Handbook of Cathodic Protection

The Theory and practice of Electrochemical Corrosion Protection Techniques

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Introduction

CATHODIC PROTECTION as a supplement to surface coating has in recent years proved to be the most effective and most economical form of protection against corrosion in extensive fields of technology.

The technique cannot be successfully applied without a thorough knowledge of the foundations of corrosion practice and extensive research into the best methods of controlling corrosion systems. A guide to the technology of cathodic protection filling these requirements has not previously been available in the German language.

Both editors of this book are not only well-known experts on basic corrosion science and protection but also on the technology of corrosion protection. They, together with their associated contributors, are to be congratulated for their efforts in uniting modern theory and practice in this handbook. They have succeeded in presenting the fundamentals and techniques in a precise and straightforward manner. I hope that as many technologists as possible will study this book, and I am quite sure that it will make a great contribution to the proper application and development of cathodic protection.

PROF. DR. HANS-JÜRGEN ENGELL
(Corrosion Working Party)

Foreword

THE DISCOVERY and use of metals at the end of the stone age was one of the most important steps in the development of modern technology. Most base metals are, unfortunately, not stable. In unfavourable environments they can be destroyed at variable rates by corrosion. The study of such corrosion reactions and the methods by which metallic corrosion can be fought is a task of great economic significance.

The processes of cathodic protection can be scientifically explained far more concisely than many other protective systems. Metallic corrosion in aqueous solutions or in the soil is principally an electrolytic process controlled by an electric tension, i.e. the potential of a metal in an electrolyte solution. According to the laws of electrochemistry the reaction tendency and the rate of reaction will decrease with reducing potential. Although these relationships have been known for more than a century and although cathodic protection has been practised in isolated cases for a long time, it required an extended period for its technical application on a wider scale. This may have been because cathodic protection used to appear far-fetched and strange and the electrical engineering requirements hindered its practical application. The practice of cathodic protection is indeed more complex than its theoretical base.

There are extensive publications on many specific individual problems together with practical instructions. However, it was difficult for the technologist in Germany to master the subject, as no comprehensive up-to-date publication was available in German. The Sub-committee for Corrosion of the DVGW instigated the publication of a Handbook of Cathodic Protection, and a number of members offered their co-operation as authors of individual chapters.

The Handbook deals mainly with the practice of cathodic protection, but the discussion includes fundamentals and related fields as far as these are necessary for a complete review of the subject. We thought it appropriate to include a historical introduction in order to explain the technological development of corrosion protection. The second chapter explains the theoretical basis of metal corrosion and corrosion protection. We have deliberately given practical examples of combinations of various materials and media in order to exemplify the numerous fields of application of electrochemical protection.

At present cathodic protection is only generally applied in contact with natural waters and soil, but for the future applications are envisaged for industrial plants and containers. For this reason we have included a chapter on anodic protection which has been applied in isolated cases during the last ten years. Cathodic and anodic protection are basically very similar systems and justify the description *electrochemical protection* in the sub-title of this book.

Most applications combine cathodic protection with a physical protection system, or surface coating. The chapter on physical protective systems seemed appropriate because of the various interactions which must be allowed for. A chapter on general measuring technology has also been added since the practice of cathodic protection has repeatedly shown how important is the careful study

of measuring problems. It requires experience to account for possible sources of error in calculations, and it is always necessary to check unusual measured results by independant monitoring. Impressed current installations present particular measurement problems, remembering that an installation with reversed polarity generates intensive corrosion. This is worse than an inoperative system or no corrosion protection at all.

Further chapters cover in detail the characteristics and applications of galvanic anodes and of cathodic protection rectifiers, including specialised instruments for stray current protection and impressed current anodes. The fields of application discussed are: buried pipelines, storage tanks, tank farms, telephone, power and gas-pressurised cables, ships, harbour installations and the internal protection of water mains and industrial plant. A special chapter deals with the problems of high-tension effects on pipelines and cables. A study of costs and economic factors concludes the discussion. The appendix contains those tables and mathematical derivations which appeared appropriate for practical purposes and for rounding-off the subject.

The editors take the opportunity to thank all the contributors for their efforts, Ruhrgas AG and Mannesmann Research Institute GmbH for their kind assistance, and last but not least the publishers Verlag Chemie for their generous help in publishing and designing this handbook.

Essen and Duisburg,
Spring, 1971

W. v. BAECKMANN
AND W. SCHWENCK

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Note on "potential" and "tension"

IT IS usual in English to use the terms " potential ", " potential difference " or " electromotive force " to describe quantities commonly met in electrochemical and corrosion studies. In fact the CITCE Committee on Electrochemical Nomenclature and Definitions recommends a different system. " Potential " is reserved to mean the absolute charge density within a phase. Differences between the potentials of phases are referred to as " Tensions ".

The translators have retained the system used by the authors, which may be described as follows:

Potential. This term describes a value measured without significant current drain in the measuring circuit. The value is actually a potential difference with respect to a standard reference electrode.

Tension. This is a potential difference or electromotive force across a cell, or between two terminals. It may be roughly equated to the expression " voltage " and implies a practical measurement rather than a theoretical concept.

While the " Tension " nomenclature has not generally been adopted in textbooks of electrochemistry, its use in electrical engineering is very familiar, particularly from phases such as " high tension ".

British Standard Code of Practice CP 1021 : 1973

Since the preparation of the English translation of this book a British Standard Code of Practice relevant to Cathodic Protection has been issued. Where appropriate this should be consulted in addition to the standards and regulations quoted in the text. The code of practice also includes a glossary of technical expressions in common use which do not always correspond with those used in this translation. For example, the descriptive term " applied current testing " is used instead of the common expression " drainage testing " (British Standard) or " polarisation testing ", both of which can carry other connotations in the field of corrosion technology.

See also the note on " Potential and Tension ".

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