Outdoor Atmospheric Corrosion

Herbert E. Townsend
Editor

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Each paper published in this volume was evaluated by two peer reviewers and at least one editor. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM International Committee on Publications.

To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

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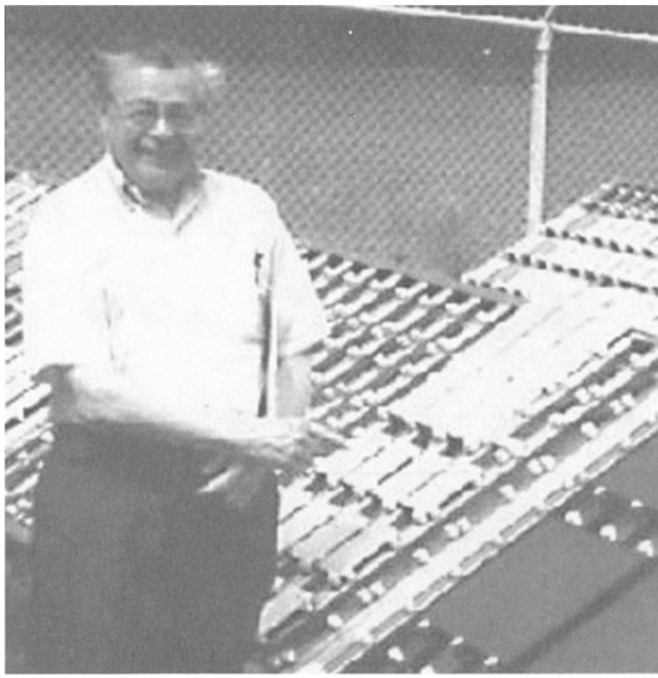
Foreword

This publication, Outdoor Atmospheric Corrosion, contains papers presented at the symposium of the same name held in Phoenix, Arizona, on 8-9 May 2001. The symposium was sponsored by ASTM International Committee G1 on Corrosion of Metals. The symposium co-chairman was Herbert E. Townsend, Consultant, Center Valley, PA.

Dedication to Seymour K. Coburn
1917–2001



This volume is dedicated to the memory of Seymour K. Coburn, who passed away on January 4, 2001.

Sy, as he was known to many of his friends, was born in Chicago in 1917. He received a BS in Chemistry from the University of Chicago in 1940, and an MS from Illinois Institute of Technology in 1951. After initially working for Minor laboratories, Lever Brothers, and the Association of American Railroads, he began a long career as a corrosion specialist at the Applied Research Laboratories of US Steel Corporation.

Working with C. P. Larabee at US Steel, he became well known throughout the industry for pioneering their studies of the effects of alloying elements on the corrosion of steels. To do this, they studied the corrosion performance of hundreds of steel compositions exposed to rural, marine, and industrial environments, and defined the beneficial effects of copper, nickel, phosphorus, chromium, and silicon. No treatment of the subject is complete without a reference to their classic paper, "The Atmospheric Corrosion of Steels as Influenced by Changes in Chemical Composition," that was presented in 1961 to the First International Congress on Metallic Corrosion in London.

Sy went on to become one of the leading advocates of weathering steels, that is, low-alloy steels which develop a protective patina during exposure in the atmosphere so that they become corrosion-resistant without painting for use in applications such as bridges, utility towers, and buildings. He was US Steel's research consultant for the John Deere Headquarters on Moline, IL, the first building constructed with weathering steel, as well as the Chicago Civic Center, and some of the first unpainted weathering steel bridges.

In 1970, he was transferred to the Special Technical Services unit of US Steel's Metallurgical Department where he became the top promoter and trouble-shooter for bridges and other weathering steel applications. But it was not until he attended a workshop of the Steel Structures Paint Council that he achieved his real goal in life—he became a teacher.

An active member of ASTM International, Sy chaired Subcommittee G1.04 on Atmospheric Corrosion from 1964 to 1970, and was instrumental in organizing this subcommittee. He also was the prime mover in organizing and editing STP 646, "Atmospheric Factors Affecting the Corrosion of Engineering Materials," and he chaired the symposium that led to that STP, a celebration of 50 years of exposure testing at the State College, PA, ASTM International atmospheric corrosion test site in May 1976.

After retiring in 1984, he continued to teach and actively consult around the world in matters related to weathering steels and protective coatings. In addition to his ASTM International activities, Sy was also a member of the American Chemical Society, The American Society for Metals, the National Association of Corrosion Engineers, and the Steel Structures Painting Council.

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Overview

This book is a collection of papers presented at the ASTM International Symposium on Outdoor and Indoor Atmospheric Corrosion that was held in Phoenix, AZ in May 2001. With presentations from authors representing ten counties in North and South America, Europe, and Asia, the symposium was truly international.

The symposium was originally conceived as a vehicle to present results of the 1976 ASTM International outdoor atmospheric corrosion test program. During the initial scheduling, it was combined with another symposium being planned by Robert Baboian on indoor corrosion to form a joint symposium on both outdoor and indoor corrosion. Although a joint symposium was organized accordingly, contributions on the indoor topic did not materialize. Consequently, this STP is devoted entirely to the outdoor topic.

Corrosion of metals in the atmosphere has been an important topic for many years, as evidenced by the many symposium volumes previously published by ASTM International.

- *STP 67, Symposium on Atmospheric Exposure Tests on Nonferrous Metals,* 1946.
- *STP 175, Symposium on Atmospheric Corrosion of Non-Ferrous Metals,* 1956.
- *STP 290, Twenty-Year Atmospheric Investigation of Zinc-Coated and Uncoated Wire and Wire Products,* 1959.
- *STP 435, Metal Corrosion in the Atmosphere,* 1968.
- *STP 558, Corrosion in Natural Environments,* 1974.
- *STP 646, Atmospheric Factors Affecting the Corrosion of Engineering Materials,* 1978, S. K. Coburn, Editor.
- *STP 767, Atmospheric Corrosion of Metals,* 1982, S. W. Dean, Jr. and E. C. Rhea, Editors.
- *STP 965, Degradation of Metals in the Atmosphere,* 1988, S. W. Dean, Jr. and T. S. Lee, Editors.
- *STP 1239, Atmospheric Corrosion,* 1995, W. W. Kirk and Herbert H. Lawson, Editors.
- *STP 1399, Marine Corrosion in Tropical Environments,* 2000, S. W. Dean, Jr., Guillermo Hernandez-Duque Delgadillo, and James B. Bushman, Editors.

The present volume can be viewed as the most recent in a series on a topic of continuing economic and ecological significance. As previously discussed (see "Extending the Limits of Growth through Development of Corrosion-Resistant Steel Products," *Corrosion,* Vol. 55, No. 6, 1999, 547–553), controlling losses of the world's resources due to atmospheric corrosion may be an important component of continuing economic development. Four major themes are evident in this collection.

Prediction of Outdoor Corrosion Performance

One theme focuses on prediction of atmospheric corrosion performance from climatic data, particularly in relation to methods being developed by the International Standards Organization (ISO). These attempt to classify the corrosivity of a location based either on short-term exposure of standard coupons, or on local time of wetness, and deposition rates of chloride and sulfate. Many of the assumptions in developing the ISO methodology are now being reconsidered in the light of recently completed testing, and work continues to improve the models.

Laboratory and Specialized Outdoor Test Methods

A second theme considers laboratory tests related to outdoor corrosion, and specialized outdoor methods. These include methods of evaluating the results of outdoor tests, ways to predict outdoor performance based on laboratory tests, and on work to develop a seaside (salt-resistant) steel by additions of calcium and sulfur.

Effects of Corrosion Products on the Environment

A third theme examines the ecological effects of corrosion product runoff, a subject that blends corrosion science, environmental technology, analytical chemistry and politics. Contributions from the Swedish Royal Institute of Technology, and the US Department of Energy reflect a growing concern in developed countries for the ecological effects of dissolved metals.

Long-Term Outdoor Corrosion Performance of Engineering Materials

The fourth theme is the documentation of the actual long-term outdoor behavior of engineering materials. This topic includes reports of the 21-year results of the 1976 ASTM International outdoor atmospheric corrosion test program on nickel alloys, Galvalume, galvanized, and aluminum-coated steel sheet. Articles on the performance of unpainted, low-alloy weathering steel include a survey of utility poles in a wide range of environments, work to establish a lean-alloy (Cu-P) grade as an inexpensive alternative to A588A, and the development of a new ASTM G101 corrosion index for estimating relative corrosion resistance from composition.

I am indebted to many for support and to the success of the symposium and this book. These include the members of the Atmospheric Corrosion Subcommittee G1.04, symposium co-chairman Robert Baboian, a plethora of skilled reviewers, the presenters and authors of a large number of high-quality papers, and the help of ASTM International staff including Dorothy Fitzpatrick, Annette Adams, and Maria Langiewicz. This book, like the symposium, is dedicated to the memory of Seymour Coburn, a pioneer in the development of weathering steels, and an active contributor to the efforts of ASTM International in the field of outdoor atmospheric corrosion.

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Outdoor atmospheric corrosion occurs whenever the metal surface becomes wet with moisture and is aggravated by chloride deposition and sulfur dioxide absorption. Chlorides originate from marine sources or from the application of road deicing salt. Sulfur dioxides originate most often from fossil fuel combustion, especially coal. Indoor corrosion is aggravated by a number of compounds depending on the types of activity occurring in the building. @inproceedings{Mendoza2000OutdoorAI, title={Outdoor and indoor atmospheric corrosion of non-ferrous metals}, author={Antonio Ram{\'i}rez Mendoza and Francisco Corvo}, year={2000} }. Antonio RamÃrez Mendoza, Francisco Corvo. Published 2000. Materials Science. In the present paper, a study of the atmospheric corrosion of copper, zinc and aluminium exposed on three test sites indoors and outdoors (coastal, urban-industrial and rural) under different exposure conditions up to 18 months is reported.