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Control of Electrochemical Corrosion of Underground Metallic Structures

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PREFACE

This is the third edition of C22.3 No. 4, it supersedes previous editions published in 1936 and 1958.

In the first edition, major emphasis was placed upon the corrosive effects of stray currents originating in direct-current electric railway systems. In fact, the title of the first edition was "Principles and Practices for Protecting Underground Structures from the Effects of Stray Currents Originating in Direct-Current Electric Railway Systems".

In preparing the second edition of C22.3 No. 4, the Committee recognized certain major changes that were occurring throughout the country. Many transportation systems had discontinued operation of electrically operated railways employing grounded rails, or were in the process of eliminating this type of system. For this reason, the stray current situation was undergoing a radical change, and often this change resulted in more severe corrosion problems than existed during the operation of the electric railway. For example, many street railways have in the past cooperated extensively with the owners of other subsurface structures by, designing their systems to limit stray currents and by permitting the installation of drainage bonds between the two systems at strategic locations. The net result of this cooperation has been a large measure of cathodic protection to the other system. With the elimination of the street railway, however, this protection has been withdrawn, and corrosion due to other causes has been permitted to take place.

It should be recognized that electrically operated railways employing grounded rail returns are not the only source of stray currents. Other types Of systems utilizing grounded direct-current circuits often act as sources of stray currents in the earth. One such source that is becoming of major importance is the pipeline equipped with cathodic protection.

While the electric railway is becoming of decreasing importance as a source of stray currents, considerable experience in the mitigation of corrosion due to stray currents originating in such railways has accumulated over the years. For this reason some of the Rules contained in this Code apply specifically to railways. It should be realized, however, that these Rules apply in general to all systems which originate stray earth currents, and that railways are mentioned specifically merely for convenience.

The Committee charged with the preparation of the second edition foresaw the gradual abolition of electric railways and attempted to emphasize cathodic protection systems as a new and important source of stray dc current. In the interim between the publication of the second edition and the preparation of the third edition it is now apparent that electric traction systems may see increasing use in urban and inter-urban service. With the advent of high voltage direct current transmission for the long distance transportation of power and the almost universal use of cathodic protection on oil and gas piping systems the up-dating of this Standard is most timely.

This Standard was prepared by the Task Group on Electrochemical Corrosion of Underground Metallic Structures under the jurisdiction of the Subcommittee on Ground Current Coordination and the Committee on Canadian Electrical Code, Part III and was formally approved by these Committees.

REXDALE, APRIL, 1974

NOTE: In order to keep abreast of progress in the industries concerned, CSA Publications are subject to periodic review. Suggestions for improvement will be welcomed at all times. They will be recorded and in due course brought to the attention of the appropriate Committee for consideration.

Also, requests for interpretation will be accepted by the Committee. They should be worded in such a manner as to permit a simple "yes" or "no" answer based on the literal text of the requirements concerned.

All enquiries regarding this Standard should be addressed to Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9W IR3.

1. SCOPE

1.1
The provisions of this Standard, forming a part of the Canadian Electrical code, Part III, embody the applicable principles and general practices where underground metallic structures are subject to the risk of electro-chemical corrosion.

1.2
This Standard is issued for the guidance of all parties owning, controlling, or operating grounded electric systems and subsurface structures such as metallic pipes, metallic cable sheaths, or other structures with underground metallic components.

2. SAFETY REQUIREMENT

2.1
Where corrosion of underground systems or structures could result in a hazard to persons preventive measures shall be instituted. This demands the cooperation of all parties concerned.

NOTE: If any of the parties concerned are not sufficiently familiar wish the engineering details involved in the mitigation of electrochemical corrosion as set forth in the principles and practices contained therein, such party should obtain technical advice from qualified experts. information on the formation of Electrolysis Committees, as well as a directory of existing Committees, can be obtained from the National Association of Corrosion Engineers.

3. DEFINITIONS

3.1
The following definitions apply in this Standard:

Anode means an electrode through which current enters an electrolyte. In corrosion processes, the anode is the electrode that usually has the greater tendency to go into solution, or to corrode;

Cathode means an electrode through which current leaves an electrolyte. In corrosion processes, the cathode is usually the area that is not attacked;

Cathodic corrosion (corrosion by cathodic products) means corrosion occurring on the surface of a cathode due to the chemicals released there by electrolytic action, usually when the surrounding electrolyte is alkaline;

Cathodic protection means reduction or prevention of corrosion of a metal surface by making it all cathodic:

Concentration cell means an electrolytic cell, the emf of which is due to differences in strength or composition of the electrolyte at anode and cathode areas;

Corrosion means the deterioration of a substance, usually a metal, because of a reaction with its environment;

Differential aeration cell means an electrolytic cell, the emf of which is due to a difference in oxygen concentration at two otherwise similar electrodes;

Drainage means a technique whereby a metallic conductor is installed between structures to provide a preferential path for stray currents which would otherwise pass through the soil or other electrolyte;

Electrolysis means the production of chemical changes by the passage of current through an electrolyte. This term commonly refers to corrosion problems caused by stray currents;

Electrolysis survey means the operation of determining by means of measurements, relevant facts pertaining to electrolysis conditions. These measurements include determination of voltages, currents, voltage gradients, condition of the soil surrounding underground structures, the extent of corrosion that may have occurred, and other factors, so that the risk of corrosion may be assessed and suitable mitigative measures determined;

Electrolyte means a chemical substance, usually liquid containing ions which migrate in an electric field. For the purposes of this Standard electrolyte refers to the soil adjacent to and in contact with an underground metallic structure, including the moisture and other chemicals contained therein;

Forced drainage means the use of a rectifier or other dc source in a drainage bond to overcome an IR drop in the bond due to the passage of drainage current;

Galvanic anode means an anode constructed of a metal high in the galvanic series, usually magnesium, sometimes zinc. A galvanic anode is used to protect an underground structure of metal lower in the galvanic series. The galvanic