

Sacrificial Cathodic Protection of Reinforced Concrete Elements— A State-of-the-Art Report

This NACE International technical committee report represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not included in this report. Nothing contained in this NACE report is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This report should in no way be interpreted as a restriction on the use of better procedures or materials not discussed herein. Neither is this report intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this report in specific instances. NACE assumes no responsibility for the interpretation or use of this report by other parties.

Users of this NACE report are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this report prior to its use. This NACE report may not necessarily address all potential health and safety problems, or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this report. Users of this NACE report are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this report.

CAUTIONARY NOTICE: The user is cautioned to obtain the latest edition of this report. NACE reports are subject to periodic review, and may be revised, or withdrawn at any time without prior notice. NACE reports are automatically withdrawn if more than 10 years old. Purchasers of NACE reports may receive current information on all NACE publications by contacting the NACE FirstService Department, 15835 Park Ten Place, Houston, TX 77084-5145 (tel: +1 281-228-6200, email: firstservice@nace.org).

ABSTRACT

This technical report presents state-of-the-art information on several commercially available galvanic cathodic protection/prevention systems for protecting atmospherically exposed reinforced concrete structures. The information contained in this report has been provided by key manufacturers of these systems and is intended as a technical resource for engineers responsible for the rehabilitation of reinforced concrete structures. It may also be useful to owners, contractors, and other practitioners related to the field of galvanic cathodic protection (CP). All information related to galvanic CP is intended for atmospherically exposed concrete structures and may not be applicable to concrete containing epoxy-coated reinforcing steel, galvanized, or other coated or nonferrous reinforcement.

KEYWORDS

Cathodic protection, galvanic, sacrificial anode, reinforced concrete, metallized coating, TG 557.

Foreword

The purpose of this technical committee report is to present state-of-the-art information on several commercially available galvanic cathodic protection/prevention systems for protecting atmospherically exposed reinforced concrete structures. A summary of these systems is presented in Appendix A. It is beyond the scope of this report to fully address all factors associated with design, criteria, implementation, quality control, cost, maintenance, and monitoring of these systems. The information contained in this report has been provided by key manufacturers of these systems and is intended as a technical resource for engineers responsible for the rehabilitation of reinforced concrete structures. It may also be useful to owners, contractors, and other practitioners related to the field of galvanic cathodic protection (CP). All information as it relates to galvanic CP is intended for atmospherically exposed concrete structures and may not be applicable to concrete containing epoxy-coated reinforcing steel, galvanized, or other coated or nonferrous reinforcement. Galvanic CP has also been successfully applied to buried or submerged reinforced concrete structures; however, this aspect is not addressed in this state-of-the-art report.

This NACE technical committee report was originally prepared in 2005 by Task Group (TG) 047 on Sacrificial Cathodic Protection of Reinforced Concrete Elements, which was administered by Specific Technology Group (STG) 01 on Reinforced Concrete and sponsored by STG 05 on Cathodic/Anodic Protection. It was revised in 2020 by TG 557 on Sacrificial Cathodic Protection of Reinforced Concrete Elements. TG 557 is administered by STG 01 and sponsored by STG 05. This report is issued by NACE International under the auspices of STG 01.

NACE technical committee reports are intended to convey technical information or state-of-the-art knowledge regarding corrosion. In many cases, they discuss specific applications of corrosion mitigation technology, whether considered successful or not. Statements used to convey this information are factual and are provided to the reader as input and guidance for consideration when applying this technology in the future. However, these statements are not intended to be recommendations for general application of this technology and must not be construed as such.

Sacrificial Cathodic Protection of Reinforced Concrete Elements— A State-of-the-Art Report

| | | |
|----|---|----|
| 1. | Introduction | 5 |
| 2. | Definitions | 5 |
| 3. | General Principles of Cathodic Protection | 6 |
| 4. | Sacrificial Anode Cathodic Protection | 6 |
| 5. | Types of Galvanic (SACP) Systems..... | 8 |
| 6. | Galvanic Corrosion Prevention for Concrete Repair | 15 |
| 7. | Project Case Studies..... | 16 |
| | References..... | 27 |
| | Bibliography | 27 |
| | Appendix A: Current Galvanic Sacrificial Anode Systems..... | 29 |

Tables and Figures

| | |
|--|----|
| Figure 1: Thermal Spray Zinc on Concrete | 9 |
| Figure 2: Thermal Spray Zinc Layering | 9 |
| Figure 3: Temperature-Humidity Chamber Performance of Thermally Sprayed Zinc | 10 |
| Figure 4: Temperature-Humidity Chamber Performance of Thermally Sprayed Al-20Zn-0.2In | 10 |
| Table 1: Seasonal Effects on Current Density and Polarization (mV) | 10 |
| Figure 5: Zinc Mesh Attached to FRP Jacket..... | 11 |
| Figure 6: Finished Zinc Mesh Jacket with Junction Box | 11 |
| Figure 7: Alkali-Activated Distributed Zinc Anodes in Stay-In-Place Jacket..... | 12 |
| Figure 8: Corrosion Rate of Pure Zinc in Water as a Function of pH..... | 12 |
| Figure 9: Cast Zinc in Wicking Socks..... | 13 |
| Figure 10: Wicking Anodes Cast into Stay-In-Place PVC Jackets | 13 |
| Figure 11: Alkali-Activated Distributed Zinc Anodes with Concrete Overlays and Enlargements | 13 |
| Figure 12: Zinc Mesh Embedded into Activated Grout Binder Matrix | 14 |
| Figure 13: Zinc-Hydrogel Connection Drawing | 14 |
| Figure 14: Bulk Zinc Anodes for Bridge Pilings | 15 |
| Figure 15: Galvanic Anodes In Patch Repairs | 15 |
| Figure 16: Galvanic Anodes in Parent Concrete | 15 |
| Figure 17: Topcoat Application | 16 |
| Figure 18: Completed Al/Zn/In Metalizing | 16 |
| Figure 19: Current Density Measurements of Zinc Metalizing with Humectant in Monitored Zones at Conveyor Tower ... | 17 |