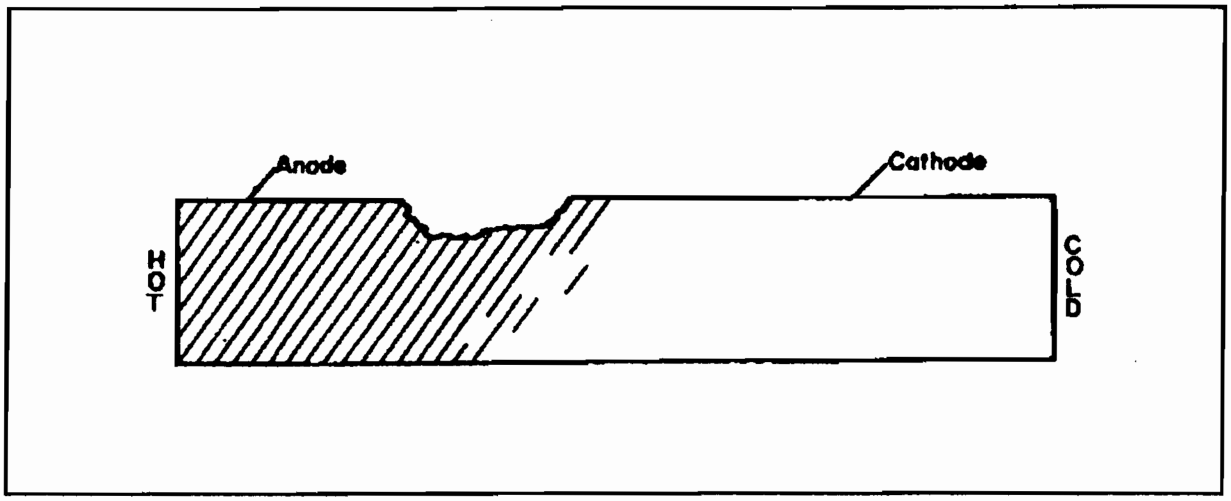


Figure 2-23 : Thermogalvanic corrosion

2.4.17.2 Cause

When a metal is subjected to a thermal gradient by uneven heating or dissipation of heat, there is a similar effect on the metal as in galvanic corrosion. The metal is differentially polarised, and anodic and cathodic areas are formed, causing preferential attack to develop.

2.5 SUMMARY

The basic theory of the corrosion process may be summarised as follows:

(1) Oxygen and water (the electrolyte) must normally be present for corrosion of metal to occur (but there are exceptions) .

(2) Corrosion involves movement of electrons; thus an electric current flows in the metal.

(3) Corrosion of metal does not take place evenly over the surface; there are local areas of corrosion which give rise to pitting.

(4) The corrosion product, e.g. rust, may form at some distance from the points of origin, namely at a point where anodic and cathodic products combine.

(5) A high concentration of oxygen encourages the formation of a cathode, and the area immediately beyond this becomes the anode and corrodes.Corrosion is accelerated when the oxygen concentration increases at the cathode or reduces at the anode.

(6) The extent of corrosion reaction between dissimilar metals depends on the emf potential difference between the metals, the electrolyte and the spacing and the relative areas of the two metals.

(7) Films form on the surface of all metals, giving the metal a degree of corrosion resistance, which depends on the nature of the film. Materials with tightly adherent (insoluble) films have greater corrosion resistance than materials with soluble films. Breakage of the film initiates further corrosion of the bare metal.

(8) Corrosion of metals is influenced by their environment. The degree of this influence is relative to the physical state of the environment, its temperature, concentration and working conditions (e.g. time of exposure, osmosis, effect of cycling).

(9) Corrosion of metals is influenced by their metallurgical composition and microstructure.

The next chapter reviews the corrosion of building materials, and specially the corrosion of reinforcing steel embedded in concrete.

CHAPTER 3

CORROSION OF REINFORCEMENT STEEL

3.1 Introduction

The importance of corrosion in our modern, high-tech society can be measured by the magnitude of the direct and indirect problems which result from this degradation process. Certainly, the effects on our infrastructure are a great contributor because of the magnitude of the problems which exist today, basically because of the increasingly aggressive environment. Throughout the world, elements of the infrastructures are deteriorating to such a degree that it is considered to be of critical importance. The infrastructure consists basically of highways, bridges, parking garages, water supply and sewage disposal systems, harbours, reservoirs, and subway systems, etc. Corrosion of reinforcing steel in concrete (rebar) is an extremely important problem, not only because of cost and safety concerns, but also because of the inconvenience involved in making repairs.

Concrete and steel will continue to be essential materials for construction for the foreseeable future. Recent research has identified new additives, coatings, and applications of these materials to the durability and resistance of the infrastructure elements. Concrete is considerably stronger in compression than in tension. To compensate for its low tensile strength, concrete is reinforced with steel. Concrete is also porous and acts like a sponge in the presence of water and liquids. Under normal conditions, concrete possesses an alkaline environment. In this case, steel rebars form an oxide film that prevents further corrosion while this film remains intact. When this protective layer is disturbed, corrosion of steel begins and continue until it causes deterioration of the concrete. The main reason for the deterioration is that the corrosion products occupy a much larger volume than the steel, which leads to cracking and delamination followed by spalling.

3.2 Main Causes of Rebar Corrosion

The principal reasons for corrosion of the reinforcing steel bars are:

1. Chloride ions cause breakdown of the protective layer and start of the corrosion process. Research has determined that a content of 0.6 to 0.8 kg of chloride per cubic meter of concrete is enough to destroy the passivity of the steel and promote active corrosion.

2. Differences in chloride ion concentration lead to a difference in potential, creating anodic and cathodic areas of steel.

3. Oxygen is another important contributor to corrosion of steel in concrete.

4. A drop in the pH of the concrete to a level of 9 to 10 is another contributor to rebar corrosion. This can result from the absorption of carbon dioxide in the concrete.

5. Stray D.C. currents entering a steel reinforced concrete structure create cathodic areas; when they leave, the steel becomes anodic, causing it to corrode.

3.3 The Effects of Concrete Properties on corrosion

Concrete is a finely porous material. The pore sizes vary from a few Ångström (one Å= 10^{-7}mm) to several millimeters. This pore system is more or less filled with a solution which contains varying quantities of different salts. The design, volume and structure of the pore system vary widely depending on the quantities of constituents in the concrete. One feature which is common to all concretes is that the pore solutions which surround the embedded steel have an extremely high pH-value (13-14). As a result, the steel surface frequently receives a very dense oxide layer which is difficult to dissolve. This limits further disintegration, thus leading to what is known as passivation.

Corrosion commences only if this passivity is destroyed. This normally happens either by carbonation of the concrete around the steel, which reduces its alkalinity, or the presence of even small quantities of chlorides in the concrete around the steel. Steel corrosion in the presence of chlorides is an electrochemical process, with moist chloride-containing concrete serving as the electrolyte. The depth of the penetration of chlorides is a function of time and permeability of the concrete. Once the steel becomes depassivated, the rate of corrosion depends mainly upon the availability of moisture and oxygen near the steel surface. In the absence of either of these, normally corrosion will not occur.

General rusting is the most readily recognised form of steel corrosion, and is often described as a simple chemical reaction that occurs when steel is exposed to air and water. In fact, it is a complex electrochemical process that can be controlled if certain conditions are maintained.

When rusting takes place, small electrical currents flow between areas of differing voltage potential on the steel, through a surrounding medium, or 'electrolyte'. In doing this, they transport ions of metal from anodic to cathodic areas, reducing the steel cross-section at the anode, and depositing the material at the cathode, where it forms rust. For these corrosion currents to occur on steel in concrete, three essential conditions must be met :

1- There must be a difference in voltage potential between points on the steel surface or the surrounding material.
2- The concrete must be conductive to form the electrolyte.
3- The concrete must have electrical contact with the steel.

The engineer has little control over the first condition, for variations in the steel surface impurities, and the stresses resulting from bending or fabrication all induce potential differences. Cover concrete, however, provides an opportunity to control the latter two conditions.

To control corrosion, the engineer must be concerned with maintaining the conditions that prevent the flow of corrosion currents. This requires knowledge of the physical, chemical, and electrical properties of the materials.

Concrete: Typical concrete is a mixture of cement, sand, coarse aggregates, and water. Cement itself is a mixture of calcium, aluminum, silicon and iron. Aggregate is usually crushed rock, or gravel. Most gravel is a mixture of rocks, depending on their source, a river bed or glacier. Sand is also occasionally a mixture of different types of rock particles. The water must be of drinkable quality, but usually contains some traces of minerals, organic matter, fluorides and chlorides.

Some mixes are difficult to compact and therefore less dense. In this case some microcracking occurs during the initial curing resulting in shrinkage at the interfaces between the large concrete aggregates and the steel. The permeability of concrete is always an order of magnitude higher than that of the pure cement paste.

Aggregates and reinforcement also tend to encourage micro cracking by restraining the free shrinkage of the surrounding cement paste. The larger is the aggregate or the steel reinforcement, the more extensive is the microcracking. Aggregate type also affects microcracking. Minerals such as quartz, granite or flint produce a weaker bond with the cement paste than with limestone or dolomite. The weak bonds break during normal temperature and humidity changes and cause microcracking, particularly at the cement paste/aggregate interface. This is of course the same process that permits natural rock erosion to take place.

Microcracking also tends to occur during curing due to differential temperature stresses, particularly in larger elements and where curing is achieved by membrane rather than by water spray, which helps to reduce the temperature. Microcracking is also caused by the stresses or strains caused by the mechanical loadings.

The range of materials present in concrete is important, because they determine its permeability, and density. They affect the type and the rate of corrosion that may occur. Where admixtures are used, they may well introduce further variables. An example in this case is that at one time calcium chloride was used commonly to accelerate the setting of cement. This released free chlorides into the concrete, which were later found to be a key catalyst in the corrosion process.

3.4 Corrosion of reinforcing steel

As stated before, for corrosion of embedded steel to occur, the protective, passivating properties of overlying concrete must be destroyed, and this can happen in many ways, though they can be summarised in three broad categories :

- Chemical attack on concrete from the environment or spillage

- Chemical attack on steel of an internal or external nature

- Physical damage, such as cracks from impact, settlement, overloading, or fire damage, and erosion or stripping.

3.4.1 Chemical attack on Concrete - Carbonation:

As an example of atmospheric or environmental attack, the carbonation process shows the interaction which occurs during the deterioration of concrete. Cement paste has a submicroscopic pore matrix, and absorbs moisture by capillary action. It 'breathes' with changes in humidity, atmospheric pressure, and temperature. Carbon dioxide penetrates the concrete and reacts with the pore moisture, forming carbonic acid. (Fig 3.1). This in turn reacts with the alkaline calcium hydroxide in the cement to form calcium carbonate, reducing the pH of the matrix to around 9-10. By causing a reduction in the alkalinity of concrete, carbonation can destroy the ability of the concrete to maintain the protective oxide layer on any embedded steel, and thus open the way for corrosion.(Fig 3.2).

The rate of carbonation is influenced mainly by the following:

<u>a. Humidity.</u> The rate of carbonation is a maximum at 50-70% relative humidity, while under water, it is almost zero.

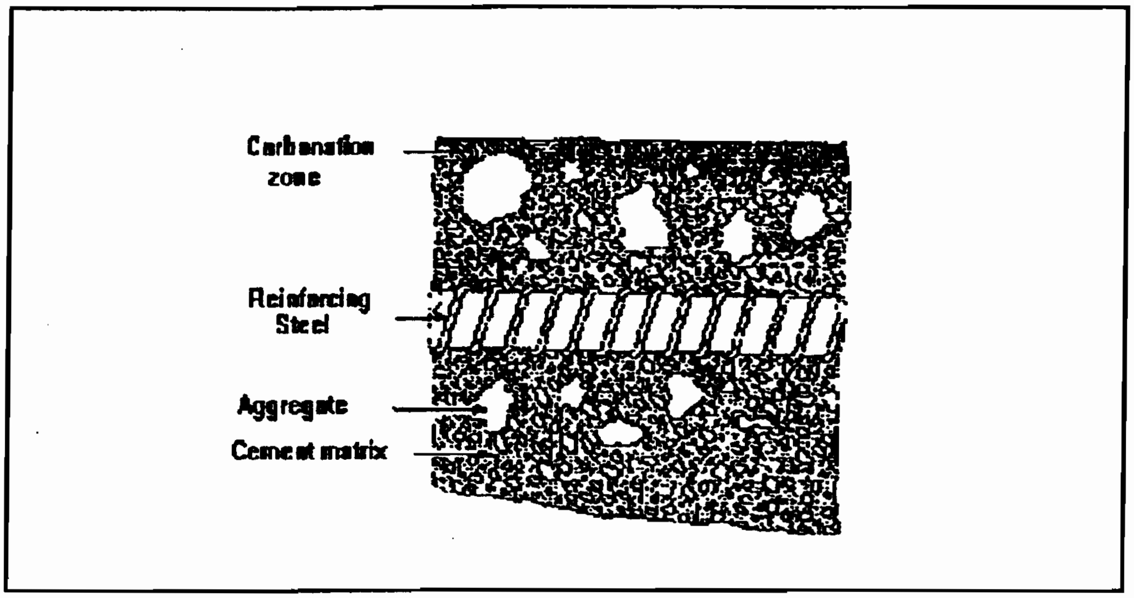


Figure 3.1 : Diagrammatic view of steel protected from corrosion in partially-carbonated concrete.

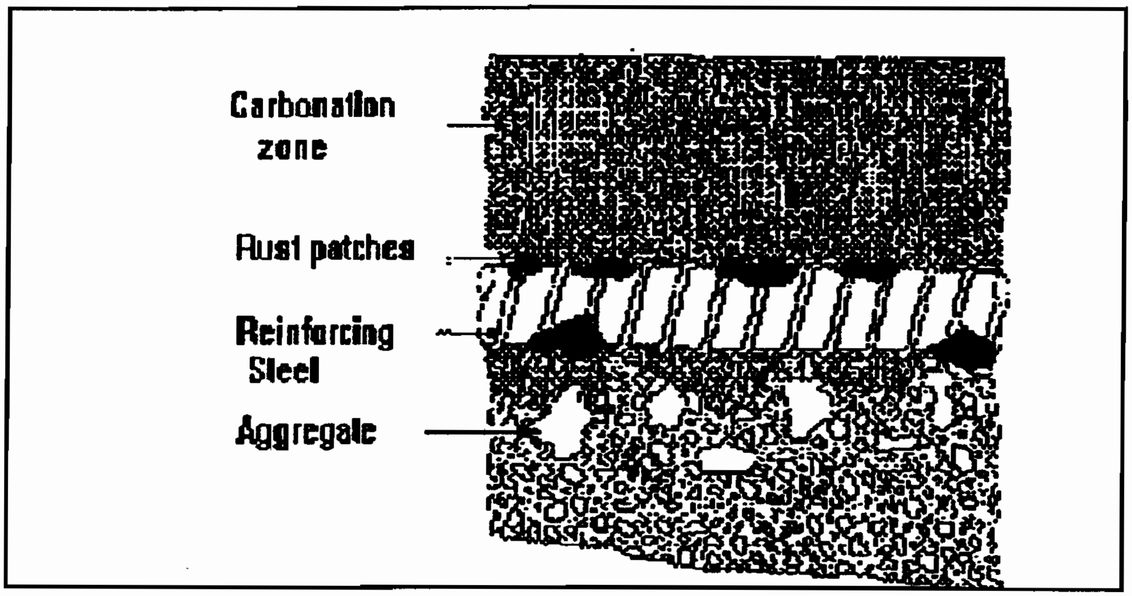


Figure 3.2: Diagrammatic view of steel corroding in carbonated concrete

b. The composition of the concrete, particularly the water to cement ratio. As the water to cement ratio rises a more porous structure develops. Carbonation rates increase as follows with increasing water to cement ratios[41,42,66]:

W/C ratio	Carbonation rate
0.6	1
0.8	2
0.45	0.4

Table 3.1: Carbonation rates relating to W/C ratios.

Portland cement concrete carbonates more slowly than blast furnace cement concrete.

c. Curing: If concrete is kept moist for a longer period of time, its resistance against carbonation increases.

d. Time: At constant temperature and average humidity the progress of carbonation is roughly proportional to the square root of time[32,41], i.e., with increasing time the rate of carbonation falls. When concrete is completely wetted through, carbonation stops altogether. Depths of carbonation of roughly 40 mm have been observed with concrete about 50 years old.

3.4.2 Chemical attack on Steel - Chlorides :

A secondary effect of carbonation involves chloro-aluminates[58,59], which are harmless in the concrete. However these compounds are stable only at high pH levels, therefore carbonation, in reducing the alkalinity of the concrete, also causes breakdown of chloro-aluminates, releasing chloride ions. The presence of sufficient quantities of chloride ions in the concrete can stimulate reinforcement corrosion even in highly alkaline conditions. The mechanism of corrosion of reinforcement in chloride-containing concrete is complex. The majority (perhaps 90 per cent) of chloride ion introduced during the earliest stages of cement hydration reacts with the calcium aluminate minerals in the cement to form solid compounds, thus being effectively immobilized. The remainder exists as free chloride in the pore solution and, if in sufficient concentration, it may stimulate subsequent corrosion reactions. Cements with low tricalcium aluminate do not have the capacity to immobilize chlorides and so steel corrosion can be initiated at lower chloride levels.

Free chlorides increase the electrical conductivity of moisture present in the carbonated concrete, and promote depassivation of the steel by chemical reaction. In the process, they create both of the conditions that make the concrete conductive , and good electrical contact between concrete and steel. The chlorides thus take an active part in both destroying the protective properties of the concrete, and in the corrosion process itself. However, the risk of corrosion increases with the increasing concentration of the free chloride in the pore water.

A major distinction is made between chloride introduced before the setting of the concrete and that introduced subsequently. Prior to setting, chlorides can be introduced rarely as contaminants in the mix ingredients, or deliberately as the set accelerator calcium chloride. Because the problems of chloride-induced reinforcement corrosion have been recognized, restrictions on the introduction of chloride at the mixing stage are made in the various codes of practice. Limits are placed on chloride concentrations in admixtures and on the acceptable amount of natural chloride in aggregates. The chloride content of the concrete mix should be in the range of 0.35 - 0.5 expressed as percentage of chloride ion by weight of cement. Provided that these limits are achieved in good quality dense concrete, it is reasonable to anticipate that, given adequate depth of cover, there should be no additional corrosion risk.

Subsequent to setting, chloride can be introduced either by exposure in marine environments or as contamination from chloride bearing de-icing salts. Much greater risk of long-term corrosion could be expected in these conditions.

There are two reasons for this: (a) possible build-up of chloride ion within the concrete to levels high enough to stimulate corrosion, and (b) modification of the chemical reaction involving the formation of the chloride-bearing hydrated cement minerals. The second point results in a reduced amount of chloride being incorporated into the solid cement hydrates. This gives rise to greater free chloride concentration within the pore water than with pre-hydration introduction of a similar concentration of chloride, and therefore, it increases the corrosion risk.

3.4.3 Other Chemicals :

Airborne sulfates, or 'acid rain' can be highly aggressive to concrete, and may seriously affect the integrity of the structure. Sulfates penetrate the concrete in a manner similar to that for carbon dioxide. They react with certain calcium compounds in the cement paste to form gypsum and ettringite. These products weaken the paste structure, and reduce the strength of the concrete. This process is also expansive, generating stresses that crack the weakened concrete, creating easier ingress for additional moisture and contaminants. When the steel level is reached, the access created for air and moisture almost inevitably induces corrosion.

3.4.4 Physical and External Damage

Most literature on the subject of cracking in plain and reinforced concrete considers it in terms of strength and stability, concentrating on drying shrinkage, deflection under load, and structural movement. There is little that addresses problems of durability caused by cracking. Some standards have been set for assessment of crack sizes, and for reporting on crack patterns, distribution, etc.[61] but in general they deal with large, visible cracks. There is little information available on micro-scale cracking.

3.4.4.1 Cracking

When one considers the effect of a crack, it is reasonable to expect that, away from the crack, carbonation or chlorides will take some years to penetrate any significant distance, but down the crack they can move in very quickly. Hence, carbonation and chloride "fronts" will dip locally so that there will be a patch at the base of the crack where the passivity of the steel will be destroyed and lead to local corrosion. Therefore, the presence of a crack tends to initiate corrosion, but only at the point where the crack crosses the bar. (Figure 3.3).

Whilst this may appear to be serious and although the evidence

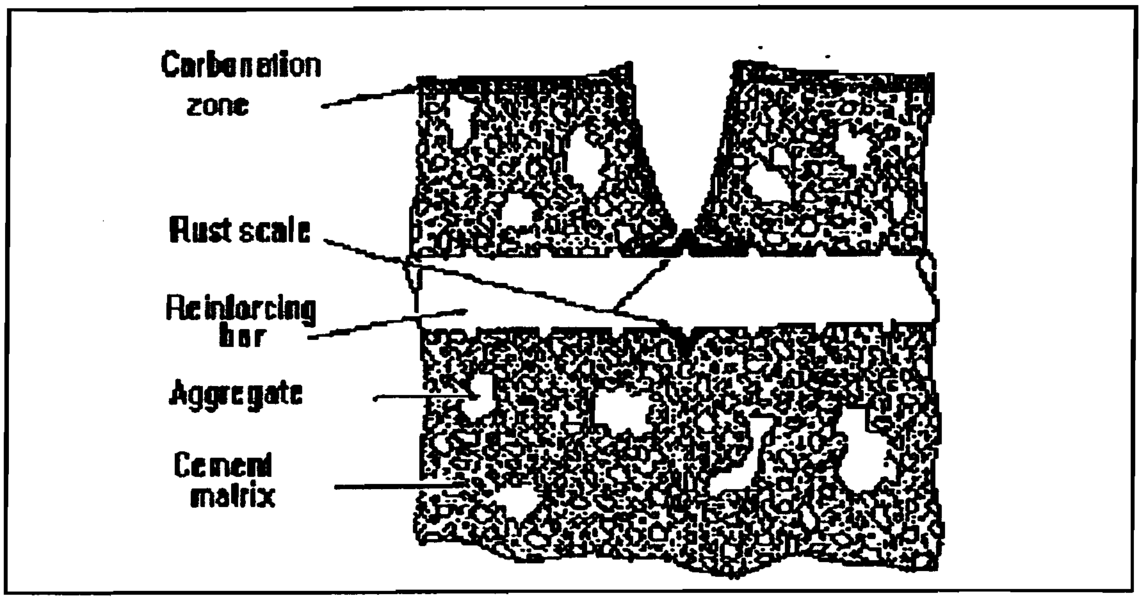


Figure 3.3: Corrosion at a crack

suggests that cracks do act as corrosion initiators, their effect may not be particularly serious.

In the first place, there is a certain amount of information on the rate of corrosion in and around cracks, the most recent being from Tuutti[46] in Sweden, who found from a large number of tests that there is initial corrosion at the base of a crack. However, the corrosion products and other matters gradually seal the crack, so that after a time corrosion is halted. Examination of specimens showed that certainly there was corrosion at each crack, but it was not extensive, and that it was not active beyond a certain time.

The second source of information on cracking comes from surveys of actual structures. One which was carried out some years ago concerned railway bridges in France, where it was concluded that, although there were quite a number of flexural cracks, there was no evidence that these cracks had ever caused any reduction in the durability of the structures. More recently there was a fairly extensive surveys on some partially prestressed bridges in Denmark. Whilst it was found that there were far more flexural cracks than had been expected, there were no cases where it could be said that flexural cracking had in any way affected the durability of the structure[64,65]. Any durability problems always arose from other causes.

It seems quite likely therefore, that although patches of rust tend to occur where there are cracks, they do not appear to be sufficiently serious to affect the structure generally - at least, when the cracks are transverse to the bars.

Exposure tests on beams with a variety of cracks tend to confirm this view and also show no relationship between crack width and the amount of corrosion. Therefore it seems pointless, from the point of view of corrosion control, to devote much design time to calculating the expected widths of any cracks.

3.4.4.2 Erosion and Surface Stripping

These are processes that will gradually strip away the surface layers of concrete, thereby progressively reducing the thickness of the concrete cover protecting the steel reinforcement. Apart from abrasion by traffic tires on bridge-decks etc, erosion can be caused by air-borne debris and dust, or water-borne particles. Two other important processes cause surface stripping that reduces concrete cover over a period of time, and may eventually expose the embedded steel. Those are:

a. Freeze/Thaw Cycles

Moisture in concrete will freeze if the temperature is low enough, and ice occupies more volume than the original water. If the surface layer of concrete is saturated, the expansion forces generated by freezing can be large enough to crack the concrete, and the outer layer will flake off as the ice melts. Typically it will only affect a few millimetres of concrete at a time, but the cumulative effects of repeated freeze and thaw cycles will eventually remove significant amounts of concrete.

Where such action is anticipated, its effects can be controlled or eliminated by using air-entrained concrete. Small air voids are deliberately included in the concrete mix to provide room for the expansion of any ice.

b. Cavitation

Structures exposed to fast-flowing turbulent water can be subjected to cavitation. This occurs when small momentary pockets of low pressure or vacuum are created by the turbulence. Bubbles of water vapour form, and collapse again as the flow carries them out of the low pressure area. In collapsing, they create pockets of very high pressure that is capable of pitting the surface of any steel or concrete on which it impinges. The rate of deterioration depends on the water volume and turbulence, but it is capable of producing significant damage in a period of a few months, rather than a few years.

3.5 Types of corrosion in high tensile steels

The following types of corrosion occur only with high tensile steels.

a. Stress corrosion. This is a tearing effect, which may be inter- or intracrystalline, of a metallic material due to the simultaneous action of tensile stresses and a corrosive agent (e.g., chlorides or nitrates). High tensile stresses occur at corrosion scars to cause fractures, without anything being visible from the outside.

b. Hydrogen embrittlement. Sulfides, which are present in clay and blast furnace cement, can lead to the formation of hydrogen sulfide (H_2S), which forms hydrogen in the presence of steel. As this is only possible when the pH is below 9, hydrogen embrittlement should not occur with any properly prepared cement or with blast furnace cement. Clay cement is, however, vulnerable.

Atomic hydrogen, which is liberated in the decomposition of H_2S, can penetrate into the crystal lattice of steel because of its small atomic radius. If it reaches grain interfaces or faults, it causes a change in its properties. Plastic properties, in particular, are affected extremely unfavourably, and cracking can take place. The energy required is provided by the hydrogen, as it changes from the atomic state to the molecular state.

3.6 Service life with regard to reinforcement corrosion

The service life of a structure component or material is defined in ASTM E632 as: "the period of time after installation during which all properties exceed the minimum acceptable values when routinely maintained."The unexpected, premature deterioration in reinforced concrete structures have generated several theories and models in order to predict service life of a structure as a function of different sources of aggressive agents and of different rate determining parameters.

Service life prediction is a complex matter in which both technical topics and economical consequences are involved. This concept has been expressed in different ways, an adequate one, perhaps, being the period in which a structure fulfils its structural requirements.

Many aspects concerning nominal design life and residual service life remain unexplored. In the case of failures due to rebar corrosion, some of the more key aspects are related to the deterioration rate of rebars and the acceptable limit of deterioration. This is the maximum tolerable amount of corrosion corresponding to the condition of failure, or that which may affect the load-carrying capacity of the structure.

The most suitable scheme for modelling the service life of corroding structures is that presented by Tuutti[46], shown in Fig.(3.4). This model describes corrosion in two parts: (1) initiation period in which external aggressive elements enter into the concrete cover, and (2) a propagation period which starts when the steel depassivates. The residual lifetime of the structure depends on the rate of deterioration. An unacceptable degree of corrosion, not quantified by Tuuti, is reached when a repair should be undertaken.

The quantification of this deterioration period attains crucial importance in the assessment of damaged structures. Different laws of diffusion of chlorides and carbon dioxide (CO_2) have been proposed in order to calculate the time of

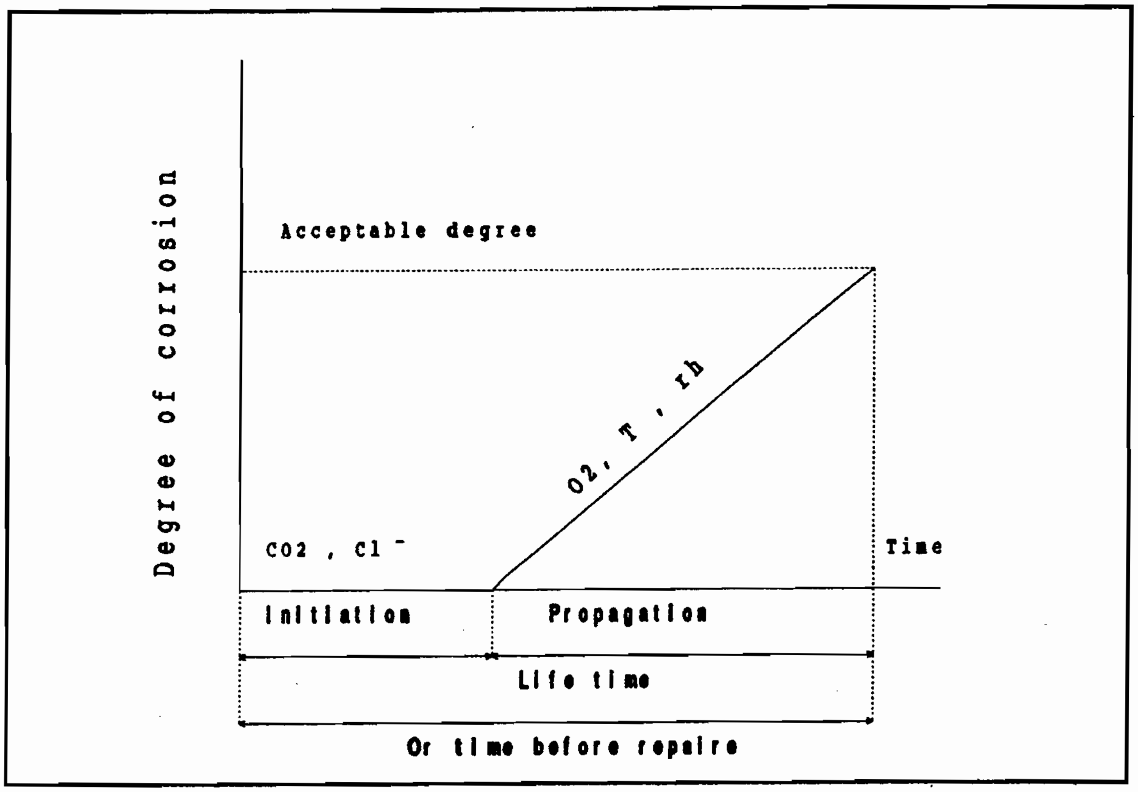


Figure 3.4: Tuuti's model of service life[66]

corrosion initiation as a function of different parameters[13,14] (cover quality, cover thickness, etc.).

The propagation period, however, has received less attention, perhaps because of the scarce data in the literature on deterioration rates. In addition, the determination of an unacceptable level of corrosion has been described more philosophically than quantitatively.

For this propagation period model, three different steps need to be set out to calculate the residual service life of corroding structures: (1) a more accurate definition of the level or levels of deterioration which may affect the serviceability or the load-carrying capacity of the structure; (2) definition of parameters which require measurement to enable quantification of damage; and finally, (3) the transformation of the experimental data for steel corrosion rates into a form applicable to the determining parameter. When introduced in Tuutti's model, the transformed data will allow evaluation of the residual service life of the structure.

3.7 Conclusion

The main objective of this chapter was to make it clear that corrosion of embedded steel in concrete will eventually cause damage to the contrete. Conversely, any damage to, or deterioration of the concrete can lead to the corrosion of the embedded steel. They are interdependent processes, and it is futile to treat the symptoms of decay without first having identified and remedied the cause. Structural and cosmetic repairs often suffer early failure because the cause of the original damage had not been identified and corrected.

How to protect our structures from corrosion? What are the techniques used to prevent penetration of chloride or ensure resistance to chloride induced rebar corrosion? The answers to these questions will be the main subject for the following chapter "Corrosion protection of reinforced steel".

CHAPTER 4

CORROSION PROTECTION OF REINFORCEMENT STEEL

4.1 Introduction

Steel reinforced concrete is the most commonly used civil engineering construction material worldwide. Concrete and steel durability are affected to different degrees by the various aggressive chemicals. It is also affected by any chemical reaction arising from the aggregates. In particular, the natural passivity of steel in the alkaline environment provided by the concrete is disrupted by chloride ions. The reinforcing steel in concrete will corrode and lose its effectiveness, and the resulting corrosion product, because of its increased volume, will cause concrete cracking, spalling, delamination and eventual failure of the structure. Several areas of infrastructure are subjected to severe chloride ingress. These are decks and some other components of bridges and parking structures in locations where deicing salts are used to keep the roads open to traffic in the winter, and marine structures which are subjected to a daily severe salt exposure. In the absence of chlorides, these structures would last many years longer without the need for additional corrosion protection.

An analysis was made by many research departments in North America to determine the length of time until spalling (induced by reinforcing steel corrosion) occurs and the relative cost for different conventional concrete bridge deck designs. Research results have shown that the length of time until corrosion, or spalling, is primarily a function of:

1. The frequency and rate of deicing salt applications, combined with the time duration for which the deck is wet.
2. The water-cement ratio of the concrete, and
3. The depth of concrete cover over the reinforcing steel.

If it is assumed that deicing salts will continue to be used during the foreseeable future, then remedial steps must be taken to ensure that the problem does not worsen. Recognizing this, the necessity for advanced research and field programs to investigate the feasibility of a number of potential solutions to the problem including (a) polymer impregnation of bridge decks, b) cathodic protection of reinforcing steel, (c) protection of the reinforcing steel through the use of various coatings, (d) application of impermeable membranes or coatings to the concrete, and (e) sophisticated rehabilitation procedures involving removal of chloride-contaminated concrete to below steel levels and subsequent protection of the steel (e.g., with epoxy coatings) before new concrete is placed. One means of providing extended service life to existing chloride -contaminated concrete structures is the removal of the chloride ions from the concrete.

4.2 Protective mechanisms

When exposed to air, steel rapidly develops an oxide scale ('rust') on its surface as the normal mechanism of corrosion. A wide range of protective systems can be used to prevent this spontaneous corrosion including paints, plastics and metallic coatings, and inhibitive environments provided by certain types of chemicals. Among the inhibitive systems is the protection offered by hydraulic cements in concrete. When hydrated, the cement component in the concrete produces alkaline compounds which raise the pH of the matrix to between 12.6 and 13.5. Steel remains passive within this pH range, and the limited oxidation required to retain passivity has no practical physical effect on the metal or its surrounding concrete. Furthermore, a barrier to the ingress of moisture and oxygen is provided by the cement matrix, thereby providing both chemical and physical protection to the reinforcement. The period for which this protection remains effective depends on a number of factors including the retention of a high pH and the physical integrity of the cover.

4.3 Loss of protection

Alkaline materials will usually be unstable in the atmosphere because they react with the highly acidic solutions of carbon dioxide and sulphur dioxide formed in moist conditions. Therefore, the alkalinity near the surface of the concrete is reduced as a result of reactions with these acidic atmospheric gases (carbonation)[53]. The extent to which the protective alkalinity is lost will depend on several factors, but the most important are the permeability of the concrete, the extent and depth of cracking, the humidity and the concentration of acidic gases in the atmosphere. The depth of carbonation increases with time and with increase in concrete permeability; its rate is greatest where the relative humidity is in the range 50 to 70% . For dense concrete, the rate of carbonation will be low and, given an initially appropriate depth of cover, steel will remain protected from corrosion throughout the life of the structure. However, if the concrete is permeable, or if it is severely cracked, paths will be available for the ingress of atmospheric gases leading to an increased depth of carbonation with consequent corrosion of the reinforcement. The corrosion products occupy a greater volume than the metal from which they are formed and this volumetric expansion imparts internal tensile forces to the concrete cover causing cracking and spalling. At the same time, the cross-sectional area of sound steel will be reduced but, with ordinary reinforcement, significant structural weakening is unlikely to occur until some time following the onset of cracking. However, when cracked cover associated with reinforcement corrosion is identified, remedial action should be taken as soon possible. Depths of cover appropriate to a range of concretes are given in the various codes of practice. Exposure in an industrially polluted atmosphere with higher concentration of acidic gases will induce a greater depth of carbonation of the concrete than in a rural environment. Therefore, depth of cover for a given concrete must be increased when exposed in polluted atmospheric conditions to compensate for increased carbonation, otherwise the carbonation front can reach the reinforcement within the life of the building leading to a corrosive situation.

4.4 Protection methods

Concrete cover has a good protective effect for reinforcing steel, but, where a large cover thickness is not provided or where cracks are involved, its protective effect is lost.

The main techniques available for protecting the reinforcement steel from corrosion are:

4.4.1 Cathodic protection

Cathodic protection has been defined as " reduction or prevention of corrosion of a metal surface by making it cathodic by the use of sacrificial anodes or impressed current. The basis of the method is to force the steel to take up an electrical potential such that corrosion cannot take place. Two basic methods of cathodic protection are:

(a) Use of sacrificial anodes. Here a metal which will corrode preferentially to the steel (usually zinc) is connected to the reinforcement. This metal acts as the anode of a corrosion cell and corrodes while the steel is forced into a cathodic state. The anodes may have to be replaced at intervals.

(b) Impressed current systems. In this case, a voltage is applied externally which maintains the steel in a non-corroding state. (Figure 4.1).

Both methods have been tried on bridge decks in the United States but impressed current systems are more popular. The practical problem is that the reinforcement must be subjected to a fairly uniform potential. This is achieved, in the case of bridge decks, by casting anodes into a conductive screed. Anodes may be isolated discs cast into this screed or wires placed in grooves in the deck filled with a conductive

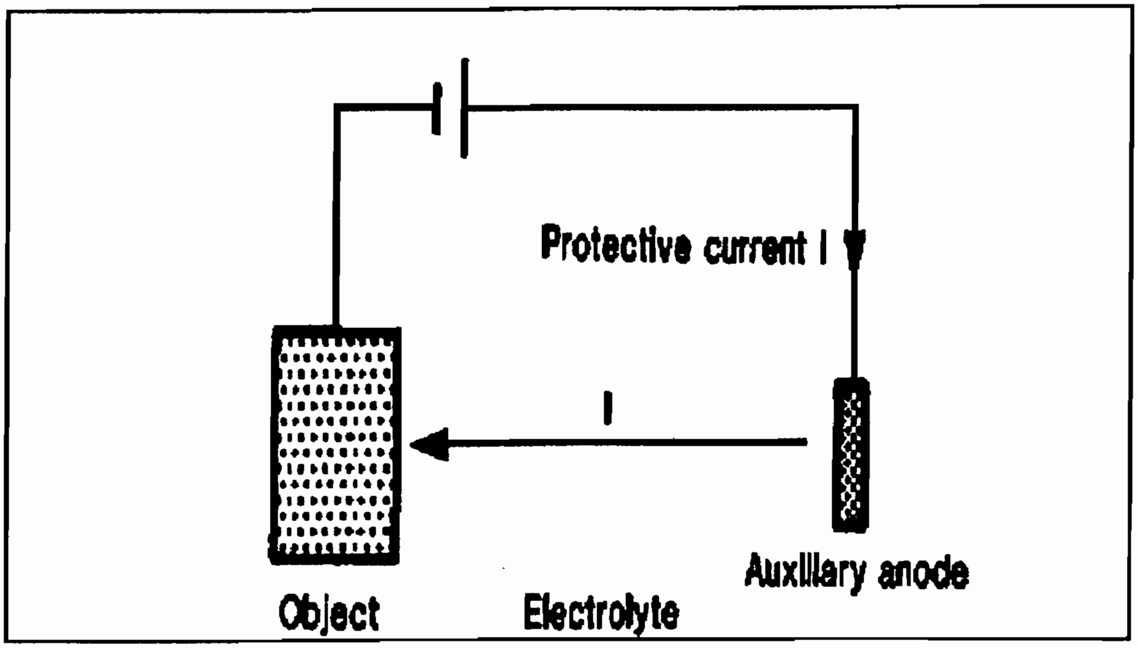


Figure 4.1: Principle of cathodic protection by impressed current

material. Development work is still in progress, but a number of bridge decks have now been cathodically protected and results are understood to be highly satisfactory. Running costs for a cathodic protection system for a bridge deck are understood to be around $200 per year. (Figure 4.2).

Recent studies by the Federal Highway Administration (FHWA) have shown that the cheapest method of obtaining a full 40 year design life in a bridge deck is to construct it without any special measures to protect the steel against corrosion and then, when the corrosion starts, to install cathodic protection[44,71].

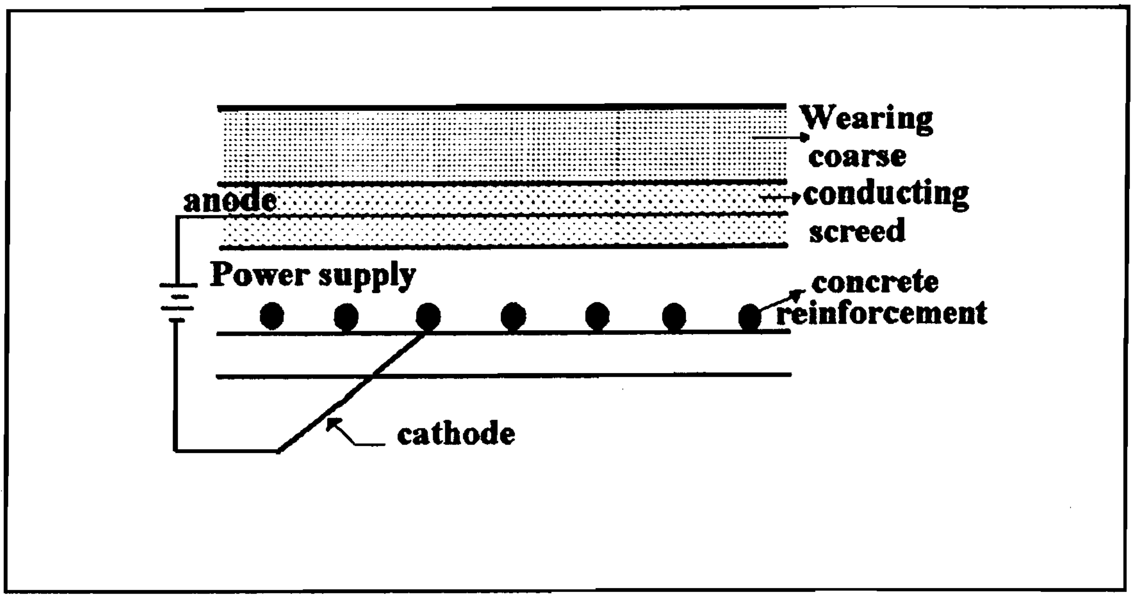


Figure 4.2: Cathodic protection circuit of bridge deck

4.4.2 Inhibitors

An inhibitor is a substance which, when added in small concentration to an environment, decreases the corrosion rate. In a sense, an inhibitor can be considered as a retarding catalyst.

The most commonly mentioned inhibitor is calcium nitrite ($Ca(NO_2)_2$). This is an anodic inhibitor (it suppresses the anodic reaction) and, in the presence of chlorides, it can significantly delay the initiation of corrosion. Tests by Hart and Rosenberg[68] on specimens exposed to seawater showed that addition of 4% by weight of cement of calcium nitrite roughly doubled the time to the initiation of corrosion compared with the case with no additives. The Office of Research and Development of the Federal Highway Administration in the

United States have also been carrying out tests to assess the effectiveness of calcium nitrite in bridge decks. The report[67] on this work states that 'Outdoor slab tests using 2.75% (by weight of cement) of calcium nitrite indicate that the material is very promising...'. Calcium nitrite has also been used on an experimental basis in some bridge decks.

In summary, it can be stated that, while inhibitors do not provide a total cure to corrosion problems, they may be able to assist significantly in retarding and significantly reducing the corrosion of the steel reinforcement. However, still in an experimental stage and their true value cannot yet be assessed with confidence. Equally, the possibility that they might be of value in the future should not be discounted.

4.4.3 Organic coatings

Organic coatings as a class of materials are used mainly to protect the surfaces of steel reinforcement from deterioration. Powder epoxy-coated reinforcement has had most use especially in bridge decks. This is an area where there have been considerable corrosion problems because of contamination by de-icing salts. Research on epoxy-coated steel bars in these conditions has shown a significant increase in protection and reduction in cracking of the concrete cover, compared with the normal reinforcing steel. However, these tests are of a relatively short-term nature (under 10 years) and there is still some question that such coatings may be subject to underfilm attack and pitting at localized breaks in the coatings. Although some breaks in the coatings are to be expected, care should be taken when using epoxy-coated bar to ensure that handling and placing on site does not produce any further significant physical damage to the coating system. If that does occur, the damage should be made good with appropriate epoxy paints.

4.4.4 Treatment of concrete surfaces

Both the initiation phase, where carbon dioxide or chlorides are permeating into the concrete, and the active phase, where corrosion is taking place, can theoretically be slowed down or stopped by sealing the surface of the concrete.

For example, it has been standard practice for many years to protect bridge decks from the deleterious effects of de-icing salts by the use of a waterproof membrane. A problem with bridge decks is that the membrane must either be protected from traffic, or it must be strong enough to withstand the rigours caused by the traffic. Membranes are generally protected by screeds and a wearing course, but successful results have been obtained in the United States with the use of very dense concrete screeds or screeds using latex modified concrete as a waterproof membrane and running surface. Another method would be to use a relatively impermeable sheet as a permanent shutter to the concrete. In the USA, for example, considerable amounts of galvanised steel shuttering have been used on bridges. Another possibility would be to use a fibre-reinforced concrete sheet - even plastic sheeting as a permanent shutter could possibly act to stop chlorides or carbonation entering the concrete.

It is generally agreed, however, that coatings will not be effective in reducing corrosion rates where chlorides have already reached the steel. Theoretically, if a surface coating can be applied so that the ingress of oxygen and water is completely stopped, then corrosion should not occur. However, in practice it is normally possible to obtain a complete sealing of the whole surface.

4.5 Conclusion

This chapter has attempted very briefly to outline some of the possible ways in which corrosion problems can be avoided. Inhibitors and cathodic protection are possible methods but may still be worth consideration in particular cases. Surface coatings, epoxy-coated reinforcement, provision of extra concrete cover thickness or an improvement in concrete quality are more commonly used approaches and may in many cases prove to be more economical than the use of special steel reinforcement. With the possible exception of stainless steel, no method of protection can be guaranteed to give a trouble free structure for fifty or more years. It is suggested that perfection is not required but merely that maintenance costs should be kept within acceptable limits during the expected design life and that protection methods should be approached from this perspective.

CHAPTER 5

CORROSION TESTING METHODS

5.1 Introduction

A wide range of methods is now available to the engineer to determine the true causes of damage, and measure its extent and the rate of progress. These methods can be used to predict the likelihood of corrosion taking place, and identify the areas of a structure most at risk. They can be loosely grouped into two categories :

- Destructive (Coring, sampling, drilling, etc.)

- Non-Destructive (In-situ tests with no damage to the structure or disfigurement of the concrete surface)

Generally speaking, the destructive tests involve testing a sample to failure, and rely on laboratory facilities for full analysis. Non-destructive tests are usually carried out on site, although complete analysis of the test data may be done subsequently at an office or in a laboratory.

Space does not allow a full description of every method here, but the following is a review of the more commonly used tests with a brief summary of the methodology used, and information which can be obtained. It should assist in determining which methods would be relevant to a given set of circumstances. There is also a cautionary note about limitations of some methods. If a test is incorrectly applied, ambiguities or measurement errors can occur which may make the test data inconclusive. Although some of the methods described were developed in Europe, they are all available in the USA and Canada through specialist companies.

5.2 Destructive Tests

5.2.1 Core sampling :

A sample of concrete is core-drilled from the structure, and analyzed by a selected combination of the following laboratory procedures :

- Visual inspection for aggregate size and type, cracks, voids, depth of surface deterioration, presence of steel.

- Physical measurements for density, moisture content, rate of water absorption, and air permeability. Testing for compressive, tensile, and shear strength, elastic modulus and Poisson's ratio.

- Ultrasonic Pulse Velocity (UPV) tests to be correlated with in-situ test results from the rest of the structure. (UPV testing is described in the next section)

- Petrographic (microscopic) examination for mix type and proportions, presence of ASR (Alkali Silicate Reaction) or sulphate products etc. Accelerated growth test to determine if ASR is active

- Chemical analyses for cement content, presence and depth of any contaminants, carbonation depth, identification of high alumina cement (HAC), and measure degree of conversion[43].

Note : Cores should be kept moist until tested unless specified otherwise, e.g. sealed in plastic film or a sample box with water retaining packing such as sawdust.

5.2.2 Drilled samples :

Concrete sampled by collecting the dust from a masonry drill can be analyzed in a laboratory for :

- Percentage cement content and alkalinity .

- Percentage and depth of penetration of contaminants such as chlorides or sulfates.

- High alumina cement and degree of conversion[43].

- The drill hole can be used to check depth of reinforcing steel, and to carry out carbonation depth tests.

Note : Careful control of drill depth and cleaning of the drill bit and hole between samples is essential when sampling from specific depths. For HAC testing, a low speed drill or chisel is used to avoid pre-heating of the sample, which destroys evidence of HAC conversion.

5.2.3 Steel sampling :

Reinforcing steel is exposed by removing cover concrete. This permits visual assessment of corrosion damage, and measurement of the residual thickness. Samples of the steel may be taken for laboratory tests to determine steel type, tensile strength, corrosion resistance, etc.

5.2.4 Carbonation Depth :

This test is usually carried out with the previous tests, and it requires a freshly broken concrete face perpendicular to the outer face. A small chisel is used to flake off the side of a drilled or cored hole. A chemical indicator (phenolphthalein) sprayed onto the test face indicates alkalinity or acidity of the cement by colour change. This indicator has a very strong pink colour, easily visible on any concrete that has retained its alkalinity, yet it was colourless on concrete which was no longer adequately alkaline to protect reinforcing bar from corrosion. Though not as accurate as laboratory testing, it is a good site guide to determine the depth of carbonation.

5.2.5 Pull-out test :

This test determines approximate concrete strength by measuring the force required to pull a set of standard expansion anchors out of standard drilled holes. It provides a good approximation if a large enough number of samples are used, and correlated with crushing tests on a core sample taken from the same area.

5.3 Non-destructive Tests (NDT)

5.3.1 Rebound Hammer :

The rebound hammer, also known as the Schmidt or the Swiss hammer, is used to measure the rebound distance of a standard steel projectile, propelled against the concrete with a standard force. A scale on the tool shows the rebound distance as a 'rebound number'. This number can be used to check concrete uniformity by comparison of the test data. If calibrated with laboratory tests, it can give an indication of the compressive strength.

Note : The actual property of the concrete measured is surface hardness. The comparatively small cross-section of the projectile tip may mean that impact is on a piece of hard aggregate at the surface, whereas a subsequent test may be on the softer cement paste between the aggregate particles. This creates measurement disparity which can only be resolved by making a large number of tests and averaging the data. Processes that have a surface hardening effect, such as curing membranes or carbonation, may give rise to optimistic strength estimates.

Surface finish, curvature, and presence of water affect the uniformity of the impact, and therefore the degree of rebound recorded. The method also assumes a standard velocity for the projectile at impact, but this will be affected by gravity, and friction. A difference will be noted between measurements made by the same instrument in the vertical and horizontal planes on the same test piece.

5.3.2 Ultra-sonic Pulse Velocity (UPV) :

Two transducers, a transmitter and a receiver are placed on the test piece. An electronic trigger/timer device measures the transit time of an ultrasonic pulse through the material between the transducers.

UPV is calculated from the transit time and the measured path length. Since UPV is a function of the modulus of elasticity and density of the material, it provides comparative data for the assessment of concrete uniformity. Cracks, inclusions, honeycombing, and voids affect transit time by diverting the pulse, or reducing its velocity. UPV can also measure crack depth and direction in some circumstances. Correlation with compressive strength tests on core samples will enable estimates of strength in other parts of a structure cast from the same concrete.

It should be noted that the UPV test should not be used to estimate the concrete strength without correlation with laboratory test samples. If repeatability is required for long term monitoring, the UPV transmission path must be precisely duplicated, using fixed, permanent reference points. Accuracy of the calculated velocity depends on the accuracy of path length measurement, angle between transducers, and diameter of transducer faces. The results are the most accurate when transducers are placed on opposite, parallel faces of the test piece (direct path). The results are less accurate when the transducers are placed on faces at 90° to each other, i.e. at corners (semi-direct). The results are the least accurate when both transducers are on the same face, (indirect path).

Steel extending across a crack can transmit the pulse and 'hide' the crack if the test is made too close to the steel.

5.3.3 Sonic-Logging :

Sonic-logging can be used to apply the UPV test in many inaccessible areas, such as underwater etc. Transducers are sealed probes lowered down in preplaced access tubes or coreholes. The probe cables are drawn over a special winch, which measures and records the probe depth.

Sonic logging provides a continuous profile of transit time between the probes as they are withdrawn. Measurement densities of up to two per vertical inch make the method less susceptible to repeatability error caused by the normal variation in the concrete quality than the conventional UPV test. It can be used in coreholes extending through the foundation base to assess the quality of the contact between bedrock and the foundation.

5.3.4 Mechanical Impedance :

The test point is struck with a small hammer containing a load-cell. The response is monitored by a geophone. The transducer signals are recorded by a data acquisition system, and processed by a personal computer. In the frequency domain, velocity is divided by force to give the transfer function, or mechanical impedance response graph, providing information on dynamic stiffness, structural resonance, concrete quality and integrity.

The method can detect low density or honeycombed concrete micro-cracking or delamination due to deterioration, and loss of support or voids beneath concrete pavements, floors, dam spillway linings and runways. It can be used to assess the bonding of screeds, finishes, tiles, and asphalt overlays on concrete.

It should be noted that specialized experience is needed for application and interpretation of the data. Transducers must be used on a clean, sound surface, with no debris or flaking concrete.

5.3.5 Re-bar Locator :

A sensor coil, generating an electromagnetic field, is passed over the surface of the concrete or masonry. Magnetic material entering the field will cause variations in the magnetic flux that can be measured electronically.

From these measurements, the location and orientation of the material can be determined. Some devices enable the size and depth of the concrete cover to steel bars to be determined by using spacer shims of known dimensions to increase the distance between the transducer and the reinforcing steel, and then comparing the measurements.

It should be emphasized that the method uses electro-magnetism to detect the target and can be 'blinded' by a magnetic mass (steel beams, columns or plates, magnetic aggregate). It may be unable to discriminate individual bars if re-bars are bundled, or if the steel is misplaced, and if the bars are too close together.

5.3.6 Ground Penetrating Radar (GPR) :

GPR systems send pulses of microwave energy through the test piece. Some pulse energy is reflected from the interfaces between different materials, back to the surface, where it is recorded.

The method can be used to determine layer thicknesses if correlation with a sample of known depth is made. It can locate the deep embedded conduits and steel, or those not detectable by re-bar locators. In certain circumstances GPR can locate or map the extent of voids or delamination.

The pulse energy reflected depends on the difference in the dielectric constants of the materials at the interface, and bulk conductivity. High conductivity materials dissipate pulse energy as heat. The dielectric constant is the ratio of pulse velocity in air to the velocity through the test material. Conductivity and pulse velocity vary with moisture content and density, therefore radar may not be able to detect interfaces between saturated materials.

5.3.7 Half-cell Potential Test :

Typical Half-cell probes may be either a copper electrode in copper sulfate electrolyte, or silver in silver chloride. Half-cells generate a known reference voltage that can be used to assess the electrical potential difference at any point on the reinforcing steel in a concrete structure.

Empirical evidence from research and commercial testing has not yet proven any specific voltage at which corrosion will occur, but it has been shown that the likelihood of corrosion is proportional to the potential difference. Mapping of 'potential contours' for a structure readily identifies the most 'active' areas, and therefore it provides a focus for other test and evaluation methods. Test results are usually analyzed in conjunction with resistivity test data.

5.3.8 Bulk Resistivity :

Resistivity testing measures the bulk resistance of the concrete to the flow of the electrical currents necessary for electrolytic corrosion. An array of two or four electrodes in contact with the concrete surface pass an alternating current using the concrete to complete the electrical circuit. According to the concrete type, the device may use a constant current, and measure voltage loss, or measure the amount of current required to maintain a constant voltage.

Resistivity measurements should be correlated with half cell potential data to determine the likelihood of corrosion activity. Again, the data is empirical, but experience has shown that high resistivity is associated with low corrosion risk and vice-versa.

It must be noted that the electrical resistance of concrete is affected by its moisture content. In dry conditions, half-cell or resistivity tests may show no evidence of corrosion risk, even where the process is well advanced. Tests should be planned for wet parts of the year, or after thorough wetting of the structure.

Caution must be used when using the methods on structures with post-tensioning tendons. Usually the tendons do not have intimate contact with the concrete. Test results for concrete and the reinforcing steel around tendon ducts may not be relevant to the condition of the tendons themselves.

5.4 Passive Monitoring

If effective repairs are to be made, the engineer must know if any cracks in the structure are still active as load or climate condition changes, and therefore likely to recur in any repair material at some later date. Much information can be gathered from visual inspection and what are referred to as 'Passive' monitoring methods. These include devices such as tell-tale plates, crack monitoring gages, and other movement measurement instruments.

5.4.1 Visual Inspection :

A key part of a structural evaluation is the visual inspection. It is used to establish reference points and select sites for other tests. Comparison of test results from apparently sound areas with those from damaged areas will often provide much useful information in later analysis. Exposure conditions, the prevailing weather patterns and construction details such as overhangs, ledges and joints are all considered when analyzing the test results.

In addition to noting surface anomalies such as spalling, stains, pitting, and efflorescence (furry or scaly deposits) crack size should be measured using a calibrated pocket microscope. Any deposits or gel in the cracks will also be seen with this device.

5.4.2 Tell-Tale Plates :

The simplest crack monitors are thin glass plates glued across the crack. Any crack movement will break the glass. A more sophisticated unit is the Avongard monitor, which consists of two acrylic plates. One is etched with a fine grid pattern, the other with a simple cross-hair marking. The plates are glued on either side of the crack, the cross-hairs overlapping the grid, and centered on it. Any subsequent movement of the sides of the crack can be measured from the position of the cross-hairs on the grid.

5.4.3 Strain Gages :

These may be electrical or mechanical, and are used to monitor relatively slow movement around the cracks as load or thermal gradients change. They can therefore provide 'spot' measurements, or record a history of movement over time, when coupled to a suitable data-logging system.

5.4.4 Acoustic Emission :

Change in load or temperature induces stresses in a structure that can result in minute movements of the structural material around such anomalies as cracks, voids, or inclusions. These movements generate acoustic noise that can be monitored and recorded. Analysis of the data can characterize each noise source 'signature', by amplitude for a given stress, and frequency content. Once the base-line signature for a point on the structure has been established, changes in the signature, either in frequency content or in amplitude, will indicate a corresponding change in structural condition, such as an increase in crack length.

5.4.5 Settlement :

If settlement may have caused cracking, more complex devices such as extensometers or inclinometers may be used to monitor the movement over time, to determine if it is on-going, before an effective repair strategy can be planned.

5.5 Recent Developments

There have been significant developments in this field, particularly in the last two to three years. The increasing power and portability of personal computers has had a profound effect on test methods, increasing speed, data accuracy and reliability, and in reducing costs. Data processing methods on modern PC's have greatly increased the information available in the field from techniques such as Sonic Logging, Ground Penetrating Radar, and Mechanical Impedance tests. Data from methods such as Half-cell Potential and Resistivity tests can be presented as simple 'contour' maps of the structure, that show areas of high and low activity with clarity.

Researchers at Cornell University, funded in part by the Strategic Highway Research Program, have developed a simple in-situ test to identify the presence of ASR without the need for core-drilling. [60] The method can provide an important 'early warning' of ASR before visible damage occurs. A number of researchers are also currently evaluating methods for the determination of the chloride content of in-situ concrete.

There are ongoing research and development programs for high-speed pavement condition measurement systems, some of which have shown the capability of locating the cracks and delamination caused by corrosion in bridge decks. The methods under investigation include Infra-Red Radiation, Radar, Stress Wave Analysis and Deflection. Several papers were presented on the subject at the Transportation Research Board meeting in Washington DC, January 1991. [62]

One of the difficulties facing the engineer in trying to carry out a preliminary inspection on a large structure is that of access. Where parts of the structure are beyond the reach of mobile platforms, and scaffolding is too costly, such surveys are often carried out solely by observation through binoculars. A number of agencies and universities in the USA, England, and France are currently working on the development of robotic devices that can not only carry a video-camera to record surface detail, but also to carry out a number of other sampling procedures or non-destructive tests.

5.6 CONCLUSION - PLANNING AN INSPECTION PROGRAM

This chapter has presented a brief review of the techniques currently available to predict and evaluate corrosion damage to concrete, and the reasons for their use. An informed choice of test and inspection methods can make assessments more accurate and economical, and can make maintenance more effective. An article in Hydro-review Journal recently gave some case histories and typical test program combinations for concrete structures[63].

With an understanding of the causes of deterioration, and by knowing the capabilities and limitation of the technology available, the engineer can plan an inspection program that will yield a maximum of information. Quality of construction and repairs can be monitored, and scheduling of maintenance needs can be carried out more objectively with information gathered by such programs.

Though the general deterioration of infrastructure is of widespread concern, local circumstances can mean that some structures face unique construction and operational problems, such as composition of locally mined aggregates, impact from marine vessels, or chemically contaminated atmosphere. Having identified the cause and mechanism of deterioration on any particular structure, the engineer is better able to design the rehabilitation works or replacement project specifically to counter the influences of local environmental conditions, material properties, or unusual operational requirements.

CHAPTER 6

ACCELERATED CORROSION TESTING

6.1 Introduction

Reinforced concrete is used widely to build large projects like bridges, tunnels, and offshore structures. It is now recognized that corrosion of reinforcing steel is an important problem to be solved in order to increase the reliability of the structure and to reduce maintenance costs.

In concrete, steel is in a passive condition, because of the high level of pH (12.5 to 13.7) of the solution contained in the pores of the concrete. The corrosion of reinforcing bars can occur when this passivation is destroyed by the penetration of chloride ions at the metal concrete interface and by a decrease of pH as a result of the action of various phenomena such as carbonation and ingress of chlorides. The rate of corrosion is mainly controlled by the diffusion of dissolved oxygen through the concrete cover. The corrosion products formed at the surface of rebars introduce tensile stresses in the material resulting the cracking and spalling of the concrete.

Many laboratory studies and site inspections have been carried out to study this phenomenon along with an early detection of the attack. Considering the nature of this phenomenon, electrochemical methods are often used. The most widely used method consists of measurement of the electrode potential of the rebars which, in some cases, allows differentiation between the active and passive states of the steel.

An accelerated electrochemical corrosion testing program was undertaken at McGill University in 1990. The main objective of this program was to determine the minimum clear concrete cover depth to protect the steel from corrosion. A preliminary testing of several parameters was performed to help define the main variables to be examined in the experimental program. Two test series with the same concrete cover thickness variation, but with different concentrations of the electrolyte were examined by Palumbo[72].

This chapter describes the experimental set-up and the tests undertaken at McGill University from May 1992 to January 1993.

6.2 Experimental Procedure

6.2.1 Equipment

The basic equipment consisted of the following:

(i)- Nine aquarium tanks with dimensions 16 in.(406mm) length by 8 in.(203mm) width, and 10 in.(254mm) height.

(ii)- Nine plywood boards 1/2 in.(13mm) thick, and of dimensions 20 in.(508mm) by 12 in.(305mm) to cover the tanks

(iii)- Nine reference saturated calomel electrodes (SCE).

(iv)- Voltmeter (HICKOK Digital Systems - Model DP100).

(v) - Ammeter (MICRONTA 320 mA range).

(vi)- Power Supply, 1 Volt DC.

(vii) - Electric wires and clips.

6.2.2 Specimen Preparation

Nine concrete cylinders were cast in each series, these cylinders had the same height 6 in.(152mm), but different diameters according to the desired depth of the concrete cover. Nine steel reinforcing bars No.15, 12 in.(305mm) long were embedded centrally into the concrete cylinders as shown in Fig 6.1. An electroplater adhesive tape was installed at the steel-concrete interface to protect the specimens from possible corrosion which may occurred in that region.

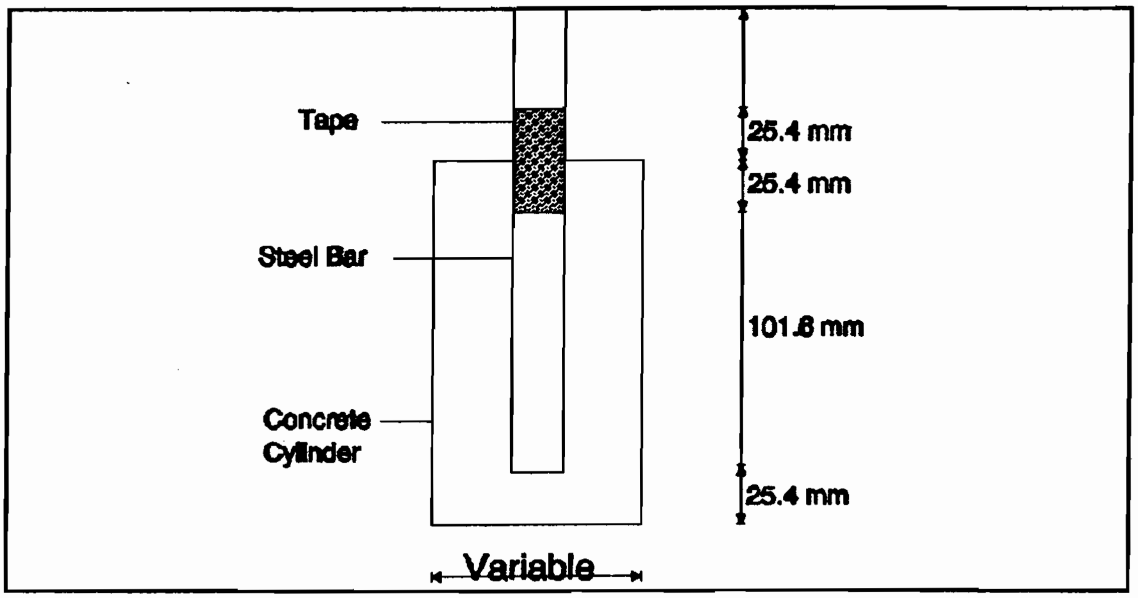


Figure 6.1: Schematic Diagram of the concrete specimen

6.2.3 Description Of The Experimental Set-Up.

A schematic plan of the experiment set-up is shown in Fig 6.2.

The aquarium tanks were filled with an electrolytic solution (distilled water containing 3.5 percent sodium chloride (NaCl) by weight of water). The concrete specimens and the rebars were then immersed in the tanks spaced at a distant of 4 in (102mm) between the bars. This was provided

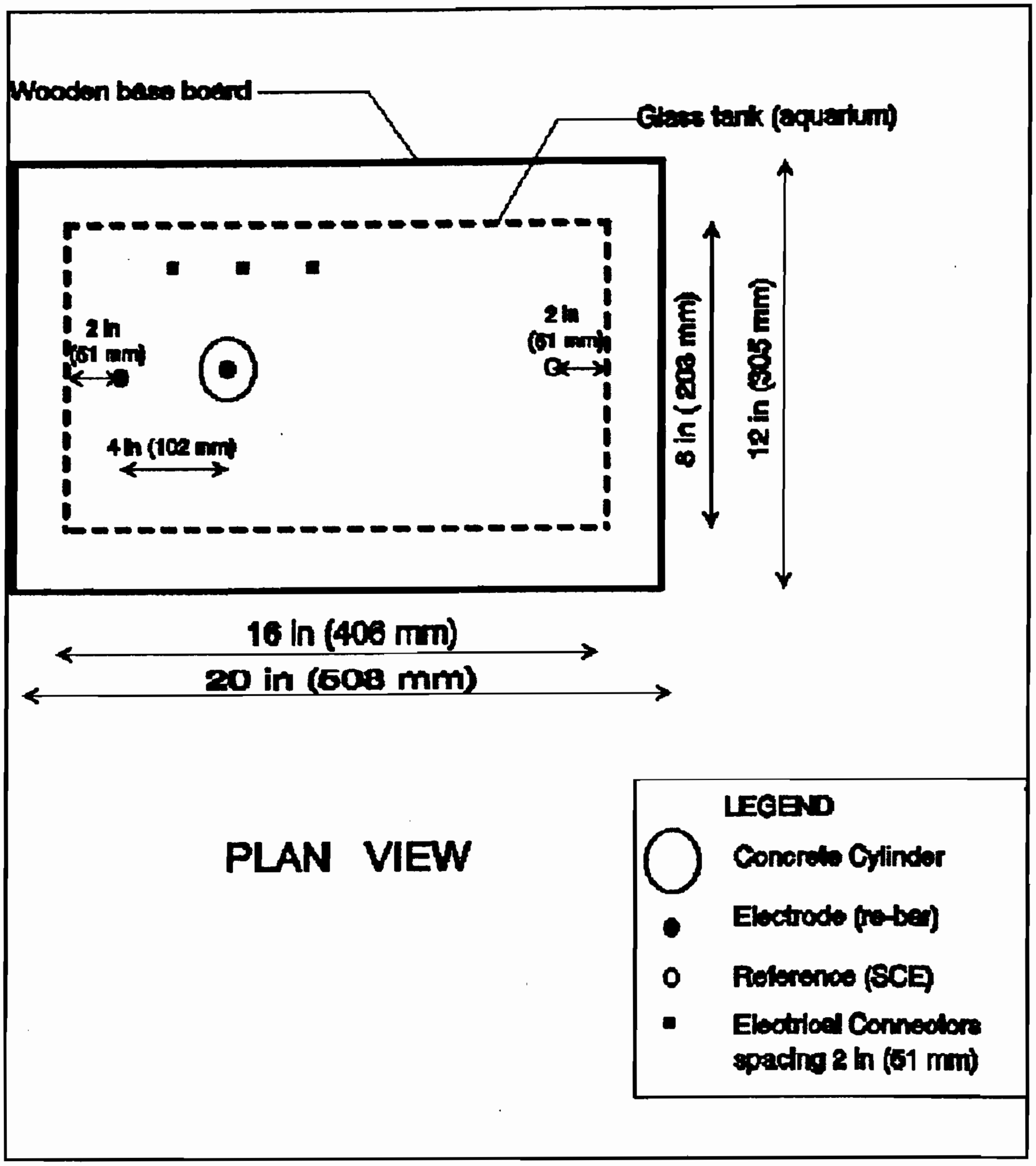


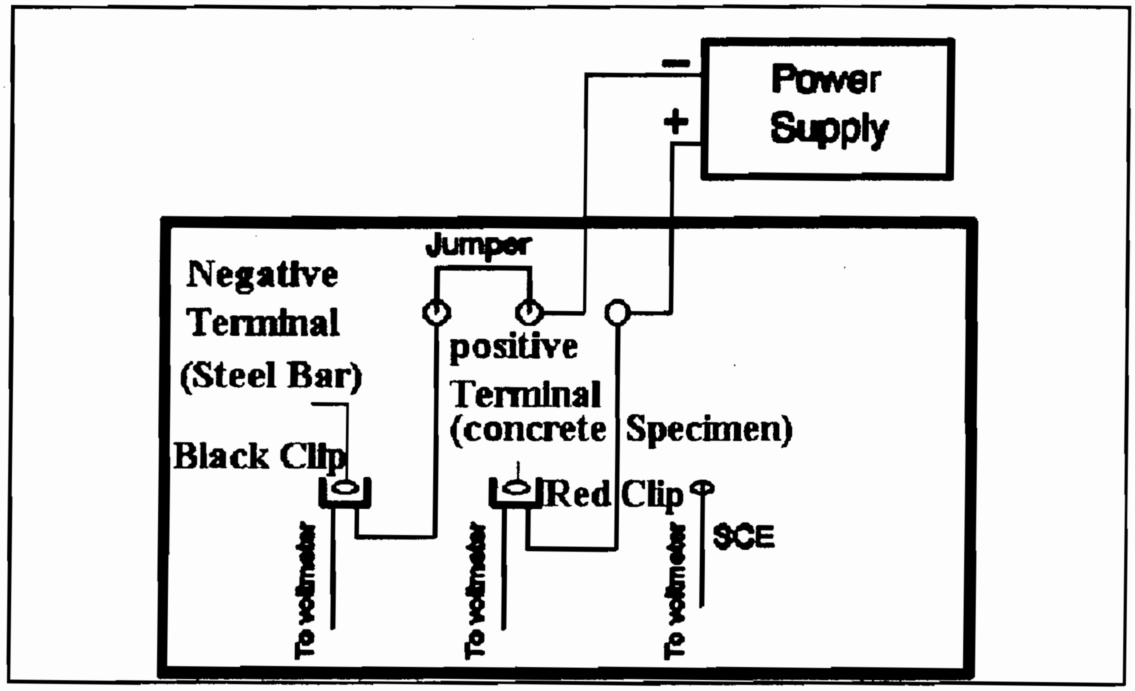
Figure 6.2: Plan View Of Experiment Set-Up

by appropriate holes drilled in the wooden boards which were placed on top of the tanks. The wood boards also used as bases for the electrical circuit required to impress the necessary voltage, and as a cover to prevent the electrolyte solution from evaporation. Another hole was drilled in each board to facilitate placement of the reference electrode in the aqueous solution.

Lead electrical wires were soldered to each end of 30 amp rated battery clips, which were connected to the protruding part of each rebar. Three equally-spaced "connectors" were mounted on the wooden board to complete the electrical circuit. One lead wire from each battery clip was "spliced" and attached to the appropriate "connector" on the board. The "connector" with the lead wire from the specimen was then connected to the positive terminal of a direct current (DC) power supply (Red clip). The negative terminal (Black clip) was linked to the middle "connector" by means of another electrical wire. In order to connect the negative terminal "connector" to the "connector" with the lead wire from the bare electrode, a "jumper" wire was used. Both ends of the "jumper" were fitted with connections that could be inserted directly into the "connectors", thus enabling the "jumper" to be used as a switch. To "open" or "close" the electrical circuit, the "jumper" could be removed or inserted easily. Figure 6.3 illustrates the electrical circuitry.

The steel reinforcing bars act as electrodes, with the one connected to the positive terminal being the anode and the other connected to the negative terminal being the cathode.

As mentioned before, the measurement of the electrode potential is the most widely method used, and to determine the



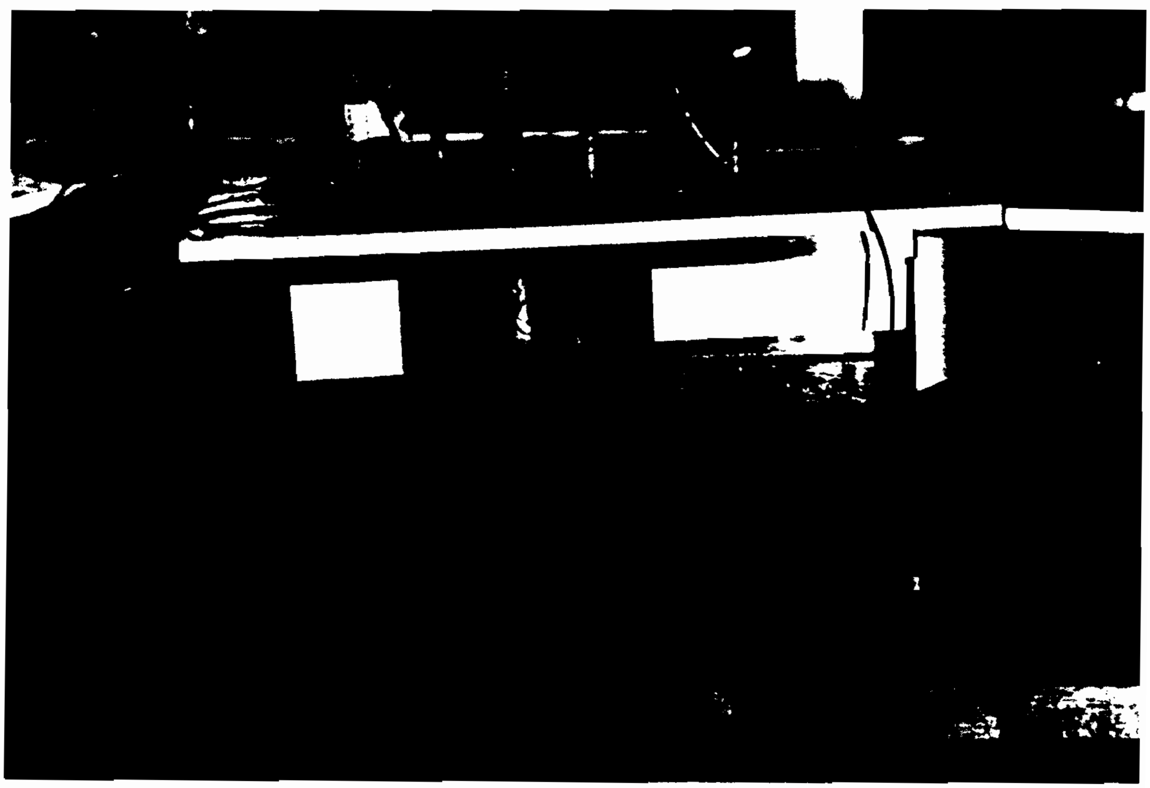


Figure 6.3 : Electrical Circuitry

potentials of both electrodes, a reference saturated calomel electrode (SCE) was immersed in the electrolyte solution. This consisted of a mercury/mercury chloride reference element surrounded by saturated potassium chloride (KCl) contained in the outer tube. When immersed in the NaCl solution, electrical contact is made between the sample and the electrolyte solution at the opening located at the end of the electrode. This opening forms a conductive bridge between the reference electrode, the sample, and the indicating electrode.

In order to permit proper electrolyte flow during the test, the reference electrode must have its re-fill hole open when taking measurements. A re-fill hole is a small circular opening located at the top of the reference electrode, where the spout of the re-fill bottle is inserted. Each electrode was periodically refilled with KCl solution to make sure that the electrolyte always covered the tip of the internal element. The level of KCl solution was maintained above the surface of the aqueous solution, assuring that the NaCl solution would not backflow into the electrode.

This experimental set-up provided a clean and safe approach of accelerating the corrosion process. All of the electrical equipment and materials were utilized repeatedly for the various experiments.

6.2.4 Measurements

In order to measure the voltage in each electrode, the following steps were undertaken:

1. The positive-terminal probe of the voltmeter was connected to the anode, by means of the battery clip connectors, while the negative-terminal was connected to the SCE. Measurements were recorded when stable reading were obtained (approximately 5 to 10 minutes). Two sets of readings were recorded, one with the power operating (circuit "closed") and the other with the power interrupted (circuit "open"). The latter was achieved by removing the "jumper" between the "connectors". (see Figure 6.4).
2. The above step was repeated, however, the positive terminal probe was connected to the bare electrode to measure its potential. (see Figure 6.5). Both steps 1 and 2 were taken in the normal polarity position.

3. The polarity was reversed by exchanging the lead wires of the DC power supply in the appropriate "connectors".

4. Two sets of readings were recorded for each electrode in the reversed polarity position, The negative-terminal probe of the voltmeter was connected to the respective electrodes, while the positive-terminal probe was connected to the SCE

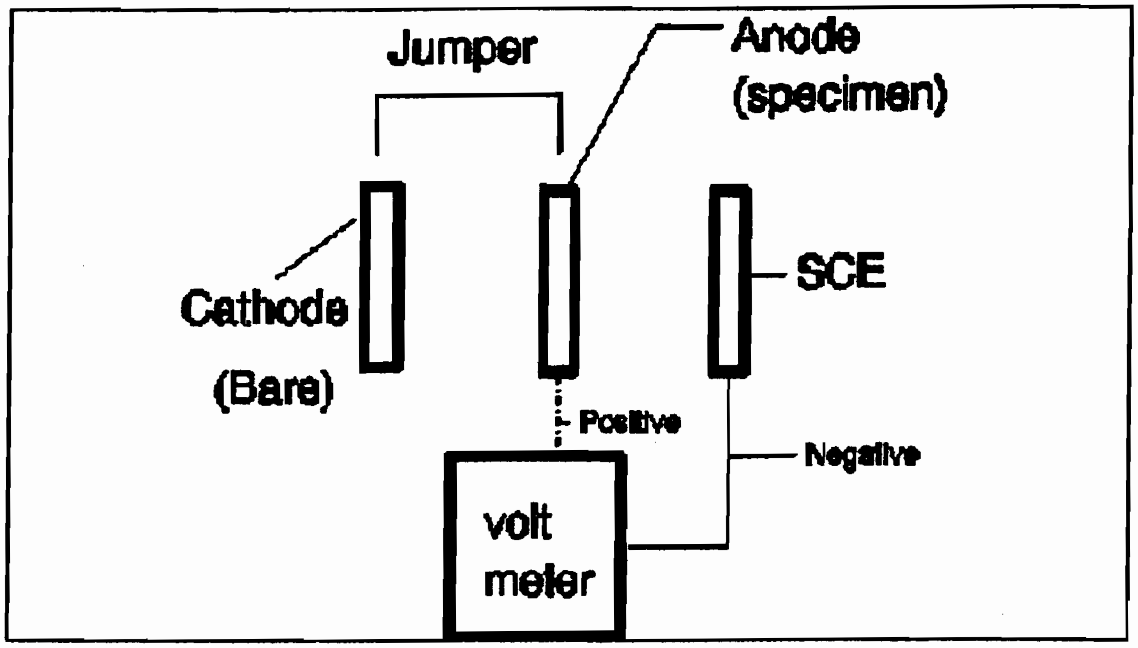


Figure 6.4: Connections Diagram for Anode Voltage Measurements in Normal Polarity Position.

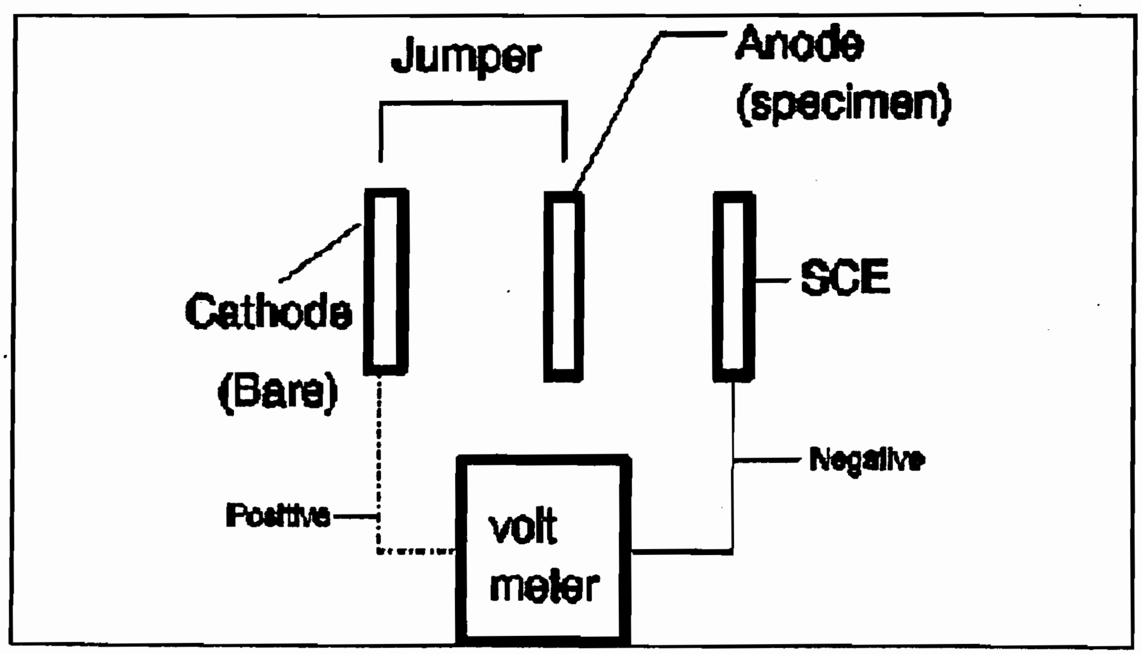


Figure 6.5: Connections Diagram for Cathode Voltage Measurement in Normal Polarity Position.

(Figure 6.6 and 6.7). The readings were recorded when stable values were obtained (approximately 5 to 10 minutes). Two sets of readings were obtained, both for the "open" and the "closed" circuits.

The voltage measured on each electrode in the interrupted power mode (circuit "open") is termed the **polarization potential**. This reflects any chemical or physical changes that may be occurring on the metal surface. The voltage recorded in the operating power mode (circuit " closed") is termed the operating potential, This includes both the polarization potential and any voltage drop in the electrolyte solution between the electrode and the point of measurement.

The current readings were recorded in the following manner:

1. The positive-terminal probe of the voltmeter was connected to the specimen anode, while the negative-terminal probe was connected to the bare cathode by means of battery clip connectors. The "jumper" was then removed from the "connectors" and replaced by the probe ends of the ammeter. Once again, the positive-terminal probe was connected to the specimen anode, whereas the negative-terminal probe was connected to the bare cathode. As soon as stable readings were obtained (approximately 5 to 10 minutes), simultaneous readings of both the current and the voltage were recorded,

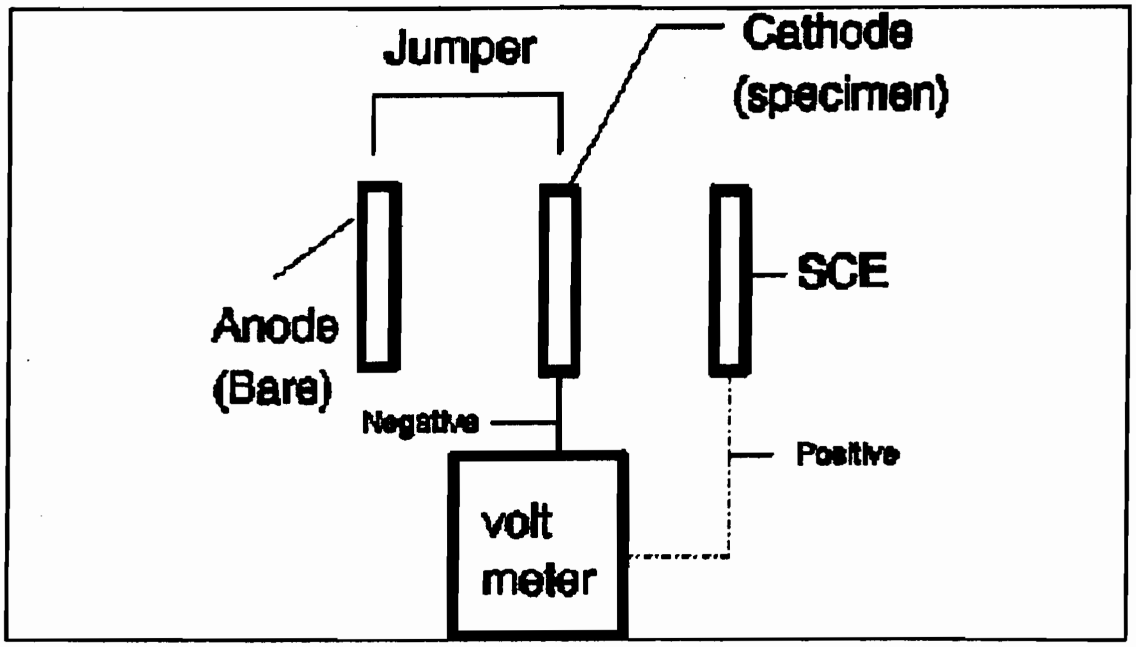


Figure 6.6: Connection Diagram For Cathode Voltage Measurement in Reversed Polarity Position.

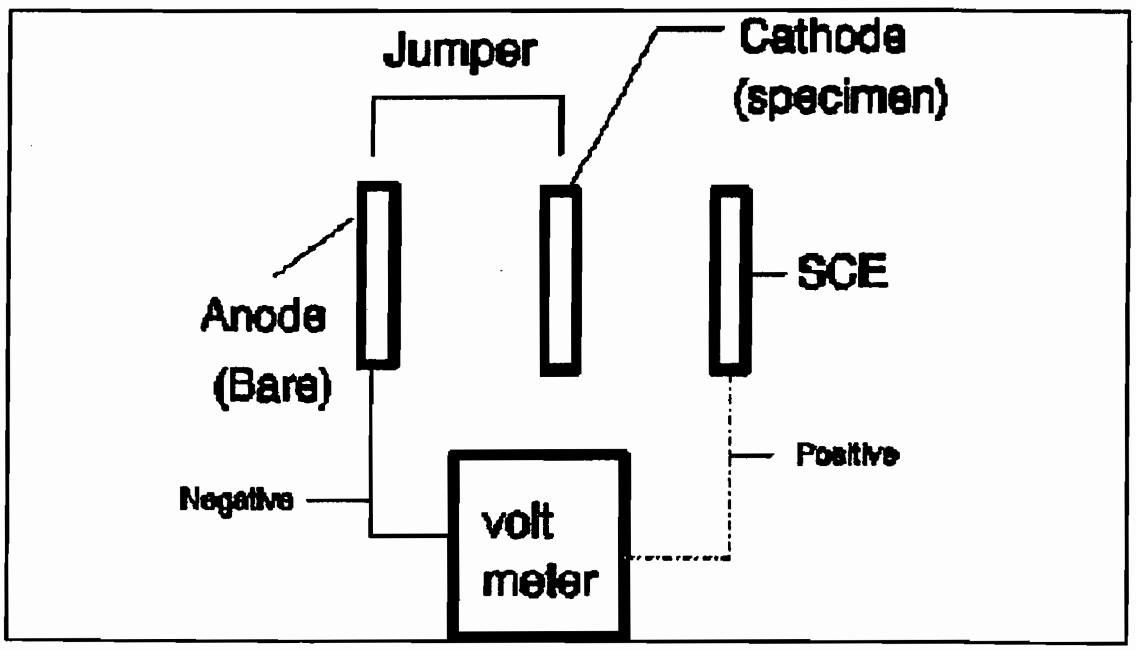


Figure 6.7: Connection Diagram For Anode Voltage Measurement in Reversed Polarity Position.

Figure 6.8 demonstrates the set-up for a typical current measurement.

2. In the reversed polarity position, Step 1 was repeated. Appropriate connections were made, that is, the negative and the positive terminals probes connected to the specimen cathode and bare anode, respectively. (see Figure 6.9). Simultaneous voltage and current measurements were recorded.

The resistance of each electrode is computed as the difference between the operating and polarization potentials divided by the corresponding current.

In between the daily readings, the concrete specimen was left connected to the positive terminal of the power supply (i.e., as an anode), while the bare steel reinforcing bar was connected to the negative terminal (i.e., as a cathode). This enabled the electrolytic process to continue, with the transfer of ions in the electrolyte solution.

6.2.5 Testing Parameters

According the preliminary testing by Palumbo[71], the following parameters were used in the present Series:

1. Impressed voltage: 1.0 V
2. Distance between electrodes: 4 in. (102mm)
3. Water-cement ratio : 0.40 - 0.45
4. Electrolyte concentration: 3.5% by weight of water.
5. Immersion time: 45 Days
6. Reinforcing bars: No. 15

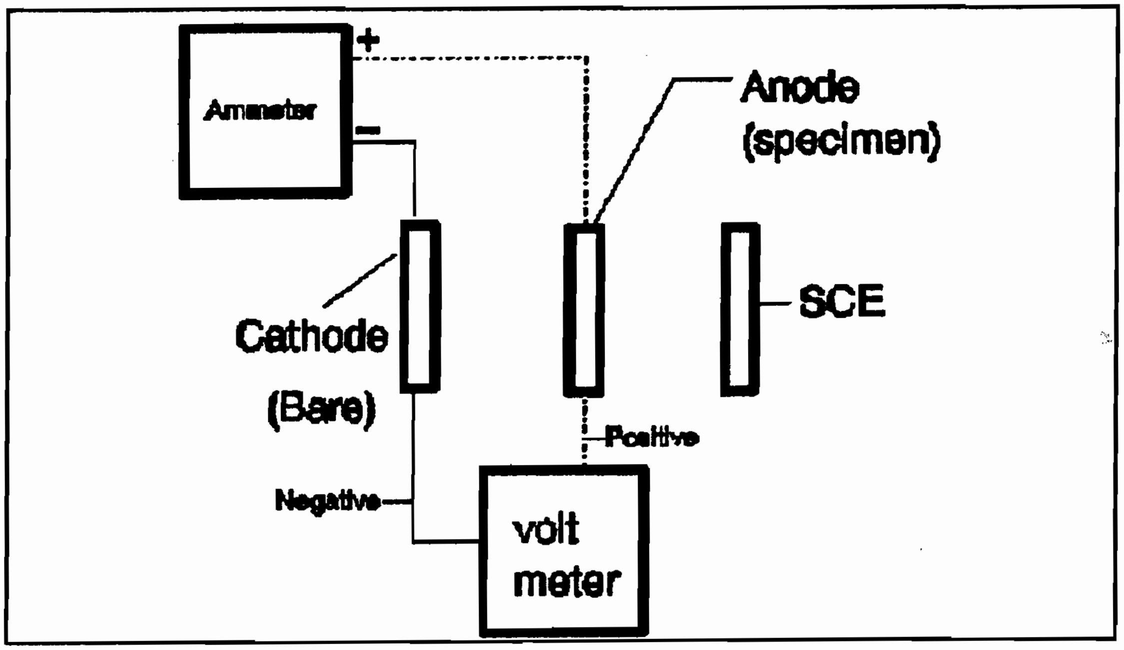


Figure 6.8: Connections Diagram For Current Measurements in Normal Polarity Position.

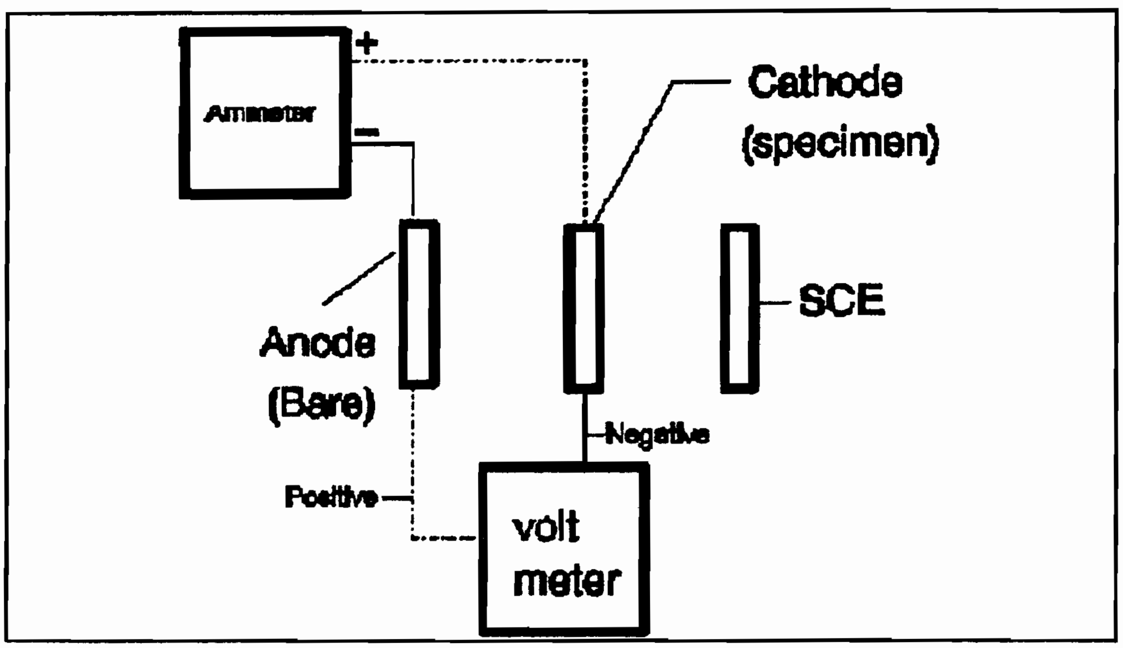


Figure 6.9: Connection Diagram For Current Measurement in Reversed Polarity Position.

7. Cement type: **Portland cement, Type 10**

8. Fine sand, coarse aggregates (1/4 in. - 6.4mm crushed stone)

6.2.6 Cover Thickness Variations

The variation of the concrete cover thickness was achieved by means of plexiglass and plastic molds with varying inside diameters. The range of clear cover depths examined are listed in Table 6.1.

SPECIMEN	MOLD INNER DIAMETER in.	(mm)	NOMINAL BAR DIAMETER in.	(mm)	CLEAR DEPTH OF CONCRETE COVER in.	(mm)
A	4-3/4	(121)	0-10/16	(15.9)	2-1/16	(52.4)
B	4-1/2	(114)	0-10/16	(15.9)	1-15/16	(49.2)
C	4-0	(102)	0-10/16	(15.9)	1-11/16	(42.9)
D	3-1/2	(89)	0-10/16	(15.9)	1-7/16	(36.5)
E	3-0	(76)	0-10/16	(15.9)	1-3/16	(30.2)
F	2-3/4	(70)	0-10/16	(15.9)	1-1/16	(27.0)
G	2-1/4	(57)	0-10/16	(15.9)	13/16	(20.6)
H	2-0	(51)	0-10/16	(15.9)	11/16	(17.5)
I	1-1/5	(38)	0-10/16	(15.9)	7/16	(11.1)

Table 6.1: Mold Sizes and Clear Concrete Cover Depths

6.3 First Set-Up (Test Series #1)

In this series the specimens from (A to I) were immersed in the tanks, normal concrete was used in casting the specimens with a compressive strength equal to 35 MPa.

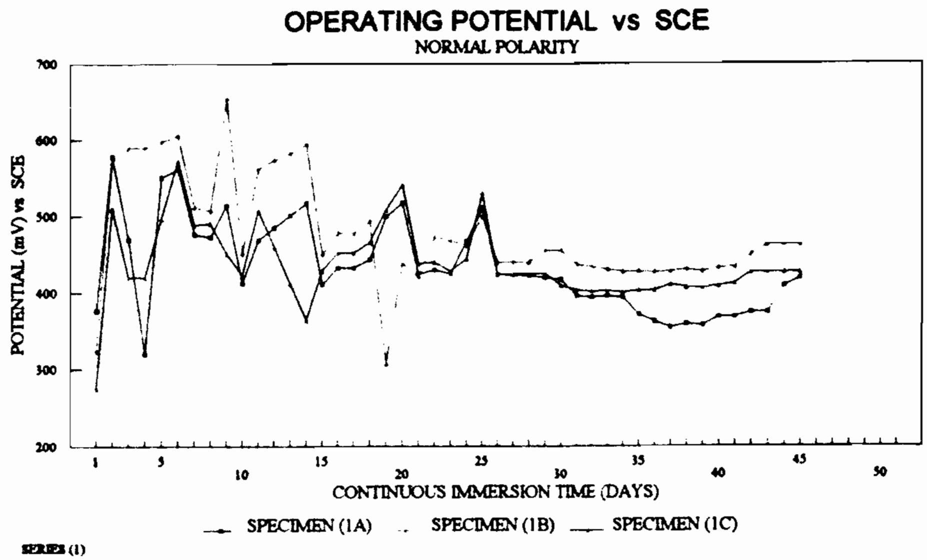
6.3.1 **Visual observations:** were made on all test specimens during the period of this test. Specimen 1I started forming bubbles on the second day. On the fourth day, corrosion products appeared along the surface of the specimen; these products formed were of a dark reddish-black colour. Accumulation of the corrosion product continued until the 13th day when a large yellow spot formed on top of the specimen. Small red and black spots appeared on Specimens 1G, 1H on the fifth day. The surface of Specimen 1H showed corrosion products on the seventh day. No signs of corrosion were observed on the other specimens (see Appendix A).

6.3.2 Electrode Potentials And Current Measurements

Daily readings of both the anode and the cathode operating and polarization potentials were recorded for normal and reversed polarity positions, that is, with the specimens acting as anodes and cathodes, respectively. Measurement of current flow, in milli-amp (mA) range, and the corresponding voltage (IR) drop in the electrolyte were also recorded. Appendix (B) presents the various test data.

Figures 6.10, 6.11 and 6.12 illustrate graphically the variation of the operating potentials with the reference SCE of the specimens in this series.

Figures 6.13, 6.14 and 6.15 present the variations of current flow for both normal and reversed polarity positions.



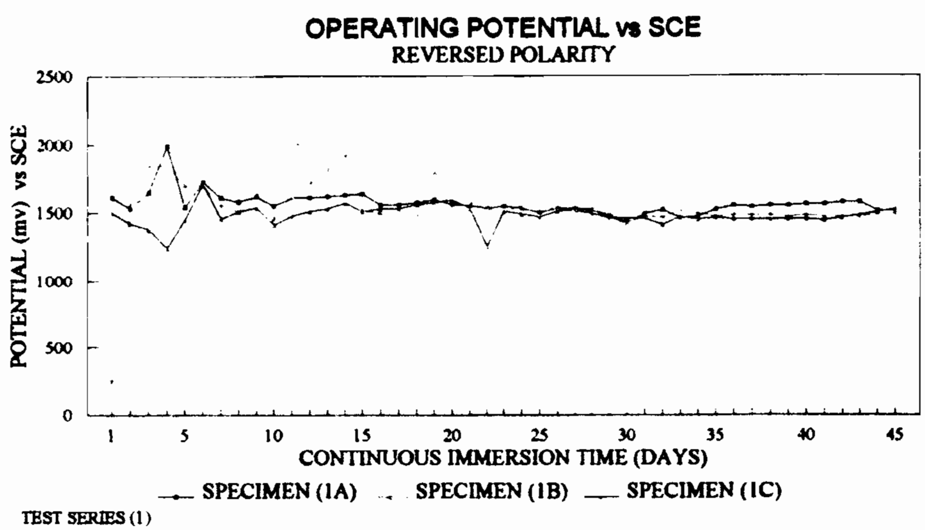
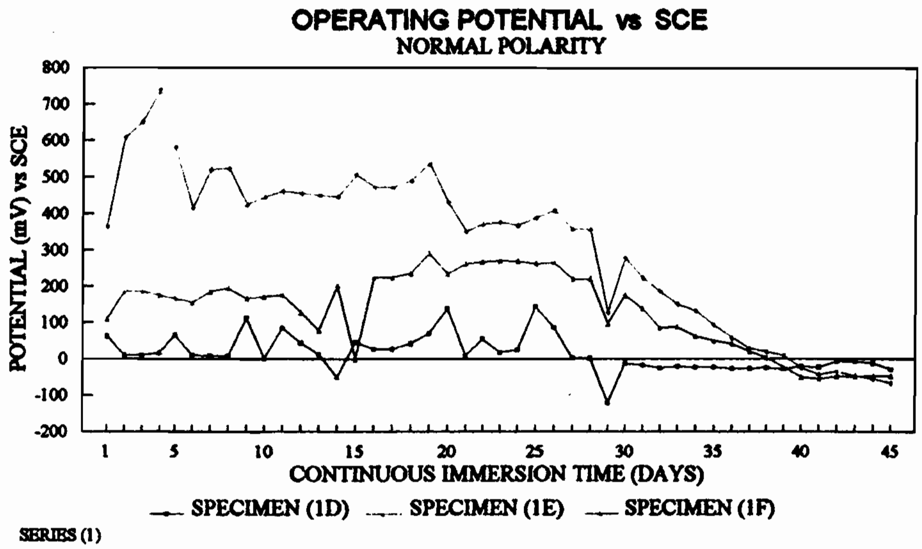


Figure 6.10 : Operating Potentials Versus SCE - Series 1



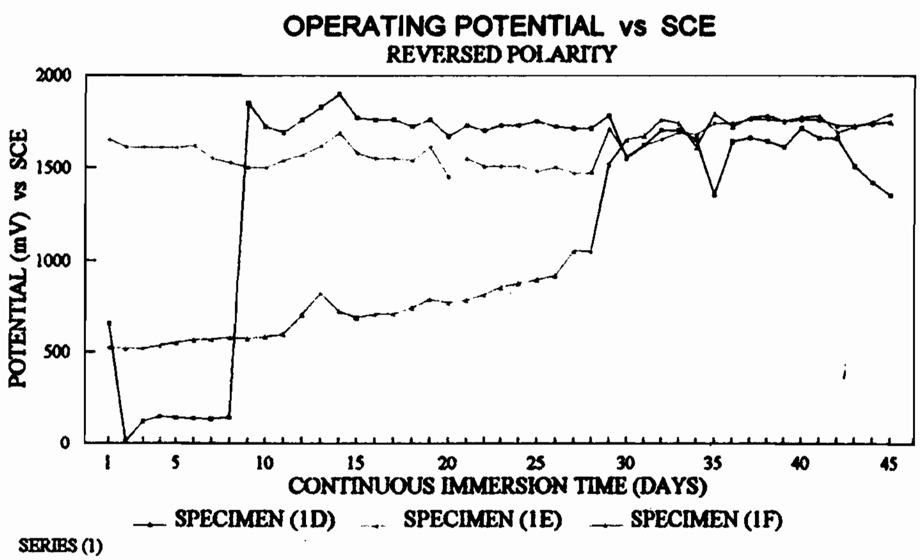


Figure 6.11 : Operating Potential Versus SCE - Series 1

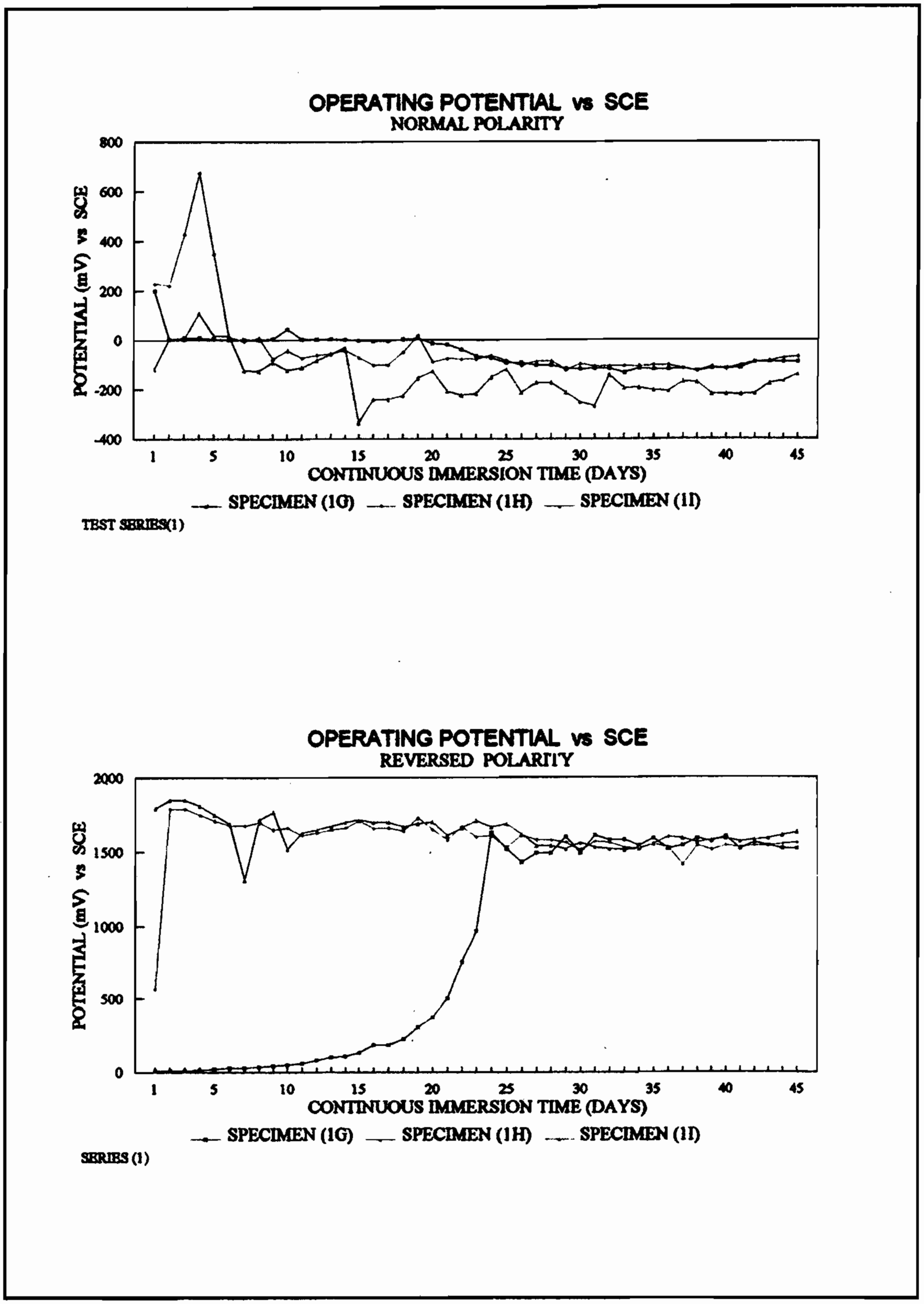
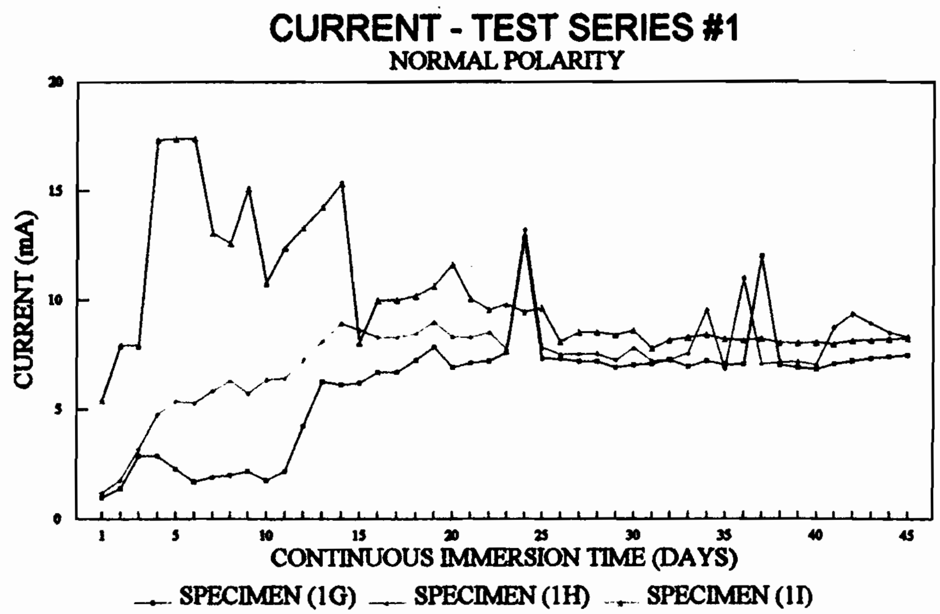


Figure 6.12 : Operating Potential Versus SCE - Series 1



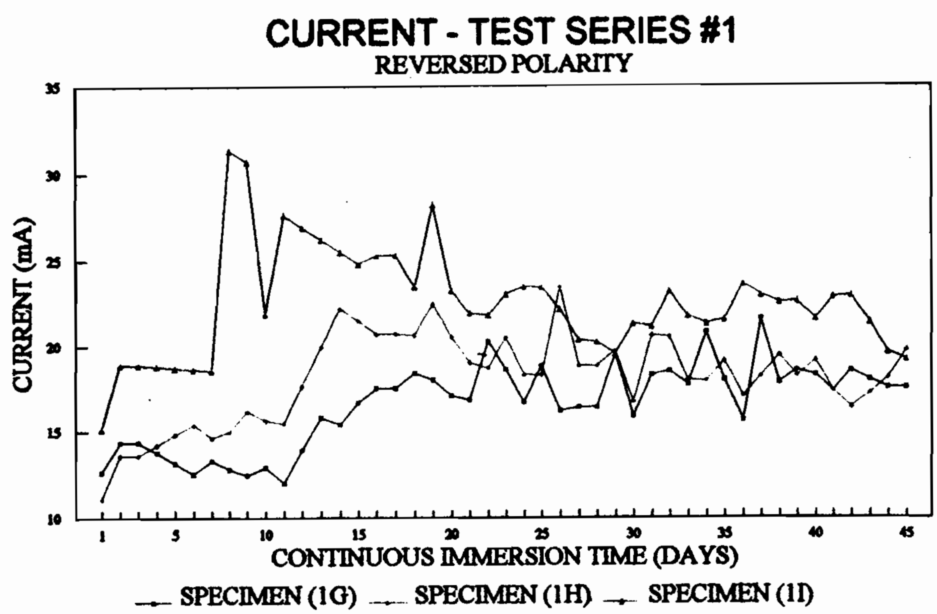


Figure 6.13 : Current flow - Series No. 1

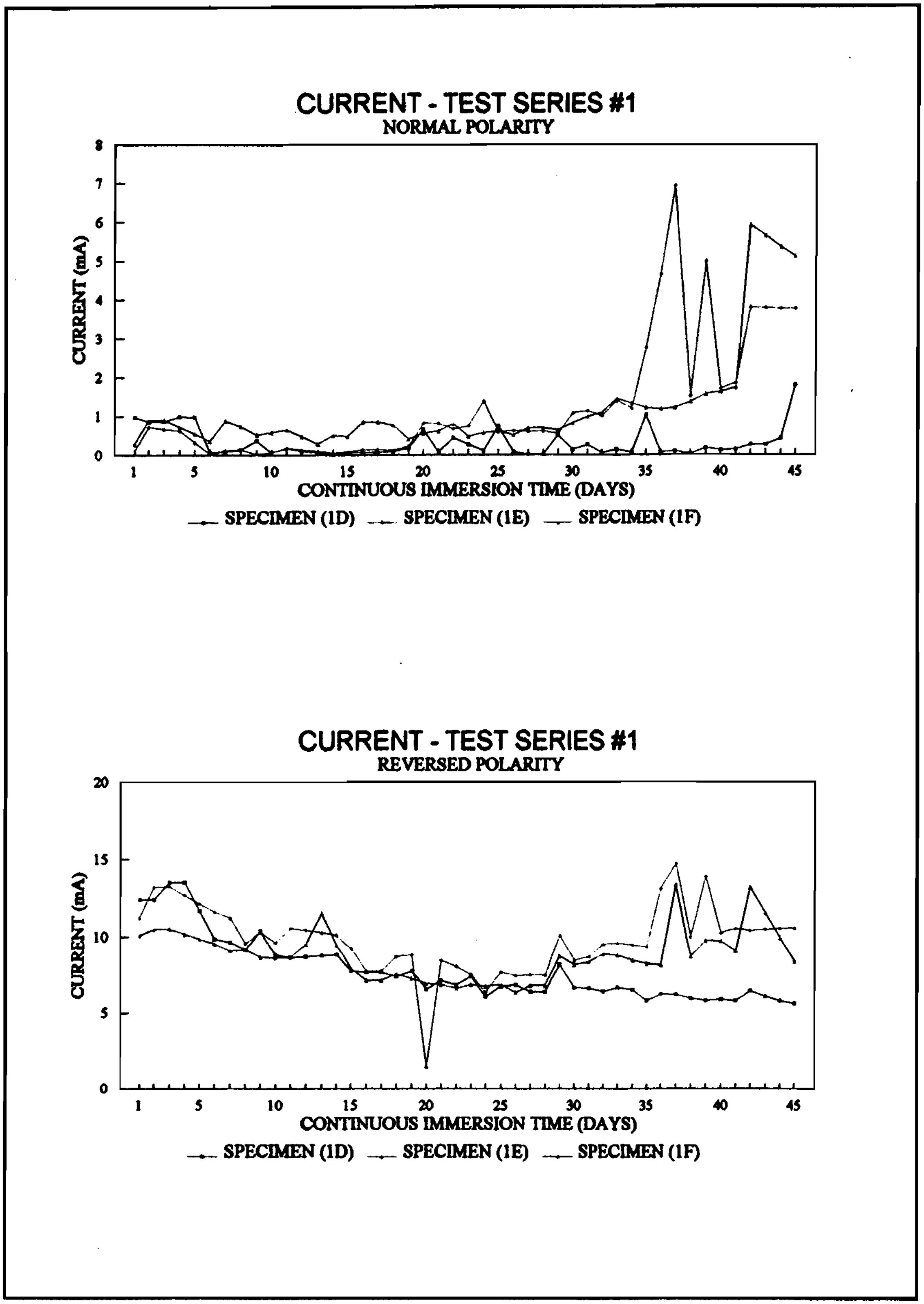
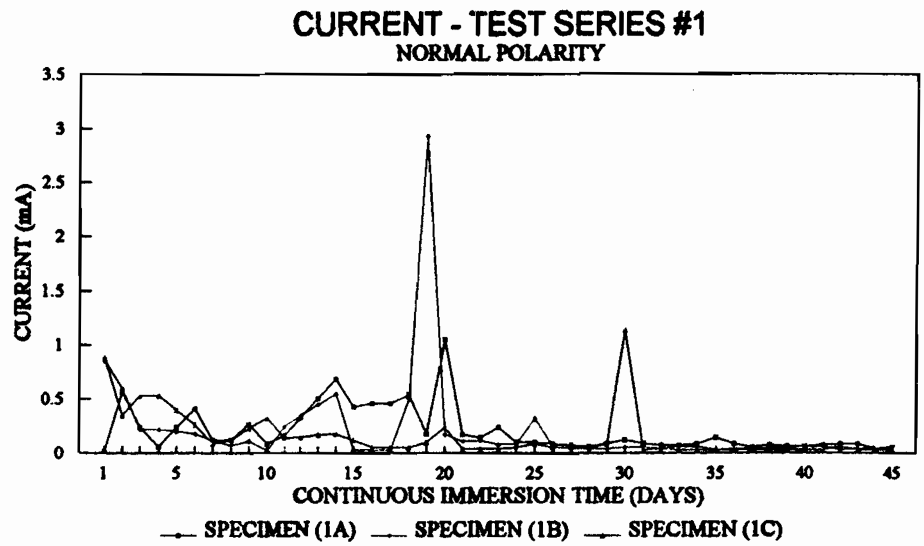


Figure 6.14 : Current flow - Series No. 1



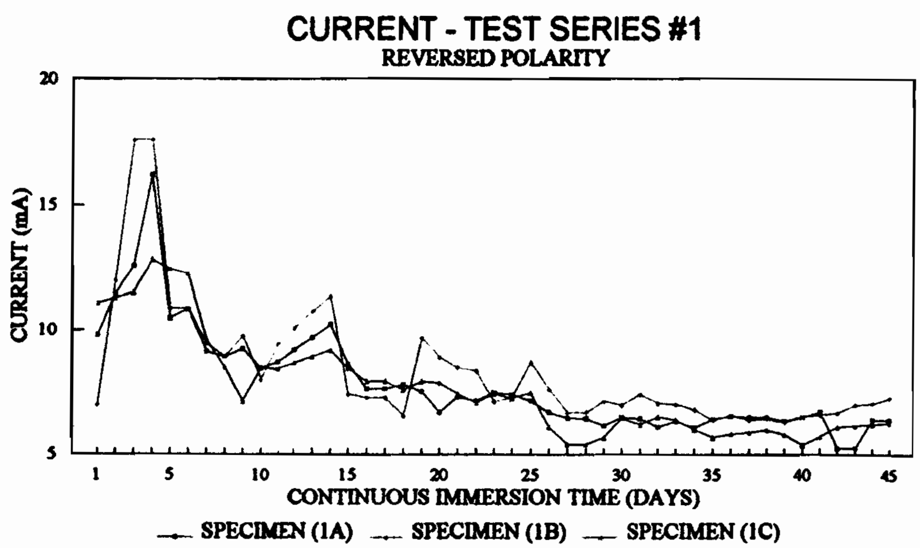


Figure 6.15 : Current flow - Series No. 1

6.4 Second Set-Up (Test Series 2 and 3)

The main difference between this series and the previous one is the quality of the concrete (compressive strength equal to 45 MPa), and the steel bars (epoxy coated bars). Actually Series 2 consists of two series according to the thickness of the epoxy layer over the bars.

Therefore, it was divided into two Series, No.2 with epoxy bars with the layer thickness between 6-8 mils, and No.3 which has the epoxy bars with layer thickness between 10-12 mils (1 mil = 0.025 mm). The concrete cover variation used in Series 2 and Series 3 are illustrated in Tables 6.2 and 6.3 respectively

SPECIMEN	MOLD INNER DIAMETER		NOMINAL BAR DIAMETER		CLEAR DEPTH OF CONCRETE COVER	
	in.	(mm)	in.	(mm)	in.	(mm)
A	1-1/5	(38.1)	0-10/16	(15.9)	7/16	(11.1)
B	2-0	(50.8)	0-10/16	(15.9)	11/16	(17.5)
C	3-0	(76.2)	0-10/16	(15.9)	1-3/16	(30.2)
D	4-0	(101.6)	0-10/16	(15.9)	1-11/16	(42.9)
E	4-3/4	(120.7)	0-10/16	(15.9)	2-1/16	(52.4)

TABLE 6.2: Mold Sizes and Clear Concrete Cover Depths

SPECIMEN	MOLD INNER DIAMETER		NOMINAL BAR DIAMETER		CLEAR DEPTH OF CONCRETE COVER	
	in.	(mm)	in.	(mm)	in.	(mm)
A	1-1/5	(38.1)	0-10/16	(15.9)	7/16	(11.1)
B	2-0	(50.8)	0-10/16	(15.9)	11/16	(17.5)
C	3-0	(76.2)	0-10/16	(15.9)	1-3/16	(30.2)
D	4-3/4	(120.7)	0-10/16	(15.9)	2-1/16	(52.4)

TABLE 6.3: Mold Sizes and Clear Concrete Cover Depths

The number of specimens were reduced in Series 2 and Series 3 because, based on the results of Test Series 1, after a certain cover depth, the corrosion attack did not influence these specimens.

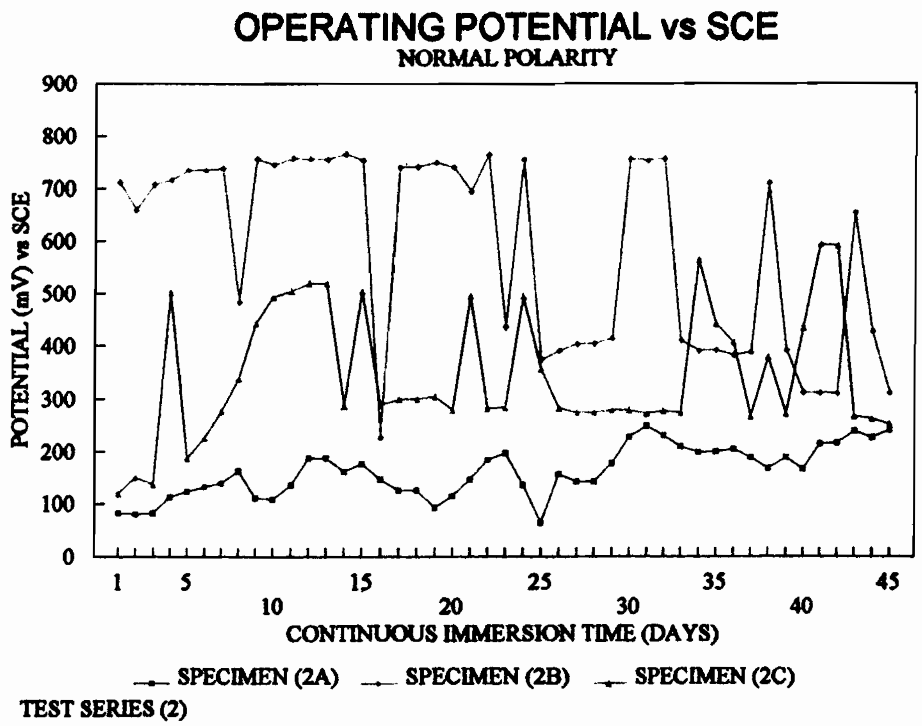
6.4.1 Visual Observations: No corrosion products formed on the surface of all the specimens during the set-up period.

6.4.2 Electrode Potentials And Current Measurements

Appendix (C) contains the daily readings recorded during the testing period of Series 2 and 3. Figures 6.16 and 6.17 depict the operating potentials versus reference SCE for Series 2 and Figures 6.18, 6.19 for Series 3. The current flow versus immersion time for Series 2 and 3 can be seen in Figure 6.20.

6.5 Third Set-Up (Test Series 4 and 5)

Two different kinds of sealing compounds were used to coat the concrete specimens in these series. The first one was Sikagard 71 which is a colourless liquid acting as water-repellent penetrating sealer that closes the pores of cementitious substrates. Because it minimizes the penetration of both water and chlorides, it shields the embedded rebars



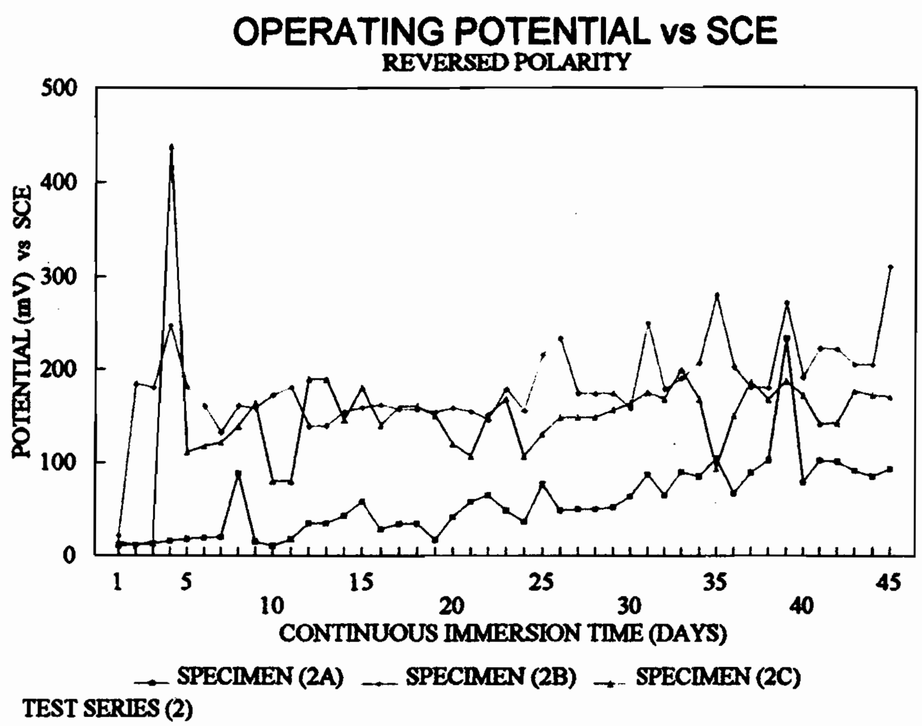
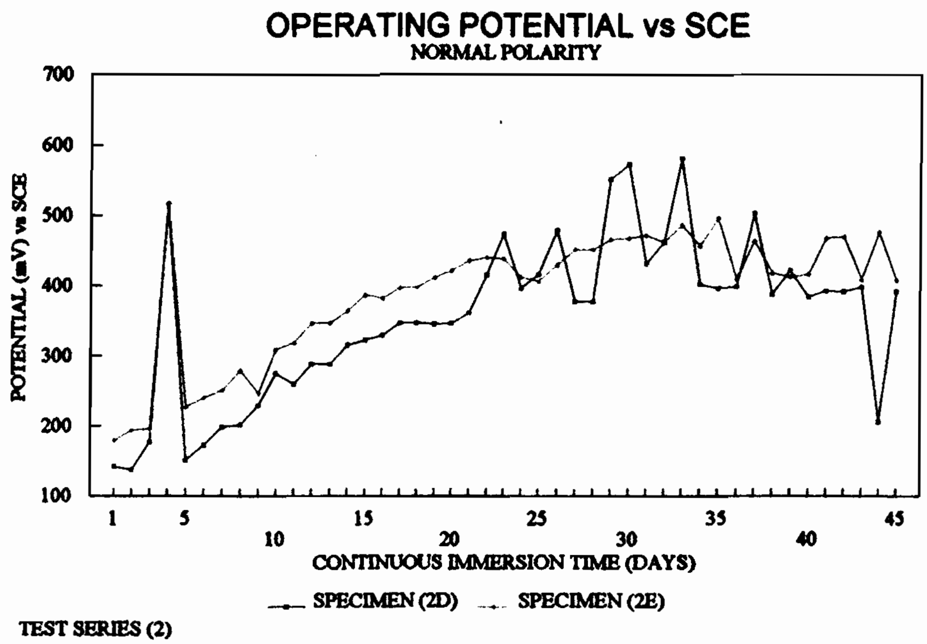


Figure 6.16 : Operating Potential Versus SCE - Series 2



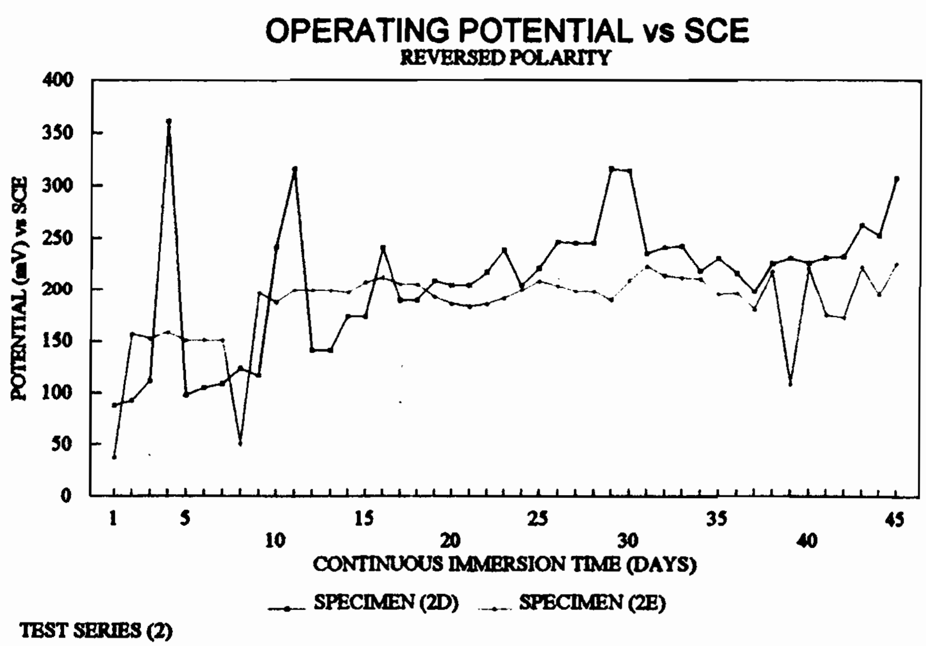


Figure 6.17 : Operating Potential Versus SCE - Series 2

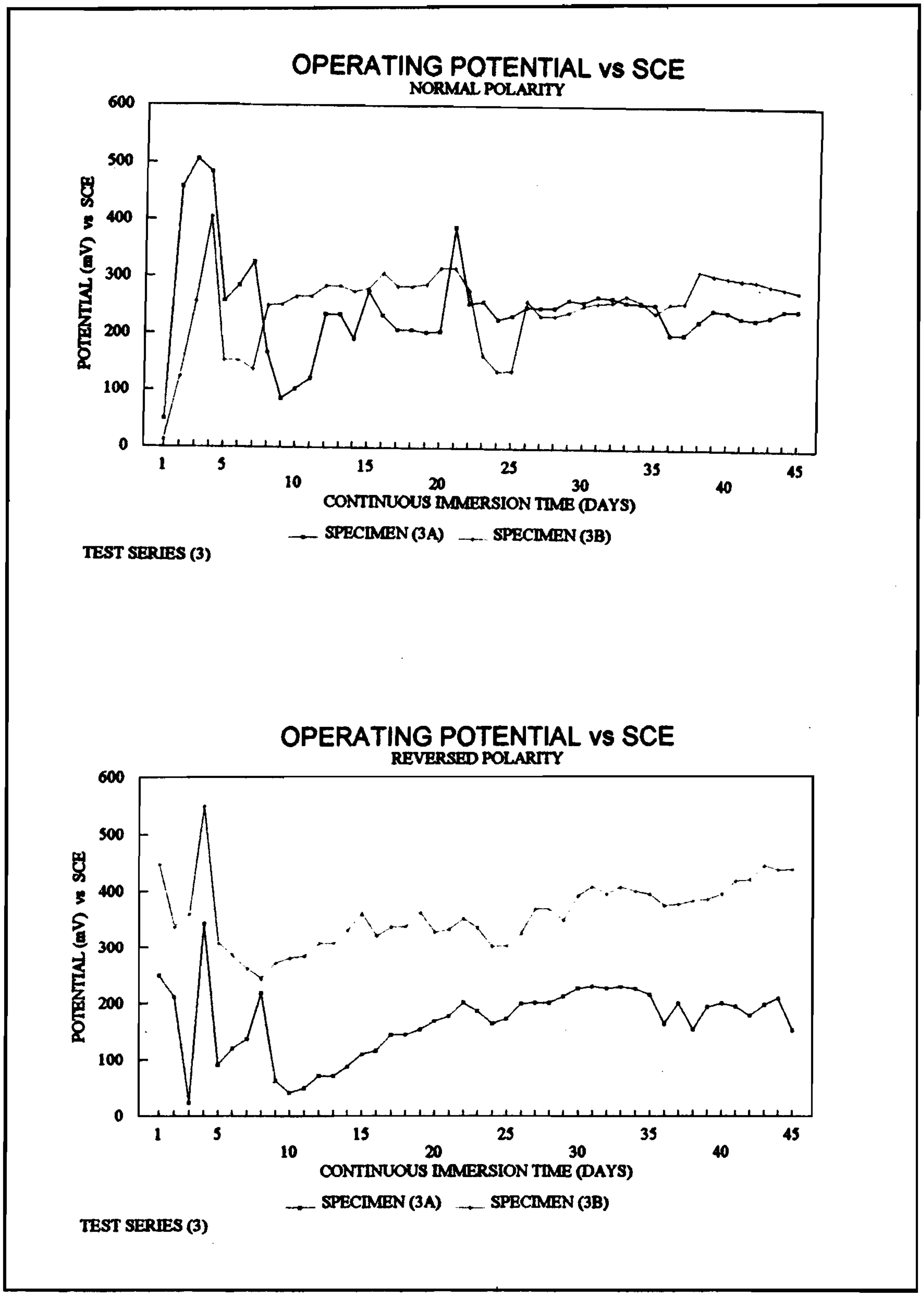


Figure 6.18 : Operating Potential Versus SCE - Series 3

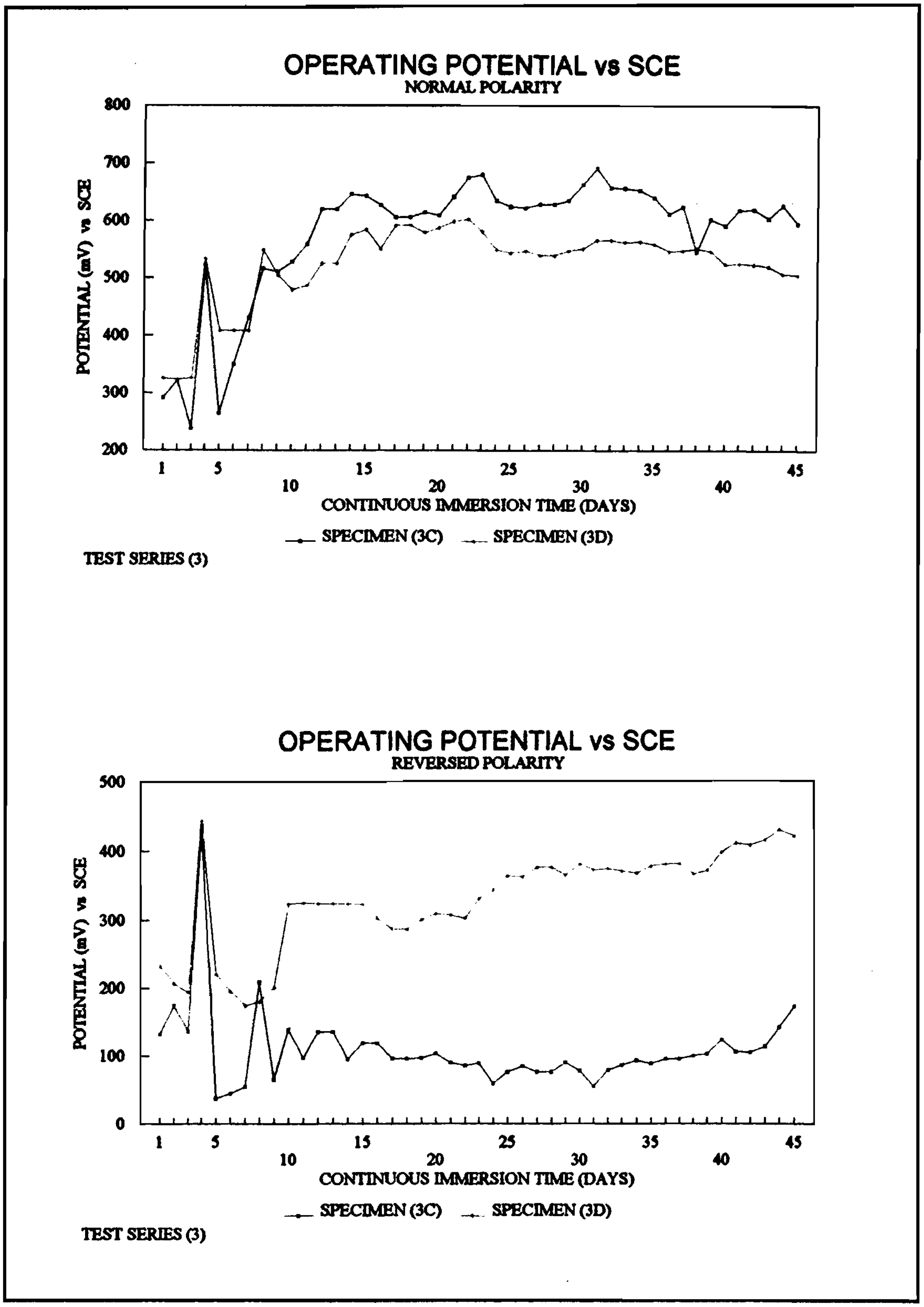


Figure 6.19 : Operating Potential Versus SCE - Series 3

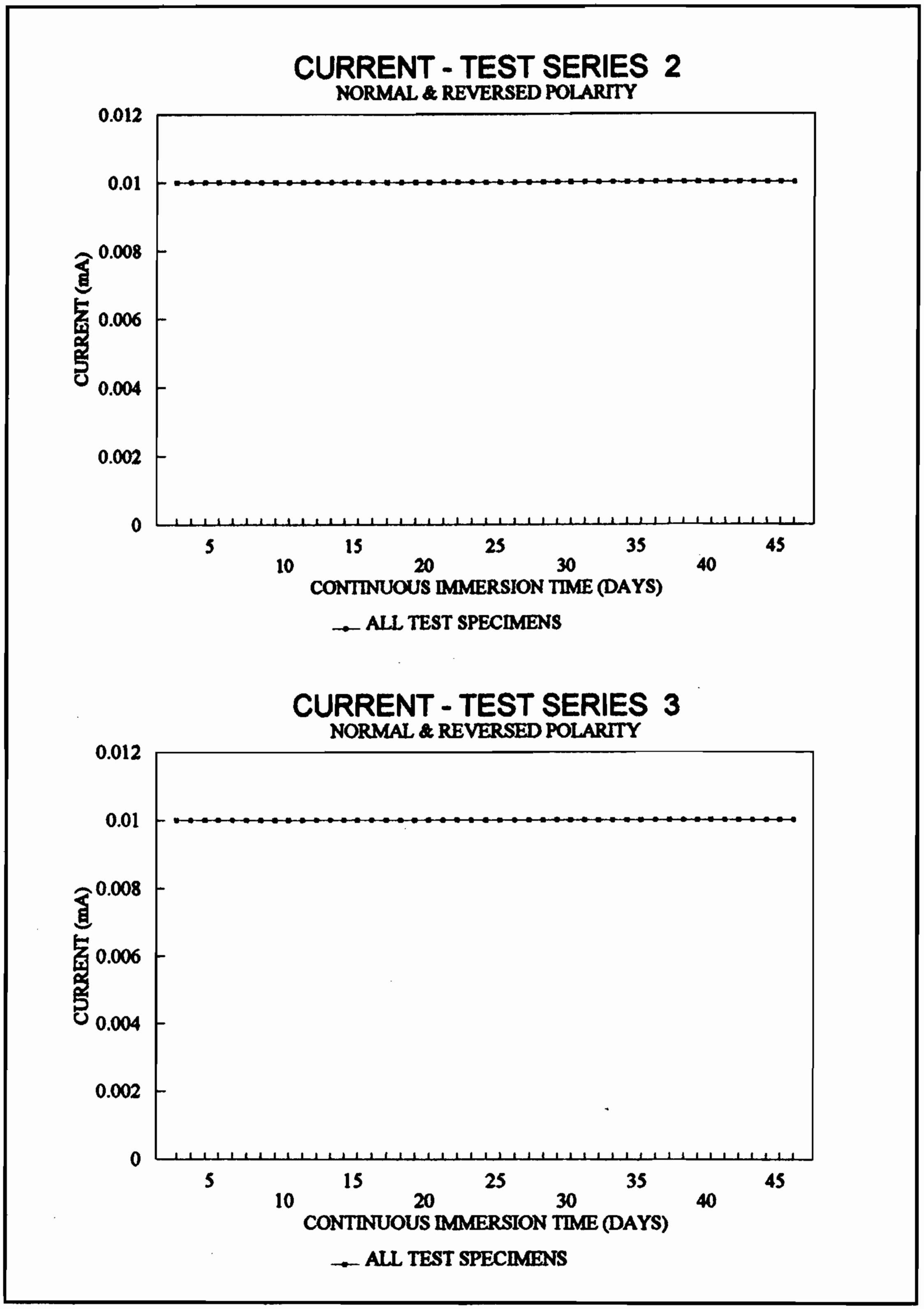


Figure 6.20 : Current Flow - Series No. 2 and No. 3

from these deleterious liquids. The second compound was Sikagard Cure/Hard Seal which is clear water-white solvent solution of styrene acrylate resins, plasticizers and adhesive agent. This satisfy the requirements of ASTM Standard C 309-72. The variation of clear cover depths for Series 4 and 5 are shown in Table 6.4 and 6.5 respectively.

SPECIMEN	MOLD INNER DIAMETER		NOMINAL BAR DIAMETER		CLEAR DEPTH OF CONCRETE COVER	
	in.	(mm)	in.	(mm)	in.	(mm)
A	1-1/5	(38.1)	0-10/16	(15.9)	7/16	(11.1)
B	2-0	(50.8)	0-10/16	(15.9)	11/16	(17.5)
C	2-1/4	(57.20)	0-10/16	(15.9)	13/16	(20.6)
D	2-3/4	(69.90)	0-10/16	(15.9)	1-1/16	(27)
E	3-0	(76.2)	0-10/16	(15.9)	1-3/16	(30.2)

TABLE 6.4: Mold Sizes and Clear Concrete Cover Depths

SPECIMEN	MOLD INNER DIAMETER		NOMINAL BAR DIAMETER		CLEAR DEPTH OF CONCRETE COVER	
	in.	(mm)	in.	(mm)	in.	(mm)
A	1-1/5	(38.1)	0-10/16	(15.9)	7/16	(11.1)
B	2-0	(50.8)	0-10/16	(15.9)	11/16	(17.5)
C	2-1/4	(57.2)	0-10/16	(15.9)	13/16	(20.6)
D	3-0	(76.2)	0-10/16	(15.9)	1-3/16	(30.2)

TABLE 6.5: Mold Sizes and Clear Concrete Cover Depths

The compressive strength of the concrete used in casting the specimens was 45 MPa.

6.5.1 **Visual Observations:** No corrosion products were formed on the surface of the specimens in both series except for small red spot at the bottom of Specimen 5b on the fifth day because of the missing seal on the area where the spot appeared. The specimen was taken out of the tank, re-sealed properly, and then re-immersed in the electrolytic solution. The spot remained as it was before the treatment, without showing signs of any further corrosion.

6.5.2 Electrode Potentials And Current Measurements

The daily readings and the results for these series are listed in Appendix (D). The operating potentials versus the reference SCE plots for the specimens in Series 4 and 5 are plotted in Figures 6.21, 6.22, 6.23 and 6.24 respectively. Also plots of the current flow versus immersion time for the same series are shown in Figures 6.25 through 6.28.

6.6 Fourth Set-Up (Test Series 6, 7 and 8).

The aim of this test was to run simultaneously a combination of Series 1, 4, 5 and to apply the seal on the specimens representing Series 1 when it starts to corrode to see the effect of the seal after the corrosion takes place in the concrete specimens.

The same concrete (45 MPa) and clear cover depths were used in the three series, (Table 6.6).

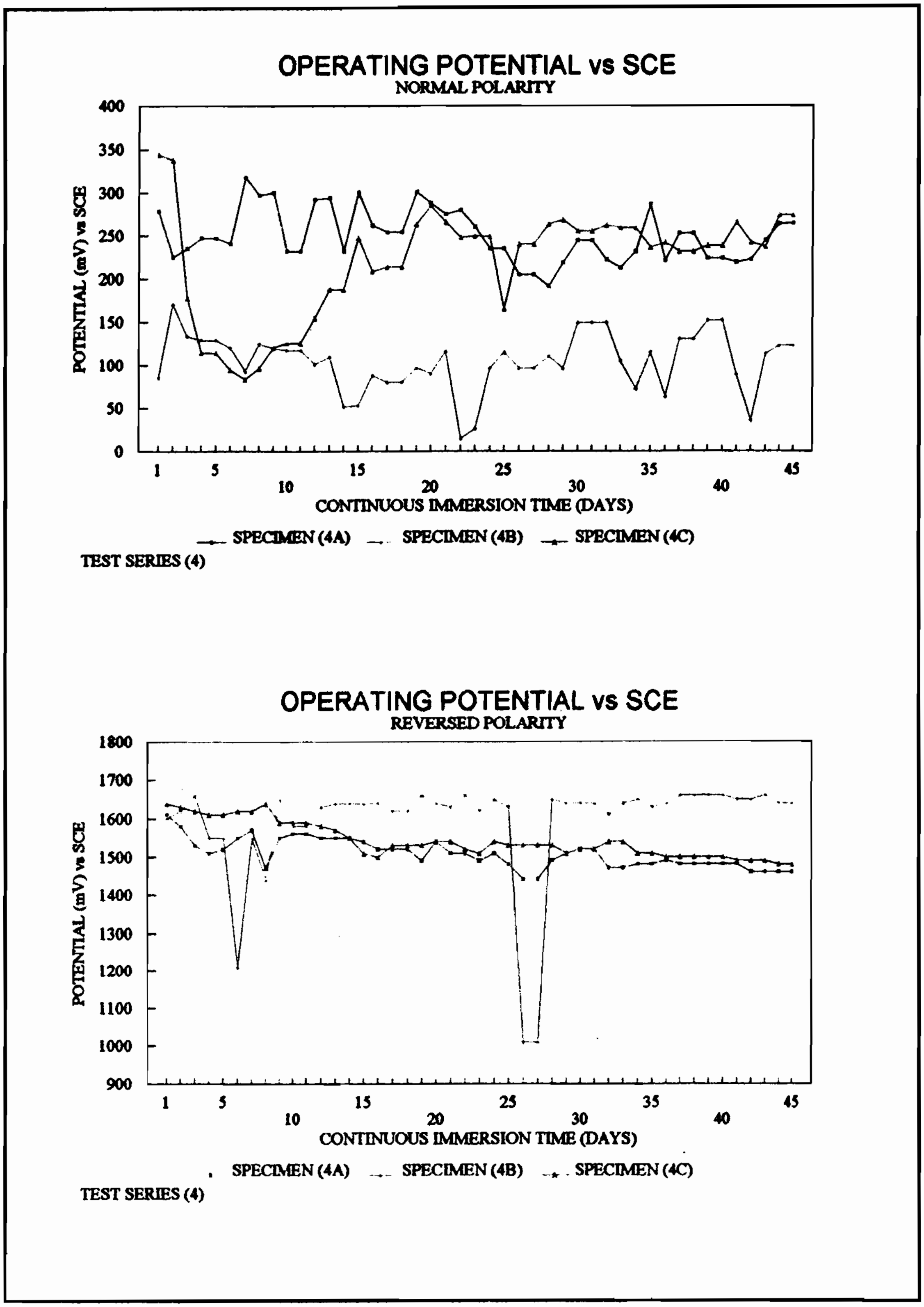
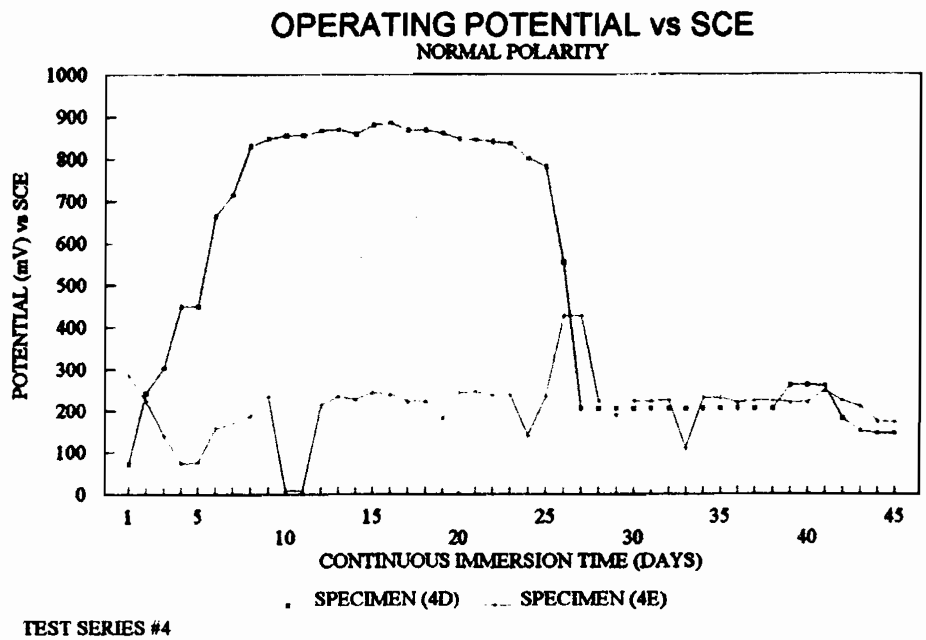


Figure 6.21 : Operating Potential Versus SCE - Series 4



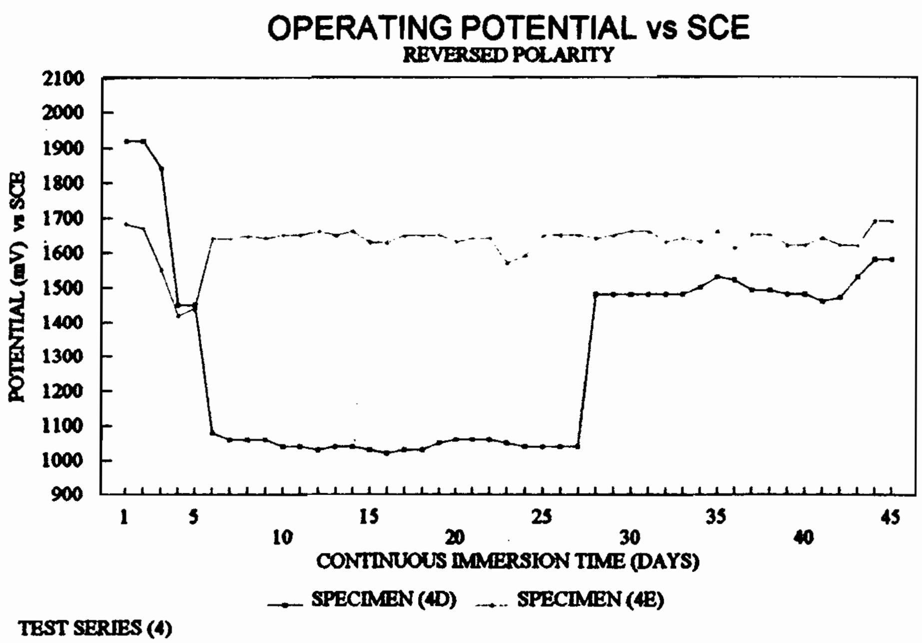
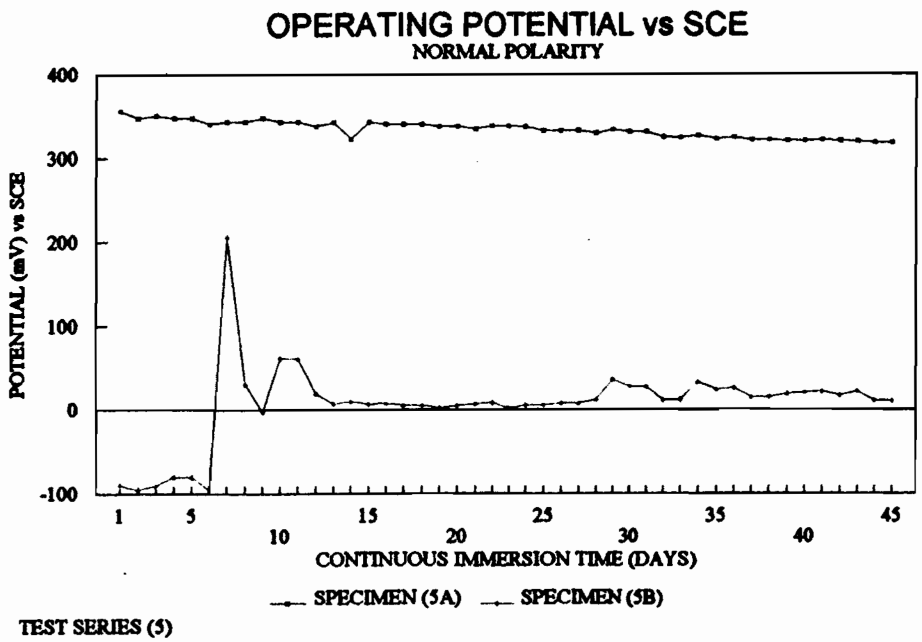


Figure 6.22 : Operating Potential Versus SCE - Series 4



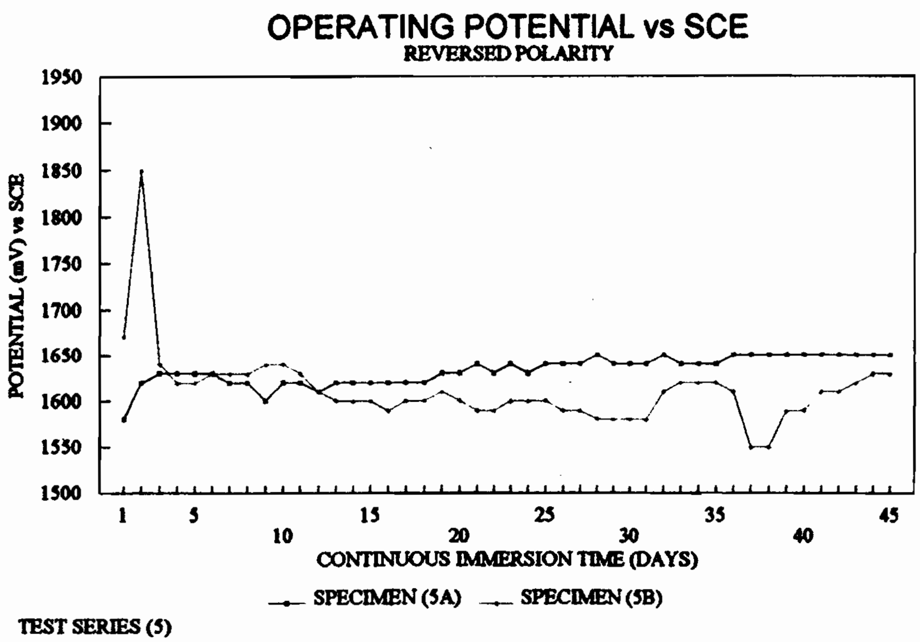


Figure 6.23 : Operating Potential Versus SCE - Series 5

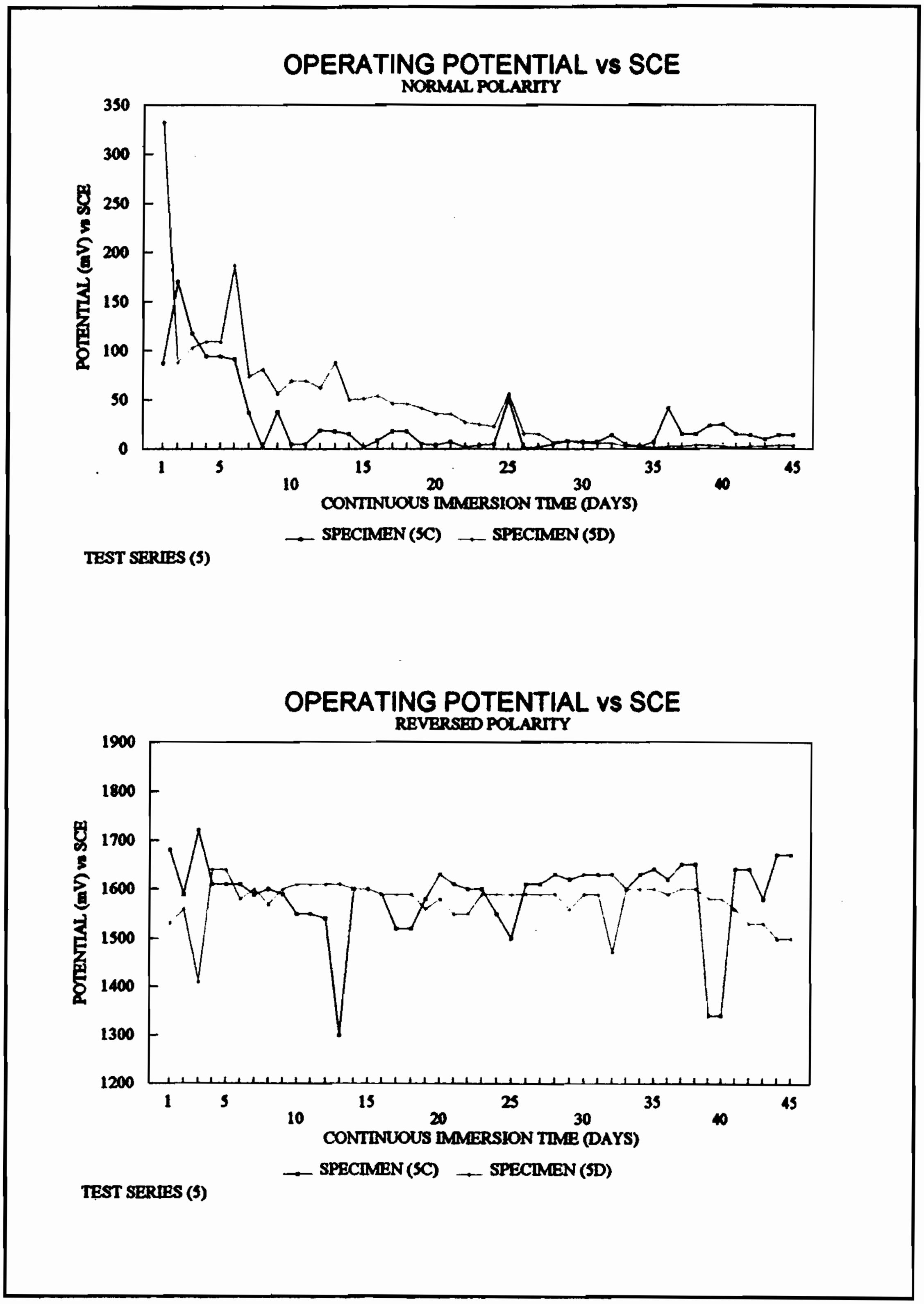


Figure 6.24 : Operating Potential Versus SCE - Series 5

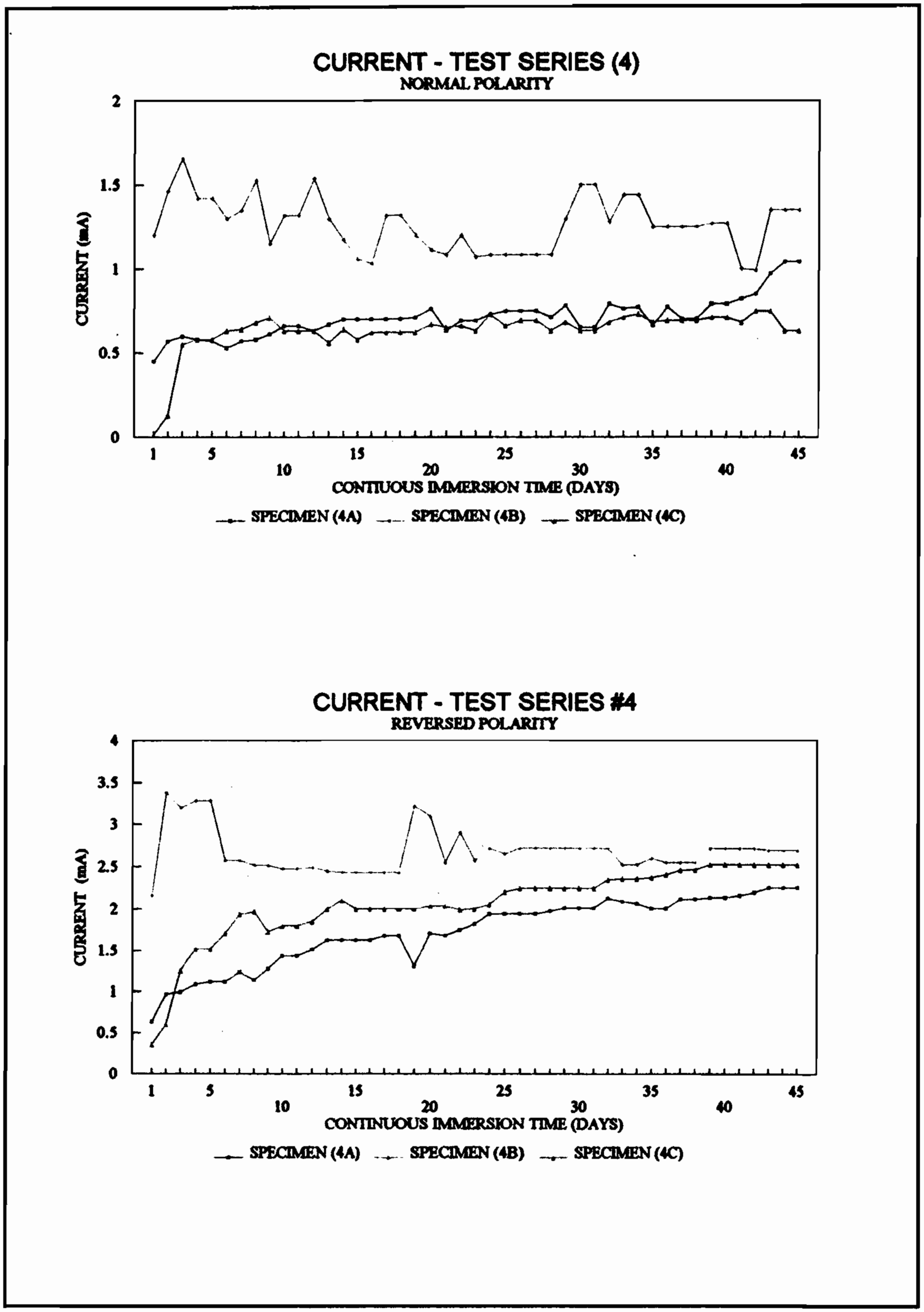


Figure 6.25 : Current Flow - Series No. 4

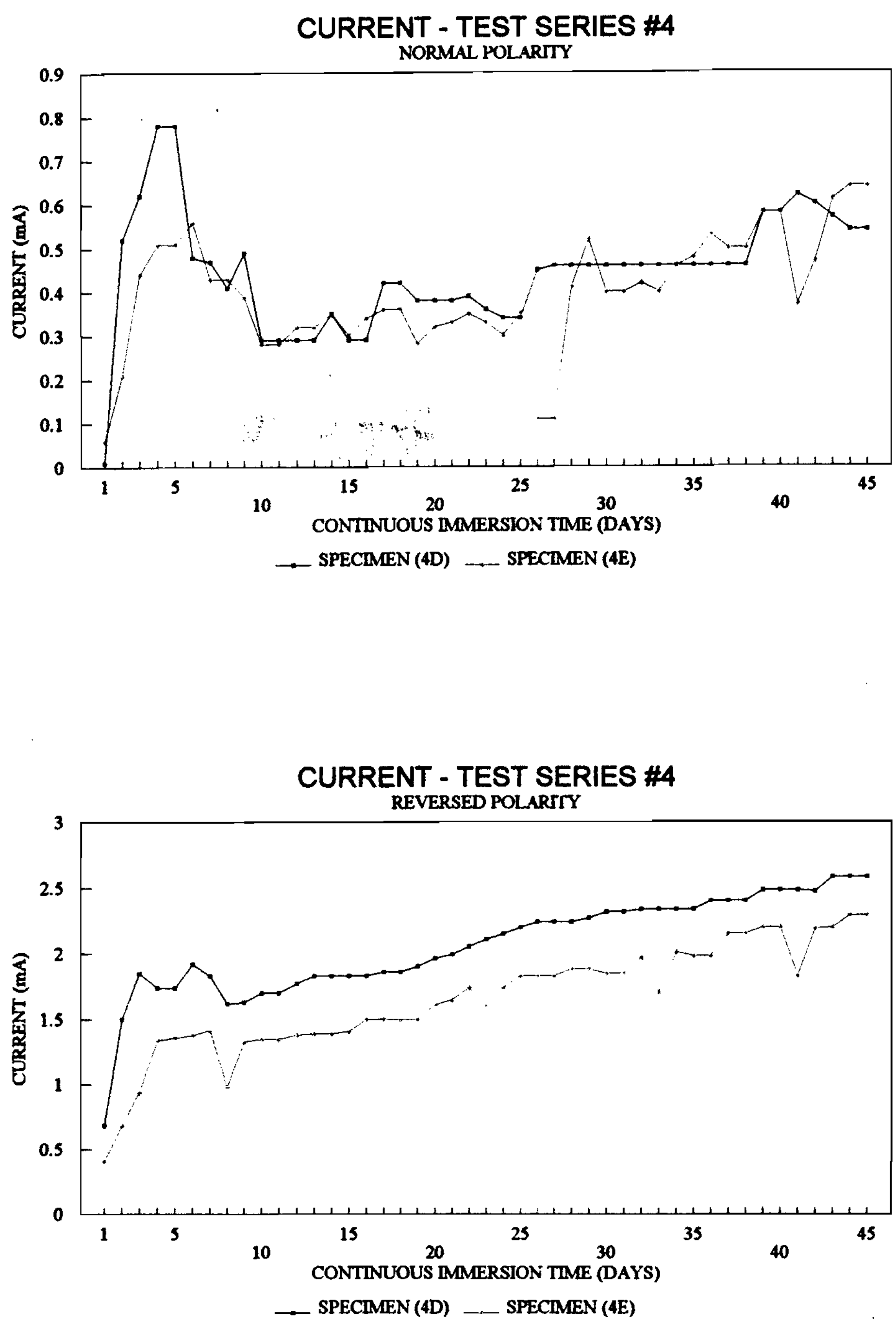
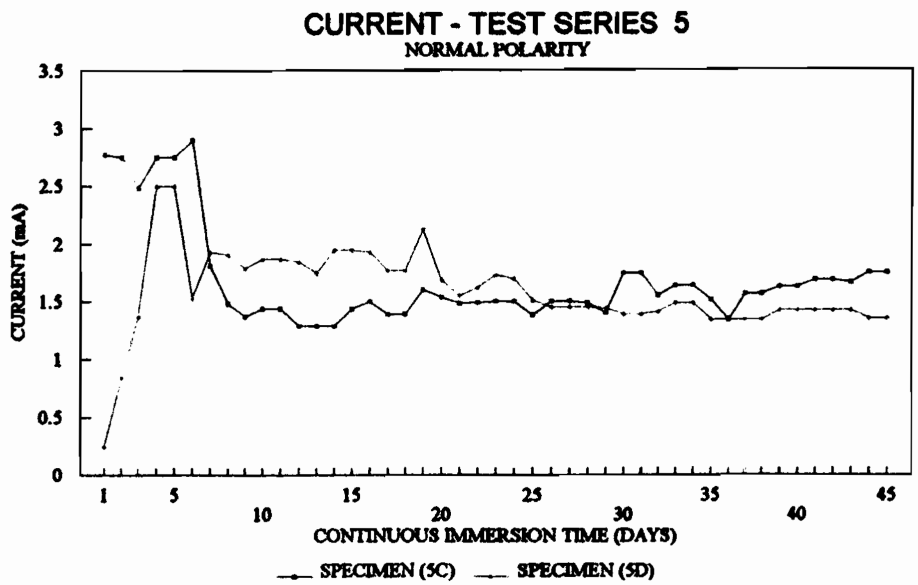


Figure 6.26 : Current Flow - Series No. 4



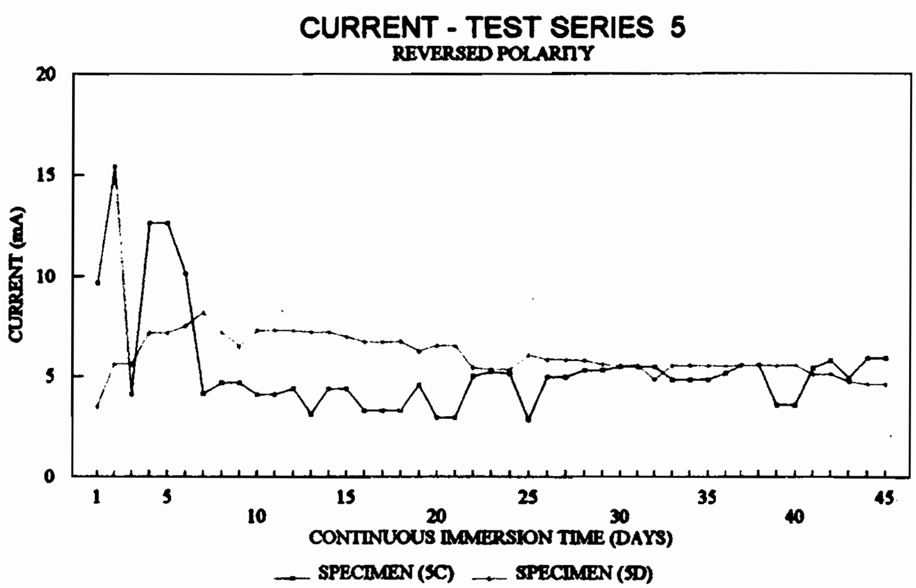


Figure 6.28 : Current Flow - Series No. 5

SPECIMEN	MOLD INNER DIAMETER in.	(mm)	NOMINAL BAR DIAMETER in.	(mm)	CLEAR DEPTH OF CONCRETE COVER in.	(mm)
A	1-1/2	(38.1)	0-10/16	(15.9)	7/16	(11.1)
B	2-0	(50.8)	0-10/16	(15.9)	11/16	(17.5)
C	3-0	(76.2)	0-10/16	(15.9)	1-3/16	(30.2)

TABLE 6.6: Mold Sizes and Clear Concrete Cover Depths

6.6.1 Visual Observation

- Series 6: Sikagard 71 was used to cover the concrete specimens and no signs of corrosion appeared on the surface of the specimens.

- Series 7: Sikagard Cure/Hard was used to seal the specimens and there were no signs of corrosion.

- Series 8: The specimens used in this series represents Series No.1. Bubbles was formed on the surface of specimen 8A on the third day and the corrosion products appeared on the sixth day. The specimens was then removed from the solution and sealed with Sikagard Cure/Hard and returned to the tank after it got dry on the following day. Further formation of corrosion products stopped in the later dates on and around the defected area for the period of the experiment.

For Specimen 8B with a Sikagard 71 seal, the formation of bubbles started on the fourth day, and the corrosion products appeared on the 25th day. Again, when the seal was applied and the specimen was re-immersed in the solution, no new corrosion signs were observed, indicating ceasing of any further corrosion.

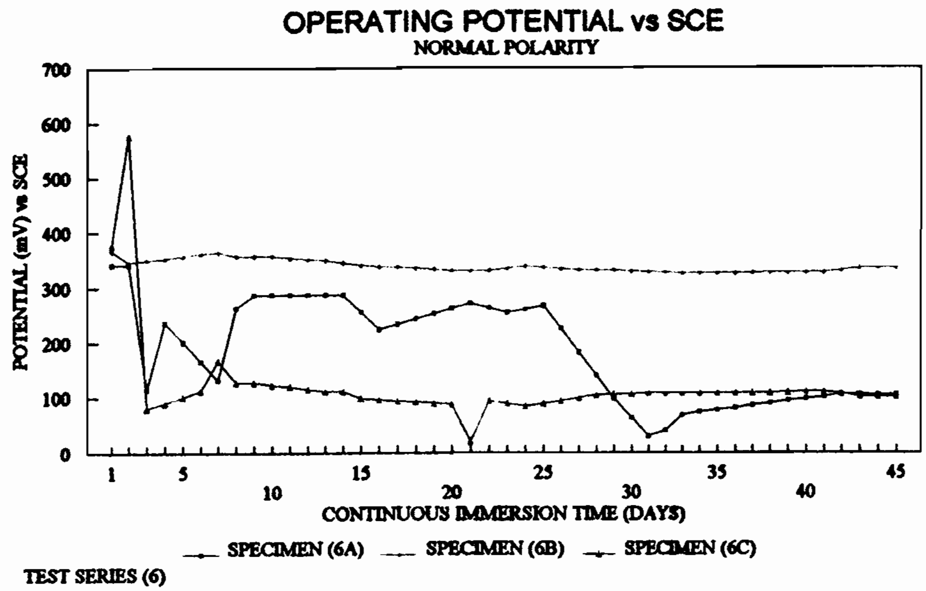
Specimen 8C did not show any signs of corrosion during the testing period.

6.6.2 Electrode Potentials And Current Measurements

A similar approach was used to record electrode potentials and current flow for these series (see Appendix E for the experimental data). Figures 6.29, 6.30 and 6.31 illustrate graphically the operating potentials versus the reference SCE and Figures 6.32, 6.33 and 6.34 present the relationship between the current flow and the immersion time for Series 6, 7 and 8 respectively.

6.7 Chloride Contents

As described previously the mechanism by which chlorides initiate corrosion is by breaking down locally the passive film which forms on steel in the highly alkaline concrete pore solution. However, the breakdown of passivity requires a certain concentration of chlorides. The amount of chloride is highly dependent on a large number of factors including:



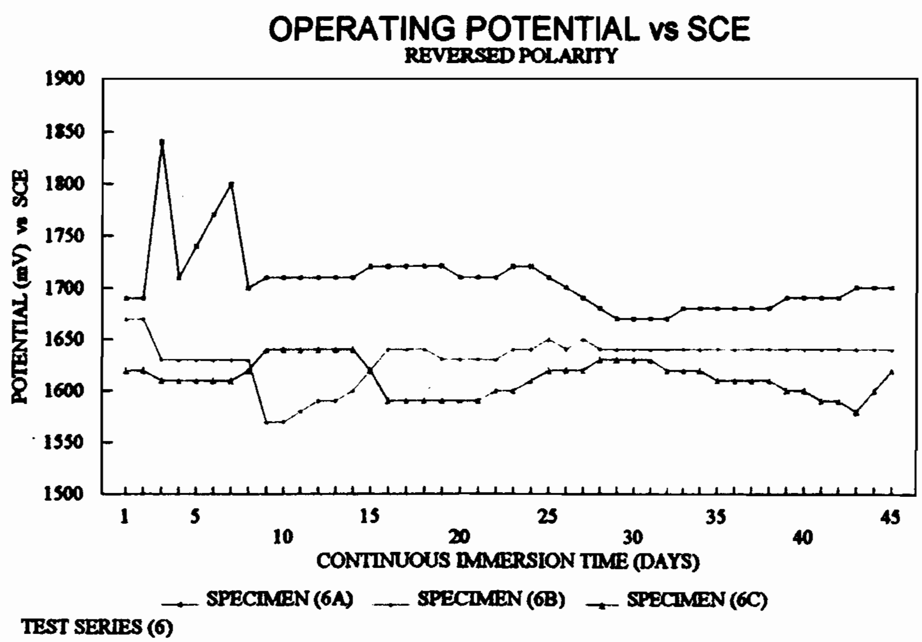


Figure 6.29 : Operating Potential Versus SCE - Series 6

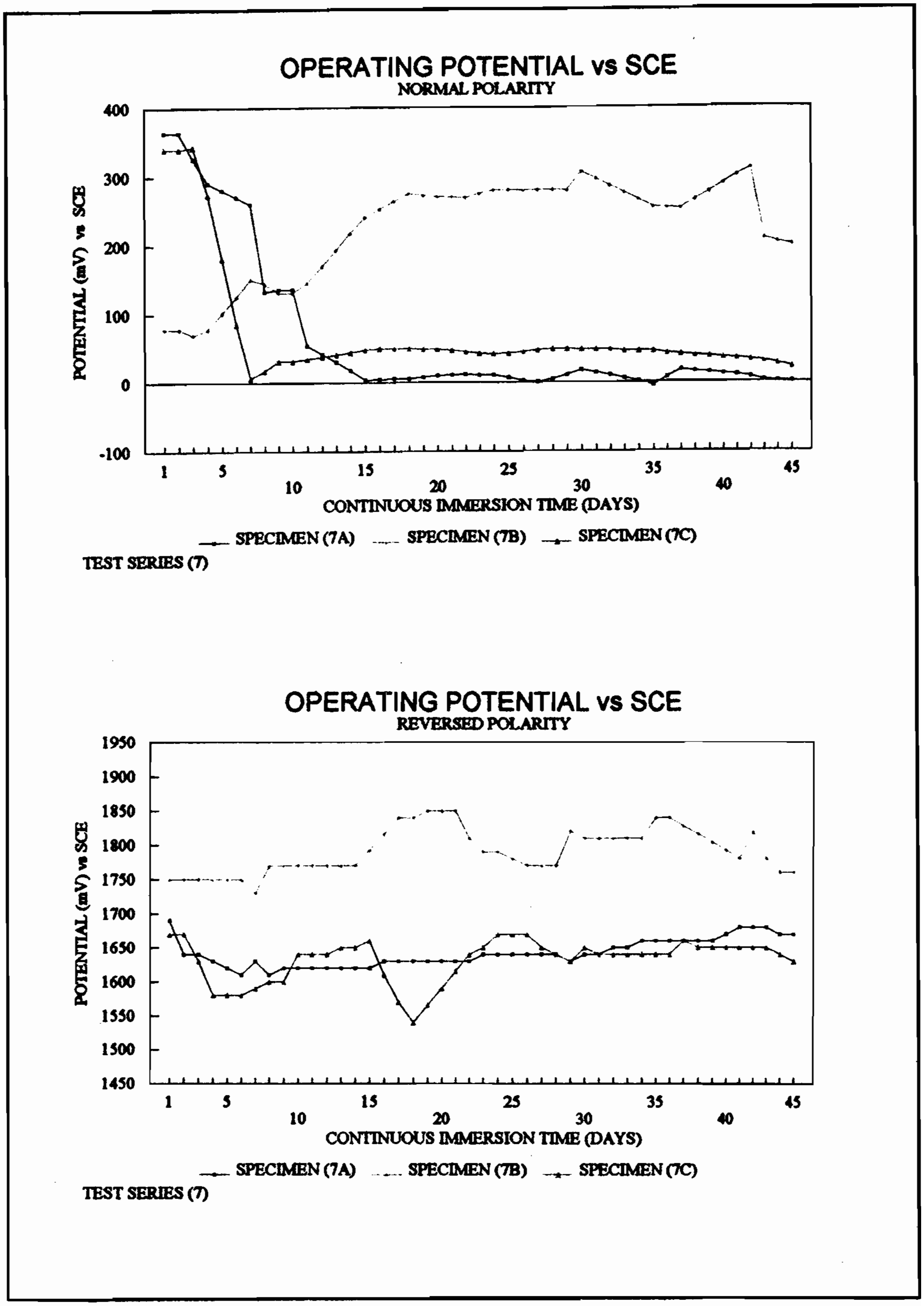


Figure 6.30 : Operating Potential Versus SCE - Series 7

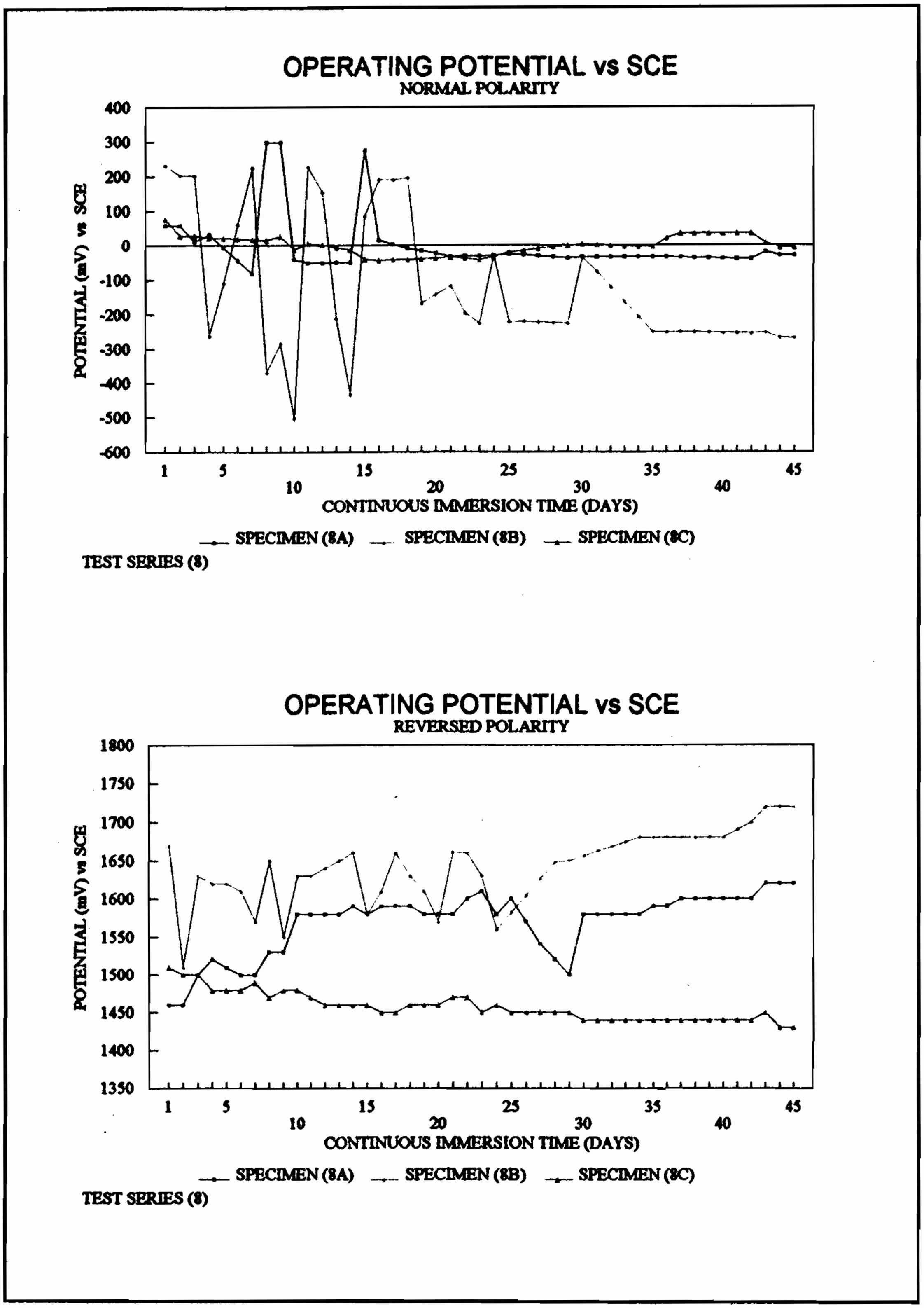
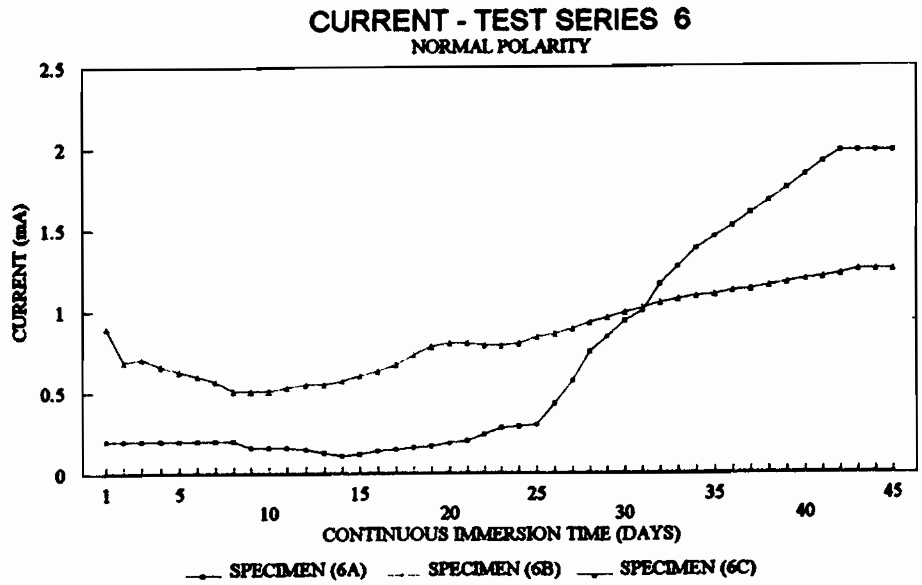


Figure 6.31 : Operating Potential Versus SCE - Series 8



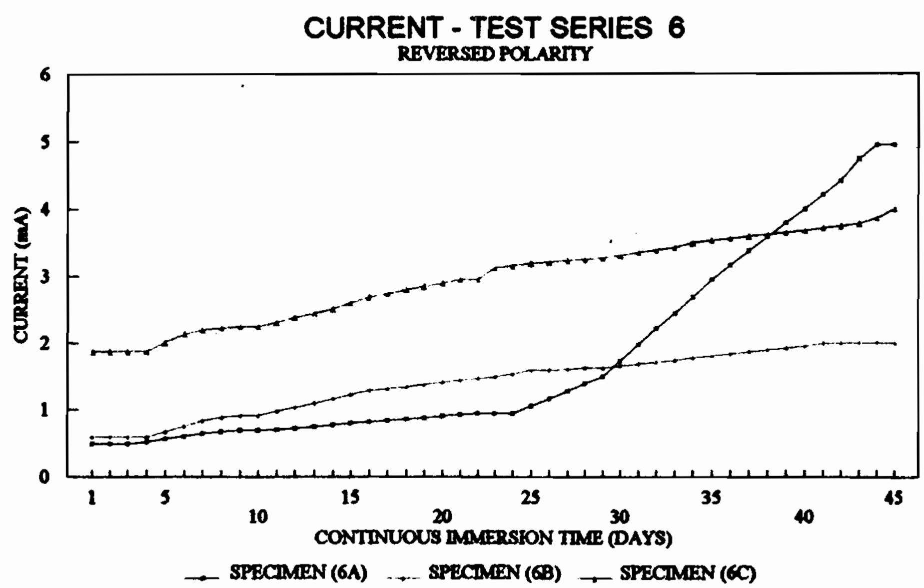
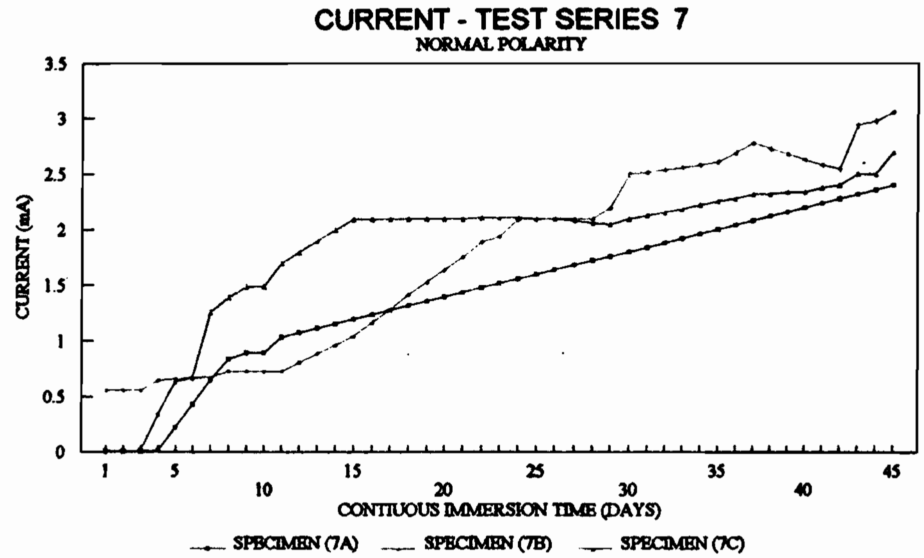


Figure 6.32 : Current Flow - Series No. 6



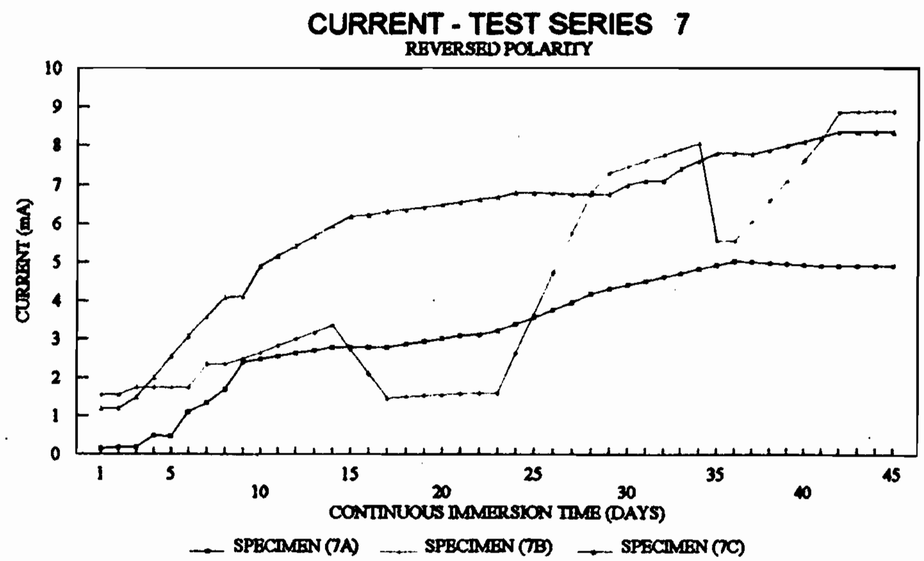
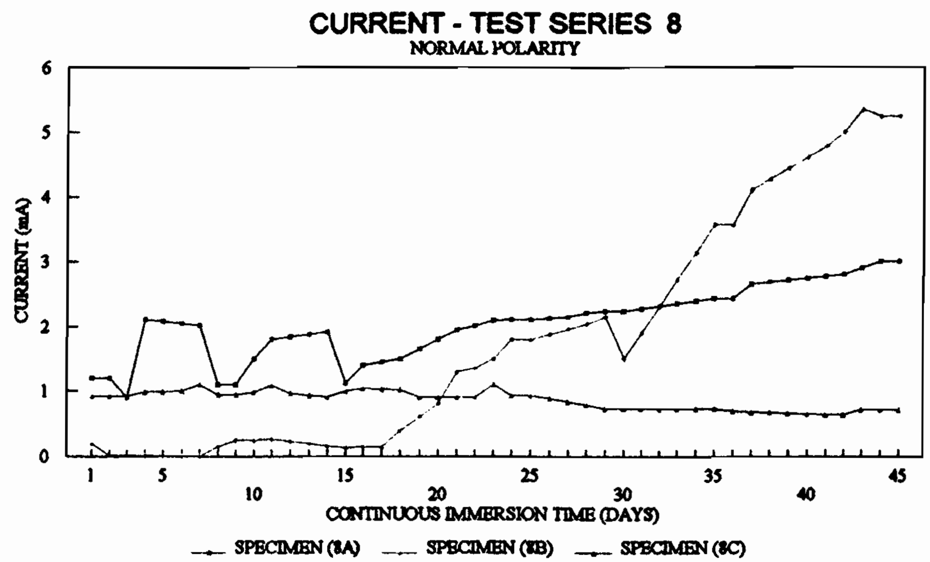


Figure 6.33 : Current Flow - Series No. 7



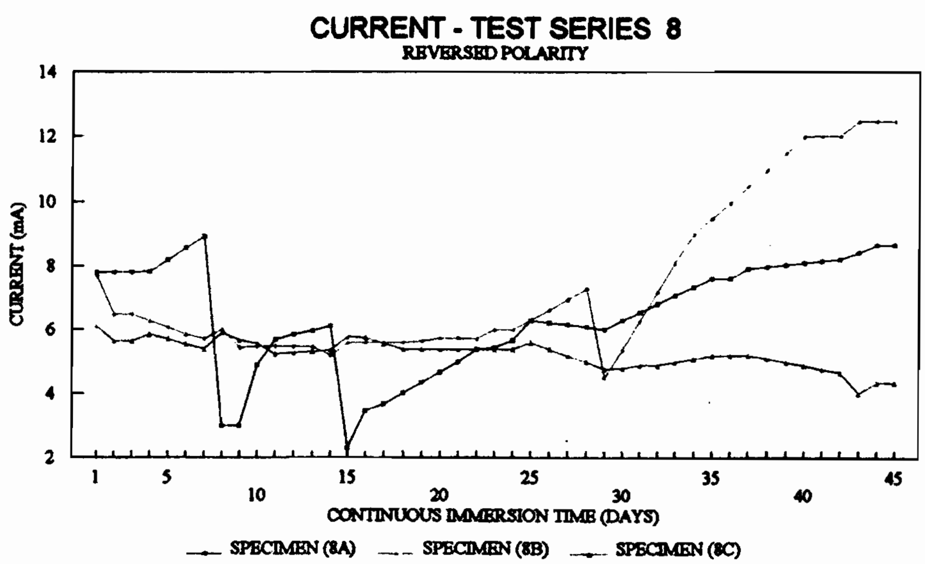


Figure 6.34 : Current Flow - Series No. 8

(1) whether the chloride is present in the original concrete mix or penetrates the concrete from the atmosphere, (2) the degree of porosity and amount of free water in the cement paste, and (3) the curing conditions.

The determination of chloride contents in the concrete is very important because of its impact on the deterioration of steel reinforced concrete structures.

The procedure for determinating the chloride contents of the specimens in all series was as follows:
Three holes were drilled into the concrete at three heights (top, middle, bottom) along the surface of each specimen. Figure 6.35 shows a typical specimen after the extraction of concrete in the three locations. The resulting powder from each location was collected in small sealed plastic bags and sent to the Chemical Laboratory in the Otto Maass Chemistry Building of McGill University for analysis. This analysis was conducted according to the British Standard on Testing Concrete - Part 124.[74] The basis of the procedure is the Volhard Method, a precipitation titration method used for the indirect determination of the chloride contents. A known excess of standard silver nitrate solution ($AgNO_3$) is added to the concrete sample, dispersed with a nitric acid solution (HNO_3). The excess is determined by back titration with a standard thiocyanate solution (KSCN). Ammonium ferric sulphate

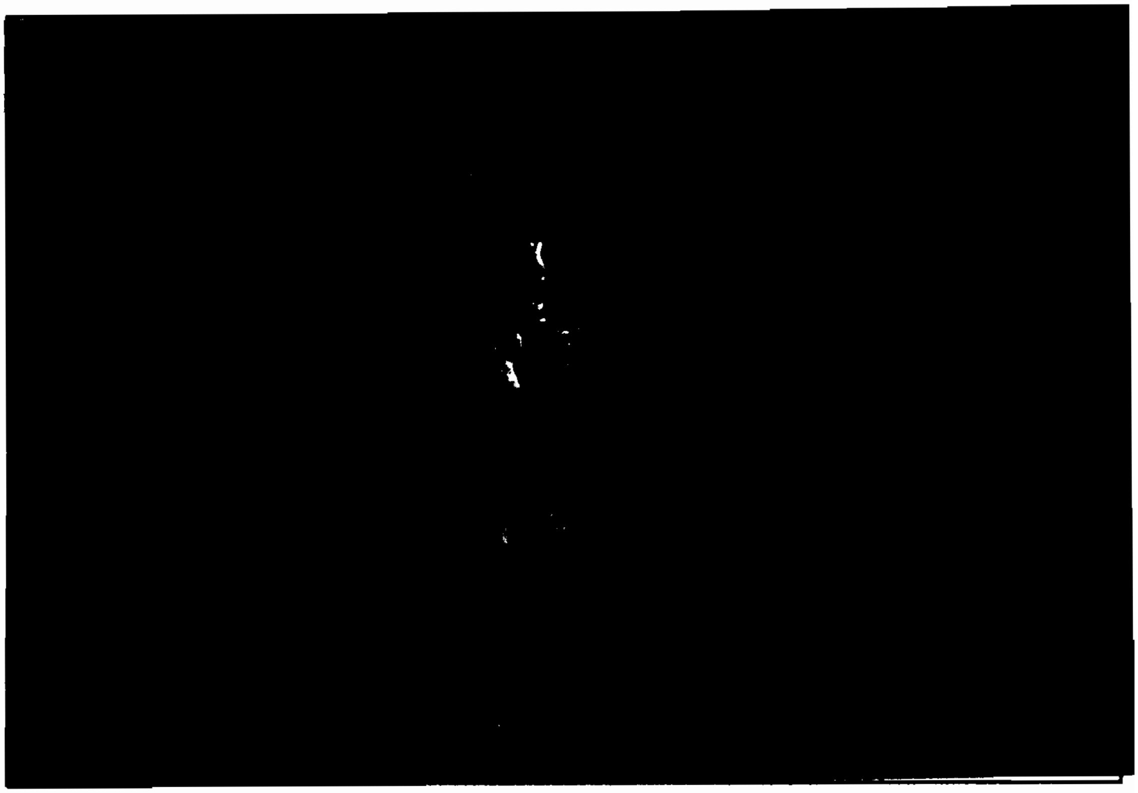


Figure 6.35 : Locations of Extracted Concrete Samples.

$FeNH_4(SO_4)_2.12H_2O$ serves as the indicator to determine the appearance of the first permanent red colour.[73]

The chloride content is calculated as a percentage of the cement to the nearest 0.01% (m/m) using the following expression[74]:

$$J = \{V_5 - (V_6.m/0.1)\} * (0.003545/M_c) * (100/C_1) \qquad (6.1)$$

where V_5 = volume of silver nitrate solution ($AgNO_3$) (ml)

V_6 = volume of thiocyanate solution (KSCN) (ml)

m = molarity of thiocyanate solution (mol/L)

M_c = mass of concrete sample used (g)

C_1 = Percentage of cement in the concrete sample (%)

The above equation may be modified according to the varying concentrations of the silver nitrate and thiocyanate solutions.

Appendix (F) presents the result obtained from the chloride contents for Series 1 through 8. The variation of the chloride content along the cylinder hight versus the depth of concrete cover are also presented.

CHAPTER 7

ANALYSIS AND DISCUSSION

The results of the accelerated electrochemical corrosion testing program presented in Chapter 6 will be analyzed and outlined in this chapter. In addition, the electrode resistance in both normal and reversed polarities, the effect of immersion time on corrosion, and the values of corrosion current, electrical conductance for each Series are calculated and plotted.

7.1 Electrode Resistance - R_e

The electrode resistance for normal and reversed polarity can be computed from the recorded measurements of the voltage and the current in each Test Series. It is equal to the difference between the electrode operating and polarization potentials divided by the corresponding current. Figures 7.1 to 7.3 show the polarization resistance of the Specimens for Test Series No. 1. The electrode resistance for Series No. 2 to No. 8 are presented in Appendix M.

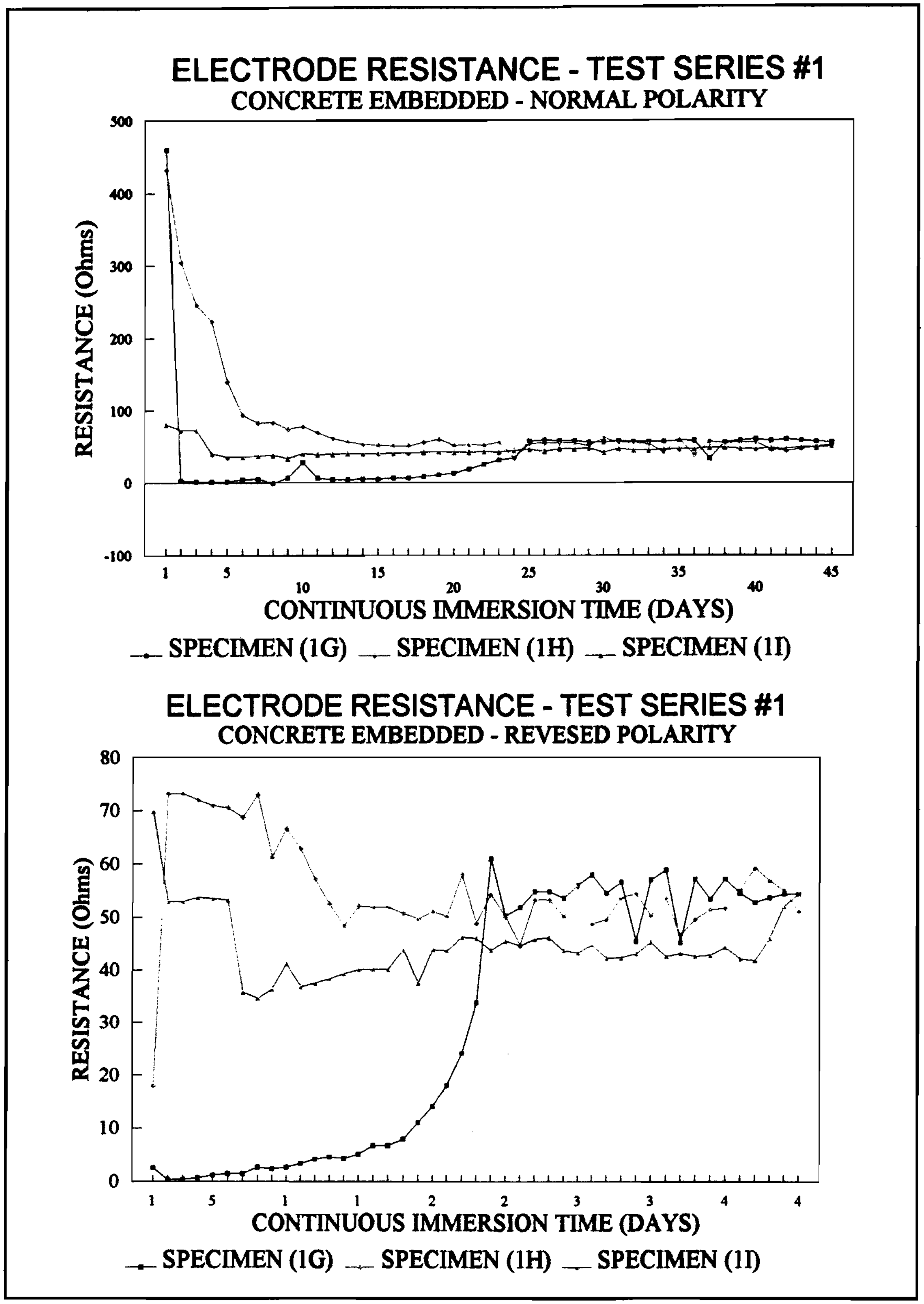
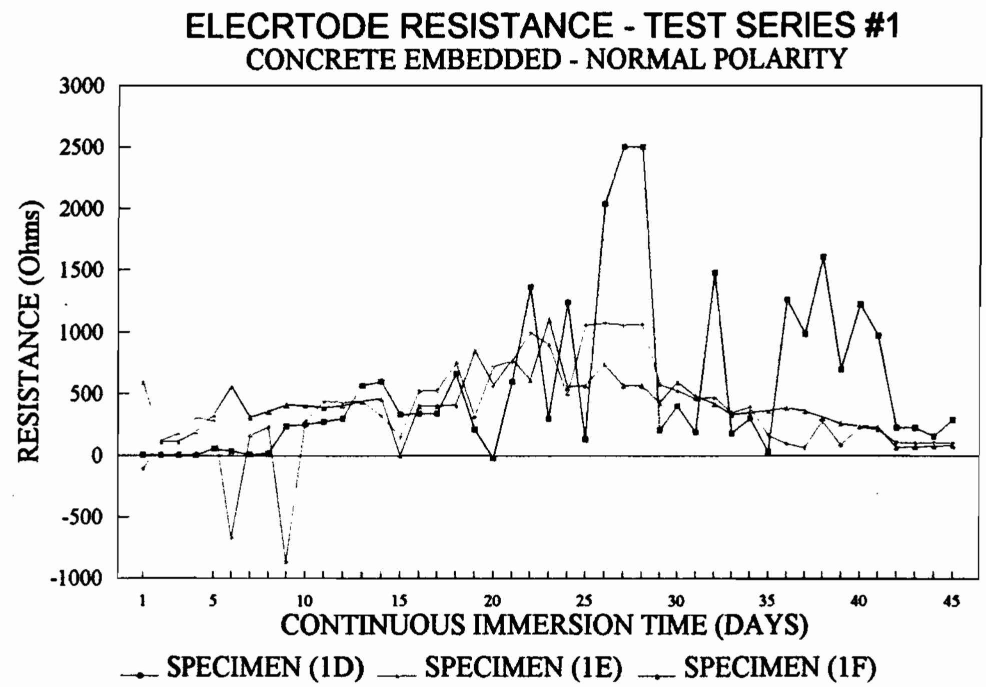


Figure 7.1 : Electrode Resistance - Series No. 1



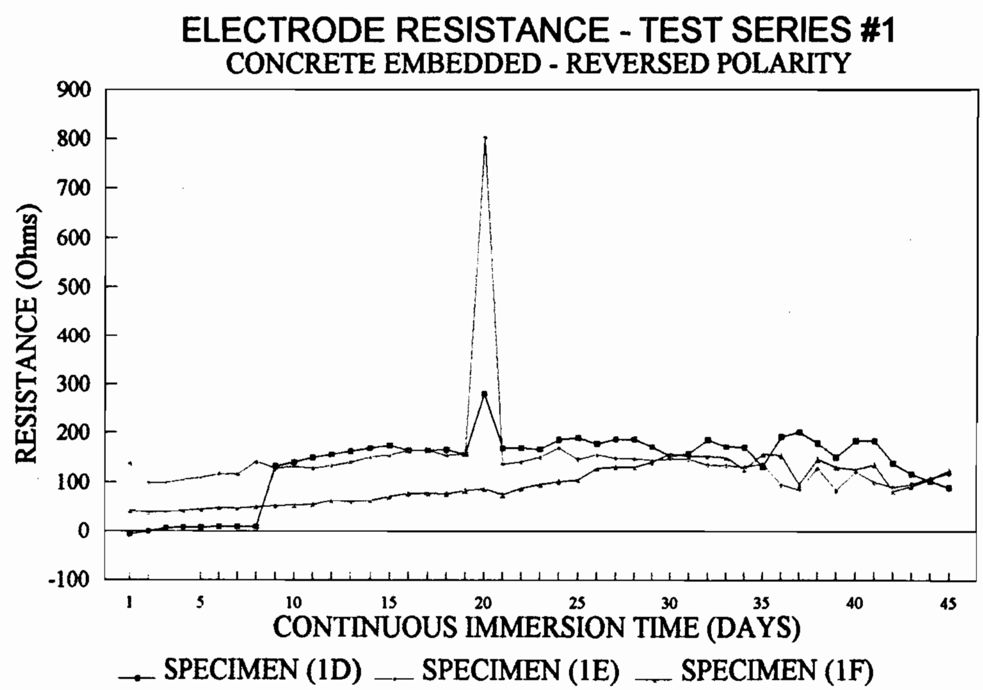


Figure 7.2 : Electrode Resistance - Series No. 1

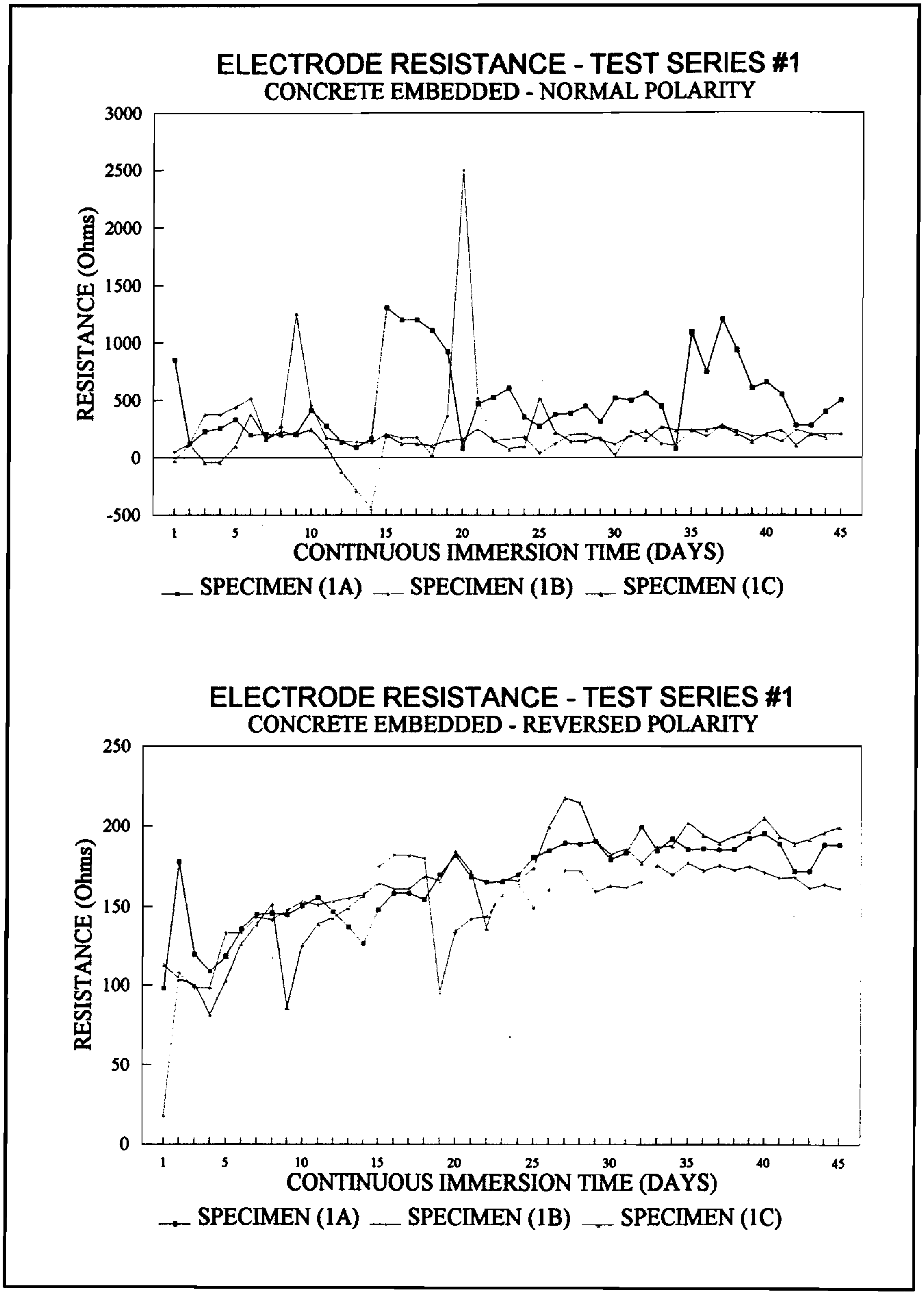


Figure 7.3 : Electrode Resistance - Series No. 1

7.1.1 Normal Polarity Position

The concrete embedded electrode acts as an anode (connected to the positive terminal of the power supply). The current is interrupted until an essentially constant polarization potential E at that electrode is obtained. The chemical reaction is assumed to be that of oxygen half-cell[75]:

$$2OH^{-} \rightleftharpoons 1/2O_2 + H_2O + 2e^{-} \qquad (7.1)$$

The hydroxyl ions, OH^-, yield free oxygen and water. Under the continuous influence of current discharge, this reaction may ultimately consume the alkalinity of the concrete at the steel surface, resulting in corrosion.

The oxygen half-cell potential with respect to the reference SCE is given by[75]:

$$E = -0.987 + 0.059\ pH - 0.015 \log O_2 \quad \text{Volts} \qquad (7.2)$$

Assuming that oxygen gas is evolved at atmospheric pressure, then;

$$\log O_2 = \log 1 = 0 \qquad (7.3)$$

Therefore, the half-cell potential equation becomes:

$$E = -0.987 + 0.059\ pH \qquad (7.4)$$

7.1.2 Reversed Polarity Position

The concrete-coated electrode exhibits cathodic characteristics and behaves similar to a hydrogen half-cell at a pH value approximately that of the surrounding concrete. The reaction occurring at the metal surface consists of the electrolysis of water and evolution of hydrogen gas according to the following equation[75]:

$$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^- \qquad (7.5)$$

The potential for this half reaction with respect to the reference SCE is:

$$E = 0.242 + 0.059\ p + 0.030 \log H_2 \ \text{Volts} \qquad (7.6)$$

Assuming that hydrogen is evolved at atmospheric pressure;

$$\log H_2 = \log 1 = 0 \qquad (7.7)$$

Therefore, the half-cell potential equation becomes:

$$E = 0.242 + 0.059\ p \qquad (7.8)$$

7.2 Effect of Immersion Time on Corrosion

The effect of the immersion period, along with the impressed voltage of 1 V, on each specimen can be determined based on the resistance offered. This can be calculated as follows:

$$R = \frac{V}{I} \tag{7.9}$$

where R = resistance provided by the electrode specimen

I = current measurement between electrodes

V = voltage measurement between electrodes

The reciprocal of the resistance, i.e. I/V is plotted versus the immersion time. Appendix (G) presents these graphs for the various Set-Ups in both polarity positions.

7.3 Corrosion Current - icorr

In order to calculate the corrosion current, Stern's formula was used:

$$I_{corr} = \frac{B}{R_p} \tag{7.10}$$

where I_{corr} = corrosion current (uA/cm^2)

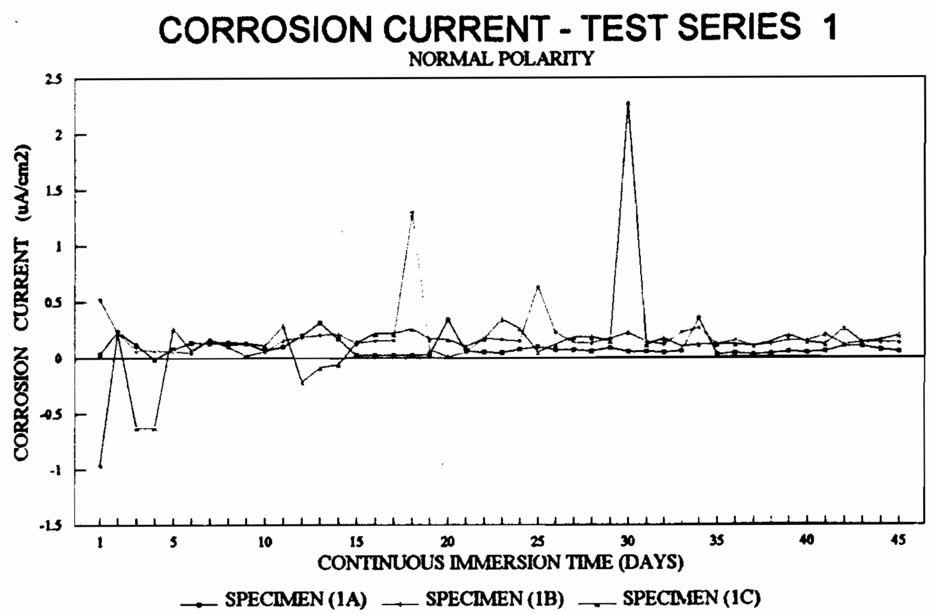
B = corrosion constant (assumed to be about 26 mV for active iron)

R_p = polarization resistance (ohms)

As it can be seen from the above equation, the corrosion current is related to the polarization resistance. The values of the corrosion current can be determined from the results obtained in Section (7.1). Figures (7.4) to (7.7) depict current density versus immersion time curves for Test Series No 1. Appendix (H) presents the remainder of the graphs of the current variations for Test Series No.2 to 8.

7.4 Electrical Conductance

The electrical conductance G is a parameter indicating the flow of the current in the electrolyte solution (see Section 2.3.7). It can be calculated by taking the reciprocal of the polarization resistance, $1/R_p$ (units 1/ohms). The logarithm of the conductance, log G, for Test Series No.1 is plotted versus immersion time in Figures 7.8 and 7.9. The conductance for each experimental specimen is summarized in Appendix (I).



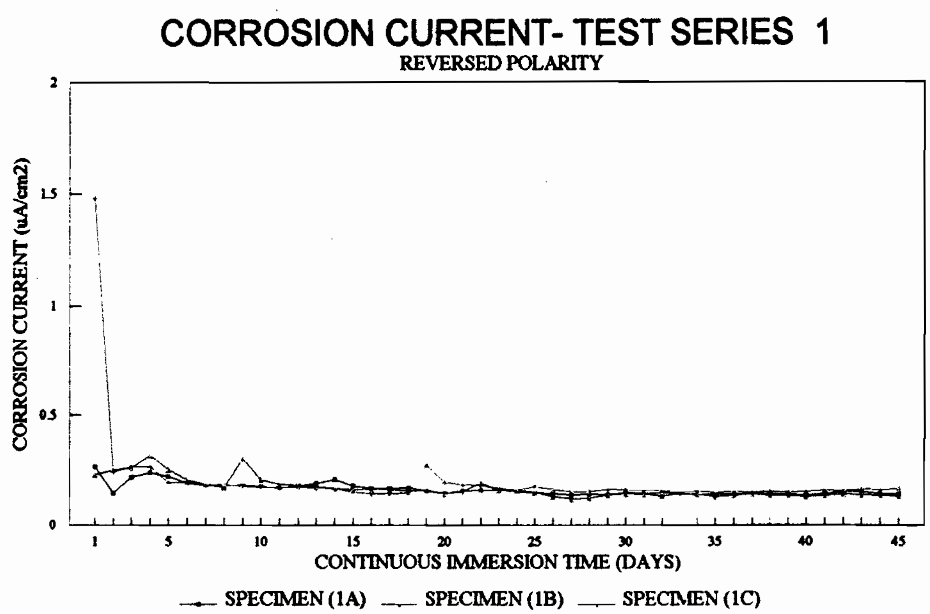


Figure 7.4 : Corrosion Current - Series No. 1

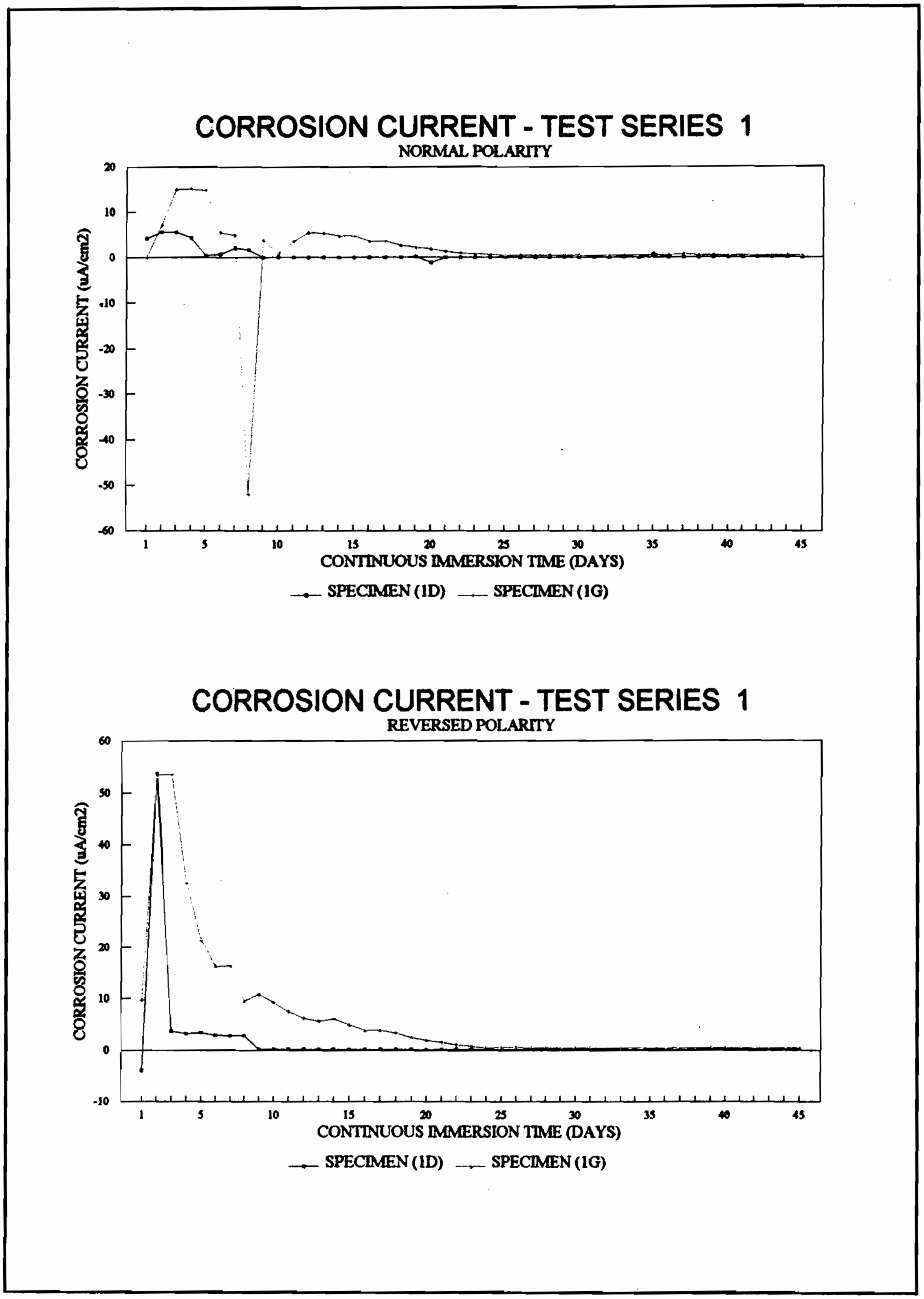


Figure 7.5 : Corrosion Current - Series No. 1

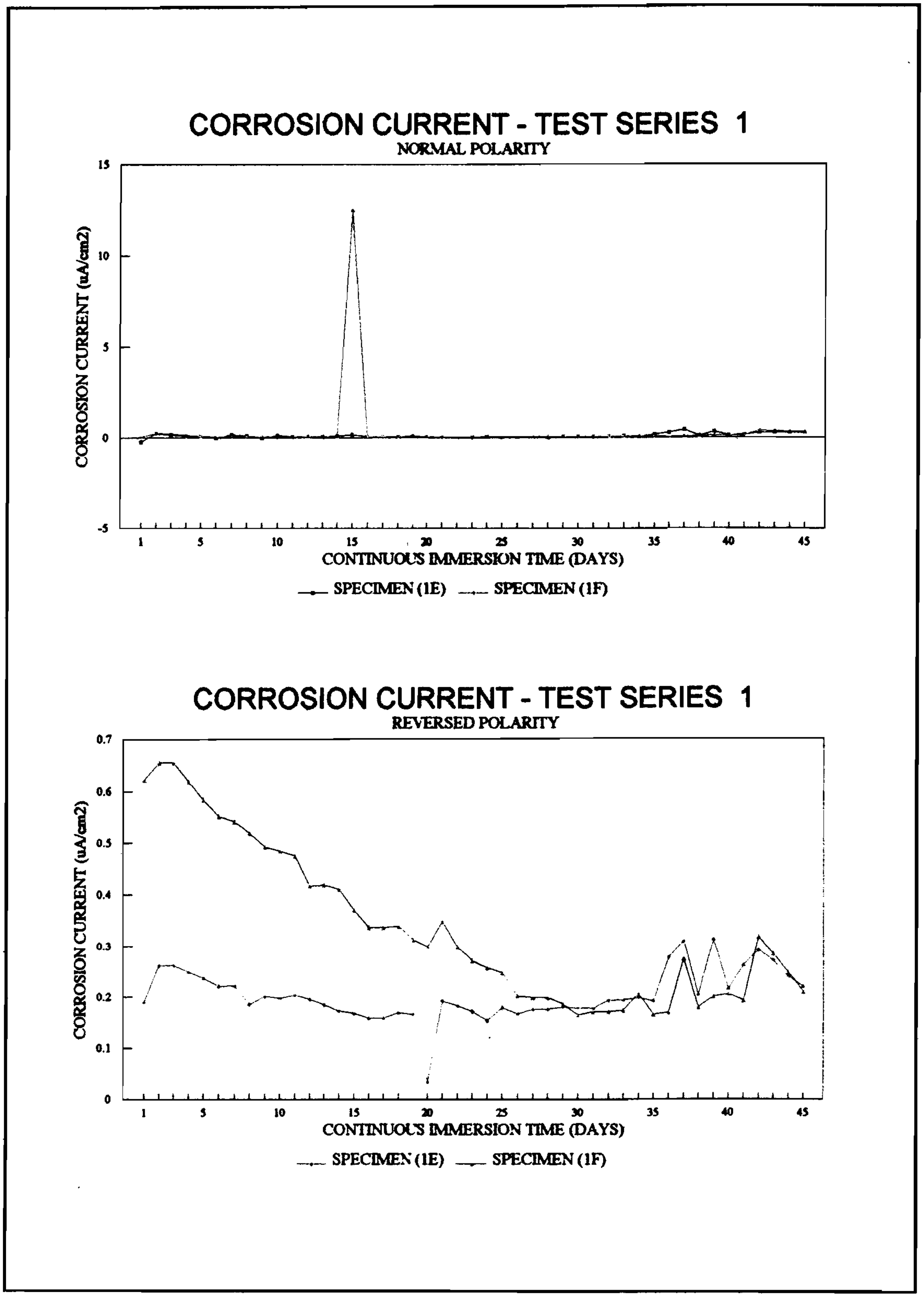


Figure 7.6 : Corrosion Current - Series No. 1

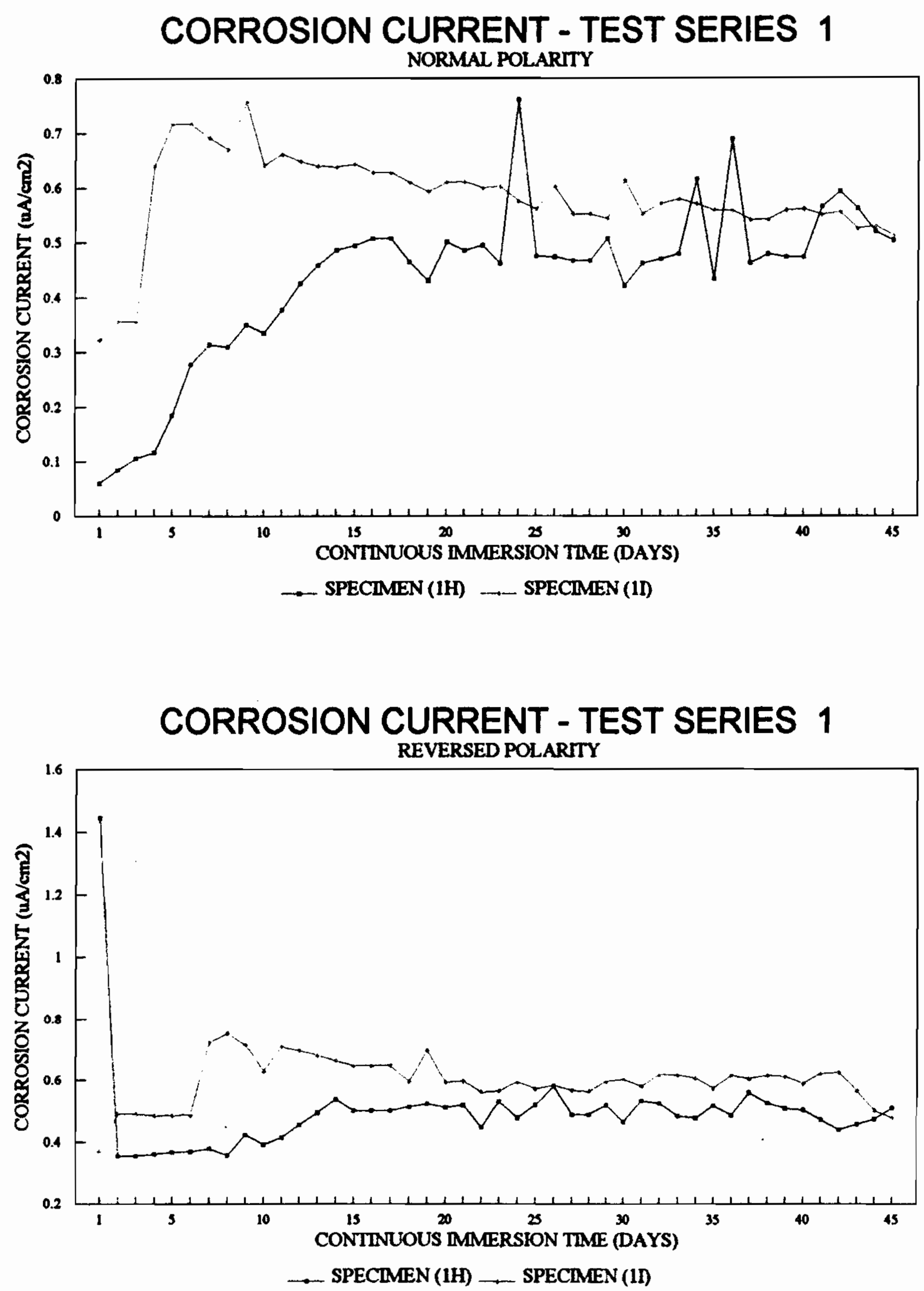
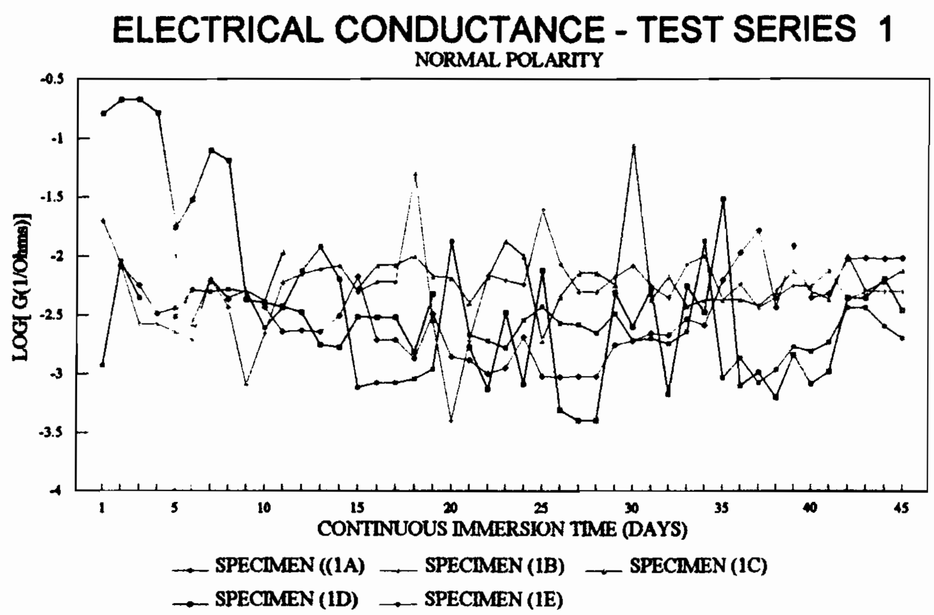


Figure 7.7 : Corrosion Current - Series No. 1



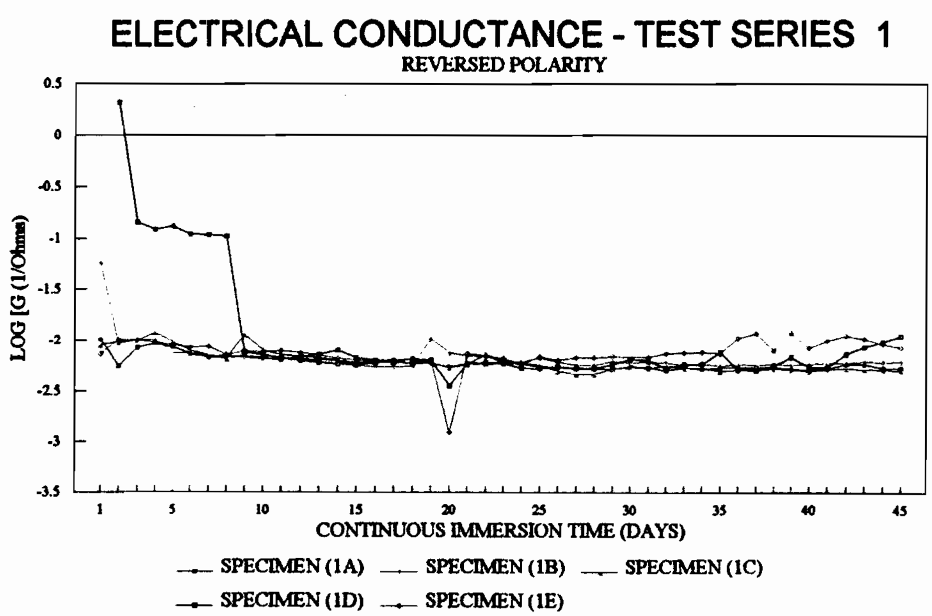


Figure 7.8 : Electrical Conductance - Series No. 1

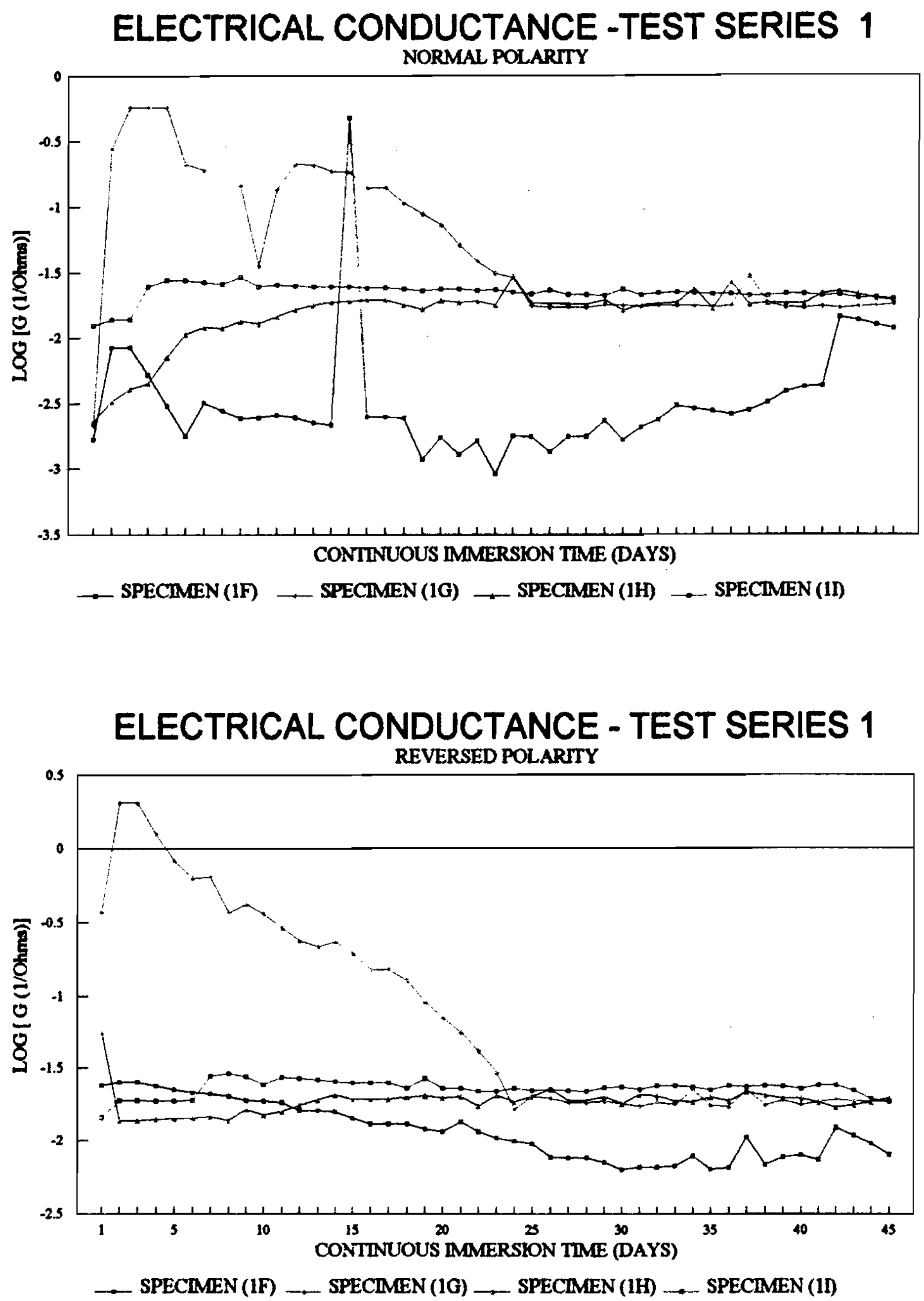


Figure 7.9 : Electrical Conductance - Series No. 1

7.5 Oxidation Rate

The oxidation rate can be calculated according to the following equation[76]:

$$dw/dt = I * M_W / (n*F) \qquad (7.11)$$

where dw/dt = iron oxidation rate (g/sec)

M_w = molar weight of iron (55.847 g/mol)

n = oxidation state (assumed to be +2)

F = Faraday's constant

($9.648 * 10^4$ Coulombs/mol)

Both maximum and minimum values of the current, as well as the average value, are used to determine the maximum, minimum, and average iron oxidation rates for the concrete-embedded electrode of every specimen (see Appendix J). By multiplying the average oxidation rate by the duration of the immersion period (45 days), the average mass loss of the concrete-embedded steel re-bar can be obtained (see Appendix K). The iron oxidation rate equation can be applied to both concrete-embedded and/or bare steel electrodes.

7.6 Analysis Of Results

As mentioned before, the main objective of this test program is to study the effect of concrete cover depth on the corrosion of embedded reinforcement in concrete, as well as studying this effect on a better quality concrete, using two types of epoxy coated bars and two types of surface sealing. Analysis of the results is based on these points.

7.6.1 Effect of Concrete Cover Depth

1. Visual Observations

The visual observations for Test Series 1 to 8 are described in Chapter 6. In general, the specimens having the smallest concrete cover in Test Series 1 and 8 showed a clear signs of corrosion, whereas the specimens having the larger cover depths in the same Series and the other specimens with protection measures did not show any visible signs of corrosion.

2. Electrode Potentials

The measurements of the electrode operating potentials versus SCE supports the visual observations. The negative values (around -150 mV) of electrode potentials were measured in the specimens having the smallest cover are an indicator of active corrosion. However, positive values were recorded in the specimens having the larger cover (refer to assorted Figures in Chapter 6). Reversal of potential values from positive to negative indicates initiation of corrosion. No signs of active corrosion were measured in the reversed polarity position.

3. Current Measurements

The test specimens having smaller concrete cover thickness allowed greater current flows, for both polarity positions. A large current flow was measured in the reversed polarity position than for the normal polarity position except for Test Series No. 2, no current flow was recorded in both positions.

4. Chloride Contents

The results of analysis for chloride contents, presented in Appendix (F), show an inverse relation between the clear cover depth and the chloride contents. An increase in the concrete cover results a reduction of chloride contents in all tests. This holds true along the entire height of the concrete specimen (i.e., for all samples extracted from the top, middle, and bottom).

5. Concrete Mass Loss And Oxidation Rate

The reinforcement mass loss and the oxidation rate are inversely proportional to the cover thickness (see Appendixes J & K). The mass loss and the oxidation rate decrease as the cover thickness increases.

6. Electrode Resistance

For Test Series 1, in the normal polarity position, the specimens with the smallest cover (1G, 1H, 1I) showed a resistance below 100 ohms while the specimens with the larger cover had a resistance in the range of a thousand ohms and more. The same conclusion was reached for the other Test Series but with a different ranges of resistance values. (see Figures 7.1 to 7.3 and Appendix M).

7. Corrosion Current

The values of corrosion current, i_{corr}, for the specimens having the small cover thickness in all Test Series are higher than the values for the specimens having larger cover thickness. This is noted in both polarity positions (see Appendix H).

8. Electrical Conductance

The test specimens having the smallest cover depth are more electrically conductive than the specimens with larger cover thickness. In another word the electrical conductance is inversely proportional to the thickness of the clear cover (see Appendix I).

7.6.2 Effect of Epoxy Coated Bars

Results of Test Series Nos. 2 and 3 can outline the effect of using the epoxy coated bars for reinforcing the concrete as follows:

1. No visible signs of corrosion were encountered on any specimen during the test period of 45 days.

2. No negative values of electrode potential were measured in both tests during the immersion period.

3. No current flow in the electrical circuit. A nominal value of 0.01 mV was considered in the daily readings (see Appendix C).

4. Electrode resistance values were in the range of 1000 to 9000 ohms.

5. Electrical conductance, G, values were in the range of -2 to -4 ohms.

6. There is no mass loss in the specimens of both Series. The real value of the oxidation rate is equal to zero but it was calculated according to the nominal value of the current flow and considered to be 0.25 mg/day (see Appendices J & K).

7. Chloride contents values were in the range of (0.022 - 0.082) for Series No. 2, and (0.022 - 0.077) in Series No. 3 (see Appendix F).

From the above results, it can be concluded that the epoxy coating bars performed good protection against the corrosion.

7.6.3 Effect of Sealing

As described before, two types of sealing were used, one in Series No. 4 (SIKAGARD 71), and the other in Series No. 5 (SIKAGARD CURE/HARD). To examine this effect, a brief consideration of the results obtained from both Series will be helpful as follows:

i- Series No. 4

1. No visible signs of corrosion were observed during the 45 days immersion period.

2. No negative values of potential were recorded during the test period.

3. Current measurements were in the range of (0.13 - 1.5)mA

4. Electrode resistance values were in the range of (300 - 2000) ohms.

5. Electrical conductance values were in the range of (-2.5 to -3.5) ohm-.

6. The oxidation rates were in the range of (34 - 69) mg/day (Appendix J). This results in an average mass loss of around 2.5g in this Series, after 45 days immersion period (Appendix K).

7. Chloride contents in the specimens of this Series are less than all the other Series (see Appendix F).

<u>ii- Series No. 5</u>

1. No visible signs of corrosion were observed in this Series, except Specimen 5B because of the missing seal on the place where the corrosion takes place. The problem was treated by re-sealing that location; no advanced signs of corrosion were observed after this treatment.

2. Negative operating potential values in the first five days were recorded in Specimen 5B (around -100 mV) then, and after treatment, no negative values were measured for this specimen and for the others.

3. Current flow values were in the range of 0.01 to 2.75 mA except for Specimen 5B in the first five days, which were

around 4 mA.

4. Electrode resistance values were in the range of 350 - 1800 ohms.

5. Electrical conductance values were in the range of -2 to -3 ohm-.

6. The average oxidation rate was around 180 mg/day, and the average mass loss was around 7 g after 45 days immersion period.

7. The chloride contents in the specimens of this Series were higher than Series No. 4 but less than the values for Series No. 2 and 3 (see Appendix F).

7.6.4 Effect of Concrete Quality

Low water/ cement ratio and high cement ratio in the concrete mixtures are necessary for durable concrete. A major effect of increasing the w/c ratio is an increase of in the porosity of the concrete. This has a negative effect from the point of view of reinforcement corrosion: a more rapid diffusion of chloride ions into the steel surface, easier ingress of oxygen and lower electrical resistivity. To explain this effect more clearly, a comparison between the results of

Test Series No. 1 (concrete compressive strength 35 MPa) and the results obtained from Test Series No. 8 (concrete compressive strength 45 MPa) are compared.

In order to simplify the comparison, only the specimens with a clear cover depth equal to 11.1 mm are compared:

1. The maximum negative values recorded in the specimens with clear concrete covers equal to 11.1 mm in Series No. 1 and Series No. 8 were -335 mV, -49 mV, respectively.

2. The maximum value of current flow in these specimens were 15 mA in Series No. 1, and 3 mA in Series No. 8

3. Electrode resistance values for these specimens were around 43 ohms in Series No. 1 and in the range of 250 ohms for Series No. 8.

4. The oxidation rate in these specimens was 581 mg/day in Series No. 1 and 140 mg/day in Series No. 8

5. The mass loss values for these specimens were 18.5 g and 3.5 g in Series No. 1 and No. 8, respectively.

6. The chloride content, always for the same specimen, in Series No. 8 is less than Series No. 1

The effect of concrete quality can be seen readily from the above comparison. It can be concluded that the high quality concrete plays a major rule in protecting the embedded steel from the corrosion attack.

7.7 SUMMARY AND CONCLUSIONS

From the results of the tests presented here, the following conclusion can be drawn.

1. The visual observation often provides the first indication of a corrosion problem but is unable to provide sufficient information for a comprehensive survey.

2. The negative operating potential values versus a saturated calomel reference electrode (SCE) indicate a sign of corrosion. Additionally, any specimen whose operating potential varies from positive to negative values during the test period signifies the passing of reinforcing steel from a passive to an active state.

3. The current flow measurements are also a very good indicator of the corrosion state. A current value of 4 mA and above signifies corrosion activity at the level of reinforcing steel. Higher values of current flow indicates an advanced

stage of corrosion.

4. The concrete cover depth values has a direct effect on the measured potential values and consequentially on corrosion. With increasing concrete cover, the potential values tends to be positive which means no corrosion attack. Based upon this fact and the current flow readings, the minimum clear cover depth required to protect the steel from corrosion attack in Test Series No. 1 (normal steel) is 1" 7/16 in. (37 mm).

5. Epoxy coated bars used in Series No. 2 and 3 showed satisfactory results in providing effective protection against corrosion even when chloride ions directly reach the metal surface of the bar. No negative potential values were recorded in both Series. Also no current flow readings were observed. The minimum clear cover depth used in both Series was 7/16 in. (11 mm). It is recommended then the requirements of the CSA Standard CAN3-A23.3-M84 for the minimum concrete cover depth be implemented in this respect.

6. Two different kinds of concrete surface sealing were applied to Series No. 4 and Series No. 5. Good results were obtained in Series No. 4 where SIKAGARD 71 was used. This kind of sealant penetrates the concrete and fills its pores forming a protective layer that prevents the embedded steel from chloride ingress (see Appendix L for the technical data

sheet). Also no negative potential values were recorded. The maximum current reading was about 1.6 mA. SIKAGARD Cure/Hard was used to protect the specimens in Series No. 5. This kind of sealant forms a protective layer on the outer surface of the concrete (see Appendix L for the technical data sheet). The disadvantage of using this sealant is the need to ensure that the seal reaches every point on the concrete surface and is perfectly clean and free of gaps which results from a bubble on its surface. Specimen 5B is a good example for these conditions. It started to corrode because of a small gap on its surface which had no seal on it. For the rest of the specimens, no negative electrode potentials were observed and the maximum current reading was about 2.5 mA.

7. It must be emphasized that an increased concrete cover thickness is no substitute for poor quality concrete cover. A higher quality concrete cover is more effective in the protection of the steel reinforcement than a more permeable concrete cover of greater thickness.

8. It can be concluded from the results of Test Series No. 8 that the application of the sealant on the specimens after it started to corrode is a good solution to stop the progression of the corrosion attack at that stage.

9. A minimum cover of 1 1/16 in. (27 mm) is recommended for

the specimens with seal protection to ensure that the service life of the structure is prolonged. The reason for this recommendation depends on the increased current flow values in the last days of the test period. It is also recommended for the future accelerated electrochemical testing to extend the period of immersion beyond 45 days for further observations if exist.

10. Some irregular values were recorded in the daily readings of the electrode potentials due to a shutdown in the power supply, which in turn results an inadequate voltage application to the electrical circuitry.

11. It is strongly recommended that intensive care should be undertaken into consideration during the application of the sealant on the concrete surface to obtain perfect protection.

In order to improve the accuracy of any future results obtained from the experimental work described earlier, an automatic data recording device connected to both electrodes is really necessary for daily measurements of current flow, operating potentials, and polarization potentials with respect to a saturated calomel reference electrode.

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APPENDIX A

PHOTOGRAPHS OF DIFFERENT SPECIMENS IN DIFFERENT AGES

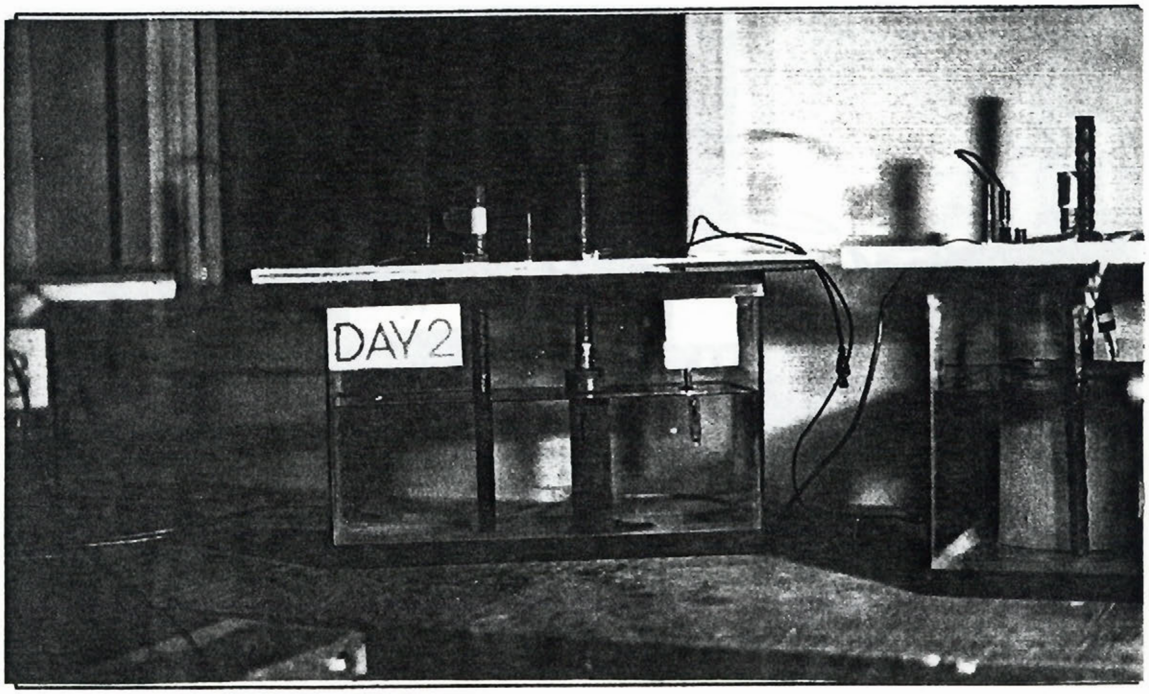


Figure A.1 : Experiment Specimen 1I - (DAY 2).

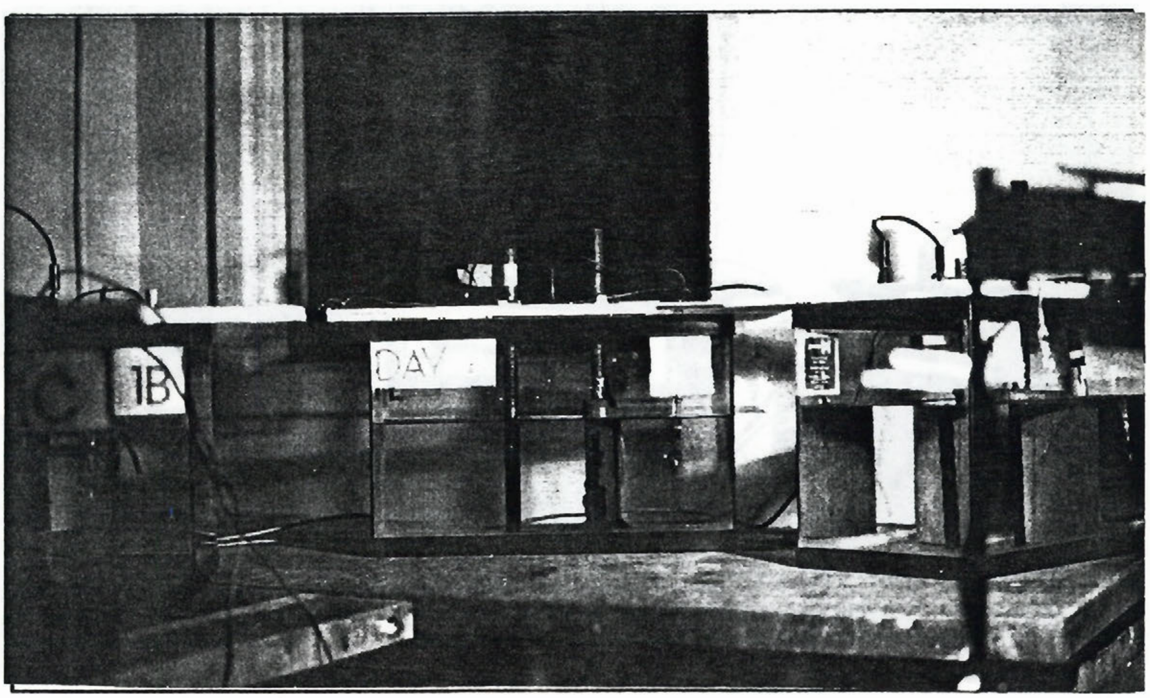


Figure A.2 : Experiment Specimen 1I - (DAY 4)

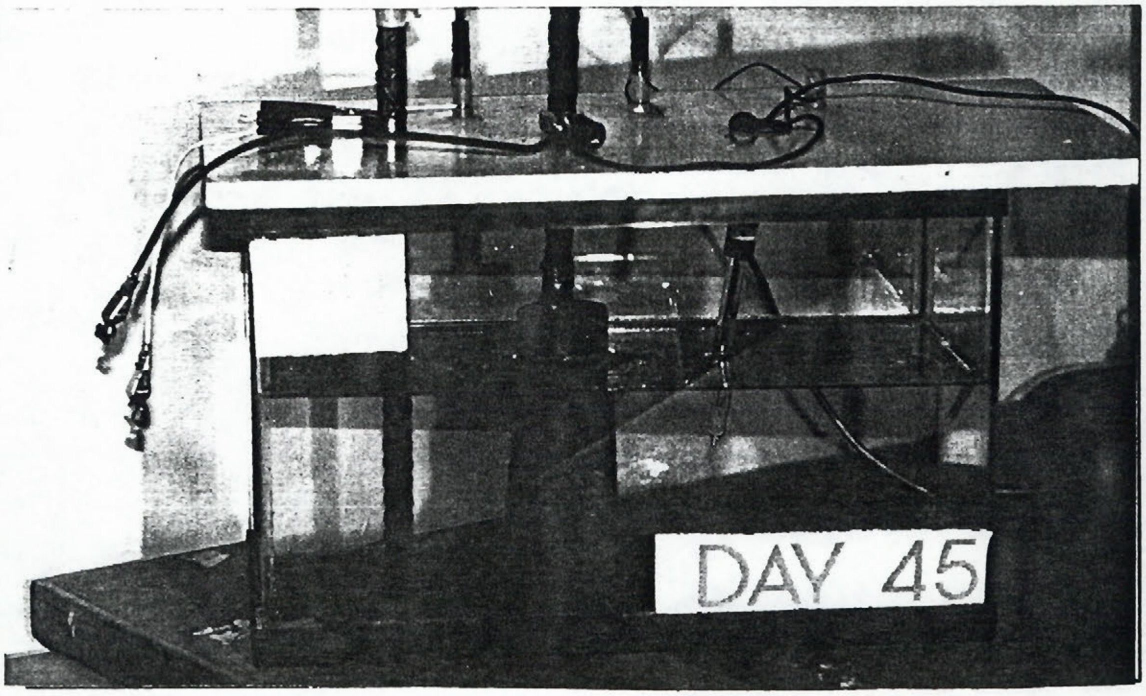


Figure A.11 : Experiment Specimen 1H - (45 DAYS).

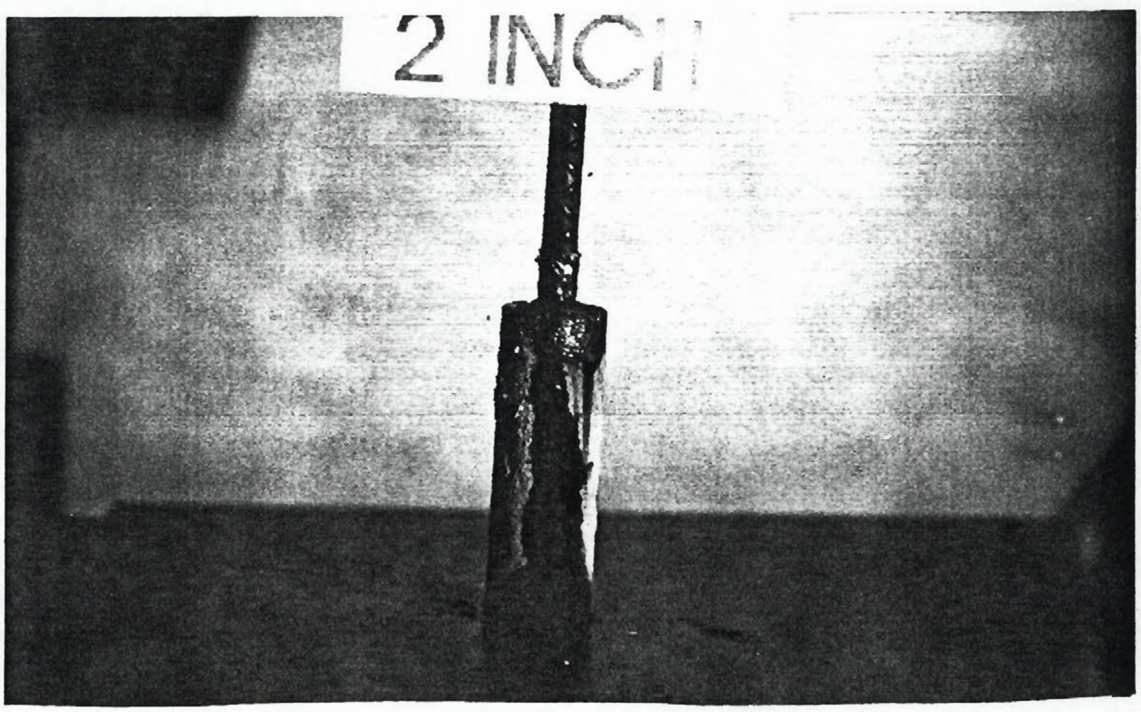


Figure A.12 : Experiment Specimen 1H - (AFTER 45 DAYS)

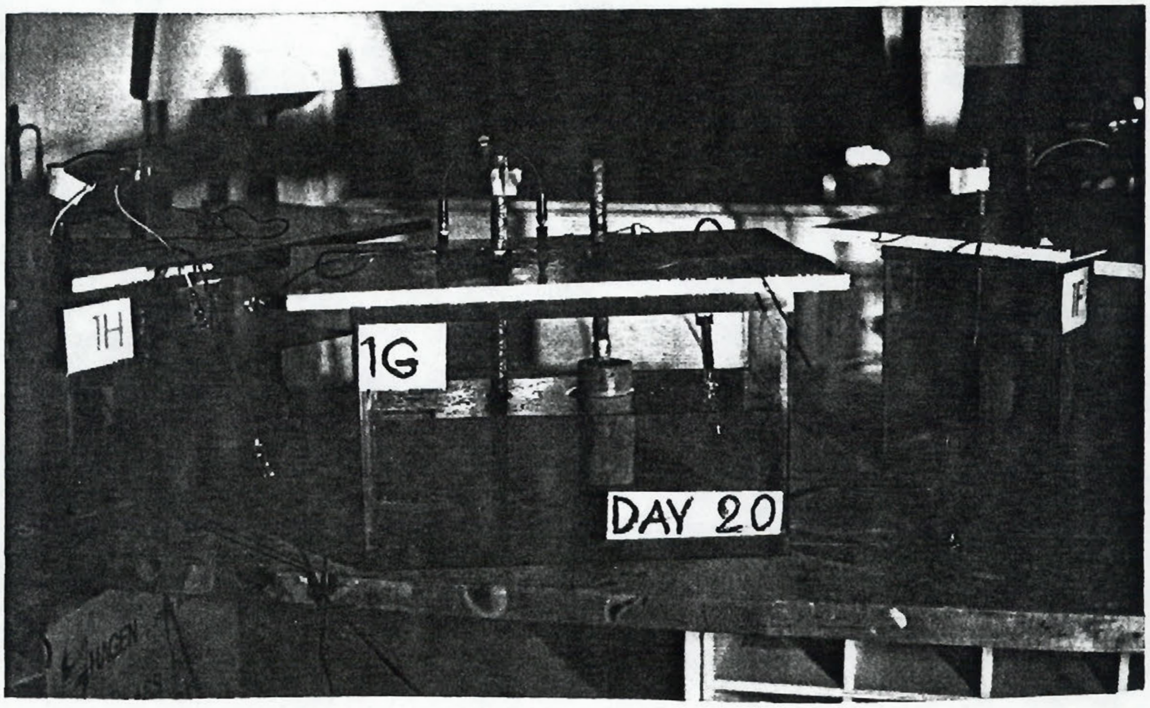


Figure A.13 : Experiment Specimen 1G - (DAY 20).

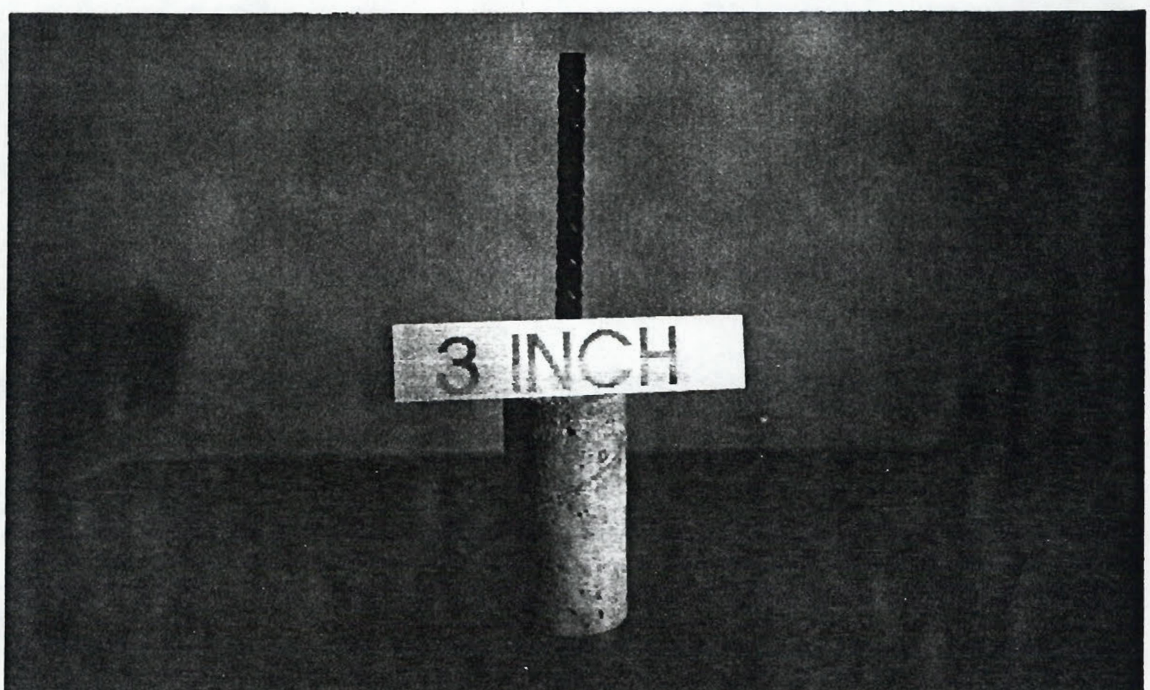


Figure A.14 : Experiment Specimen 1E - (AFTER 45 DAYS)

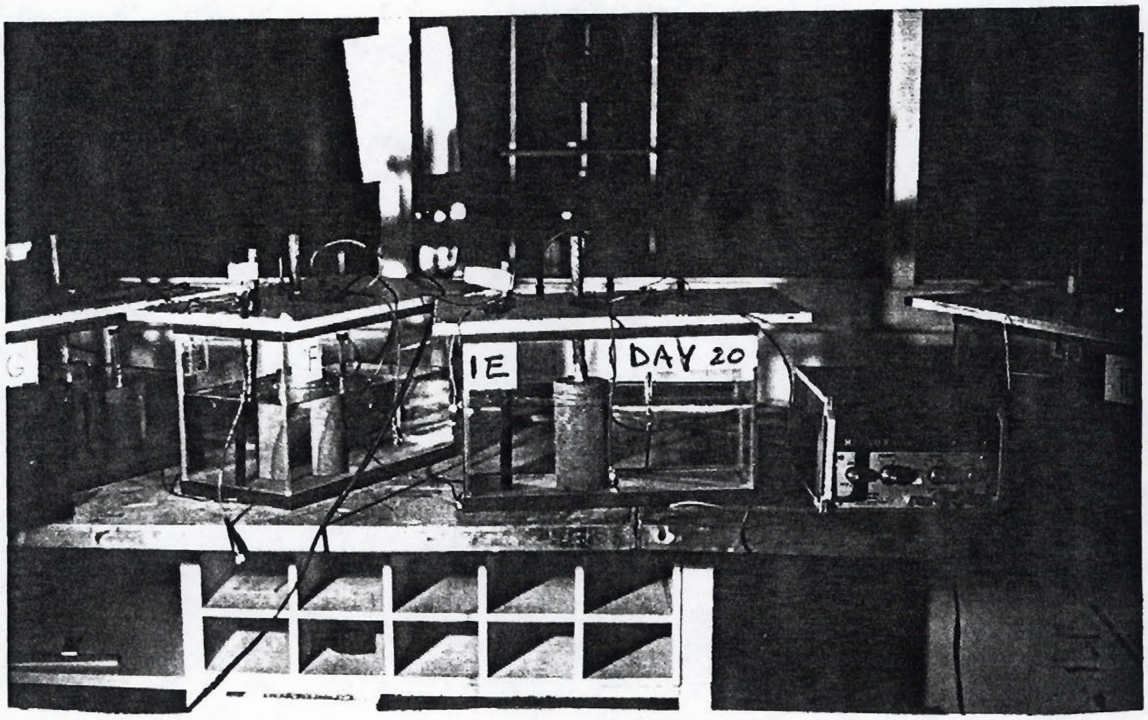


Figure A.15 : Experiment Specimen 1E - (DAY 20).

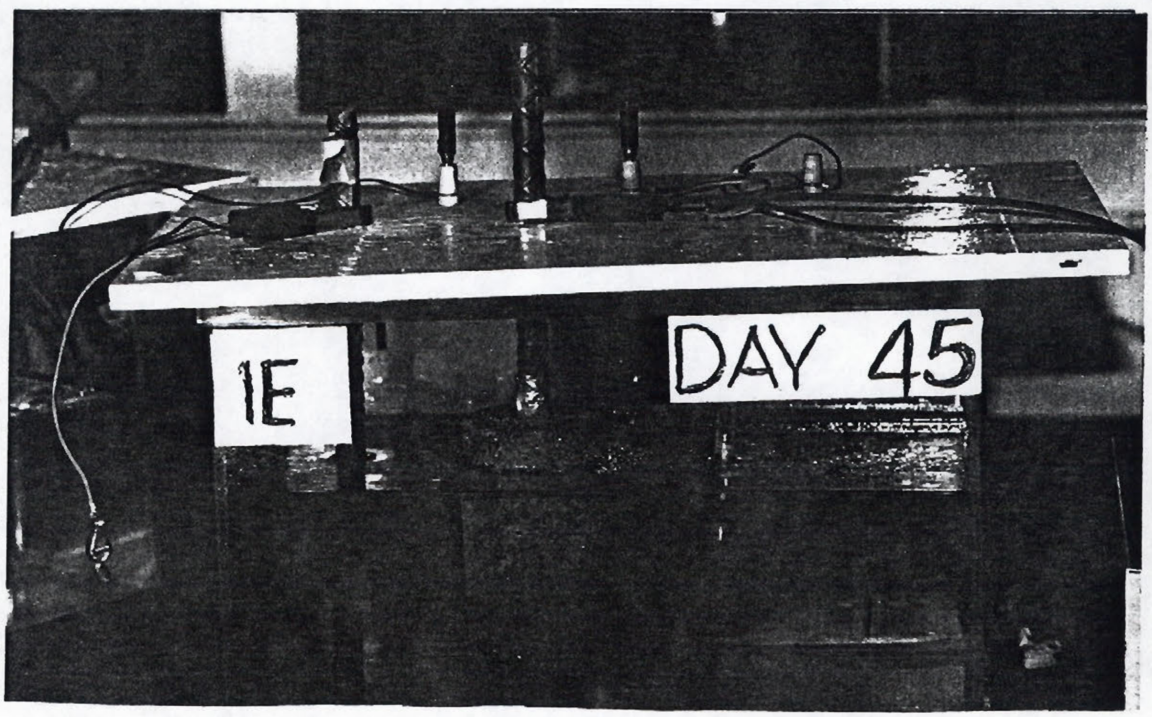


Figure A.16 : Experiment Specimen 1E - (DAY 45)

Figure A.17 : Experiment Specimen 1G - (AFTER 45 DAYS).

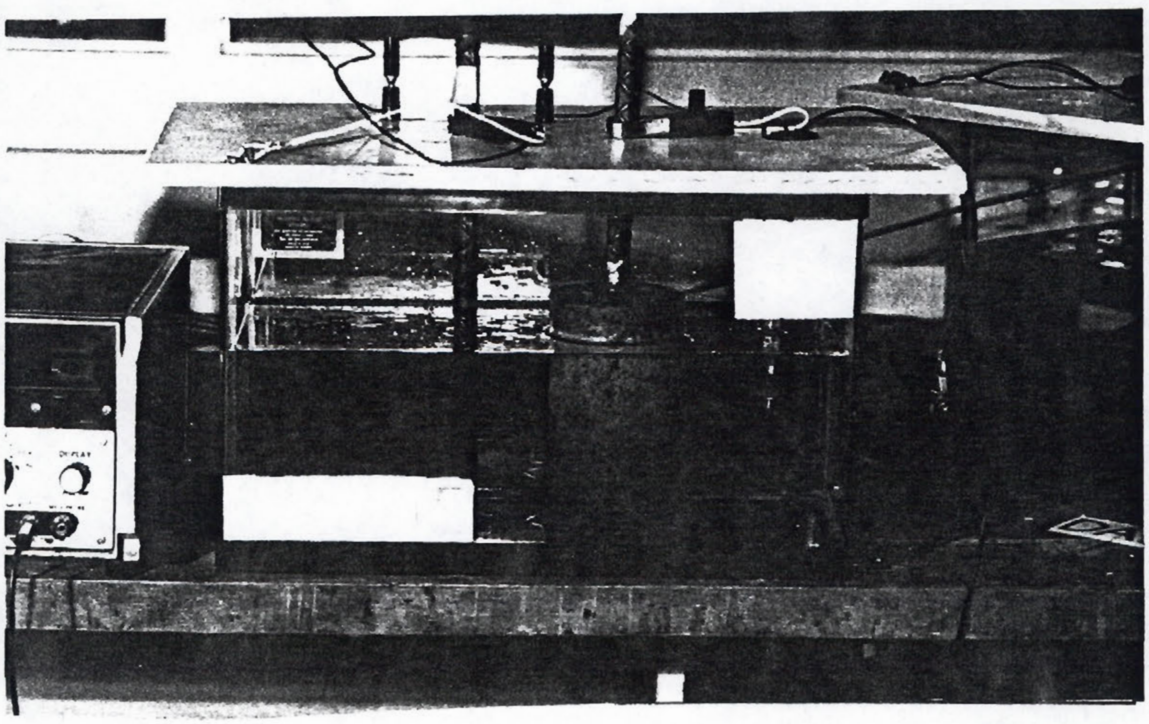


Figure A.18 : Experiment Specimen 1D - (DAY 45)

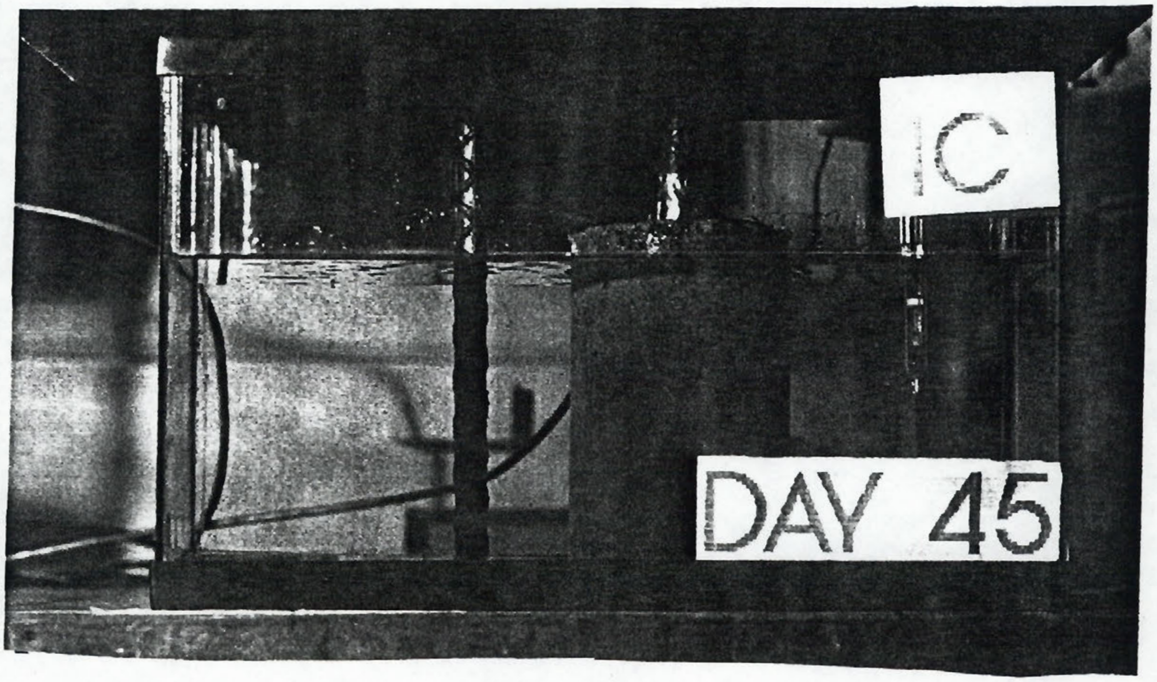


Figure A.19 : Experiment Specimen 1C - (DAY 45).

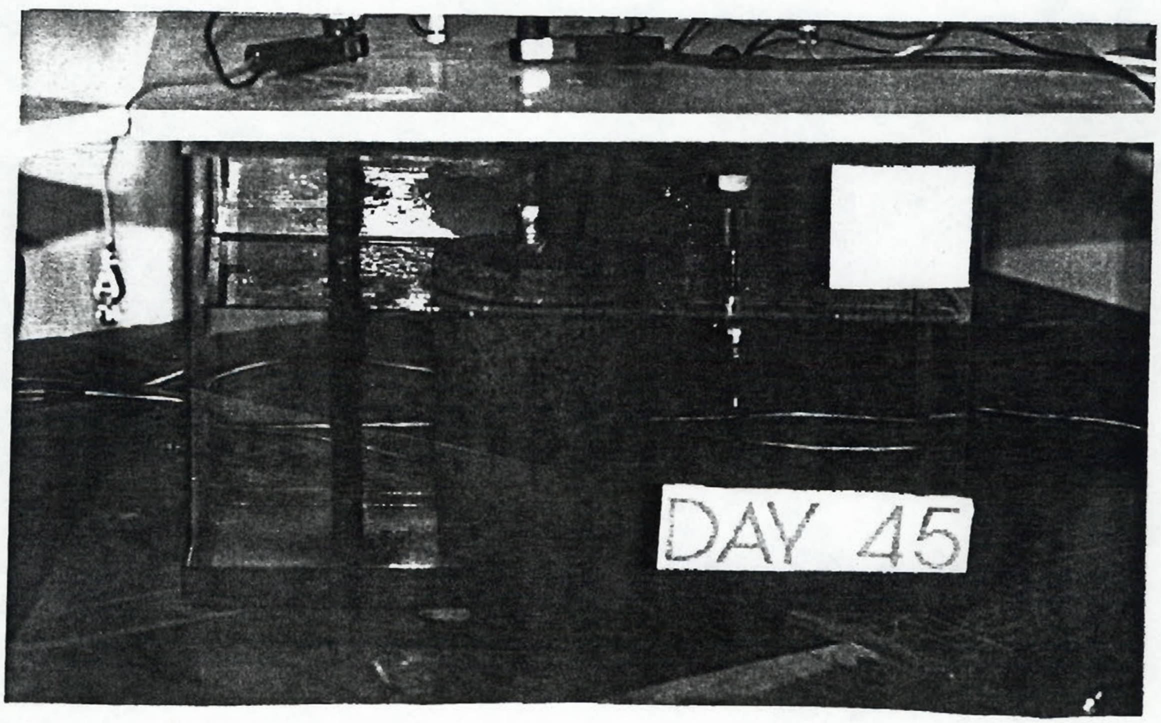


Figure A.20 : Experiment Specimen 1B - (DAY 45)

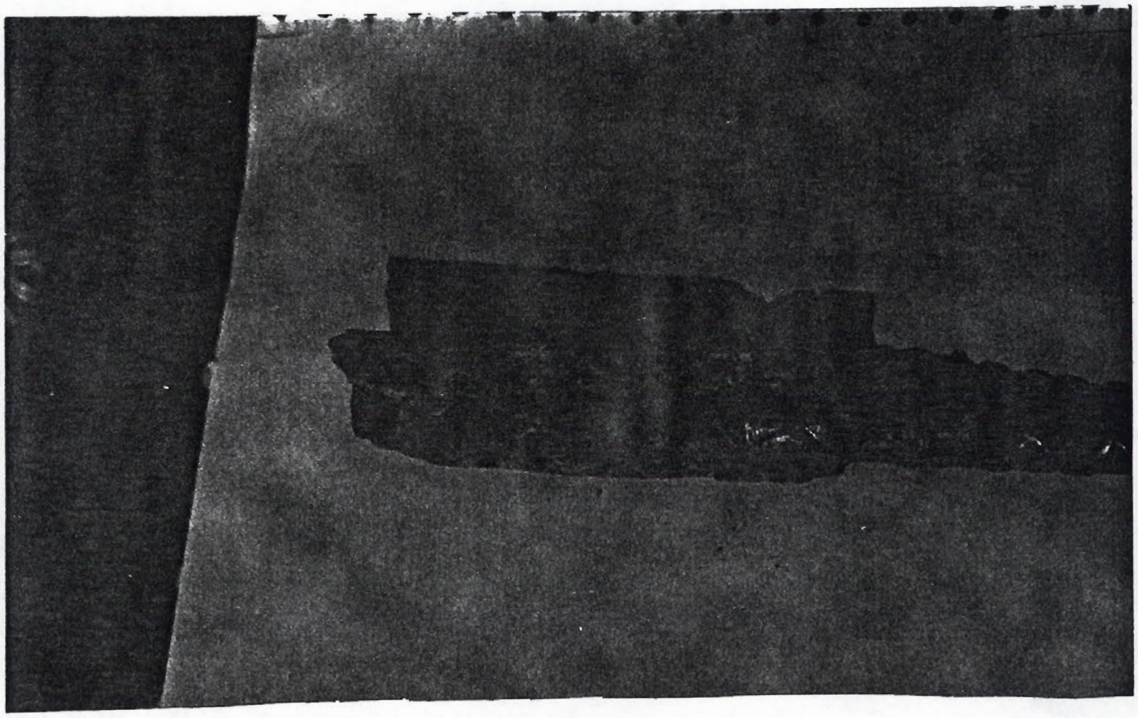


Figure A.21 : Experiment Specimen 1I.

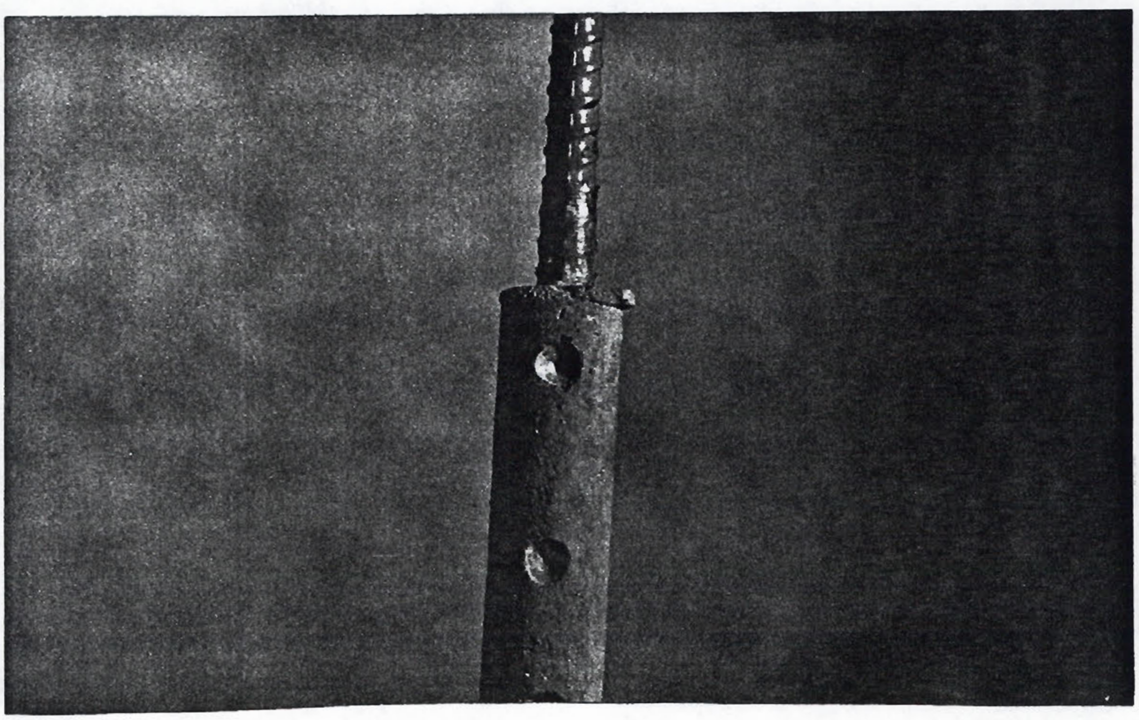


Figure A.22 : Experiment Specimen 2A - (AFTER 45 DAYS)

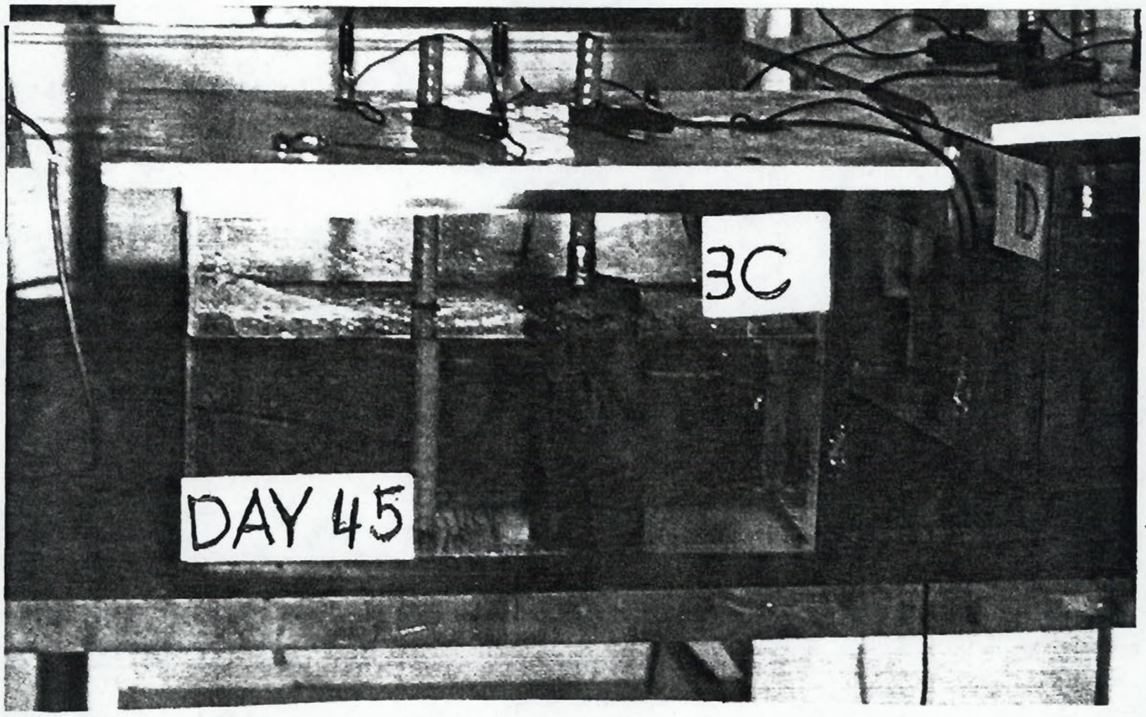


Figure A.23 : Experiment Specimen 3C - (DAY 45).

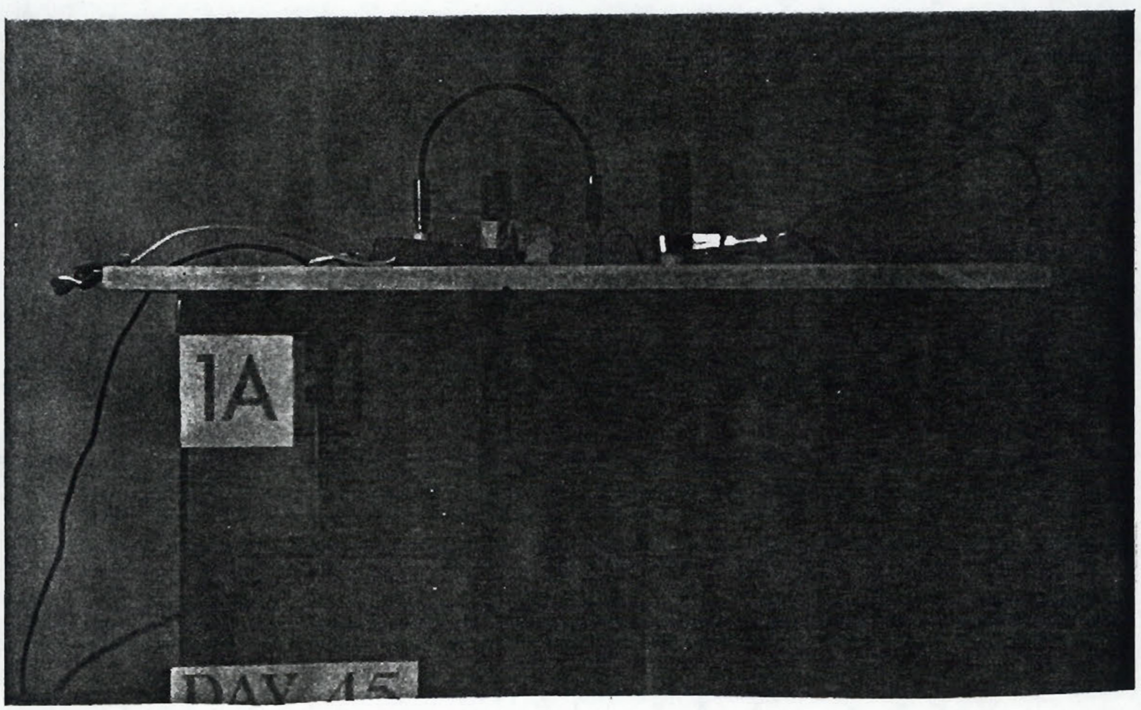


Figure A.24 : Experiment Specimen 4A - (DAY 45)

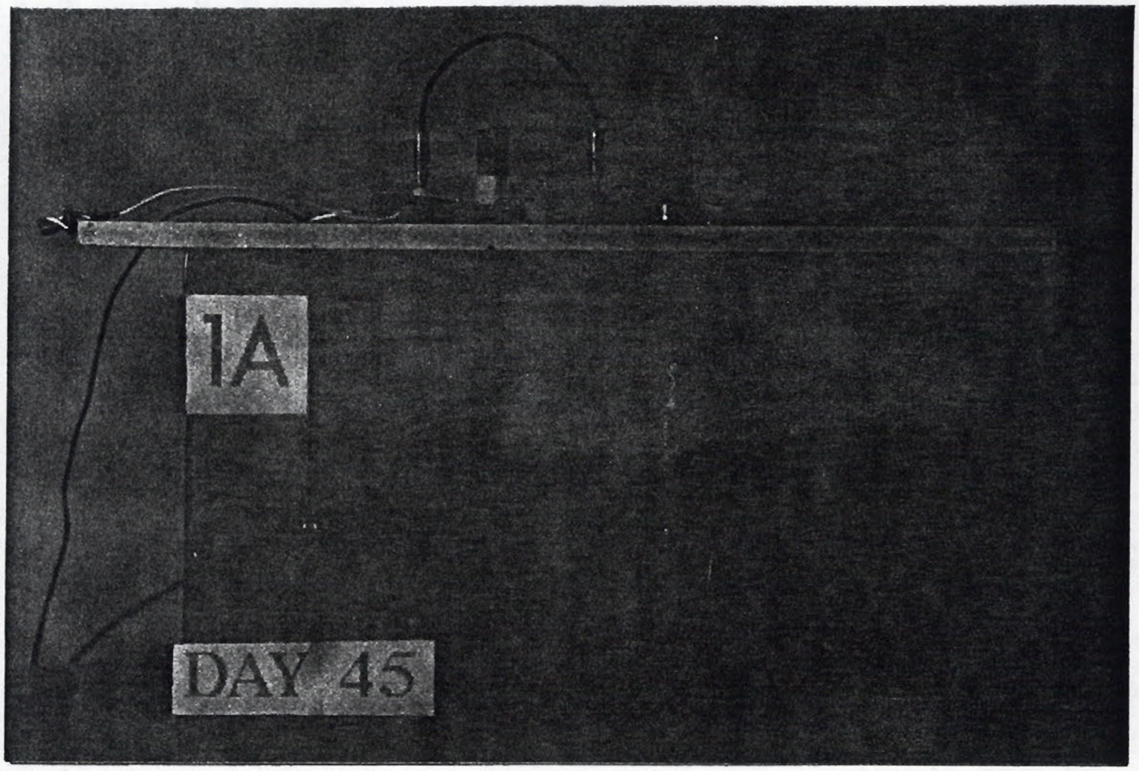


Figure A.25 : Experiment Specimen 5A - (DAY 45).

APPENDIX B

TEST SERIES No. 1

POTENTIAL
AND
CURRENT MEASUREMENTS

NORMAL POLARITY
SPECIMEN #1A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	0.02	1.14	0.377	0.36	-0.643	-0.643	850.00	0.00
30-May-92	0.57	1.23	0.578	0.515	-0.649	-0.615	110.53	-59.65
31-May-92	0.24	1.18	0.47	0.416	-0.649	-0.615	225.00	-141.67
01-Jun-92	0.06	1.38	0.32	0.305	-1	-1	250.00	0.00
02-Jun-92	0.24	1.14	0.551	0.472	-0.615	-0.609	329.17	-25.00
03-Jun-92	0.41	1.23	0.562	0.483	-0.688	-0.683	192.68	-12.20
04-Jun-92	0.12	1.11	0.476	0.452	-0.626	-0.625	200.00	-8.33
05-Jun-92	0.12	1.1	0.473	0.45	-0.629	-0.627	191.67	-16.67
06-Jun-92	0.27	1.15	0.515	0.461	-0.638	-0.634	200.00	-14.81
07-Jun-92	0.09	1.03	0.413	0.376	-0.625	-0.624	411.11	-11.11
08-Jun-92	0.16	1.1	0.469	0.425	-0.622	-0.62	275.00	-12.50
09-Jun-92	0.33	1.18	0.485	0.441	-0.664	-0.662	133.33	-6.06
10-Jun-92	0.51	1.24	0.501	0.458	-0.707	-0.705	84.31	-3.92
11-Jun-92	0.68	1.35	0.517	0.41	-0.75	-0.747	157.35	-4.41
12-Jun-92	0.43	1.12	0.411	-0.149	-0.713	-0.706	1302.33	-16.28
13-Jun-92	0.46	1.05	0.433	-0.118	-0.622	-0.619	1197.83	-6.52
14-Jun-92	0.46	1.05	0.433	-0.118	-0.622	-0.619	1197.83	-6.52
15-Jun-92	0.54	1.06	0.444	-0.152	-0.624	-0.615	1103.70	-16.67
16-Jun-92	0.18	1.12	0.499	0.333	-0.623	-0.615	922.22	-44.44
17-Jun-92	1.05	1.16	0.517	0.437	-0.61	-0.607	76.19	-2.86
18-Jun-92	0.17	1.04	0.425	0.345	-0.615	-0.612	470.59	-17.65
19-Jun-92	0.14	1.05	0.43	0.356	-0.615	-0.613	528.57	-14.29
20-Jun-92	0.24	1.05	0.425	0.28	-0.61	-0.606	604.17	-16.67
21-Jun-92	0.1	1.04	0.467	0.432	-0.581	-0.58	350.00	-10.00
22-Jun-92	0.1	1.08	0.51	0.483	-0.572	-0.571	270.00	-10.00
23-Jun-92	0.08	1.04	0.425	0.395	-0.607	-0.606	375.00	-12.50
24-Jun-92	0.07	1.03	0.423	0.396	-0.607	-0.606	385.71	-14.29
25-Jun-92	0.06	1.03	0.423	0.396	-0.607	-0.606	450.00	-16.67
26-Jun-92	0.09	1.02	0.42	0.392	-0.611	-0.61	311.11	-11.11
27-Jun-92	0.12	1	0.417	0.355	-0.581	-0.58	516.67	-8.33
28-Jun-92	0.09	1	0.396	0.351	-0.604	-0.603	500.00	-11.11
29-Jun-92	0.07	1	0.394	0.355	-0.605	-0.604	557.14	-14.29
30-Jun-92	0.07	1	0.396	0.365	-0.604	-0.603	442.86	-14.29
01-Jul-92	0.08	1	0.394	0.388	-0.606	-0.605	75.00	-12.50
02-Jul-92	0.14	1	0.372	0.22	-0.625	-0.624	1085.71	-7.14
03-Jul-92	0.08	1	0.363	0.304	-0.637	-0.636	737.50	-12.50
04-Jul-92	0.05	1	0.355	0.295	-0.646	-0.644	1200.00	-40.00
05-Jul-92	0.07	1	0.36	0.295	-0.64	-0.639	928.57	-14.29
06-Jul-92	0.06	1	0.358	0.322	-0.643	-0.642	600.00	-16.67
07-Jul-92	0.06	1	0.369	0.33	-0.637	-0.636	650.00	-16.67
08-Jul-92	0.07	1	0.369	0.331	-0.636	-0.635	542.86	-14.29
09-Jul-92	0.08	1.02	0.375	0.353	-0.638	-0.637	275.00	-12.50
10-Jul-92	0.08	1.02	0.375	0.353	-0.638	-0.637	275.00	-12.50
11-Jul-92	0.04	1.03	0.41	0.394	-0.621	-0.62	400.00	-25.00
12-Jul-92	0.05	1.02	0.42	0.395	-0.624	-0.623	500.00	-20.00

REVERSED POLARITY
SPECIMEN #1A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	9.8	1.04	1.612	0.65	0.507	0.61	98.16	-10.51
30-May-92	11.44	1.15	1.53	-0.505	0.41	0.55	177.88	-12.24
31-May-92	12.65	1.21	1.65	0.145	0.588	0.647	118.97	-4.68
01-Jun-92	16.2	1.29	1.99	0.23	0.633	0.735	108.64	-6.30
02-Jun-92	10.45	1.07	1.54	0.307	0.384	0.546	117.99	-15.50
03-Jun-92	10.83	1.16	1.73	0.254	0.462	0.595	136.29	-12.28
04-Jun-92	9.15	1.05	1.61	0.283	0.486	0.571	145.03	-9.29
05-Jun-92	8.95	1.04	1.58	0.277	0.487	0.571	145.59	-9.39
06-Jun-92	9.24	1.04	1.62	0.282	0.475	0.559	144.81	-9.09
07-Jun-92	8.45	0.988	1.55	0.282	0.507	0.575	150.06	-8.05
08-Jun-92	8.7	1.05	1.61	0.257	0.485	0.566	155.52	-9.31
09-Jun-92	9.2	1.14	1.61	0.26	0.493	0.577	146.74	-9.13
10-Jun-92	9.7	1.23	1.62	0.291	0.502	0.588	137.01	-8.87
11-Jun-92	10.22	1.32	1.63	0.335	0.511	0.601	126.71	-8.81
12-Jun-92	8.63	1.08	1.64	0.363	0.52	0.611	147.97	-10.54
13-Jun-92	7.64	1.01	1.56	0.352	0.483	0.557	158.12	-9.69
14-Jun-92	7.64	1.01	1.56	0.352	0.483	0.557	158.12	-9.69
15-Jun-92	7.82	1.02	1.57	0.363	0.478	0.549	154.35	-9.08
16-Jun-92	7.52	1.07	1.59	0.316	0.437	0.573	169.41	-18.09
17-Jun-92	6.72	1.15	1.56	0.339	0.425	0.545	181.70	-17.86
18-Jun-92	7.29	0.996	1.55	0.324	0.475	0.555	168.18	-10.97
19-Jun-92	7.15	1	1.53	0.351	0.473	0.584	164.90	-15.52
20-Jun-92	7.48	1	1.55	0.314	0.481	0.57	165.24	-11.90
21-Jun-92	7.4	1	1.53	0.278	0.449	0.534	169.46	-11.49
22-Jun-92	7.15	1.04	1.5	0.211	0.406	0.522	180.28	-16.22
23-Jun-92	6.7	0.992	1.53	0.294	0.461	0.549	184.48	-13.13
24-Jun-92	6.47	0.993	1.53	0.305	0.454	0.554	189.34	-15.46
25-Jun-92	6.45	0.992	1.52	0.303	0.453	0.556	188.68	-15.97
26-Jun-92	6.18	0.956	1.47	0.294	0.446	0.568	190.29	-19.74
27-Jun-92	6.5	0.962	1.42	0.256	0.439	0.551	179.08	-17.23
28-Jun-92	6.44	0.961	1.49	0.312	0.465	0.544	182.92	-12.27
29-Jun-92	6.12	0.965	1.52	0.302	0.471	0.547	199.02	-12.42
30-Jun-92	6.35	0.964	1.46	0.29	0.445	0.525	184.25	-12.60
01-Jul-92	6.1	0.961	1.47	0.301	0.452	0.528	191.64	-12.46
02-Jul-92	6.42	0.963	1.52	0.332	0.515	0.598	185.05	-12.93
03-Jul-92	6.55	0.963	1.55	0.337	0.535	0.605	185.19	-10.69
04-Jul-92	6.5	0.962	1.54	0.34	0.54	0.616	184.62	-11.69
05-Jul-92	6.51	0.963	1.55	0.345	0.53	0.605	185.10	-11.52
06-Jul-92	6.35	0.963	1.55	0.332	0.523	0.603	191.81	-12.60
07-Jul-92	6.5	0.966	1.56	0.294	0.515	0.595	194.77	-12.31
08-Jul-92	6.7	0.965	1.56	0.296	0.506	0.596	188.66	-13.43
09-Jul-92	5.27	0.966	1.57	0.665	0.514	0.588	171.73	-14.04
10-Jul-92	5.27	0.966	1.57	0.665	0.514	0.588	171.73	-14.04
11-Jul-92	6.41	0.968	1.51	0.306	0.473	0.567	187.83	-14.66
12-Jul-92	6.41	0.968	1.51	0.306	0.473	0.567	187.83	-14.66

NORMAL POLARITY
SPECIMEN #1B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 15/16 IN - 49.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
0.86	1.3	0.323	0.28	-0.66	-0.659	50.00	-1.16
0.6	1.23	0.57	0.5	-0.617	-0.603	116.67	-23.33
0.22	1.45	0.59	0.507	-0.885	-0.884	377.27	-4.55
0.22	1.45	0.59	0.507	-0.885	-0.884	377.27	-4.55
0.2	1.37	0.597	0.509	-0.773	-0.769	440.00	-20.00
0.18	1.21	0.605	0.512	-0.661	-0.655	516.67	-33.33
0.11	1.11	0.512	0.495	-0.584	-0.583	154.55	-9.09
0.07	1.1	0.507	0.488	-0.594	-0.593	271.43	-14.29
0.11	1.15	0.654	0.517	-0.623	-0.619	1245.45	-36.36
0.02	1.02	0.451	0.442	-0.587	-0.588	450.00	50.00
0.25	1.15	0.563	0.521	-0.585	-0.583	168.00	-8.00
0.35	1.2	0.573	0.523	-0.591	-0.588	142.86	-8.57
0.45	1.25	0.583	0.525	-0.598	-0.593	128.89	-11.11
0.55	1.32	0.593	0.526	-0.703	-0.699	121.82	-7.27
0.03	1.03	0.45	0.444	-0.582	-0.583	200.00	33.33
0.03	1.05	0.478	0.473	-0.58	-0.579	166.67	-33.33
0.03	1.05	0.478	0.473	-0.58	-0.579	166.67	-33.33
0.5	1.06	0.494	0.484	-0.579	-0.58	20.00	2.00
2.93	1.04	0.307	-0.763	-0.804	-0.724	365.19	-27.30
0.17	1.14	0.438	0.013	-0.689	-0.688	2500.00	-5.88
0.11	1.04	0.421	0.364	-0.616	-0.613	518.18	-27.27
0.11	1.05	0.473	0.457	-0.575	-0.574	145.45	-9.09
0.08	1.05	0.467	0.454	-0.582	-0.581	162.50	-12.50
0.08	1.15	0.462	0.448	-0.587	-0.588	175.00	12.50
0.32	1.03	0.499	0.486	-0.571	-0.57	40.63	-3.13
0.06	1.03	0.44	0.433	-0.585	-0.584	116.67	-16.67
0.04	1.03	0.44	0.432	-0.586	-0.585	200.00	-25.00
0.04	1.03	0.44	0.432	-0.586	-0.585	200.00	-25.00
0.04	0.999	0.455	0.449	-0.576	-0.575	150.00	-25.00
0.05	0.999	0.455	0.449	-0.547	-0.546	120.00	-20.00
0.05	0.999	0.437	0.428	-0.565	-0.564	180.00	-20.00
0.04	1	0.434	0.425	-0.568	-0.567	225.00	-25.00
0.06	1	0.431	0.424	-0.573	-0.572	116.67	-16.67
0.06	1	0.428	0.422	-0.573	-0.574	100.00	16.67
0.03	1	0.428	0.421	-0.575	-0.576	233.33	33.33
0.04	1	0.427	0.42	-0.577	-0.576	175.00	-25.00
0.04	1	0.429	0.418	-0.574	-0.573	275.00	-25.00
0.04	1	0.431	0.422	-0.573	-0.572	225.00	-25.00
0.05	1	0.428	0.419	-0.577	-0.576	180.00	-20.00
0.06	1	0.433	0.422	-0.575	-0.574	183.33	-16.67
0.06	1	0.434	0.426	-0.576	-0.575	133.33	-16.67
0.03	1	0.45	0.443	-0.576	-0.575	233.33	-33.33
0.04	1.02	0.463	0.455	-0.575	-0.574	200.00	-25.00
0.04	1.01	0.463	0.455	-0.575	-0.574	200.00	-25.00
0.04	1.01	0.463	0.455	-0.575	-0.574	200.00	-25.00

REVERSED POLARITY
SPECIMEN #1B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 15/16 IN - 49.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	7	1.01	0.253	0.13	0.295	0.235	17.57	8.57
30-May-92	11.98	1.15	1.55	0.26	0.36	0.47	107.68	-9.18
31-May-92	17.63	1.35	1.84	0.105	0.547	0.708	98.41	-9.13
01-Jun-92	17.63	1.35	1.84	0.105	0.547	0.708	98.41	-9.13
02-Jun-92	10.88	1.16	1.7	0.245	0.418	0.574	133.73	-14.34
03-Jun-92	10.88	1.16	1.7	0.245	0.418	0.574	133.73	-14.34
04-Jun-92	9.47	1.05	1.56	0.201	0.446	0.528	143.51	-8.66
05-Jun-92	8.93	1.05	1.51	0.244	0.42	0.551	141.77	-14.67
06-Jun-92	9.75	1.11	1.64	0.199	0.422	0.528	147.79	-10.87
07-Jun-92	8.03	0.982	1.46	0.232	0.427	0.552	152.93	-15.57
08-Jun-92	9.46	1.09	1.62	0.193	0.446	0.535	150.85	-9.41
09-Jun-92	10.1	1.12	1.72	0.172	0.475	0.583	153.27	-10.69
10-Jun-92	10.74	1.18	1.82	0.152	0.505	0.632	155.31	-11.82
11-Jun-92	11.38	1.26	1.92	0.132	0.535	0.68	157.12	-12.74
12-Jun-92	7.42	0.982	1.52	0.226	0.463	0.535	174.39	-9.70
13-Jun-92	7.26	1.01	1.49	0.171	0.416	0.54	181.68	-17.08
14-Jun-92	7.26	1.01	1.49	0.171	0.416	0.54	181.68	-17.08
15-Jun-92	6.58	1.04	1.47	0.288	0.446	0.565	179.64	-18.09
16-Jun-92	9.7	1.01	1.79	0.865	0.68	0.731	95.36	-5.26
17-Jun-92	8.91	1.1	1.65	0.452	0.524	0.647	134.46	-13.80
18-Jun-92	8.48	0.989	1.58	0.373	0.493	0.538	142.33	-5.31
19-Jun-92	8.34	0.995	1.52	0.322	0.447	0.503	143.65	-6.71
20-Jun-92	7.13	0.993	1.511	0.394	0.464	0.521	156.66	-7.99
21-Jun-92	7.27	1	1.56	0.361	0.465	0.525	163.55	-8.25
22-Jun-92	8.72	1.09	1.55	0.252	0.426	0.496	148.85	-8.03
23-Jun-92	7.62	0.985	1.52	0.295	0.461	0.524	160.76	-8.27
24-Jun-92	6.72	0.99	1.51	0.352	0.454	0.518	172.32	-9.52
25-Jun-92	6.72	0.99	1.51	0.352	0.454	0.518	172.32	-9.52
26-Jun-92	7.15	0.988	1.49	0.355	0.448	0.52	158.74	-10.07
27-Jun-92	7	0.985	1.43	0.29	0.41	0.477	162.86	-9.57
28-Jun-92	7.4	0.955	1.47	0.276	0.435	0.503	161.35	-9.19
29-Jun-92	7.06	0.958	1.47	0.302	0.446	0.516	165.44	-9.92
30-Jun-92	7.02	0.958	1.51	0.281	0.453	0.519	175.07	-9.40
01-Jul-92	6.82	0.961	1.49	0.336	0.447	0.517	169.21	-10.26
02-Jul-92	6.4	0.963	1.47	0.34	0.456	0.519	176.56	-9.84
03-Jul-92	6.58	0.962	1.46	0.349	0.461	0.525	171.88	-9.73
04-Jul-92	6.4	0.963	1.48	0.362	0.452	0.525	174.69	-11.41
05-Jul-92	6.43	0.962	1.48	0.373	0.46	0.518	172.16	-9.02
06-Jul-92	6.3	0.964	1.47	0.371	0.462	0.519	174.44	-9.05
07-Jul-92	6.52	0.965	1.48	0.365	0.457	0.515	171.01	-8.90
08-Jul-92	6.6	0.968	1.47	0.365	0.455	0.523	167.42	-10.30
09-Jul-92	6.68	0.985	1.47	0.35	0.446	0.517	167.66	-10.63
10-Jul-92	6.99	0.99	1.47	0.345	0.444	0.512	160.94	-9.73
11-Jul-92	7.04	0.994	1.48	0.33	0.442	0.508	163.35	-9.38
12-Jul-92	7.24	1	1.49	0.326	0.44	0.504	160.77	-8.84

NORMAL POLARITY
SPECIMEN #1C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 11/16 IN - 42.9mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	0.88	1.3	0.276	0.3	-0.615	-0.615	-27.27	0.00
30-May-92	0.35	1.24	0.51	0.47	-0.58	-0.58	114.29	0.00
31-May-92	0.53	1.38	0.421	0.443	-0.823	-0.825	-41.51	3.77
01-Jun-92	0.53	1.38	0.421	0.443	-0.823	-0.825	-41.51	3.77
02-Jun-92	0.4	1.33	0.497	0.458	-0.739	-0.735	97.50	-10.00
03-Jun-92	0.26	1.28	0.573	0.474	-0.651	-0.645	380.77	-23.08
04-Jun-92	0.09	1.1	0.489	0.475	-0.55	-0.549	155.56	-11.11
05-Jun-92	0.12	1.1	0.491	0.464	-0.562	-0.561	225.00	-8.33
06-Jun-92	0.23	1.05	0.452	0.407	-0.574	-0.567	195.65	-30.43
07-Jun-92	0.33	1.02	0.424	0.345	-0.585	-0.579	239.39	-18.18
08-Jun-92	0.14	1.11	0.508	0.495	-0.589	-0.588	92.86	-7.14
09-Jun-92	0.15	1.09	0.46	0.478	-0.621	-0.622	-120.00	6.67
10-Jun-92	0.17	1.07	0.412	0.461	-0.653	-0.656	-288.24	17.65
11-Jun-92	0.18	1.06	0.365	0.444	-0.685	-0.691	-438.89	33.33
12-Jun-92	0.12	1.05	0.43	0.407	-0.607	-0.605	191.67	-16.67
13-Jun-92	0.05	1.06	0.453	0.447	-0.605	-0.604	120.00	-20.00
14-Jun-92	0.05	1.06	0.453	0.447	-0.605	-0.604	120.00	-20.00
15-Jun-92	0.05	1.07	0.466	0.461	-0.606	-0.605	100.00	-20.00
16-Jun-92	0.1	1.07	0.509	0.494	-0.613	-0.611	150.00	-20.00
17-Jun-92	0.24	1.15	0.542	0.505	-0.615	-0.614	154.17	-4.17
18-Jun-92	0.04	1.03	0.438	0.428	-0.603	-0.602	250.00	-25.00
19-Jun-92	0.04	1.04	0.44	0.434	-0.604	-0.605	150.00	25.00
20-Jun-92	0.04	1.04	0.428	0.425	-0.615	-0.616	75.00	25.00
21-Jun-92	0.05	1.05	0.445	0.44	-0.604	-0.605	100.00	20.00
22-Jun-92	0.09	1.03	0.531	0.484	-0.616	-0.609	522.22	-77.78
23-Jun-92	0.05	1.03	0.425	0.414	-0.602	-0,601	220.00	-20.00
24-Jun-92	0.05	1.03	0.425	0.418	-0.603	-0.602	140.00	-20.00
25-Jun-92	0.05	1.03	0.426	0.419	-0.603	-0.602	140.00	-20.00
26-Jun-92	0.08	1.02	0.426	0.412	-0.604	-0.603	175.00	-12.50
27-Jun-92	1.14	0.993	0.41	0.397	-0.591	-0.59	11.40	-0.88
28-Jun-92	0.03	0.999	0.404	0.397	-0.595	-0.596	233.33	33.33
29-Jun-92	0.04	1	0.402	0.396	-0.598	-0.599	150.00	25.00
30-Jun-92	0.03	1	0.403	0.395	-0.599	-0.6	266.67	33.33
01-Jul-92	0.03	1	0.401	0.394	-0.599	-0.6	233.33	33.33
02-Jul-92	0.03	1	0.404	0.397	-0.596	-0.597	233.33	33.33
03-Jul-92	0.03	1	0.404	0.397	-0.595	-0.596	233.33	33.33
04-Jul-92	0.03	1	0.411	0.403	-0.592	-0.593	266.67	33.33
05-Jul-92	0.03	1	0.408	0.402	-0.593	-0.594	200.00	33.33
06-Jul-92	0.03	1	0.407	0.403	-0.593	-0.594	133.33	33.33
07-Jul-92	0.03	1	0.41	0.404	-0.595	-0.596	200.00	33.33
08-Jul-92	0.03	1	0.413	0.406	-0.593	-0.594	233.33	33.33
09-Jul-92	0.06	1.02	0.427	0.421	-0.596	-0.597	100.00	16.67
10-Jul-92	0.03	1	0.427	0.421	-0.596	-0.597	200.00	33.33
11-Jul-92	0.03	1	0.427	0.422	-0.596	-0.598	166.67	66.67
12-Jul-92	0.03	1.05	0.427	0.423	-0.597	-0.598	133.33	33.33

REVERSED POLARITY
SPECIMEN #1C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 11/16 IN - 42.9mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	11.08	1.07	1.5	0.25	0.52	0.566	112.82	-4.15
30-May-92	11.3	1.14	1.42	0.248	0.355	0.49	103.72	-11.95
31-May-92	11.5	1.16	1.38	0.225	0.41	0.56	100.43	-13.04
01-Jun-92	12.88	1.17	1.24	0.185	0.446	0.635	81.91	-14.67
02-Jun-92	12.5	1.17	1.45	0.163	0.446	0.595	102.96	-11.92
03-Jun-92	12.3	1.18	1.71	0.151	0.447	0.556	126.75	-8.86
04-Jun-92	9.61	1.03	1.46	0.122	0.406	0.501	139.23	-9.89
05-Jun-92	8.51	1.04	1.51	0.221	0.44	0.509	151.47	-8.11
06-Jun-92	7.14	1.15	1.54	0.923	0.395	0.528	86.41	-18.63
07-Jun-92	8.47	0.982	1.41	0.345	0.394	0.532	125.74	-16.29
08-Jun-92	8.42	1.05	1.48	0.308	0.384	0.549	139.19	-19.60
09-Jun-92	8.68	1.04	1.51	0.267	0.404	0.55	143.20	-16.82
10-Jun-92	8.94	1.02	1.53	0.197	0.425	0.551	149.11	-14.09
11-Jun-92	9.21	1.01	1.57	0.127	0.446	0.552	156.68	-11.51
12-Jun-92	8.46	1	1.51	0.118	0.449	0.547	164.54	-11.58
13-Jun-92	7.93	1	1.53	0.255	0.475	0.559	160.78	-10.59
14-Jun-92	7.93	1	1.53	0.255	0.475	0.559	160.78	-10.59
15-Jun-92	7.61	1.02	1.56	0.276	0.478	0.564	168.73	-11.56
16-Jun-92	7.93	1.08	1.57	0.253	0.467	0.557	166.08	-11.35
17-Jun-92	7.89	1.11	1.59	0.138	0.45	0.568	184.03	-14.96
18-Jun-92	7.45	0.986	1.53	0.251	0.475	0.582	171.68	-14.36
19-Jun-92	7.06	0.984	1.25	0.284	0.537	0.568	136.83	-4.39
20-Jun-92	7.44	1	1.51	0.268	0.468	0.572	166.94	-13.98
21-Jun-92	7.24	1	1.49	0.291	0.457	0.545	165.61	-12.15
22-Jun-92	7.47	0.936	1.47	0.17	0.445	0.557	174.03	-14.99
23-Jun-92	6.13	0.925	1.51	0.285	0.456	0.562	199.84	-17.29
24-Jun-92	5.42	0.971	1.51	0.33	0.451	0.545	217.71	-17.34
25-Jun-92	5.42	0.971	1.49	0.327	0.45	0.546	214.58	-17.71
26-Jun-92	5.7	1.02	1.46	0.373	0.424	0.522	190.70	-17.19
27-Jun-92	6.45	0.958	1.46	0.285	0.478	0.553	182.17	-11.63
28-Jun-92	6.22	0.962	1.46	0.304	0.455	0.536	185.85	-13.02
29-Jun-92	6.52	0.959	1.41	0.258	0.471	0.548	176.69	-11.81
30-Jun-92	6.41	0.955	1.47	0.274	0.46	0.538	186.58	-12.17
01-Jul-92	6.01	0.957	1.45	0.324	0.452	0.531	187.35	-13.14
02-Jul-92	5.7	0.911	1.46	0.309	0.455	0.546	201.93	-15.96
03-Jul-92	5.84	0.946	1.45	0.317	0.452	0.548	194.01	-16.44
04-Jul-92	5.89	0.965	1.45	0.337	0.44	0.54	188.96	-16.98
05-Jul-92	6	0.962	1.45	0.29	0.448	0.544	193.33	-16.00
06-Jul-92	5.8	0.963	1.45	0.312	0.455	0.55	196.21	-16.38
07-Jul-92	5.41	0.923	1.45	0.341	0.443	0.535	204.99	-17.01
08-Jul-92	5.72	0.952	1.44	0.335	0.481	0.545	193.18	-11.19
09-Jul-92	6.12	0.983	1.46	0.305	0.447	0.542	188.73	-15.52
10-Jul-92	6.18	0.989	1.46	0.295	0.448	0.556	191.75	-17.48
11-Jul-92	6.22	0.996	1.5	0.281	0.45	0.67	195.98	-35.37
12-Jul-92	6.27	1.01	1.52	0.272	0.45	0.673	199.04	-35.57

NORMAL POLARITY
SPECIMEN #1D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 7/16 IN - 36.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	0.97	1.3	0.062	0.056	-0.05	-0.045	6.19	-5.15
30-May-92	0.86	1.22	0.011	0.007	-0.052	-0.051	4.65	-1.16
31-May-92	0.86	1.22	0.011	0.007	-0.052	-0.051	4.65	-1.16
01-Jun-92	0.99	1.52	0.016	0.01	-0.076	-0.076	6.06	0.00
02-Jun-92	0.97	1.52	0.066	0.01	-0.105	-0.102	57.73	-3.09
03-Jun-92	0.06	1.18	0.011	0.009	-0.074	-0.075	33.33	16.67
04-Jun-92	0.08	1.11	0.008	0.007	-0.071	-0.073	12.50	25.00
05-Jun-92	0.13	1.11	0.008	0.006	-0.073	-0.079	15.38	46.15
06-Jun-92	0.37	1.19	0.113	0.026	-0.871	-0.872	235.14	2.70
07-Jun-92	0.06	1.03	0.001	-0.014	-0.844	-0.852	250.00	133.33
08-Jun-92	0.17	1.13	0.086	0.04	-0.865	-0.872	270.59	41.18
09-Jun-92	0.11	1.11	0.045	0.012	-0.899	-0.871	300.00	-254.55
10-Jun-92	0.06	1.07	0.012	-0.022	-0.933	-0.869	566.67	-1066.67
11-Jun-92	0.01	1.04	-0.051	-0.057	-0.967	-0.867	600.00	-10000.00
12-Jun-92	0.07	1.08	0.047	0.024	-0.855	-0.865	328.57	142.86
13-Jun-92	0.06	1.08	0.026	0.006	-0.845	-0.859	333.33	233.33
14-Jun-92	0.06	1.06	0.026	0.006	-0.845	-0.854	333.33	150.00
15-Jun-92	0.1	1.07	0.043	-0.023	-0.843	-0.849	660.00	60.00
16-Jun-92	0.18	1.04	0.069	0.031	-0.855	-0.841	211.11	-77.78
17-Jun-92	0.65	1.02	0.137	0.152	-0.89	-0.884	-23.08	-9.23
18-Jun-92	0.06	1.03	0.008	-0.028	-0.867	-0.885	600.00	300.00
19-Jun-92	0.43	1.04	0.055	-0.533	-0.816	-0.814	1367.44	-4.65
20-Jun-92	0.27	1.05	0.017	-0.064	-0.859	-0.865	300.00	22.22
21-Jun-92	0.11	1.05	0.024	-0.112	-0.728	-0.732	1236.36	36.36
22-Jun-92	0.73	1.03	0.143	0.047	-0.828	-0.822	131.51	-8.22
23-Jun-92	0.08	1.03	0.085	-0.078	-0.811	-0.805	2037.50	-75.00
24-Jun-92	0.01	1.01	0.002	-0.023	-0.864	-0.851	2500.00	-1300.00
25-Jun-92	0.01	1.01	0.002	-0.023	-0.863	-0.851	2500.00	-1200.00
26-Jun-92	0.5	0.995	-0.121	-0.223	-1.04	-1.06	204.00	40.00
27-Jun-92	0.13	1	-0.013	-0.065	-0.834	-0.835	400.00	7.69
28-Jun-92	0.25	0.998	-0.019	-0.066	-0.77	-0.769	188.00	-4.00
29-Jun-92	0.05	1.01	-0.025	-0.099	-0.86	-0.859	1480.00	-20.00
30-Jun-92	0.14	0.995	-0.022	-0.047	-0.844	-0.843	178.57	-7.14
01-Jul-92	0.07	1	-0.024	-0.045	-0.846	-0.847	300.00	14.29
02-Jul-92	1.03	0.994	-0.023	-0.057	-0.844	-0.845	33.01	0.97
03-Jul-92	0.07	1	-0.027	-0.115	-0.85	-0.852	1257.14	28.57
04-Jul-92	0.1	1	-0.027	-0.125	-0.845	-0.848	980.00	30.00
05-Jul-92	0.03	0.975	-0.025	-0.073	-0.852	-0.857	1600.00	166.67
06-Jul-92	0.17	1	-0.029	-0.148	-0.844	-0.845	700.00	5.88
07-Jul-92	0.12	1	-0.022	-0.169	-0.874	-0.876	1225.00	16.67
08-Jul-92	0.14	1	-0.024	-0.16	-0.886	-0.89	971.43	28.57
09-Jul-92	0.26	1.03	-0.007	-0.066	-0.872	-0.876	226.92	15.38
10-Jul-92	0.26	1.03	-0.007	-0.066	-0.872	-0.876	226.92	15.38
11-Jul-92	0.42	1.03	-0.012	-0.078	-0.859	-0.864	157.14	11.90
12-Jul-92	1.8	1.04	-0.028	-0.55	-0.856	-0.86	290.00	2.22

REVERSED POLARITY
SPECIMEN #1D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 7/16 IN - 36.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	12.4	1.06	0.66	0.74	0.74	0.725	-6.45	1.21
30-May-92	12.4	1.1	0.01	0.004	0.004	0.005	0.48	-0.08
31-May-92	13.5	1.25	0.12	0.025	0.042	0.055	7.04	-0.96
01-Jun-92	13.5	1.42	0.146	0.036	0.054	0.065	8.15	-0.81
02-Jun-92	11.68	1.26	0.141	0.052	0.054	0.062	7.62	-0.68
03-Jun-92	9.87	1.1	0.136	0.047	0.054	0.06	9.02	-0.61
04-Jun-92	9.67	1.04	0.134	0.045	0.058	0.001	9.20	5.89
05-Jun-92	9.17	1.05	0.143	0.056	0.058	0.066	9.49	-0.87
06-Jun-92	10.38	1.13	1.85	0.472	0.686	0.815	132.76	-12.43
07-Jun-92	8.75	0.981	1.72	0.494	0.721	0.788	140.11	-7.66
08-Jun-92	8.56	0.99	1.69	0.407	0.68	0.79	149.88	-12.85
09-Jun-92	8.64	1	1.76	0.407	0.72	0.788	156.60	-7.87
10-Jun-92	8.72	1.01	1.83	0.407	0.761	0.786	163.19	-2.87
11-Jun-92	8.8	1.02	1.9	0.407	0.804	0.784	169.66	2.27
12-Jun-92	7.76	1.04	1.77	0.412	0.706	0.776	175.00	-9.02
13-Jun-92	7.66	1.01	1.76	0.502	0.726	0.782	164.23	-7.31
14-Jun-92	7.66	1.01	1.76	0.502	0.726	0.782	164.23	-7.31
15-Jun-92	7.33	1.02	1.72	0.504	0.693	0.765	165.89	-9.82
16-Jun-92	7.71	1.04	1.76	0.553	0.668	0.757	156.55	-11.54
17-Jun-92	6.51	1	1.67	-0.155	0.646	0.875	280.34	-35.18
18-Jun-92	7.08	0.998	1.73	0.532	0.717	0.765	169.21	-9.60
19-Jun-92	6.78	0.999	1.7	0.554	0.695	0.808	169.03	-16.67
20-Jun-92	7.34	1.01	1.73	0.507	0.714	0.775	166.62	-8.31
21-Jun-92	6.04	1.02	1.73	0.603	0.674	0.751	186.59	-12.75
22-Jun-92	6.72	0.995	1.75	0.475	0.705	0.818	189.73	-16.82
23-Jun-92	6.8	0.992	1.72	0.508	0.695	0.767	178.24	-10.59
24-Jun-92	6.34	0.994	1.71	0.521	0.693	0.775	187.54	-12.93
25-Jun-92	6.34	0.994	1.71	0.521	0.693	0.775	187.54	-12.93
26-Jun-92	8.12	0.954	1.78	0.383	0.845	0.928	172.04	-10.22
27-Jun-92	6.63	0.957	1.55	0.54	0.642	0.74	152.34	-14.78
28-Jun-92	6.58	0.962	1.62	0.584	0.719	0.772	157.45	-8.05
29-Jun-92	6.4	0.963	1.7	0.506	0.712	0.785	186.56	-11.41
30-Jun-92	6.61	0.962	1.7	0.565	0.717	0.774	171.71	-8.62
01-Jul-92	6.49	0.964	1.65	0.545	0.704	0.759	170.26	-8.47
02-Jul-92	5.72	0.968	1.35	0.6	0.756	0.798	131.12	-7.34
03-Jul-92	6.23	0.965	1.64	0.45	0.684	0.765	191.01	-13.00
04-Jul-92	6.18	0.964	1.66	0.42	0.7	0.769	200.65	-11.17
05-Jul-92	5.9	0.965	1.64	0.585	0.691	0.765	178.81	-12.54
06-Jul-92	5.77	0.968	1.61	0.748	0.675	0.716	149.39	-7.11
07-Jul-92	5.85	0.972	1.71	0.632	0.753	0.793	184.27	-6.84
08-Jul-92	5.75	0.972	1.66	0.602	0.692	0.777	184.00	-14.78
09-Jul-92	6.41	0.996	1.66	0.779	0.74	0.842	137.44	-15.91
10-Jul-92	6.04	0.998	1.51	0.805	0.748	0.837	116.72	-14.74
11-Jul-92	5.73	0.999	1.42	0.832	0.753	0.832	102.62	-13.79
12-Jul-92	5.57	1.03	1.35	0.851	0.765	0.827	89.59	-11.13

NORMAL POLARITY
SPECIMEN #1E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	0.1	1.09	0.366	0.377	-0.675	-0.674	-110.00	-10.00
30-May-92	0.72	1.23	0.607	0.52	-0.616	-0.61	120.83	-8.33
31-May-92	0.67	1.35	0.652	0.533	-0.625	-0.612	177.61	-19.40
01-Jun-92	0.63	1.52	0.739	0.544	-0.637	-0.628	309.52	-14.29
02-Jun-92	0.33	1.31	0.581	0.49	-0.649	-0.644	275.76	-15.15
03-Jun-92	0.03	1.09	0.416	0.436	-0.674	-0.676	-666.67	66.67
04-Jun-92	0.11	1.1	0.522	0.504	-0.583	-0.582	163.64	-9.09
05-Jun-92	0.13	1.11	0.525	0.495	-0.592	-0.591	230.77	-7.69
06-Jun-92	0.03	1.04	0.425	0.451	-0.613	-0.614	-866.67	33.33
07-Jun-92	0.07	1.03	0.447	0.428	-0.585	-0.584	271.43	-14.29
08-Jun-92	0.18	1.04	0.462	0.383	-0.586	-0.585	438.89	-5.56
09-Jun-92	0.14	1.07	0.455	0.395	-0.615	-0.611	428.57	-28.57
10-Jun-92	0.1	1.09	0.451	0.407	-0.645	-0.639	440.00	-60.00
11-Jun-92	0.05	1.12	0.447	0.431	-0.675	-0.676	320.00	20.00
12-Jun-92	0.08	1.09	0.507	0.495	-0.578	-0.58	150.00	25.00
13-Jun-92	0.13	1.05	0.473	0.405	-0.584	-0.583	523.08	-7.69
14-Jun-92	0.13	1.05	0.473	0.405	-0.584	-0.583	523.08	-7.69
15-Jun-92	0.12	1.07	0.49	0.4	-0.584	-0.582	750.00	-16.67
16-Jun-92	0.23	1.04	0.538	0.466	-0.584	-0.581	313.04	-13.04
17-Jun-92	0.82	1.02	0.432	-0.163	-0.604	-0.597	725.61	-8.54
18-Jun-92	0.81	1.03	0.351	-0.271	-0.681	-0.675	767.90	-7.41
19-Jun-92	0.67	1.04	0.371	-0.299	-0.661	-0.65	1000.00	-16.42
20-Jun-92	0.74	1.03	0.376	-0.29	-0.651	-0.64	900.00	-14.86
21-Jun-92	1.4	1	0.368	-0.312	-0.653	-0.644	485.71	-6.43
22-Jun-92	0.61	1.03	0.389	-0.255	-0.62	-0.608	1055.74	-19.67
23-Jun-92	0.63	1.02	0.409	-0.265	-0.602	-0.592	1069.84	-15.87
24-Jun-92	0.61	1.03	0.356	-0.29	-0.655	-0.648	1059.02	-11.48
25-Jun-92	0.61	1.03	0.356	-0.29	-0.655	-0.648	1059.02	-11.48
26-Jun-92	0.54	0.998	0.126	-0.182	-0.852	-0.85	570.37	-3.70
27-Jun-92	1.08	0.994	0.279	-0.29	-0.704	-0.693	526.85	-10.19
28-Jun-92	1.14	0.994	0.223	-0.295	-0.766	-0.756	454.39	-8.77
29-Jun-92	1	0.995	0.185	-0.286	-0.809	-0.803	471.00	-6.00
30-Jun-92	1.4	0.993	0.15	-0.332	-0.845	-0.83	344.29	-10.71
01-Jul-92	1.2	0.995	0.132	-0.336	-0.864	-0.856	390.00	-6.67
02-Jul-92	2.76	0.985	0.092	-0.352	-0.903	-0.895	160.87	-2.90
03-Jul-92	4.66	0.974	0.058	-0.379	-0.932	-0.923	93.78	-1.93
04-Jul-92	6.93	0.959	0.028	-0.397	-0.956	-0.943	61.33	-1.88
05-Jul-92	1.52	0.993	0.019	-0.401	-0.972	-0.959	276.32	-8.55
06-Jul-92	5	0.875	0.008	-0.408	-0.976	-0.968	83.20	-1.60
07-Jul-92	1.71	0.996	-0.026	-0.417	-1.02	-1	228.65	-11.70
08-Jul-92	1.86	0.995	-0.044	-0.436	-1.02	-1	210.75	-10.75
09-Jul-92	3.8	1	-0.035	-0.439	-1.02	-1.01	106.32	-2.63
10-Jul-92	3.78	1	-0.046	-0.447	-1.03	-1.01	106.08	-5.29
11-Jul-92	3.77	1.01	-0.056	-0.456	-1.05	-1.02	106.10	-7.96
12-Jul-92	3.77	1.03	-0.067	-0.463	-1.08	-1.03	105.04	-13.26

REVERSED POLARITY
SPECIMEN #1E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	11.25	0.853	1.65	0.1	0.5	0.665	137.78	-14.67
30-May-92	13.23	1.03	1.61	0.3	0.41	0.5	99.02	-6.80
31-May-92	13.23	1.03	1.61	0.3	0.41	0.5	99.02	-6.80
01-Jun-92	12.69	1.02	1.61	0.285	0.441	0.532	104.41	-7.17
02-Jun-92	12.15	1.02	1.61	0.271	0.472	0.564	110.21	-7.57
03-Jun-92	11.62	1.02	1.62	0.257	0.503	0.596	117.30	-8.00
04-Jun-92	11.23	1.03	1.55	0.241	0.443	0.542	116.56	-8.82
05-Jun-92	9.61	0.954	1.53	0.175	0.408	0.549	141.00	-14.67
06-Jun-92	10.33	0.982	1.5	0.166	0.446	0.552	129.14	-10.26
07-Jun-92	9.62	0.975	1.5	0.23	0.454	0.555	132.02	-10.50
08-Jun-92	10.55	0.983	1.54	0.187	0.466	0.535	128.25	-6.54
09-Jun-92	10.41	0.991	1.57	0.18	0.484	0.575	133.53	-8.74
10-Jun-92	10.27	0.996	1.62	0.173	0.501	0.625	140.90	-12.07
11-Jun-92	10.13	1.02	1.69	0.166	0.517	0.655	150.44	-13.62
12-Jun-92	9.23	1.03	1.58	0.155	0.475	0.535	154.39	-6.50
13-Jun-92	7.76	0.947	1.55	0.277	0.482	0.541	164.05	-7.60
14-Jun-92	7.76	0.947	1.55	0.277	0.482	0.541	164.05	-7.60
15-Jun-92	8.67	1.01	1.54	0.213	0.469	0.53	153.06	-7.04
16-Jun-92	8.76	1.08	1.61	0.231	0.451	0.539	157.42	-10.05
17-Jun-92	1.44	0.988	1.45	0.295	0.427	0.561	802.08	-93.06
18-Jun-92	8.41	0.991	1.55	0.405	0.457	0.596	136.15	-16.53
19-Jun-92	8.04	0.993	1.51	0.366	0.415	0.523	142.29	-13.43
20-Jun-92	7.49	0.999	1.51	0.377	0.403	0.508	151.27	-14.02
21-Jun-92	6.32	1.01	1.51	0.439	0.412	0.554	169.46	-22.47
22-Jun-92	7.65	0.985	1.48	0.365	0.438	0.509	145.75	-9.28
23-Jun-92	7.4	0.985	1.5	0.344	0.375	0.473	156.22	-13.24
24-Jun-92	7.46	0.986	1.47	0.366	0.395	0.596	147.99	-26.94
25-Jun-92	7.46	0.986	1.47	0.366	0.395	0.596	147.99	-26.94
26-Jun-92	10.11	0.935	1.71	0.247	0.685	0.755	144.71	-6.92
27-Jun-92	8.41	0.937	1.56	0.329	0.502	0.571	146.37	-8.20
28-Jun-92	8.64	0.871	1.62	0.353	0.553	0.598	146.64	-5.21
29-Jun-92	9.52	0.944	1.65	0.363	0.541	0.628	135.19	-9.14
30-Jun-92	9.6	0.944	1.69	0.4	0.643	0.702	134.38	-6.15
01-Jul-92	9.47	0.947	1.68	0.433	0.63	0.696	131.68	-6.97
02-Jul-92	9.33	0.947	1.74	0.468	0.675	0.78	136.33	-11.25
03-Jul-92	13.14	0.924	1.74	0.497	0.662	0.765	94.60	-7.84
04-Jul-92	14.75	0.908	1.76	0.521	0.675	0.745	84.00	-4.75
05-Jul-92	10.02	0.941	1.76	0.475	0.71	0.775	128.24	-6.49
06-Jul-92	13.92	0.915	1.75	0.591	0.686	0.754	83.26	-4.89
07-Jul-92	10.25	0.944	1.77	0.525	0.676	0.745	121.46	-6.73
08-Jul-92	10.54	0.945	1.78	0.728	0.678	0.765	99.81	-8.25
09-Jul-92	10.39	0.974	1.69	0.761	0.773	0.815	89.41	-4.04
10-Jul-92	10.46	0.982	1.72	0.71	0.743	0.791	96.56	-4.59
11-Jul-92	10.52	0.988	1.75	0.602	0.691	0.766	109.13	-7.13
12-Jul-92	10.56	0.991	1.79	0.538	0.651	0.755	118.56	-9.85

NORMAL POLARITY
SPECIMEN #1F
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 1/16 IN - 26.9mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	0.29	1.1	0.109	-0.063	-0.21	-0.207	593.10	-10.34
30-May-92	0.9	1.23	0.186	0.08	-0.209	-0.204	117.78	-5.56
31-May-92	0.9	1.23	0.186	0.08	-0.209	-0.204	117.78	-5.56
01-Jun-92	0.72	1.18	0.175	0.037	-0.217	-0.212	191.67	-6.94
02-Jun-92	0.54	1.13	0.165	-0.012	-0.226	-0.221	327.78	-9.26
03-Jun-92	0.36	1.09	0.155	-0.047	-0.234	-0.23	561.11	-11.11
04-Jun-92	0.88	1.09	0.186	-0.088	-0.215	-0.21	311.36	-5.68
05-Jun-92	0.73	1.11	0.194	-0.067	-0.22	-0.213	357.53	-9.59
06-Jun-92	0.51	1.04	0.165	-0.044	-0.222	-0.218	409.80	-7.84
07-Jun-92	0.58	1.04	0.171	-0.063	-0.228	-0.224	403.45	-6.90
08-Jun-92	0.66	1.04	0.177	-0.078	-0.234	-0.231	386.36	-4.55
09-Jun-92	0.47	1.11	0.128	-0.062	-0.318	-0.312	404.26	-12.77
10-Jun-92	0.28	1.17	0.078	-0.045	-0.401	-0.402	439.29	3.57
11-Jun-92	0.5	1.13	0.201	-0.03	-0.294	-0.291	462.00	-6.00
12-Jun-92	0.48	1.09	-0.001	-0.002	-0.085	-0.064	2.08	-43.75
13-Jun-92	0.84	1.05	0.224	-0.111	-0.279	-0.272	398.81	-8.33
14-Jun-92	0.84	1.05	0.224	-0.111	-0.279	-0.272	398.81	-8.33
15-Jun-92	0.76	1.06	0.236	-0.076	-0.289	-0.285	410.53	-5.26
16-Jun-92	0.41	1.14	0.291	-0.058	-0.285	-0.279	851.22	-14.63
17-Jun-92	0.56	1.03	0.234	-0.087	-0.302	-0.296	573.21	-10.71
18-Jun-92	0.61	1.03	0.262	-0.214	-0.33	-0.328	780.33	-3.28
19-Jun-92	0.81	1.03	0.267	-0.23	-0.339	-0.336	613.58	-3.70
20-Jun-92	0.48	1.04	0.271	-0.258	-0.35	-0.341	1102.08	-18.75
21-Jun-92	0.57	1.05	0.27	-0.048	-0.341	-0.335	557.89	-10.53
22-Jun-92	0.61	1.03	0.262	-0.083	-0.353	-0.347	565.57	-9.84
23-Jun-92	0.51	1.03	0.265	-0.113	-0.385	-0.377	741.18	-15.69
24-Jun-92	0.7	1.03	0.219	-0.179	-0.464	-0.457	568.57	-10.00
25-Jun-92	0.7	1.03	0.219	-0.179	-0.464	-0.457	568.57	-10.00
26-Jun-92	0.64	0.996	0.097	-0.176	-0.739	-0.734	426.56	-7.81
27-Jun-92	0.82	0.995	0.175	-0.317	-0.803	-0.795	600.00	-9.76
28-Jun-92	0.99	0.994	0.138	-0.335	-0.846	-0.839	477.78	-7.07
29-Jun-92	1.09	0.994	0.085	-0.372	-0.895	-0.889	419.27	-5.50
30-Jun-92	1.45	0.993	0.088	-0.387	-0.916	-0.907	327.59	-6.21
01-Jul-92	1.33	0.994	0.063	-0.395	-0.914	-0.904	344.36	-7.52
02-Jul-92	1.22	0.995	0.049	-0.392	-0.935	-0.928	361.48	-5.74
03-Jul-92	1.17	0.995	0.04	-0.405	-0.942	-0.931	380.34	-9.40
04-Jul-92	1.22	0.995	0.02	-0.413	-0.956	-0.948	354.92	-6.56
05-Jul-92	1.36	0.993	0.004	-0.419	-0.978	-0.97	311.03	-5.88
06-Jul-92	1.57	0.993	-0.023	-0.429	-1	-0.99	258.60	-6.37
07-Jul-92	1.63	0.996	-0.051	-0.439	-1.02	-1.01	238.04	-6.13
08-Jul-92	1.74	1	-0.055	-0.458	-1.04	-1.02	231.61	-11.49
09-Jul-92	5.92	0.958	-0.048	-0.459	-1.04	-1.01	69.43	-5.07
10-Jul-92	5.65	0.994	-0.048	-0.465	-1.04	-1.01	73.81	-5.31
11-Jul-92	5.36	0.996	-0.047	-0.476	-1.04	-1.01	80.04	-5.60
12-Jul-92	5.12	1.04	-0.047	-0.486	-1.04	-1.01	85.74	-5.86

REVERSED POLARITY
SPECIMEN #1F
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 1/16 IN - 26.98mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	10.1	1.01	0.522	0.1	0.153	0.176	41.78	-2.28
30-May-92	10.48	1.18	0.518	0.102	0.164	0.173	39.69	-0.86
31-May-92	10.48	1.18	0.518	0.102	0.164	0.173	39.69	-0.86
01-Jun-92	10.17	1.12	0.533	0.105	0.165	0.181	42.08	-1.57
02-Jun-92	9.87	1.07	0.549	0.109	0.167	0.188	44.58	-2.13
03-Jun-92	9.57	1.03	0.563	0.112	0.168	0.196	47.13	-2.93
04-Jun-92	9.06	1.05	0.565	0.13	0.161	0.185	48.01	-2.65
05-Jun-92	9.14	1.06	0.575	0.117	0.16	0.187	50.11	-2.95
06-Jun-92	8.61	1	0.568	0.113	0.165	0.191	52.85	-3.02
07-Jun-92	8.59	0.997	0.581	0.119	0.171	0.197	53.78	-3.03
08-Jun-92	8.57	0.995	0.595	0.125	0.178	0.209	54.84	-3.62
09-Jun-92	9.54	0.998	0.709	0.114	0.231	0.261	62.37	-3.14
10-Jun-92	11.52	1.1	0.824	0.108	0.284	0.312	62.15	-2.43
11-Jun-92	9.45	1.08	0.725	0.127	0.225	0.25	63.28	-2.65
12-Jun-92	7.93	1.04	0.695	0.137	0.205	0.223	70.37	-2.27
13-Jun-92	7.11	1.01	0.711	0.161	0.201	0.245	77.36	-6.19
14-Jun-92	7.11	1.01	0.711	0.161	0.201	0.245	77.36	-6.19
15-Jun-92	7.51	1.03	0.745	0.168	0.217	0.242	76.83	-3.33
16-Jun-92	7.2	1.13	0.788	0.189	0.208	0.265	83.19	-7.92
17-Jun-92	6.9	0.994	0.772	0.171	0.233	0.262	87.10	-4.20
18-Jun-92	6.84	0.985	0.787	0.275	0.243	0.291	74.85	-7.02
19-Jun-92	6.59	1	0.817	0.242	0.246	0.292	87.25	-6.98
20-Jun-92	6.83	1	0.854	0.197	0.258	0.295	96.19	-5.71
21-Jun-92	6.74	1.01	0.877	0.195	0.261	0.312	101.19	-7.57
22-Jun-92	6.82	0.993	0.894	0.176	0.274	0.309	105.28	-5.13
23-Jun-92	6.31	0.995	0.918	0.104	0.279	0.311	129.00	-5.07
24-Jun-92	6.75	0.991	1.05	0.166	0.293	0.366	130.96	-10.81
25-Jun-92	6.75	0.991	1.05	0.166	0.293	0.366	130.96	-10.81
26-Jun-92	8.68	0.98	1.52	0.304	0.649	0.685	140.09	-4.15
27-Jun-92	8.12	0.952	1.65	0.368	0.629	0.689	157.88	-7.39
28-Jun-92	8.31	0.951	1.67	0.402	0.585	0.646	152.59	-7.34
29-Jun-92	8.81	0.949	1.76	0.418	0.582	0.635	152.33	-6.02
30-Jun-92	8.7	0.951	1.74	0.44	0.603	0.669	149.43	-7.59
01-Jul-92	8.41	0.952	1.61	0.545	0.589	0.665	126.63	-9.04
02-Jul-92	8.21	0.951	1.79	0.504	0.605	0.669	156.64	-7.80
03-Jul-92	8.14	0.954	1.72	0.473	0.601	0.665	153.19	-7.86
04-Jul-92	13.37	0.924	1.77	0.5	0.62	0.67	94.99	-3.74
05-Jul-92	8.65	0.95	1.78	0.522	0.645	0.697	145.43	-6.01
06-Jul-92	9.77	0.945	1.75	0.463	0.665	0.725	129.68	-6.14
07-Jul-92	9.75	0.949	1.76	0.527	0.652	0.715	126.46	-6.46
08-Jul-92	9.02	0.961	1.78	0.536	0.685	0.772	135.70	-9.65
09-Jul-92	13.21	0.92	1.73	0.65	0.675	0.823	81.76	-11.20
10-Jul-92	11.5	0.96	1.73	0.671	0.685	0.812	92.09	-12.78
11-Jul-92	9.95	1	1.74	0.692	0.656	0.799	105.33	-14.37
12-Jul-92	8.33	1.04	1.75	0.713	0.647	0.788	124.49	-16.93

NORMAL POLARITY
SPECIMEN #1G
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	1	1.09	0.2	-0.26	-0.005	-0.004	460.00	-1.00
30-May-92	1.4	1.22	0.003	-0.002	-0.007	-0.006	3.57	-0.71
31-May-92	2.9	1.71	0.008	0.003	-0.012	-0.011	1.72	-0.34
01-Jun-92	2.9	1.71	0.008	0.003	-0.012	-0.011	1.72	-0.34
02-Jun-92	2.3	1.4	0.005	0.001	-0.017	-0.014	1.74	-1.30
03-Jun-92	1.7	1.09	0.003	-0.005	-0.017	-0.016	4.71	-0.59
04-Jun-92	1.91	1.09	0.003	-0.007	-0.02	-0.019	5.24	-0.52
05-Jun-92	2	1.07	0.002	0.003	-0.023	-0.024	-0.50	0.50
06-Jun-92	2.16	1.03	0.004	-0.011	-0.026	-0.025	6.94	-0.46
07-Jun-92	1.75	1.05	0.043	-0.006	-0.036	-0.031	28.00	-2.86
08-Jun-92	2.17	1.03	0.002	-0.014	-0.039	-0.038	7.37	-0.46
09-Jun-92	4.22	1.05	0.003	-0.017	-0.022	-0.048	4.74	6.16
10-Jun-92	6.28	1.08	0.005	-0.025	-0.06	-0.058	4.78	-0.32
11-Jun-92	6.13	1.06	0.002	-0.031	-0.07	-0.067	5.38	-0.49
12-Jun-92	6.22	1.05	-0.003	-0.037	-0.082	-0.078	5.47	-0.64
13-Jun-92	6.73	1.02	-0.004	-0.052	-0.115	-0.108	7.13	-1.04
14-Jun-92	6.73	1.02	-0.004	-0.052	-0.115	-0.108	7.13	-1.04
15-Jun-92	7.25	1.03	0.002	-0.066	-0.144	-0.135	9.38	-1.24
16-Jun-92	7.84	1.15	0.006	-0.083	-0.184	-0.172	11.35	-1.53
17-Jun-92	6.91	0.99	-0.015	-0.11	-0.245	-0.229	13.75	-2.32
18-Jun-92	7.14	0.993	-0.019	-0.158	-0.351	-0.324	19.47	-3.78
19-Jun-92	7.23	0.998	-0.038	-0.228	-0.535	-0.474	26.28	-8.44
20-Jun-92	7.62	0.999	-0.064	-0.309	-0.691	-0.63	32.15	-8.01
21-Jun-92	12.88	0.982	-0.072	-0.52	-1.12	-1.02	34.78	-7.76
22-Jun-92	7.36	0.988	-0.092	-0.515	-1.11	-1	57.55	-14.97
23-Jun-92	7.31	0.989	-0.093	-0.523	-1.11	-0.991	58.82	-16.28
24-Jun-92	7.19	0.989	-0.104	-0.526	-1.13	-1	58.69	-18.08
25-Jun-92	7.19	0.989	-0.104	-0.526	-1.13	-1	58.69	-18.08
26-Jun-92	6.94	0.959	-0.115	-0.505	-1.11	-1.02	56.20	-12.97
27-Jun-92	7.05	0.959	-0.118	-0.515	-1.1	-1.01	56.31	-12.77
28-Jun-92	7.1	0.999	-0.117	-0.526	-1.1	-1.01	57.61	-12.68
29-Jun-92	7.27	0.959	-0.115	-0.528	-1.1	-1.01	56.81	-12.38
30-Jun-92	6.96	0.959	-0.133	-0.529	-1.11	-1.01	56.90	-14.37
01-Jul-92	7.23	0.958	-0.116	-0.529	-1.11	-1.01	57.12	-13.83
02-Jul-92	7.04	0.961	-0.121	-0.531	-0.108	-0.995	58.24	125.99
03-Jul-92	7.08	0.961	-0.12	-0.526	-1.11	-1	57.34	-15.54
04-Jul-92	12.01	0.932	-0.115	-0.519	-1.08	-1	33.64	-6.66
05-Jul-92	7.06 `	0.961	-0.126	-0.516	-1.11	-1	55.24	-15.58
06-Jul-92	6.92	0.962	-0.116	-0.522	-1.11	-0.997	58.67	-16.33
07-Jul-92	6.84	0.965	-0.116	-0.525	-1.08	-0.965	59.80	-13.89
08-Jul-92	7.08	0.974	-0.114	-0.523	-1.1	-0.979	57.77	-17.09
09-Jul-92	7.23	0.953	-0.091	-0.521	-1.09	-0.991	59.47	-13.69
10-Jul-92	7.35	0.989	-0.091	-0.517	-1.11	0.993	57.96	-286.12
11-Jul-92	7.44	0.999	-0.09	-0.513	-1.12	0.994	56.85	-284.14
12-Jul-92	7.49	1.02	-0.089	-0.509	-1.13	-0.995	56.07	-18.02

REVERSED POLARITY
SPECIMEN #1G
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	12.66	1.09	0.011	-0.023	0.005	0.004	2.69	0.08
30-May-92	14.4	1.11	0.012	0.005	0.005	0.004	0.49	0.07
31-May-92	14.4	1.11	0.012	0.005	0.005	0.004	0.49	0.07
01-Jun-92	13.78	1.08	0.017	0.006	0.006	0.007	0.80	-0.07
02-Jun-92	13.17	1.05	0.023	0.007	0.007	0.009	1.21	-0.15
03-Jun-92	12.56	1.02	0.028	0.008	0.01	0.011	1.59	-0.08
04-Jun-92	13.32	1.03	0.031	0.01	0.011	0.013	1.58	-0.15
05-Jun-92	12.82	1.02	0.036	0.001	0.012	0.013	2.73	-0.08
06-Jun-92	12.48	0.964	0.045	0.015	0.017	0.018	2.40	-0.08
07-Jun-92	12.94	0.988	0.051	0.015	0.018	0.02	2.78	-0.15
08-Jun-92	12.04	0.977	0.062	0.02	0.023	0.025	3.49	-0.17
09-Jun-92	13.92	0.998	0.085	0.026	0.029	0.035	4.24	-0.43
10-Jun-92	15.81	1.01	0.105	0.032	0.038	0.042	4.62	-0.25
11-Jun-92	15.41	0.987	0.108	0.042	0.04	0.052	4.28	-0.78
12-Jun-92	16.7	0.989	0.134	0.048	0.049	0.054	5.15	-0.30
13-Jun-92	17.54	0.955	0.185	0.068	0.07	0.076	6.67	-0.34
14-Jun-92	17.54	0.955	0.185	0.068	0.07	0.076	6.67	-0.34
15-Jun-92	18.4	0.965	0.226	0.08	0.083	0.094	7.93	-0.60
16-Jun-92	17.98	1.14	0.305	0.108	0.105	0.129	10.96	-1.33
17-Jun-92	17.08	0.935	0.374	0.134	0.136	0.165	14.05	-1.70
18-Jun-92	16.84	0.928	0.501	0.197	0.163	0.237	18.05	-4.39
19-Jun-92	20.25	0.925	0.752	0.264	0.275	0.317	24.10	-2.07
20-Jun-92	18.61	0.936	0.968	0.341	0.341	0.414	33.69	-3.92
21-Jun-92	16.67	0.947	1.63	0.615	0.552	0.748	60.89	-11.76
22-Jun-92	18.85	0.923	1.52	0.574	0.495	0.725	50.19	-12.20
23-Jun-92	16.2	0.935	1.43	0.591	0.407	0.816	51.79	-25.25
24-Jun-92	16.37	0.936	1.49	0.594	0.461	0.752	54.73	-17.78
25-Jun-92	16.37	0.936	1.49	0.594	0.461	0.752	54.73	-17.78
26-Jun-92	19.55	0.885	1.6	0.553	0.605	0.708	53.55	-5.27
27-Jun-92	15.86	0.908	1.49	0.603	0.499	0.717	55.93	-13.75
28-Jun-92	18.28	0.994	1.61	0.552	0.581	0.711	57.88	-7.11
29-Jun-92	18.52	0.893	1.58	0.572	0.535	0.689	54.43	-8.32
30-Jun-92	17.71	0.997	1.58	0.578	0.513	0.677	56.58	-9.26
01-Jul-92	20.78	0.998	1.54	0.597	0.548	0.84	45.38	-14.05
02-Jul-92	18	0.895	1.59	0.565	0.535	0.695	56.94	-8.89
03-Jul-92	15.66	0.909	1.52	0.6	0.465	0.713	58.75	-15.84
04-Jul-92	21.5	0.875	1.54	0.57	0.49	0.823	45.12	-15.49
05-Jul-92	17.82	0.896	1.59	0.573	0.512	0.689	57.07	-9.93
06-Jul-92	18.53	0.894	1.57	0.584	0.52	0.695	53.21	-9.44
07-Jul-92	18.26	0.898	1.6	0.559	0.5	0.673	57.01	-9.47
08-Jul-92	17.36	0.911	1.52	0.577	0.452	0.685	54.32	-13.42
09-Jul-92	18.5	0.886	1.56	0.585	0.522	0.738	52.70	-11.68
10-Jul-92	18	0.972	1.54	0.576	0.485	0.716	53.56	-12.83
11-Jul-92	17.54	0.974	1.52	0.569	0.441	0.698	54.22	-14.54
12-Jul-92	17.54	0.974	1.52	0.569	0.441	0.698	54.22	-14.54

NORMAL POLARITY
SPECIMEN #1H
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	1.18	1.21	0.23	-0.28	-0.827	-0.815	432.20	-10.17
30-May-92	1.8	1.23	0.22	-0.329	-0.976	-0.93	305.00	-25.56
31-May-92	3.2	1.46	0.425	-0.359	-0.986	-0.941	245.00	-14.06
01-Jun-92	4.75	1.21	0.675	-0.385	-1.05	-0.955	223.16	-20.00
02-Jun-92	5.35	1.06	0.345	-0.406	-1.12	-0.936	140.37	-34.39
03-Jun-92	5.3	1.04	0.012	-0.485	-1.09	-1.02	93.77	-13.21
04-Jun-92	5.81	1.07	-0.004	-0.486	-1.08	-1	82.96	-13.77
05-Jun-92	6.34	1.09	0.009	-0.525	-1.06	-0.955	84.23	-16.56
06-Jun-92	5.74	1	-0.078	-0.505	-1.1	-1	74.39	-17.42
07-Jun-92	6.37	1.02	-0.042	-0.536	-1.09	-1.02	77.86	-10.99
08-Jun-92	6.42	0.99	-0.074	-0.517	-1.07	-0.983	69.00	-13.55
09-Jun-92	7.26	1.02	-0.063	-0.507	-1.28	-1.02	61.16	-35.81
10-Jun-92	8.1	1.06	-0.056	-0.515	-1.1	-1.03	56.67	-8.64
11-Jun-92	8.95	1.04	-0.04	-0.518	-1.08	-1.02	53.41	-6.70
12-Jun-92	8.64	0.99	-0.071	-0.525	-1.07	-1.01	52.55	-6.94
13-Jun-92	8.32	1.01	-0.101	-0.527	-1.09	-1.01	51.20	-9.62
14-Jun-92	8.32	1.01	-0.101	-0.527	-1.09	-1.01	51.20	-9.62
15-Jun-92	8.46	1.01	-0.05	-0.525	-1.1	-1.01	56.01	-10.61
16-Jun-92	9	1.13	0.018	-0.527	-1.11	-1.03	60.56	-8.89
17-Jun-92	8.31	0.984	-0.091	-0.523	-1.06	-1.01	51.99	-6.02
18-Jun-92	8.29	0.968	-0.076	-0.52	-1.08	-1.01	53.56	-8.44
19-Jun-92	8.54	0.978	-0.077	-0.526	-1.09	-1.006	52.58	-9.84
20-Jun-92	7.76	0.956	-0.077	-0.513	-1.09	-1.02	56.19	-9.02
21-Jun-92	13.24	0.976	-0.063	-0.515	-1.09	-1.01	34.14	-6.04
22-Jun-92	7.86	0.981	-0.083	-0.513	-1.1	-1.01	54.71	-11.45
23-Jun-92	7.52	0.986	-0.102	-0.515	-1.11	-1	54.92	-14.63
24-Jun-92	7.51	0.978	-0.087	-0.505	-1.11	-1.01	55.66	-13.32
25-Jun-92	7.51	0.978	-0.087	-0.505	-1.11	-1.01	55.66	-13.32
26-Jun-92	7.26	0.955	-0.122	-0.494	-1.1	-1.01	51.24	-12.40
27-Jun-92	7.82	0.934	-0.097	-0.581	-1.09	-1	61.89	-11.51
28-Jun-92	7.21	0.942	-0.107	-0.512	-1.09	-1	56.17	-12.48
29-Jun-92	7.29	0.956	-0.105	-0.508	-1.08	-1	55.28	-10.97
30-Jun-92	7.57	0.954	-0.106	-0.516	-1.07	-0.997	54.16	-9.64
01-Jul-92	9.58	0.933	-0.107	-0.512	-1.08	-0.992	42.28	-9.19
02-Jul-92	6.87	0.945	-0.104	-0.516	-1.08	-0.996	59.97	-12.23
03-Jul-92	11	0.931	-0.102	-0.517	-1.06	-0.991	37.73	-6.27
04-Jul-92	7.08	0.936	-0.116	-0.514	-1.1	-0.999	56.21	-14.27
05-Jul-92	7.15	0.953	-0.125	-0.514	-1.09	-0.986	54.41	-14.55
06-Jul-92	7.18	0.958	-0.109	-0.504	-1.1	-1	55.01	-13.93
07-Jul-92	7.04	0.958	-0.118	-0.505	-1.11	-1	54.97	-15.63
08-Jul-92	8.74	0.958	-0.102	-0.505	-1.1	-1	46.11	-11.44
09-Jul-92	9.36	0.934	-0.09	-0.501	-1.1	-1	43.91	-10.68
10-Jul-92	8.96	0.984	-0.085	-0.5	-1.1	0.999	46.32	-234.26
11-Jul-92	8.52	0.99	-0.072	-0.499	-1.1	0.997	50.12	-246.13
12-Jul-92	8.31	1.03	-0.069	-0.499	-1.11	-0.995	51.74	-13.84

REVERSED POLARITY
SPECIMEN #1H
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

			ELECTRODE POTENTIALES (V)					
DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	11.1	1	0.57	0.37	0.52	0.64	18.02	-10.81
30-May-92	13.65	1.11	1.79	0.79	0.56	0.65	73.26	-6.59
31-May-92	13.65	1.11	1.79	0.79	0.56	0.65	73.26	-6.59
01-Jun-92	14.24	1.06	1.75	0.724	0.563	0.66	72.05	-6.81
02-Jun-92	14.84	1.02	1.71	0.658	0.566	0.667	70.89	-6.81
03-Jun-92	15.43	1	1.68	0.592	0.568	0.675	70.51	-6.93
04-Jun-92	14.63	1.02	1.68	0.675	0.579	0.701	68.69	-8.34
05-Jun-92	15.01	1.03	1.7	0.604	0.552	0.669	73.02	-7.79
06-Jun-92	16.21	0.939	1.65	0.656	0.581	0.675	61.32	-5.80
07-Jun-92	15.68	0.962	1.66	0.615	0.554	0.665	66.65	-7.08
08-Jun-92	15.5	0.937	1.61	0.637	0.516	0.663	62.77	-9.48
09-Jun-92	17.7	0.937	1.63	0.621	0.539	0.697	57.01	-8.93
10-Jun-92	19.96	0.936	1.65	0.603	0.562	0.731	52.45	-8.47
11-Jun-92	22.22	0.935	1.66	0.587	0.585	0.765	48.29	-8.10
12-Jun-92	21.43	0.912	1.71	0.595	0.605	0.755	52.03	-7.00
13-Jun-92	20.72	0.919	1.66	0.586	0.584	0.765	51.83	-8.74
14-Jun-92	20.72	0.919	1.66	0.586	0.584	0.765	51.83	-8.74
15-Jun-92	20.62	0.938	1.64	0.596	0.569	0.778	50.63	-10.14
16-Jun-92	22.43	1.13	1.73	0.616	0.604	0.72	49.67	-5.17
17-Jun-92	20.52	0.912	1.65	0.604	0.585	0.728	50.97	-6.97
18-Jun-92	19.04	0.919	1.58	0.625	0.562	0.684	50.16	-6.41
19-Jun-92	18.68	0.918	1.67	0.588	0.534	0.765	57.92	-12.37
20-Jun-92	20.5	0.924	1.6	0.598	0.556	0.718	48.88	-7.90
21-Jun-92	18.3	1.04	1.61	0.617	0.537	0.724	54.26	-10.22
22-Jun-92	18.27	0.919	1.53	0.615	0.517	0.745	50.08	-12.48
23-Jun-92	23.41	0.863	1.61	0.562	0.608	0.901	44.77	-12.52
24-Jun-92	18.85	0.868	1.58	0.577	0.56	0.778	53.21	-11.56
25-Jun-92	18.85	0.868	1.58	0.577	0.56	0.778	53.21	-11.56
26-Jun-92	19.7	0.877	1.56	0.575	0.541	0.689	50.00	-7.51
27-Jun-92	16.7	0.672	1.51	0.578	0.574	0.717	55.81	-8.56
28-Jun-92	20.61	0.862	1.57	0.566	0.553	0.695	48.71	-6.89
29-Jun-92	20.51	0.865	1.56	0.544	0.539	0.714	49.54	-8.53
30-Jun-92	18	0.889	1.53	0.565	0.506	0.699	53.61	-10.72
01-Jul-92	17.9	0.892	1.52	0.547	0.502	0.68	54.36	-9.94
02-Jul-92	19.1	0.884	1.55	0.59	0.482	0.72	50.26	-12.46
03-Jul-92	17.05	0.888	1.53	0.618	0.542	0.712	53.49	-9.97
04-Jul-92	18.22	0.835	1.41	0.564	0.47	0.81	46.43	-18.66
05-Jul-92	19.43	0.865	1.54	0.579	0.53	0.723	49.46	-9.93
06-Jul-92	18.2	0.862	1.51	0.576	0.541	0.718	51.32	-9.73
07-Jul-92	19.14	0.893	1.54	0.552	0.493	0.673	51.62	-9.40
08-Jul-92	17.35	0.852	1.53	0.575	0.525	0.734	55.04	-12.05
09-Jul-92	16.4	0.9	1.54	0.57	0.508	0.757	59.15	-15.18
10-Jul-92	17.2	0.921	1.54	0.564	0.506	0.739	56.74	-13.55
11-Jul-92	18.1	0.938	1.55	0.558	0.504	0.721	54.81	-11.99
12-Jul-92	19.73	0.947	1.56	0.554	0.502	0.695	50.99	-9.78

NORMAL POLARITY
SPECIMEN #11
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
29-May-92	5.4	1.1	-0.118	-0.555	-1.16	0.948	80.93	-390.37
30-May-92	7.92	1.18	0.003	-0.576	-1.15	-1.08	73.11	-11.36
31-May-92	7.92	1.18	0.003	-0.576	-1.15	-1.08	73.11	-11.36
01-Jun-92	17.35	1.3	0.11	-0.595	-1.22	-1.08	40.63	-8.07
02-Jun-92	17.42	1.17	0.016	-0.615	-1.21	-1.12	36.22	-5.17
03-Jun-92	17.42	1.17	0.016	-0.615	-1.21	-1.12	36.22	-5.17
04-Jun-92	13.07	1.03	-0.123	-0.615	-1.16	-1.08	37.64	-6.12
05-Jun-92	12.6	1.03	-0.125	-0.613	-1.16	-1.1	38.73	-4.76
06-Jun-92	15.12	1.15	-0.09	-0.608	-1.16	-1.07	34.26	-5.95
07-Jun-92	10.78	0.975	-0.123	-0.56	-1.15	-1.04	40.54	-10.20
08-Jun-92	12.38	1.08	-0.112	-0.598	-1.17	-1.07	39.26	-8.08
09-Jun-92	13.3	1.09	-0.084	-0.617	-1.21	-1.09	40.08	-9.02
10-Jun-92	14.25	1.14	-0.057	-0.636	-1.23	-1.12	40.63	-7.72
11-Jun-92	15.36	1.2	-0.03	-0.655	-1.27	-1.14	40.69	-8.46
12-Jun-92	8.06	0.979	-0.335	-0.661	-1.33	-1.13	40.45	-24.81
13-Jun-92	10.03	0.997	-0.241	-0.656	-1.25	-1.14	41.38	-10.97
14-Jun-92	10.03	0.997	-0.241	-0.656	-1.25	-1.14	41.38	-10.97
15-Jun-92	10.19	1.01	-0.225	-0.66	-1.25	-1.1	42.69	-14.72
16-Jun-92	10.65	1.05	-0.154	-0.621	-1.22	-1.08	43.85	-13.15
17-Jun-92	11.63	1.08	-0.127	-0.623	-1.23	-1.11	42.65	-10.32
18-Jun-92	10.08	0.982	-0.208	-0.637	-1.2	-1.1	42.56	-9.92
19-Jun-92	9.58	0.989	-0.224	-0.639	-1.22	-1.08	43.32	-14.61
20-Jun-92	9.83	0.989	-0.217	-0.641	-1.205	-1.07	43.13	-13.73
21-Jun-92	9.49	0.995	-0.151	-0.579	-1.18	-1.08	45.10	-12.64
22-Jun-92	9.65	1	-0.118	-0.565	-1.18	-1.03	46.32	-15.54
23-Jun-92	8.07	0.985	-0.212	-0.561	-1.23	-1.04	43.25	-23.54
24-Jun-92	8.52	0.982	-0.173	-0.575	-1.18	-1.063	47.18	-13.73
25-Jun-92	8.53	0.981	-0.174	-0.576	-1.18	-1.065	47.13	-13.48
26-Jun-92	8.42	0.982	-0.212	-0.615	-1.19	-1.1	47.86	-10.69
27-Jun-92	8.63	0.949	-0.251	-0.616	-1.18	-1.09	42.29	-10.43
28-Jun-92	7.78	0.954	-0.266	-0.632	-1.22	-1.09	47.04	-16.71
29-Jun-92	8.18	0.952	-0.141	-0.513	-1.13	-1	45.48	-15.89
30-Jun-92	8.3	0.953	-0.198	-0.568	-1.16	-1.05	44.82	-13.25
01-Jul-92	8.4	0.952	-0.192	-0.575	-1.16	-1.05	45.60	-13.10
02-Jul-92	8.21	0.951	-0.203	-0.585	-1.16	-1.06	46.53	-12.18
03-Jul-92	8.18	0.954	-0.206	-0.587	-1.16	-1.07	46.58	-11.00
04-Jul-92	8.23	0.953	-0.17	-0.565	-1.14	-1.02	48.00	-14.58
05-Jul-92	8.06	0.953	-0.171	-0.558	-1.15	-1.04	48.01	-13.65
06-Jul-92	8.04	0.954	-0.218	-0.592	-1.18	-1.08	46.52	-12.44
07-Jul-92	8.05	0.957	-0.219	-0.593	-1.18	-1.08	46.46	-12.42
08-Jul-92	8	0.958	-0.221	-0.599	-1.18	-1.07	47.25	-13.75
09-Jul-92	8.13	0.967	-0.216	-0.597	-1.19	-1.09	46.86	-12.30
10-Jul-92	8.17	0.971	-0.175	-0.58	-1.18	-1.06	49.57	-14.69
11-Jul-92	8.22	0.972	-0.166	-0.57	-1.17	-1.04	49.15	-15.82
12-Jul-92	8.27	0.974	-0.14	-0.56	-1.16	-1.03	50.79	-15.72

REVERSED POLARITY
SPECIMEN #11
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
29-May-92	15.18	1.01	1.793	0.732	0.698	0.809	69.89	-7.31
30-May-92	18.9	1.11	1.85	0.85	0.655	0.837	52.91	-9.63
31-May-92	18.9	1.11	1.85	0.85	0.655	0.837	52.91	-9.63
01-Jun-92	18.82	1.08	1.81	0.798	0.539	0.834	53.77	-15.67
02-Jun-92	18.74	1.01	1.75	0.747	0.423	0.831	53.52	-21.77
03-Jun-92	18.66	0.965	1.69	0.696	0.307	0.828	53.27	-27.92
04-Jun-92	18.59	0.994	1.31	0.645	0.191	0.825	35.77	-34.10
05-Jun-92	31.3	0.909	1.72	0.638	0.625	0.816	34.57	-6.10
06-Jun-92	30.7	1.09	1.77	0.655	0.583	0.754	36.32	-5.57
07-Jun-92	21.83	0.819	1.52	0.621	0.508	0.746	41.18	-10.99
08-Jun-92	27.6	0.979	1.63	0.617	0.491	0.766	36.70	-9.96
09-Jun-92	26.9	0.956	1.65	0.644	0.532	0.773	37.40	-8.96
10-Jun-92	26.2	0.933	1.675	0.672	0.574	0.78	38.28	-7.86
11-Jun-92	25.5	0.91	1.7	0.699	0.615	0.788	39.25	-6.78
12-Jun-92	24.81	0.887	1.72	0.727	0.657	0.795	40.02	-5.56
13-Jun-92	25.29	0.912	1.7	0.686	0.627	0.804	40.09	-7.00
14-Jun-92	25.29	0.912	1.7	0.686	0.627	0.804	40.09	-7.00
15-Jun-92	23.41	0.935	1.67	0.646	0.595	0.752	43.74	-6.71
16-Jun-92	28.2	0.938	1.69	0.635	0.589	0.922	37.41	-11.81
17-Jun-92	23.16	1	1.7	0.685	0.531	0.779	43.83	-10.71
18-Jun-92	21.9	0.874	1.61	0.654	0.553	0.763	43.65	-9.59
19-Jun-92	21.79	0.917	1.66	0.652	0.566	0.765	46.26	-9.13
20-Jun-92	22.94	0.914	1.71	0.654	0.617	0.755	46.03	-6.02
21-Jun-92	23.42	0.912	1.67	0.645	0.583	0.749	43.77	-7.09
22-Jun-92	23.37	0.932	1.69	0.627	0.575	0.735	45.49	-6.85
23-Jun-92	22.09	0.896	1.62	0.634	0.532	0.776	44.64	-11.05
24-Jun-92	20.32	0.907	1.54	0.609	0.508	0.746	45.82	-11.81
25-Jun-92	20.21	0.912	1.54	0.609	0.504	0.749	46.07	-12.12
26-Jun-92	19.52	0.915	1.52	0.669	0.511	0.815	43.60	-15.57
27-Jun-92	21.24	0.875	1.56	0.644	0.498	0.745	43.13	-11.63
28-Jun-92	21.12	0.875	1.53	0.583	0.51	0.728	44.84	-10.32
29-Jun-92	23.11	0.861	1.52	0.549	0.575	0.72	42.02	-6.27
30-Jun-92	21.71	0.873	1.51	0.596	0.467	0.725	42.10	-11.88
01-Jul-92	21.26	0.846	1.52	0.608	0.524	0.743	42.90	-10.30
02-Jul-92	21.46	0.872	1.55	0.576	0.589	0.744	45.34	-7.22
03-Jul-92	23.55	0.861	1.6	0.604	0.574	0.734	42.29	-6.79
04-Jul-92	22.9	0.865	1.59	0.606	0.565	0.726	42.97	-7.03
05-Jul-92	22.5	0.862	1.56	0.608	0.557	0.718	42.31	-7.16
06-Jul-92	22.55	0.868	1.58	0.62	0.607	0.757	42.57	-6.65
07-Jul-92	21.5	0.875	1.59	0.64	0.591	0.745	44.19	-7.16
08-Jul-92	22.77	0.868	1.57	0.617	0.595	0.752	41.85	-6.90
09-Jul-92	22.85	0.882	1.58	0.63	0.603	0.756	41.58	-6.70
10-Jul-92	21.31	0.889	1.59	0.612	0.599	0.757	45.89	-7.41
11-Jul-92	19.61	0.902	1.61	0.591	0.595	0.758	51.98	-8.31
12-Jul-92	19.22	0.907	1.63	0.587	0.591	0.759	54.27	-8.74

APPENDIX C

TEST SERIES No. 2 AND No.3

POTENTIAL

AND

CURRENT MEASUREMENTS

NORMAL POLARITY
SPECIMEN #2A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.082	0.08	-0.013	-0.009	200	-400
28-Jul-92	0.01	1	0.08	0.078	-0.014	-0.01	200	-400
29-Jul-92	0.01	1	0.082	0.08	-0.015	-0.011	200	-400
30-Jul-92	0.01	1	0.112	0.094	-0.021	-0.017	1800	-400
31-Jul-92	0.01	1	0.123	0.104	-0.024	-0.02	1900	-400
01-Aug-92	0.01	1	0.131	0.118	-0.025	-0.018	1300	-700
02-Aug-92	0.01	1	0.139	0.132	-0.026	-0.017	700	-900
03-Aug-92	0.01	1	0.163	0.055	-0.01	-0.006	10800	-400
04-Aug-92	0.01	1	0.111	0.099	-0.017	-0.012	1200	-500
05-Aug-92	0.01	1	0.108	0.102	-0.019	-0.015	600	-400
06-Aug-92	0.01	1	0.136	0.13	-0.03	-0.024	600	-600
07-Aug-92	0.01	1	0.187	0.18	-0.062	-0.052	700	-1000
08-Aug-92	0.01	1	0.187	0.18	-0.062	-0.052	700	-1000
09-Aug-92	0.01	1	0.161	0.156	-0.045	-0.034	500	-1100
10-Aug-92	0.01	1	0.176	0.168	-0.066	-0.053	800	-1300
11-Aug-92	0.01	1	0.147	0.143	-0.034	-0.028	400	-600
12-Aug-92	0.01	1	0.126	0.122	-0.038	-0.03	400	-800
13-Aug-92	0.01	1	0.126	0.122	-0.038	-0.03	400	-800
14-Aug-92	0.01	1	0.093	0.091	-0.035	-0.026	200	-900
15-Aug-92	0.01	1	0.115	0.112	-0.042	-0.037	300	-500
16-Aug-92	0.01	1	0.147	0.145	-0.058	-0.046	200	-1200
17-Aug-92	0.01	1	0.184	0.182	-0.076	-0.063	200	-1300
18-Aug-92	0.01	1	0.197	0.192	-0.06	-0.049	500	-1100
19-Aug-92	0.01	1	0.136	0.127	-0.047	-0.039	900	-800
20-Aug-92	0.01	1	0.064	0.054	-0.126	-0.122	1000	-400
21-Aug-92	0.01	1	0.156	0.15	-0.061	-0.054	600	-700
22-Aug-92	0.01	1	0.142	0.139	-0.059	-0.052	300	-700
23-Aug-92	0.01	1	0.142	0.139	-0.059	-0.052	300	-700
24-Aug-92	0.01	1	0.178	0.174	-0.057	-0.05	400	-700
25-Aug-92	0.01	1	0.228	0.221	-0.083	-0.07	700	-1300
26-Aug-92	0.01	1	0.249	0.241	-0.081	-0.064	800	-1700
27-Aug-92	0.01	1	0.231	0.223	-0.091	-0.078	800	-1300
28-Aug-92	0.01	1	0.209	0.2	-0.089	-0.072	900	-1700
29-Aug-92	0.01	1	0.198	0.191	-0.103	-0.086	700	-1700
30-Aug-92	0.01	1	0.199	0.193	-0.044	-0.084	600	4000
31-Aug-92	0.01	1	0.204	0.198	-0.108	-0.095	600	-1300
01-Sep-92	0.01	1	0.189	0.181	-0.084	-0.072	800	-1200
02-Sep-92	0.01	1	0.167	0.159	-0.092	-0.086	800	-600
03-Sep-92	0.01	1	0.188	0.181	-0.088	-0.083	700	-500
04-Sep-92	0.01	1	0.166	0.162	-0.087	-0.08	400	-700
05-Sep-92	0.01	1	0.215	0.206	-0.106	-0.089	900	-1700
06-Sep-92	0.01	1	0.217	0.208	-0.105	-0.087	900	-1800
07-Sep-92	0.01	1	0.239	0.232	-0.091	-0.073	700	-1800
08-Sep-92	0.01	1	0.226	0.218	-0.083	-0.068	800	-1500
09-Sep-92	0.01	1	0.241	0.232	-0.109	-0.091	900	-1800

REVERSED POLARITY
SPECIMEN #2A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.011	0.006	-0.079	-0.08	500	100
28-Jul-92	0.01	1	0.012	0.006	-0.09	-0.087	600	-300
29-Jul-92	0.01	1	0.013	0.008	-0.089	-0.087	500	-200
30-Jul-92	0.01	1	0.016	0.009	-0.094	-0.091	700	-300
31-Jul-92	0.01	1	0.018	0.011	-0.099	-0.094	700	-500
01-Aug-92	0.01	1	0.019	0.012	-0.112	-0.108	700	-400
02-Aug-92	0.01	1	0.02	0.012	-0.126	-0.119	800	-700
03-Aug-92	0.01	1	0.088	0.049	-0.075	-0.068	3900	-700
04-Aug-92	0.01	1	0.015	0.01	-0.102	-0.115	500	1300
05-Aug-92	0.01	1	0.011	0.005	-0.082	-0.07	600	-1200
06-Aug-92	0.01	1	0.018	0.012	-0.106	-0.092	600	-1400
07-Aug-92	0.01	1	0.035	0.024	-0.152	-0.144	1100	-800
08-Aug-92	0.01	1	0.035	0.024	-0.152	-0.144	1100	-800
09-Aug-92	0.01	1	0.0435	0.0365	-0.162	-0.154	500	-800
10-Aug-92	0.01	1	0.058	0.047	-0.188	-0.174	1100	-1400
11-Aug-92	0.01	1	0.028	0.021	-0.108	-0.101	700	-700
12-Aug-92	0.01	1	0.034	0.026	-0.104	-0.096	800	-800
13-Aug-92	0.01	1	0.034	0.026	-0.104	-0.096	800	-800
14-Aug-92	0.01	1	0.017	0.013	-0.069	-0.065	400	-400
15-Aug-92	0.01	1	0.042	0.033	-0.121	-0.117	900	-400
16-Aug-92	0.01	1	0.058	0.042	-0.162	-0.159	1600	-300
17-Aug-92	0.01	1	0.065	0.053	-0.196	-0.193	1200	-300
18-Aug-92	0.01	1	0.049	0.038	-0.203	-0.193	1100	-1000
19-Aug-92	0.01	1	0.036	0.028	-0.118	-0.108	800	-1000
20-Aug-92	0.01	1	0.077	0.065	-0.157	-0.152	1200	-500
21-Aug-92	0.01	1	0.049	0.04	-0.124	-0.118	900	-600
22-Aug-92	0.01	1	0.05	0.04	-0.153	-0.149	1000	-400
23-Aug-92	0.01	1	0.05	0.04	-0.153	-0.149	1000	-400
24-Aug-92	0.01	1	0.052	0.04	-0.198	-0.193	1200	-500
25-Aug-92	0.01	1	0.064	0.051	-0.204	-0.198	1300	-600
26-Aug-92	0.01	1	0.087	0.062	-0.262	-0.253	2500	-900
27-Aug-92	0.01	1	0.065	0.051	-0.157	-0.155	1400	-200
28-Aug-92	0.01	1	0.09	0.07	-0.243	-0.233	2000	-1000
29-Aug-92	0.01	1	0.085	0.069	-0.192	-0.184	1600	-800
30-Aug-92	0.01	1	0.104	0.084	-0.219	-0.214	2000	-500
31-Aug-92	0.01	1	0.067	0.056	-0.169	-0.162	1100	-700
01-Sep-92	0.01	1	0.089	0.075	-0.183	-0.179	1400	-400
02-Sep-92	0.01	1	0.103	0.087	-0.185	-0.182	1600	-300
03-Sep-92	0.01	1	0.232	0.185	-0.19	-0.184	4700	-600
04-Sep-92	0.01	1	0.079	0.06	-0.184	-0.179	1900	-500
05-Sep-92	0.01	1	0.102	0.083	-0.214	-0.208	1900	-600
06-Sep-92	0.01	1	0.101	0.082	-0.212	-0.206	1900	-600
07-Sep-92	0.01	1	0.091	0.072	-0.251	-0.244	1900	-700
08-Sep-92	0.01	1	0.085	0.068	-0.25	-0.245	1700	-500
09-Sep-92	0.01	1	0.093	0.074	-0.253	-0.247	1900	-600

NORMAL POLARITY
SPECIMEN #2B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.713	0.697	-0.208	-0.157	1600	-5100
28-Jul-92	0.01	1	0.66	0.65	-0.17	-0.126	1000	-4400
29-Jul-92	0.01	1	0.708	0.696	-0.172	-0.13	1200	-4200
30-Jul-92	0.01	1	0.716	0.705	-0.265	-0.239	1100	-4600
31-Jul-92	0.01	1	0.735	0.721	-0.16	-0.119	1400	-4100
01-Aug-92	0.01	1	0.736	0.723	-0.158	-0.117	1300	-4100
02-Aug-92	0.01	1	0.738	0.725	-0.156	-0.115	1300	-4100
03-Aug-92	0.01	1	0.465	0.453	-0.1	-0.072	3200	-2800
04-Aug-92	0.01	1	0.757	0.746	-0.168	-0.131	1100	-3700
05-Aug-92	0.01	1	0.746	0.734	-0.172	-0.135	1200	-3700
06-Aug-92	0.01	1	0.758	0.748	-0.154	-0.121	1000	-3300
07-Aug-92	0.01	1	0.757	0.747	-0.151	-0.121	1000	-3000
08-Aug-92	0.01	1	0.757	0.747	-0.151	-0.121	1000	-3000
09-Aug-92	0.01	1	0.766	0.756	-0.156	-0.123	1000	-3300
10-Aug-92	0.01	1	0.755	0.745	-0.164	-0.129	1000	-3500
11-Aug-92	0.01	1	0.228	0.216	-0.164	-0.151	1200	-1300
12-Aug-92	0.01	1	0.742	0.733	-0.16	-0.13	900	-3000
13-Aug-92	0.01	1	0.742	0.733	-0.16	-0.13	900	-3000
14-Aug-92	0.01	1	0.751	0.742	-0.157	-0.129	900	-2800
15-Aug-92	0.01	1	0.741	0.732	-0.163	-0.135	900	-2800
16-Aug-92	0.01	1	0.695	0.686	-0.164	-0.136	900	-2800
17-Aug-92	0.01	1	0.765	0.752	-0.153	-0.123	1300	-3000
18-Aug-92	0.01	1	0.436	0.423	-0.184	-0.167	1300	-1700
19-Aug-92	0.01	1	0.756	0.746	-0.16	-0.13	800	-3000
20-Aug-92	0.01	1	0.375	0.367	-0.224	-0.203	800	-2100
21-Aug-92	0.01	1	0.39	0.38	-0.242	-0.22	1000	-2200
22-Aug-92	0.01	1	0.404	0.384	-0.245	-0.226	2000	-1900
23-Aug-92	0.01	1	0.404	0.384	-0.245	-0.226	2000	-1900
24-Aug-92	0.01	1	0.415	0.4	-0.255	-0.236	1500	-1900
25-Aug-92	0.01	1	0.757	0.745	-0.169	-0.128	1200	-4100
26-Aug-92	0.01	1	0.754	0.745	-0.191	-0.155	900	-3600
27-Aug-92	0.01	1	0.758	0.747	-0.183	-0.143	1100	-4000
28-Aug-92	0.01	1	0.41	0.397	-0.289	-0.258	1300	-3100
29-Aug-92	0.01	1	0.392	0.378	-0.286	-0.268	1400	-1800
30-Aug-92	0.01	1	0.392	0.378	-0.283	-0.265	1400	-1800
31-Aug-92	0.01	1	0.383	0.367	-0.271	-0.246	1600	-2500
01-Sep-92	0.01	1	0.388	0.372	-0.271	-0.246	1600	-2500
02-Sep-92	0.01	1	0.711	0.702	-0.182	-0.146	900	-3600
03-Sep-92	0.01	1	0.393	0.384	-0.275	-0.254	900	-2100
04-Sep-92	0.01	1	0.312	0.263	-0.689	-0.69	4900	100
05-Sep-92	0.01	1	0.312	0.265	-0.689	-0.69	4700	100
06-Sep-92	0.01	1	0.311	0.264	-0.689	-0.69	4700	100
07-Sep-92	0.01	1	0.656	0.648	-0.314	-0.28	800	-3400
08-Sep-92	0.01	1	0.428	0.405	-0.291	-0.272	2300	-1900
09-Sep-92	0.01	1	0.312	0.363	-0.69	-0.689	-5100	-100

REVERSED POLARITY
SPECIMEN #2B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.021	0.016	-0.072	-0.07	500	-200
28-Jul-92	0.01	1	0.184	0.137	-0.716	-0.702	4700	-1400
29-Jul-92	0.01	1	0.18	0.13	-0.722	-0.708	5000	-1400
30-Jul-92	0.01	1	0.247	0.196	-0.752	-0.733	5100	-1900
31-Jul-92	0.01	1	0.181	0.132	-0.74	-0.725	4900	-1500
01-Aug-92	0.01	1	0.161	0.118	-0.745	-0.731	4300	-1400
02-Aug-92	0.01	1	0.132	0.1	-0.605	-0.597	3200	-800
03-Aug-92	0.01	1	0.161	0.122	-0.75	-0.736	3900	-1400
04-Aug-92	0.01	1	0.159	0.127	-0.737	-0.726	3200	-1100
05-Aug-92	0.01	1	0.172	0.137	-0.752	-0.741	3500	-1100
06-Aug-92	0.01	1	0.18	0.156	-0.137	-0.135	2400	-200
07-Aug-92	0.01	1	0.139	0.116	-0.708	-0.696	2300	-1200
08-Aug-92	0.01	1	0.139	0.116	-0.708	-0.696	2300	-1200
09-Aug-92	0.01	1	0.155	0.124	-0.772	-0.761	3100	-1100
10-Aug-92	0.01	1	0.159	0.128	-0.755	-0.745	3100	-1000
11-Aug-92	0.01	1	0.162	0.129	-0.749	-0.736	3300	-1300
12-Aug-92	0.01	1	0.157	0.128	-0.744	-0.734	2900	-1000
13-Aug-92	0.01	1	0.157	0.128	-0.744	-0.734	2900	-1000
14-Aug-92	0.01	1	0.154	0.127	-0.753	-0.744	2700	-900
15-Aug-92	0.01	1	0.158	0.132	-0.716	-0.709	2600	-700
16-Aug-92	0.01	1	0.155	0.126	0.745	0.737	2900	800
17-Aug-92	0.01	1	0.146	0.126	-0.404	-0.391	2000	-1300
18-Aug-92	0.01	1	0.179	0.151	-0.398	-0.395	2800	-300
19-Aug-92	0.01	1	0.156	0.125	-0.77	-0.76	3100	-1000
20-Aug-92	0.01	1	0.216	0.192	-0.372	-0.362	2400	-1000
21-Aug-92	0.01	1	0.233	0.205	-0.386	-0.375	2800	-1100
22-Aug-92	0.01	1	0.173	0.142	-0.737	-0.727	3100	-1000
23-Aug-92	0.01	1	0.173	0.142	-0.737	-0.727	3100	-1000
24-Aug-92	0.01	1	0.173	0.143	-0.757	-0.747	3000	-1000
25-Aug-92	0.01	1	0.158	0.124	-0.77	-0.76	3400	-1000
26-Aug-92	0.01	1	0.25	0.222	-0.465	-0.455	2800	-1000
27-Aug-92	0.01	1	0.178	0.139	-0.765	-0.753	3900	-1200
28-Aug-92	0.01	1	0.19	0.151	-0.749	-0.737	3900	-1200
29-Aug-92	0.01	1	0.206	0.167	-0.733	-0.723	3900	-1000
30-Aug-92	0.01	1	0.28	0.249	-0.399	-0.391	3100	-800
31-Aug-92	0.01	1	0.202	0.165	-0.666	-0.653	3700	-1300
01-Sep-92	0.01	1	0.18	0.143	-0.725	-0.716	3700	-900
02-Sep-92	0.01	1	0.18	0.144	-0.722	-0.718	3600	-400
03-Sep-92	0.01	1	0.271	0.241	-0.385	-0.317	3000	-6800
04-Sep-92	0.01	1	0.191	0.157	-0.7	-0.69	3400	-1000
05-Sep-92	0.01	1	0.222	0.185	-0.676	-0.664	3700	-1200
06-Sep-92	0.01	1	0.221	0.184	-0.675	-0.663	3700	-1200
07-Sep-92	0.01	1	0.204	0.168	-0.715	-0.704	3600	-1100
08-Sep-92	0.01	1	0.204	0.171	-0.639	-0.63	3300	-900
09-Sep-92	0.01	1	0.31	0.284	-0.303	-0.3	2600	-300

NORMAL POLARITY
SPECIMEN #2C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.119	0.117	-0.15	-0.11	200	-4000
28-Jul-92	0.01	1	0.15	0.148	-0.18	-0.13	200	-5000
29-Jul-92	0.01	1	0.137	0.134	-0.016	-0.012	300	-400
30-Jul-92	0.01	1	0.503	0.459	-0.5	-0.466	4400	-3400
31-Jul-92	0.01	1	0.187	0.163	-0.113	-0.09	400	-2300
01-Aug-92	0.01	1	0.226	0.221	-0.075	-0.066	500	-900
02-Aug-92	0.01	1	0.277	0.271	-0.051	-0.047	600	-400
03-Aug-92	0.01	1	0.339	0.328	-0.174	-0.155	1100	-1900
04-Aug-92	0.01	1	0.444	0.432	-0.074	-0.06	1200	-1400
05-Aug-92	0.01	1	0.494	0.479	-0.089	-0.071	1500	-1800
06-Aug-92	0.01	1	0.505	0.488	-0.08	-0.069	1700	-1100
07-Aug-92	0.01	1	0.52	0.485	-0.101	-0.088	3500	-1300
08-Aug-92	0.01	1	0.52	0.485	-0.101	-0.088	3500	-1300
09-Aug-92	0.01	1	0.287	0.252	-0.711	-0.71	3500	-100
10-Aug-92	0.01	1	0.506	0.485	-0.22	-0.203	2100	-1700
11-Aug-92	0.01	1	0.288	0.271	-0.71	-0.709	1700	-100
12-Aug-92	0.01	1	0.3	0.273	-0.697	-0.698	2700	-100
13-Aug-92	0.01	1	0.3	0.273	-0.697	-0.698	2700	-100
14-Aug-92	0.01	1	0.304	0.291	-0.694	-0.695	1300	100
15-Aug-92	0.01	1	0.278	0.275	-0.722	-0.723	300	100
16-Aug-92	0.01	1	0.495	0.483	-0.109	-0.096	1200	-1300
17-Aug-92	0.01	1	0.282	0.279	-0.715	-0.717	300	200
18-Aug-92	0.01	1	0.283	0.269	-0.713	-0.712	1400	-100
19-Aug-92	0.01	1	0.495	0.483	-0.11	-0.092	1200	-1800
20-Aug-92	0.01	1	0.356	0.345	-0.138	-0.132	1100	-600
21-Aug-92	0.01	1	0.282	0.302	-0.715	-0.712	-2000	-300
22-Aug-92	0.01	1	0.274	0.293	-0.719	-0.724	-1900	500
23-Aug-92	0.01	1	0.274	0.293	-0.719	-0.724	-1900	500
24-Aug-92	0.01	1	0.278	0.304	-0.722	-0.725	-2600	300
25-Aug-92	0.01	1	0.279	0.296	-0.722	-0.724	-1700	200
26-Aug-92	0.01	1	0.273	0.27	-0.728	-0.731	300	300
27-Aug-92	0.01	1	0.277	0.253	-0.738	-0.739	2400	100
28-Aug-92	0.01	1	0.274	0.247	-0.729	-0.733	2700	400
29-Aug-92	0.01	1	0.564	0.545	-0.093	-0.071	1900	-2200
30-Aug-92	0.01	1	0.442	0.425	-0.155	-0.133	1700	-2200
31-Aug-92	0.01	1	0.406	0.392	-0.147	-0.129	1400	-1800
01-Sep-92	0.01	1	0.266	0.233	-0.732	-0.731	3300	-100
02-Sep-92	0.01	1	0.379	0.364	-0.165	-0.144	1500	-2100
03-Sep-92	0.01	1	0.271	0.228	-0.726	-0.727	4300	100
04-Sep-92	0.01	1	0.435	0.417	-0.162	-0.142	1800	-2000
05-Sep-92	0.01	1	0.594	0.573	-0.143	-0.115	2100	-2800
06-Sep-92	0.01	1	0.592	0.572	-0.142	-0.114	2000	-2800
07-Sep-92	0.01	1	0.267	0.302	-0.706	-0.712	-3500	600
08-Sep-92	0.01	1	0.262	0.285	-0.736	-0.738	-2300	200
09-Sep-92	0.01	1	0.253	0.241	0.747	0.745	1200	200

REVERSED POLARITY
SPECIMEN #2C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.015	0.01	-0.119	-0.116	500	-300
28-Jul-92	0.01	1	0.012	0.008	-0.109	-0.106	400	-300
29-Jul-92	0.01	1	0.015	0.011	-0.128	-0.125	400	-300
30-Jul-92	0.01	1	0.438	0.388	-0.544	-0.5	5000	-4400
31-Jul-92	0.01	1	0.111	0.087	-0.17	-0.167	2400	-300
01-Aug-92	0.01	1	0.118	0.093	-0.236	-0.229	2500	-700
02-Aug-92	0.01	1	0.122	0.096	-0.3	-0.295	2600	-500
03-Aug-92	0.01	1	0.139	0.118	-0.346	-0.342	2100	-400
04-Aug-92	0.01	1	0.164	0.141	-0.344	-0.326	2300	-1800
05-Aug-92	0.01	1	0.08	0.062	-0.564	-0.554	1800	-1000
06-Aug-92	0.01	1	0.08	0.064	-0.562	-0.554	1600	-800
07-Aug-92	0.01	1	0.19	0.174	-0.394	-0.387	1600	-700
08-Aug-92	0.01	1	0.19	0.174	-0.394	-0.387	1600	-700
09-Aug-92	0.01	1	0.146	0.13	-0.459	-0.448	1600	-1100
10-Aug-92	0.01	1	0.18	0.152	-0.506	-0.495	2800	-1100
11-Aug-92	0.01	1	0.14	0.122	-0.448	-0.435	1800	-1300
12-Aug-92	0.01	1	0.16	0.146	-0.285	-0.279	1400	-600
13-Aug-92	0.01	1	0.16	0.146	-0.285	-0.279	1400	-600
14-Aug-92	0.01	1	0.15	0.135	-0.368	-0.36	1500	-800
15-Aug-92	0.01	1	0.12	0.104	-0.477	-0.469	1600	-800
16-Aug-92	0.01	1	0.107	0.092	-0.481	-0.471	1500	-1000
17-Aug-92	0.01	1	0.151	0.134	-0.456	-0.446	1700	-1000
18-Aug-92	0.01	1	0.168	0.153	-0.337	-0.334	1500	-300
19-Aug-92	0.01	1	0.107	0.091	-0.543	-0.525	1600	-1800
20-Aug-92	0.01	1	0.131	0.117	-0.354	-0.346	1400	-800
21-Aug-92	0.01	1	0.148	0.135	-0.524	-0.512	1300	-1200
22-Aug-92	0.01	1	0.148	0.127	-0.536	-0.524	2100	-1200
23-Aug-92	0.01	1	0.148	0.127	-0.536	-0.524	2100	-1200
24-Aug-92	0.01	1	0.158	0.132	-0.558	-0.545	2400	-1300
25-Aug-92	0.01	1	0.163	0.136	-0.539	-0.527	2700	-1200
26-Aug-92	0.01	1	0.175	0.146	-0.493	-0.478	2900	-1500
27-Aug-92	0.01	1	0.168	0.137	-0.544	-0.527	3100	-1700
28-Aug-92	0.01	1	0.199	0.174	-0.34	-0.327	2500	-1300
29-Aug-92	0.01	1	0.167	0.131	-0.504	-0.482	3600	-2200
30-Aug-92	0.01	1	0.093	0.073	-0.34	-0.334	2000	-600
31-Aug-92	0.01	1	0.15	0.127	-0.443	-0.431	2300	-1200
01-Sep-92	0.01	1	0.186	0.166	-0.319	-0.304	2000	-1500
02-Sep-92	0.01	1	0.167	0.148	-0.439	-0.424	1900	-1500
03-Sep-92	0.01	1	0.187	0.165	-0.36	-0.345	2200	-1500
04-Sep-92	0.01	1	0.171	0.152	-0.355	-0.342	1900	-1300
05-Sep-92	0.01	1	0.141	0.115	-0.605	-0.585	2600	-2000
06-Sep-92	0.01	1	0.142	0.116	-0.698	-0.694	2600	-400
07-Sep-92	0.01	1	0.176	0.155	-0.635	-0.614	2100	-2100
08-Sep-92	0.01	1	0.171	0.143	-0.48	-0.462	2800	-1800
09-Sep-92	0.01	1	0.17	0.141	-0.515	-0.494	2900	-2100

NORMAL POLARITY
SPECIMEN #2D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (1" 11/16 IN - 42.9mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.143	0.13	-0.09	-0.059	1300	-3100
28-Jul-92	0.01	1	0.138	0.128	-0.087	-0.055	1000	-3200
29-Jul-92	0.01	1	0.178	0.165	-0.107	-0.071	1300	-3600
30-Jul-92	0.01	1	0.516	0.433	-0.466	-0.364	8300	-10200
31-Jul-92	0.01	1	0.152	0.143	-0.096	-0.065	900	-3300
01-Aug-92	0.01	1	0.173	0.166	-0.105	-0.071	700	-3400
02-Aug-92	0.01	1	0.199	0.184	-0.11	-0.076	1500	-3400
03-Aug-92	0.01	1	0.202	0.186	-0.119	-0.083	1600	-3600
04-Aug-92	0.01	1	0.23	0.213	-0.127	-0.091	1700	-3600
05-Aug-92	0.01	1	0.275	0.256	-0.239	-0.137	1900	-10200
06-Aug-92	0.01	1	0.26	0.243	-0.319	-0.219	1700	-10000
07-Aug-92	0.01	1	0.289	0.268	-0.141	-0.103	2100	-3800
08-Aug-92	0.01	1	0.289	0.268	-0.141	-0.103	2100	-3800
09-Aug-92	0.01	1	0.316	0.293	-0.177	-0.132	2300	-4500
10-Aug-92	0.01	1	0.323	0.297	-0.18	-0.137	2600	-4300
11-Aug-92	0.01	1	0.33	0.307	-0.196	-0.15	2300	-4600
12-Aug-92	0.01	1	0.347	0.323	-0.203	-0.155	2400	-4800
13-Aug-92	0.01	1	0.347	0.323	-0.203	-0.155	2400	-4800
14-Aug-92	0.01	1	0.345	0.322	-0.213	-0.166	2300	-4700
15-Aug-92	0.01	1	0.346	0.325	-0.206	-0.162	2100	-4400
16-Aug-92	0.01	1	0.361	0.338	-0.202	-0.153	2300	-4900
17-Aug-92	0.01	1	0.416	0.387	-0.221	-0.176	2900	-4500
18-Aug-92	0.01	1	0.475	0.438	-0.246	-0.2	3700	-4600
19-Aug-92	0.01	1	0.397	0.374	-0.229	-0.188	2300	-4100
20-Aug-92	0.01	1	0.417	0.388	-0.23	-0.19	2900	-4000
21-Aug-92	0.01	1	0.479	0.449	-0.246	-0.206	3000	-4000
22-Aug-92	0.01	1	0.378	0.361	-0.228	-0.188	1700	-4000
23-Aug-92	0.01	1	0.378	0.361	-0.228	-0.188	1700	-4000
24-Aug-92	0.01	1	0.551	0.515	-0.314	-0.269	3600	-4500
25-Aug-92	0.01	1	0.573	0.532	-0.314	-0.271	4100	-4300
26-Aug-92	0.01	1	0.431	0.408	-0.245	-0.207	2300	-3800
27-Aug-92	0.01	1	0.463	0.437	-0.245	-0.209	2600	-3600
28-Aug-92	0.01	1	0.581	0.544	-0.312	-0.274	3700	-3800
29-Aug-92	0.01	1	0.402	0.385	-0.238	-0.206	1700	-3200
30-Aug-92	0.01	1	0.396	0.381	-0.238	-0.207	1500	-3100
31-Aug-92	0.01	1	0.399	0.383	-0.222	-0.19	1600	-3200
01-Sep-92	0.01	1	0.503	0.476	-0.323	-0.286	2700	-3700
02-Sep-92	0.01	1	0.388	0.373	-0.216	-0.187	1500	-2900
03-Sep-92	0.01	1	0.422	0.409	-0.241	-0.213	1300	-2800
04-Sep-92	0.01	1	0.384	0.373	-0.221	-0.194	1100	-2700
05-Sep-92	0.01	1	0.392	0.378	-0.229	-0.202	1400	-2700
06-Sep-92	0.01	1	0.391	0.376	-0.228	-0.201	1500	-2700
07-Sep-92	0.01	1	0.398	0.381	-0.263	-0.235	1700	-2800
08-Sep-92	0.01	1	0.206	0.176	-0.788	-0.791	3000	300
09-Sep-92	0.01	1	0.391	0.381	-0.265	-0.241	1000	-2400

REVERSED POLARITY
SPECIMEN #2D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (1" 11/16 IN - 42.9mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.088	0.058	-0.145	-0.132	3000	-1300
28-Jul-92	0.01	1	0.093	0.06	-0.15	-0.138	3300	-1200
29-Jul-92	0.01	1	0.111	0.073	-0.177	-0.162	3800	-1500
30-Jul-92	0.01	1	0.361	0.461	-0.54	-0.446	-10000	-9400
31-Jul-92	0.01	1	0.098	0.064	-0.162	-0.15	3400	-1200
01-Aug-92	0.01	1	0.105	0.067	0.176	0.162	3800	1400
02-Aug-92	0.01	1	0.109	0.071	-0.19	-0.175	3800	-1500
03-Aug-92	0.01	1	0.124	0.088	-0.218	-0.201	3600	-1700
04-Aug-92	0.01	1	0.117	0.08	-0.209	-0.193	3700	-1600
05-Aug-92	0.01	1	0.241	0.145	-0.27	-0.254	9600	-1600
06-Aug-92	0.01	1	0.316	0.216	-0.257	-0.241	10000	-1600
07-Aug-92	0.01	1	0.141	0.1	-0.277	-0.257	4100	-2000
08-Aug-92	0.01	1	0.141	0.1	-0.277	-0.257	4100	-2000
09-Aug-92	0.01	1	0.174	0.128	-0.317	-0.292	4600	-2500
10-Aug-92	0.01	1	0.174	0.131	-0.312	-0.291	4300	-2100
11-Aug-92	0.01	1	0.241	0.188	-0.502	-0.438	5300	-6400
12-Aug-92	0.01	1	0.189	0.143	-0.342	-0.318	4600	-2400
13-Aug-92	0.01	1	0.189	0.143	-0.342	-0.318	4600	-2400
14-Aug-92	0.01	1	0.209	0.165	-0.365	-0.34	4400	-2500
15-Aug-92	0.01	1	0.205	0.159	-0.364	-0.334	4600	-3000
16-Aug-92	0.01	1	0.205	0.16	-0.388	-0.361	4500	-2700
17-Aug-92	0.01	1	0.217	0.173	-0.359	-0.336	4400	-2300
18-Aug-92	0.01	1	0.239	0.193	-0.472	-0.434	4600	-3800
19-Aug-92	0.01	1	0.205	0.165	-0.335	-0.314	4000	-2100
20-Aug-92	0.01	1	0.221	0.183	-0.464	-0.431	3800	-3300
21-Aug-92	0.01	1	0.246	0.205	-0.53	-0.49	4100	-4000
22-Aug-92	0.01	1	0.245	0.205	-0.558	-0.514	4000	-4400
23-Aug-92	0.01	1	0.245	0.205	-0.558	-0.514	4000	-4400
24-Aug-92	0.01	1	0.316	0.271	-0.546	-0.508	4500	-3800
25-Aug-92	0.01	1	0.314	0.269	-0.567	-0.527	4500	-4000
26-Aug-92	0.01	1	0.235	0.2	-0.426	-0.405	3500	-2100
27-Aug-92	0.01	1	0.241	0.205	-0.464	-0.434	3600	-3000
28-Aug-92	0.01	1	0.242	0.209	-0.394	-0.377	3300	-1700
29-Aug-92	0.01	1	0.218	0.184	-0.403	-0.389	3400	-1400
30-Aug-92	0.01	1	0.23	0.198	-0.396	-0.382	3200	-1400
31-Aug-92	0.01	1	0.216	0.187	-0.402	-0.384	2900	-1800
01-Sep-92	0.01	1	0.198	0.171	-0.356	-0.345	2700	-1100
02-Sep-92	0.01	1	0.225	0.195	-0.481	-0.462	3000	-1900
03-Sep-92	0.01	1	0.23	0.202	-0.462	-0.443	2800	-1900
04-Sep-92	0.01	1	0.226	0.199	-0.388	-0.373	2700	-1500
05-Sep-92	0.01	1	0.231	0.205	-0.477	-0.46	2600	-1700
06-Sep-92	0.01	1	0.232	0.206	-0.476	-0.459	2600	-1700
07-Sep-92	0.01	1	0.262	0.233	-0.396	-0.383	2900	-1300
08-Sep-92	0.01	1	0.252	0.225	-0.513	-0.493	2700	-2000
09-Sep-92	0.01	1	0.307	0.283	-0.383	-0.369	2400	-1400

NORMAL POLARITY
SPECIMEN #2E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.18	0.169	-0.037	-0.023	1100	-1400
28-Jul-92	0.01	1	0.195	0.183	-0.035	-0.026	1200	-900
29-Jul-92	0.01	1	0.196	0.185	-0.036	-0.025	1100	-1100
30-Jul-92	0.01	1	0.518	0.437	-0.463	-0.391	8100	-9200
31-Jul-92	0.01	1	0.228	0.214	-0.043	-0.028	1400	-1500
01-Aug-92	0.01	1	0.241	0.229	-0.105	-0.096	1200	-900
02-Aug-92	0.01	1	0.252	0.24	-0.154	-0.104	1200	-5000
03-Aug-92	0.01	1	0.28	0.266	-0.16	-0.105	1400	-5500
04-Aug-92	0.01	1	0.247	0.215	-0.29	-0.154	3200	-13600
05-Aug-92	0.01	1	0.309	0.291	-0.189	-0.137	1800	-5200
06-Aug-92	0.01	1	0.319	0.301	-0.203	-0.149	1800	-5400
07-Aug-92	0.01	1	0.347	0.327	-0.207	-0.156	2000	-5100
08-Aug-92	0.01	1	0.347	0.327	-0.207	-0.156	2000	-5100
09-Aug-92	0.01	1	0.365	0.343	-0.202	-0.149	2200	-5300
10-Aug-92	0.01	1	0.388	0.362	-0.213	-0.157	2600	-5600
11-Aug-92	0.01	1	0.382	0.357	-0.216	-0.16	2500	-5600
12-Aug-92	0.01	1	0.398	0.374	-0.209	-0.162	2400	-4700
13-Aug-92	0.01	1	0.398	0.374	-0.209	-0.162	2400	-4700
14-Aug-92	0.01	1	0.412	0.389	-0.197	-0.152	2300	-4500
15-Aug-92	0.01	1	0.422	0.399	-0.189	-0.145	2300	-4400
16-Aug-92	0.01	1	0.436	0.412	-0.187	-0.143	2400	-4400
17-Aug-92	0.01	1	0.441	0.416	-0.194	-0.149	2500	-4500
18-Aug-92	0.01	1	0.439	0.412	-0.194	-0.148	2700	-4600
19-Aug-92	0.01	1	0.413	0.386	-0.201	-0.153	2700	-4800
20-Aug-92	0.01	1	0.407	0.382	-0.216	-0.17	2500	-4600
21-Aug-92	0.01	1	0.43	0.403	-0.207	-0.161	2700	-4600
22-Aug-92	0.01	1	0.452	0.421	-0.199	-0.148	3100	-5100
23-Aug-92	0.01	1	0.452	0.421	-0.199	-0.148	3100	-5100
24-Aug-92	0.01	1	0.466	0.435	-0.2	-0.151	3100	-4900
25-Aug-92	0.01	1	0.468	0.427	-0.257	-0.22	4100	-3700
26-Aug-92	0.01	1	0.472	0.415	-0.303	-0.274	5700	-2900
27-Aug-92	0.01	1	0.463	0.428	-0.229	-0.174	3500	-5500
28-Aug-92	0.01	1	0.487	0.455	-0.214	-0.158	3200	-5600
29-Aug-92	0.01	1	0.457	0.426	-0.216	-0.163	3100	-5300
30-Aug-92	0.01	1	0.496	0.467	-0.199	-0.143	2900	-5600
31-Aug-92	0.01	1	0.409	0.318	-0.592	-0.594	9100	200
01-Sep-92	0.01	1	0.465	0.435	-0.185	-0.137	3000	-4800
02-Sep-92	0.01	1	0.418	0.33	-0.585	-0.584	8800	-100
03-Sep-92	0.01	1	0.413	0.325	-0.588	-0.589	8800	100
04-Sep-92	0.01	1	0.417	0.327	-0.585	-0.584	9000	-100
05-Sep-92	0.01	1	0.468	0.436	-0.175	-0.127	3200	-4800
06-Sep-92	0.01	1	0.47	0.434	-0.173	-0.126	3600	-4700
07-Sep-92	0.01	1	0.409	0.322	-0.592	-0.593	8700	100
08-Sep-92	0.01	1	0.477	0.433	-0.211	-0.166	4400	-4500
09-Sep-92	0.01	1	0.407	0.312	-0.595	-0.596	9500	100

REVERSED POLARITY
SPECIMEN #2E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (6-8)mil
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.036	0.025	-0.187	-0.173	1300	-1400
28-Jul-92	0.01	1	0.157	0.108	-0.192	-0.181	4900	-1100
29-Jul-92	0.01	1	0.153	0.106	-0.197	-0.185	4700	-1200
30-Jul-92	0.01	1	0.158	0.118	-0.211	-0.199	4000	-1200
31-Jul-92	0.01	1	0.151	0.101	-0.224	-0.212	5000	-1200
01-Aug-92	0.01	1	0.151	0.101	-0.224	-0.212	5000	-1200
02-Aug-92	0.01	1	0.151	0.1	-0.253	-0.241	5100	-1200
03-Aug-92	0.01	1	0.051	0.035	-0.282	-0.268	1600	-1400
04-Aug-92	0.01	1	0.196	0.135	-0.276	-0.26	6100	-1600
05-Aug-92	0.01	1	0.187	0.134	-0.308	-0.292	5300	-1600
06-Aug-92	0.01	1	0.199	0.146	-0.322	-0.305	5300	-1700
07-Aug-92	0.01	1	0.199	0.149	-0.347	-0.328	5000	-1900
08-Aug-92	0.01	1	0.199	0.149	-0.347	-0.328	5000	-1900
09-Aug-92	0.01	1	0.197	0.143	-0.366	-0.343	5400	-2300
10-Aug-92	0.01	1	0.208	0.153	-0.388	-0.363	5500	-2500
11-Aug-92	0.01	1	0.213	0.157	-0.382	-0.358	5600	-2400
12-Aug-92	0.01	1	0.206	0.159	-0.4	-0.375	4700	-2500
13-Aug-92	0.01	1	0.206	0.159	-0.4	-0.375	4700	-2500
14-Aug-92	0.01	1	0.192	0.147	-0.408	-0.387	4500	-2100
15-Aug-92	0.01	1	0.186	0.141	-0.419	-0.397	4500	-2200
16-Aug-92	0.01	1	0.183	0.138	-0.436	-0.413	4500	-2300
17-Aug-92	0.01	1	0.186	0.141	-0.442	-0.418	4500	-2400
18-Aug-92	0.01	1	0.191	0.144	-0.433	-0.41	4700	-2300
19-Aug-92	0.01	1	0.199	0.15	-0.405	-0.382	4900	-2300
20-Aug-92	0.01	1	0.209	0.162	-0.404	-0.383	4700	-2100
21-Aug-92	0.01	1	0.204	0.157	-0.427	-0.405	4700	-2200
22-Aug-92	0.01	1	0.198	0.149	-0.444	-0.418	4900	-2600
23-Aug-92	0.01	1	0.198	0.149	-0.444	-0.418	4900	-2600
24-Aug-92	0.01	1	0.189	0.143	-0.463	-0.436	4600	-2700
25-Aug-92	0.01	1	0.21	0.156	-0.463	-0.433	5400	-3000
26-Aug-92	0.01	1	0.223	0.166	-0.462	-0.431	5700	-3100
27-Aug-92	0.01	1	0.214	0.157	-0.46	-0.429	5700	-3100
28-Aug-92	0.01	1	0.212	0.153	-0.494	-0.457	5900	-3700
29-Aug-92	0.01	1	0.211	0.145	-0.457	-0.422	6600	-3500
30-Aug-92	0.01	1	0.195	0.142	-0.507	-0.475	5300	-3200
31-Aug-92	0.01	1	0.196	0.146	-0.453	-0.428	5000	-2500
01-Sep-92	0.01	1	0.18	0.133	-0.463	-0.437	4700	-2600
02-Sep-92	0.01	1	0.218	0.168	-0.436	-0.409	5000	-2700
03-Sep-92	0.01	1	0.108	0.083	-0.421	-0.396	2500	-2500
04-Sep-92	0.01	1	0.221	0.171	-0.419	-0.395	5000	-2400
05-Sep-92	0.01	1	0.175	0.125	-0.47	-0.44	5000	-3000
06-Sep-92	0.01	1	0.173	0.124	-0.468	-0.438	4900	-3000
07-Sep-92	0.01	1	0.222	0.174	-0.45	-0.418	4800	-3200
08-Sep-92	0.01	1	0.195	0.155	-0.461	-0.434	4000	-2700
09-Sep-92	0.01	1	0.226	0.171	-0.445	-0.418	5500	-2700

NORMAL POLARITY
SPECIMEN #3A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE	RESISTANCE
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.05	0.049	-0.029	-0.018	100	-1100
28-Jul-92	0.01	1	0.457	0.445	-0.146	-0.092	1200	-5400
29-Jul-92	0.01	1	0.506	0.488	-0.161	-0.096	1800	-6500
30-Jul-92	0.01	1	0.463	0.427	-0.52	-0.453	5600	-6700
31-Jul-92	0.01	1	0.257	0.188	-0.133	-0.09	6900	-4300
01-Aug-92	0.01	1	0.285	0.226	-0.118	-0.075	5900	-4300
02-Aug-92	0.01	1	0.326	0.318	-0.088	-0.064	800	-2400
03-Aug-92	0.01	1	0.167	0.165	-0.049	-0.038	200	-1100
04-Aug-92	0.01	1	0.086	0.084	-0.033	-0.026	200	-700
05-Aug-92	0.01	1	0.103	0.1	-0.038	-0.033	300	-500
06-Aug-92	0.01	1	0.121	0.119	-0.047	-0.038	200	-900
07-Aug-92	0.01	1	0.234	0.231	-0.079	-0.066	300	-1300
08-Aug-92	0.01	1	0.234	0.231	-0.079	-0.066	300	-1300
09-Aug-92	0.01	1	0.192	0.19	-0.102	-0.091	200	-1100
10-Aug-92	0.01	1	0.275	0.27	-0.11	-0.1	500	-1000
11-Aug-92	0.01	1	0.233	0.227	-0.12	-0.107	600	-1300.
12-Aug-92	0.01	1	0.207	0.204	-0.152	-0.14	300	-1200
13-Aug-92	0.01	1	0.207	0.204	-0.152	-0.14	300	-1200
14-Aug-92	0.01	1	0.203	0.201	-0.154	-0.136	200	-1800
15-Aug-92	0.01	1	0.205	0.202	-0.171	-0.161	300	-1000
16-Aug-92	0.01	1	0.388	0.365	-0.176	-0.164	2300	-1200
17-Aug-92	0.01	1	0.254	0.249	-0.193	-0.187	500	-600
18-Aug-92	0.01	1	0.257	0.252	-0.188	-0.183	500	-500
19-Aug-92	0.01	1	0.227	0.221	-0.193	-0.184	600	-900
20-Aug-92	0.01	1	0.233	0.229	-0.172	-0.165	400	-700
21-Aug-92	0.01	1	0.248	0.235	-0.194	-0.185	1300	-900
22-Aug-92	0.01	1	0.247	0.241	-0.198	-0.192	600	-600
23-Aug-92	0.01	1	0.247	0.241	-0.198	-0.192	600	-600
24-Aug-92	0.01	1	0.261	0.255	-0.217	-0.209	600	-800
25-Aug-92	0.01	1	0.257	0.253	-0.223	-0.214	400	-900
26-Aug-92	0.01	1	0.267	0.262	-0.232	-0.225	500	-700
27-Aug-92	0.01	1	0.265	0.261	-0.223	-0.216	400	-700
28-Aug-92	0.01	1	0.257	0.252	-0.235	-0.224	500	-1100
29-Aug-92	0.01	1	0.255	0.25	-0.225	-0.215	500	-1000
30-Aug-92	0.01	1	0.254	0.249	-0.247	-0.237	500	-1000
31-Aug-92	0.01	1	0.201	0.195	-0.172	-0.168	600	-400
01-Sep-92	0.01	1	0.201	0.195	-0.172	-0.168	600	-400
02-Sep-92	0.01	1	0.225	0.22	-0.18	-0.171	500	-900
03-Sep-92	0.01	1	0.245	0.241	-0.186	-0.18	400	-600
04-Sep-92	0.01	1	0.242	0.239	-0.219	-0.215	300	-400
05-Sep-92	0.01	1	0.231	0.229	-0.206	-0.204	200	-200
06-Sep-92	0.01	1	0.229	0.227	-0.203	-0.202	200	-100
07-Sep-92	0.01	1	0.234	0.231	-0.214	-0.21	300	-400
08-Sep-92	0.01	1	0.245	0.239	-0.207	-0.205	600	-200
09-Sep-92	0.01	1	0.245	0.215	-0.159	-0.152	3000	-700

REVERSED POLARITY
SPECIMEN #3A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.25	0.233	-0.048	-0.046	1700	-200
28-Jul-92	0.01	1	0.211	0.201	-0.057	-0.056	1000	-100
29-Jul-92	0.01	1	0.025	0.014	-0.055	-0.053	1100	-200
30-Jul-92	0.01	1	0.343	0.262	-0.657	-0.606	8100	-5100
31-Jul-92	0.01	1	0.091	0.061	-0.331	-0.321	3000	-1000
01-Aug-92	0.01	1	0.121	0.075	-0.431	-0.419	4600	-1200
02-Aug-92	0.01	1	0.137	0.099	-0.533	-0.517	3800	-1600
03-Aug-92	0.01	1	0.219	0.164	-0.488	-0.477	5500	-1100
04-Aug-92	0.01	1	0.063	0.049	-0.181	-0.178	1400	-300
05-Aug-92	0.01	1	0.042	0.036	-0.099	-0.101	600	200
06-Aug-92	0.01	1	0.05	0.042	-0.188	-0.184	800	-400
07-Aug-92	0.01	1	0.072	0.062	-0.168	-0.166	1000	-200
08-Aug-92	0.01	1	0.072	0.062	-0.168	-0.166	1000	-200
09-Aug-92	0.01	1	0.088	0.081	-0.176	-0.169	700	-700
10-Aug-92	0.01	1	0.11	0.097	-0.262	-0.26	1300	-200
11-Aug-92	0.01	1	0.117	0.105	-0.234	-0.227	1200	-700
12-Aug-92	0.01	1	0.145	0.133	-0.194	-0.198	1200	400
13-Aug-92	0.01	1	0.145	0.133	-0.194	-0.198	1200	400
14-Aug-92	0.01	1	0.154	0.147	-0.196	-0.193	700	-300
15-Aug-92	0.01	1	0.168	0.155	-0.198	-0.194	1300	-400
16-Aug-92	0.01	1	0.177	0.162	-0.345	-0.34	1500	-500
17-Aug-92	0.01	1	0.201	0.185	-0.26	-0.252	1600	-800
18-Aug-92	0.01	1	0.186	0.174	-0.234	-0.243	1200	900
19-Aug-92	0.01	1	0.164	0.157	-0.214	-0.22	700	600
20-Aug-92	0.01	1	0.172	0.168	-0.235	-0.231	400	-400
21-Aug-92	0.01	1	0.199	0.187	-0.232	-0.227	1200	-500
22-Aug-92	0.01	1	0.2	0.191	-0.241	-0.239	900	-200
23-Aug-92	0.01	1	0.2	0.191	-0.241	-0.239	900	-200
24-Aug-92	0.01	1	0.211	0.202	-0.249	-0.243	900	-600
25-Aug-92	0.01	1	0.226	0.217	-0.264	-0.256	900	-800
26-Aug-92	0.01	1	0.23	0.223	-0.256	-0.254	700	-200
27-Aug-92	0.01	1	0.226	0.222	-0.256	-0.253	400	-300
28-Aug-92	0.01	1	0.229	0.215	-0.245	-0.237	1400	-800
29-Aug-92	0.01	1	0.225	0.214	-0.239	-0.243	1100	400
30-Aug-92	0.01	1	0.214	0.21	-0.238	-0.231	400	-700
31-Aug-92	0.01	1	0.163	0.16	-0.191	-0.189	300	-200
01-Sep-92	0.01	1	0.199	0.192	-0.195	-0.196	700	100
02-Sep-92	0.01	1	0.153	0.149	-0.193	-0.192	400	-100
03-Sep-92	0.01	1	0.193	0.178	-0.217	-0.219	1500	200
04-Sep-92	0.01	1	0.199	0.191	-0.209	-0.211	800	200
05-Sep-92	0.01	1	0.194	0.186	-0.215	-0.212	800	-300
06-Sep-92	0.01	1	0.177	0.171	-0.214	-0.211	600	-300
07-Sep-92	0.01	1	0.196	0.191	-0.226	-0.223	500	-300
08-Sep-92	0.01	1	0.207	0.205	-0.222	-0.235	200	1300
09-Sep-92	0.01	1	0.152	0.146	-0.209	-0.207	600	-200

NORMAL POLARITY
SPECIMEN #3B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.014	0.01	-0.046	-0.04	400	-600
28-Jul-92	0.01	1	0.125	0.096	-0.346	-0.297	2900	-4900
29-Jul-92	0.01	1	0.255	0.221	-0.379	-0.305	3400	-7400
30-Jul-92	0.01	1	0.404	0.34	-0.597	-0.484	6400	-11300
31-Jul-92	0.01	1	0.153	0.115	-0.315	-0.278	3800	-3700
01-Aug-92	0.01	1	0.153	0.115	-0.315	-0.278	3800	-3700
02-Aug-92	0.01	1	0.137	0.105	-0.275	-0.229	3200	-4600
03-Aug-92	0.01	1	0.25	0.218	-0.262	-0.22	3200	-4200
04-Aug-92	0.01	1	0.252	0.216	-0.284	-0.246	3600	-3800
05-Aug-92	0.01	1	0.266	0.234	-0.287	-0.25	3200	-3700
06-Aug-92	0.01	1	0.266	0.235	-0.292	-0.258	3100	-3400
07-Aug-92	0.01	1	0.284	0.252	-0.307	-0.275	3200	-3200
08-Aug-92	0.01	1	0.284	0.252	-0.307	-0.275	3200	-3200
09-Aug-92	0.01	1	0.275	0.245	-0.341	-0.294	3000	-4700
10-Aug-92	0.01	1	0.28	0.252	-0.37	-0.331	2800	-3900
11-Aug-92	0.01	1	0.307	0.281	-0.327	-0.29	2600	-3700
12-Aug-92	0.01	1	0.284	0.26	-0.359	-0.326	2400	-3300
13-Aug-92	0.01	1	0.284	0.26	-0.359	-0.326	2400	-3300
14-Aug-92	0.01	1	0.288	0.261	-0.341	-0.312	2700	-2900
15-Aug-92	0.01	1	0.316	0.291	-0.337	-0.304	2500	-3300
16-Aug-92	0.01	1	0.315	0.291	-0.346	-0.306	2400	-4000
17-Aug-92	0.01	1	0.277	0.254	-0.355	-0.322	2300	-3300
18-Aug-92	0.01	1	0.163	0.126	-0.338	-0.308	3700	-3000
19-Aug-92	0.01	1	0.135	0.114	-0.322	-0.293	2100	-2900
20-Aug-92	0.01	1	0.136	0.114	-0.312	-0.281	2200	-3100
21-Aug-92	0.01	1	0.259	0.235	-0.319	-0.292	2400	-2700
22-Aug-92	0.01	1	0.233	0.21	-0.366	-0.328	2300	-3800
23-Aug-92	0.01	1	0.233	0.21	-0.366	-0.328	2300	-3800
24-Aug-92	0.01	1	0.24	0.22	-0.359	-0.316	2000	-4300
25-Aug-92	0.01	1	0.252	0.225	-0.392	-0.348	2700	-4400
26-Aug-92	0.01	1	0.256	0.211	-0.409	-0.368	4500	-4100
27-Aug-92	0.01	1	0.257	0.237	-0.398	-0.365	2000	-3300
28-Aug-92	0.01	1	0.269	0.238	-0.405	-0.36	3100	-4500
29-Aug-92	0.01	1	0.258	0.254	-0.414	-0.37	400	-4400
30-Aug-92	0.01	1	0.239	0.215	-0.436	-0.391	2400	-4500
31-Aug-92	0.01	1	0.255	0.235	-0.362	-0.336	2000	-2600
01-Sep-92	0.01	1	0.256	0.237	-0.362	-0.338	1900	-2400
02-Sep-92	0.01	1	0.313	0.296	-0.356	-0.327	1700	-2900
03-Sep-92	0.01	1	0.306	0.291	-0.39	-0.339	1500	-5100
04-Sep-92	0.01	1	0.302	0.283	-0.396	-0.357	1900	-3900
05-Sep-92	0.01	1	0.298	0.282	-0.417	-0.379	1600	-3800
06-Sep-92	0.01	1	0.296	0.28	-0.415	-0.38	1600	-3500
07-Sep-92	0.01	1	0.289	0.272	-0.443	-0.397	1700	-4600
08-Sep-92	0.01	1	0.284	0.268	-0.457	-0.409	1600	-4800
09-Sep-92	0.01	1	0.278	0.266	-0.443	-0.401	1200	-4200

REVERSED POLARITY
SPECIMEN #3B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.448	0.341	-0.12	-0.115	10700	-500
28-Jul-92	0.01	1	0.339	0.272	-0.15	-0.117	6700	-3300
29-Jul-92	0.01	1	0.361	0.288	-0.164	-0.135	7300	-2900
30-Jul-92	0.01	1	0.549	0.443	-0.453	-0.383	10600	-7000
31-Jul-92	0.01	1	0.308	0.28	-0.23	-0.19	2800	-4000
01-Aug-92	0.01	1	0.286	0.253	-0.245	-0.211	3300	-3400
02-Aug-92	0.01	1	0.262	0.214	-0.262	-0.221	4800	-4100
03-Aug-92	0.01	1	0.245	0.202	-0.105	-0.083	4300	-2200
04-Aug-92	0.01	1	0.273	0.231	-0.115	-0.093	4200	-2200
05-Aug-92	0.01	1	0.281	0.232	-0.14	-0.133	4900	-700
06-Aug-92	0.01	1	0.284	0.233	-0.16	-0.13	5100	-3000
07-Aug-92	0.01	1	0.307	0.257	-0.143	-0.134	5000	-900
08-Aug-92	0.01	1	0.307	0.257	-0.143	-0.134	5000	-900
09-Aug-92	0.01	1	0.332	0.276	-0.155	-0.14	5600	-1500
10-Aug-92	0.01	1	0.361	0.297	-0.18	-0.17	6400	-1000
11-Aug-92	0.01	1	0.322	0.271	-0.172	-0.147	5100	-2500
12-Aug-92	0.01	1	0.338	0.288	-0.18	-0.169	5000	-1100
13-Aug-92	0.01	1	0.338	0.288	-0.18	-0.169	5000	-1100
14-Aug-92	0.01	1	0.362	0.326	-0.188	-0.162	3600	-2600
15-Aug-92	0.01	1	0.329	0.28	-0.184	-0.163	4900	-2100
16-Aug-92	0.01	1	0.333	0.282	-0.198	-0.176	5100	-2200
17-Aug-92	0.01	1	0.352	0.301	-0.168	-0.152	5100	-1600
18-Aug-92	0.01	1	0.336	0.287	-0.153	-0.131	4900	-2200
19-Aug-92	0.01	1	0.302	0.266	-0.138	-0.117	3600	-2100
20-Aug-92	0.01	1	0.302	0.266	-0.147	-0.136	3600	-1100
21-Aug-92	0.01	1	0.327	0.284	-0.146	-0.13	4300	-1600
22-Aug-92	0.01	1	0.368	0.314	-0.147	-0.137	5400	-1000
23-Aug-92	0.01	1	0.368	0.314	-0.147	-0.137	5400	-1000
24-Aug-92	0.01	1	0.348	0.317	-0.163	-0.14	3100	-2300
25-Aug-92	0.01	1	0.391	0.338	-0.159	-0.138	5300	-2100
26-Aug-92	0.01	1	0.407	0.353	-0.161	-0.147	5400	-1400
27-Aug-92	0.01	1	0.394	0.339	-0.175	-0.147	5500	-2800
28-Aug-92	0.01	1	0.406	0.351	-0.17	-0.14	5500	-3000
29-Aug-92	0.01	1	0.399	0.346	-0.181	-0.158	5300	-2300
30-Aug-92	0.01	1	0.393	0.332	-0.174	-0.158	6100	-1600
31-Aug-92	0.01	1	0.374	0.297	-0.159	-0.144	7700	-1500
01-Sep-92	0.01	1	0.376	0.3	-0.158	-0.145	7600	-1300
02-Sep-92	0.01	1	0.382	0.335	-0.172	-0.158	4700	-1400
03-Sep-92	0.01	1	0.385	0.342	-0.296	-0.279	4300	-1700
04-Sep-92	0.01	1	0.393	0.35	-0.17	-0.16	4300	-1000
05-Sep-92	0.01	1	0.416	0.413	-0.191	-0.185	300	-600
06-Sep-92	0.01	1	0.418	0.414	-0.189	-0.183	400	-600
07-Sep-92	0.01	1	0.443	0.392	-0.296	-0.28	5100	-1600
08-Sep-92	0.01	1	0.436	0.385	-0.194	-0.183	5100	-1100
09-Sep-92	0.01	1	0.437	0.386	-0.31	-0.289	5100	-2100

NORMAL POLARITY
SPECIMEN #3C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.292	0.269	-0.056	-0.045	2300	-1100
28-Jul-92	0.01	1	0.322	0.293	-0.075	-0.066	2900	-900
29-Jul-92	0.01	1	0.238	0.226	-0.05	-0.042	1200	-800
30-Jul-92	0.01	1	0.522	0.462	-0.481	-0.416	6000	-6500
31-Jul-92	0.01	1	0.265	0.252	-0.047	-0.038	1300	-900
01-Aug-92	0.01	1	0.351	0.329	-0.076	-0.065	2200	-1100
02-Aug-92	0.01	1	0.431	0.403	-0.096	-0.079	2800	-1700
03-Aug-92	0.01	1	0.517	0.47	-0.148	-0.134	4700	-1400
04-Aug-92	0.01	1	0.511	0.476	-0.084	-0.07	3500	-1400
05-Aug-92	0.01	1	0.527	0.496	-0.088	-0.07	3100	-1800
06-Aug-92	0.01	1	0.559	0.523	-0.115	-0.1	3600	-1500
07-Aug-92	0.01	1	0.62	0.576	-0.151	-0.13	4400	-2100
08-Aug-92	0.01	1	0.62	0.576	-0.151	-0.13	4400	-2100
09-Aug-92	0.01	1	0.646	0.605	-0.085	-0.067	4100	-1800
10-Aug-92	0.01	1	0.643	0.599	-0.115	-0.094	4400	-2100
11-Aug-92	0.01	1	0.627	0.59	-0.12	-0.095	3700	-2500
12-Aug-92	0.01	1	0.606	0.565	-0.094	-0.074	4100	-2000
13-Aug-92	0.01	1	0.606	0.565	-0.094	-0.074	4100	-2000
14-Aug-92	0.01	1	0.614	0.568	-0.088	-0.065	4600	-2300
15-Aug-92	0.01	1	0.609	0.566	-0.105	-0.09	4300	-1500
16-Aug-92	0.01	1	0.641	0.593	-0.09	-0.071	4800	-1900
17-Aug-92	0.01	1	0.675	0.618	-0.085	-0.058	5700	-2900
18-Aug-92	0.01	1	0.68	0.642	-0.078	-0.07	3800	-800
19-Aug-92	0.01	1	0.635	0.595	-0.065	-0.04	4000	-2500
20-Aug-92	0.01	1	0.625	0.582	-0.076	-0.057	4300	-1900
21-Aug-92	0.01	1	0.622	0.579	-0.071	-0.054	4300	-1700
22-Aug-92	0.01	1	0.628	0.585	-0.072	-0.055	4300	-1700
23-Aug-92	0.01	1	0.628	0.585	-0.072	-0.055	4300	-1700
24-Aug-92	0.01	1	0.635	0.596	-0.075	-0.066	3900	-900
25-Aug-92	0.01	1	0.662	0.626	-0.054	-0.04	3600	-1400
26-Aug-92	0.01	1	0.691	0.653	-0.042	-0.026	3800	-1600
27-Aug-92	0.01	1	0.657	0.616	-0.051	-0.034	4100	-1700
28-Aug-92	0.01	1	0.656	0.621	-0.062	-0.042	3500	-2000
29-Aug-92	0.01	1	0.652	0.617	-0.065	-0.047	3500	-1800
30-Aug-92	0.01	1	0.639	0.602	-0.06	-0.041	3700	-1900
31-Aug-92	0.01	1	0.612	0.572	-0.067	-0.05	4000	-1700
01-Sep-92	0.01	1	0.624	0.584	-0.07	-0.053	4000	-1700
02-Sep-92	0.01	1	0.545	0.546	-0.075	-0.057	-100	-1800
03-Sep-92	0.01	1	0.602	0.564	-0.069	-0.052	3800	-1700
04-Sep-92	0.01	1	0.591	0.552	-0.095	-0.076	3900	-1900
05-Sep-92	0.01	1	0.618	0.578	-0.084	-0.068	4000	-1600
06-Sep-92	0.01	1	0.619	0.579	-0.083	-0.066	4000	-1700
07-Sep-92	0.01	1	0.604	0.57	-0.12	-0.105	3400	-1500
08-Sep-92	0.01	1	0.626	0.584	-0.109	-0.089	4200	-2000
09-Sep-92	0.01	1	0.595	0.559	-0.142	-0.127	3600	-1500

REVERSED POLARITY
SPECIMEN #3C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.132	0.1	-0.317	-0.289	3200	-2800
28-Jul-92	0.01	1	0.174	0.141	-0.338	-0.31	3300	-2800
29-Jul-92	0.01	1	0.136	0.103	-0.209	-0.202	3300	-700
30-Jul-92	0.01	1	0.436	0.376	-0.565	-0.497	6000	-6800
31-Jul-92	0.01	1	0.037	0.028	-0.249	-0.237	900	-1200
01-Aug-92	0.01	1	0.044	0.035	-0.337	-0.324	900	-1300
02-Aug-92	0.01	1	0.054	0.042	-0.414	-0.39	1200	-2400
03-Aug-92	0.01	1	0.208	0.167	-0.515	-0.488	4100	-2700
04-Aug-92	0.01	1	0.065	0.048	-0.496	-0.467	1700	-2900
05-Aug-92	0.01	1	0.138	0.118	-0.525	-0.495	2000	-3000
06-Aug-92	0.01	1	0.097	0.078	-0.553	-0.522	1900	-3100
07-Aug-92	0.01	1	0.135	0.122	-0.605	-0.564	1300	-4100
08-Aug-92	0.01	1	0.135	0.122	-0.605	-0.564	1300	-4100
09-Aug-92	0.01	1	0.095	0.066	-0.634	-0.594	2900	-4000
10-Aug-92	0.01	1	0.118	0.096	-0.636	-0.605	2200	-3100
11-Aug-92	0.01	1	0.118	0.088	-0.626	-0.593	3000	-3300
12-Aug-92	0.01	1	0.096	0.079	-0.597	-0.56	1700	-3700
13-Aug-92	0.01	1	0.096	0.079	-0.597	-0.56	1700	-3700
14-Aug-92	0.01	1	0.097	0.064	-0.605	-0.565	3300	-4000
15-Aug-92	0.01	1	0.103	0.087	-0.601	-0.561	1600	-4000
16-Aug-92	0.01	1	0.09	0.07	-0.706	-0.656	2000	-5000
17-Aug-92	0.01	1	0.085	0.065	-0.657	-0.614	2000	-4300
18-Aug-92	0.01	1	0.089	0.049	-0.669	-0.631	4000	-3800
19-Aug-92	0.01	1	0.059	0.042	-0.622	-0.588	1700	-3400
20-Aug-92	0.01	1	0.076	0.058	-0.609	-0.571	1800	-3800
21-Aug-92	0.01	1	0.084	0.061	-0.595	-0.558	2300	-3700
22-Aug-92	0.01	1	0.076	0.058	-0.614	-0.576	1800	-3800
23-Aug-92	0.01	1	0.076	0.058	-0.614	-0.576	1800	-3800
24-Aug-92	0.01	1	0.09	0.068	-0.615	-0.58	2200	-3500
25-Aug-92	0.01	1	0.077	0.058	-0.642	-0.604	1900	-3800
26-Aug-92	0.01	1	0.055	0.037	-0.674	-0.638	1800	-3600
27-Aug-92	0.01	1	0.078	0.056	-0.627	-0.592	2200	-3500
28-Aug-92	0.01	1	0.086	0.066	-0.631	-0.597	2000	-3400
29-Aug-92	0.01	1	0.093	0.072	-0.606	-0.596	2100	-1000
30-Aug-92	0.01	1	0.088	0.067	-0.613	-0.576	2100	-3700
31-Aug-92	0.01	1	0.095	0.075	-0.581	-0.548	2000	-3300
01-Sep-92	0.01	1	0.095	0.075	-0.58	-0.549	2000	-3100
02-Sep-92	0.01	1	0.1	0.08	-0.57	-0.535	2000	-3500
03-Sep-92	0.01	1	0.102	0.083	-0.574	-0.541	1900	-3300
04-Sep-92	0.01	1	0.123	0.104	-0.569	-0.533	1900	-3600
05-Sep-92	0.01	1	0.105	0.085	-0.585	-0.552	2000	-3300
06-Sep-92	0.01	1	0.104	0.087	-0.583	-0.55	1700	-3300
07-Sep-92	0.01	1	0.113	0.095	-0.602	-0.567	1800	-3500
08-Sep-92	0.01	1	0.141	0.123	-0.57	-0.536	1800	-3400
09-Sep-92	0.01	1	0.172	0.15	-0.581	-0.545	2200	-3600

NORMAL POLARITY
SPECIMEN #30
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
27-Jul-92	0.01	1	0.326	0.323	-0.234	-0.21	300	-2400
28-Jul-92	0.01	1	0.324	0.323	-0.212	-0.217	100	500
29-Jul-92	0.01	1	0.326	0.331	-0.196	-0.205	-500	900
30-Jul-92	0.01	1	0.533	0.525	-0.471	-0.46	800	-1100
31-Jul-92	0.01	1	0.409	0.405	-0.183	-0.199	400	1600
01-Aug-92	0.01	1	0.409	0.405	-0.183	-0.199	400	1600
02-Aug-92	0.01	1	0.409	0.414	-0.185	-0.203	-500	1800
03-Aug-92	0.01	1	0.549	0.552	-0.186	-0.209	-300	2300
04-Aug-92	0.01	1	0.505	0.508	-0.199	-0.223	-300	2400
05-Aug-92	0.01	1	0.479	0.482	-0.231	-0.251	-300	2000
06-Aug-92	0.01	1	0.467	0.493	-0.236	-0.205	-600	-3100
07-Aug-92	0.01	1	0.526	0.53	-0.265	-0.286	-400	2100
08-Aug-92	0.01	1	0.526	0.53	-0.265	-0.286	-400	2100
09-Aug-92	0.01	1	0.576	0.581	-0.256	-0.274	-500	1800
10-Aug-92	0.01	1	0.585	0.589	-0.316	-0.279	-400	-3700
11-Aug-92	0.01	1	0.552	0.556	-0.305	-0.325	-400	2000
12-Aug-92	0.01	1	0.592	0.594	-0.289	-0.306	-200	1700
13-Aug-92	0.01	1	0.592	0.594	-0.289	-0.306	-200	1700
14-Aug-92	0.01	1	0.579	0.583	-0.301	-0.315	-400	1400
15-Aug-92	0.01	1	0.588	0.591	-0.31	-0.327	-300	1700
16-Aug-92	0.01	1	0.599	0.602	-0.309	-0.326	-300	1700
17-Aug-92	0.01	1	0.602	0.605	-0.303	-0.317	-300	1400
18-Aug-92	0.01	1	0.581	0.585	-0.331	-0.346	-400	1500
19-Aug-92	0.01	1	0.55	0.553	-0.345	-0.372	-300	2700
20-Aug-92	0.01	1	0.544	0.546	-0.366	-0.372	-200	600
21-Aug-92	0.01	1	0.547	0.552	-0.364	-0.37	-500	600
22-Aug-92	0.01	1	0.54	0.543	-0.381	-0.384	-300	300
23-Aug-92	0.01	1	0.54	0.543	-0.381	-0.384	-300	300
24-Aug-92	0.01	1	0.548	0.55	-0.371	-0.364	-200	-700
25-Aug-92	0.01	1	0.552	0.556	-0.385	-0.387	-400	200
26-Aug-92	0.01	1	0.566	0.567	-0.375	-0.368	-100	-700
27-Aug-92	0.01	1	0.566	0.568	-0.377	-0.381	-200	400
28-Aug-92	0.01	1	0.563	0.565	-0.377	-0.381	-200	400
29-Aug-92	0.01	1	0.564	0.565	-0.373	-0.375	-100	200
30-Aug-92	0.01	1	0.559	0.561	-0.381	-0.386	-200	500
31-Aug-92	0.01	1	0.547	0.55	-0.383	-0.39	-300	700
01-Sep-92	0.01	1	0.548	0.551	-0.381	-0.389	-300	800
02-Sep-92	0.01	1	0.552	0.55	-0.367	-0.365	200	-200
03-Sep-92	0.01	1	0.547	0.549	-0.374	-0.375	-200	100
04-Sep-92	0.01	1	0.524	0.529	-0.402	-0.4	-500	-200
05-Sep-92	0.01	1	0.525	0.527	-0.411	-0.412	-200	100
06-Sep-92	0.01	1	0.524	0.526	-0.408	-0.409	-200	100
07-Sep-92	0.01	1	0.52	0.523	-0.418	-0.419	-300	100
08-Sep-92	0.01	1	0.507	0.509	-0.43	-0.435	-200	500
09-Sep-92	0.01	1	0.506	0.508	-0.427	-0.423	-200	-400

REVERSED POLARITY
SPECIMEN #3D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES EPOXY No.15 (10-12)mil
CLEAR COVER (2" 1/16 IN - 52.38mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
27-Jul-92	0.01	1	0.232	0.207	-0.322	-0.326	2500	400
28-Jul-92	0.01	1	0.207	0.21	-0.323	-0.321	-300	-200
29-Jul-92	0.01	1	0.194	0.202	-0.323	-0.319	-800	-400
30-Jul-92	0.01	1	0.445	0.433	-0.558	-0.548	1200	-1000
31-Jul-92	0.01	1	0.22	0.236	-0.402	-0.409	-1600	700
01-Aug-92	0.01	1	0.196	0.211	-0.405	-0.413	-1500	800
02-Aug-92	0.01	1	0.174	0.186	-0.408	-0.415	-1200	700
03-Aug-92	0.01	1	0.18	0.198	-0.536	-0.542	-1600	600
04-Aug-92	0.01	1	0.201	0.219	-0.503	-0.511	-1800	800
05-Aug-92	0.01	1	0.323	0.25	-0.479	-0.492	7300	1300
06-Aug-92	0.01	1	0.325	0.263	-0.504	-0.514	6200	1000
07-Aug-92	0.01	1	0.324	0.279	-0.532	-0.542	4500	1000
08-Aug-92	0.01	1	0.324	0.279	-0.532	-0.542	4500	1000
09-Aug-92	0.01	1	0.324	0.292	-0.576	-0.585	3200	900
10-Aug-92	0.01	1	0.323	0.298	-0.59	-0.591	2500	100
11-Aug-92	0.01	1	0.303	0.321	-0.555	-0.565	-1800	1000
12-Aug-92	0.01	1	0.287	0.301	-0.593	-0.602	-1400	900
13-Aug-92	0.01	1	0.287	0.301	-0.593	-0.602	-1400	900
14-Aug-92	0.01	1	0.3	0.313	-0.579	-0.587	-1300	800
15-Aug-92	0.01	1	0.309	0.323	-0.587	-0.595	-1400	800
16-Aug-92	0.01	1	0.307	0.322	-0.601	-0.61	-1500	900
17-Aug-92	0.01	1	0.302	0.315	-0.602	-0.609	-1300	700
18-Aug-92	0.01	1	0.331	0.342	-0.581	-0.59	-1100	900
19-Aug-92	0.01	1	0.344	0.348	-0.551	-0.557	-400	600
20-Aug-92	0.01	1	0.364	0.368	-0.546	-0.552	-400	600
21-Aug-92	0.01	1	0.362	0.365	-0.552	-0.56	-300	800
22-Aug-92	0.01	1	0.376	0.378	-0.545	-0.551	-200	600
23-Aug-92	0.01	1	0.376	0.378	-0.545	-0.551	-200	600
24-Aug-92	0.01	1	0.365	0.362	-0.555	-0.557	300	200
25-Aug-92	0.01	1	0.381	0.38	-0.555	-0.56	100	500
26-Aug-92	0.01	1	0.372	0.369	-0.569	-0.575	300	600
27-Aug-92	0.01	1	0.374	0.379	-0.57	-0.573	-500	300
28-Aug-92	0.01	1	0.371	0.372	-0.563	-0.567	-100	400
29-Aug-92	0.01	1	0.367	0.368	-0.561	-0.567	-100	600
30-Aug-92	0.01	1	0.378	0.38	-0.562	-0.567	-200	500
31-Aug-92	0.01	1	0.381	0.384	-0.547	-0.554	-300	700
01-Sep-92	0.01	1	0.381	0.384	-0.547	-0.554	-300	700
02-Sep-92	0.01	1	0.366	0.361	-0.551	-0.556	500	500
03-Sep-92	0.01	1	0.371	0.367	-0.549	-0.555	400	600
04-Sep-92	0.01	1	0.398	0.394	-0.528	-0.534	400	600
05-Sep-92	0.01	1	0.41	0.407	-0.53	-0.537	300	700
06-Sep-92	0.01	1	0.408	0.406	-0.528	-0.535	200	700
07-Sep-92	0.01	1	0.415	0.412	-0.525	-0.531	300	600
08-Sep-92	0.01	1	0.429	0.43	-0.508	-0.517	-100	900
09-Sep-92	0.01	1	0.421	0.417	-0.512	-0.514	400	200

APPENDIX D

TEST SERIES No. 4 AND No. 5

POTENTIAL

AND

CURRENT MEASUREMENTS

NORMAL POLARITY
SPECIMEN #4A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.45	0.998	0.279	-0.456	-0.707	-0.675	1633.33	-71.11
22-Sep-92	0.57	0.997	0.225	-0.395	-0.708	-0.691	1087.72	-29.82
23-Sep-92	0.6	0.997	0.235	-0.385	-0.725	-0.685	1033.33	-66.67
24-Sep-92	0.58	0.997	0.247	-0.358	-0.689	-0.652	1043.10	-63.79
25-Sep-92	0.57	0.998	0.247	-0.359	-0.692	-0.654	1063.16	-66.67
26-Sep-92	0.53	0.995	0.241	-0.378	-0.705	-0.644	1167.92	-115.09
27-Sep-92	0.57	0.997	0.318	-0.353	-0.668	-0.615	1177.19	-92.98
28-Sep-92	0.58	0.997	0.297	-0.356	-0.676	-0.618	1125.86	-100.00
29-Sep-92	0.61	0.995	0.3	-0.336	-0.659	-0.602	1042.62	-93.44
30-Sep-92	0.66	0.997	0.232	-0.356	-0.733	-0.628	890.91	-159.09
01-Oct-92	0.66	0.997	0.232	-0.356	-0.733	-0.628	890.91	-159.09
02-Oct-92	0.63	0.997	0.292	-0.353	-0.725	-0.613	1023.81	-177.78
03-Oct-92	0.67	0.997	0.294	-0.357	-0.716	-0.612	971.64	-155.22
04-Oct-92	0.7	0.997	0.232	-0.382	-0.725	-0.615	877.14	-157.14
05-Oct-92	0.7	0.997	0.301	-0.362	-0.695	-0.591	947.14	-148.57
06-Oct-92	0.7	0.997	0.262	-0.346	-0.715	-0.595	868.57	-171.43
07-Oct-92	0.7	0.997	0.254	-0.335	-0.735	-0.588	841.43	-210.00
08-Oct-92	0.7	0.997	0.254	-0.335	-0.735	-0.588	841.43	-210.00
09-Oct-92	0.71	0.996	0.301	-0.303	-0.675	-0.576	850.70	-139.44
10-Oct-92	0.76	0.995	0.288	-0.323	-0.725	-0.589	803.95	-178.95
11-Oct-92	0.63	0.996	0.275	-0.318	-0.725	-0.569	941.27	-247.62
12-Oct-92	0.69	0.995	0.28	-0.316	-0.725	-0.573	863.77	-220.29
13-Oct-92	0.69	0.996	0.26	-0.319	-0.725	-0.572	839.13	-221.74
14-Oct-92	0.73	0.995	0.235	-0.321	-0.734	-0.572	761.64	-221.92
15-Oct-92	0.75	0.995	0.235	-0.322	-0.738	-0.565	742.67	-230.67
16-Oct-92	0.75	0.995	0.205	-0.316	-0.775	-0.585	694.67	-253.33
17-Oct-92	0.75	0.995	0.205	-0.316	-0.775	-0.585	694.67	-253.33
18-Oct-92	0.71	0.995	0.191	-0.323	-0.765	-0.597	723.94	-236.62
19-Oct-92	0.78	0.995	0.218	-0.417	-0.785	-0.601	814.10	-235.90
20-Oct-92	0.65	0.996	0.244	-0.334	-0.778	-0.56	889.23	-335.38
21-Oct-92	0.65	0.996	0.244	-0.334	-0.778	-0.56	889.23	-335.38
22-Oct-92	0.79	0.995	0.222	-0.318	-0.774	-0.571	683.54	-256.96
23-Oct-92	0.76	0.995	0.213	-0.306	-0.765	-0.582	682.89	-240.79
24-Oct-92	0.77	0.995	0.231	-0.305	-0.773	-0.581	696.10	-249.35
25-Oct-92	0.66	0.995	0.286	-0.298	-0.717	-0.546	884.85	-259.09
26-Oct-92	0.77	0.995	0.221	-0.305	-0.775	-0.585	683.12	-246.75
27-Oct-92	0.7	0.995	0.252	-0.295	-0.735	-0.577	781.43	-225.71
28-Oct-92	0.7	0.995	0.252	-0.295	-0.735	-0.577	781.43	-225.71
29-Oct-92	0.79	0.995	0.223	-0.333	-0.745	-0.534	703.80	-267.09
30-Oct-92	0.79	0.995	0.223	-0.333	-0.745	-0.534	703.80	-267.09
31-Oct-92	0.82	0.995	0.219	-0.319	-0.763	-0.554	656.10	-254.88
01-Nov-92	0.85	0.995	0.222	-0.317	-0.765	-0.565	634.12	-235.29
02-Nov-92	0.97	0.995	0.244	-0.345	-0.754	-0.535	607.22	-225.77
03-Nov-92	1.04	0.995	0.263	-0.345	-0.735	-0.535	584.62	-192.31
04-Nov-92	1.04	0.995	0.264	-0.344	-0.735	-0.535	584.62	-192.31

REVERSED POLARITY
SPECIMEN #4A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	0.64	0.996	1.61	0.45	0.617	0.637	1812.50	-31.25
22-Sep-92	0.97	0.995	1.58	0.439	0.572	0.596	1176.29	-24.74
23-Sep-92	0.99	0.993	1.53	0.435	0.544	0.615	1106.06	-71.72
24-Sep-92	1.08	0.995	1.51	0.422	0.507	0.608	1007.41	-93.52
25-Sep-92	1.11	0.995	1.52	0.422	0.507	0.608	989.19	-90.99
26-Sep-92	1.11	0.993	1.55	0.425	0.554	0.613	1013.51	-53.15
27-Sep-92	1.24	0.994	1.57	0.43	0.569	0.615	919.35	-37.10
28-Sep-92	1.14	0.994	1.47	0.422	0.468	0.606	919.30	-121.05
29-Sep-92	1.28	0.989	1.55	0.417	0.566	0.618	885.16	-40.63
30-Sep-92	1.43	0.993	1.56	0.432	0.562	0.615	788.81	-37.06
01-Oct-92	1.43	0.993	1.56	0.432	0.562	0.615	788.81	-37.06
02-Oct-92	1.51	0.993	1.55	0.428	0.561	0.615	743.05	-35.76
03-Oct-92	1.63	0.992	1.55	0.425	0.555	0.613	690.18	-35.58
04-Oct-92	1.63	0.992	1.55	0.43	0.548	0.604	687.12	-34.36
05-Oct-92	1.63	0.992	1.54	0.432	0.546	0.596	679.75	-30.67
06-Oct-92	1.63	0.992	1.52	0.465	0.531	0.585	647.24	-33.13
07-Oct-92	1.68	0.991	1.52	0.434	0.534	0.585	646.43	-30.36
08-Oct-92	1.68	0.991	1.52	0.434	0.534	0.585	646.43	-30.36
09-Oct-92	1.3	0.992	1.49	0.411	0.477	0.543	830.00	-50.77
10-Oct-92	1.7	0.99	1.54	0.428	0.533	0.591	654.12	-34.12
11-Oct-92	1.68	0.991	1.51	0.432	0.502	0.565	641.67	-37.50
12-Oct-92	1.75	0.989	1.51	0.43	0.498	0.564	617.14	-37.71
13-Oct-92	1.82	0.989	1.49	0.429	0.486	0.557	582.97	-39.01
14-Oct-92	1.94	0.988	1.51	0.437	0.506	0.575	553.09	-35.57
15-Oct-92	1.94	0.988	1.48	0.432	0.467	0.558	540.21	-46.91
16-Oct-92	1.94	0.988	1.44	0.432	0.444	0.558	519.59	-58.76
17-Oct-92	1.94	0.988	1.44	0.432	0.444	0.558	519.59	-58.76
18-Oct-92	1.97	0.988	1.49	0.435	0.495	0.571	535.53	-38.58
19-Oct-92	2.01	0.988	1.51	0.435	0.508	0.591	534.83	-41.29
20-Oct-92	2.01	0.988	1.52	0.427	0.522	0.587	543.78	-32.34
21-Oct-92	2.01	0.988	1.52	0.427	0.522	0.587	543.78	-32.34
22-Oct-92	2.12	0.987	1.47	0.43	0.459	0.553	490.57	-44.34
23-Oct-92	2.08	0.987	1.47	0.431	0.466	0.551	499.52	-40.87
24-Oct-92	2.06	0.987	1.48	0.433	0.486	0.556	508.25	-33.98
25-Oct-92	2	0.987	1.48	0.423	0.475	0.548	528.50	-36.50
26-Oct-92	2	0.987	1.49	0.434	0.49	0.558	528.00	-34.00
27-Oct-92	2.11	0.986	1.48	0.421	0.475	0.545	501.90	-33.18
28-Oct-92	2.11	0.986	1.48	0.421	0.475	0.545	501.90	-33.18
29-Oct-92	2.13	0.987	1.48	0.432	0.478	0.548	492.02	-32.86
30-Oct-92	2.13	0.987	1.48	0.432	0.478	0.548	492.02	-32.86
31-Oct-92	2.15	0.986	1.48	0.432	0.471	0.544	487.44	-33.95
01-Nov-92	2.19	0.986	1.46	0.432	0.452	0.543	469.41	-41.55
02-Nov-92	2.25	0.986	1.46	0.432	0.458	0.535	456.89	-34.22
03-Nov-92	2.25	0.988	1.46	0.427	0.45	0.528	459.11	-34.67
04-Nov-92	2.25	0.988	1.46	0.427	0.45	0.528	459.11	-34.67

NORMAL POLARITY
SPECIMEN #4B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71- ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	1.2	0.985	0.085	-0.63	-1.03	-1.02	595.83	-8.33
22-Sep-92	1.47	0.981	0.171	-0.636	-1.04	-1.03	548.98	-6.80
23-Sep-92	1.66	0.984	0.133	-0.609	-1.02	-1	446.99	-12.05
24-Sep-92	1.42	0.994	0.129	-0.57	-1.04	-1.02	492.25	-14.08
25-Sep-92	1.42	0.994	0.129	-0.57	-1.04	-1.02	492.25	-14.08
26-Sep-92	1.3	0.994	0.121	-0.548	-1.05	-1.03	514.62	-15.38
27-Sep-92	1.35	0.993	0.093	-0.545	-0.994	-0.97	472.59	-17.78
28-Sep-92	1.53	0.993	0.125	-0.547	-0.955	-0.912	439.22	-28.10
29-Sep-92	1.15	0.995	0.12	-0.543	-0.857	-0.78	576.52	-66.96
30-Sep-92	1.32	0.994	0.117	-0.556	-0.933	-0.871	509.85	-46.97
01-Oct-92	1.32	0.994	0.117	-0.556	-0.933	-0.871	509.85	-46.97
02-Oct-92	1.54	0.993	0.101	-0.551	-1.05	-0.932	423.38	-76.62
03-Oct-92	1.3	0.994	0.11	-0.53	-0.96	-0.88	492.31	-61.54
04-Oct-92	1.17	0.994	0.052	-0.552	-0.906	-0.85	516.24	-47.86
05-Oct-92	1.06	0.995	0.053	-0.53	-0.897	-0.835	550.00	-58.49
06-Oct-92	1.03	0.995	0.088	-0.549	-0.959	-0.904	618.45	-53.40
07-Oct-92	1.32	0.993	0.08	-0.55	-0.917	-0.83	477.27	-65.91
08-Oct-92	1.32	0.993	0.08	-0.55	-0.917	-0.83	477.27	-65.91
09-Oct-92	1.2	0.993	0.097	-0.518	-0.945	-0.856	512.50	-74.17
10-Oct-92	1.11	0.993	0.09	-0.522	-0.946	-0.846	551.35	-90.09
11-Oct-92	1.08	0.994	0.116	-0.541	-0.945	-0.819	608.33	-116.67
12-Oct-92	1.2	0.993	0.015	-0.389	-0.879	-0.81	336.67	-57.50
13-Oct-92	1.07	0.994	0.026	-0.465	-0.87	-0.81	458.88	-56.07
14-Oct-92	1.08	0.995	0.096	-0.516	-0.93	-0.808	566.67	-112.96
15-Oct-92	1.08	0.995	0.115	-0.533	-0.966	-0.842	600.00	-114.81
16-Oct-92	1.08	0.995	0.096	-0.539	-0.955	-0.815	587.96	-129.63
17-Oct-92	1.08	0.995	0.096	-0.539	-0.955	-0.815	587.96	-129.63
18-Oct-92	1.08	0.995	0.11	-0.518	-0.975	-0.832	581.48	-132.41
19-Oct-92	1.3	0.993	0.096	-0.54	-1.15	-0.79	489.23	-276.92
20-Oct-92	1.5	0.992	0.149	-0.574	-1.1	-0.82	482.00	-186.67
21-Oct-92	1.5	0.992	0.149	-0.574	-1.1	-0.82	482.00	-186.67
22-Oct-92	1.28	0.993	0.149	-0.565	-1.09	-0.876	557.81	-167.19
23-Oct-92	1.44	0.992	0.104	-0.54	-1.05	-0.83	447.22	-152.78
24-Oct-92	1.44	0.992	0.072	-0.498	-1.06	-0.795	395.83	-184.03
25-Oct-92	1.25	0.992	0.115	-0.544	-1	-0.764	527.20	-188.80
26-Oct-92	1.25	0.993	0.063	-0.486	-1.03	-0.786	439.20	-195.20
27-Oct-92	1.25	0.993	0.13	-0.557	-1.09	-0.767	549.60	-258.40
28-Oct-92	1.25	0.993	0.13	-0.556	-1.09	-0.767	548.80	-258.40
29-Oct-92	1.27	0.992	0.152	-0.572	-1.14	-0.78	570.08	-283.46
30-Oct-92	1.27	0.992	0.152	-0.572	-1.14	-0.78	570.08	-283.46
31-Oct-92	1	0.994	0.088	-0.545	-1.08	-0.786	633.00	-294.00
01-Nov-92	0.99	0.994	0.035	-0.506	-1.03	-0.761	546.46	-271.72
02-Nov-92	1.35	0.992	0.113	-0.552	-1.1	-0.732	492.59	-272.59
03-Nov-92	1.35	0.992	0.123	-0.542	-1.11	-0.736	492.59	-277.04
04-Nov-92	1.35	0.992	0.123	-0.542	-1.11	-0.73	492.59	-281.48

REVERSED POLARITY
SPECIMEN #4B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71- CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	2.16	0.963	1.6	0.644	0.652	0.692	442.59	-18.52
22-Sep-92	3.38	0.968	1.62	0.578	0.624	0.694	308.28	-20.71
23-Sep-92	3.2	0.955	1.66	0.561	0.658	0.687	343.44	-9.06
24-Sep-92	3.28	0.935	1.55	0.542	0.703	0.739	307.32	-10.98
25-Sep-92	3.28	0.935	1.55	0.542	0.703	0.739	307.32	-10.98
26-Sep-92	2.58	0.984	1.21	0.527	0.212	0.742	264.73	-205.43
27-Sep-92	2.58	0.984	1.55	0.518	0.656	0.696	400.00	-15.50
28-Sep-92	2.52	0.984	1.44	0.518	0.622	0.682	365.87	-23.81
29-Sep-92	2.52	0.984	1.65	0.603	0.664	0.703	415.48	-15.48
30-Sep-92	2.48	0.984	1.58	0.509	0.648	0.693	431.85	-18.15
01-Oct-92	2.48	0.984	1.58	0.509	0.648	0.693	431.85	-18.15
02-Oct-92	2.49	0.982	1.63	0.563	0.653	0.697	428.51	-17.67
03-Oct-92	2.45	0.982	1.64	0.561	0.661	0.704	440.41	-17.55
04-Oct-92	2.43	0.982	1.64	0.561	0.671	0.705	444.03	-13.99
05-Oct-92	2.43	0.982	1.64	0.555	0.671	0.705	446.50	-13.99
06-Oct-92	2.43	0.982	1.64	0.55	0.663	0.698	448.56	-14.40
07-Oct-92	2.43	0.982	1.62	0.537	0.65	0.694	445.68	-18.11
08-Oct-92	2.43	0.982	1.62	0.537	0.65	0.694	445.68	-18.11
09-Oct-92	3.22	0.965	1.66	0.535	0.654	0.695	349.38	-12.73
10-Oct-92	3.1	0.973	1.64	0.555	0.648	0.694	350.00	-14.84
11-Oct-92	2.55	0.985	1.63	0.537	0.667	0.706	428.63	-15.29
12-Oct-92	2.9	0.983	1.66	0.534	0.663	0.704	388.28	-14.14
13-Oct-92	2.57	0.985	1.62	0.538	0.641	0.692	421.01	-19.84
14-Oct-92	2.72	0.978	1.65	0.545	0.658	0.705	406.25	-17.28
15-Oct-92	2.65	0.985	1.63	0.534	0.655	0.705	413.58	-18.87
16-Oct-92	2.72	0.985	1.01	0.531	0.665	0.705	176.10	-14.71
17-Oct-92	2.72	0.985	1.01	0.531	0.665	0.705	176.10	-14.71
18-Oct-92	2.72	0.985	1.65	0.55	0.653	0.697	404.41	-16.18
19-Oct-92	2.72	0.985	1.64	0.558	0.635	0.692	397.79	-20.96
20-Oct-92	2.72	0.985	1.64	0.559	0.654	0.703	397.43	-18.01
21-Oct-92	2.72	0.985	1.64	0.559	0.654	0.703	397.43	-18.01
22-Oct-92	2.71	0.985	1.61	0.552	0.639	0.696	390.41	-21.03
23-Oct-92	2.52	0.985	1.64	0.53	0.645	0.697	440.48	-20.63
24-Oct-92	2.52	0.985	1.65	0.537	0.615	0.685	441.67	-27.78
25-Oct-92	2.6	0.984	1.63	0.495	0.636	0.691	436.54	-21.15
26-Oct-92	2.55	0.985	1.64	0.55	0.643	0.7	427.45	-22.35
27-Oct-92	2.55	0.985	1.66	0.543	0.666	0.713	436.04	-18.43
28-Oct-92	2.55	0.985	1.66	0.543	0.666	0.713	436.04	-18.43
29-Oct-92	2.71	0.985	1.66	0.54	0.661	0.712	413.28	-18.82
30-Oct-92	2.71	0.985	1.66	0.54	0.661	0.712	413.28	-18.82
31-Oct-92	2.71	0.985	1.65	0.545	0.656	0.706	407.75	-18.45
01-Nov-92	2.71	0.985	1.65	0.558	0.655	0.709	402.95	-19.93
02-Nov-92	2.69	0.985	1.66	0.542	0.659	0.714	415.61	-20.45
03-Nov-92	2.69	0.985	1.64	0.548	0.635	0.681	405.95	-17.10
04-Nov-92	2.69	0.985	1.64	0.548	0.635	0.691	405.95	-20.82

NORMAL POLARITY
SPECIMEN #4C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.01	1	0.344	0.321	-0.658	-0.659	2300.00	100.00
22-Sep-92	0.13	1	0.338	-0.159	-0.663	-0.658	3823.08	-38.46
23-Sep-92	0.55	0.998	0.178	-0.402	-0.784	-0.768	1054.55	-29.09
24-Sep-92	0.58	0.998	0.115	-0.395	-0.855	-0.835	879.31	-34.48
25-Sep-92	0.58	0.998	0.115	-0.395	-0.855	-0.835	879.31	-34.48
26-Sep-92	0.63	0.997	0.095	-0.4	-0.859	-0.833	785.71	-41.27
27-Sep-92	0.64	0.997	0.084	-0.396	-0.864	-0.813	750.00	-79.69
28-Sep-92	0.68	0.986	0.097	-0.394	-0.829	-0.77	722.06	-86.76
29-Sep-92	0.71	0.996	0.121	-0.407	-0.759	-0.655	743.66	-146.48
30-Sep-92	0.63	0.997	0.126	-0.372	-0.795	-0.705	790.48	-142.86
01-Oct-92	0.63	0.997	0.126	-0.372	-0.795	-0.705	790.48	-142.86
02-Oct-92	0.63	0.997	0.155	-0.35	-0.775	-0.697	801.59	-123.81
03-Oct-92	0.56	0.997	0.188	-0.335	-0.755	-0.687	933.93	-121.43
04-Oct-92	0.64	0.997	0.188	-0.332	-0.735	-0.661	812.50	-115.62
05-Oct-92	0.58	0.997	0.246	-0.269	-0.705	-0.641	891.38	-110.34
06-Oct-92	0.62	0.996	0.209	-0.284	-0.705	-0.641	795.16	-103.23
07-Oct-92	0.62	0.995	0.214	-0.287	-0.719	-0.635	808.06	-135.48
08-Oct-92	0.62	0.995	0.214	-0.287	-0.719	-0.635	808.06	-135.48
09-Oct-92	0.62	0.995	0.263	-0.275	-0.695	-0.616	867.74	-127.42
10-Oct-92	0.67	0.995	0.285	-0.295	-0.692	-0.595	865.67	-144.78
11-Oct-92	0.65	0.996	0.266	-0.287	-0.698	-0.605	850.77	-143.08
12-Oct-92	0.66	0.995	0.248	-0.288	-0.718	-0.615	812.12	-156.06
13-Oct-92	0.63	0.996	0.25	-0.288	-0.723	-0.616	853.97	-169.84
14-Oct-92	0.73	0.996	0.249	-0.41	-0.735	-0.631	902.74	-142.47
15-Oct-92	0.66	0.996	0.165	-0.315	-0.765	-0.658	727.27	-162.12
16-Oct-92	0.69	0.996	0.24	-0.308	-0.708	-0.611	794.20	-140.58
17-Oct-92	0.69	0.996	0.24	-0.308	-0.708	-0.611	794.20	-140.58
18-Oct-92	0.63	0.996	0.263	-0.269	-0.712	-0.615	844.44	-153.97
19-Oct-92	0.68	0.996	0.268	-0.268	-0.715	-0.622	788.24	-136.76
20-Oct-92	0.63	0.996	0.255	-0.279	-0.725	-0.615	847.62	-174.60
21-Oct-92	0.63	0.996	0.255	-0.279	-0.725	-0.615	847.62	-174.60
22-Oct-92	0.68	0.996	0.262	-0.272	-0.721	-0.616	785.29	-154.41
23-Oct-92	0.71	0.995	0.259	-0.285	-0.732	-0.611	766.20	-170.42
24-Oct-92	0.73	0.995	0.259	-0.283	-0.728	-0.611	742.47	-160.27
25-Oct-92	0.68	0.995	0.236	-0.282	-0.737	-0.621	761.76	-170.59
26-Oct-92	0.69	0.995	0.242	-0.278	-0.745	-0.627	753.62	-171.01
27-Oct-92	0.69	0.995	0.231	-0.276	-0.757	-0.624	734.78	-192.75
28-Oct-92	0.69	0.995	0.231	-0.276	-0.757	-0.624	734.78	-192.75
29-Oct-92	0.71	0.995	0.238	-0.285	-0.755	-0.615	736.62	-197.18
30-Oct-92	0.71	0.995	0.238	-0.285	-0.755	-0.615	736.62	-197.18
31-Oct-92	0.68	0.995	0.265	-0.286	-0.759	-0.615	810.29	-211.76
01-Nov-92	0.75	0.995	0.242	-0.276	-0.752	-0.618	690.67	-178.67
02-Nov-92	0.75	0.995	0.237	-0.299	-0.764	-0.612	714.67	-202.67
03-Nov-92	0.63	0.997	0.274	-0.266	-0.726	-0.598	857.14	-203.17
04-Nov-92	0.63	0.997	0.274	-0.266	-0.726	-0.598	857.14	-203.17

REVERSED POLARITY
SPECIMEN #4C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	0.36	1	1.64	-0.115	0.645	0.654	4875.00	-25.00
22-Sep-92	0.6	1.01	1.63	0.315	0.637	0.649	2191.67	-20.00
23-Sep-92	1.25	0.995	1.62	0.425	0.601	0.638	956.00	-29.60
24-Sep-92	1.52	0.992	1.61	0.429	0.572	0.625	776.97	-34.87
25-Sep-92	1.52	0.992	1.61	0.429	0.572	0.625	776.97	-34.87
26-Sep-92	1.71	0.992	1.62	0.423	0.557	0.635	700.00	-45.61
27-Sep-92	1.94	0.99	1.62	0.417	0.606	0.649	620.10	-22.16
28-Sep-92	1.97	0.989	1.64	0.406	0.605	0.647	626.40	-21.32
29-Sep-92	1.73	0.992	1.59	0.415	0.591	0.627	679.19	-20.81
30-Sep-92	1.8	0.991	1.59	0.405	0.592	0.634	658.33	-23.33
01-Oct-92	1.8	0.991	1.59	0.405	0.592	0.634	658.33	-23.33
02-Oct-92	1.85	0.989	1.58	0.396	0.584	0.625	640.00	-22.16
03-Oct-92	2	0.989	1.57	0.376	0.574	0.626	597.00	-26.00
04-Oct-92	2.1	0.988	1.55	0.39	0.56	0.609	552.38	-23.33
05-Oct-92	2	0.988	1.51	0.37	0.524	0.598	570.00	-37.00
06-Oct-92	2	0.988	1.5	0.356	0.5	0.565	572.00	-32.50
07-Oct-92	2	0.988	1.53	0.377	0.535	0.595	576.50	-30.00
08-Oct-92	2	0.988	1.53	0.377	0.535	0.595	576.50	-30.00
09-Oct-92	2	0.987	1.53	0.374	0.517	0.581	578.00	-32.00
10-Oct-92	2.03	0.987	1.54	0.372	0.525	0.594	575.37	-33.99
11-Oct-92	2.03	0.987	1.54	0.384	0.521	0.592	569.46	-34.98
12-Oct-92	1.99	0.988	1.52	0.401	0.518	0.588	562.31	-35.18
13-Oct-92	2	0.988	1.51	0.394	0.51	0.583	558.00	-36.50
14-Oct-92	2.05	0.988	1.54	0.405	0.544	0.605	553.66	-29.76
15-Oct-92	2.2	0.987	1.53	0.407	0.531	0.597	510.45	-30.00
16-Oct-92	2.24	0.987	1.53	0.396	0.528	0.595	506.25	-29.91
17-Oct-92	2.24	0.987	1.53	0.396	0.528	0.595	506.25	-29.91
18-Oct-92	2.24	0.987	1.53	0.398	0.525	0.594	506.25	-30.80
19-Oct-92	2.24	0.986	1.51	0.402	0.496	0.587	494.64	-40.62
20-Oct-92	2.24	0.987	1.52	0.412	0.506	0.597	494.64	-40.62
21-Oct-92	2.24	0.987	1.52	0.412	0.506	0.597	494.64	-40.62
22-Oct-92	2.34	0.986	1.54	0.44	0.528	0.595	470.09	-28.63
23-Oct-92	2.35	0.986	1.54	0.401	0.51	0.585	484.68	-31.91
24-Oct-92	2.35	0.986	1.51	0.408	0.504	0.581	468.94	-32.77
25-Oct-92	2.37	0.985	1.51	0.417	0.498	0.561	461.18	-26.58
26-Oct-92	2.4	0.985	1.5	0.403	0.501	0.565	457.08	-26.67
27-Oct-92	2.46	0.985	1.5	0.414	0.492	0.559	441.46	-27.24
28-Oct-92	2.46	0.985	1.5	0.414	0.492	0.559	441.46	-27.24
29-Oct-92	2.52	0.985	1.5	0.414	0.475	0.545	430.95	-27.78
30-Oct-92	2.52	0.985	1.5	0.414	0.475	0.545	430.95	-27.78
31-Oct-92	2.52	0.985	1.49	0.389	0.474	0.548	436.90	-29.37
01-Nov-92	2.52	0.985	1.49	0.406	0.47	0.546	430.16	-30.16
02-Nov-92	2.52	0.985	1.49	0.411	0.467	0.548	428.17	-32.14
03-Nov-92	2.52	0.985	1.48	0.327	0.465	0.551	457.54	-34.13
04-Nov-92	2.52	0.985	1.48	0.327	0.465	0.551	457.54	-34.13

NORMAL POLARITY
SPECIMEN #4D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 1/16 IN - 26.98mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71- ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.01	1.01	0.073	-0.084	-1.02	-1.03	15700.00	1000.00
22-Sep-92	0.52	1	0.242	-0.742	-1.11	-1.1	1892.31	-19.23
23-Sep-92	0.62	0.997	0.302	-0.737	-1.16	-1.15	1675.81	-16.13
24-Sep-92	0.78	0.996	0.449	-0.259	-0.549	-0.526	907.69	-29.49
25-Sep-92	0.78	0.996	0.448	-0.258	-0.549	-0.526	905.13	-29.49
26-Sep-92	0.48	0.996	0.664	0.181	-0.28	-0.25	1006.25	-62.50
27-Sep-92	0.47	0.998	0.715	0.223	-0.225	-0.18	1046.81	-95.74
28-Sep-92	0.41	0.998	0.831	0.296	-0.155	-0.122	1304.88	-80.49
29-Sep-92	0.49	0.997	0.848	0.24	-0.16	-0.119	1240.82	-83.67
30-Sep-92	0.29	0.998	0.856	0.323	-0.141	-0.109	1837.93	-110.34
01-Oct-92	0.29	0.998	0.856	0.323	-0.141	-0.109	1837.93	-110.34
02-Oct-92	0.29	0.998	0.867	0.354	-0.13	-0.105	1768.97	-86.21
03-Oct-92	0.29	0.998	0.87	0.345	-0.126	-0.101	1810.34	-86.21
04-Oct-92	0.35	0.998	0.858	0.329	-0.148	-0.096	1511.43	-148.57
05-Oct-92	0.29	0.998	0.88	0.345	-0.116	-0.092	1844.83	-82.76
06-Oct-92	0.29	0.998	0.884	0.343	-0.109	-0.09	1865.52	-65.52
07-Oct-92	0.42	0.997	0.868	0.33	-0.122	-0.096	1260.95	-61.90
08-Oct-92	0.42	0.997	0.868	0.33	-0.122	-0.096	1260.95	-61.90
09-Oct-92	0.38	0.997	0.86	0.284	-0.147	-0.111	1515.79	-94.74
10-Oct-92	0.38	0.997	0.846	0.281	-0.148	-0.119	1486.84	-76.32
11-Oct-92	0.38	0.997	0.844	0.281	-0.153	-0.123	1461.58	-78.95
12-Oct-92	0.39	0.997	0.84	0.276	-0.159	-0.125	1446.15	-87.18
13-Oct-92	0.36	0.997	0.835	0.279	-0.159	-0.13	1544.44	-80.56
14-Oct-92	0.34	0.997	0.802	0.275	-0.17	-0.142	1550.00	-82.35
15-Oct-92	0.34	0.997	0.782	0.275	-0.173	-0.146	1491.18	-79.41
16-Oct-92	0.45	0.997	0.553	0.01	-0.355	-0.34	1206.67	-33.33
17-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
18-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
19-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
20-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
21-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
22-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
23-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
24-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
25-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
26-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
27-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
28-Oct-92	0.46	0.996	0.206	-0.324	-0.647	-0.624	1152.17	-50.00
29-Oct-92	0.58	0.996	0.261	-0.301	-0.639	-0.606	968.97	-56.90
30-Oct-92	0.58	0.996	0.261	-0.301	-0.639	-0.606	968.97	-56.90
31-Oct-92	0.62	0.996	0.259	-0.287	-0.614	-0.586	880.65	-45.16
01-Nov-92	0.6	0.996	0.181	-0.33	-0.67	-0.63	851.67	-66.67
02-Nov-92	0.57	0.996	0.151	-0.337	-0.705	-0.676	856.14	-50.88
03-Nov-92	0.54	0.998	0.145	-0.366	-0.715	-0.686	946.30	-53.70
04-Nov-92	0.54	0.998	0.145	-0.366	-0.715	-0.686	946.30	-53.70

REVERSED POLARITY
SPECIMEN #4D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 1/16 IN - 26.98mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	0.68	1	1.92	0.478	0.965	0.983	2120.59	-26.47
22-Sep-92	1.5	1	1.92	0.741	0.925	0.981	786.00	-37.33
23-Sep-92	1.85	0.991	1.84	0.59	0.867	0.93	675.68	-34.05
24-Sep-92	1.74	0.991	1.45	0.237	0.451	0.484	697.13	-18.97
25-Sep-92	1.74	0.991	1.45	0.237	0.451	0.484	697.13	-18.97
26-Sep-92	1.92	0.988	1.08	-0.135	0.094	0.146	632.81	-27.08
27-Sep-92	1.83	0.991	1.06	-0.16	0.077	0.125	666.67	-26.23
28-Sep-92	1.62	0.992	1.06	-0.175	0.069	0.112	762.35	-26.54
29-Sep-92	1.63	0.992	1.06	-0.169	0.067	0.115	753.99	-29.45
30-Sep-92	1.7	0.991	1.04	-0.214	0.051	0.107	737.65	-32.94
01-Oct-92	1.7	0.991	1.04	-0.214	0.051	0.107	737.65	-32.94
02-Oct-92	1.77	0.989	1.03	-0.197	0.046	0.102	693.22	-31.64
03-Oct-92	1.83	0.99	1.04	-0.217	0.054	0.1	686.89	-25.14
04-Oct-92	1.83	0.99	1.04	-0.206	0.055	0.099	680.87	-24.04
05-Oct-92	1.83	0.99	1.03	-0.239	0.044	0.09	693.44	-25.14
06-Oct-92	1.83	0.99	1.02	-0.259	0.029	0.088	698.91	-32.24
07-Oct-92	1.86	0.989	1.03	-0.219	0.048	0.095	671.51	-25.27
08-Oct-92	1.86	0.989	1.03	-0.219	0.048	0.095	671.51	-25.27
09-Oct-92	1.9	0.988	1.05	-0.206	0.068	0.11	661.05	-22.11
10-Oct-92	1.96	0.987	1.06	-0.18	0.074	0.118	632.65	-22.45
11-Oct-92	1.99	0.986	1.06	-0.176	0.076	0.123	621.11	-23.62
12-Oct-92	2.05	0.986	1.06	-0.171	0.076	0.123	600.49	-22.93
13-Oct-92	2.11	0.986	1.05	-0.188	0.078	0.127	586.73	-23.22
14-Oct-92	2.15	0.986	1.04	-0.152	0.089	0.137	554.42	-22.33
15-Oct-92	2.2	0.986	1.04	-0.159	0.079	0.126	545.00	-21.36
16-Oct-92	2.24	0.986	1.04	0.079	0.167	0.248	429.02	-36.16
17-Oct-92	2.24	0.986	1.04	0.079	0.167	0.248	429.02	-36.16
18-Oct-92	2.24	0.986	1.48	0.325	0.473	0.502	515.62	-12.95
19-Oct-92	2.27	0.986	1.48	0.35	0.486	0.531	497.80	-19.82
20-Oct-92	2.32	0.985	1.48	0.366	0.502	0.553	480.17	-21.98
21-Oct-92	2.32	0.985	1.48	0.366	0.502	0.553	480.17	-21.98
22-Oct-92	2.34	0.985	1.48	0.375	0.506	0.51	472.22	-1.71
23-Oct-92	2.34	0.985	1.48	0.35	0.494	0.539	482.91	-19.23
24-Oct-92	2.34	0.985	1.5	0.362	0.494	0.539	486.32	-19.23
25-Oct-92	2.34	0.985	1.53	0.368	0.526	0.569	496.58	-18.38
26-Oct-92	2.4	0.985	1.52	0.373	0.528	0.575	477.92	-19.58
27-Oct-92	2.4	0.985	1.49	0.345	0.526	0.575	477.08	-20.42
28-Oct-92	2.4	0.985	1.49	0.345	0.526	0.575	477.08	-20.42
29-Oct-92	2.48	0.984	1.48	0.341	0.492	0.544	459.27	-20.97
30-Oct-92	2.48	0.984	1.48	0.341	0.492	0.544	459.27	-20.97
31-Oct-92	2.48	0.984	1.46	0.337	0.468	0.522	452.82	-21.77
01-Nov-92	2.47	0.984	1.47	0.405	0.499	0.584	431.17	-34.41
02-Nov-92	2.58	0.984	1.53	0.44	0.554	0.616	422.48	-24.03
03-Nov-92	2.58	0.985	1.58	0.446	0.604	0.608	439.53	-1.55
04-Nov-92	2.58	0.985	1.58	0.446	0.604	0.608	439.53	-1.55

NORMAL POLARITY
SPECIMEN #4E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.06	1	0.285	-0.008	-0.69	-0.684	4883.33	-100.00
22-Sep-92	0.21	0.999	0.224	-0.329	-0.759	-0.752	2633.33	-33.33
23-Sep-92	0.44	0.998	0.14	-0.29	-0.814	-0.79	977.27	-54.55
24-Sep-92	0.51	0.998	0.075	-0.473	-0.858	-0.838	1074.51	-39.22
25-Sep-92	0.51	0.998	0.076	-0.475	-0.862	-0.835	1080.39	-52.94
26-Sep-92	0.56	0.996	0.157	-0.278	-0.812	-0.762	776.79	-89.29
27-Sep-92	0.43	0.998	0.171	-0.357	-0.785	-0.756	1227.91	-67.44
28-Sep-92	0.43	0.998	0.189	-0.359	-0.786	-0.759	1274.42	-62.79
29-Sep-92	0.39	0.998	0.236	-0.332	-0.757	-0.728	1456.41	-74.36
30-Sep-92	0.28	0.998	0.01	-0.355	-1	-0.733	1303.57	-953.57
01-Oct-92	0.28	0.998	0.01	-0.355	-1	-0.733	1303.57	-953.57
02-Oct-92	0.32	0.998	0.214	-0.353	-0.784	-0.758	1771.88	-81.25
03-Oct-92	0.32	0.998	0.234	-0.333	-0.765	-0.739	1771.88	-81.25
04-Oct-92	0.35	0.998	0.228	-0.327	-0.783	-0.738	1585.71	-128.57
05-Oct-92	0.3	0.998	0.246	-0.331	-0.756	-0.735	1923.33	-70.00
06-Oct-92	0.34	0.998	0.241	-0.329	-0.759	-0.736	1676.47	-67.65
07-Oct-92	0.36	0.998	0.224	-0.33	-0.785	-0.737	1536.89	-133.33
08-Oct-92	0.36	0.998	0.224	-0.33	-0.785	-0.737	1536.89	-133.33
09-Oct-92	0.28	0.997	0.18	-0.4	-1.18	-0.735	2071.43	-1589.29
10-Oct-92	0.32	0.997	0.244	-0.334	-0.757	-0.732	1806.25	-78.13
11-Oct-92	0.33	0.997	0.245	-0.328	-0.751	-0.731	1736.36	-60.61
12-Oct-92	0.35	0.997	0.237	-0.331	-0.764	-0.731	1622.86	-94.29
13-Oct-92	0.33	0.997	0.241	-0.328	-0.759	-0.731	1724.24	-84.85
14-Oct-92	0.3	0.997	0.142	-0.407	-1.18	-0.737	1830.00	-1476.67
15-Oct-92	0.35	0.998	0.234	-0.329	-0.76	-0.734	1608.57	-74.29
16-Oct-92	0.11	0.999	0.426	-0.483	-1.42	-0.735	8263.64	-6227.27
17-Oct-92	0.11	0.999	0.426	-0.483	-1.42	-0.735	8263.64	-6227.27
18-Oct-92	0.41	0.997	0.223	-0.358	-0.768	-0.727	1417.07	-100.00
19-Oct-92	0.52	0.997	0.19	-0.427	-0.831	-0.704	1186.54	-244.23
20-Oct-92	0.4	0.997	0.223	-0.348	-0.772	-0.73	1427.50	-105.00
21-Oct-92	0.4	0.997	0.223	-0.348	-0.772	-0.73	1427.50	-105.00
22-Oct-92	0.42	0.997	0.227	-0.354	-0.771	-0.733	1383.33	-90.48
23-Oct-92	0.4	0.997	0.109	-0.352	-0.916	-0.734	1152.50	-455.00
24-Oct-92	0.46	0.996	0.232	-0.346	-0.768	-0.731	1256.52	-80.43
25-Oct-92	0.48	0.996	0.231	-0.347	-0.764	-0.731	1204.17	-68.75
26-Oct-92	0.53	0.996	0.221	-0.348	-0.764	-0.731	1073.58	-62.26
27-Oct-92	0.5	0.996	0.225	-0.34	-0.762	-0.731	1130.00	-62.00
28-Oct-92	0.5	0.996	0.225	-0.34	-0.762	-0.731	1130.00	-62.00
29-Oct-92	0.58	0.996	0.221	-0.383	-0.76	-0.712	1041.38	-82.76
30-Oct-92	0.58	0.996	0.221	-0.383	-0.76	-0.712	1041.38	-82.76
31-Oct-92	0.37	0.997	0.248	-0.346	-0.744	-0.716	1605.41	-75.68
01-Nov-92	0.47	0.996	0.223	-0.348	-0.764	-0.731	1214.89	-70.21
02-Nov-92	0.61	0.996	0.211	-0.394	-0.785	-0.725	991.80	-98.36
03-Nov-92	0.64	0.997	0.174	-0.421	-0.825	-0.765	929.69	-93.75
04-Nov-92	0.64	0.997	0.174	-0.421	-0.825	-0.765	929.69	-93.75

REVERSED POLARITY
SPECIMEN #4E
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	0.41	1	1.68	0.173	0.69	0.699	3675.61	-21.95
22-Sep-92	0.68	0.996	1.67	0.342	0.673	0.693	1952.94	-29.41
23-Sep-92	0.94	0.995	1.55	0.284	0.615	0.637	1346.81	-23.40
24-Sep-92	1.34	0.994	1.42	0.38	0.52	0.566	776.12	-34.33
25-Sep-92	1.36	0.994	1.44	0.379	0.518	0.564	780.15	-33.82
26-Sep-92	1.38	0.993	1.64	0.451	0.639	0.697	861.59	-42.03
27-Sep-92	1.42	0.992	1.64	0.409	0.641	0.684	866.90	-30.28
28-Sep-92	0.98	0.995	1.65	0.387	0.65	0.698	1288.78	-48.98
29-Sep-92	1.33	0.993	1.64	0.402	0.646	0.689	930.83	-32.33
30-Sep-92	1.35	0.993	1.65	0.407	0.654	0.685	920.74	-22.96
01-Oct-92	1.35	0.993	1.65	0.407	0.654	0.685	920.74	-22.96
02-Oct-92	1.38	0.993	1.66	0.389	0.661	0.697	921.01	-26.09
03-Oct-92	1.39	0.993	1.65	0.388	0.65	0.691	907.91	-29.50
04-Oct-92	1.39	0.993	1.66	0.377	0.655	0.693	923.02	-27.34
05-Oct-92	1.41	0.993	1.63	0.369	0.633	0.677	894.33	-31.21
06-Oct-92	1.5	0.991	1.63	0.375	0.632	0.678	836.67	-30.67
07-Oct-92	1.5	0.991	1.65	0.377	0.648	0.685	848.67	-24.67
08-Oct-92	1.5	0.991	1.65	0.377	0.648	0.685	848.67	-24.67
09-Oct-92	1.5	0.991	1.65	0.425	0.648	0.685	816.67	-24.67
10-Oct-92	1.61	0.99	1.63	0.372	0.627	0.667	781.37	-24.84
11-Oct-92	1.65	0.991	1.64	0.387	0.637	0.678	759.39	-24.85
12-Oct-92	1.74	0.989	1.64	0.385	0.643	0.681	721.26	-21.84
13-Oct-92	1.61	0.99	1.57	0.373	0.567	0.681	743.48	-70.81
14-Oct-92	1.74	0.989	1.59	0.428	0.595	0.678	667.82	-47.70
15-Oct-92	1.83	0.989	1.65	0.443	0.657	0.696	659.56	-21.31
16-Oct-92	1.83	0.989	1.65	0.448	0.646	0.686	656.83	-21.86
17-Oct-92	1.83	0.989	1.65	0.448	0.646	0.686	656.83	-21.86
18-Oct-92	1.88	0.989	1.64	0.427	0.636	0.676	645.21	-21.28
19-Oct-92	1.88	0.989	1.65	0.489	0.649	0.688	617.55	-20.74
20-Oct-92	1.85	0.989	1.66	0.484	0.665	0.703	635.68	-20.54
21-Oct-92	1.85	0.989	1.66	0.484	0.665	0.703	635.68	-20.54
22-Oct-92	1.97	0.988	1.63	0.403	0.63	0.678	622.84	-24.37
23-Oct-92	1.7	0.989	1.64	0.404	0.638	0.674	727.06	-21.18
24-Oct-92	2.01	0.987	1.63	0.428	0.633	0.678	598.01	-22.39
25-Oct-92	1.98	0.987	1.66	0.479	0.662	0.703	596.46	-20.71
26-Oct-92	1.98	0.987	1.61	0.412	0.61	0.665	605.05	-27.78
27-Oct-92	2.15	0.986	1.65	0.468	0.654	0.695	549.77	-19.07
28-Oct-92	2.15	0.986	1.65	0.468	0.654	0.695	549.77	-19.07
29-Oct-92	2.2	0.986	1.62	0.436	0.62	0.671	538.18	-23.18
30-Oct-92	2.2	0.986	1.62	0.436	0.62	0.671	538.18	-23.18
31-Oct-92	1.83	0.988	1.64	0.414	0.645	0.685	669.95	-21.86
01-Nov-92	2.19	0.986	1.62	0.415	0.62	0.67	550.23	-22.83
02-Nov-92	2.2	0.986	1.62	0.433	0.622	0.67	539.55	-21.82
03-Nov-92	2.29	0.987	1.69	0.512	0.686	0.733	514.41	-20.52
04-Nov-92	2.29	0.987	1.69	0.512	0.686	0.733	514.41	-20.52

NORMAL POLARITY
SPECIMEN #5A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.39	0.997	0.356	0.324	-0.645	-0.646	82.05	2.56
22-Sep-92	0.01	1.01	0.348	0.329	-0.652	-0.653	1900.00	100.00
23-Sep-92	0.01	1.01	0.351	0.333	-0.651	-0.652	1800.00	100.00
24-Sep-92	0.01	1	0.348	0.332	-0.655	-0.656	1600.00	100.00
25-Sep-92	0.01	1	0.348	0.332	-0.655	-0.656	1600.00	100.00
26-Sep-92	0.01	1	0.341	0.331	-0.659	-0.66	1000.00	100.00
27-Sep-92	0.01	1	0.343	0.334	-0.656	-0.657	900.00	100.00
28-Sep-92	0.12	1	0.343	0.334	0.657	0.658	75.00	-8.33
29-Sep-92	0.01	1	0.348	0.335	-0.654	-0.655	1300.00	100.00
30-Sep-92	0.01	1	0.343	0.335	-0.658	-0.659	800.00	100.00
01-Oct-92	0.01	1	0.343	0.335	-0.658	-0.659	800.00	100.00
02-Oct-92	0.01	1	0.338	0.329	-0.66	-0.661	900.00	100.00
03-Oct-92	0.01	1	0.342	0.33	-0.659	-0.66	1200.00	100.00
04-Oct-92	0.01	1	0.322	0.317	-0.656	-0.657	500.00	100.00
05-Oct-92	0.01	1	0.342	0.333	-0.657	-0.658	900.00	100.00
06-Oct-92	0.04	1	0.34	0.332	-0.658	-0.659	200.00	25.00
07-Oct-92	0.02	1	0.34	0.332	-0.659	-0.66	400.00	50.00
08-Oct-92	0.02	1	0.34	0.332	-0.659	-0.66	400.00	50.00
09-Oct-92	0.02	1	0.338	0.331	-0.66	-0.661	350.00	50.00
10-Oct-92	0.02	1	0.338	0.331	-0.659	-0.66	350.00	50.00
11-Oct-92	0.02	1	0.335	0.329	-0.663	-0.664	300.00	50.00
12-Oct-92	0.01	1	0.338	0.331	-0.661	-0.662	700.00	100.00
13-Oct-92	0.01	1	0.338	0.33	-0.661	-0.662	800.00	100.00
14-Oct-92	0.01	1	0.337	0.321	-0.664	-0.665	1600.00	100.00
15-Oct-92	0.01	1	0.332	0.323	-0.666	-0.667	900.00	100.00
16-Oct-92	0.01	1	0.332	0.323	-0.666	-0.667	900.00	100.00
17-Oct-92	0.01	1	0.332	0.322	-0.666	-0.667	1000.00	100.00
18-Oct-92	0.01	1	0.329	0.322	-0.668	-0.669	700.00	100.00
19-Oct-92	0.01	1	0.333	0.323	-0.665	-0.666	1000.00	100.00
20-Oct-92	0.01	1	0.331	0.322	-0.668	-0.669	900.00	100.00
21-Oct-92	0.01	1	0.331	0.322	-0.668	-0.669	900.00	100.00
22-Oct-92	0.06	0.999	0.325	0.316	-0.673	-0.674	150.00	16.67
23-Oct-92	0.01	1	0.324	0.316	-0.673	-0.674	800.00	100.00
24-Oct-92	0.01	0.998	0.326	0.317	-0.672	-0.673	900.00	100.00
25-Oct-92	0.01	0.999	0.322	0.308	-0.676	-0.677	1400.00	100.00
26-Oct-92	0.01	0.999	0.324	0.308	-0.676	-0.677	1600.00	100.00
27-Oct-92	0.01	0.998	0.321	0.304	-0.679	-0.68	1700.00	100.00
28-Oct-92	0.01	0.998	0.321	0.304	-0.679	-0.68	1700.00	100.00
29-Oct-92	0.01	0.998	0.32	0.306	-0.679	-0.68	1400.00	100.00
30-Oct-92	0.01	0.998	0.32	0.306	-0.679	-0.68	1400.00	100.00
31-Oct-92	0.01	0.999	0.321	0.303	-0.676	-0.677	1800.00	100.00
01-Nov-92	0.01	0.999	0.32	0.307	-0.68	-0.681	1300.00	100.00
02-Nov-92	0.01	0.999	0.319	0.306	-0.681	-0.682	1300.00	100.00
03-Nov-92	0.01	1	0.318	0.292	-0.682	-0.683	2600.00	100.00
04-Nov-92	0.01	1	0.318	0.292	-0.682	-0.683	2600.00	100.00

REVERSED POLARITY
SPECIMEN #5A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	1.05	0.995	1.58	0.215	0.61	0.627	1300.00	-16.19
22-Sep-92	0.91	0.955	1.62	0.131	0.619	0.651	1636.26	-35.16
23-Sep-92	1.3	0.994	1.63	0.133	0.625	0.653	1151.54	-21.54
24-Sep-92	1.37	0.982	1.63	0.172	0.625	0.653	1064.23	-20.44
25-Sep-92	1.37	0.982	1.63	0.172	0.625	0.653	1064.23	-20.44
26-Sep-92	1.48	0.992	1.63	0.186	0.622	0.656	975.68	-22.97
27-Sep-92	1.52	0.991	1.62	0.147	0.623	0.656	969.08	-21.71
28-Sep-92	1.44	0.991	1.62	0.15	0.625	0.655	1020.83	-20.83
29-Sep-92	1.47	0.993	1.6	0.148	0.611	0.654	987.76	-29.25
30-Sep-92	1.5	0.993	1.62	0.115	0.625	0.656	1003.33	-20.67
01-Oct-92	1.5	0.993	1.62	0.115	0.625	0.656	1003.33	-20.67
02-Oct-92	1.54	0.989	1.61	0.165	0.625	0.656	938.31	-20.13
03-Oct-92	1.52	0.992	1.62	0.062	0.63	0.655	1025.00	-16.45
04-Oct-92	1.42	0.993	1.62	0.108	0.629	0.654	1066.20	-17.61
05-Oct-92	1.4	0.993	1.62	0.184	0.629	0.652	1025.71	-16.43
06-Oct-92	1.3	0.993	1.62	0.13	0.631	0.654	1146.15	-17.69
07-Oct-92	1.34	0.993	1.62	0.142	0.625	0.653	1102.99	-20.90
08-Oct-92	1.34	0.993	1.62	0.142	0.625	0.653	1102.99	-20.90
09-Oct-92	1.26	0.993	1.63	0.146	0.633	0.653	1177.78	-15.87
10-Oct-92	1.26	0.993	1.63	0.075	0.629	0.657	1234.13	-22.22
11-Oct-92	1.26	0.993	1.64	0.107	0.636	0.657	1216.67	-16.67
12-Oct-92	1.26	0.993	1.63	0.166	0.631	0.659	1161.90	-22.22
13-Oct-92	1.3	0.993	1.64	0.093	0.637	0.655	1190.00	-13.85
14-Oct-92	1.3	0.993	1.63	0.101	0.634	0.659	1176.15	-19.23
15-Oct-92	1.32	0.993	1.64	0.153	0.638	0.661	1126.52	-17.42
16-Oct-92	1.3	0.993	1.64	0.105	0.642	0.659	1180.77	-13.08
17-Oct-92	1.3	0.993	1.64	0.105	0.642	0.659	1180.77	-13.08
18-Oct-92	1.26	0.993	1.65	0.07	0.641	0.664	1253.97	-18.25
19-Oct-92	1.26	0.993	1.64	0.108	0.644	0.664	1215.87	-15.87
20-Oct-92	1.29	0.993	1.64	0.15	0.646	0.665	1155.04	-14.73
21-Oct-92	1.29	0.993	1.64	0.15	0.646	0.665	1155.04	-14.73
22-Oct-92	1.24	0.993	1.65	0.046	0.646	0.667	1293.55	-16.94
23-Oct-92	1.21	0.993	1.64	0.114	0.647	0.666	1261.16	-15.70
24-Oct-92	1.2	0.993	1.64	0.115	0.647	0.667	1270.83	-16.67
25-Oct-92	1.2	0.993	1.64	0.1	0.651	0.669	1283.33	-15.00
26-Oct-92	1.2	0.993	1.65	0.134	0.65	0.668	1263.33	-15.00
27-Oct-92	1.2	0.993	1.65	0.147	0.652	0.673	1252.50	-17.50
28-Oct-92	1.2	0.993	1.65	0.147	0.652	0.673	1252.50	-17.50
29-Oct-92	1.2	0.992	1.65	0.155	0.653	0.672	1245.83	-15.83
30-Oct-92	1.2	0.992	1.65	0.155	0.653	0.672	1245.83	-15.83
31-Oct-92	1.18	0.993	1.65	0.108	0.654	0.673	1306.78	-16.10
01-Nov-92	1.18	0.993	1.65	0.113	0.654	0.672	1302.54	-15.25
02-Nov-92	1.2	0.993	1.65	0.089	0.654	0.674	1300.83	-16.67
03-Nov-92	1.18	0.994	1.65	0.128	0.657	0.673	1289.83	-13.56
04-Nov-92	1.18	0.994	1.65	0.128	0.657	0.673	1289.83	-13.56

NORMAL POLARITY
SPECIMEN #5B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	2.53	0.986	-0.09	-0.474	-1.04	-0.955	151.78	-33.60
22-Sep-92	3.97	0.977	-0.095	-0.507	-1.07	-0.95	103.78	-30.23
23-Sep-92	4.6	0.975	-0.09	-0.519	-1.06	-0.936	93.26	-26.96
24-Sep-92	4.03	0.976	-0.08	-0.515	-1.06	-0.936	107.94	-30.27
25-Sep-92	4.03	0.976	-0.08	-0.515	-1.06	-0.936	107.94	-30.27
26-Sep-92	3.55	0.981	-0.095	-0.525	-1.08	-0.915	121.13	-46.48
27-Sep-92	1.45	0.993	0.207	-0.605	-0.779	-0.737	560.00	-28.97
28-Sep-92	1.46	0.994	0.031	-0.545	-0.858	-0.8	394.52	-39.73
29-Sep-92	1.85	0.991	-0.003	-0.545	-0.898	-0.825	292.97	-39.46
30-Sep-92	1.25	0.994	0.061	-0.535	-0.969	-0.833	476.80	-108.80
01-Oct-92	1.25	0.994	0.061	-0.535	-0.969	-0.833	476.80	-108.80
02-Oct-92	1.46	0.993	0.019	-0.531	-0.935	-0.825	376.71	-75.34
03-Oct-92	1.48	0.993	0.007	-0.533	-0.962	-0.815	364.86	-99.32
04-Oct-92	1.52	0.993	0.01	-0.525	-0.945	-0.805	351.97	-92.11
05-Oct-92	1.43	0.993	0.007	-0.526	-0.934	-0.805	372.73	-90.21
06-Oct-92	1.6	0.992	0.008	-0.465	-0.934	-0.805	295.63	-80.63
07-Oct-92	1.45	0.993	0.006	-0.537	-0.936	-0.785	374.48	-104.14
08-Oct-92	1.45	0.993	0.006	-0.537	-0.936	-0.785	374.48	-104.14
09-Oct-92	1.55	0.992	0.003	-0.508	-0.934	-0.777	329.68	-101.29
10-Oct-92	1.47	0.992	0.005	-0.514	-0.926	-0.729	353.06	-134.01
11-Oct-92	1.47	0.992	0.007	-0.513	-0.929	-0.646	353.74	-191.16
12-Oct-92	1.47	0.992	0.009	-0.513	-0.946	-0.73	355.10	-146.26
13-Oct-92	1.47	0.992	0.002	-0.511	-0.957	-0.802	348.98	-105.44
14-Oct-92	1.37	0.993	0.006	-0.508	-0.937	-0.73	375.18	-151.09
15-Oct-92	1.41	0.992	0.006	-0.515	-0.968	-0.764	369.50	-144.68
16-Oct-92	1.43	0.993	0.008	-0.515	-0.965	-0.757	365.73	-145.45
17-Oct-92	1.43	0.993	0.008	-0.515	-0.965	-0.757	365.73	-145.45
18-Oct-92	1.4	0.993	0.012	-0.513	-0.968	-0.754	375.00	-152.86
19-Oct-92	1.4	0.993	0.036	-0.564	-0.992	-0.688	428.57	-217.14
20-Oct-92	1.41	0.993	0.027	-0.516	-0.962	-0.744	365.11	-154.61
21-Oct-92	1.41	0.993	0.027	-0.516	-0.962	-0.744	365.11	-154.61
22-Oct-92	1.41	0.993	0.012	-0.513	-0.966	-0.751	372.34	-152.48
23-Oct-92	1.41	0.993	0.012	-0.513	-0.965	-0.731	372.34	-165.96
24-Oct-92	1.41	0.992	0.033	-0.516	-0.963	-0.721	389.36	-171.63
25-Oct-92	1.41	0.992	0.024	-0.513	-0.977	-0.736	380.85	-170.92
26-Oct-92	1.37	0.992	0.026	-0.514	-0.975	-0.742	394.16	-170.07
27-Oct-92	1.41	0.992	0.015	-0.55	-0.982	-0.717	400.71	-187.94
28-Oct-92	1.41	0.992	0.015	-0.55	-0.982	-0.717	400.71	-187.94
29-Oct-92	1.46	0.992	0.019	-0.555	-0.979	-0.713	393.15	-182.19
30-Oct-92	1.46	0.992	0.02	-0.555	-0.979	-0.713	393.84	-182.19
31-Oct-92	1.47	0.992	0.022	-0.546	-0.979	-0.731	386.39	-168.71
01-Nov-92	1.46	0.992	0.017	-0.549	-0.982	-0.729	387.67	-173.29
02-Nov-92	1.46	0.992	0.022	-0.535	-0.979	-0.734	381.51	-167.81
03-Nov-92	1.52	0.991	0.011	-0.53	-0.988	-0.737	355.92	-165.13
04-Nov-92	1.52	0.991	0.011	-0.53	-0.988	-0.737	355.92	-165.13

REVERSED POLARITY
SPECIMEN #5B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	7.19	0.955	1.67	0.486	0.621	0.665	164.67	-6.12
22-Sep-92	2.2	1	1.85	0.527	0.849	0.873	601.36	-10.91
23-Sep-92	9.55	0.882	1.64	0.597	0.641	0.709	109.21	-7.12
24-Sep-92	11.98	0.932	1.62	0.637	0.631	0.728	82.05	-8.10
25-Sep-92	11.98	0.932	1.62	0.637	0.631	0.728	82.05	-8.10
26-Sep-92	11.7	0.934	1.63	0.634	0.625	0.706	85.13	-6.92
27-Sep-92	1.46	0.993	1.63	0.646	0.614	0.642	673.97	-19.18
28-Sep-92	2.55	0.986	1.63	0.585	0.625	0.66	409.80	-13.73
29-Sep-92	3.36	0.984	1.64	0.612	0.604	0.689	305.95	-25.30
30-Sep-92	3.3	0.984	1.64	0.612	0.604	0.689	311.52	-25.76
01-Oct-92	3.6	0.98	1.63	0.571	0.593	0.649	294.17	-15.56
02-Oct-92	3.62	0.98	1.61	0.569	0.595	0.646	287.57	-14.09
03-Oct-92	3.65	0.979	1.6	0.568	0.602	0.645	282.74	-11.78
04-Oct-92	3.65	0.979	1.6	0.566	0.602	0.643	283.29	-11.23
05-Oct-92	3.65	0.979	1.6	0.547	0.589	0.636	288.49	-12.88
06-Oct-92	3.7	0.978	1.59	0.583	0.578	0.631	272.16	-14.32
07-Oct-92	3.7	0.978	1.6	0.557	0.582	0.634	281.89	-14.05
08-Oct-92	3.7	0.978	1.6	0.557	0.582	0.634	281.89	-14.05
09-Oct-92	3.7	0.978	1.61	0.554	0.585	0.633	285.41	-12.97
10-Oct-92	3.7	0.978	1.6	0.553	0.576	0.629	282.97	-14.32
11-Oct-92	3.7	0.978	1.59	0.545	0.56	0.632	282.43	-19.46
12-Oct-92	3.7	0.978	1.59	0.55	0.574	0.625	281.08	-13.78
13-Oct-92	3.7	0.978	1.6	0.555	0.584	0.638	282.43	-14.59
14-Oct-92	3.87	0.977	1.6	0.558	0.575	0.626	269.25	-13.18
15-Oct-92	3.72	0.978	1.6	0.558	0.585	0.642	280.11	-15.32
16-Oct-92	3.75	0.978	1.59	0.56	0.587	0.642	274.67	-14.67
17-Oct-92	3.75	0.978	1.59	0.56	0.587	0.642	274.67	-14.67
18-Oct-92	3.7	0.978	1.58	0.552	0.564	0.648	277.84	-22.70
19-Oct-92	3.6	0.978	1.58	0.571	0.567	0.629	280.28	-17.22
20-Oct-92	3.75	0.977	1.58	0.573	0.579	0.633	268.53	-14.40
21-Oct-92	3.75	0.977	1.58	0.573	0.579	0.633	268.53	-14.40
22-Oct-92	3.75	0.977	1.61	0.55	0.575	0.648	282.67	-19.47
23-Oct-92	3.62	0.977	1.62	0.551	0.591	0.656	295.30	-17.96
24-Oct-92	3.65	0.976	1.62	0.565	0.605	0.656	291.78	-13.97
25-Oct-92	3.65	0.977	1.62	0.55	0.603	0.668	293.15	-17.81
26-Oct-92	3.65	0.977	1.61	0.561	0.603	0.657	287.40	-14.79
27-Oct-92	3.65	0.977	1.55	0.554	0.544	0.676	272.88	-36.16
28-Oct-92	3.65	0.977	1.55	0.554	0.544	0.676	272.88	-36.16
29-Oct-92	3.73	0.977	1.59	0.561	0.593	0.659	275.87	-17.69
30-Oct-92	3.73	0.977	1.59	0.561	0.593	0.659	275.87	-17.69
31-Oct-92	3.75	0.977	1.61	0.55	0.604	0.681	282.67	-20.53
01-Nov-92	3.81	0.975	1.61	0.557	0.606	0.672	276.38	-17.32
02-Nov-92	3.9	0.975	1.62	0.551	0.621	0.675	274.10	-13.85
03-Nov-92	3.9	0.975	1.63	0.548	0.63	0.686	277.44	-14.36
04-Nov-92	3.9	0.975	1.63	0.548	0.63	0.686	277.44	-14.36

NORMAL POLARITY
SPECIMEN #5C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	2.77	0.985	0.087	-0.443	-1.05	-0.959	191.34	-32.85
22-Sep-92	2.75	0.985	0.17	-0.462	-1.15	-0.94	229.82	-76.36
23-Sep-92	2.48	0.987	0.117	-0.447	-1.1	-0.951	227.42	-60.08
24-Sep-92	2.75	0.985	0.094	-0.449	-1.08	-0.942	197.45	-50.18
25-Sep-92	2.75	0.985	0.094	-0.449	-1.08	-0.942	197.45	-50.18
26-Sep-92	2.9	0.984	0.091	-0.448	-1.07	-0.925	185.86	-50.00
27-Sep-92	1.81	0.991	0.037	-0.49	-0.943	-0.87	291.16	-40.33
28-Sep-92	1.48	0.99	0.001	-0.472	-0.949	-0.901	319.59	-32.43
29-Sep-92	1.37	0.994	0.038	-0.465	-0.96	-0.825	361.75	-98.54
30-Sep-92	1.44	0.993	0.005	-0.472	-0.948	-0.862	331.25	-59.72
01-Oct-92	1.44	0.993	0.005	-0.472	-0.948	-0.862	331.25	-59.72
02-Oct-92	1.29	0.994	0.019	-0.473	-0.923	-0.85	381.40	-56.59
03-Oct-92	1.29	0.994	0.018	-0.471	-0.929	-0.855	379.07	-57.36
04-Oct-92	1.29	0.994	0.015	-0.472	-0.913	-0.823	377.52	-69.77
05-Oct-92	1.44	0.993	0.002	-0.472	-0.965	-0.83	329.17	-93.75
06-Oct-92	1.5	0.992	0.008	-0.518	-0.965	-0.83	360.67	-90.00
07-Oct-92	1.39	0.993	0.018	-0.472	-0.968	-0.837	352.52	-94.24
08-Oct-92	1.39	0.993	0.018	-0.472	-0.968	-0.837	352.52	-94.24
09-Oct-92	1.6	0.991	0.005	-0.472	-0.936	-0.825	298.12	-69.38
10-Oct-92	1.53	0.991	0.004	-0.479	-0.961	-0.751	315.69	-137.25
11-Oct-92	1.48	0.992	0.007	-0.475	-0.961	-0.783	325.68	-120.27
12-Oct-92	1.49	0.992	0.002	-0.484	-0.967	-0.846	326.17	-81.21
13-Oct-92	1.5	0.992	0.004	-0.482	-0.964	-0.803	324.00	-107.33
14-Oct-92	1.5	0.992	0.005	-0.478	-0.952	-0.765	322.00	-124.67
15-Oct-92	1.38	0.993	0.051	-0.461	-1.01	-0.822	385.51	-136.23
16-Oct-92	1.5	0.992	0.002	-0.491	-0.983	-0.845	328.67	-92.00
17-Oct-92	1.5	0.992	0.002	-0.491	-0.983	-0.845	328.67	-92.00
18-Oct-92	1.48	0.992	0.005	-0.486	-0.976	-0.83	331.76	-98.65
19-Oct-92	1.4	0.993	0.008	-0.488	-0.992	-0.738	354.29	-181.43
20-Oct-92	1.74	0.991	0.007	-0.482	-0.985	-0.785	281.03	-114.94
21-Oct-92	1.74	0.991	0.007	-0.482	-0.985	-0.785	281.03	-114.94
22-Oct-92	1.55	0.992	0.014	-0.482	-0.997	-0.832	320.00	-106.45
23-Oct-92	1.63	0.991	0.005	-0.476	-0.993	-0.803	295.09	-116.56
24-Oct-92	1.63	0.991	0.003	-0.483	-1	-0.76	298.16	-147.24
25-Oct-92	1.51	0.992	0.007	-0.487	-1.02	-0.778	327.15	-160.26
26-Oct-92	1.34	0.993	0.041	-0.484	-1.07	-0.772	391.79	-222.39
27-Oct-92	1.56	0.992	0.015	-0.528	-1.02	-0.757	348.08	-168.59
28-Oct-92	1.56	0.992	0.015	-0.528	-1.02	-0.757	348.08	-168.59
29-Oct-92	1.62	0.991	0.024	-0.538	-1.02	-0.755	346.91	-163.58
30-Oct-92	1.62	0.991	0.025	-0.538	-1.02	-0.755	347.53	-163.58
31-Oct-92	1.68	0.991	0.015	-0.528	-0.999	-0.772	323.21	-135.12
01-Nov-92	1.68	0.991	0.014	-0.531	-1.01	-0.77	324.40	-142.86
02-Nov-92	1.66	0.991	0.01	-0.524	-1.01	-0.643	321.69	-221.08
03-Nov-92	1.75	0.991	0.014	-0.516	-1.01	-0.777	302.86	-133.14
04-Nov-92	1.75	0.991	0.014	-0.516	-1.01	-0.777	302.86	-133.14

REVERSED POLARITY
SPECIMEN #5C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (13/16 IN - 20.6mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	9.7	0.944	1.68	0.565	0.644	0.699	114.95	-5.67
22-Sep-92	15.42	0.912	1.59	0.665	0.581	0.672	59.99	-5.90
23-Sep-92	4.09	0.977	1.72	0.49	0.677	0.733	300.73	-13.69
24-Sep-92	12.65	0.926	1.61	0.606	0.596	0.698	79.37	-8.06
25-Sep-92	12.65	0.926	1.61	0.606	0.596	0.698	79.37	-8.06
26-Sep-92	10.15	0.943	1.61	0.536	0.662	0.707	105.81	-4.43
27-Sep-92	4.14	0.976	1.59	0.584	0.58	0.657	243.00	-18.60
28-Sep-92	4.7	0.975	1.6	0.53	0.605	0.665	227.66	-12.77
29-Sep-92	4.7	0.974	1.59	0.54	0.585	0.651	223.40	-14.04
30-Sep-92	4.1	0.976	1.55	0.541	0.545	0.655	246.10	-26.83
01-Oct-92	4.1	0.976	1.55	0.541	0.545	0.655	246.10	-26.83
02-Oct-92	4.4	0.976	1.54	0.523	0.539	0.649	231.14	-25.00
03-Oct-92	3.17	0.984	1.3	0.508	0.313	0.649	249.84	-105.99
04-Oct-92	4.4	0.975	1.6	0.524	0.595	0.646	244.55	-11.59
05-Oct-92	4.4	0.975	1.6	0.525	0.59	0.647	244.32	-12.95
06-Oct-92	3.31	0.982	1.59	0.54	0.585	0.643	317.22	-17.52
07-Oct-92	3.31	0.982	1.52	0.522	0.578	0.649	301.51	-21.45
08-Oct-92	3.31	0.982	1.52	0.522	0.578	0.649	301.51	-21.45
09-Oct-92	4.57	0.975	1.58	0.539	0.574	0.655	227.79	-17.72
10-Oct-92	2.97	0.983	1.63	0.529	0.611	0.656	370.71	-15.15
11-Oct-92	2.97	0.983	1.61	0.539	0.584	0.666	360.61	-27.61
12-Oct-92	5	0.971	1.6	0.545	0.584	0.666	211.00	-16.40
13-Oct-92	5.2	0.97	1.6	0.52	0.604	0.672	207.69	-13.08
14-Oct-92	5.11	0.97	1.55	0.54	0.547	0.679	197.65	-25.83
15-Oct-92	2.83	0.985	1.5	0.537	0.49	0.715	340.28	-79.51
16-Oct-92	4.95	0.972	1.61	0.571	0.596	0.695	209.90	-20.00
17-Oct-92	4.95	0.972	1.61	0.571	0.596	0.695	209.90	-20.00
18-Oct-92	5.27	0.97	1.63	0.555	0.607	0.694	203.98	-16.51
19-Oct-92	5.27	0.97	1.62	0.547	0.607	0.69	203.61	-15.75
20-Oct-92	5.48	0.968	1.63	0.57	0.633	0.708	193.43	-13.69
21-Oct-92	5.48	0.968	1.63	0.57	0.633	0.708	193.43	-13.69
22-Oct-92	5.48	0.968	1.63	0.535	0.626	0.707	199.82	-14.78
23-Oct-92	4.85	0.972	1.6	0.52	0.587	0.716	222.68	-26.60
24-Oct-92	4.85	0.976	1.63	0.56	0.621	0.731	220.62	-22.68
25-Oct-92	4.85	0.976	1.64	0.537	0.628	0.715	227.42	-17.94
26-Oct-92	5.12	0.971	1.62	0.553	0.6	0.705	208.40	-20.51
27-Oct-92	5.54	0.967	1.65	0.584	0.648	0.725	192.42	-13.90
28-Oct-92	5.54	0.967	1.65	0.584	0.648	0.725	192.42	-13.90
29-Oct-92	3.56	0.979	1.34	0.537	0.325	0.739	225.56	-116.29
30-Oct-92	3.56	0.979	1.34	0.537	0.325	0.739	225.56	-116.29
31-Oct-92	5.4	0.967	1.64	0.541	0.646	0.719	203.52	-13.15
01-Nov-92	5.77	0.965	1.64	0.546	0.635	0.722	189.60	-15.08
02-Nov-92	4.91	0.972	1.58	0.529	0.58	0.776	214.05	-39.92
03-Nov-92	5.92	0.966	1.67	0.568	0.673	0.746	186.15	-12.33
04-Nov-92	5.92	0.966	1.67	0.568	0.673	0.746	186.15	-12.33

NORMAL POLARITY
SPECIMEN #5D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
21-Sep-92	0.25	0.975	0.333	-0.169	-0.684	-0.66	2008.00	-96.00
22-Sep-92	0.84	0.994	0.088	-0.354	-0.885	-0.685	526.19	-238.10
23-Sep-92	1.37	0.89	0.103	-0.428	-0.969	-0.93	387.59	-28.47
24-Sep-92	2.5	0.985	0.109	-0.443	-1.06	-0.903	220.80	-62.80
25-Sep-92	2.5	0.985	0.109	-0.443	-1.06	-0.903	220.80	-62.80
26-Sep-92	1.53	0.993	0.187	-0.452	-1.14	-0.908	417.65	-151.63
27-Sep-92	1.93	0.974	0.074	-0.445	-1.01	-0.884	268.91	-65.28
28-Sep-92	1.91	0.992	0.081	-0.45	-1	-0.905	278.01	-49.74
29-Sep-92	1.79	0.99	0.056	-0.467	-1.02	-0.818	292.18	-112.85
30-Sep-92	1.87	0.98	0.069	-0.453	-1.01	-0.865	279.14	-77.54
01-Oct-92	1.87	0.98	0.069	-0.453	-1.01	-0.865	279.14	-77.54
02-Oct-92	1.84	0.991	0.062	-0.448	-1.02	-0.88	277.17	-76.09
03-Oct-92	1.75	0.991	0.088	-0.455	-1.04	-0.855	310.29	-105.71
04-Oct-92	1.95	0.99	0.05	-0.463	-1.02	-0.841	263.08	-91.79
05-Oct-92	1.95	0.99	0.051	-0.468	-1.02	-0.841	266.15	-91.79
06-Oct-92	1.93	0.99	0.054	-0.483	-1.02	-0.841	278.24	-92.75
07-Oct-92	1.77	0.99	0.046	-0.467	-1.01	-0.816	289.83	-109.60
08-Oct-92	1.77	0.99	0.046	-0.467	-1.01	-0.816	289.83	-109.60
09-Oct-92	2.12	0.985	0.041	-0.468	-0.999	-0.807	240.09	-90.57
10-Oct-92	1.68	0.99	0.036	-0.475	-0.907	-0.812	304.17	-56.55
11-Oct-92	1.55	0.99	0.035	-0.484	-0.99	-0.832	334.84	-101.94
12-Oct-92	1.62	0.991	0.027	-0.485	-1	-0.806	316.05	-119.75
13-Oct-92	1.73	0.99	0.025	-0.479	-1	-0.806	291.33	-112.14
14-Oct-92	1.7	0.99	0.023	-0.495	-0.993	-0.805	304.71	-110.59
15-Oct-92	1.51	0.992	0.056	-0.491	-1.04	-0.816	362.25	-148.34
16-Oct-92	1.45	0.992	0.016	-0.479	-0.994	-0.812	341.38	-125.52
17-Oct-92	1.45	0.992	0.016	-0.479	-0.994	-0.812	341.38	-125.52
18-Oct-92	1.45	0.992	0.007	-0.491	-0.976	-0.8	343.45	-121.38
19-Oct-92	1.44	0.992	0.008	-0.485	-1	-0.746	342.36	-176.39
20-Oct-92	1.39	0.993	0.006	-0.488	-0.985	-0.779	355.40	-148.20
21-Oct-92	1.39	0.993	0.006	-0.488	-0.985	-0.779	355.40	-148.20
22-Oct-92	1.41	0.993	0.006	-0.481	-0.99	-0.807	345.39	-129.79
23-Oct-92	1.48	0.99	0.01	-0.482	-0.99	-0.75	332.43	-162.16
24-Oct-92	1.48	0.99	0.007	-0.478	-0.993	-0.74	327.70	-170.95
25-Oct-92	1.34	0.993	0.003	-0.477	-1	-0.744	358.21	-191.04
26-Oct-92	1.34	0.993	0.002	-0.477	-1	-0.745	357.46	-190.30
27-Oct-92	1.34	0.993	0.006	-0.532	-0.991	-0.718	401.49	-203.73
28-Oct-92	1.34	0.993	0.006	-0.532	-0.991	-0.718	401.49	-203.73
29-Oct-92	1.42	0.992	0.003	-0.541	-0.999	-0.715	383.10	-200.00
30-Oct-92	1.42	0.992	0.003	-0.541	-0.999	-0.715	383.10	-200.00
31-Oct-92	1.42	0.992	0.002	-0.529	-1.014	-0.736	373.94	-195.77
01-Nov-92	1.42	0.992	0.003	-0.537	-1	-0.731	380.28	-189.44
02-Nov-92	1.42	0.992	0.003	-0.537	-1	-0.731	380.28	-189.44
03-Nov-92	1.35	0.993	0.004	-0.528	-1	-0.742	394.07	-191.11
04-Nov-92	1.35	0.993	0.004	-0.528	-1	-0.742	394.07	-191.11

REVERSED POLARITY
SPECIMEN #5D
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
21-Sep-92	3.49	0.893	1.53	0.307	0.255	0.643	350.43	-111.17
22-Sep-92	5.63	0.963	1.56	0.365	0.567	0.647	208.70	-14.21
23-Sep-92	5.63	0.967	1.41	0.459	0.415	0.686	168.92	-48.13
24-Sep-92	7.175	0.959	1.64	0.503	0.625	0.724	158.47	-13.80
25-Sep-92	7.175	0.959	1.64	0.503	0.625	0.724	158.47	-13.80
26-Sep-92	7.52	0.956	1.58	0.48	0.57	0.665	146.28	-12.63
27-Sep-92	8.2	0.939	1.6	0.487	0.597	0.705	135.73	-13.17
28-Sep-92	7.2	0.96	1.57	0.482	0.56	0.73	151.11	-23.61
29-Sep-92	6.5	0.964	1.6	0.512	0.608	0.71	167.38	-15.69
30-Sep-92	7.3	0.96	1.61	0.527	0.618	0.705	148.36	-11.92
01-Oct-92	7.3	0.96	1.61	0.527	0.618	0.705	148.36	-11.92
02-Oct-92	7.3	0.96	1.61	0.502	0.613	0.7	151.78	-11.92
03-Oct-92	7.2	0.96	1.61	0.512	0.612	0.706	152.50	-13.06
04-Oct-92	7.2	0.96	1.6	0.514	0.601	0.686	150.83	-11.81
05-Oct-92	7	0.96	1.6	0.524	0.601	0.685	153.71	-12.00
06-Oct-92	6.71	0.96	1.59	0.542	0.596	0.682	156.18	-12.82
07-Oct-92	6.71	0.96	1.59	0.55	0.59	0.679	154.99	-13.26
08-Oct-92	6.71	0.96	1.59	0.55	0.59	0.679	154.99	-13.26
09-Oct-92	6.25	0.955	1.56	0.532	0.563	0.667	164.48	-16.64
10-Oct-92	6.5	0.96	1.58	0.562	0.577	0.686	156.62	-16.77
11-Oct-92	6.5	0.96	1.55	0.546	0.545	0.684	154.46	-21.38
12-Oct-92	5.4	0.966	1.55	0.536	0.547	0.67	187.41	-22.78
13-Oct-92	5.35	0.967	1.59	0.53	0.585	0.655	198.13	-13.08
14-Oct-92	5.35	0.967	1.59	0.541	0.585	0.667	196.07	-15.33
15-Oct-92	6.06	0.965	1.59	0.573	0.591	0.668	167.82	-12.71
16-Oct-92	5.85	0.965	1.59	0.572	0.594	0.665	174.02	-12.14
17-Oct-92	5.85	0.965	1.59	0.572	0.594	0.665	174.02	-12.14
18-Oct-92	5.8	0.965	1.59	0.548	0.593	0.665	179.66	-12.41
19-Oct-92	5.6	0.966	1.56	0.546	0.56	0.662	181.07	-18.21
20-Oct-92	5.52	0.966	1.59	0.564	0.591	0.676	185.87	-15.40
21-Oct-92	5.52	0.966	1.59	0.564	0.591	0.676	185.87	-15.40
22-Oct-92	4.85	0.972	1.47	0.545	0.457	0.678	190.72	-45.57
23-Oct-92	5.52	0.966	1.6	0.557	0.595	0.669	188.95	-13.41
24-Oct-92	5.52	0.966	1.6	0.512	0.597	0.668	197.10	-12.86
25-Oct-92	5.52	0.966	1.6	0.527	0.601	0.672	194.38	-12.86
26-Oct-92	5.5	0.967	1.59	0.542	0.586	0.665	190.55	-14.36
27-Oct-92	5.52	0.966	1.6	0.553	0.593	0.666	189.67	-13.22
28-Oct-92	5.52	0.966	1.6	0.553	0.593	0.666	189.67	-13.22
29-Oct-92	5.52	0.966	1.58	0.547	0.575	0.664	187.14	-16.12
30-Oct-92	5.52	0.966	1.58	0.547	0.575	0.664	187.14	-16.12
31-Oct-92	5.1	0.969	1.56	0.552	0.545	0.669	197.65	-24.31
01-Nov-92	5.1	0.969	1.53	0.544	0.533	0.673	193.33	-27.45
02-Nov-92	4.73	0.972	1.53	0.544	0.533	0.673	208.46	-29.60
03-Nov-92	4.6	0.973	1.5	0.554	0.483	0.685	205.65	-43.91
04-Nov-92	4.6	0.973	1.5	0.554	0.483	0.685	205.65	-43.91

APPENDIX E

TEST SERIES Nos. 6, 7 AND 8

POTENTIAL AND CURRENT MEASUREMENTS

NORMAL POLARITY
SPECIMEN #6A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.2	1	0.342	-0.35	-0.675	-0.664	3460.00	-55.00
23-Nov-92	0.2	1	0.342	-0.35	-0.675	-0.664	3460.00	-55.00
24-Nov-92	0.2	1	0.114	-0.53	-0.885	-0.873	3220.00	-60.00
25-Nov-92	0.2	1	0.236	-0.22	-0.738	-0.724	2280.00	-70.00
26-Nov-92	0.2	1	0.202	-0.441	-0.78	-0.767	3215.00	-65.00
27-Nov-92	0.2	1	0.167	-0.46	-0.823	-0.81	3135.00	-65.00
28-Nov-92	0.2	1	0.132	-0.481	-0.865	-0.853	3065.00	-60.00
29-Nov-92	0.2	1	0.263	-0.352	-0.733	-0.723	3075.00	-50.00
30-Nov-92	0.16	1	0.287	-0.332	-0.729	-0.716	3868.75	-81.25
01-Dec-92	0.16	1	0.287	-0.332	-0.729	-0.716	3868.75	-81.25
02-Dec-92	0.16	1	0.287	-0.332	-0.729	-0.716	3868.75	-81.25
03-Dec-92	0.15	1	0.287	-0.298	-0.729	-0.719	3900.00	-66.67
04-Dec-92	0.13	1	0.287	-0.264	-0.729	-0.72	4238.46	-69.23
05-Dec-92	0.11	1	0.287	-0.23	-0.729	-0.721	4700.00	-72.73
06-Dec-92	0.12	1	0.256	-0.24	-0.748	-0.741	4133.33	-58.33
07-Dec-92	0.14	1	0.225	-0.25	-0.767	-0.761	3392.86	-42.86
08-Dec-92	0.15	1	0.234	-0.254	-0.761	-0.754	3253.33	-46.67
09-Dec-92	0.16	1	0.244	-0.258	-0.755	-0.747	3137.50	-50.00
10-Dec-92	0.17	1	0.253	-0.262	-0.744	-0.741	3029.41	-17.65
11-Dec-92	0.19	1	0.262	-0.266	-0.743	-0.734	2778.95	-47.37
12-Dec-92	0.2	1	0.272	-0.27	-0.738	-0.727	2710.00	-55.00
13-Dec-92	0.24	1	0.263	-0.311	-0.742	-0.729	2391.67	-54.17
14-Dec-92	0.28	1	0.255	-0.352	-0.75	-0.731	2167.86	-67.86
15-Dec-92	0.29	1	0.261	-0.357	-0.749	-0.73	2131.03	-65.52
16-Dec-92	0.3	1	0.267	-0.362	-0.748	-0.729	2096.67	-63.33
17-Dec-92	0.43	1	0.226	-0.398	-0.764	-0.732	1451.16	-74.42
18-Dec-92	0.57	1	0.183	-0.433	-0.779	-0.734	1080.70	-78.95
19-Dec-92	0.75	1	0.14	-0.47	-0.795	-0.738	813.33	-76.00
20-Dec-92	0.84	1	0.098	-0.504	-0.81	-0.74	716.67	-83.33
21-Dec-92	0.94	1	0.064	-0.515	-0.834	-0.755	615.96	-84.04
22-Dec-92	1	1	0.03	-0.526	-0.858	-0.77	556.00	-88.00
23-Dec-92	1.16	1	0.04	-0.537	-0.882	-0.785	497.41	-83.62
24-Dec-92	1.27	1	0.069	-0.548	-0.906	-0.8	465.83	-83.46
25-Dec-92	1.38	1	0.074	-0.558	-0.93	-0.815	457.97	-83.33
26-Dec-92	1.45	1	0.078	-0.558	-0.944	-0.825	438.62	-82.07
27-Dec-92	1.52	1	0.082	-0.559	-0.958	-0.835	421.71	-80.92
28-Dec-92	1.6	1	0.086	-0.559	-0.972	-0.845	403.13	-79.38
29-Dec-92	1.67	1	0.09	-0.559	-0.986	-0.855	388.62	-78.44
30-Dec-92	1.75	1	0.094	-0.56	-1	-0.865	373.71	-77.14
31-Dec-92	1.83	1	0.098	-0.56	-1.014	-0.875	359.56	-75.96
01-Jan-93	1.91	1	0.102	-0.561	-1.028	-0.885	347.12	-74.87
02-Jan-93	1.98	1	0.106	-0.561	-1.042	-0.895	336.87	-74.24
03-Jan-93	1.98	1	0.106	-0.568	-1.04	-0.905	340.40	-68.18
04-Jan-93	1.98	1	0.105	-0.575	-1.04	-0.92	343.43	-60.61
05-Jan-93	1.98	1	0.105	-0.575	-1.04	-0.92	343.43	-60.61

REVERSED POLARITY
SPECIMEN #6A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	0.5	1	1.69	0.4	0.64	0.657	2580.00	-34.00
23-Nov-92	0.5	1	1.69	0.4	0.64	0.657	2580.00	-34.00
24-Nov-92	0.5	1	1.84	0.56	0.835	0.852	2560.00	-34.00
25-Nov-92	0.53	1	1.71	0.442	0.704	0.723	2392.45	-35.85
26-Nov-92	0.57	1	1.74	0.463	0.734	0.753	2240.35	-33.33
27-Nov-92	0.61	1	1.77	0.484	0.764	0.783	2108.20	-31.15
28-Nov-92	0.65	1	1.8	0.505	0.794	0.813	1992.31	-29.23
29-Nov-92	0.68	1	1.7	0.384	0.688	0.709	1935.29	-30.88
30-Nov-92	0.7	1	1.71	0.37	0.694	0.716	1914.29	-31.43
01-Dec-92	0.7	1	1.71	0.37	0.694	0.716	1914.29	-31.43
02-Dec-92	0.71	1	1.71	0.363	0.696	0.718	1897.18	-30.99
03-Dec-92	0.73	1	1.71	0.356	0.698	0.72	1854.79	-30.14
04-Dec-92	0.75	1	1.71	0.349	0.7	0.722	1814.67	-29.33
05-Dec-92	0.77	1	1.71	0.342	0.702	0.724	1776.62	-28.57
06-Dec-92	0.8	1	1.72	0.336	0.708	0.731	1730.00	-28.75
07-Dec-92	0.82	1	1.72	0.331	0.714	0.735	1693.90	-25.61
08-Dec-92	0.84	1	1.72	0.336	0.712	0.734	1647.62	-26.19
09-Dec-92	0.86	1	1.72	0.341	0.71	0.732	1603.49	-25.58
10-Dec-92	0.88	1	1.72	0.346	0.708	0.731	1561.36	-26.14
11-Dec-92	0.91	1	1.71	0.351	0.706	0.729	1493.41	-25.27
12-Dec-92	0.93	1	1.71	0.356	0.704	0.728	1455.91	-25.81
13-Dec-92	0.95	1	1.71	0.389	0.704	0.728	1390.53	-25.26
14-Dec-92	0.95	1	1.72	0.421	0.703	0.727	1367.37	-25.26
15-Dec-92	0.95	1	1.72	0.414	0.703	0.727	1374.74	-25.26
16-Dec-92	1.06	1	1.71	0.444	0.694	0.722	1194.34	-26.42
17-Dec-92	1.17	1	1.7	0.474	0.685	0.717	1047.86	-27.35
18-Dec-92	1.28	1	1.69	0.504	0.676	0.712	926.56	-28.13
19-Dec-92	1.39	1	1.68	0.534	0.667	0.707	824.46	-28.78
20-Dec-92	1.5	0.998	1.67	0.561	0.658	0.701	739.33	-28.67
21-Dec-92	1.74	0.996	1.67	0.57	0.66	0.704	632.18	-25.29
22-Dec-92	1.98	0.994	1.67	0.579	0.662	0.707	551.01	-22.73
23-Dec-92	2.22	0.992	1.67	0.588	0.664	0.71	487.39	-20.72
24-Dec-92	2.46	0.99	1.68	0.597	0.666	0.713	440.24	-19.11
25-Dec-92	2.7	0.99	1.68	0.606	0.668	0.716	397.78	-17.78
26-Dec-92	2.95	0.989	1.68	0.615	0.67	0.72	361.02	-16.95
27-Dec-92	3.16	0.989	1.68	0.618	0.671	0.722	336.08	-16.14
28-Dec-92	3.37	0.987	1.68	0.621	0.672	0.724	314.24	-15.43
29-Dec-92	3.58	0.985	1.68	0.624	0.673	0.726	294.97	-14.80
30-Dec-92	3.79	0.985	1.69	0.627	0.674	0.728	280.47	-14.25
31-Dec-92	4	0.985	1.69	0.63	0.676	0.73	265.00	-13.50
01-Jan-93	4.21	0.984	1.69	0.633	0.678	0.732	251.07	-12.83
02-Jan-93	4.42	0.983	1.69	0.636	0.68	0.734	238.46	-12.22
03-Jan-93	4.74	0.985	1.7	0.638	0.682	0.741	224.05	-12.45
04-Jan-93	4.95	0.985	1.7	0.64	0.684	0.745	214.14	-12.32
05-Jan-93	4.95	0.985	1.7	0.64	0.684	0.745	214.14	-12.32

NORMAL POLARITY
SPECIMEN #6B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.01	1	0.368	0.34	-0.659	-0.66	2800	100
23-Nov-92	0.01	1	0.347	0.295	-0.656	-0.657	5200	100
24-Nov-92	0.01	1	0.35	0.2	-0.655	-0.654	15000	-100
25-Nov-92	0.01	1	0.354	0.243	-0.653	-0.652	11100	-100
26-Nov-92	0.01	1	0.358	0.286	-0.651	-0.65	7200	-100
27-Nov-92	0.01	1	0.363	0.329	-0.648	-0.647	3400	-100
28-Nov-92	0.01	1	0.365	0.326	-0.649	-0.648	3900	-100
29-Nov-92	0.01	1	0.358	0.336	-0.656	-0.655	2200	-100
30-Nov-92	0.01	1	0.358	0.336	-0.656	-0.655	2200	-100
01-Dec-92	0.01	1	0.358	0.336	-0.656	-0.655	2200	-100
02-Dec-92	0.01	1	0.355	0.334	-0.659	-0.658	2100	-100
03-Dec-92	0.01	1	0.352	0.332	-0.662	-0.661	2000	-100
04-Dec-92	0.01	1	0.35	0.33	-0.665	-0.664	2000	-100
05-Dec-92	0.01	1	0.346	0.328	-0.668	-0.667	1800	-100
06-Dec-92	0.01	1	0.342	0.325	-0.67	-0.669	1700	-100
07-Dec-92	0.01	1	0.34	0.324	-0.671	-0.67	1600	-100
08-Dec-92	0.01	1	0.338	0.323	-0.672	-0.671	1500	-100
09-Dec-92	0.01	1	0.336	0.322	-0.673	-0.672	1400	-100
10-Dec-92	0.01	1	0.334	0.321	-0.674	-0.673	1300	-100
11-Dec-92	0.01	1	0.332	0.32	-0.676	-0.675	1200	-100
12-Dec-92	0.01	1	0.332	0.32	-0.676	-0.675	1200	-100
13-Dec-92	0.01	1	0.332	0.32	-0.676	-0.675	1200	-100
14-Dec-92	0.01	1	0.336	0.322	-0.678	-0.677	1400	-100
15-Dec-92	0.01	1	0.339	0.324	-0.679	-0.678	1500	-100
16-Dec-92	0.01	1	0.337	0.323	-0.678	-0.677	1400	-100
17-Dec-92	0.01	1	0.335	0.322	-0.677	-0.676	1300	-100
18-Dec-92	0.01	1	0.333	0.321	-0.676	-0.675	1200	-100
19-Dec-92	0.01	1	0.331	0.321	-0.676	-0.675	1000	-100
20-Dec-92	0.01	1	0.331	0.321	-0.676	-0.675	1000	-100
21-Dec-92	0.01	1	0.33	0.32	-0.677	-0.676	1000	-100
22-Dec-92	0.01	1	0.329	0.319	-0.679	-0.678	1000	-100
23-Dec-92	0.01	1	0.328	0.318	-0.681	-0.68	1000	-100
24-Dec-92	0.01	1	0.327	0.318	-0.683	-0.682	900	-100
25-Dec-92	0.01	1	0.327	0.319	-0.683	-0.682	800	-100
26-Dec-92	0.01	1	0.327	0.32	-0.683	-0.682	700	-100
27-Dec-92	0.01	1	0.327	0.321	-0.684	-0.683	600	-100
28-Dec-92	0.01	1	0.327	0.322	-0.684	-0.683	500	-100
29-Dec-92	0.01	1	0.328	0.323	-0.684	-0.683	500	-100
30-Dec-92	0.01	1	0.328	0.325	-0.684	-0.683	300	-100
31-Dec-92	0.01	1	0.328	0.327	-0.685	-0.684	100	-100
01-Jan-93	0.01	1	0.328	0.329	-0.685	-0.684	-100	-100
02-Jan-93	0.01	1	0.332	0.33	-0.683	-0.682	200	-100
03-Jan-93	0.01	1	0.336	0.33	-0.681	-0.68	600	-100
04-Jan-93	0.01	1	0.336	0.33	-0.681	-0.68	600	-100
05-Jan-93	0.01	1	0.336	0.33	-0.681	-0.68	600	-100

REVERSED POLARITY
SPECIMEN #6B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	0.6	1	1.67	-0.008	0.634	-0.657	2796.67	2151.67
23-Nov-92	0.6	1	1.67	-0.008	0.634	-0.657	2796.67	2151.67
24-Nov-92	0.6	1	1.63	-0.018	0.63	0.656	2746.67	-43.33
25-Nov-92	0.6	1	1.63	0.042	0.627	0.653	2646.67	-43.33
26-Nov-92	0.68	1	1.63	0.014	0.626	0.651	2376.47	-36.76
27-Nov-92	0.76	1	1.63	-0.014	0.625	0.65	2163.16	-32.89
28-Nov-92	0.84	1	1.63	-0.042	0.624	0.649	1990.48	-29.76
29-Nov-92	0.89	1	1.63	-0.031	0.622	0.649	1866.29	-30.34
30-Nov-92	0.92	1	1.57	-0.052	0.622	0.649	1763.04	-29.35
01-Dec-92	0.92	1	1.57	-0.052	0.622	0.649	1763.04	-29.35
02-Dec-92	0.96	1	1.58	-0.053	0.623	0.651	1666.33	-28.57
03-Dec-92	1.04	1	1.59	-0.053	0.624	0.653	1579.81	-27.88
04-Dec-92	1.1	1	1.59	-0.054	0.625	0.655	1494.55	-27.27
05-Dec-92	1.16	1	1.6	-0.055	0.626	0.658	1426.72	-27.59
06-Dec-92	1.23	1	1.62	-0.063	0.629	0.662	1368.29	-26.83
07-Dec-92	1.29	1	1.64	-0.07	0.631	0.666	1325.58	-27.13
08-Dec-92	1.32	1	1.64	-0.05	0.63	0.667	1280.30	-28.03
09-Dec-92	1.35	1	1.64	-0.03	0.629	0.667	1237.04	-28.15
10-Dec-92	1.38	1	1.63	-0.01	0.628	0.668	1188.41	-28.99
11-Dec-92	1.41	1	1.63	0.01	0.627	0.669	1148.94	-29.79
12-Dec-92	1.45	1	1.63	0.03	0.625	0.67	1103.45	-31.03
13-Dec-92	1.47	1	1.63	-0.01	0.626	0.671	1115.65	-30.61
14-Dec-92	1.5	1	1.64	-0.03	0.628	0.673	1113.33	-30.00
15-Dec-92	1.54	1	1.64	-0.016	0.629	0.674	1075.32	-29.22
16-Dec-92	1.6	1	1.65	-0.004	0.63	0.674	1033.75	-27.50
17-Dec-92	1.6	1	1.64	-0.019	0.63	0.674	1036.87	-27.50
18-Dec-92	1.61	1	1.65	-0.034	0.63	0.674	1045.96	-27.33
19-Dec-92	1.63	1	1.64	-0.049	0.629	0.673	1036.20	-26.99
20-Dec-92	1.63	0.999	1.64	-0.064	0.629	0.673	1046.40	-26.99
21-Dec-92	1.66	0.999	1.64	-0.048	0.629	0.673	1016.87	-26.51
22-Dec-92	1.69	0.999	1.64	-0.032	0.629	0.673	989.35	-26.04
23-Dec-92	1.72	0.999	1.64	-0.021	0.629	0.674	965.70	-26.16
24-Dec-92	1.75	0.999	1.64	0.003	0.628	0.675	935.43	-26.86
25-Dec-92	1.78	0.999	1.64	0.019	0.628	0.678	910.67	-28.09
26-Dec-92	1.81	0.999	1.64	0.015	0.628	0.678	897.79	-27.62
27-Dec-92	1.84	0.999	1.64	0.011	0.628	0.678	885.33	-27.17
28-Dec-92	1.87	0.999	1.64	0.007	0.629	0.678	873.26	-26.20
29-Dec-92	1.9	0.999	1.64	0.003	0.629	0.679	861.58	-26.32
30-Dec-92	1.93	0.999	1.64	-0.001	0.629	0.679	850.26	-25.91
31-Dec-92	1.96	0.999	1.64	-0.005	0.63	0.679	839.29	-25.00
01-Jan-93	1.99	0.999	1.64	-0.009	0.63	0.679	828.64	-24.62
02-Jan-93	2	0.999	1.64	-0.001	0.63	0.679	820.50	-24.50
03-Jan-93	2	0.999	1.64	0.007	0.628	0.677	816.50	-24.50
04-Jan-93	2	0.999	1.64	0.015	0.628	0.677	812.50	-24.50
05-Jan-93	2	0.999	1.64	0.024	0.627	0.676	808.00	-24.50

NORMAL POLARITY
SPECIMEN #6C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.9	1	0.377	0.36	-0.643	-0.643	18.89	0.00
23-Nov-92	0.69	1	0.578	0.515	-0.649	-0.615	91.30	-49.28
24-Nov-92	0.71	1	0.081	-0.474	-0.883	-0.668	781.69	-302.82
25-Nov-92	0.66	1	0.091	-0.454	-0.862	-0.655	825.76	-313.64
26-Nov-92	0.63	1	0.102	-0.434	-0.841	-0.642	850.79	-315.87
27-Nov-92	0.6	1	0.113	-0.414	-0.818	-0.63	878.33	-313.33
28-Nov-92	0.57	1	0.168	-0.402	-0.785	-0.635	1000.00	-263.16
29-Nov-92	0.51	1	0.128	-0.404	-0.792	-0.62	1043.14	-337.25
30-Nov-92	0.51	1	0.128	-0.404	-0.792	-0.62	1043.14	-337.25
01-Dec-92	0.51	1	0.124	-0.4	-0.793	-0.631	1027.45	-317.65
02-Dec-92	0.53	1	0.12	-0.396	-0.795	-0.642	973.58	-288.68
03-Dec-92	0.55	1	0.116	-0.392	-0.796	-0.653	923.64	-260.00
04-Dec-92	0.55	1	0.112	-0.391	-0.798	-0.665	914.55	-241.82
05-Dec-92	0.57	1	0.112	-0.391	-0.798	-0.665	882.46	-233.33
06-Dec-92	0.6	1	0.099	-0.397	-0.829	-0.684	826.67	-241.67
07-Dec-92	0.63	1	0.097	-0.411	-0.841	-0.685	806.35	-247.62
08-Dec-92	0.67	1	0.095	-0.425	-0.853	-0.686	776.12	-249.25
09-Dec-92	0.73	1	0.093	-0.439	-0.865	-0.687	728.77	-243.84
10-Dec-92	0.78	1	0.091	-0.455	-0.877	-0.689	700.00	-241.03
11-Dec-92	0.8	1	0.089	-0.47	-0.89	-0.691	698.75	-248.75
12-Dec-92	0.8	1	0.021	-0.478	-0.945	-0.783	623.75	-202.50
13-Dec-92	0.79	1	0.095	-0.486	-0.975	-0.79	735.44	-234.18
14-Dec-92	0.79	1	0.09	-0.491	-1.02	-0.832	735.44	-237.97
15-Dec-92	0.8	1	0.085	-0.486	-1.07	-0.875	713.75	-243.75
16-Dec-92	0.84	1	0.09	-0.491	-1.06	-0.88	691.67	-214.29
17-Dec-92	0.86	1	0.095	-0.496	-1.05	-0.885	687.21	-191.86
18-Dec-92	0.89	1	0.1	-0.501	-1.05	-0.89	675.28	-179.78
19-Dec-92	0.93	1	0.105	-0.506	-1.04	-0.895	656.99	-155.91
20-Dec-92	0.96	1	0.106	-0.509	-1.04	-0.894	640.63	-152.08
21-Dec-92	0.99	1	0.106	-0.512	-1.04	-0.893	624.24	-148.48
22-Dec-92	1.02	1	0.108	-0.515	-1.04	-0.892	610.78	-145.10
23-Dec-92	1.05	1	0.108	-0.518	-1.04	-0.891	596.19	-141.90
24-Dec-92	1.07	1	0.108	-0.52	-1.04	-0.89	586.92	-140.19
25-Dec-92	1.09	1	0.109	-0.523	-1.04	-0.896	579.82	-132.11
26-Dec-92	1.1	1	0.109	-0.526	-1.04	-0.902	577.27	-125.45
27-Dec-92	1.12	1	0.109	-0.529	-1.4	-0.908	569.64	-439.29
28-Dec-92	1.13	1	0.109	-0.532	-1.05	-0.914	567.26	-120.35
29-Dec-92	1.15	1	0.109	-0.535	-1.05	-0.92	560.00	-113.04
30-Dec-92	1.17	1	0.11	-0.538	-1.05	-0.926	553.85	-105.98
31-Dec-92	1.19	1	0.111	-0.541	-1.06	-0.932	547.90	-107.56
01-Jan-93	1.2	1	0.111	-0.545	-1.06	-0.94	546.67	-100.00
02-Jan-93	1.22	1	0.107	-0.548	-1.06	-0.946	536.89	-93.44
03-Jan-93	1.25	1	0.102	-0.552	-1.07	-0.951	523.20	-95.20
04-Jan-93	1.25	1	0.102	-0.552	-1.07	-0.951	523.20	-95.20
05-Jan-93	1.25	1	0.102	-0.552	-1.07	-0.951	523.20	-95.20

REVERSED POLARITY
SPECIMEN #6C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA 71 - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	1.88	0.998	1.62	0.5	0.609	0.672	595.74	-33.51
23-Nov-92	1.88	0.998	1.62	0.5	0.609	0.672	595.74	-33.51
24-Nov-92	1.88	0.998	1.61	0.47	0.605	0.663	606.38	-30.85
25-Nov-92	1.88	0.998	1.61	0.475	0.597	0.654	603.72	-30.32
26-Nov-92	2.01	0.999	1.61	0.475	0.599	0.658	564.68	-29.35
27-Nov-92	2.14	0.999	1.61	0.474	0.601	0.662	530.84	-28.50
28-Nov-92	2.2	1	1.61	0.473	0.603	0.667	516.82	-29.09
29-Nov-92	2.23	1	1.62	0.468	0.613	0.672	516.59	-26.46
30-Nov-92	2.25	1	1.64	0.459	0.575	0.652	524.89	-34.22
01-Dec-92	2.25	1	1.64	0.459	0.575	0.652	524.89	-34.22
02-Dec-92	2.32	1	1.64	0.464	0.578	0.655	506.90	-33.19
03-Dec-92	2.39	1	1.64	0.469	0.581	0.658	489.96	-32.22
04-Dec-92	2.46	0.999	1.64	0.474	0.584	0.661	473.98	-31.30
05-Dec-92	2.53	0.999	1.64	0.479	0.587	0.665	458.89	-30.83
06-Dec-92	2.61	0.997	1.62	0.481	0.583	0.664	436.40	-31.03
07-Dec-92	2.7	0.995	1.59	0.482	0.578	0.662	410.37	-31.11
08-Dec-92	2.75	0.996	1.59	0.489	0.578	0.662	400.36	-30.55
09-Dec-92	2.8	0.997	1.59	0.496	0.579	0.661	390.71	-29.29
10-Dec-92	2.85	0.998	1.59	0.503	0.579	0.661	381.40	-28.77
11-Dec-92	2.9	0.999	1.59	0.51	0.58	0.66	372.41	-27.59
12-Dec-92	2.95	0.99	1.59	0.515	0.58	0.66	364.41	-27.12
13-Dec-92	2.95	0.99	1.6	0.519	0.584	0.662	366.44	-26.44
14-Dec-92	3.12	0.989	1.6	0.523	0.589	0.664	345.19	-24.04
15-Dec-92	3.15	0.997	1.61	0.529	0.596	0.669	343.17	-23.17
16-Dec-92	3.19	0.995	1.62	0.535	0.607	0.678	340.13	-22.26
17-Dec-92	3.21	0.993	1.62	0.54	0.61	0.681	336.45	-22.12
18-Dec-92	3.23	0.991	1.62	0.545	0.613	0.684	332.82	-21.98
19-Dec-92	3.25	0.989	1.63	0.55	0.615	0.687	332.31	-22.15
20-Dec-92	3.27	0.988	1.63	0.554	0.617	0.689	329.05	-22.02
21-Dec-92	3.31	0.988	1.63	0.559	0.612	0.686	323.56	-22.36
22-Dec-92	3.35	0.987	1.63	0.564	0.607	0.683	318.21	-22.69
23-Dec-92	3.39	0.987	1.62	0.569	0.602	0.68	310.03	-23.01
24-Dec-92	3.43	0.985	1.62	0.574	0.597	0.677	304.96	-23.32
25-Dec-92	3.5	0.985	1.62	0.577	0.59	0.675	298.00	-24.29
26-Dec-92	3.53	0.986	1.61	0.579	0.586	0.676	292.07	-25.50
27-Dec-92	3.56	0.986	1.61	0.581	0.582	0.677	289.04	-26.69
28-Dec-92	3.59	0.986	1.61	0.583	0.578	0.678	286.07	-27.86
29-Dec-92	3.62	0.986	1.61	0.585	0.574	0.679	283.15	-29.01
30-Dec-92	3.65	0.987	1.6	0.587	0.57	0.68	277.53	-30.14
31-Dec-92	3.68	0.987	1.6	0.589	0.566	0.681	274.73	-31.25
01-Jan-93	3.71	0.988	1.59	0.59	0.562	0.682	269.54	-32.35
02-Jan-93	3.74	0.988	1.59	0.59	0.558	0.684	267.38	-33.69
03-Jan-93	3.78	0.988	1.58	0.59	0.557	0.685	261.90	-33.86
04-Jan-93	3.87	0.99	1.6	0.591	0.581	0.69	260.72	-28.17
05-Jan-93	4	0.992	1.62	0.591	0.606	0.695	257.25	-22.25

NORMAL POLARITY
SPECIMEN #7A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.01	1	0.364	0.355	-0.667	-0.668	900.00	100.00
23-Nov-92	0.01	1	0.364	0.355	-0.667	-0.668	900.00	100.00
24-Nov-92	0.01	1	0.326	0.317	-0.667	-0.668	900.00	100.00
25-Nov-92	0.01	1	0.291	0.287	-0.669	-0.67	400.00	100.00
26-Nov-92	0.22	1	0.281	0.038	-0.681	-0.659	1104.55	-100.00
27-Nov-92	0.43	1	0.271	-0.211	-0.693	-0.648	1120.93	-104.65
28-Nov-92	0.65	1	0.261	-0.46	-0.706	-0.637	1109.23	-106.15
29-Nov-92	0.84	1	0.133	-0.483	-0.768	-0.62	733.33	-176.19
30-Nov-92	0.9	1	0.136	-0.488	-0.789	-0.633	693.33	-173.33
01-Dec-92	0.9	1	0.136	-0.488	-0.789	-0.633	693.33	-173.33
02-Dec-92	1.04	1	0.054	-0.508	-0.875	-0.777	540.38	-94.23
03-Dec-92	1.08	1	0.042	-0.507	-0.894	-0.783	508.33	-102.78
04-Dec-92	1.12	1	0.03	-0.506	-0.913	-0.789	478.57	-110.71
05-Dec-92	1.16	1	0.018	-0.505	-0.932	-0.795	450.86	-118.10
06-Dec-92	1.2	1	0.004	-0.504	-0.951	-0.8	423.33	-125.83
07-Dec-92	1.24	1	0.005	-0.502	-0.953	-0.81	408.87	-115.32
08-Dec-92	1.28	1	0.006	-0.5	-0.955	-0.82	395.31	-105.47
09-Dec-92	1.32	1	0.006	-0.499	-0.958	-0.82	382.58	-104.55
10-Dec-92	1.36	1	0.008	-0.495	-0.952	-0.812	369.85	-102.94
11-Dec-92	1.4	1	0.01	-0.491	-0.946	-0.804	357.86	-101.43
12-Dec-92	1.44	1	0.011	-0.487	-0.94	-0.796	345.83	-100.00
13-Dec-92	1.48	1	0.012	-0.482	-0.935	-0.788	333.78	-99.32
14-Dec-92	1.52	1	0.011	-0.481	-0.936	-0.784	323.68	-100.00
15-Dec-92	1.56	1	0.011	-0.481	-0.938	-0.78	315.38	-101.28
16-Dec-92	1.6	1	0.007	-0.482	-0.946	-0.791	305.62	-96.87
17-Dec-92	1.64	1	0.003	-0.483	-0.954	-0.802	296.34	-92.68
18-Dec-92	1.68	1	0.001	-0.484	-0.962	-0.813	288.69	-88.69
19-Dec-92	1.72	1	0.005	-0.485	-0.97	-0.824	284.88	-84.88
20-Dec-92	1.76	0.999	0.011	-0.485	-0.978	-0.836	281.82	-80.68
21-Dec-92	1.8	0.998	0.018	-0.489	-0.975	-0.748	281.67	-126.11
22-Dec-92	1.84	0.998	0.014	-0.492	-0.978	-0.755	275.00	-121.20
23-Dec-92	1.88	0.997	0.01	-0.495	-0.981	-0.762	268.62	-116.49
24-Dec-92	1.92	0.997	0.006	-0.498	-0.984	-0.769	262.50	-111.98
25-Dec-92	1.96	0.997	0.002	-0.501	-0.987	-0.776	256.63	-107.65
26-Dec-92	2	0.996	0.004	-0.505	-0.993	-0.785	254.50	-104.00
27-Dec-92	2.04	0.998	0.007	-0.51	-0.996	-0.79	253.43	-100.98
28-Dec-92	2.08	1	0.018	-0.515	-0.999	-0.795	256.25	-98.08
29-Dec-92	2.12	1	0.016	-0.514	-0.998	-0.795	250.00	-95.75
30-Dec-92	2.16	1	0.014	-0.514	-0.998	-0.794	244.44	-94.44
31-Dec-92	2.2	1	0.012	-0.515	-0.995	-0.795	239.55	-90.91
01-Jan-93	2.24	1	0.01	-0.515	-0.995	-0.794	234.37	-89.73
02-Jan-93	2.28	1	0.007	-0.515	-0.993	-0.795	228.95	-86.84
03-Jan-93	2.32	1	0.003	-0.502	-0.992	-0.793	217.67	-85.78
04-Jan-93	2.36	1	0.002	-0.498	-0.992	-0.81	211.86	-77.12
05-Jan-93	2.4	1	0.001	-0.495	-0.992	-0.81	208.67	-75.83

REVERSED POLARITY
SPECIMEN #7A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	0.15	1	1.69	-0.13	0.662	0.667	12133.33	-33.33
23-Nov-92	0.19	1	1.64	-0.133	0.658	0.667	9331.58	-47.37
24-Nov-92	0.19	1	1.64	-0.007	0.651	0.669	8668.42	-94.74
25-Nov-92	0.49	1	1.63	0.156	0.627	0.656	3008.16	-59.18
26-Nov-92	0.47	1	1.62	0.319	0.614	0.644	2768.09	-63.83
27-Nov-92	1.1	1	1.61	0.484	0.601	0.632	1023.64	-28.18
28-Nov-92	1.35	1	1.63	0.496	0.613	0.637	840.00	-17.78
29-Nov-92	1.7	1	1.61	0.506	0.597	0.634	649.41	-21.76
30-Nov-92	2.4	1	1.62	0.527	0.597	0.646	455.42	-20.42
01-Dec-92	2.48	0.999	1.62	0.527	0.598	0.647	440.73	-19.76
02-Dec-92	2.56	0.998	1.62	0.527	0.599	0.648	426.95	-19.14
03-Dec-92	2.64	0.997	1.62	0.528	0.6	0.649	413.64	-18.56
04-Dec-92	2.72	0.996	1.62	0.528	0.601	0.65	401.47	-18.01
05-Dec-92	2.8	0.995	1.62	0.528	0.601	0.653	390.00	-18.57
06-Dec-92	2.8	0.994	1.62	0.525	0.606	0.655	391.07	-17.50
07-Dec-92	2.8	0.993	1.63	0.522	0.613	0.658	395.71	-16.07
08-Dec-92	2.8	0.992	1.63	0.519	0.616	0.66	396.79	-15.71
09-Dec-92	2.87	0.992	1.63	0.517	0.615	0.662	387.80	-16.38
10-Dec-92	2.94	0.991	1.63	0.515	0.614	0.663	379.25	-16.67
11-Dec-92	3.01	0.991	1.63	0.514	0.614	0.664	370.76	-16.61
12-Dec-92	3.09	0.989	1.63	0.512	0.613	0.665	361.81	-16.83
13-Dec-92	3.11	0.992	1.63	0.509	0.614	0.666	360.45	-16.72
14-Dec-92	3.2	0.993	1.64	0.506	0.615	0.667	354.37	-16.25
15-Dec-92	3.39	0.991	1.64	0.51	0.616	0.671	333.33	-16.22
16-Dec-92	3.58	0.989	1.64	0.514	0.617	0.675	314.53	-16.20
17-Dec-92	3.77	0.987	1.64	0.518	0.617	0.679	297.61	-16.45
18-Dec-92	3.96	0.985	1.64	0.522	0.619	0.683	282.32	-16.16
19-Dec-92	4.17	0.983	1.64	0.527	0.619	0.686	266.91	-16.07
20-Dec-92	4.3	0.983	1.63	0.53	0.607	0.705	255.81	-22.79
21-Dec-92	4.4	0.982	1.64	0.535	0.615	0.707	251.14	-20.91
22-Dec-92	4.5	0.981	1.64	0.54	0.623	0.709	244.44	-19.11
23-Dec-92	4.6	0.98	1.65	0.545	0.631	0.711	240.22	-17.39
24-Dec-92	4.7	0.979	1.65	0.55	0.639	0.713	234.04	-15.74
25-Dec-92	4.81	0.978	1.66	0.554	0.647	0.716	229.94	-14.35
26-Dec-92	4.92	0.978	1.66	0.551	0.749	0.717	225.41	6.50
27-Dec-92	5.02	0.977	1.66	0.548	0.652	0.718	221.51	-13.15
28-Dec-92	5	0.978	1.66	0.548	0.654	0.719	222.40	-13.00
29-Dec-92	4.97	0.979	1.66	0.547	0.656	0.72	223.94	-12.88
30-Dec-92	4.95	0.981	1.66	0.547	0.658	0.721	224.85	-12.73
31-Dec-92	4.92	0.981	1.67	0.546	0.66	0.722	228.46	-12.60
01-Jan-93	4.9	0.981	1.68	0.545	0.662	0.725	231.63	-12.86
02-Jan-93	4.9	0.989	1.68	0.548	0.662	0.725	231.02	-12.86
03-Jan-93	4.9	0.987	1.68	0.545	0.663	0.726	231.63	-12.86
04-Jan-93	4.9	0.982	1.67	0.541	0.664	0.727	230.41	-12.86
05-Jan-93	4.9	0.982	1.67	0.541	0.664	0.727	230.41	-12.86

NORMAL POLARITY
SPECIMEN #7B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.56	1	0.078	-0.599	-0.96	-0.754	1208.93	-367.86
23-Nov-92	0.56	1	0.078	-0.599	-0.96	-0.754	1208.93	-367.86
24-Nov-92	0.56	1	0.07	-0.582	-0.989	-0.76	1164.29	-408.93
25-Nov-92	0.65	1	0.078	-0.577	-0.979	-0.817	1007.69	-249.23
26-Nov-92	0.66	1	0.102	-0.585	-0.979	-0.82	1040.91	-240.91
27-Nov-92	0.67	1	0.126	-0.593	-0.978	-0.823	1073.13	-231.34
28-Nov-92	0.68	1	0.151	-0.6	-0.977	-0.826	1104.41	-222.06
29-Nov-92	0.73	1	0.144	-0.587	-0.973	-0.82	1001.37	-209.59
30-Nov-92	0.73	1	0.131	-0.583	-0.968	-0.84	978.08	-175.34
01-Dec-92	0.73	1	0.131	-0.583	-0.968	-0.84	978.08	-175.34
02-Dec-92	0.73	1	0.146	-0.583	-0.986	-0.881	998.63	-143.84
03-Dec-92	0.81	1	0.17	-0.594	-1.014	-0.916	943.21	-120.99
04-Dec-92	0.89	1	0.194	-0.605	-1.042	-0.951	897.75	-102.25
05-Dec-92	0.97	1	0.218	-0.616	-1.07	-0.986	859.79	-86.60
06-Dec-92	1.05	1	0.241	-0.629	-1.1	-1.02	828.57	-76.19
07-Dec-92	1.17	1	0.253	-0.635	-1.1	-1	758.97	-85.47
08-Dec-92	1.29	0.999	0.264	-0.642	-1.1	-0.98	702.33	-93.02
09-Dec-92	1.42	0.998	0.275	-0.65	-1.1	-0.96	651.41	-98.59
10-Dec-92	1.53	0.997	0.273	-0.659	-1.1	-0.953	609.15	-96.08
11-Dec-92	1.64	0.997	0.271	-0.668	-1.11	-0.946	572.56	-100.00
12-Dec-92	1.75	0.996	0.27	-0.677	-1.12	-0.939	541.14	-103.43
13-Dec-92	1.89	0.995	0.269	-0.686	-1.12	-0.933	505.29	-98.94
14-Dec-92	1.94	0.996	0.275	-0.686	-1.13	-0.964	495.36	-85.57
15-Dec-92	2.1	0.997	0.28	-0.686	-1.15	-0.98	460.00	-80.95
16-Dec-92	2.1	0.997	0.28	-0.686	-1.15	-0.99	460.00	-76.19
17-Dec-92	2.1	0.996	0.28	-0.686	-1.15	-0.994	460.00	-74.29
18-Dec-92	2.1	0.996	0.28	-0.68	-1.15	-0.996	457.14	-73.33
19-Dec-92	2.1	0.995	0.28	-0.68	-1.15	-0.998	457.14	-72.38
20-Dec-92	2.2	0.995	0.28	-0.68	-1.15	-1	436.36	-68.18
21-Dec-92	2.5	0.993	0.306	-0.68	-1.16	-0.938	394.40	-88.80
22-Dec-92	2.52	0.993	0.296	-0.68	-1.16	-0.958	387.30	-80.16
23-Dec-92	2.54	0.993	0.286	-0.68	-1.16	-0.978	380.31	-71.65
24-Dec-92	2.56	0.993	0.276	-0.678	-1.17	-0.998	372.66	-67.19
25-Dec-92	2.58	0.993	0.266	-0.678	-1.17	-1.02	365.89	-58.14
26-Dec-92	2.61	0.992	0.255	-0.678	-1.18	-1.04	357.47	-53.64
27-Dec-92	2.69	0.992	0.254	-0.675	-1.17	-1.05	345.35	-44.61
28-Dec-92	2.78	0.992	0.253	-0.672	-1.17	-1.07	332.73	-35.97
29-Dec-92	2.73	0.993	0.265	-0.676	-1.17	-1.06	344.69	-40.29
30-Dec-92	2.68	0.993	0.277	-0.68	-1.17	-1.05	357.09	-44.78
31-Dec-92	2.63	0.993	0.289	-0.684	-1.17	-1.04	369.96	-49.43
01-Jan-93	2.58	0.993	0.301	-0.688	-1.17	-1.03	383.33	-54.26
02-Jan-93	2.55	0.993	0.311	-0.689	-1.17	-1.01	392.16	-62.75
03-Jan-93	2.94	1	0.209	-0.645	-1.16	-1.01	290.48	-51.02
04-Jan-93	2.98	0.996	0.204	-0.639	-1.15	-1.02	282.89	-43.62
05-Jan-93	3.06	0.993	0.2	-0.634	-1.14	-1.03	272.55	-35.95

REVERSED POLARITY
SPECIMEN #7B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD- CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	1.57	1	1.75	0.624	0.75	0.8	717.20	-31.85
23-Nov-92	1.57	1	1.75	0.657	0.783	0.817	696.18	-21.68
24-Nov-92	1.75	1	1.75	0.656	0.783	0.832	625.14	-28.00
25-Nov-92	1.75	1	1.75	0.662	0.774	0.821	621.71	-26.86
26-Nov-92	1.75	1	1.75	0.668	0.765	0.81	618.29	-25.71
27-Nov-92	1.75	1	1.75	0.675	0.755	0.797	614.29	-24.00
28-Nov-92	2.35	1	1.73	0.64	0.74	0.791	463.83	-21.70
29-Nov-92	2.35	1	1.77	0.596	0.763	0.815	499.57	-22.13
30-Nov-92	2.5	1	1.77	0.583	0.764	0.815	474.80	-20.40
01-Dec-92	2.67	0.999	1.77	0.589	0.765	0.818	442.32	-19.85
02-Dec-92	2.84	0.998	1.77	0.595	0.766	0.821	413.73	-19.37
03-Dec-92	3.01	0.997	1.77	0.601	0.767	0.824	388.37	-18.94
04-Dec-92	3.18	0.996	1.77	0.607	0.768	0.827	365.72	-18.55
05-Dec-92	3.35	0.994	1.77	0.615	0.769	0.831	344.78	-18.51
06-Dec-92	2.73	0.996	1.793	0.64	0.794	0.841	422.34	-17.22
07-Dec-92	2.11	0.998	1.816	0.665	0.819	0.851	545.50	-15.17
08-Dec-92	1.48	0.998	1.84	0.69	0.846	0.861	777.03	-10.14
09-Dec-92	1.51	0.998	1.84	0.69	0.841	0.866	761.59	-16.56
10-Dec-92	1.54	0.997	1.85	0.7	0.836	0.871	746.75	-22.73
11-Dec-92	1.57	0.997	1.85	0.7	0.831	0.876	732.48	-28.66
12-Dec-92	1.6	0.996	1.85	0.7	0.828	0.879	718.75	-31.88
13-Dec-92	1.6	0.996	1.81	0.708	0.804	0.862	688.75	-36.25
14-Dec-92	1.6	0.996	1.79	0.715	0.788	0.856	671.88	-42.50
15-Dec-92	2.64	0.99	1.79	0.705	0.788	0.863	410.98	-28.41
16-Dec-92	3.68	0.984	1.78	0.695	0.789	0.87	294.84	-22.01
17-Dec-92	4.72	0.978	1.77	0.685	0.789	0.877	229.87	-18.64
18-Dec-92	5.76	0.972	1.77	0.675	0.791	0.884	190.10	-16.15
19-Dec-92	6.8	0.965	1.77	0.665	0.791	0.894	162.50	-15.15
20-Dec-92	7.3	0.961	1.82	0.699	0.827	0.906	153.56	-10.82
21-Dec-92	7.45	0.958	1.81	0.706	0.825	0.903	148.19	-10.47
22-Dec-92	7.6	0.955	1.81	0.713	0.823	0.9	144.34	-10.13
23-Dec-92	7.75	0.952	1.81	0.72	0.821	0.897	140.65	-9.81
24-Dec-92	7.9	0.949	1.81	0.727	0.819	0.894	137.09	-9.49
25-Dec-92	8.06	0.943	1.81	0.732	0.819	0.891	133.75	-8.93
26-Dec-92	5.55	0.974	1.84	0.709	0.846	0.909	203.78	-11.35
27-Dec-92	5.55	0.974	1.84	0.709	0.846	0.909	203.78	-11.35
28-Dec-92	6.07	0.97	1.828	0.71	0.835	0.909	184.18	-12.19
29-Dec-92	6.59	0.966	1.816	0.711	0.824	0.91	167.68	-13.05
30-Dec-92	7.11	0.962	1.804	0.712	0.813	0.911	153.59	-13.78
31-Dec-92	7.63	0.958	1.792	0.713	0.802	0.911	141.42	-14.29
01-Jan-93	8.15	0.954	1.78	0.714	0.792	0.912	130.80	-14.72
02-Jan-93	8.85	0.963	1.82	0.722	0.829	0.908	124.07	-8.93
03-Jan-93	8.87	0.93	1.78	0.718	0.805	0.862	119.73	-8.68
04-Jan-93	8.89	0.95	1.76	0.715	0.783	0.855	117.55	-8.10
05-Jan-93	8.89	0.95	1.76	0.715	0.783	0.855	117.55	-8.10

NORMAL POLARITY
SPECIMEN #7C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.01	1	0.34	0.329	-0.695	-0.696	1100.00	100.00
23-Nov-92	0.01	1	0.34	0.329	-0.695	-0.696	1100.00	100.00
24-Nov-92	0.01	1	0.343	0.332	-0.668	-0.669	1100.00	100.00
25-Nov-92	0.34	1	0.274	-0.34	-0.695	-0.667	1805.88	-82.35
26-Nov-92	0.64	1	0.181	-0.381	-0.785	-0.725	878.13	-93.75
27-Nov-92	0.67	1	0.086	-0.422	-0.875	-0.782	758.21	-138.81
28-Nov-92	1.26	1	0.007	-0.463	-0.965	-0.84	373.02	-99.21
29-Nov-92	1.4	1	0.018	-0.474	-0.975	-0.805	351.43	-121.43
30-Nov-92	1.49	1	0.032	-0.483	-0.985	-0.804	345.64	-121.48
01-Dec-92	1.49	1	0.032	-0.483	-0.985	-0.804	345.64	-121.48
02-Dec-92	1.7	1	0.035	-0.491	-0.998	-0.835	309.41	-95.88
03-Dec-92	1.8	1	0.038	-0.497	-0.999	-0.839	297.22	-88.89
04-Dec-92	1.9	1	0.041	-0.503	-1	-0.843	286.32	-82.63
05-Dec-92	2	1	0.044	-0.509	-1.01	-0.847	276.50	-81.50
06-Dec-92	2.1	1	0.048	-0.516	-1.02	-0.851	268.57	-80.48
07-Dec-92	2.1	1	0.05	-0.519	-1.02	-0.865	270.95	-73.81
08-Dec-92	2.1	1	0.05	-0.523	-1.02	-0.879	272.86	-67.14
09-Dec-92	2.1	0.996	0.05	-0.525	-1.02	-0.895	273.81	-59.52
10-Dec-92	2.1	0.996	0.049	-0.528	-1.02	-0.898	274.76	-59.05
11-Dec-92	2.1	0.995	0.049	-0.531	-1.02	-0.899	276.19	-57.62
12-Dec-92	2.1	0.995	0.047	-0.532	-1.03	-0.903	275.71	-60.48
13-Dec-92	2.11	0.993	0.045	-0.535	-1.03	-0.906	274.88	-58.77
14-Dec-92	2.11	0.995	0.043	-0.534	-1.02	-0.895	273.46	-59.24
15-Dec-92	2.11	0.997	0.042	-0.533	-1.02	-0.88	272.51	-66.35
16-Dec-92	2.1	0.997	0.043	-0.532	-1.02	-0.875	273.81	-69.05
17-Dec-92	2.1	0.997	0.045	-0.531	-1.02	-0.868	274.29	-72.38
18-Dec-92	2.08	0.997	0.047	-0.529	-1.03	-0.863	276.92	-80.29
19-Dec-92	2.06	0.995	0.049	-0.529	-1.03	-0.858	280.58	-83.50
20-Dec-92	2.05	0.995	0.049	-0.528	-1.03	-0.853	281.46	-86.34
21-Dec-92	2.1	0.995	0.048	-0.527	-1.03	-0.863	273.81	-79.52
22-Dec-92	2.13	0.995	0.048	-0.527	-1.03	-0.864	269.95	-77.93
23-Dec-92	2.16	0.995	0.048	-0.527	-1.03	-0.864	266.20	-76.85
24-Dec-92	2.19	0.994	0.046	-0.527	-1.03	-0.864	261.64	-75.80
25-Dec-92	2.22	0.993	0.046	-0.527	-1.03	-0.864	258.11	-74.77
26-Dec-92	2.26	0.992	0.046	-0.527	-1.03	-0.864	253.54	-73.45
27-Dec-92	2.28	0.993	0.043	-0.529	-1.02	-0.864	250.88	-68.42
28-Dec-92	2.32	0.993	0.041	-0.531	-1.02	-0.865	246.55	-66.81
29-Dec-92	2.32	0.993	0.039	-0.531	-1.01	-0.857	245.69	-65.95
30-Dec-92	2.34	0.993	0.038	-0.531	-1.01	-0.849	243.16	-68.80
31-Dec-92	2.34	0.993	0.036	-0.531	-1.01	-0.841	242.31	-72.22
01-Jan-93	2.38	0.993	0.035	-0.531	-1.01	-0.833	237.82	-74.37
02-Jan-93	2.4	0.992	0.033	-0.531	-1.01	-0.825	235.00	-77.08
03-Jan-93	2.5	1	0.031	-0.531	-1	-0.812	224.80	-75.20
04-Jan-93	2.5	0.997	0.027	-0.528	-1	-0.809	222.00	-76.40
05-Jan-93	2.7	0.993	0.023	-0.526	-1	-0.804	203.33	-72.59

REVERSED POLARITY
SPECIMEN #7C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED COVERED BY SIKA GARD - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	1.2	1	1.67	-0.015	0.65	0.685	1404.17	-29.17
23-Nov-92	1.2	1	1.67	-0.015	0.65	0.685	1404.17	-29.17
24-Nov-92	1.5	1	1.63	0.06	0.63	0.67	1046.67	-26.67
25-Nov-92	2.01	1	1.58	0.365	0.606	0.652	604.48	-22.89
26-Nov-92	2.54	1	1.58	0.415	0.598	0.652	458.66	-21.26
27-Nov-92	3.07	1	1.58	0.465	0.59	0.651	363.19	-19.87
28-Nov-92	3.6	1	1.59	0.516	0.583	0.65	298.33	-18.61
29-Nov-92	4.09	1	1.6	0.524	0.591	0.65	263.08	-14.43
30-Nov-92	4.12	1	1.6	0.532	0.585	0.645	259.22	-14.56
01-Dec-92	4.9	0.986	1.64	0.552	0.616	0.695	222.04	-16.12
02-Dec-92	5.16	0.984	1.64	0.563	0.621	0.699	208.72	-15.12
03-Dec-92	5.42	0.982	1.64	0.574	0.626	0.703	196.68	-14.21
04-Dec-92	5.68	0.98	1.65	0.585	0.631	0.707	187.50	-13.38
05-Dec-92	5.94	0.978	1.65	0.596	0.636	0.711	177.44	-12.63
06-Dec-92	6.19	0.975	1.66	0.609	0.644	0.713	169.79	-11.15
07-Dec-92	6.23	0.973	1.61	0.611	0.646	0.714	160.35	-10.91
08-Dec-92	6.31	0.971	1.57	0.612	0.648	0.715	151.82	-10.62
09-Dec-92	6.36	0.965	1.54	0.612	0.652	0.715	145.91	-9.91
10-Dec-92	6.42	0.962	1.565	0.608	0.652	0.718	149.07	-10.28
11-Dec-92	6.48	0.959	1.59	0.604	0.652	0.721	152.16	-10.65
12-Dec-92	6.54	0.956	1.615	0.6	0.653	0.724	155.20	-10.86
13-Dec-92	6.62	0.954	1.64	0.597	0.653	0.726	157.55	-11.03
14-Dec-92	6.68	0.961	1.65	0.598	0.652	0.727	157.49	-11.23
15-Dec-92	6.8	0.965	1.67	0.599	0.652	0.727	157.50	-11.03
16-Dec-92	6.79	0.965	1.67	0.597	0.647	0.727	158.03	-11.78
17-Dec-92	6.77	0.964	1.67	0.595	0.642	0.727	158.79	-12.56
18-Dec-92	6.75	0.964	1.65	0.593	0.637	0.725	156.59	-13.04
19-Dec-92	6.75	0.963	1.64	0.591	0.632	0.725	155.41	-13.78
20-Dec-92	6.75	0.962	1.63	0.589	0.628	0.725	154.22	-14.37
21-Dec-92	7	0.962	1.65	0.587	0.645	0.735	151.86	-12.86
22-Dec-92	7.1	0.962	1.64	0.585	0.645	0.733	148.59	-12.39
23-Dec-92	7.1	0.962	1.64	0.583	0.644	0.731	148.87	-12.25
24-Dec-92	7.4	0.962	1.64	0.581	0.643	0.729	143.11	-11.62
25-Dec-92	7.6	0.961	1.64	0.579	0.642	0.727	139.61	-11.18
26-Dec-92	7.8	0.959	1.64	0.578	0.641	0.725	136.15	-10.77
27-Dec-92	7.8	0.959	1.64	0.578	0.641	0.725	136.15	-10.77
28-Dec-92	7.78	0.957	1.66	0.591	0.644	0.725	137.40	-10.41
29-Dec-92	7.89	0.957	1.65	0.587	0.643	0.728	134.73	-10.77
30-Dec-92	8	0.957	1.65	0.583	0.642	0.731	133.38	-11.12
31-Dec-92	8.11	0.957	1.65	0.579	0.641	0.734	132.08	-11.47
01-Jan-93	8.22	0.957	1.65	0.575	0.64	0.737	130.78	-11.80
02-Jan-93	8.35	0.956	1.65	0.572	0.637	0.738	129.10	-12.10
03-Jan-93	8.35	0.965	1.65	0.584	0.641	0.728	127.66	-10.42
04-Jan-93	8.35	0.963	1.64	0.588	0.642	0.732	125.99	-10.78
05-Jan-93	8.35	0.95	1.63	0.592	0.644	0.735	124.31	-10.90

NORMAL POLARITY
SPECIMEN #8A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	1.2	1	0.057	-0.388	-0.89	-0.588	370.83	-251.67
23-Nov-92	1.2	1	0.057	-0.388	-0.89	-0.588	370.83	-251.67
24-Nov-92	0.9	0.998	0.01	-0.394	-0.899	-0.631	448.89	-297.78
25-Nov-92	2.11	0.992	0.03	-0.394	-0.915	-0.66	200.95	-120.85
26-Nov-92	2.08	0.996	-0.007	-0.404	-0.966	-0.731	190.87	-112.98
27-Nov-92	2.05	0.998	-0.044	0.414	-1.017	-0.802	-223.41	-104.88
28-Nov-92	2.02	1	-0.082	-0.424	-1.07	-0.873	169.31	-97.52
29-Nov-92	1.1	1	0.299	-0.366	-0.703	-0.629	604.55	-67.27
30-Nov-92	1.1	1	0.299	-0.366	-0.703	-0.629	604.55	-67.27
01-Dec-92	1.5	1	-0.042	-0.463	-1.01	-0.811	280.67	-132.67
02-Dec-92	1.8	1	-0.051	-0.476	-1.03	-0.853	236.11	-98.33
03-Dec-92	1.84	1	-0.051	-0.484	-1.03	-0.847	235.33	-99.46
04-Dec-92	1.88	1	-0.049	-0.492	-1.03	-0.841	235.64	-100.53
05-Dec-92	1.92	1	-0.049	-0.504	-1.03	-0.834	236.98	-102.08
06-Dec-92	1.12	1	0.276	-0.535	-0.743	-0.653	724.11	-80.36
07-Dec-92	1.4	1	0.015	-0.515	-1.02	-0.805	378.57	-153.57
08-Dec-92	1.45	0.999	0.003	-0.517	-0.993	-0.807	358.62	-128.28
09-Dec-92	1.5	0.998	-0.009	-0.519	-0.986	-0.81	340.00	-117.33
10-Dec-92	1.65	0.997	-0.016	-0.523	-0.991	-0.815	307.27	-106.67
11-Dec-92	1.8	0.996	-0.023	-0.526	-0.995	-0.819	279.44	-97.78
12-Dec-92	1.95	0.995	-0.032	-0.53	-0.998	-0.824	255.38	-89.23
13-Dec-92	2.01	0.995	-0.031	-0.529	-1.01	-0.815	247.76	-97.01
14-Dec-92	2.1	0.995	-0.031	-0.521	-1.01	-0.842	233.33	-80.00
15-Dec-92	2.11	0.999	-0.029	-0.523	-1.01	-0.835	234.12	-82.94
16-Dec-92	2.11	1	-0.025	-0.523	-1.01	-0.835	236.02	-82.94
17-Dec-92	2.13	0.999	-0.028	-0.523	-1.01	-0.83	232.39	-84.51
18-Dec-92	2.15	0.998	-0.031	-0.523	-1.01	-0.825	228.84	-86.05
19-Dec-92	2.21	0.997	-0.034	-0.524	-1.01	-0.82	221.72	-85.97
20-Dec-92	2.24	0.996	-0.037	-0.525	-1.01	-0.815	217.86	-87.05
21-Dec-92	2.24	0.996	-0.034	-0.525	-0.996	-0.813	219.20	-81.70
22-Dec-92	2.28	0.995	-0.034	-0.526	-0.997	-0.819	215.79	-78.07
23-Dec-92	2.32	0.995	-0.034	-0.527	-0.998	-0.825	212.50	-74.57
24-Dec-92	2.36	0.995	-0.034	-0.528	-0.999	-0.831	209.32	-71.19
25-Dec-92	2.4	0.995	-0.034	-0.529	-1	-0.837	206.25	-67.92
26-Dec-92	2.44	0.994	-0.034	-0.529	-1.01	-0.844	202.87	-68.03
27-Dec-92	2.44	0.994	-0.034	-0.529	-1.01	-0.844	202.87	-68.03
28-Dec-92	2.65	0.994	-0.036	-0.529	-1.01	-0.844	186.04	-62.64
29-Dec-92	2.68	0.994	-0.037	-0.529	-1.01	-0.843	183.58	-62.31
30-Dec-92	2.71	0.994	-0.038	-0.53	-1.01	-0.843	181.55	-61.62
31-Dec-92	2.74	0.994	-0.039	-0.531	-1.01	-0.843	179.56	-60.95
01-Jan-93	2.77	0.994	-0.04	-0.531	-1.01	-0.843	177.26	-60.29
02-Jan-93	2.8	0.993	-0.04	-0.531	-1.01	-0.843	175.36	-59.64
03-Jan-93	2.9	1	-0.02	-0.524	-1.02	-0.827	173.79	-66.55
04-Jan-93	3	1	-0.029	-0.52	-1.03	-0.827	163.67	-67.67
05-Jan-93	3	1	-0.029	-0.52	-1.03	-0.827	163.67	-67.67

REVERSED POLARITY
SPECIMEN #8A
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (7/16 IN - 11.1mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	7.8	0.985	1.46	0.436	0.434	0.613	131.28	-22.95
23-Nov-92	7.8	0.985	1.46	0.436	0.434	0.613	131.28	-22.95
24-Nov-92	7.8	0.985	1.5	0.503	0.494	0.6	127.82	-13.59
25-Nov-92	7.83	0.972	1.52	0.827	0.548	0.649	88.51	-12.90
26-Nov-92	8.19	0.967	1.51	0.754	0.528	0.632	92.31	-12.70
27-Nov-92	8.55	0.962	1.5	0.681	0.508	0.615	95.79	-12.51
28-Nov-92	8.91	0.957	1.5	0.607	0.487	0.598	100.22	-12.46
29-Nov-92	3.01	0.996	1.53	0.414	0.52	0.602	370.76	-27.24
30-Nov-92	3.01	0.996	1.53	0.414	0.52	0.602	370.76	-27.24
01-Dec-92	4.9	0.985	1.58	0.523	0.56	0.629	215.71	-14.08
02-Dec-92	5.7	0.985	1.58	0.571	0.563	0.634	177.02	-12.46
03-Dec-92	5.84	0.982	1.58	0.582	0.567	0.638	170.89	-12.16
04-Dec-92	5.98	0.979	1.58	0.593	0.571	0.643	165.05	-12.04
05-Dec-92	6.13	0.977	1.59	0.604	0.575	0.648	160.85	-11.91
06-Dec-92	2.3	1	1.58	0.564	0.562	0.606	441.74	-19.13
07-Dec-92	3.46	0.992	1.59	0.58	0.56	0.634	291.91	-21.39
08-Dec-92	3.67	0.992	1.59	0.584	0.567	0.638	274.11	-19.35
09-Dec-92	4.01	0.984	1.59	0.588	0.575	0.642	249.88	-16.71
10-Dec-92	4.34	0.982	1.58	0.585	0.575	0.645	229.26	-16.13
11-Dec-92	4.67	0.98	1.58	0.582	0.575	0.648	213.70	-15.63
12-Dec-92	5	0.978	1.58	0.579	0.576	0.65	200.20	-14.80
13-Dec-92	5.4	0.975	1.6	0.571	0.576	0.65	190.56	-13.70
14-Dec-92	5.45	0.975	1.61	0.573	0.592	0.665	190.28	-13.39
15-Dec-92	5.67	0.979	1.58	0.58	0.559	0.654	176.37	-16.75
16-Dec-92	6.3	0.978	1.6	0.565	0.555	0.668	164.29	-17.94
17-Dec-92	6.23	0.978	1.57	0.565	0.538	0.671	161.32	-21.35
18-Dec-92	6.16	0.978	1.54	0.564	0.521	0.674	158.44	-24.84
19-Dec-92	6.09	0.978	1.52	0.563	0.504	0.677	157.14	-28.41
20-Dec-92	6	0.978	1.5	0.563	0.487	0.68	156.17	-32.17
21-Dec-92	6.3	0.972	1.58	0.572	0.56	0.664	160.00	-16.51
22-Dec-92	6.56	0.97	1.58	0.571	0.564	0.667	153.81	-15.70
23-Dec-92	6.82	0.968	1.58	0.57	0.568	0.67	148.09	-14.96
24-Dec-92	7.08	0.966	1.58	0.569	0.572	0.673	142.80	-14.27
25-Dec-92	7.34	0.964	1.58	0.568	0.576	0.676	137.87	-13.62
26-Dec-92	7.6	0.963	1.59	0.567	0.581	0.68	134.61	-13.03
27-Dec-92	7.6	0.963	1.59	0.59	0.591	0.72	131.58	-16.97
28-Dec-92	7.9	0.964	1.6	0.613	0.601	0.74	124.94	-17.59
29-Dec-92	7.96	0.964	1.6	0.604	0.599	0.733	125.13	-16.83
30-Dec-92	8.02	0.964	1.6	0.595	0.598	0.726	125.31	-15.98
31-Dec-92	8.08	0.964	1.6	0.586	0.596	0.719	125.50	-15.22
01-Jan-93	8.14	0.964	1.6	0.577	0.595	0.712	125.68	-14.37
02-Jan-93	8.2	0.962	1.6	0.569	0.594	0.705	125.73	-13.54
03-Jan-93	8.4	0.972	1.62	0.568	0.604	0.71	125.24	-12.62
04-Jan-93	8.63	0.965	1.62	0.566	0.604	0.715	122.13	-12.86
05-Jan-93	8.63	0.965	1.62	0.566	0.604	0.715	122.13	-12.86

NORMAL POLARITY
SPECIMEN #8B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.2	1	0.232	-0.294	-0.771	-0.769	2630.00	-10.00
23-Nov-92	0.02	0.999	0.203	0.195	-0.779	-0.777	400.00	-100.00
24-Nov-92	0.02	0.999	0.203	0.195	-0.779	-0.777	400.00	-100.00
25-Nov-92	0.02	0.999	-0.262	-0.259	-0.782	-0.78	-150.00	-100.00
26-Nov-92	0.01	0.993	-0.112	-0.151	-0.782	-0.78	3900.00	-200.00
27-Nov-92	0.01	0.985	0.062	-0.042	-0.782	-0.78	10400.00	-200.00
28-Nov-92	0.01	0.954	0.224	0.066	-0.782	-0.78	15800.00	-200.00
29-Nov-92	0.15	0.999	-0.369	-0.37	-0.775	-0.773	6.67	-13.33
30-Nov-92	0.25	1	-0.286	-0.288	-0.775	-0.776	8.00	4.00
01-Dec-92	0.25	1	-0.503	-0.501	-0.768	-0.77	-8.00	8.00
02-Dec-92	0.27	1	0.228	-0.329	-0.736	-0.737	2062.96	3.70
03-Dec-92	0.23	1	0.153	-0.363	-0.747	-0.748	2243.48	4.35
04-Dec-92	0.19	1	-0.213	-0.398	-0.758	-0.76	973.68	10.53
05-Dec-92	0.16	1	-0.434	-0.433	-0.769	-0.77	-6.25	6.25
06-Dec-92	0.14	1	0.084	0.066	-0.782	-0.785	128.57	21.43
07-Dec-92	0.15	1	0.191	0.185	-0.781	-0.782	40.00	6.67
08-Dec-92	0.15	1	0.191	0.185	-0.781	-0.782	40.00	6.67
09-Dec-92	0.4	1	0.195	-0.28	-0.831	-0.784	1187.50	-117.50
10-Dec-92	0.6	1	-0.169	-0.365	-0.894	-0.811	310.00	-138.33
11-Dec-92	0.8	1	-0.144	-0.43	-0.957	0.838	357.50	-2243.75
12-Dec-92	1.3	0.999	-0.118	-0.505	-1.02	-0.865	297.69	-119.23
13-Dec-92	1.35	0.998	-0.196	-0.545	-1.12	-1	258.52	-88.89
14-Dec-92	1.5	0.999	-0.225	-0.575	-1.2	-1.09	233.33	-73.33
15-Dec-92	1.8	1	-0.03	-0.586	-1.01	-0.851	308.89	-88.33
16-Dec-92	1.8	1	-0.22	-0.589	-1.19	-1.09	205.00	-55.56
17-Dec-92	1.88	1	-0.221	-0.593	-1.19	-1.09	197.87	-53.19
18-Dec-92	1.96	1	-0.222	-0.597	-1.19	-1.09	191.33	-51.02
19-Dec-92	2.04	1	-0.224	-0.601	-1.19	-1.09	184.80	-49.02
20-Dec-92	2.15	1	-0.225	-0.606	-1.19	-1.08	177.21	-51.16
21-Dec-92	1.5	1	-0.035	-0.594	-0.992	-0.84	372.67	-101.33
22-Dec-92	1.91	0.997	-0.078	-0.602	-1.033	-0.884	274.35	-78.01
23-Dec-92	2.32	0.994	-0.121	-0.61	-1.074	-0.928	210.78	-62.93
24-Dec-92	2.73	0.991	-0.164	-0.618	-1.115	-0.972	166.30	-52.38
25-Dec-92	3.14	0.988	-0.207	-0.626	-1.156	-1.016	133.44	-44.59
26-Dec-92	3.57	0.987	-0.252	-0.636	-1.2	-1.06	107.56	-39.22
27-Dec-92	3.57	0.987	-0.252	-0.636	-1.2	-1.06	107.56	-39.22
28-Dec-92	4.11	0.986	-0.252	-0.649	-1.23	-1.12	96.59	-26.76
29-Dec-92	4.28	0.986	-0.252	-0.652	-1.23	-1.11	93.46	-28.04
30-Dec-92	4.45	0.986	-0.253	-0.655	-1.23	-1.11	90.34	-26.97
31-Dec-92	4.62	0.986	-0.253	-0.658	-1.23	-1.11	87.66	-25.97
01-Jan-93	4.79	0.986	-0.254	-0.661	-1.23	-1.11	84.97	-25.05
02-Jan-93	5	0.983	-0.255	-0.664	-1.23	-1.11	81.80	-24.00
03-Jan-93	5.35	0.99	-0.253	-0.662	-1.23	-1.11	76.45	-22.43
04-Jan-93	5.24	0.985	-0.268	-0.676	-1.23	-1.12	77.86	-20.99
05-Jan-93	5.24	0.985	-0.268	-0.676	-1.23	-1.12	77.86	-20.99

REVERSED POLARITY
SPECIMEN #6B
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (11/16 IN - 17.5mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	7.7	0.988	1.67	0.471	0.631	0.758	155.71	-16.23
23-Nov-92	6.5	0.996	1.51	0.396	0.519	0.762	171.38	-37.38
24-Nov-92	6.5	0.996	1.63	0.296	0.653	0.765	205.23	-17.23
25-Nov-92	6.28	0.988	1.62	0.382	0.644	0.766	197.13	-19.43
26-Nov-92	6.06	0.98	1.62	0.468	0.635	0.767	190.10	-21.78
27-Nov-92	5.84	0.973	1.61	0.554	0.626	0.767	180.82	-24.14
28-Nov-92	5.72	0.978	1.57	0.783	0.596	0.738	137.59	-24.83
29-Nov-92	6.01	0.976	1.65	0.65	0.645	0.745	166.39	-16.64
30-Nov-92	5.45	0.981	1.55	0.677	0.545	0.7	160.18	-28.44
01-Dec-92	5.5	0.985	1.63	0.813	0.625	0.745	148.55	-21.82
02-Dec-92	5.5	0.985	1.63	0.809	0.626	0.744	149.27	-21.45
03-Dec-92	5.5	0.985	1.64	0.805	0.627	0.742	151.82	-20.91
04-Dec-92	5.5	0.985	1.65	0.803	0.628	0.74	154.00	-20.36
05-Dec-92	5.2	0.981	1.66	0.836	0.659	0.763	158.46	-20.00
06-Dec-92	5.6	0.977	1.58	0.415	0.586	0.692	208.04	-18.93
07-Dec-92	5.6	0.977	1.61	0.545	0.634	0.723	190.18	-15.89
08-Dec-92	5.6	0.975	1.66	0.635	0.662	0.755	183.04	-16.61
09-Dec-92	5.6	0.975	1.63	0.646	0.636	0.739	175.71	-18.39
10-Dec-92	5.65	0.975	1.61	0.657	0.611	0.723	168.67	-19.82
11-Dec-92	5.72	0.974	1.57	0.668	0.585	0.708	157.69	-21.50
12-Dec-92	5.73	0.974	1.66	0.71	0.662	0.746	165.79	-14.66
13-Dec-92	5.73	0.974	1.66	0.71	0.662	0.746	165.79	-14.66
14-Dec-92	6	0.977	1.63	0.735	0.614	0.724	149.17	-18.33
15-Dec-92	6	0.982	1.56	0.668	0.549	0.702	148.67	-25.50
16-Dec-92	6.32	0.952	1.582	0.677	0.567	0.714	143.20	-23.26
17-Dec-92	6.64	0.951	1.604	0.686	0.585	0.726	138.25	-21.23
18-Dec-92	6.96	0.949	1.626	0.695	0.603	0.738	133.76	-19.40
19-Dec-92	7.28	0.947	1.648	0.704	0.621	0.75	129.67	-17.72
20-Dec-92	4.5	0.983	1.65	0.636	0.635	0.744	225.33	-24.22
21-Dec-92	5.4	0.978	1.656	0.659	0.638	0.75	184.63	-20.74
22-Dec-92	6.3	0.973	1.662	0.682	0.641	0.756	155.56	-18.25
23-Dec-92	7.2	0.968	1.668	0.705	0.644	0.762	133.75	-16.39
24-Dec-92	8.1	0.963	1.674	0.728	0.647	0.768	116.79	-14.94
25-Dec-92	9	0.956	1.68	0.753	0.65	0.773	103.00	-13.67
26-Dec-92	9.47	0.955	1.68	0.758	0.655	0.781	97.36	-13.31
27-Dec-92	9.94	0.953	1.68	0.763	0.661	0.788	92.25	-12.78
28-Dec-92	10.45	0.951	1.68	0.76	0.664	0.795	88.04	-12.54
29-Dec-92	10.96	0.949	1.68	0.757	0.667	0.802	84.22	-12.32
30-Dec-92	11.47	0.947	1.68	0.754	0.67	0.809	80.73	-12.12
31-Dec-92	11.98	0.945	1.68	0.751	0.673	0.816	77.55	-11.94
01-Jan-93	12	0.943	1.69	0.749	0.675	0.825	78.42	-12.50
02-Jan-93	12	0.952	1.7	0.749	0.683	0.849	79.25	-13.83
03-Jan-93	12.47	0.945	1.72	0.757	0.677	0.856	77.23	-14.35
04-Jan-93	12.47	0.945	1.72	0.757	0.677	0.856	77.23	-14.35
05-Jan-93	12.47	0.945	1.72	0.757	0.677	0.856	77.23	-14.35

NORMAL POLARITY
SPECIMEN #8C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - ANODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	ANODE		CATHODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	ANODE	CATHODE
22-Nov-92	0.92	1	0.077	-0.396	-0.833	-0.581	514.13	-273.91
23-Nov-92	0.92	1	0.027	-0.402	-0.895	-0.648	466.30	-268.48
24-Nov-92	0.92	1	0.027	-0.402	-0.895	-0.648	466.30	-268.48
25-Nov-92	0.99	1	0.022	-0.388	-0.901	-0.666	414.14	-237.37
26-Nov-92	0.99	1	0.021	-0.39	-0.912	-0.664	415.15	-250.51
27-Nov-92	1	1	0.019	-0.392	-0.924	-0.661	411.00	-263.00
28-Nov-92	1.1	1	0.017	-0.394	-0.935	-0.658	373.64	-251.82
29-Nov-92	0.94	1	0.015	-0.386	-0.939	-0.71	426.60	-243.62
30-Nov-92	0.94	1	0.026	-0.376	-0.945	-0.725	427.66	-234.04
01-Dec-92	0.98	1	-0.013	-0.384	-0.96	-0.712	378.57	-253.06
02-Dec-92	1.09	1	0.005	-0.376	-0.878	-0.6	349.54	-255.05
03-Dec-92	0.96	1	0.002	-0.379	-0.901	-0.636	396.88	-276.04
04-Dec-92	0.93	1	-0.006	-0.382	-0.925	-0.673	404.30	-270.97
05-Dec-92	0.91	1	-0.012	-0.384	-0.948	-0.71	408.79	-261.54
06-Dec-92	1	1	-0.041	-0.388	-0.99	-0.775	347.00	-215.00
07-Dec-92	1.04	1	-0.043	-0.391	-0.968	-0.85	334.62	-113.46
08-Dec-92	1.03	1	-0.042	-0.395	-0.983	-0.832	342.72	-146.60
09-Dec-92	1.02	1	-0.042	-0.397	-0.998	-0.803	348.04	-191.18
10-Dec-92	0.9	1	-0.04	-0.395	-0.998	-0.812	394.44	-206.67
11-Dec-92	0.9	1	-0.038	-0.392	-1	-0.821	393.33	-198.89
12-Dec-92	0.9	1	-0.036	-0.39	-1	-0.83	393.33	-188.89
13-Dec-92	0.9	1	-0.038	-0.38	-0.999	-0.82	380.00	-198.89
14-Dec-92	1.1	1	-0.042	-0.385	-0.999	-0.815	311.82	-167.27
15-Dec-92	0.93	1	-0.033	-0.415	-0.996	-0.735	410.75	-280.65
16-Dec-92	0.93	1	-0.02	-0.379	-0.999	-0.81	386.02	-203.23
17-Dec-92	0.88	1	-0.015	-0.373	-0.994	-0.811	406.82	-207.95
18-Dec-92	0.83	1	-0.01	-0.367	-0.989	-0.812	430.12	-213.25
19-Dec-92	0.78	1	-0.005	-0.361	-0.984	-0.813	456.41	-219.23
20-Dec-92	0.72	1	-0.002	-0.355	-0.98	-0.815	490.28	-229.17
21-Dec-92	0.72	1	0.003	-0.354	-0.978	-0.81	495.83	-233.33
22-Dec-92	0.72	1	0.001	-0.354	-0.974	-0.799	493.06	-243.06
23-Dec-92	0.72	1	-0.001	-0.354	-0.97	-0.788	490.28	-252.78
24-Dec-92	0.72	1	-0.003	-0.354	-0.966	-0.777	487.50	-262.50
25-Dec-92	0.72	1	-0.005	-0.354	-0.962	-0.766	484.72	-272.22
26-Dec-92	0.72	1	-0.005	-0.354	-0.959	-0.754	484.72	-284.72
27-Dec-92	0.69	1	0.019	-0.323	-0.958	-0.755	495.65	-294.20
28-Dec-92	0.67	1	0.033	-0.308	-0.958	-0.755	508.96	-302.99
29-Dec-92	0.662	1	0.033	-0.309	-0.957	-0.759	516.62	-299.09
30-Dec-92	0.654	1	0.033	-0.309	-0.956	-0.763	522.94	-295.11
31-Dec-92	0.646	1	0.033	-0.311	-0.955	-0.767	532.51	-291.02
01-Jan-93	0.638	1	0.033	-0.311	-0.954	-0.771	539.18	-286.83
02-Jan-93	0.63	1	0.034	-0.312	-0.953	-0.775	549.21	-282.54
03-Jan-93	0.71	1	0.008	-0.334	-0.972	-0.765	478.87	-291.55
04-Jan-93	0.71	1	-0.007	-0.341	-1	-0.775	470.42	-316.90
05-Jan-93	0.71	1	-0.007	-0.341	-1	-0.775	470.42	-316.90

REVERSED POLARITY
SPECIMEN #8C
IMPRESSED VOLTAGE 1V
DISTANCE BETWEEN ELECTRODES (4 IN) 101.6mm
ELECTROLYTE SOLUTION %3.5 NACL
ELECTRODES NON EPOXY No.15
CLEAR COVER (1" 3/16 IN - 30.2mm)
IMMERSION PERIOD 45 DAYS
CONCRETE EMBEDDED - CATHODE

ELECTRODE POTENTIALES (V)

DATE	I	VOLT	CATHODE		ANODE		ELECTRODE RESISTANCE	
DD-MM-YY	(mA)	V	ON	OFF	ON	OFF	CATHODE	ANODE
22-Nov-92	6.1	0.996	1.51	0.433	0.469	0.566	176.56	-15.90
23-Nov-92	5.65	0.996	1.5	0.458	0.503	0.583	184.42	-14.16
24-Nov-92	5.65	0.996	1.5	0.458	0.503	0.583	184.42	-14.16
25-Nov-92	5.86	0.973	1.48	0.485	0.508	0.595	169.80	-14.85
26-Nov-92	5.71	0.973	1.48	0.479	0.498	0.589	175.31	-15.94
27-Nov-92	5.56	0.977	1.48	0.474	0.487	0.583	180.94	-17.27
28-Nov-92	5.41	0.978	1.49	0.468	0.477	0.577	188.91	-18.48
29-Nov-92	5.9	0.977	1.47	0.487	0.46	0.582	166.61	-20.68
30-Nov-92	5.7	0.981	1.48	0.5	0.466	0.58	171.93	-20.00
01-Dec-92	5.58	0.98	1.48	0.524	0.464	0.587	171.33	-22.04
02-Dec-92	5.25	0.985	1.47	0.56	0.455	0.585	173.33	-24.76
03-Dec-92	5.29	0.985	1.46	0.552	0.454	0.589	171.64	-25.52
04-Dec-92	5.33	0.983	1.46	0.544	0.452	0.592	171.86	-26.27
05-Dec-92	5.37	0.981	1.46	0.536	0.451	0.596	172.07	-27.00
06-Dec-92	5.8	0.981	1.46	0.557	0.447	0.604	155.69	-27.07
07-Dec-92	5.75	0.975	1.45	0.514	0.434	0.598	162.78	-28.52
08-Dec-92	5.57	0.975	1.45	0.535	0.442	0.605	164.27	-29.26
09-Dec-92	5.4	0.975	1.46	0.556	0.45	0.611	167.41	-29.81
10-Dec-92	5.4	0.975	1.46	0.559	0.452	0.612	166.85	-29.63
11-Dec-92	5.4	0.975	1.46	0.562	0.453	0.614	166.30	-29.81
12-Dec-92	5.4	0.975	1.47	0.565	0.455	0.615	167.59	-29.63
13-Dec-92	5.4	0.975	1.47	0.432	0.46	0.622	192.22	-30.00
14-Dec-92	5.4	0.975	1.45	0.514	0.434	0.605	173.33	-31.67
15-Dec-92	5.4	0.982	1.46	0.538	0.435	0.61	170.74	-32.41
16-Dec-92	5.6	0.984	1.45	0.508	0.433	0.6	168.21	-29.82
17-Dec-92	5.4	0.984	1.45	0.506	0.431	0.6	174.81	-31.30
18-Dec-92	5.2	0.984	1.45	0.504	0.428	0.6	181.92	-33.08
19-Dec-92	5	0.981	1.45	0.502	0.426	0.598	189.60	-34.40
20-Dec-92	4.78	0.978	1.45	0.5	0.423	0.597	198.74	-36.40
21-Dec-92	4.8	0.978	1.44	0.494	0.429	0.603	197.08	-36.25
22-Dec-92	4.9	0.978	1.44	0.494	0.431	0.602	193.06	-34.90
23-Dec-92	4.9	0.978	1.44	0.494	0.433	0.601	193.06	-34.29
24-Dec-92	5	0.976	1.44	0.494	0.436	0.601	189.20	-33.00
25-Dec-92	5.1	0.975	1.44	0.494	0.436	0.599	185.49	-31.96
26-Dec-92	5.2	0.973	1.44	0.495	0.437	0.598	181.73	-30.96
27-Dec-92	5.2	0.975	1.44	0.446	0.42	0.61	191.15	-36.54
28-Dec-92	5.2	0.975	1.44	0.446	0.42	0.61	191.15	-36.54
29-Dec-92	5.09	0.975	1.44	0.456	0.42	0.61	193.32	-37.33
30-Dec-92	4.98	0.975	1.44	0.466	0.42	0.61	195.58	-38.15
31-Dec-92	4.87	0.975	1.44	0.476	0.42	0.61	197.95	-39.01
01-Jan-93	4.76	0.975	1.44	0.486	0.42	0.61	200.42	-39.92
02-Jan-93	4.65	0.975	1.44	0.496	0.42	0.61	203.01	-40.86
03-Jan-93	4	0.996	1.45	0.456	0.427	0.606	248.50	-44.75
04-Jan-93	4.34	0.991	1.43	0.577	0.408	0.589	196.54	-41.71
05-Jan-93	4.34	0.991	1.43	0.577	0.408	0.589	196.54	-41.71

APPENDIX F

CHLORIDE ANALYSIS RESULTS

Results of chloride content are presented in the following pages. The tests were performed in the laboratories of the Otto Maass building at McGill University.

Volhard method was used in analyzing the cement powder extracted from each specimen (top, middle, bottom).

The variation of the chloride content along the cylinder height versus the depth of concrete cover are also plotted.

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
1A	(TOP)	2.6654	20	2.96	0.013
1A	(MIDDLE)	2.0181	30	5.35	0.021
1A	(BOTTOM)	1.5133	20	4.09	0.017
1B	(TOP)	1.5829	20	4.6	0.022
1B	(MIDDLE)	1.6481	20	1.11	0.025
1B	(BOTTOM)	1.4332	10	5.54	0.017
1C	(TOP)	1.4225	20	7.75	0.032
1C	(MIDDLE)	1.378	20	10.7	0.035
1C	(BOTTOM)	0.7705	10	5.22	0.018
1D	(TOP)	0.8442	20	9.56	0.039
1D	(MIDDLE)	0.7444	20	9.94	0.038
1D	(BOTTOM)	1.0147	20	9.2	0.038
1E	(TOP)	0.7562	10	4.02	0.049
1E	(MIDDLE)	1.4863	30	12.01	0.051
1E	(BOTTOM)	0.8499	20	9.98	0.038
1F	(TOP)	1.142	30	13.51	0.050
1F	(MIDDLE)	0.6977	10	4.45	0.067
1F	(BOTTOM)	0.6239	10	5.41	0.040
1G	(TOP)	0.9541	10	6.62	0.056
1G	(MIDDLE)	0.7775	10	3.35	0.068
1G	(BOTTOM)	1.4647	20	9.98	0.042
1H	(TOP)	0.9276	20	6.68	0.062
1H	(MIDDLE)	0.8982	30	7.48	0.082
1H	(BOTTOM)	1.2237	20	8.66	0.058
1I	(TOP)	1.2198	10	8.91	0.062
1I	(MIDDLE)	1.6423	20	6.11	0.090
1I	(BOTTOM)	0.7651	30	7.22	0.083

Chloride contents for the specimens in Test Series No. 1

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
2A	(TOP)	1.2108	30	14.27	0.082
2A	(MIDDLE)	0.9753	20	4.73	0.056
2A	(BOTTOM)	1.304	30	7.35	0.083
2B	(TOP)	1.3434	10	2.51	0.059
2B	(MIDDLE)	1.03	20	10.32	0.044
2B	(BOTTOM)	1.1228	10	1.69	0.060
2C	(TOP)	2.232	30	7.63	0.043
2C	(MIDDLE)	2.5156	30	18.53	0.036
2C	(BOTTOM)	1.5425	20	3.45	0.030
2D	(TOP)	0.9125	20	8.32	0.027
2D	(MIDDLE)	0.8479	10	2.21	0.028
2D	(BOTTOM)	0.6534	10	3.94	0.025
2E	(TOP)	0.9226	10	5.06	0.019
2E	(MIDDLE)	1.0407	10	6.05	0.015
2E	(BOTTOM)	0.7991	10	3.07	0.022

Chloride contents for the specimens in Test Series No. 2

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
3A	(TOP)	0.6697	10	1.6	0.077
3A	(MIDDLE)	0.5634	10	1.03	0.072
3A	(BOTTOM)	0.7642	10	1.13	0.095
3B	(TOP)	0.9944	10	3.06	0.033
3B	(MIDDLE)	0.9783	20	2.83	0.062
3B	(BOTTOM)	1.3211	20	4.05	0.058
3C	(TOP)	1.8587	30	9.17	0.031
3C	(MIDDLE)	1.5686	30	10.62	0.036
3C	(BOTTOM)	1.6683	30	3.81	0.032
3D	(TOP)	0.5599	10	1.05	0.026
3D	(MIDDLE)	0.5006	20	10.35	0.033
3D	(BOTTOM)	0.4737	10	4.21	0.022

Chloride contents for the specimens in Test Series No. 3

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
4A	(TOP)	1.708	20	18.63	0.010
4A	(MIDDLE)	2.508	50	49.52	0.026
4A	(BOTTOM)	1.7122	20	13.42	0.017
4B	(TOP)	1.0499	20	17.45	0.006
4B	(MIDDLE)	3.4202	50	44.75	0.01
4B	(BOTTOM)	2.6608	50	47.4	0.015
4C	(TOP)	3.7053	50	47.03	0.004
4C	(MIDDLE)	1.295	25	16.31	0.007
4C	(BOTTOM)	1.2548	25	19.61	0.009
4D	(TOP)	3.7053	50	47.03	0.004
4D	(MIDDLE)	2.4629	50	43.92	0.004
4D	(BOTTOM)	2.0177	50	45.83	0.005
4E	(TOP)	2.3769	50	47.35	0.004
4E	(MIDDLE)	2.2464	50	48.32	0.002
4E	(BOTTOM)	2.7744	50	47.46	0.005

Chloride contents for the specimens in Test Series No. 4

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
5A	(TOP)	2.2963	50	48.6	0.015
5A	(MIDDLE)	0.9385	20	18.52	0.024
5A	(BOTTOM)	1.6913	25	21.4	0.039
5B	(TOP)	1.5973	25	19.01	0.006
5B	(MIDDLE)	2.6598	50	14.33	0.007
5B	(BOTTOM)	1.1495	25	16.54	0.028
5C	(TOP)	1.8166	25	22.73	0.006
5C	(MIDDLE)	1.1235	20	12.89	0.006
5C	(BOTTOM)	2.864	50	20.3	0.015
5D	(TOP)	2.5877	50	46.95	0.004
5D	(MIDDLE)	3.1882	50	45.7	0.005
5D	(BOTTOM)	4.4251	50	33.1	0.009

Chloride contents for the specimens in Test Series No. 5

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
6A	(TOP)	2.1549	50	40.98	0.034
6A	(MIDDLE)	2.9824	50	20.18	0.038
6A	(BOTTOM)	3.4862	50	31.58	0.044
6B	(TOP)	1.0149	25	18.46	0.025
6B	(MIDDLE)	3.1973	50	37.75	0.022
6B	(BOTTOM)	2.4931	50	21.04	0.025
6C	(TOP)	0.9841	20	11.29	0.017
6C	(MIDDLE)	3.0185	50	32.68	0.015
6C	(BOTTOM)	1.4855	20	10.28	0.020

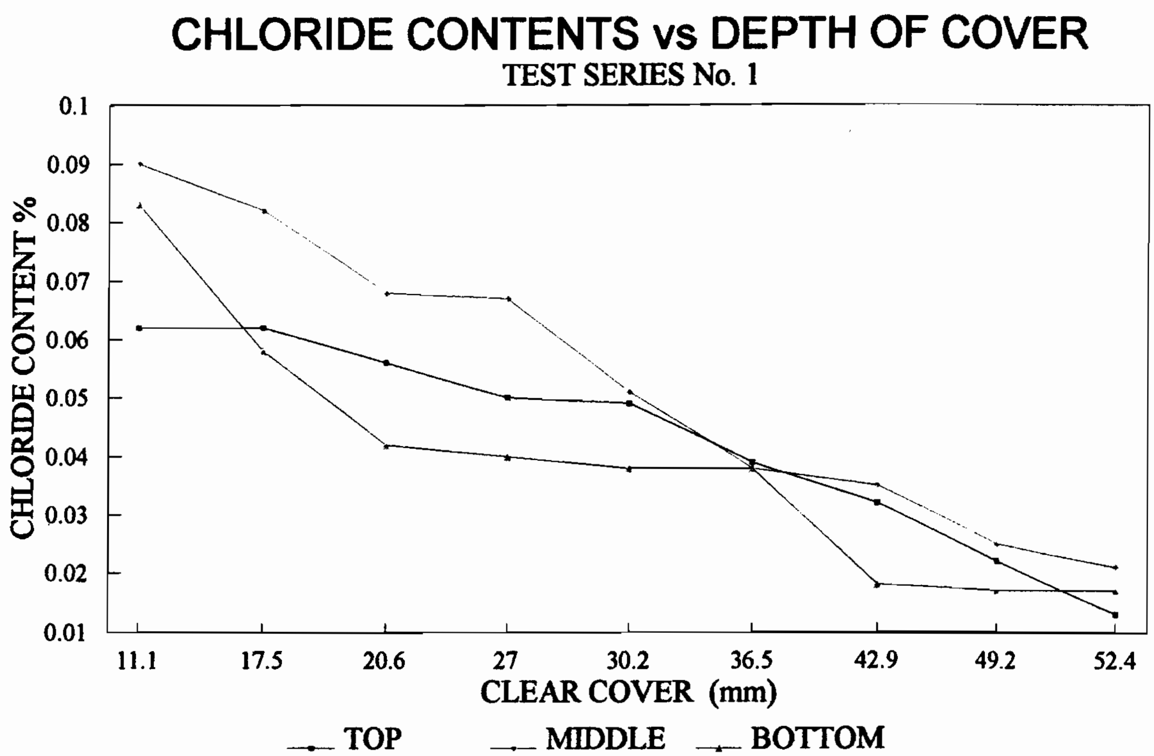
Chloride contents for the specimens in Test Series No. 6

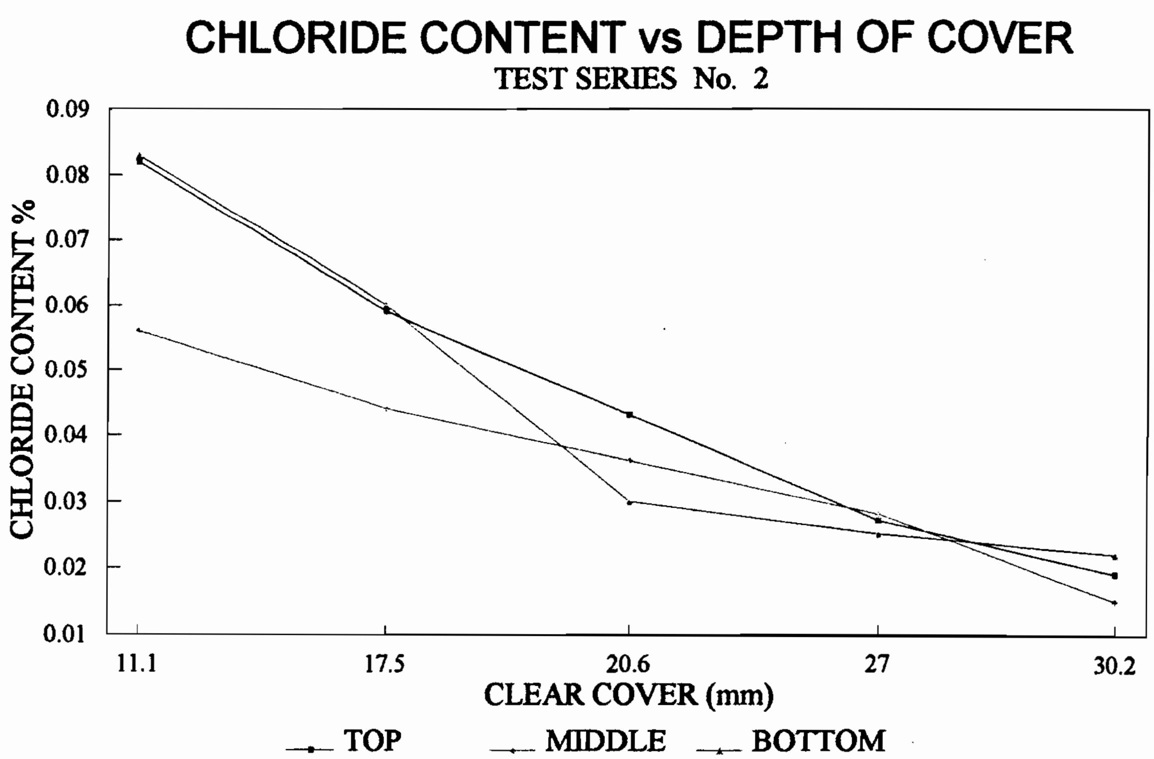
SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
7A	(TOP)	2.0197	50	41.05	0.018
7A	(MIDDLE)	1.3946	25	18.54	0.018
7A	(BOTTOM)	2.7493	50	41.02	0.016
7B	(TOP)	2.9431	50	35.32	0.019
7B	(MIDDLE)	2.9431	50	35.32	0.019
7B	(BOTTOM)	0.9475	20	16.8	0.014
7C	(TOP)	1.032	20	17.98	0.009
7C	(MIDDLE)	2.0198	25	17.32	0.015
7C	(BOTTOM)	1.5492	25	18.65	0.013

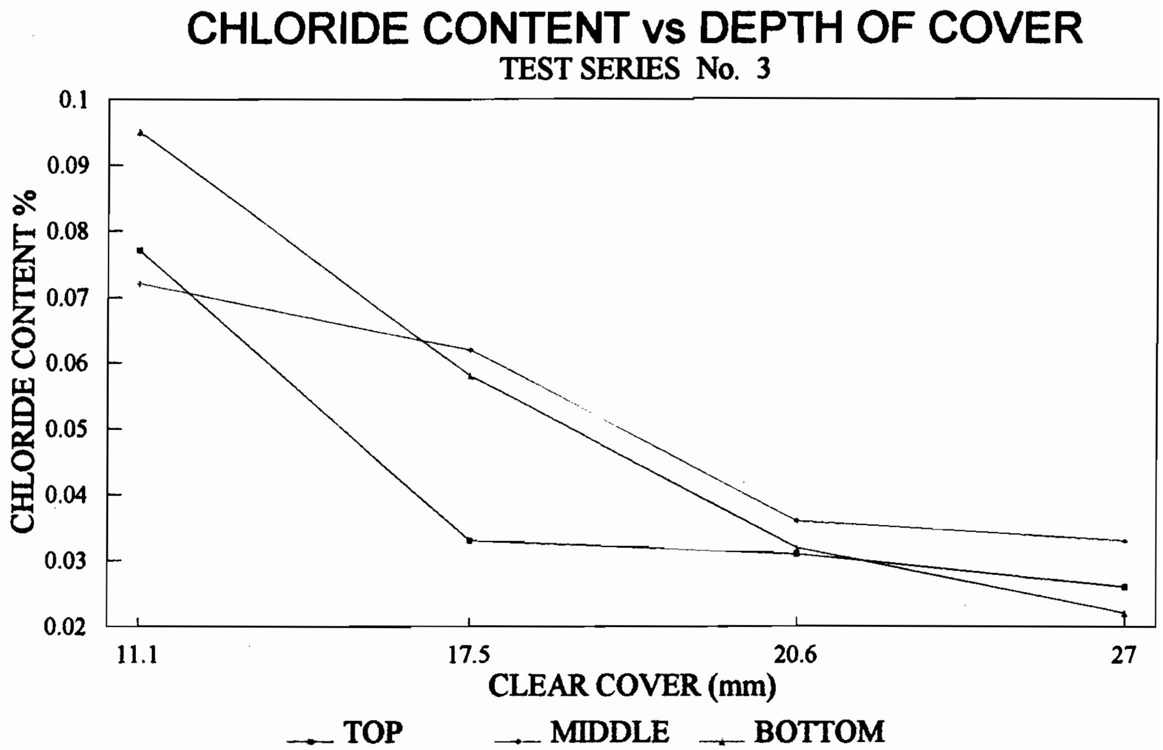
Chloride contents for the specimens in Test Series No. 7

SPECIMEN #		MASS	AgNo3	KSCN	CHLORIDE CONTENT
		g	ml	ml	%cl
8A	(TOP)	1.6974	25	14.58	0.023
8A	(MIDDLE)	3.0597	50	41.05	0.015
8A	(BOTTOM)	1.8467	25	17.45	0.026
8B	(TOP)	1.4466	25	18.04	0.019
8B	(MIDDLE)	2.5794	50	40.18	0.012
8B	(BOTTOM)	3.0465	50	37.54	0.016
8C	(TOP)	1.3589	20	15.81	0.012
8C	(MIDDLE)	1.9746	25	18.34	0.013
8C	(BOTTOM)	1.8912	25	12.04	0.016

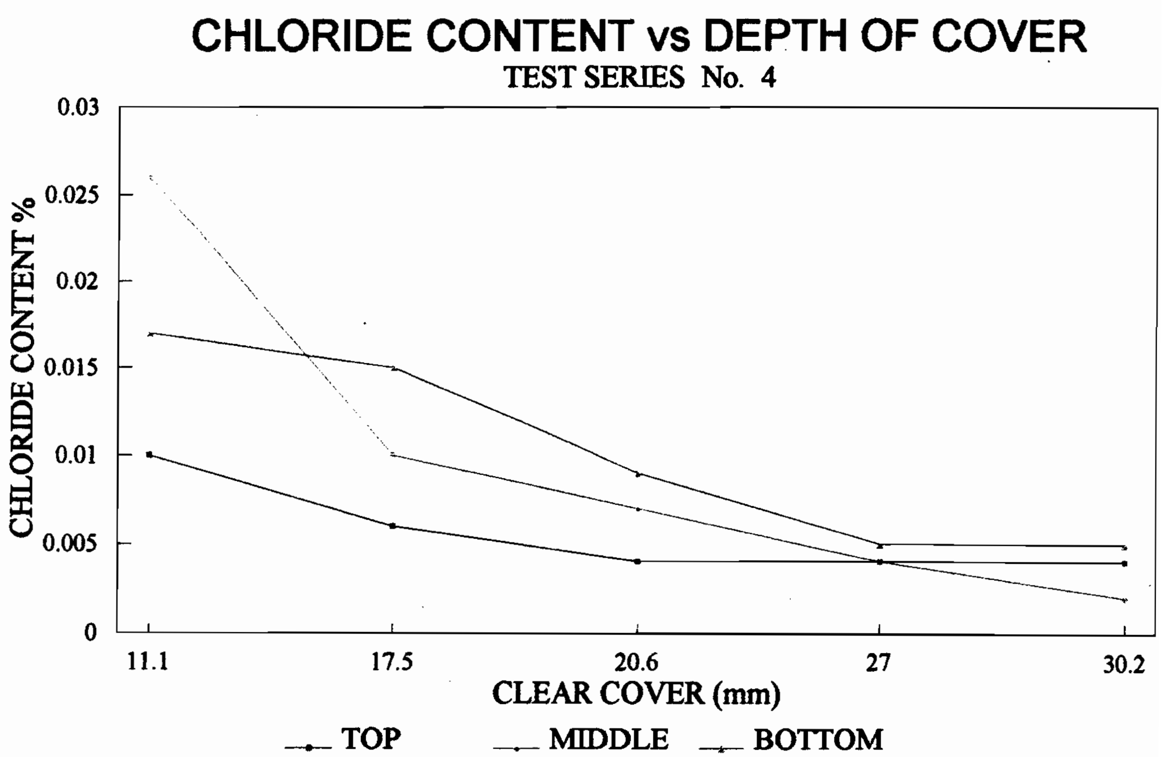
Chloride contents for the specimens in Test Series No. 8


CHLORIDE CONTENTS vs DEPTH OF COVER
TEST SERIES No. 1
CHLORIDE CONTENT %
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
11.1
17.5
20.6
27
30.2
36.5
42.9
49.2
52.4
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM


CHLORIDE CONTENT vs DEPTH OF COVER
TEST SERIES No. 2
CHLORIDE CONTENT %
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
11.1
17.5
20.6
27
30.2
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM



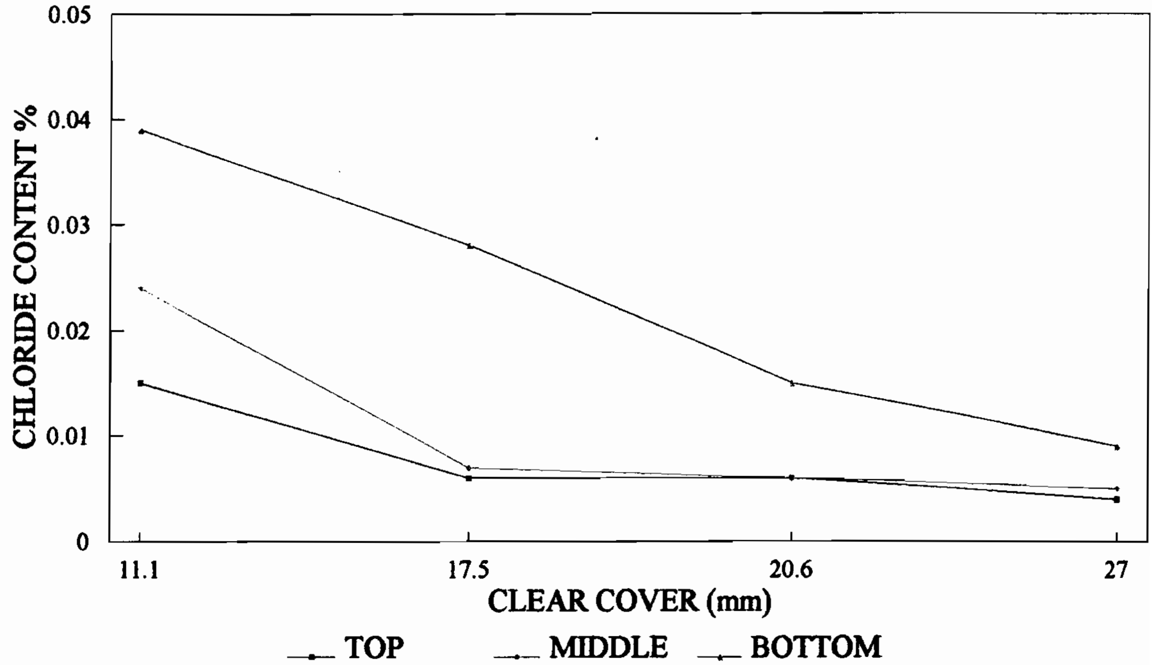
CHLORIDE CONTENT vs DEPTH OF COVER
TEST SERIES No. 3
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
CHLORIDE CONTENT %
11.1
17.5
20.6
27
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM



CHLORIDE CONTENT vs DEPTH OF COVER
TEST SERIES No. 4
0.03
0.025
0.02
0.015
0.01
0.005
0
CHLORIDE CONTENT %
11.1
17.5
20.6
27
30.2
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM

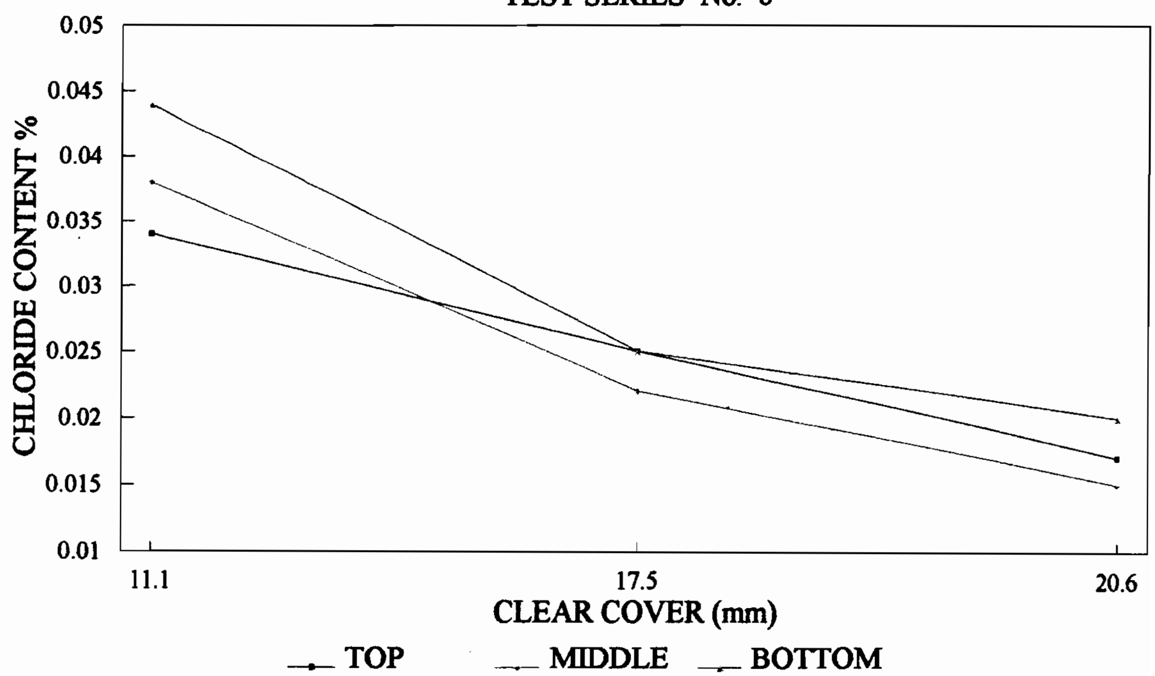
CHLORIDE CONTENT vs DEPTH OF COVER

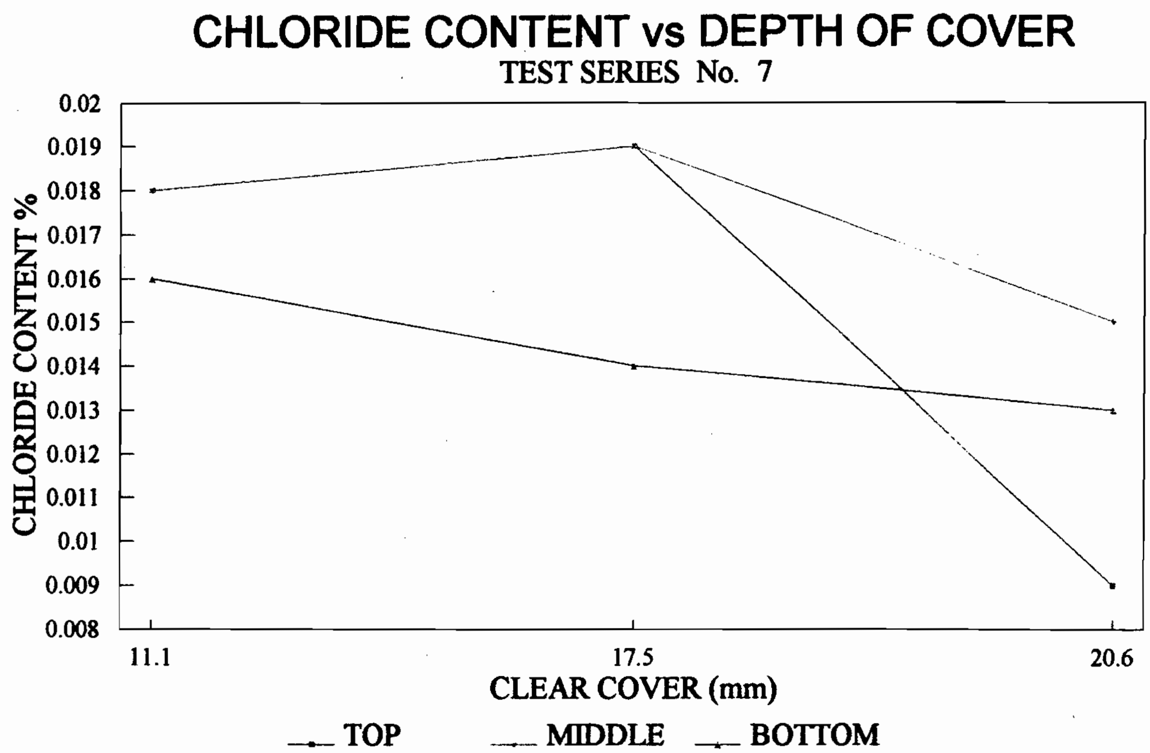
TEST SERIES No. 5

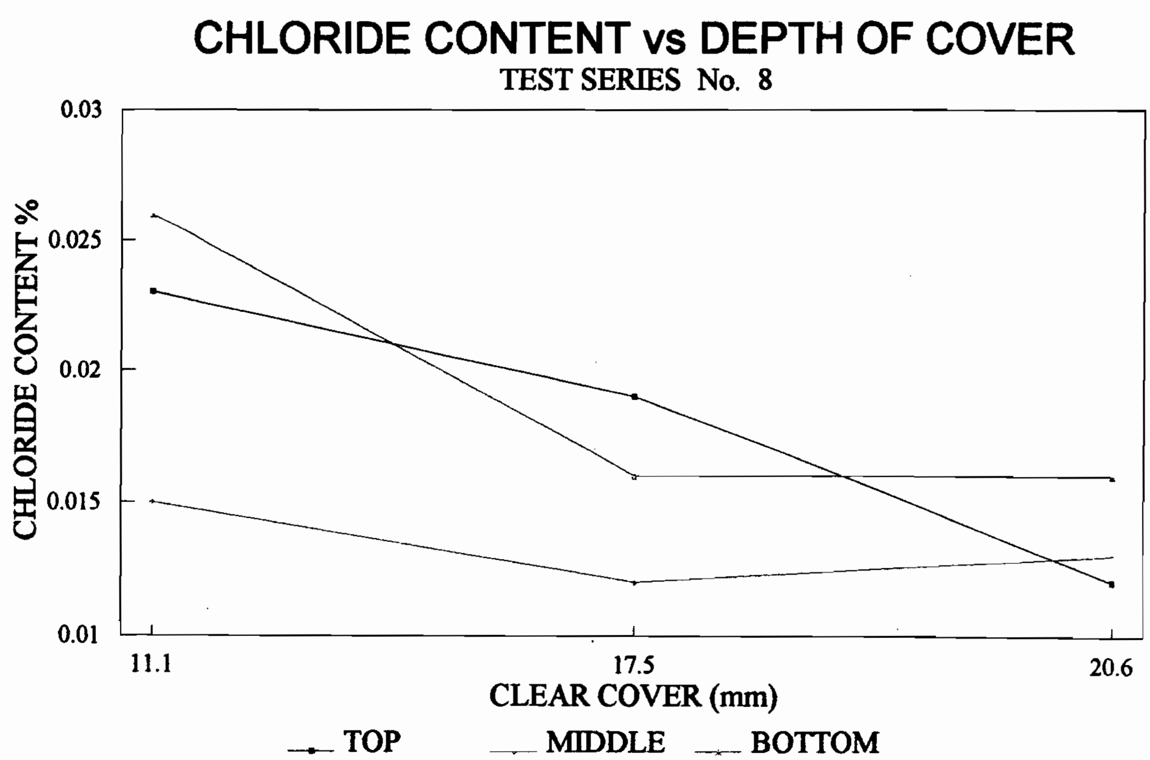


CHLORIDE CONTENT vs DEPTH OF COVER

TEST SERIES No. 6




CHLORIDE CONTENT vs DEPTH OF COVER
TEST SERIES No. 7
CHLORIDE CONTENT %
0.02
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
0.009
0.008
11.1
17.5
20.6
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM

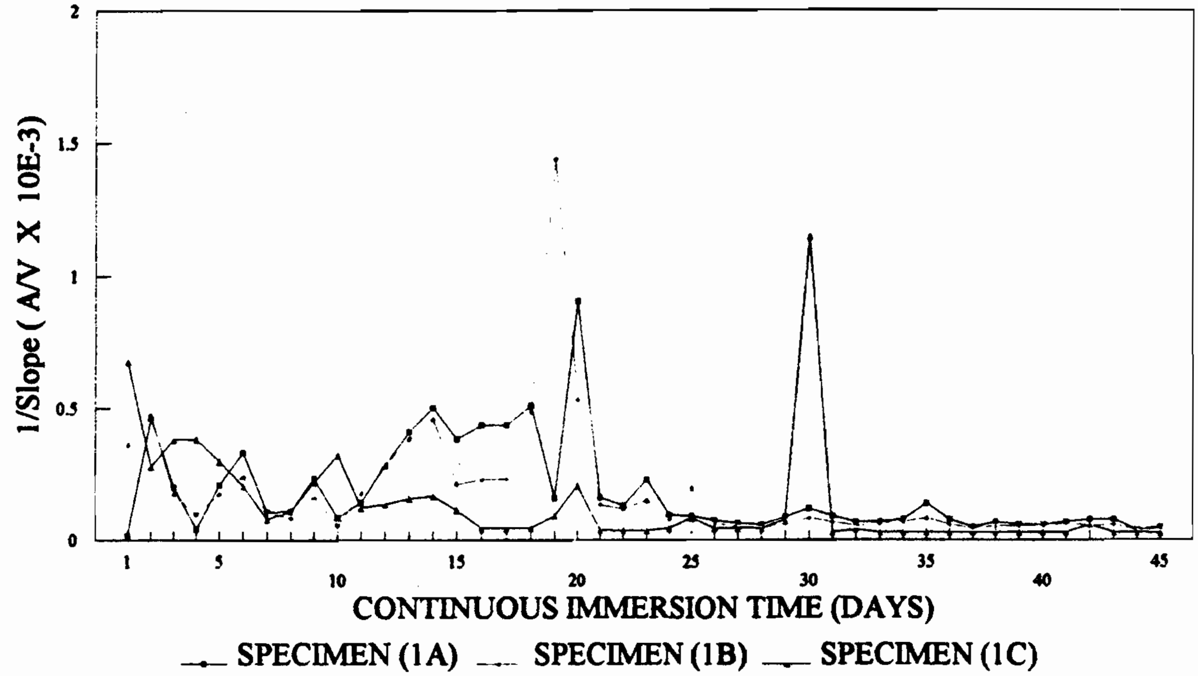

CHLORIDE CONTENT vs DEPTH OF COVER
TEST SERIES No. 8
CHLORIDE CONTENT %
0.03
0.025
0.02
0.015
0.01
11.1
17.5
20.6
CLEAR COVER (mm)
TOP
MIDDLE
BOTTOM

APPENDIX G

EFFECT OF IMMERSION TIME ON CORROSION

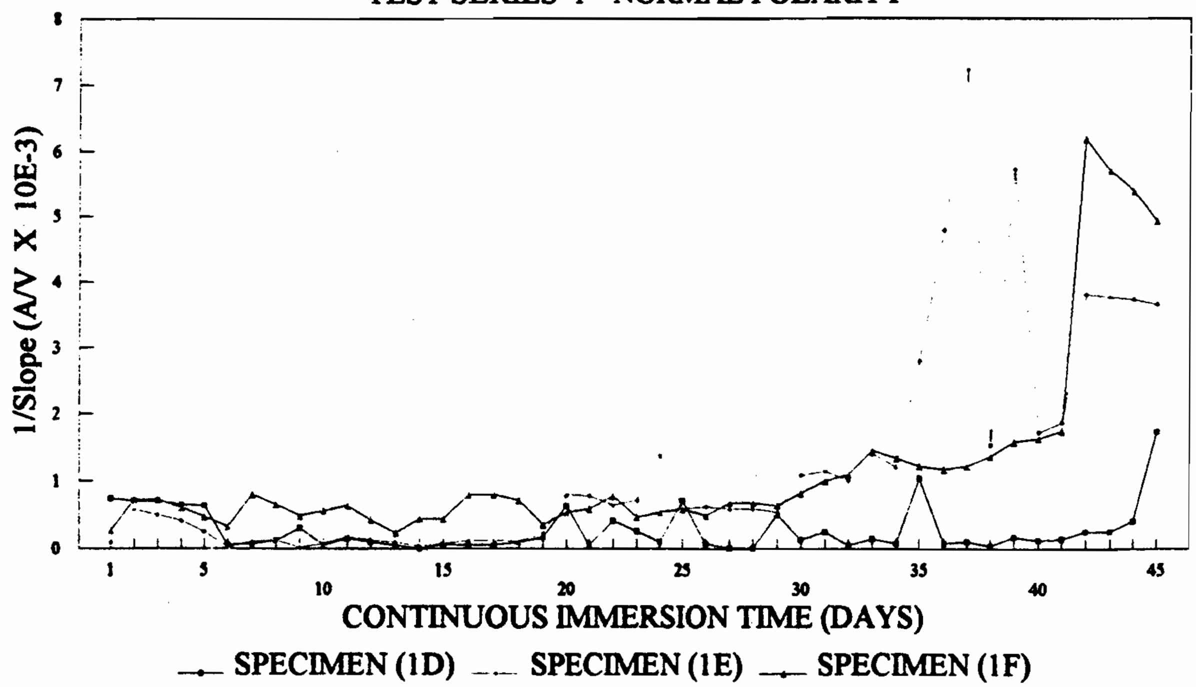
EFFECT OF IMMERSION TIME ON CORROSION

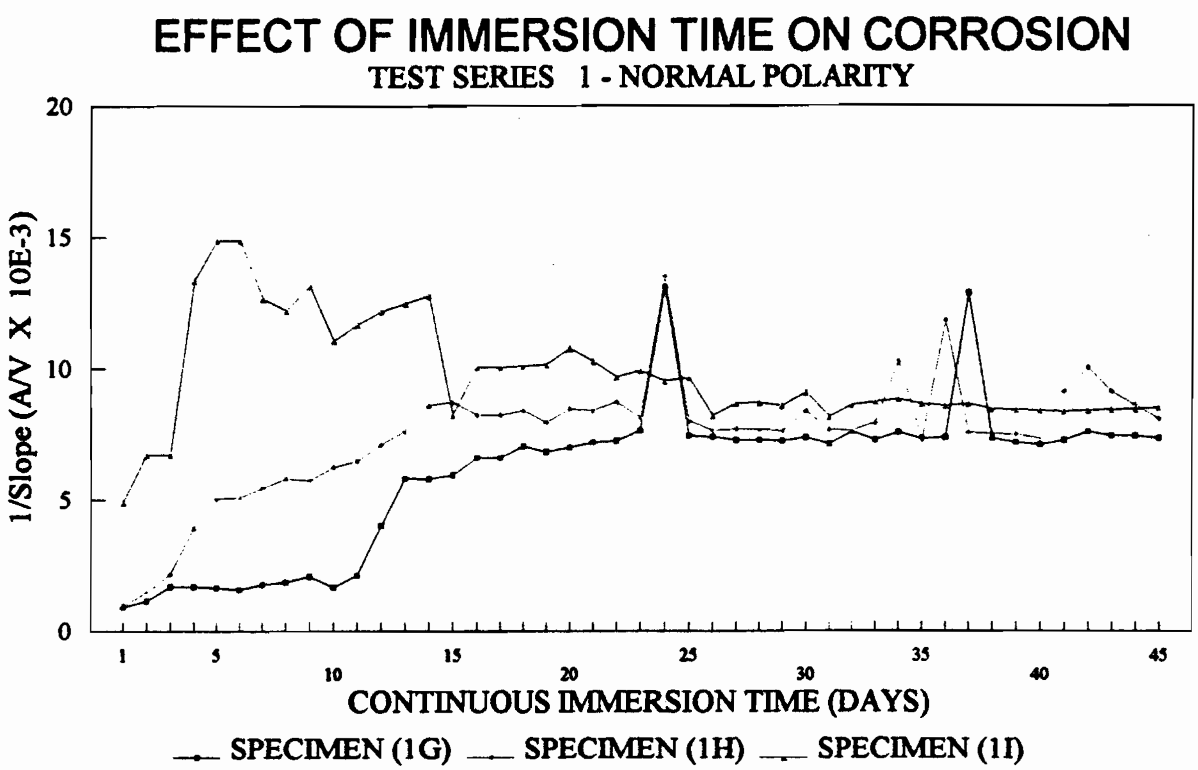
TEST SERIES 1 - NORMAL POLARITY

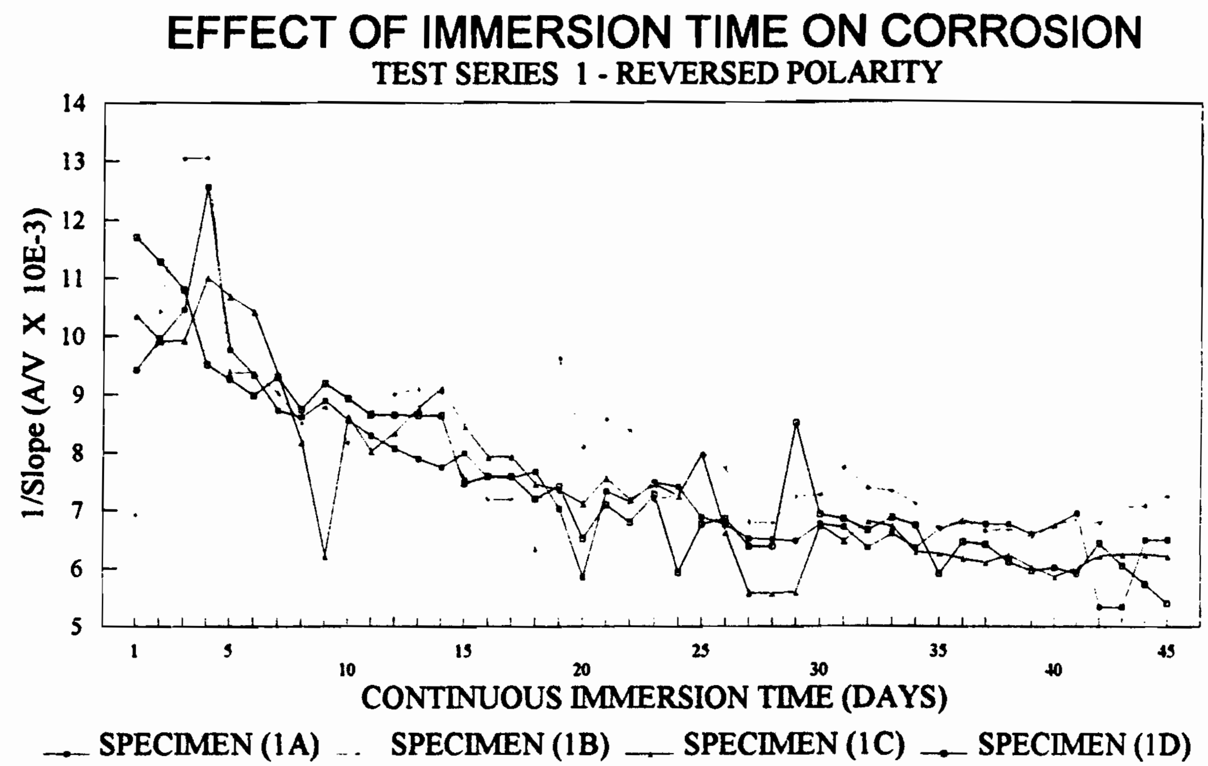


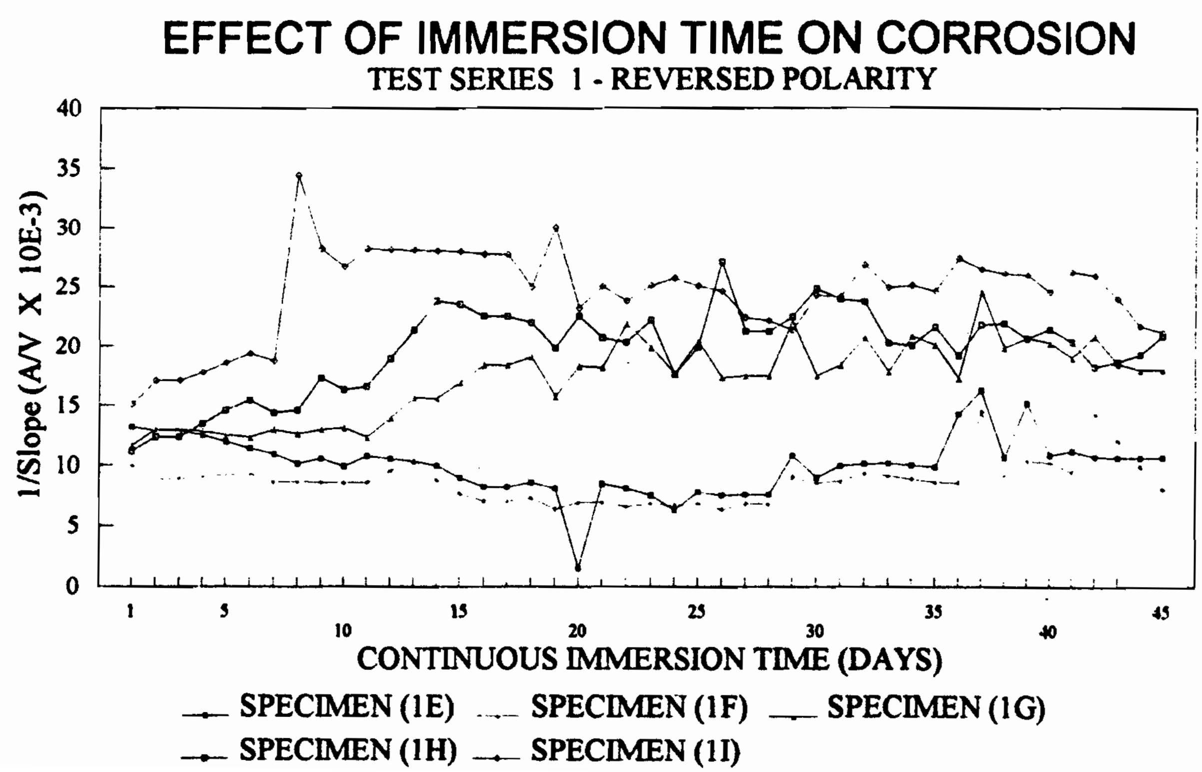
EFFECT OF IMMERSION TIME ON CORROSION

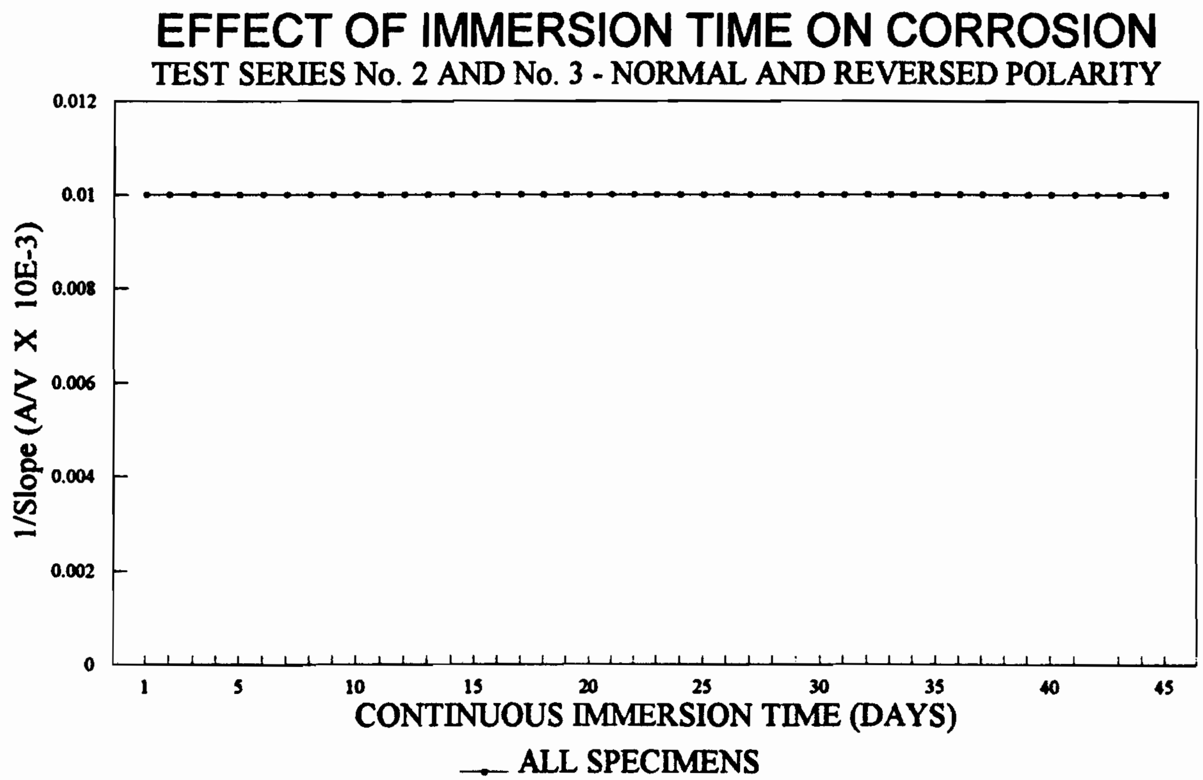
TEST SERIES 1 - NORMAL POLARITY

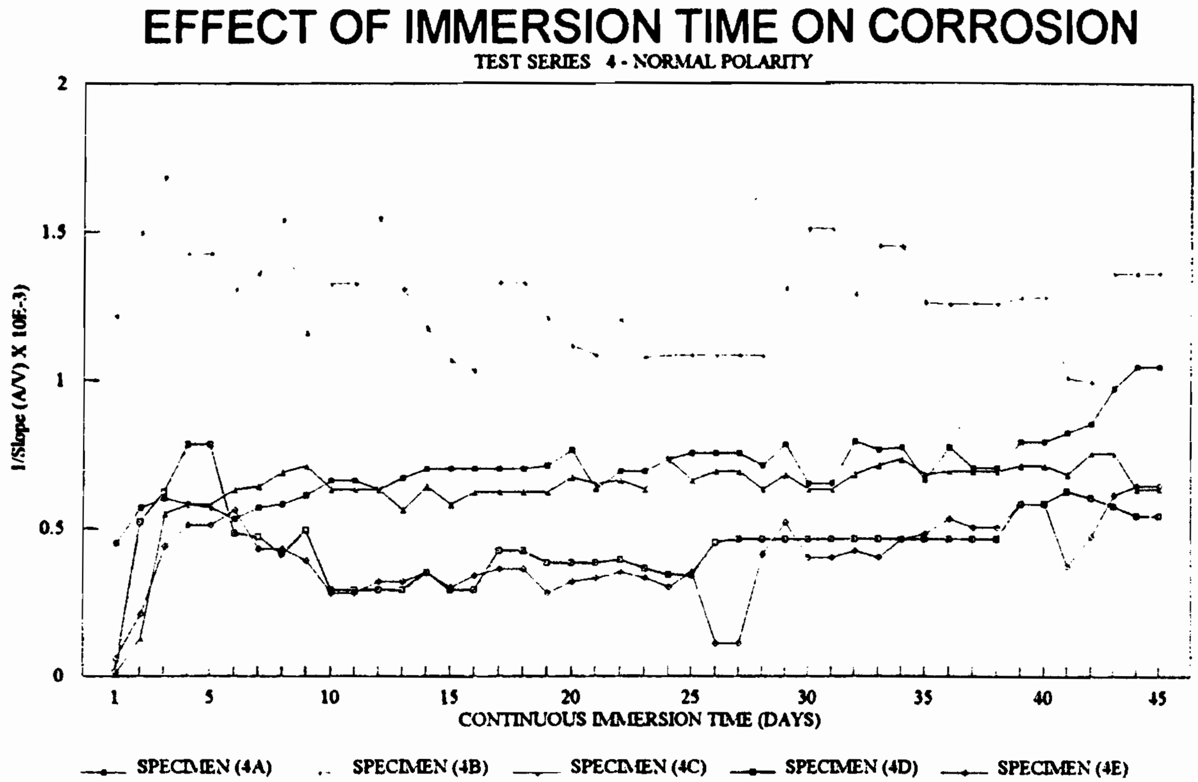


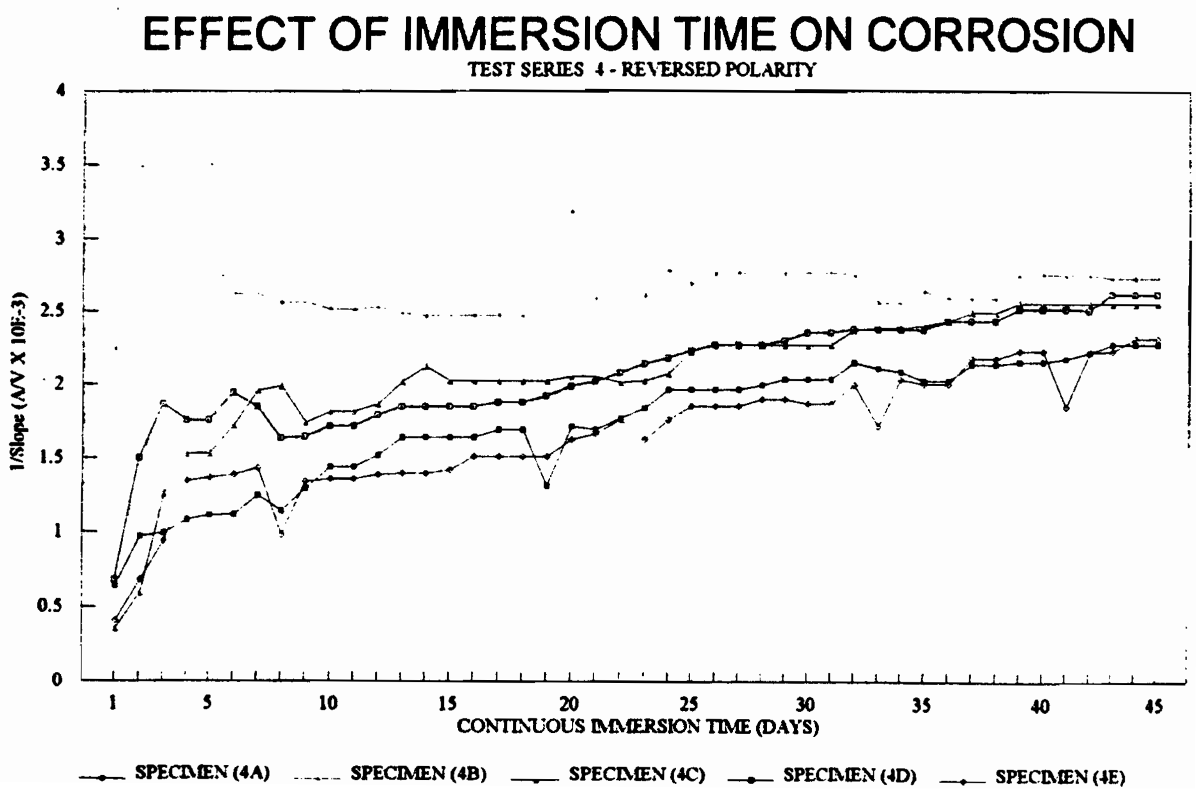

EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 1 - NORMAL POLARITY
1/Slope (A/V X 10E-3)
20
15
10
5
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (1G)
SPECIMEN (1H)
SPECIMEN (1I)


EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 1 - REVERSED POLARITY
1/Slope (A/V X 10E-3)
14
13
12
11
10
9
8
7
6
5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (1A)
SPECIMEN (1B)
SPECIMEN (1C)
SPECIMEN (1D)


EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 1 - REVERSED POLARITY
1/Slope (A/V X 10E-3)
40
35
30
25
20
15
10
5
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (1E)
SPECIMEN (1F)
SPECIMEN (1G)
SPECIMEN (1H)
SPECIMEN (1I)

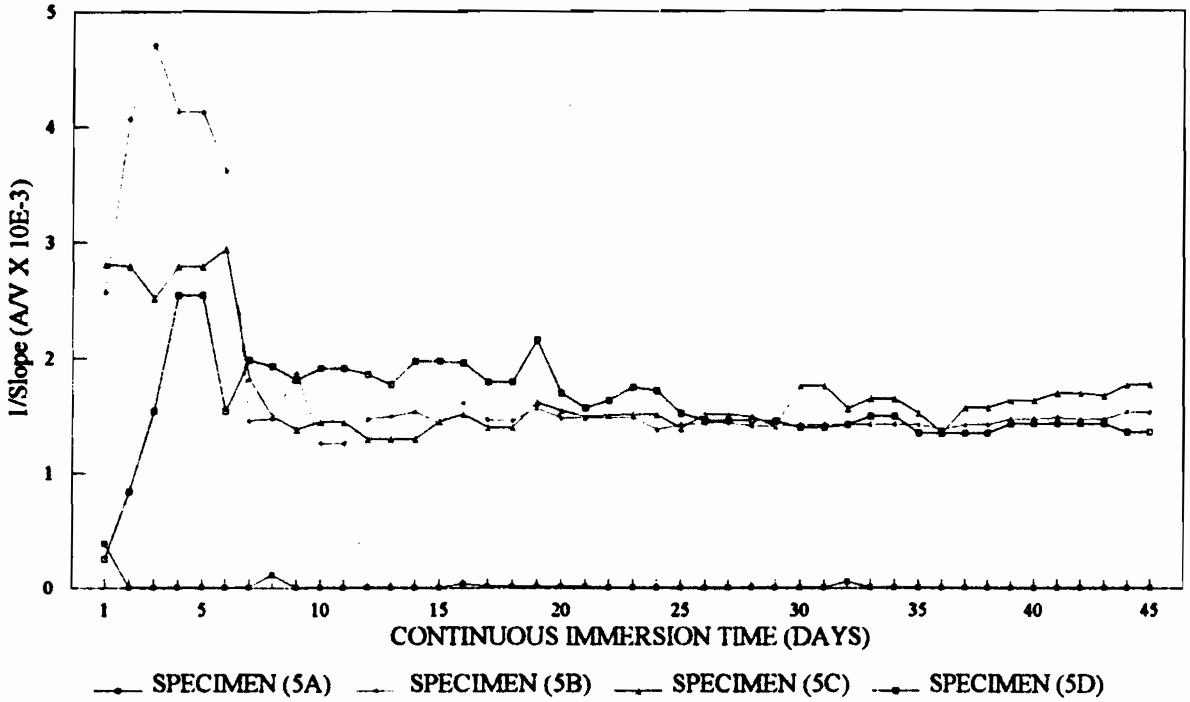

EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES No. 2 AND No. 3 - NORMAL AND REVERSED POLARITY
0.012
0.01
0.008
0.006
0.004
0.002
0
1/Slope (A/V X 10E-3)
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
ALL SPECIMENS


EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 4 - NORMAL POLARITY
1/Slope (A/V) X 10E-3)
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (4A)
SPECIMEN (4B)
SPECIMEN (4C)
SPECIMEN (4D)
SPECIMEN (4E)


EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 4 - REVERSED POLARITY
1/Slope (A/V X 10E-3)
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (4A)
SPECIMEN (4B)
SPECIMEN (4C)
SPECIMEN (4D)
SPECIMEN (4E)

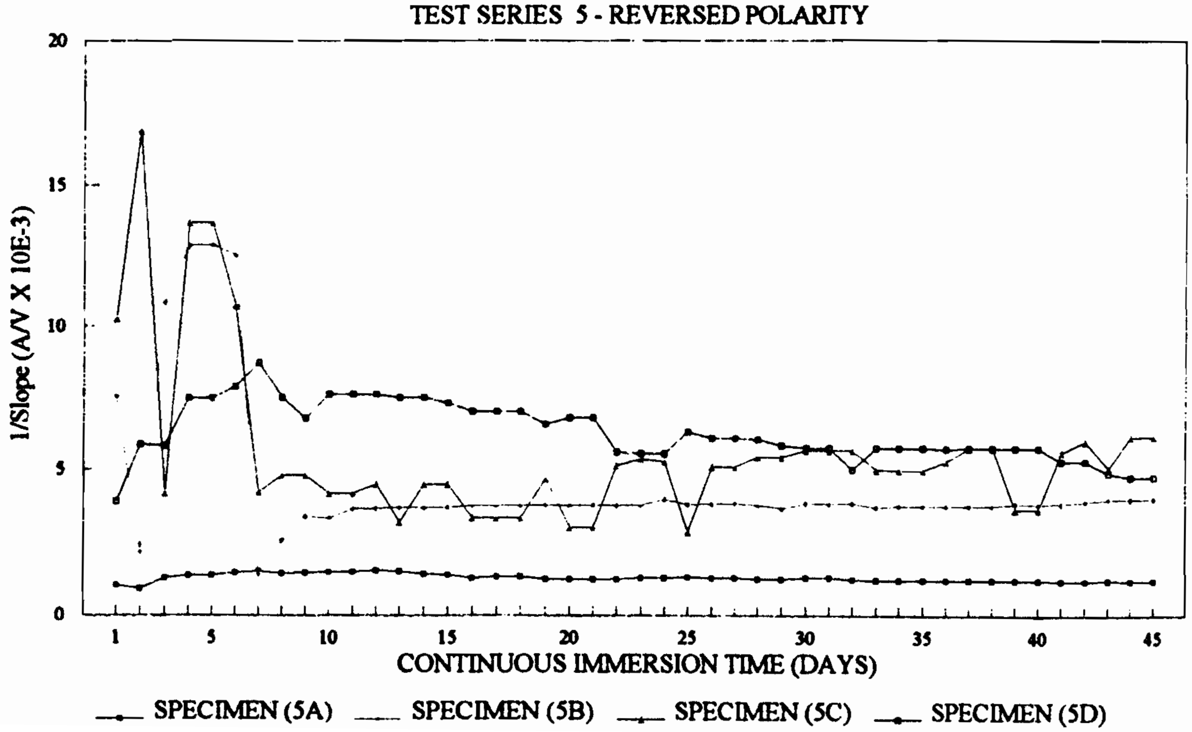
EFFECT OF IMMERSION TIME ON CORROSION

TEST SERIES 5 - NORMAL POLARITY



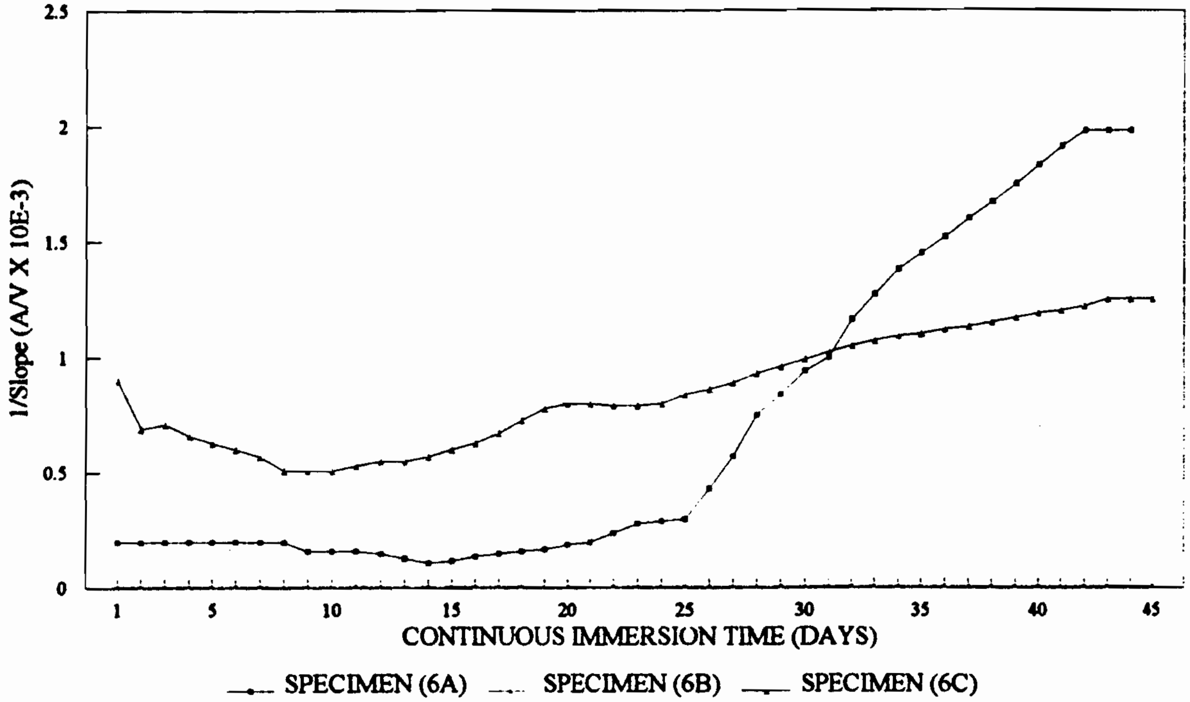
EFFECT OF IMMERSION TIME ON CORROSION

TEST SERIES 5 - REVERSED POLARITY



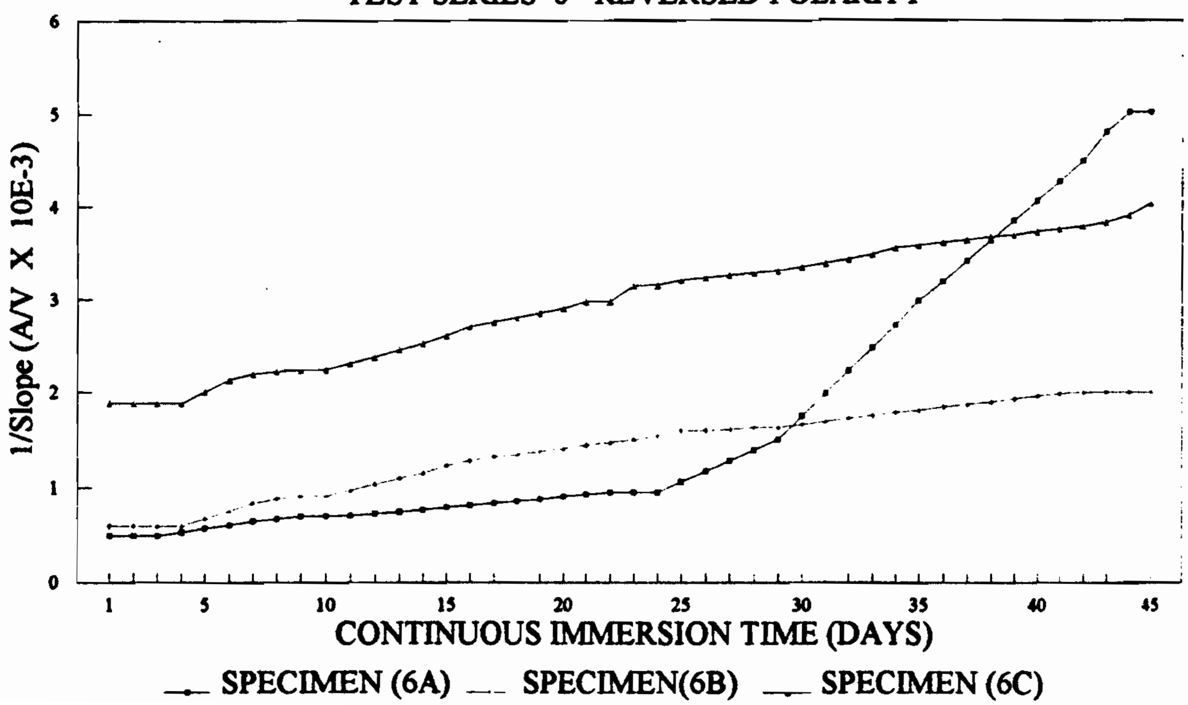
EFFECT OF IMMERSION TIME ON CORROSION

TEST SERIES 6 - NORMAL POLARITY

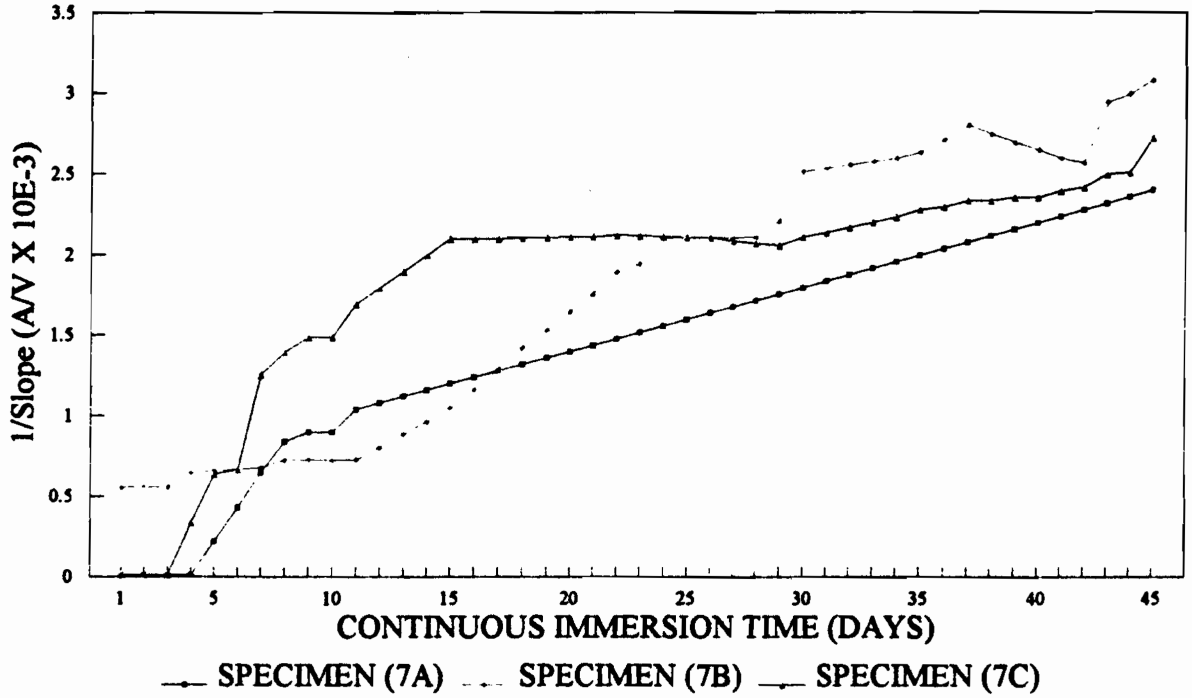


EFFECT OF IMMERSION TIME ON CORROSION

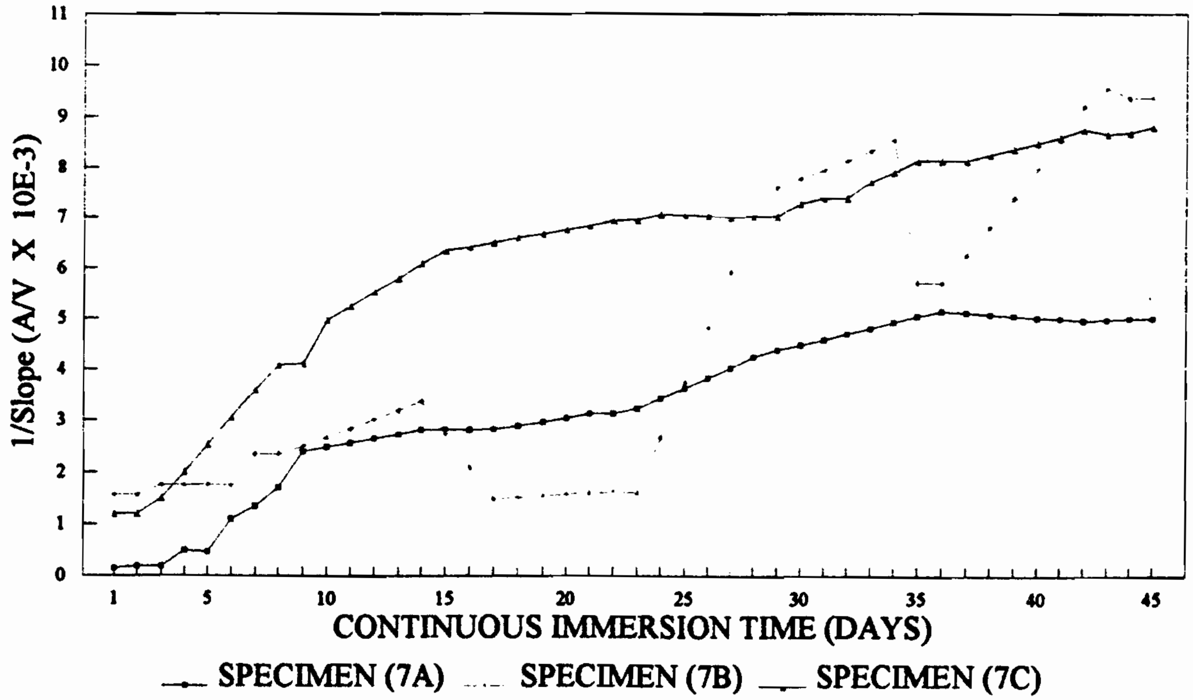
TEST SERIES 6 - REVERSED POLARITY

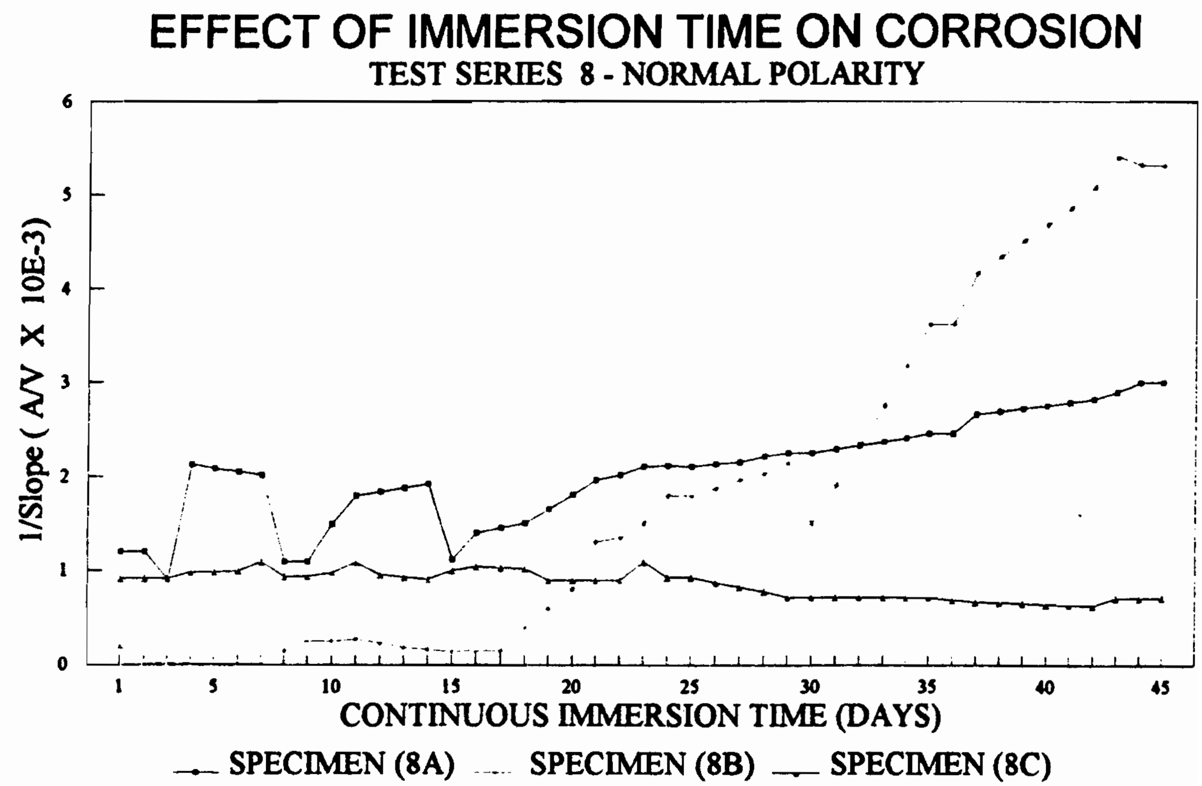


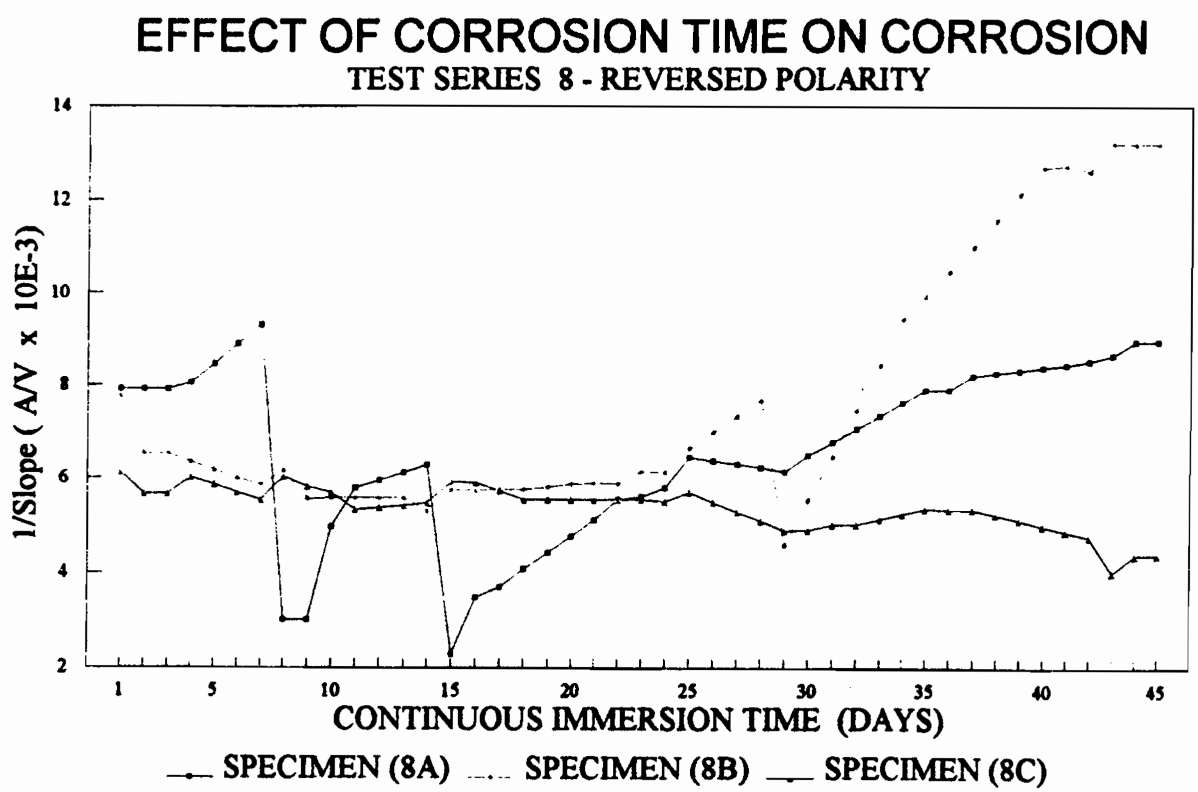
EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 7 - NORMAL POLARITY



EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 7 - REVERSED POLARITY




EFFECT OF IMMERSION TIME ON CORROSION
TEST SERIES 8 - NORMAL POLARITY
1/Slope (A/V X 10E-3)
0
1
2
3
4
5
6
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)

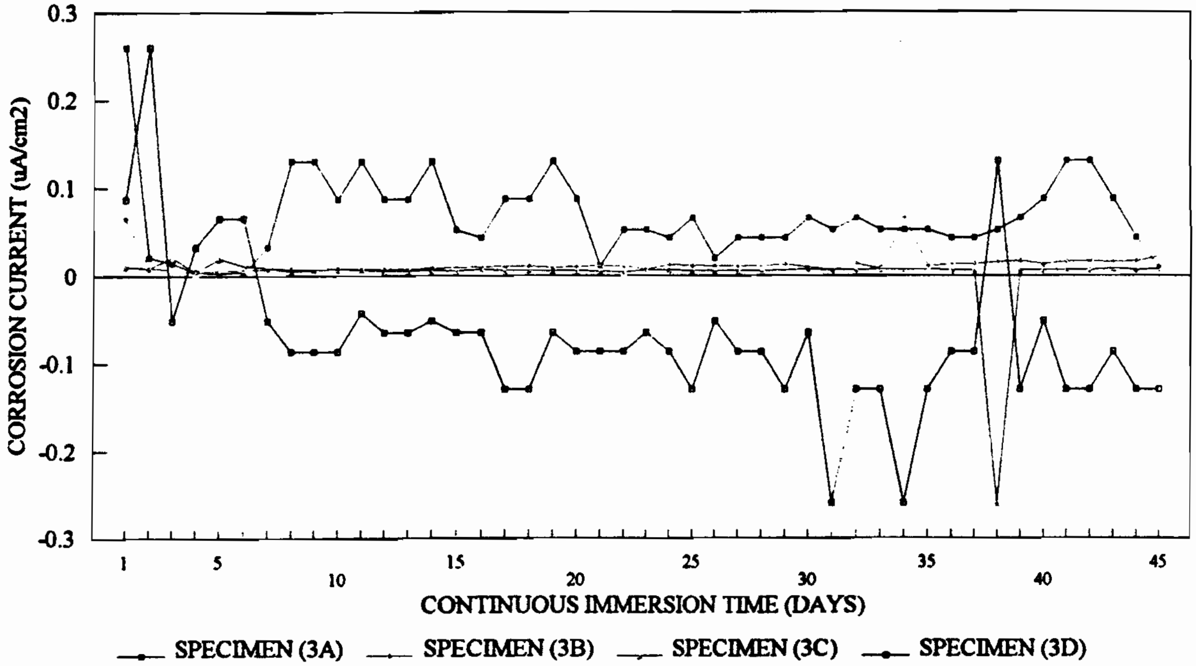

EFFECT OF CORROSION TIME ON CORROSION
TEST SERIES 8 - REVERSED POLARITY
1/Slope (A/V x 10E-3)
2
4
6
8
10
12
14
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)

APPENDIX H

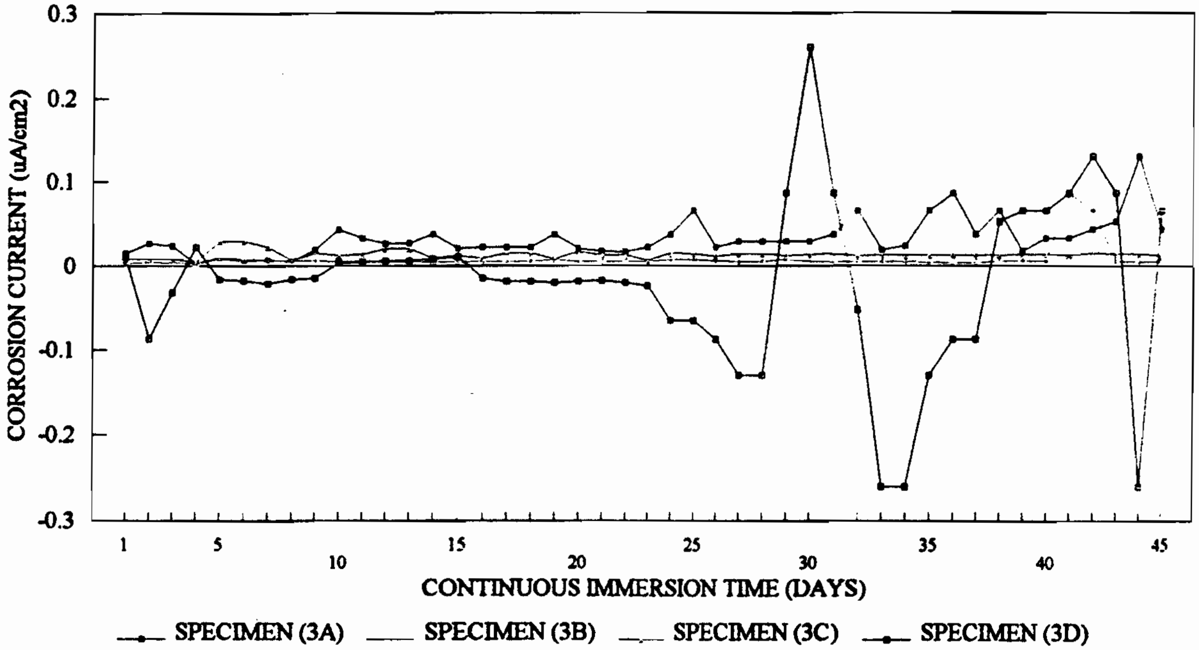
CORROSION CURRENT RESULTS

H-2 missing

CORROSION CURRENT - SERIES 3
NORMAL POLARITY

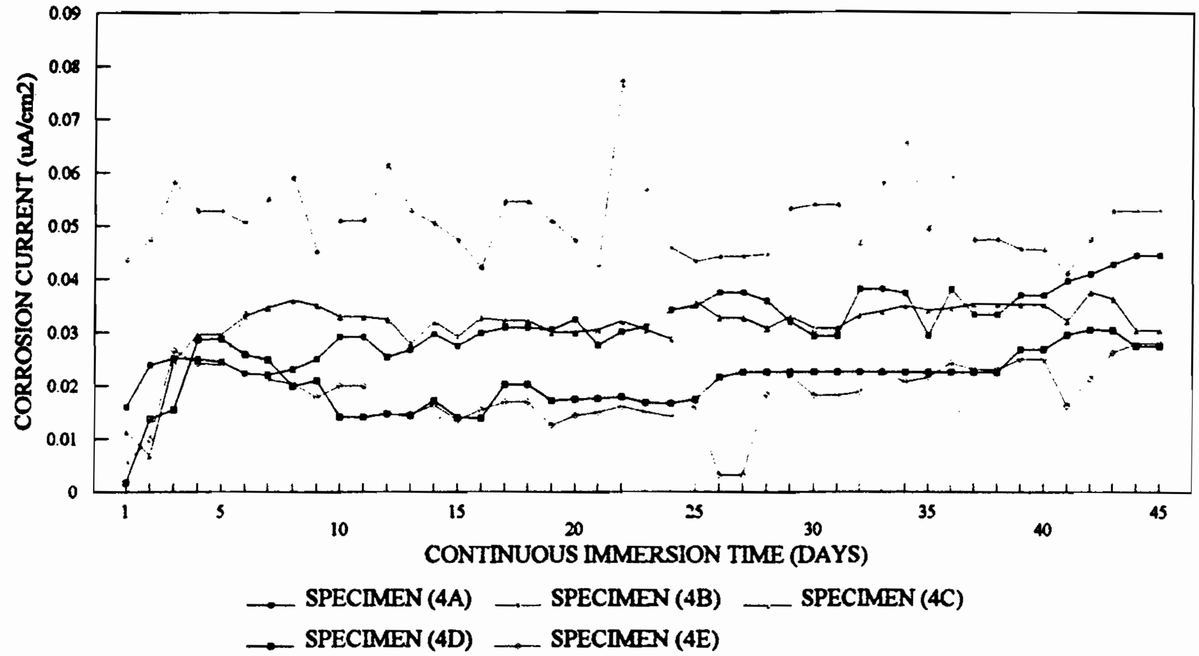


CORROSION CURRENT - SERIES 3
REVERSED POLARITY



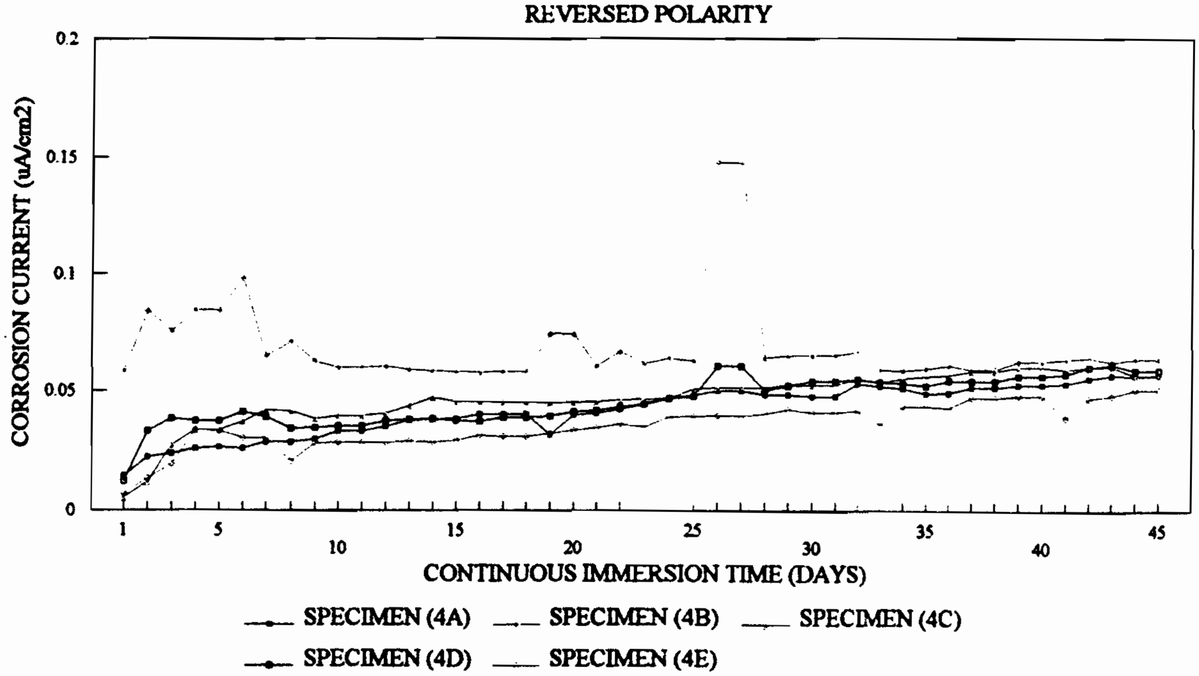
CORROSION CURRENT - TEST SERIES 4

NORMAL POLARITY

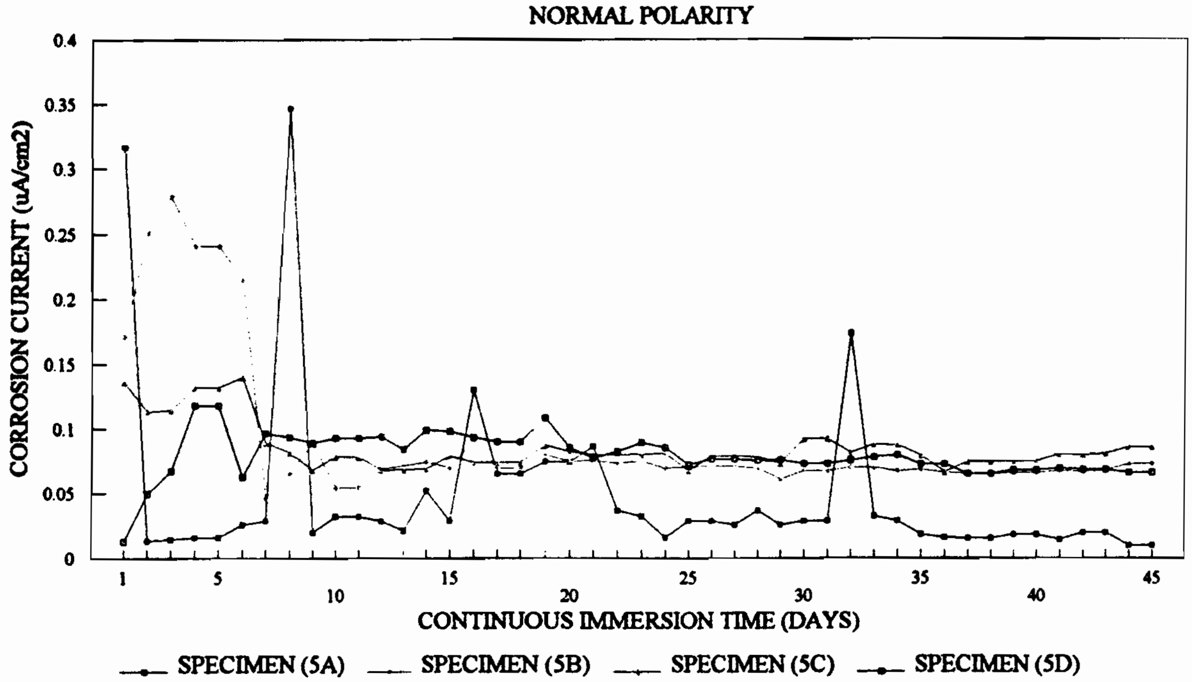


CORROSION CURRENT - TEST SERIES 4

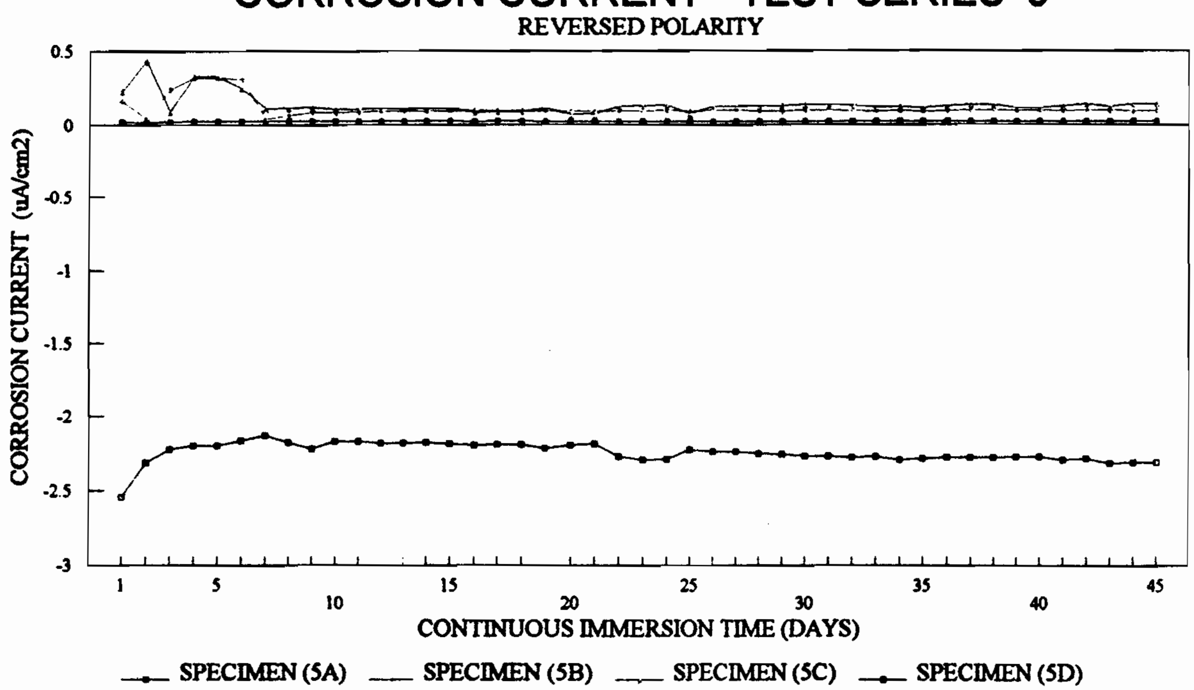
REVERSED POLARITY

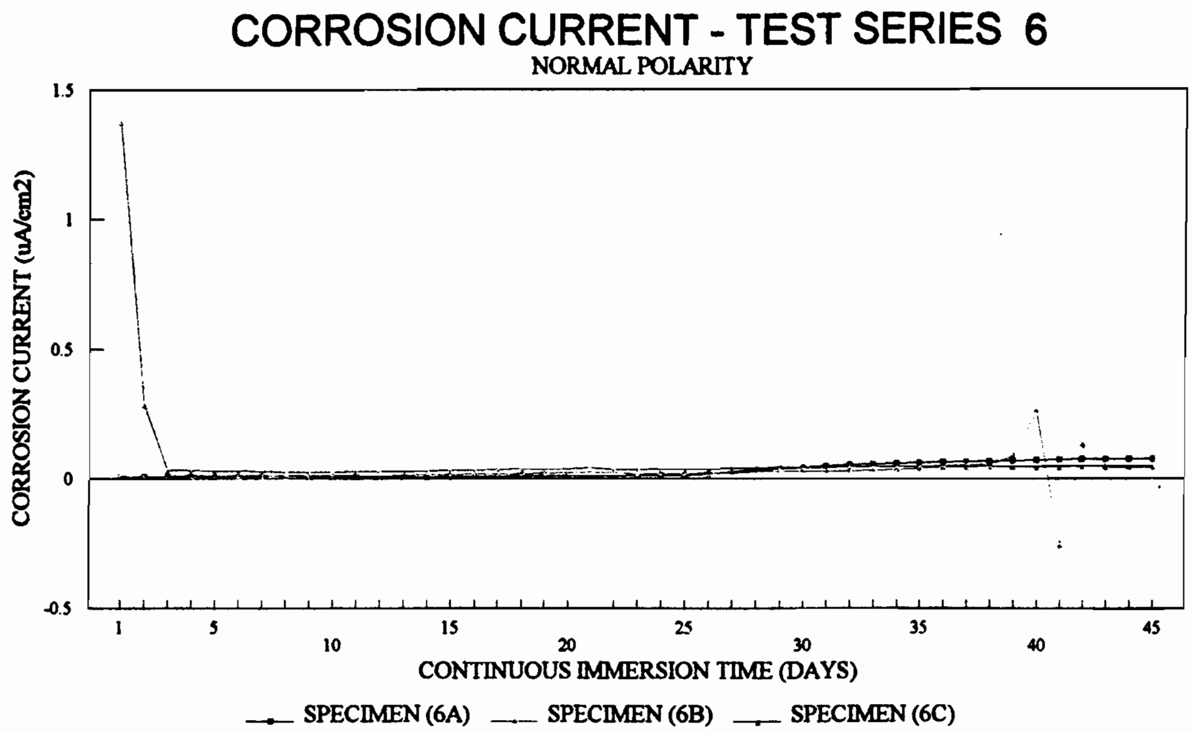


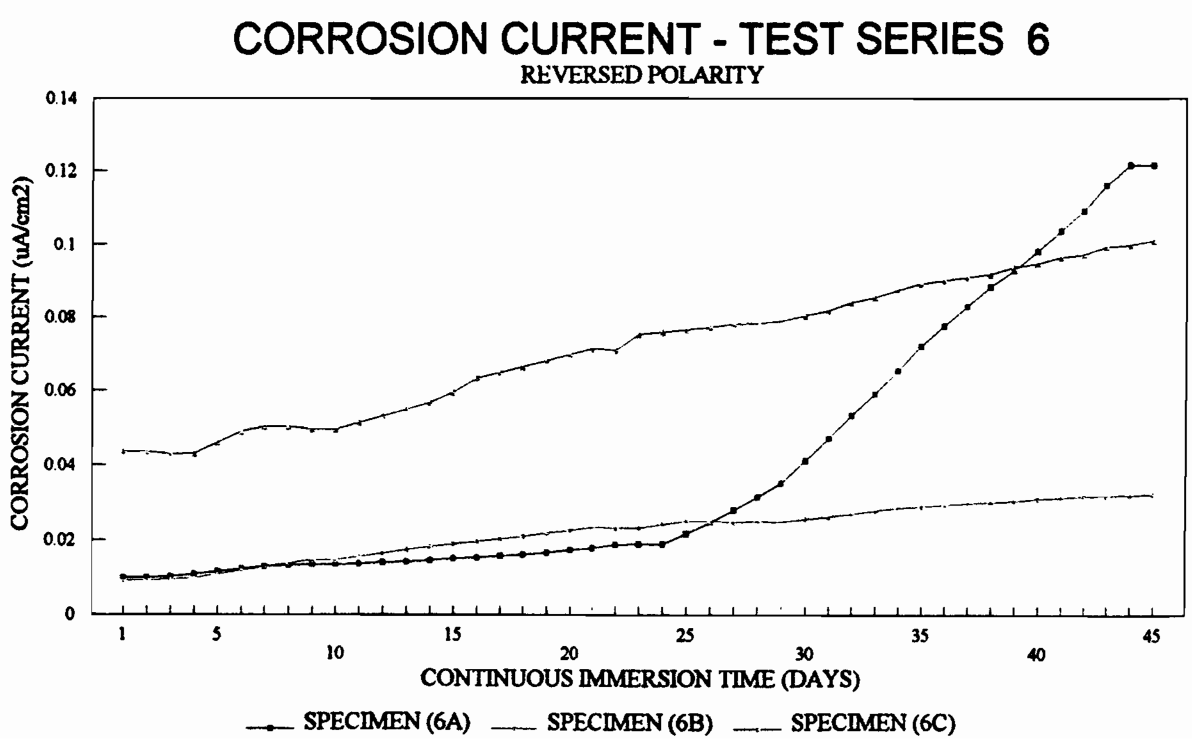
CORROSION CURRENT - SERIES 5

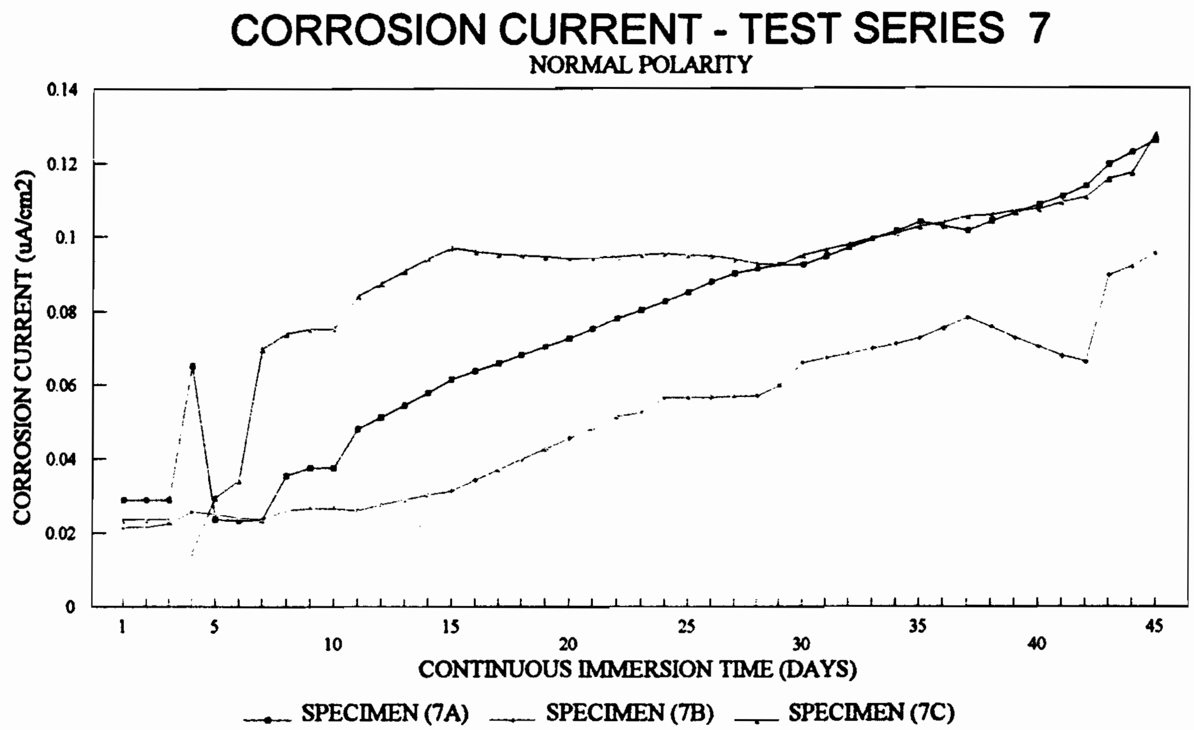


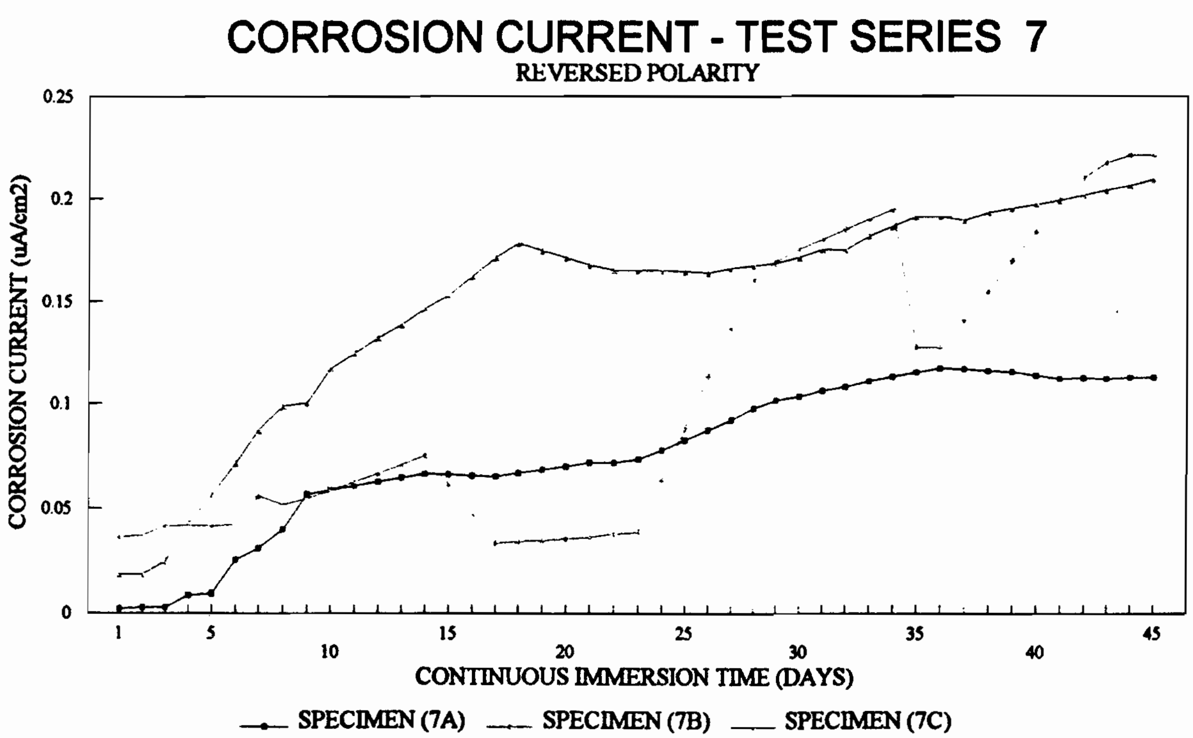
CORROSION CURRENT - TEST SERIES 5

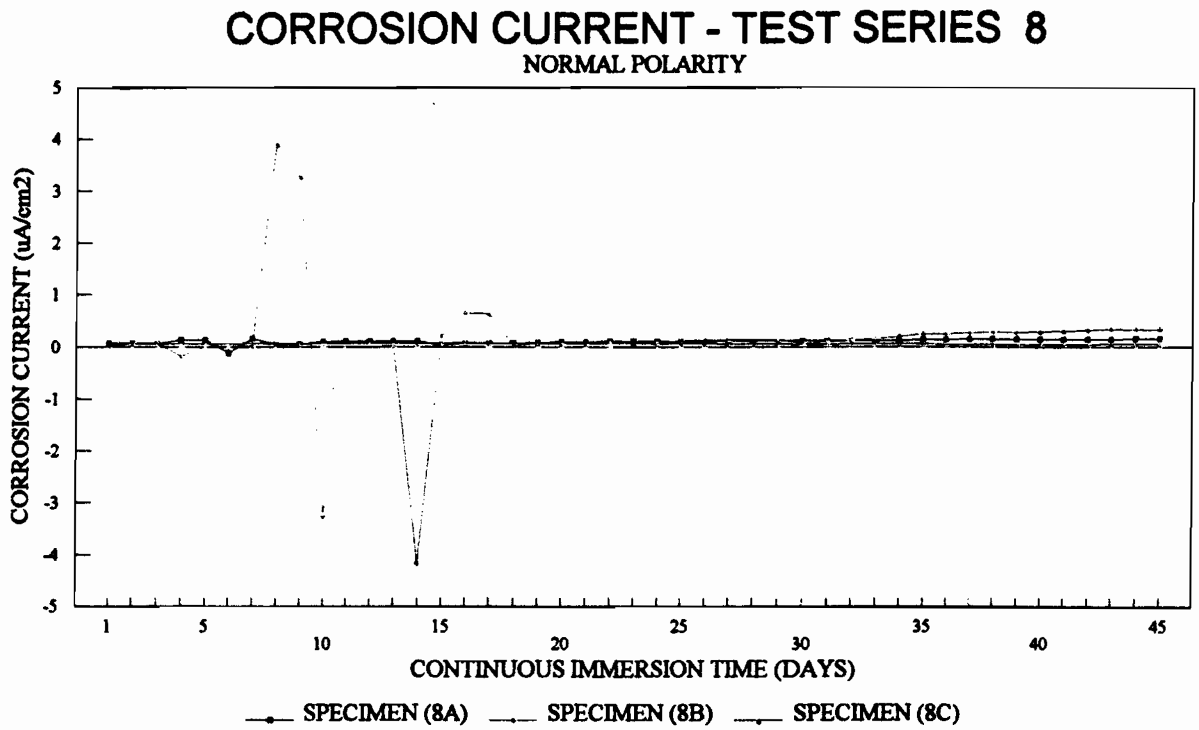


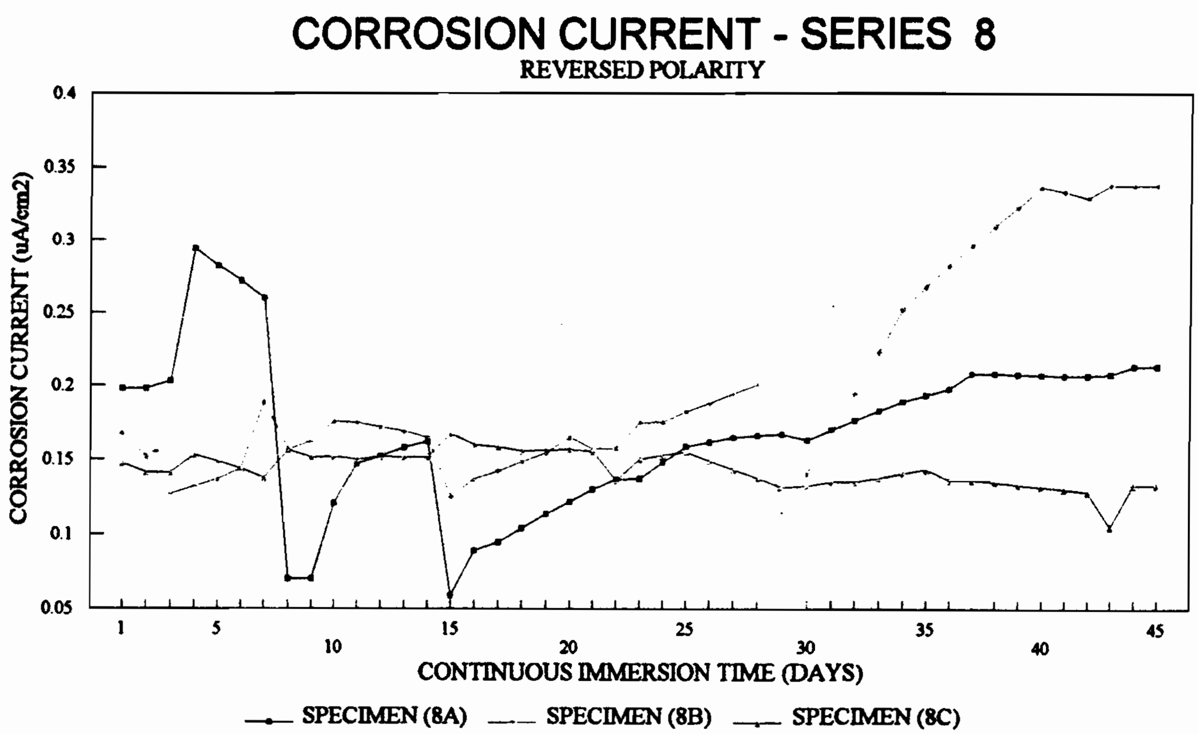

CORROSION CURRENT - TEST SERIES 6
NORMAL POLARITY
CORROSION CURRENT (uA/cm2)
1.5
1
0.5
0
-0.5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)


CORROSION CURRENT - TEST SERIES 6
REVERSED POLARITY
CORROSION CURRENT (uA/cm2)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)


CORROSION CURRENT - TEST SERIES 7
NORMAL POLARITY
CORROSION CURRENT (uA/cm2)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (7A)
SPECIMEN (7B)
SPECIMEN (7C)


CORROSION CURRENT - TEST SERIES 7
REVERSED POLARITY
CORROSION CURRENT (uA/cm2)
0.25
0.2
0.15
0.1
0.05
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (7A)
SPECIMEN (7B)
SPECIMEN (7C)


CORROSION CURRENT - TEST SERIES 8
NORMAL POLARITY
CORROSION CURRENT (uA/cm2)
5
4
3
2
1
0
-1
-2
-3
-4
-5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)

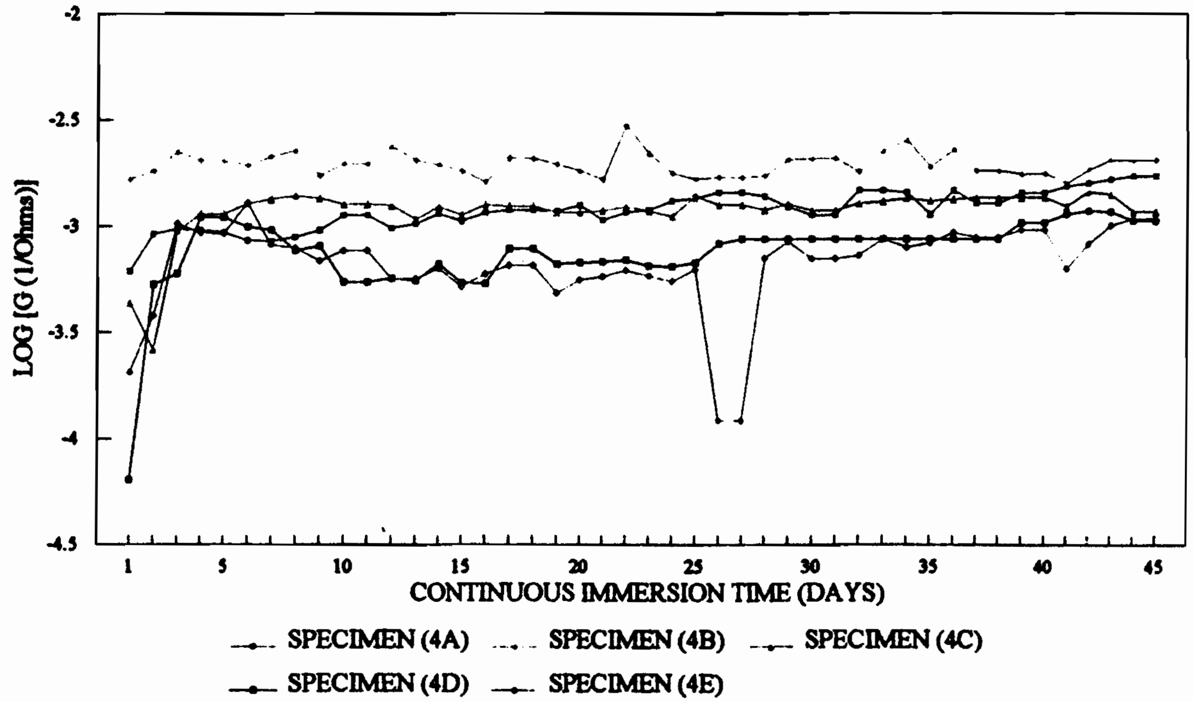

CORROSION CURRENT - SERIES 8
REVERSED POLARITY
CORROSION CURRENT (uA/cm2)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)

APPENDIX I

ELECTRICAL CONDUCTANCE RESULTS

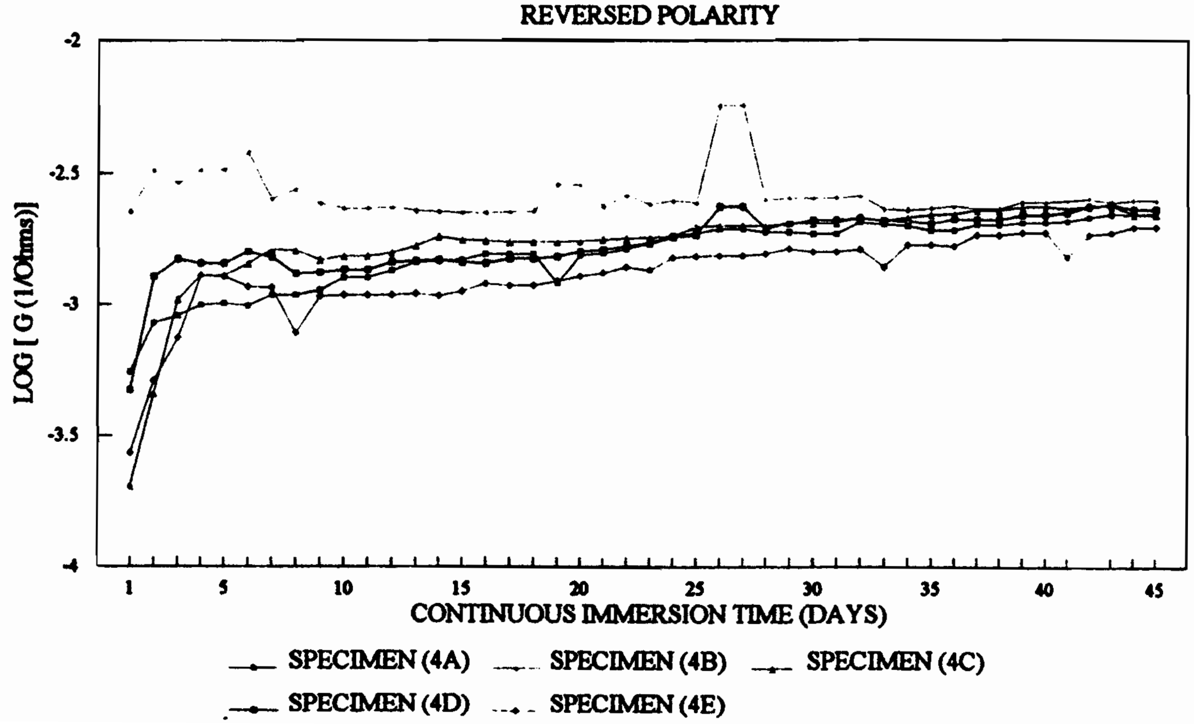
ELECTRICAL CONDUCTANCE - TEST SERIES 4

NORMAL POLARITY

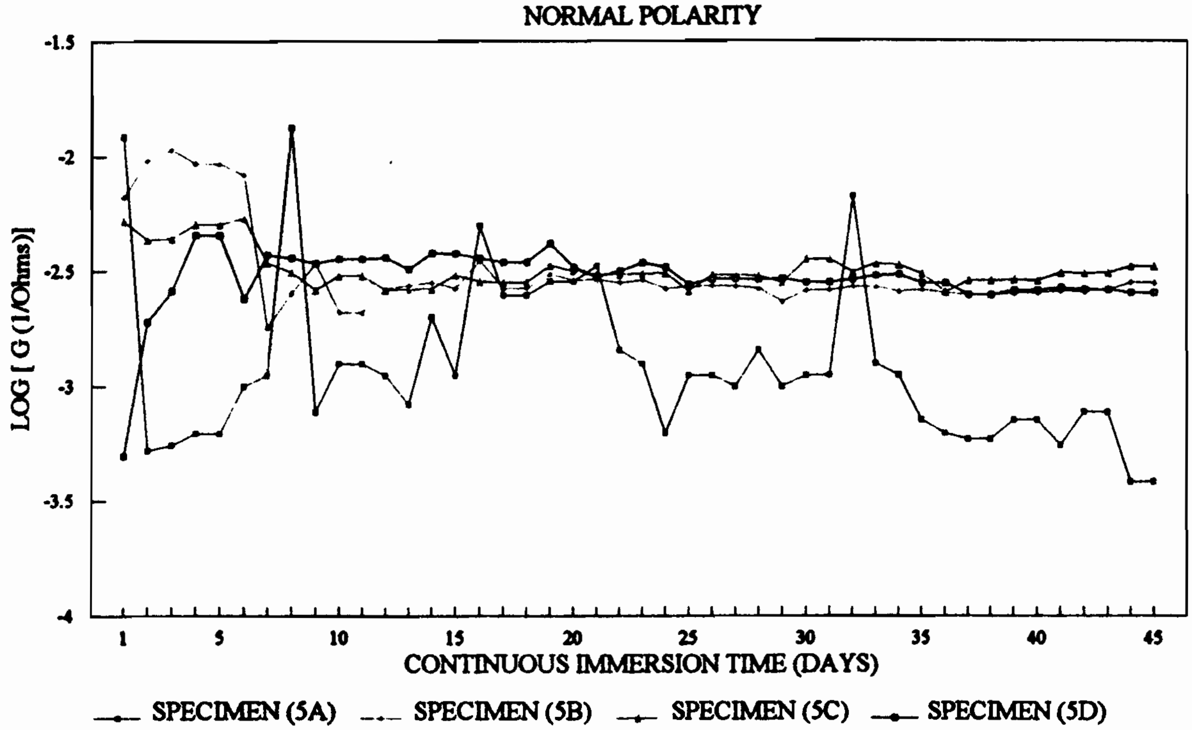


ELECTRICAL CONDUCTANCE - SERIES 4

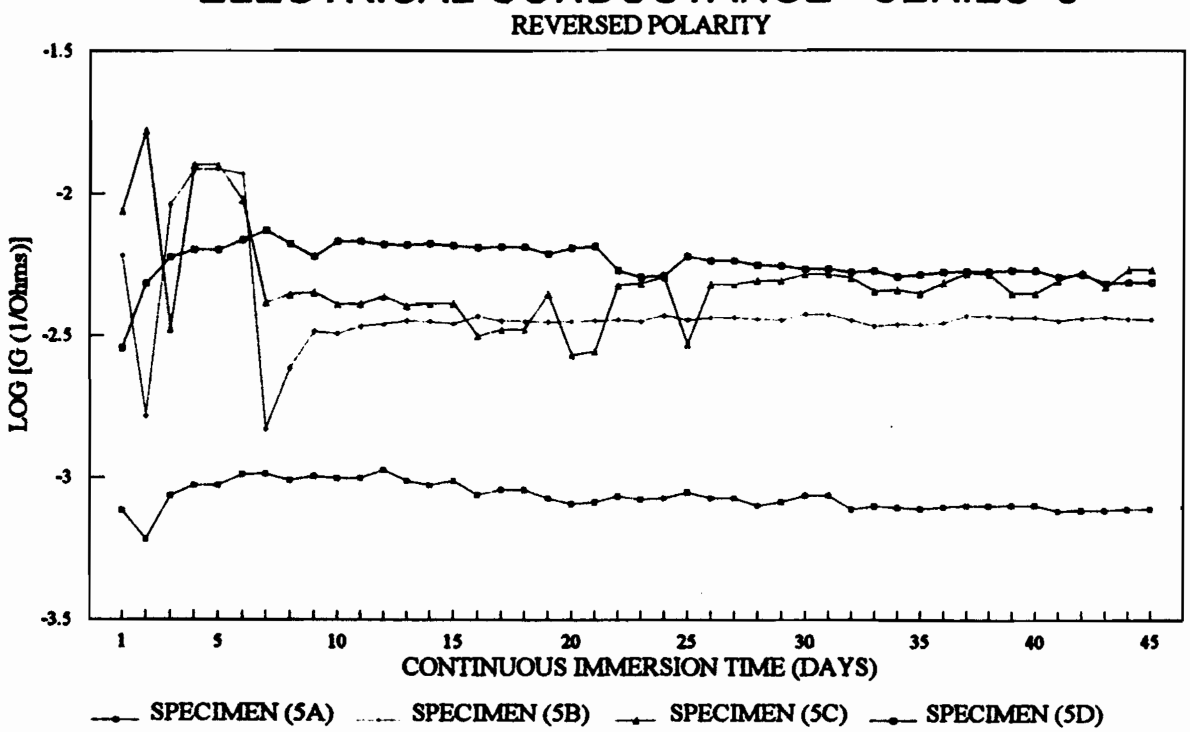
REVERSED POLARITY

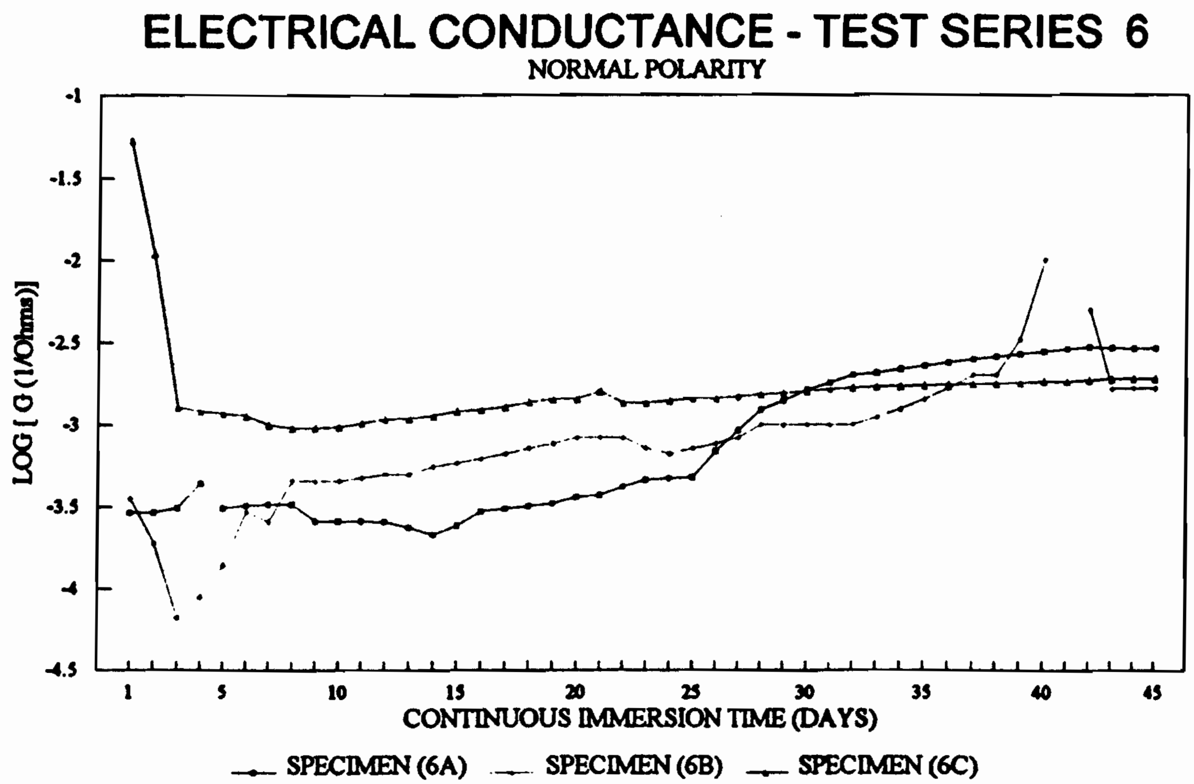


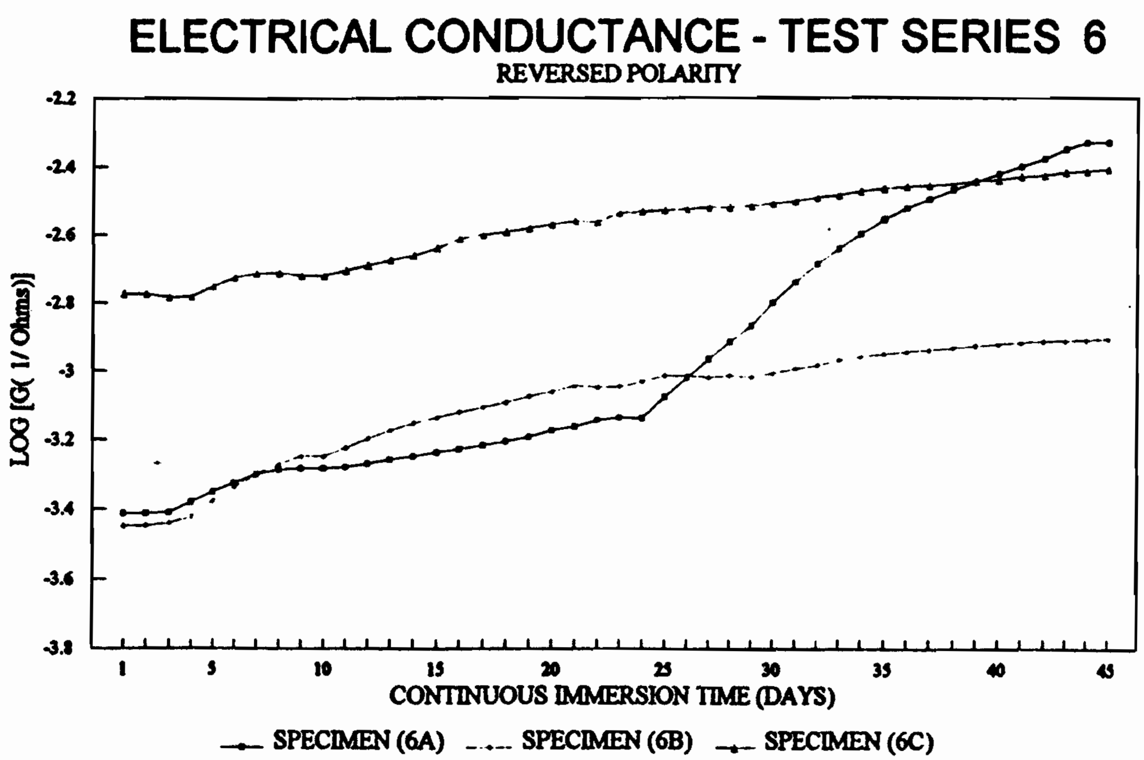
ELECTRICAL CONDUCTANCE - TEST SERIES 5



ELECTRICAL CONDUCTANCE - SERIES 5

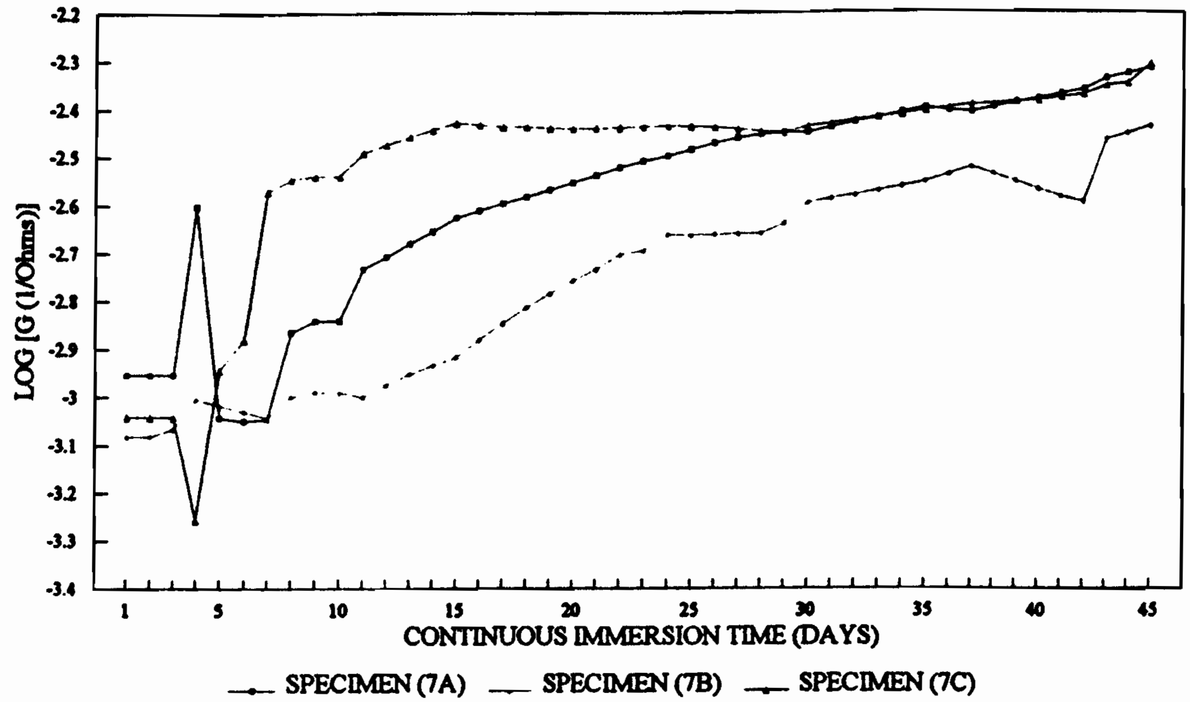



ELECTRICAL CONDUCTANCE - TEST SERIES 6
NORMAL POLARITY
LOG [G (1/Ohms)]
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)


ELECTRICAL CONDUCTANCE - TEST SERIES 6
REVERSED POLARITY
LOG [G(1/ Ohms)]
-2.2
-2.4
-2.6
-2.8
-3
-3.2
-3.4
-3.6
-3.8
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)

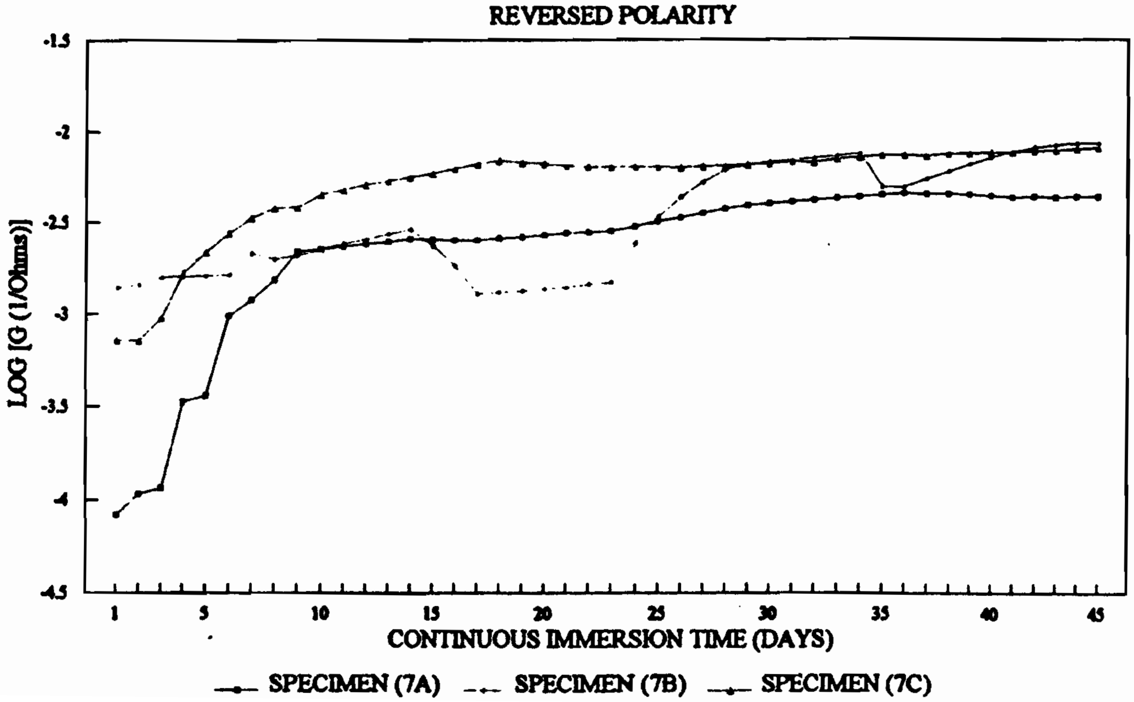
ELECTRICAL CONDUCTANCE - SERIES 7

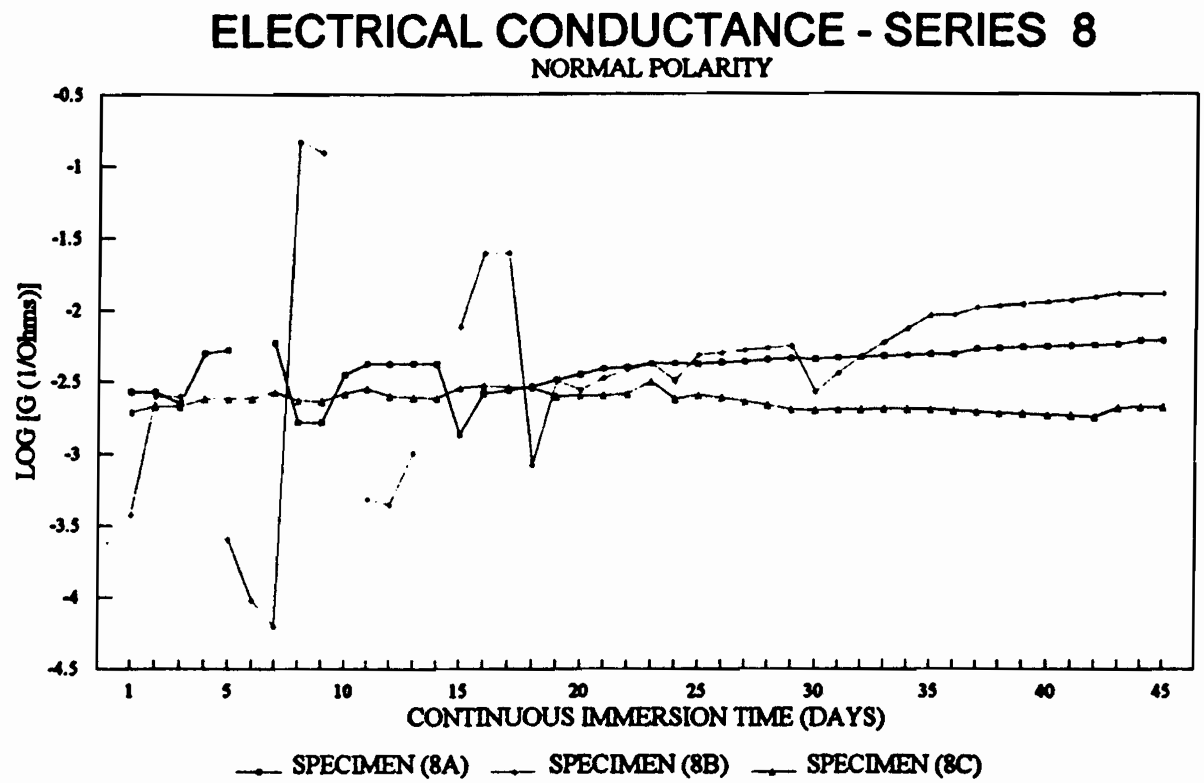
NORMAL POLARITY

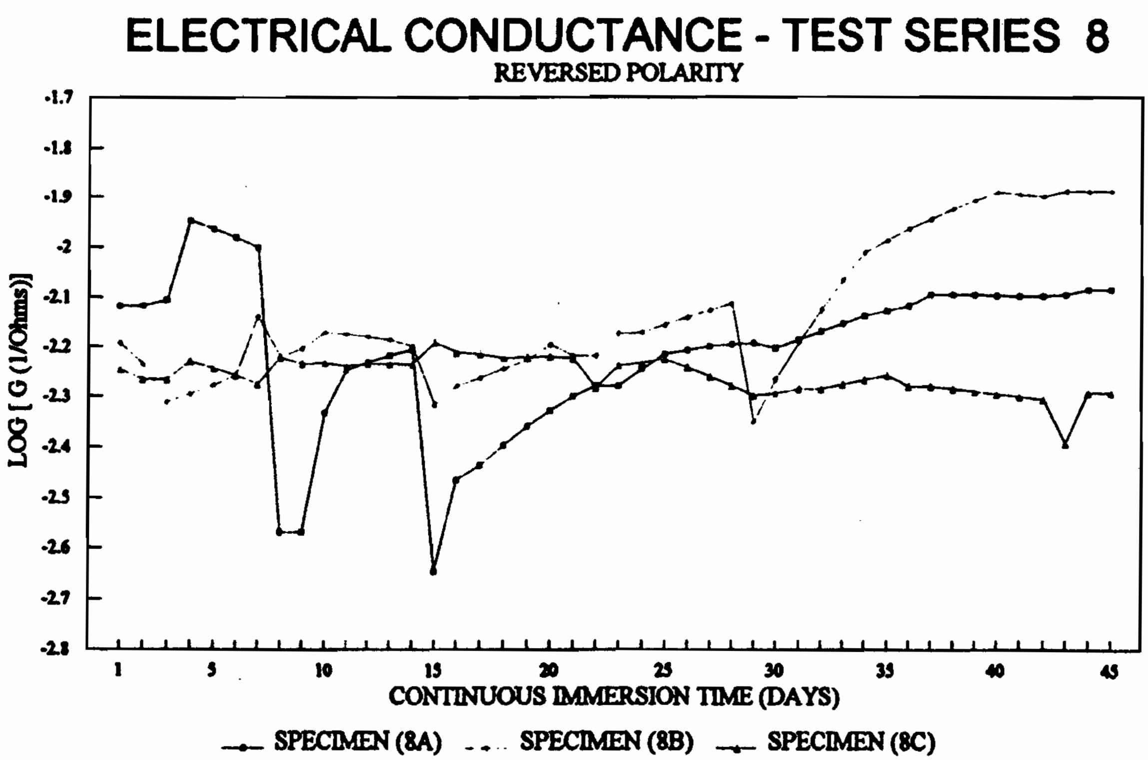


ELECTRICAL CONDUCTANCE - TEST SERIES 7

REVERSED POLARITY




ELECTRICAL CONDUCTANCE - SERIES 8
NORMAL POLARITY
LOG [G (1/Ohms)]
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)


ELECTRICAL CONDUCTANCE - TEST SERIES 8
REVERSED POLARITY
LOG [G (1/Ohms)]
-1.7
-1.8
-1.9
-2
-2.1
-2.2
-2.3
-2.4
-2.5
-2.6
-2.7
-2.8
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (8A)
SPECIMEN (8B)
SPECIMEN (8C)

APPENDIX J

OXIDATION RATE

RESULTS

The theoretical values of the oxidation rate of the steel is computed based on the measured current values. For each specimen, the maximum, the minimum, and the average current values are used to calculate the corresponding oxidation rates.

This Appendix presents the calculated oxidation rates for the eight series in both polarity positions.

IRON OXIDATION RATE
CONCRETE EMBEDDED ELECTRODES
TEST SERIES No. 1
NORMAL POLARITY

EQUATION: $dw/dt = (I * Mw) / (n * F)$

where dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
1A	0.68	0.02	0.35
1B	0.86	0.03	0.445
1C	1.14	0.03	0.585
1D	1.8	0.01	0.905
1E	6.93	0.05	3.49
1F	6.12	0.28	3.2
1G	12.88	1	6.94
1H	13.24	1.18	7.21
1I	17.42	5.4	11.41

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
17.00416	0.500122	8.752142
21.50526	0.750184	11.12772
28.50698	0.750184	14.62858
45.01101	0.250061	22.63054
173.2924	1.250306	87.27136
153.0375	7.001713	80.01958
322.0788	25.00612	173.5425
331.081	29.50722	180.2941
435.6066	135.033	285.3198

IRON OXIDATION RATE
CONCRETE EMBEDDED ELECTRODES
TEST SERIES No. 2 AND No. 3
NORMAL POLARITY

EQUATION: dw/dt = (I * Mw) / (n * F)

where dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
2A	0.01	0.01	0.01
2B	0.01	0.01	0.01
2C	0.01	0.01	0.01
2D	0.01	0.01	0.01
2E	0.01	0.01	0.01

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
3A	0.01	0.01	0.01
3B	0.01	0.01	0.01
3C	0.01	0.01	0.01
3D	0.01	0.01	0.01

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061

MAXIMUM	MINIMUM	AVERAGE
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061
0.250061	0.250061	0.250061

IRON OXIDATION RATE
CONCRETE EMBEDDED ELECTRODES
TEST SERIES No. 4 AND No. 5
NORMAL POLARITY

EQUATION: $dw/dt = (I * Mw) / (n * F)$

where
dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
4A	1.04	0.45	0.745
4B	1.66	0.99	1.325
4C	0.75	0.01	0.38
4D	0.78	0.01	0.395
4E	0.64	0.06	0.35

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
5A	0.39	0.01	0.2
5B	4.03	1.25	2.64
5C	2.77	1.37	2.07
5D	2.5	0.25	1.375

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
26.00636	11.25275	18.62956
41.51016	24.75606	33.13311
18.75459	0.250061	9.502325
19.50477	0.250061	9.877417
16.00392	1.500367	8.752142

MAXIMUM	MINIMUM	AVERAGE
9.752387	0.250061	5.001224
100.7747	31.25765	66.01616
69.26695	34.25838	51.76267
62.5153	6.25153	34.38341

IRON OXIDATION RATE
CONCRETE EMBEDDED ELECTRODES
TEST SERIES No. 6 , No. 7, No. 8
NORMAL POLARITY

EQUATION: $dw/dt = (I * Mw) / (n * F)$

where
dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
6A	1.98	0.11	1.045
6B	0.01	0.01	0.01
6C	1.25	0.51	0.88

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
7A	2.4	0.01	1.205
7B	3.06	0.56	1.81
7C	2.7	0.01	1.355

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
8A	3	0.9	1.95
8B	5.35	0.01	2.68
8C	1.1	0.63	0.865

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
49.51212	2.750673	26.13139
0.250061	0.250061	0.250061
31.25765	12.75312	22.00539

MAXIMUM	MINIMUM	AVERAGE
60.01469	0.250061	30.13237
76.51873	14.00343	45.26108
67.51652	0.250061	33.88329

MAXIMUM	MINIMUM	AVERAGE
75.01836	22.50551	48.76193
133.7827	0.250061	67.0164
27.50673	15.75386	21.63029

IRON OXIDATION RATE
CATHODES
TEST SERIES No. 1
REVERSED POLARITY

EQUATION: dw/dt = (I * Mw) / (n * F)

where dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
1A	16.2	5.27	10.735
1B	17.63	6.3	11.965
1C	12.88	5.41	9.145
1D	13.5	5.57	9.535
1E	14.75	1.44	8.095
1F	13.37	6.31	9.84
1G	21.5	12.04	16.77
1H	23.41	11.1	17.255
1I	31.3	15.18	23.24

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
405.4353	131.8916	268.6635
441.2237	157.6693	299.4465
322.3461	135.3954	228.8707
337.8628	139.3997	238.6312
369.1464	36.03869	202.5925
334.6093	157.9196	246.2644
538.0777	301.3235	419.7006
585.8791	277.7983	431.8387
783.3411	379.9079	581.6245

IRON OXIDATION RATE
CATHODES
TEST SERIES No. 2 AND No. 3
REVERSED POLARITY

EQUATION: dw/dt = (I * Mw) / (n * F)

where dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
2A	0.01	0.01	0.01
2B	0.01	0.01	0.01
2C	0.01	0.01	0.01
2D	0.01	0.01	0.01
2E	0.01	0.01	0.01

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
3A	0.01	0.01	0.01
3B	0.01	0.01	0.01
3C	0.01	0.01	0.01
3D	0.01	0.01	0.01

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269

MAXIMUM	MINIMUM	AVERAGE
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269
0.250269	0.250269	0.250269

IRON OXIDATION RATE
CATHODES
TEST SERIES No. 4 AND No. 5
REVERSED POLARITY

EQUATION: $dw/dt = (I * Mw) / (n * F)$

where
dw / dt = metal oxidation rate (g / s)
I = current (A)
Mw = molar weight of iron (g)
n = oxidation state (assume +2)
F = Faraday's constant (A s)

CURRENT (mA)

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
4A	2.25	0.64	1.445
4B	3.38	2.16	2.77
4C	2.52	0.36	1.44
4D	2.58	0.68	1.63
4E	2.29	0.41	1.35

OXIDATION RATE mg/day

MAXIMUM	MINIMUM	AVERAGE
56.31046	16.0172	36.16383
84.59083	54.05804	69.32443
63.06772	9.009674	36.03869
64.56933	17.01827	40.7938
57.31154	10.26102	33.78628

SPECIMEN	MAXIMUM	MINIMUM	AVERAGE
5A	1.54	0.91	1.225
5B	11.98	1.46	6.72
5C	15.42	2.83	9.125
5D	8.2	3.49	5.845

MAXIMUM	MINIMUM	AVERAGE
38.54138	22.77445	30.65792
299.8219	36.53923	168.1806
385.9144	70.82605	228.3702
205.2203	87.34378	146.2821

APPENDIX K

MASS LOSS

MEASUREMENTS

All of the steel reinforcing bars used as electrodes for each experimental specimen were accurately weighed before and after the immersion period (45 days) on a digital balance.

For each electrode, the actual weight loss was compared with the average mass loss. The latter was calculated by multiplying the value of the average oxidation rate obtained from Appendix J by the 45 days (immersion period).

The comparison between the theoretical and gravimetrical mass losses values are presented in this Appendix.

COMPARISON OF MASS LOSS

THEORETICAL versus GRAVIMETRIC

NORMAL POLARITY

OXIDATION RATE (mg/day)			THEORETICAL	GRAVIMETRIC
SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
1A	8.752142	45 DAYS	0.393846	1
1B	11.12772	45 DAYS	0.500748	1
1C	14.62858	45 DAYS	0.658286	1
1D	22.63054	45 DAYS	1.018374	1.5
1E	87.27136	45 DAYS	3.927211	2.7
1F	80.01958	45 DAYS	3.600881	2.7
1G	173.5425	45 DAYS	7.809411	3.2
1H	180.2941	45 DAYS	8.113235	3.5
1I	285.3198	45 DAYS	12.83939	5.4

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
2A	0.250061	45 DAYS	0.011253	0
2B	0.250061	45 DAYS	0.011253	0
2C	0.250061	45 DAYS	0.011253	0
2D	0.250061	45 DAYS	0.011253	0
2E	0.250061	45 DAYS	0.011253	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
3A	0.250061	45 DAYS	0.011253	0
3B	0.250061	45 DAYS	0.011253	0
3C	0.250061	45 DAYS	0.011253	0
3D	0.250061	45 DAYS	0.011253	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
4A	18.62956	45 DAYS	0.83833	1.25
4B	33.13311	45 DAYS	1.49099	1
4C	9.502325	45 DAYS	0.427605	0.5
4D	9.877417	45 DAYS	0.444484	0
4E	8.752142	45 DAYS	0.393846	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
5A	5.001224	45 DAYS	0.225055	1.5
5B	66.01616	45 DAYS	2.970727	1
5C	51.76267	45 DAYS	2.32932	0
5D	34.38341	45 DAYS	1.547254	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
6A	26.13139	45 DAYS	1.175913	2.5
6B	0.250061	45 DAYS	0.011253	2
6C	22.00539	45 DAYS	0.990242	1.7

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
7A	30.13237	45 DAYS	1.355957	1.5
7B	45.26108	45 DAYS	2.036748	1
7C	33.88329	45 DAYS	1.524748	1

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
8A	48.76193	45 DAYS	2.194287	2.6
8B	67.0164	45 DAYS	3.015738	2.1
8C	21.63029	45 DAYS	0.973363	1.5

COMPARISON OF MASS LOSS

THEORETICAL versus GRAVIMETRIC

REVERSED POLARITY

SPECIMEN	OXIDATION RATE (mg/day) AVERAGE	IMMERSION PERIOD	THEORETICAL AVERAGE MASS LOSS (g)	GRAVIMETRIC AVERAGE MASS LOSS (g)
1A	268.6635	45 DAYS	12.09	5.65
1B	299.4465	45 DAYS	13.48	6.98
1C	228.8707	45 DAYS	10.30	7.75
1D	238.6312	45 DAYS	10.74	7.75
1E	202.5925	45 DAYS	9.12	9.5
1F	246.2644	45 DAYS	11.08	12
1G	419.7006	45 DAYS	18.89	13.5
1H	431.8387	45 DAYS	19.43	17
1I	581.6245	45 DAYS	26.17	18.5

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
2A	0.250269	45 DAYS	0.011262	0
2B	0.250269	45 DAYS	0.011262	0
2C	0.250269	45 DAYS	0.011262	0
2D	0.250269	45 DAYS	0.011262	0
2E	0.250269	45 DAYS	0.011262	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
3A	0.250269	45 DAYS	0.011262	0
3B	0.250269	45 DAYS	0.011262	0
3C	0.250269	45 DAYS	0.011262	0
3D	0.250269	45 DAYS	0.011262	0

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
4A	36.16383	45 DAYS	1.63	1.4
4B	69.32443	45 DAYS	3.12	1.35
4C	36.03869	45 DAYS	1.62	0.9
4D	40.7938	45 DAYS	1.84	0.75
4E	33.78628	45 DAYS	1.52	0.75

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
5A	30.65792	45 DAYS	1.38	1.25
5B	168.1806	45 DAYS	7.57	1.1
5C	228.3702	45 DAYS	10.28	0.95
5D	146.2821	45 DAYS	6.58	0.75

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
6A	68.19822	45 DAYS	3.07	1.12
6B	32.53493	45 DAYS	1.46	0.93
6C	73.579	45 DAYS	3.31	0.65

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
7A	64.69446	45 DAYS	2.91	1.43
7B	129.7643	45 DAYS	5.84	1.12
7C	119.5033	45 DAYS	5.38	0.95

SPECIMEN	AVERAGE	IMMERSION PERIOD	AVERAGE MASS LOSS (g)	AVERAGE MASS LOSS (g)
8A	140.2756	45 DAYS	6.31	3.5
8B	212.353	45 DAYS	9.56	3.1
8C	123.3825	45 DAYS	5.55	2.67

APPENDIX L

TECHNICAL DATA SHEETS

FOR

THE SEALING PRODUCTS

Sikagard® Cure/Hard

Curing/Hardening Compound

0492

Technical Data Sheet

Description: Clear water-white solvent solution of styrene acrylate resins, plasticizers and adhesive agents. Meets ASTM designation C 309-72.

Applications: Resin-based coating to cure plastic-concrete slabs and harden existing concrete floors.

Advantages:

- Seals moisture into freshly placed concrete for curing and provides a hard, dust-free surface.
- On hardened concrete, impregnation makes it easy to clean and maintain floors.
- Dry coating resists oil, grease, staining, short exposure to gasoline.

Shelf Life: Unlimited in drums, 1 year in pails.

Packaging: 20 litre pails and 200 litre drums.

Coverage:

On freshly placed concrete: 5 m^2 per litre
On dry, hardened concrete: 10 m^2 per litre, per coat.
Use 2 coats for best results.

How to Use: Apply with spraying equipment on freshly placed concrete after bleed water has disappeared and before surface dries. For best results as a hardener, apply 24 hours after placing concrete. Old floors must be clean and dry. Apply with roller, brush or spray. Drying time approximately 4 hours at 21°C.

Caution: Sikagard Cure/Hard, as furnished, is flammable and has a flashpoint of 32°C. After drying, it is odourless, non-combustible and non-toxic. Good ventilation is essential during application. Avoid prolonged breathing of vapours.

First Aid: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. If overcome by vapours, remove to fresh air, contact a physician. If swallowed, do not induce vomiting, contact a physician.

KEEP OUT OF REACH OF CHILDREN

03370 CURING
Liquid curing & Hardening Compound
Sikagard Cure/Hard

Consult Sika Technical Service for any variation in product usage, application or curing methods

Sikagard® 71

Water-repellent Penetrating Sealer

Technical Data Sheet

0492

Description:

Sikagard 71 is a single-component, colourless liquid formulated to seal absorbent horizontal cementitious surfaces.

Sikagard 71 is a silane which acts as a water-repellent penetrating sealer that closes the pores of cementitious substrates. Because it minimizes the penetration of both water and chlorides, it shields the embedded rebars from these deleterious liquids. The sealer however, is not a vapor barrier.

Where to Use:

Use Sikagard 71 as a colourless , water-repellent treatment to seal absorbent traffic wearing surface such as:

- Concrete - ie; paved roadways, bridge decks, runways, parking garage decks and sidewalks.
- Restorations
- Mortar tiles
- Asbestos cement
- Brickwork (clay and sand/lime)

Preliminary site tests are recommended to determine effectiveness.

Advantages:

Sikagard 71 is both an economical and a simple-to-use sealer. Thanks to its unique ability to decrease water and chloride intrusion, Sikagard 71 helps reduce the danger of rebar corrosion.

Sikagard 71 gives you these benefits:

- Enhances concrete integrity
- Reduces efflorescence
- Reduces capillary water absorption
- Offers maximum level of water resistance after abrasion
- Improves resistance to frost and de-icing salts (chloride ion)
- Reduces dirt penetration
- Does not act as a vapor barrier
- Improves Freeze/Thaw resistance
- Is approved by Alberta Transportation and Utilities:
  - — Sealer type 1b; traffic bearing surfaces with 70% residual moisture
  - — Offers better than 82.8% improved waterproofing after surface abrasion

Coverage:

3.0 to 5.0 m^2/L, depending on porosity of substrate. For optimum results 3.6 m^2/L is recommended.

Packaging:

5 L — 20 L pails and 200 L drums.

Consult Sika Technical Service for any variation in product usage, application or curing methods

HOW TO USE

Surface Preparation:

Before applying Sikagard 71, blastrac/sandblast surface to remove surface paste. Be sure surface is clean and sound. Residual moisture does not affect the treatment. However, the drier the substrate the better the penetration. Remove all grease, curing compounds, surface treatments, coating, oils, etc. on old/new concrete by the proper means.

Application:

Apply laterally by roller, brush (horizontal surfaces), or spray.

NOTE: When spraying, it is advisable to use hand-pressure equipment rather than compressed-air drive.

Limitations:

- Avoid opening and closing of container since uncured material is moisture-sensitive.
- Do not apply at temperatures below 3° C, or when temperature is expected to fall below 3°C within 12 hours.
- Material is not intended for waterproofing under hydrostatic pressure
- Do not apply through standing water
- Material is not recommended for below-grade waterproofing.
- Material is not intended to seal visible cracks or crevices from moisture intrusion.
- Performance and penetration is dependant upon the concrete quality.
- While Sikagard 71's ability to significantly reduce the intrusion of chloride into concrete, the use of properly consolidated and cured low-water/cement-ratio concrete and deep cover over the embedded reinforcing steel, is still recommended for long-term protection in severe environments.
- New concrete should be 3-6 weeks old. The drier the substrate, the greater the penetration.

Typical Data for Sikagard 71:
(23° ± 2°C and ± 5% R.H.)

Colour:	Clear, colourless.
Viscosity:	15 mPa·s (cps).
Flash Point:	35 ° C.
Shelf Life:	6 months in original unopened container. Keep dry. Store properly since material is moisture sensitive.
Storage Conditions:	Store at maximum 30° C. Keep dry.

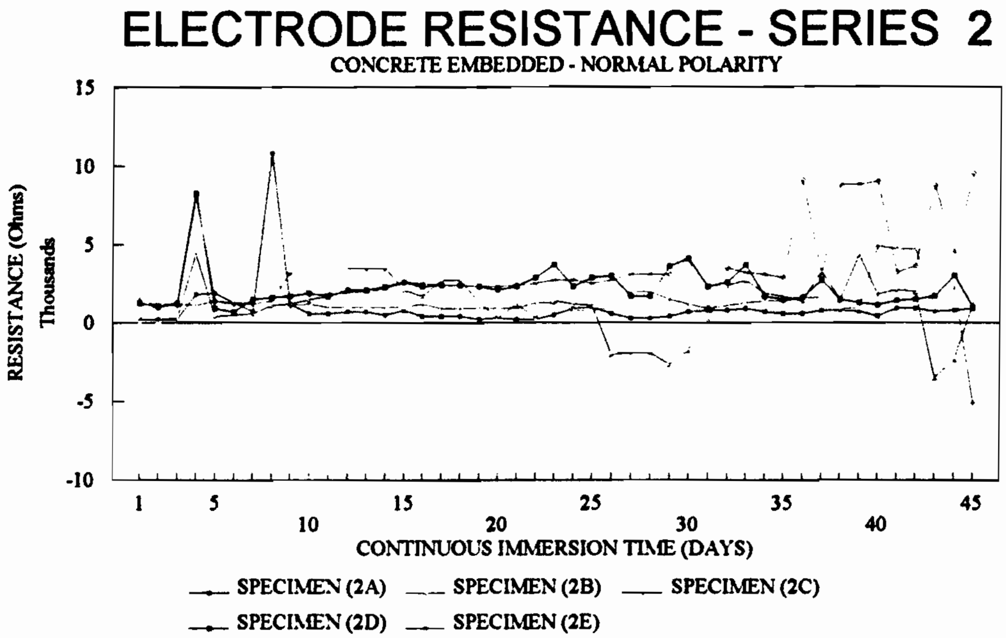
Performance Results*:

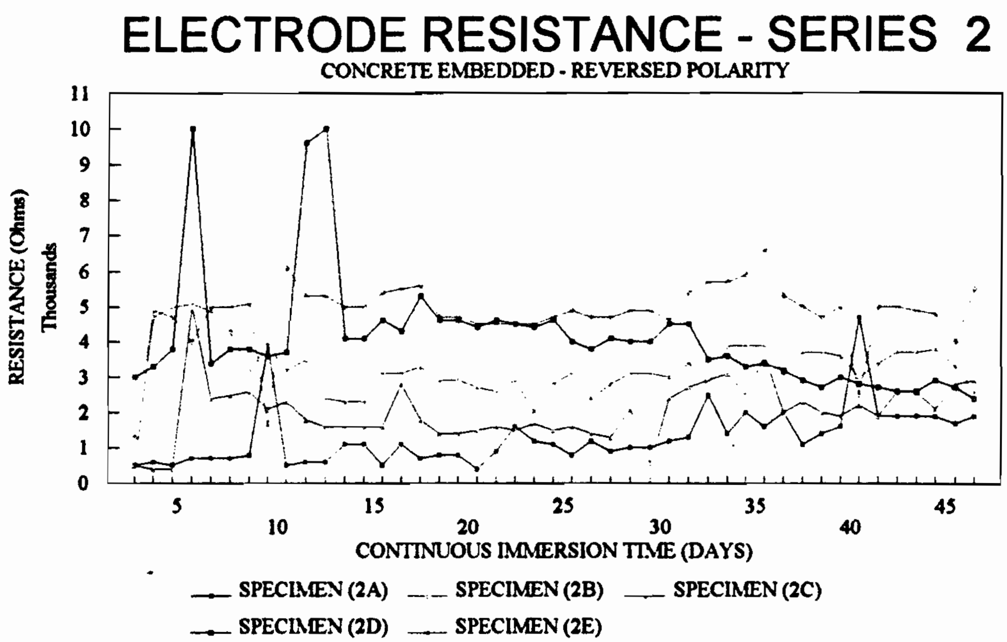
	Coverage Rate 3.62 m^2/L
Waterproofing performance	84.7%
Waterproofing after surface Abrasion	82.8%
Waterproofing after KOH Treatment (Alkali Resistance)	82.3%

*ALBERTA TRANSPORTATION AND UTILITIES

APPENDIX M

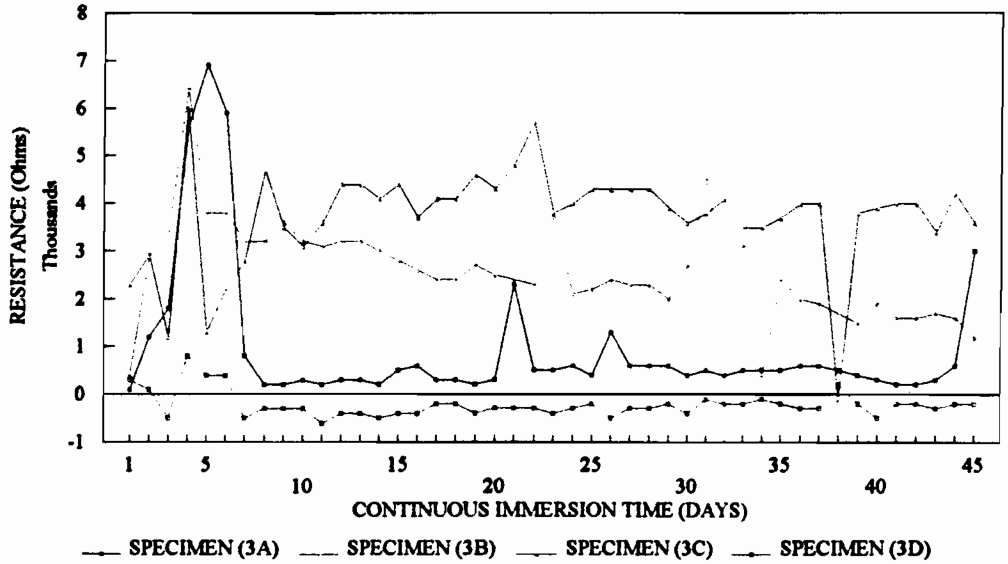
ELECTRODE RESISTANCE RESULTS


ELECTRODE RESISTANCE - SERIES 2
CONCRETE EMBEDDED - NORMAL POLARITY
RESISTANCE (Ohms) Thousands
15
10
5
0
-5
-10
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (2A)
SPECIMEN (2B)
SPECIMEN (2C)
SPECIMEN (2D)
SPECIMEN (2E)


ELECTRODE RESISTANCE - SERIES 2
CONCRETE EMBEDDED - REVERSED POLARITY
RESISTANCE (Ohms) Thousands
11
10
9
8
7
6
5
4
3
2
1
0
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (2A)
SPECIMEN (2B)
SPECIMEN (2C)
SPECIMEN (2D)
SPECIMEN (2E)

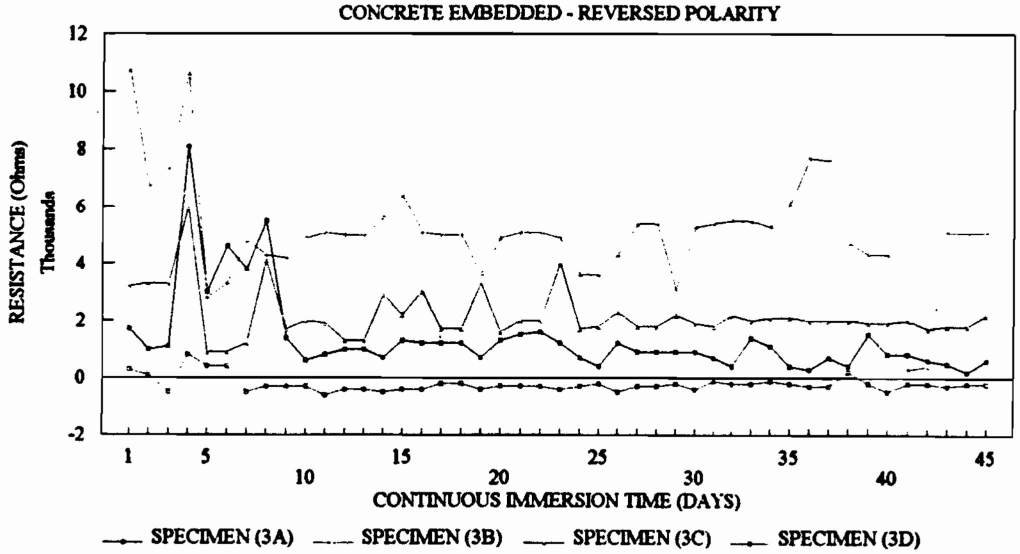
ELECTRODE RESISTANCE - SERIES 3

CONCRETE EMBEDDED - NORMAL POLARITY



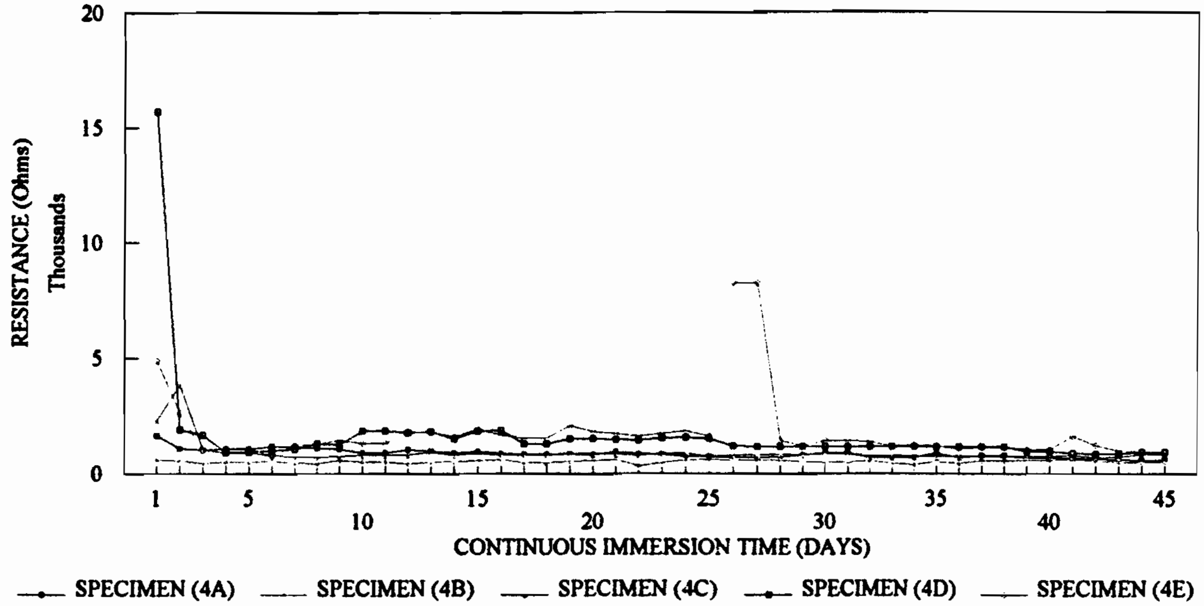
ELECTRODE RESISTANCE - SERIES 3

CONCRETE EMBEDDED - REVERSED POLARITY



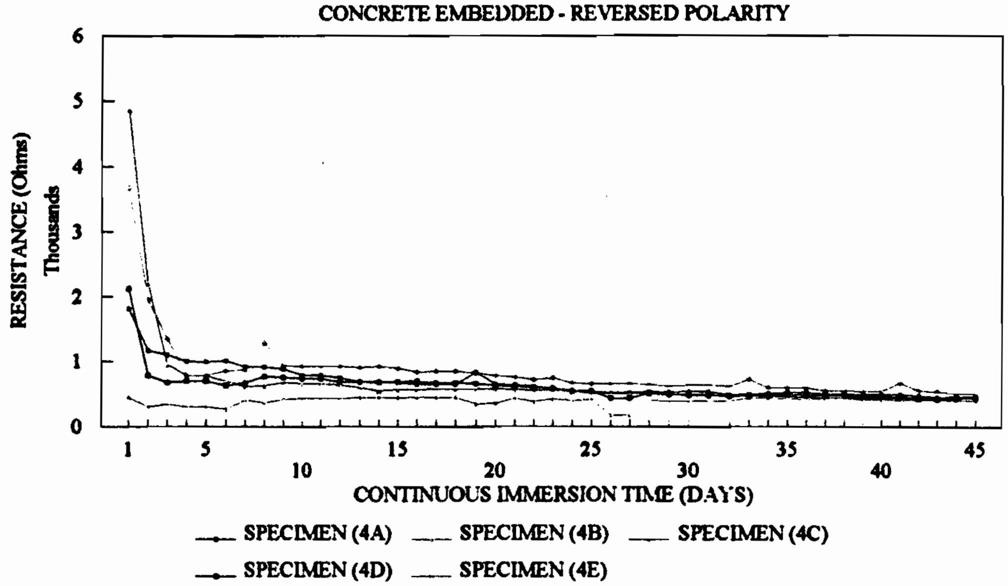
ELECTRODE RESISTANCE - SERIES 4

CONCRETE EMBEDDED - NORMAL POLARITY

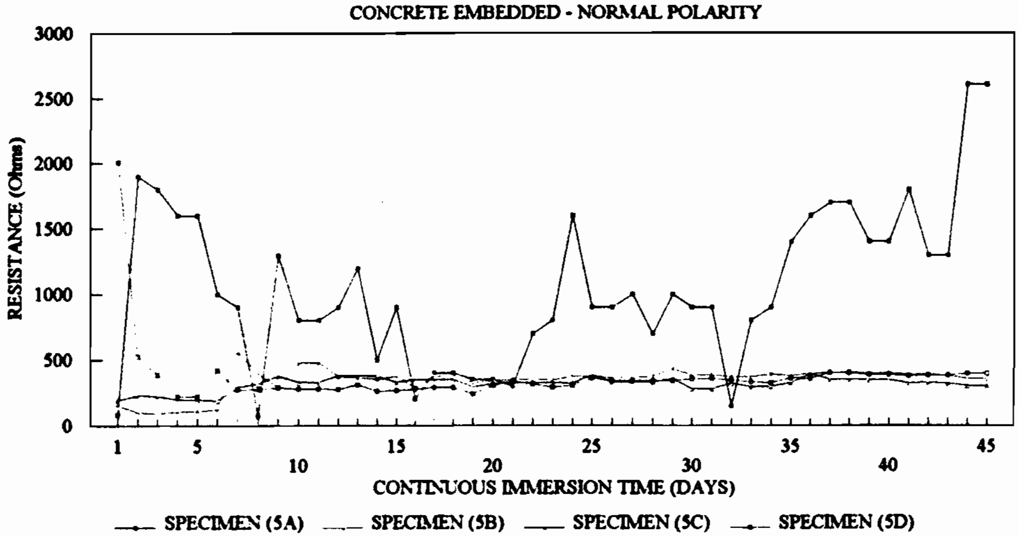


ELECTRODE RESISTANCE - SERIES 4

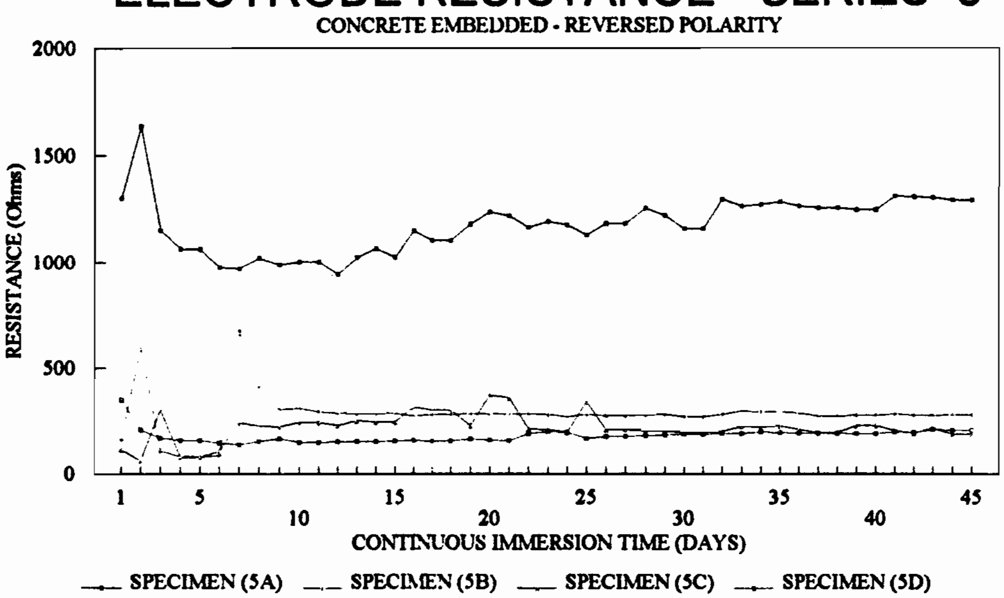
CONCRETE EMBEDDED - REVERSED POLARITY

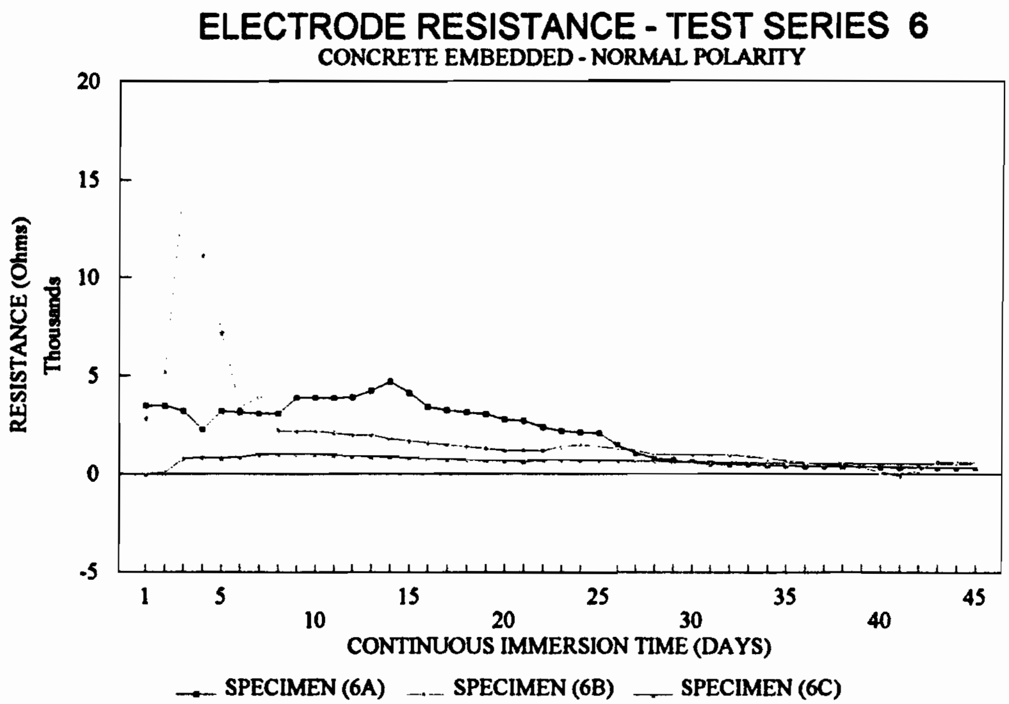


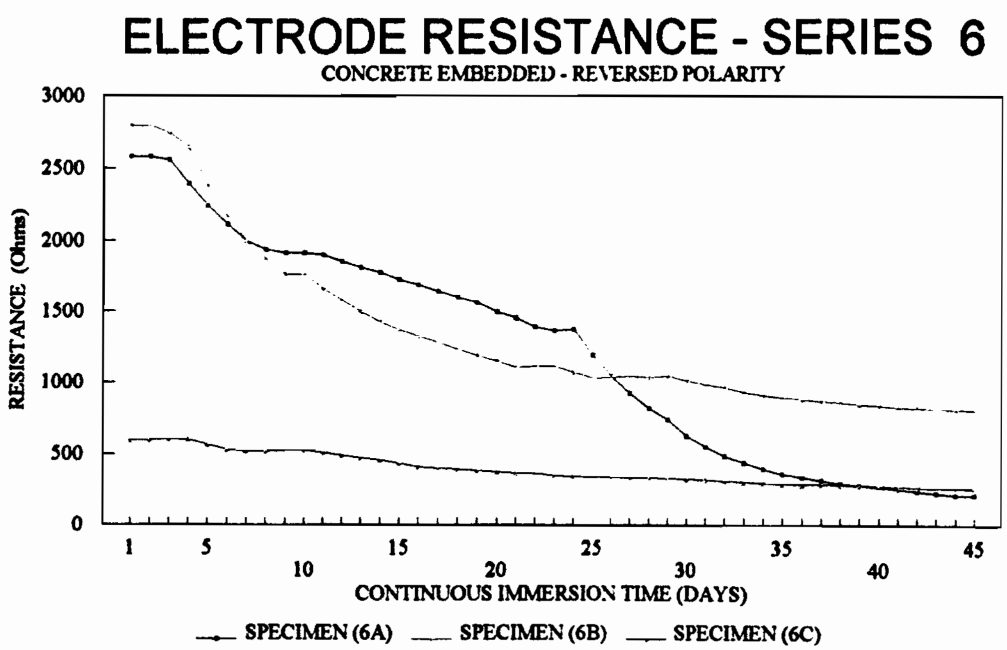
ELECTRODE RESISTANCE - SERIES 5



ELECTRODE RESISTANCE - SERIES 5

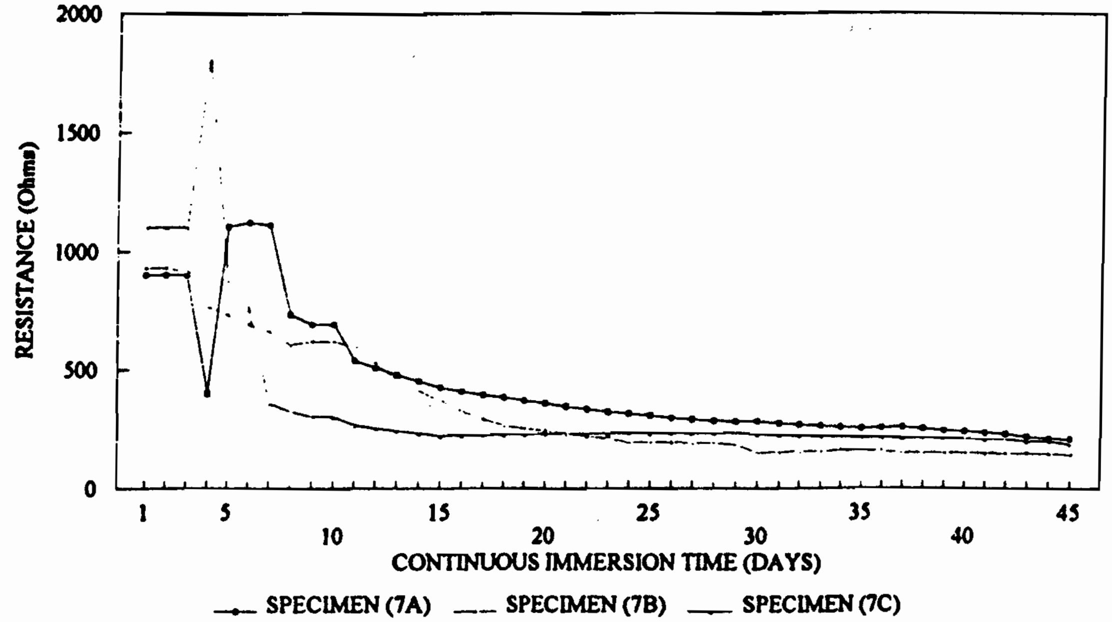



ELECTRODE RESISTANCE - TEST SERIES 6
CONCRETE EMBEDDED - NORMAL POLARITY
RESISTANCE (Ohms)
Thousands
20
15
10
5
0
-5
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)


ELECTRODE RESISTANCE - SERIES 6
CONCRETE EMBEDDED - REVERSED POLARITY
RESISTANCE (Ohms)
3000
2500
2000
1500
1000
500
0
1
5
10
15
20
25
30
35
40
45
CONTINUOUS IMMERSION TIME (DAYS)
SPECIMEN (6A)
SPECIMEN (6B)
SPECIMEN (6C)

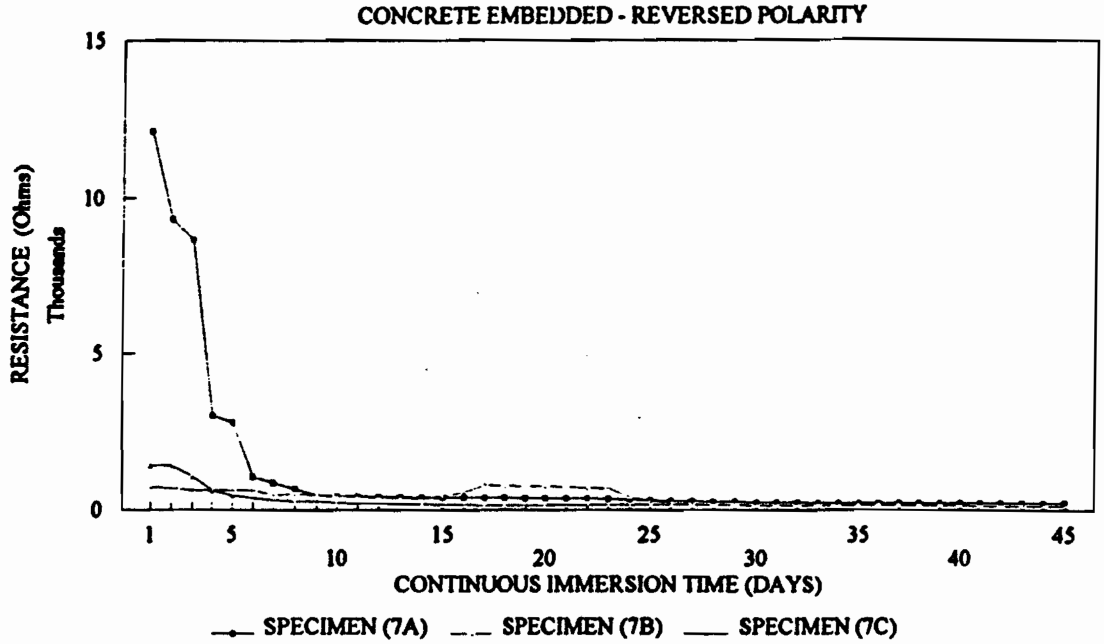
ELECTRODE RESISTANCE - SERIES 7

CONCRETE EMBEDDED - NORMAL POLARITY



ELECTRODE RESISTANCE - SERIES 7

CONCRETE EMBEDDED - REVERSED POLARITY



Do not film
Dupe!

A K

MASS LOSS

MEASUREMENTS