COMPTE-RENDU, CONGRES CORROSION 87

285468

Gouvernement du Québec
Ministère des Transports

Ste-Foy, le 11 mai 1987

Service des Relations Ministérielles
Bureau du Sous-Ministre
Ministère des Transports
700, Boul. St-Cyrille Est
31ième étage
Québec, (Qué.)
G1B 5H1

Sujet: Compte-rendu, congrès **Corrosion 87**
C.T. 87 - C - 312

A qui de droit,

Vous trouverez, ci-inclus, le compte-rendu des activités du congrès " **Corrosion 87** " , tenu à San Francisco du 9 au 13 mars 1987, et au cours duquel j'ai présenté une étude sur la protection contre la corrosion des structures d'acier par métallisation au zinc.

Des copies de sujets traités au cours de ces conférences d'intérêts plus particuliers pour le Ministère, ont été ajoutées avec mes propres commentaires.

Si d'autres informations ou discussions concernant les sujets mentionnés étaient nécessaires, soyez assuré de mon entière collaboration.

Pierre Grenon, ing.
Laboratoire Central
Ministère des Transports
2700, rue Einstein
Ste-Foy, (Qué.) 3-3198
G1P 3W8

PG/ml

N.B. CORROSION 88 à Saint-Louis, Mo. du 21 au 25 mars 1988.

Conférences " CORROSION 87 "

L'Association nationale des ingénieurs en corrosion mieux connue sous le sigle anglais " NACE " présente, à chaque année, une semaine de conférences traitant des divers aspects de la corrosion des métaux et alliages.

Dans le cadre de ces conférences, au cours de la semaine du 9 au 13 mars 1987, au Moscone Center de San Francisco , 481 sujets ont été abordés, dont 21 sur la corrosion atmosphérique parmi lesquels figurait la publication 427 " STEEL STRUCTURES COATING WITH ZINC METALLIZING " que j'ai moi-même présenté à titre de représentant du Ministère des Transports.

Cette conférence a été pour moi l'occasion de rencontrer le président de mon symposium, le Dr. David Flinn de " U. S. Bureau of Mines " , le Dr. M. Pourbaix, Directeur de l'Institut belge de corrosion CEBELCOR , plusieurs membres du comité sur la métallisation, dont Hugh Morrow de l'Institut américain du zinc à New-York, Glen Nishimura de Noranda Sales, Léo Perron de Gaz métropolitain.

La métallisation au zinc des structures d'acier est assez peu répandue aux Etats-Unis; le nettoyage intense qu'impose ce type de recouvrement s'accommode assez mal des lois anti-pollution encore plus aux Etats-Unis qu'au Québec.

Cependant, l'application de zinc ou de zinc-aluminium est un procédé de protection contre la rouille hautement considéré par rapport à tout autre procédé de recouvrement en chantier.

En conséquence, d'intenses recherches sont effectuées tant pour améliorer le procédé d'application du métal que pour le nettoyage.

PUBLICATIONS D'INTERET POUR LE MINISTERE DES TRANSPORTS

Parmi les nombreuses conférences entendues et les publications consultées, j'aimerais attirer l'attention sur les sujets suivants qui sont disponibles pour consultation. A titre d'indication, voici, ci-inclus, une copie de la première page de chacune de ces présentations.

PUBLICATION 408

" RECENT PROGRESS IN ATMOSPHERIC CORROSION TESTING "

L'auteur, M. Pourbaix y met en évidence la loi bilogarithmique linéaire sur la corrosion d'échantillons placés en milieux naturels. Ce développement facilite beaucoup les études de corrosion et permet d'établir des précisions d'une bonne fiabilité après 4 ans d'expositions et de mesures.

PUBLICATION 421

" TWENTY-YEAR ATMOSPHERIC CORROSION TESTS OF HOT-DIP COATED SHEET STEEL "

Les auteurs Townsend et Borzillo y présentent des résultats couvrant 20 ans d'essais. Evidemment, une partie des essais traite de l'acier galvanisé telle que nous la connaissons, c'est-à-dire, immersion de l'acier noir dans un bain de zinc en fusion. Si, au lieu d'utiliser un creuset de zinc en fusion, on emploie plutôt de l'aluminium en fusion, on obtient alors une galvanisation à l'aluminium (procédé moins répandu que le premier).

Pour avoir un procédé qui combine à la fois les avantages du zinc et de l'aluminium, certains procédés utilisent des alliages zinc-aluminium: c'est ainsi qu'une marque de commerce connue sous le nom de "GALVALUME" utilise un alliage comportant 55% Al et 45% Zn, et qui donne des résultats très intéressants.

PUBLICATION 431

TWENTY YEARS OF WEATHERING STEEL PERFORMANCE

Cette publication permet de clarifier certaines données concernant l'utilisation de l'acier patinable. Nous avons au Ministère plusieurs structures possédant ce type d'acier. En principe, cet acier résiste bien à la corrosion atmosphérique, en autant qu'il soit bien drainé. L'exposé indique que le bas des âmes des poutres des structures est peu à peu attaqué par la corrosion à cause des débris de toute sorte qui y demeurent et emprisonnent une humidité constante.

Sur certaines de nos structures, en acier inoxydable, nous avons déjà observé cette tendance: en conséquence, il y aurait lieu de faire une inspection plus à fond pour évaluer leur degré de corrosion et de proposer les interventions nécessaires.

PUBLICATION 420

CORROSION RESISTANCE OF ALUMINIUM ALLOY PLATE IN RURAL, INDUSTRIAL AND SEACOAST ATMOSPHERES

Cette publication de B. W. Lifka traite d'exfoliation d'alliage d'aluminium, problème que nous avons rencontré au Pont d'aluminium d'Arvida au Québec et qui a exigé la réparation des piliers.

PUBLICATION 360

ELECTROCHEMICAL PERFORMANCE OF FLAME SPRAYED ALUMINIUM COASTINGS OF STEEL IN SEA WATER

Ce travail réalisé par trois auteurs norvégiens décrit le comportement de la métallisation à l'aluminium en eau de mer.

PUBLICATION 142

CATHODIC PROTECTION FOR REINFORCED CONCRETE; IT'S APPLICATION TO BUILDINGS AND MARINE STRUCTURE

Cette publication de trois auteurs anglais décrit de façon globale les différents essais depuis les années 60 concernant la protection cathodique de l'armature dans le béton. Les avantages sont soulignés de même que les nombreuses difficultés que comportent l'opération adéquate de tels systèmes.

EQUIPEMENTS ET PRODUITS NOUVEAUX

La présentation des conférences de la " NATIONAL ASSOCIATION OF CORROSION ENGINEERS " est également l'occasion d'exposition d'équipements et de produits reliés à la mesure, au traitement et à la prévention de la corrosion:

Mentionnons ici les équipements de mettoyage "CLEMCO" qui peuvent suivant le besoin produire un sablage humide, un nettoyage à l'eau, un nettoyage à l'air, de même qu'un sablage sec.

La compagnie "UNDERWATER TECHNOLOGY CORPORATION" a développé une peinture applicable sous l'eau. Un tel produit pourrait être fort utile pour protéger les quais aux prises avec la corrosion. Il va sans dire que l'application doit se faire après un bon nettoyage.

CONCLUSION

Ce compte-rendu de "CORROSION 87 " permet de façon globale d'explorer les données les plus récentes concernant la lutte à la corrosion applicable au Ministère des Transports. A cause de l'abondance et de la variété des sujets traités au cours des conférences et des comités, le congrès annuel de la corrosion de la " NATIONAL ASSOCIATION OF CORROSION ENGINEERS " constitue une source importante de connaissances et de développements technologiques, tant du point de vue des essais expérimentaux que de l'utilisation de nouveaux procédés et produits.

PAPER NUMBER

142

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

CATHODIC PROTECTION FOR REINFORCED CONCRETE:

IT'S APPLICATION TO BUILDINGS AND MARINE STRUCTURES

J P BROOMFIELD, P E LANGFORD AND R MCANOY
TAYWOOD ENGINEERING
345 RUISLIP ROAD, SOUTHALL
MIDDLESEX, UB1 2QX, ENGLAND

ABSTRACT

Steel is usually protected from corrosion when embedded in concrete, however the ingress of sea salt in coastal areas or use of chloride contaminated constituents in the concrete mix can lead to depassivation and corrosion of the steel. A permanent repair is difficult since, to be fully effective all chloride contaminated concrete must be removed.

Cathodic protection is a well established technique for preventing corrosion of steel work in acidic and chloride infested conditions. Due to problems with de-icing salt attack in North America, cathodic protection is now being used to protect reinforced concrete bridge decks from chloride induced corrosion. Over 50 systems were installed up to 1985 and over 100 systems are being installed in 1985/86. These systems all require installation of conductive groundbeds which can add significantly to the dead load.

This paper describes the research undertaken on conductive coatings for use as impressed current cathodic protection groundbeds. The development of the system is described along with designs, installations and performance of trial installations in the UK and in Australia.

INTRODUCTION

Cathodic protection (CP) is a well established technique for preventing corrosion of metallic structures in aggressive environments. It has been extensively used since the beginning of the 20th century to protect pipelines, chemical plant and marine structures.

The first example of the application of CP to steel in concrete was to prestressed concrete pipelines in the late 1950's and early 1960's[1]. It was subsequently applied to underground tanks using conventional CP techniques. However, the first practical above ground CP application was to a Californian bridge deck in 1973, where deicing salts had initiated

PAPER NUMBER

360

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

ELECTROCHEMICAL PERFORMANCE OF FLAME SPRAYED ALUMINIUM COATINGS OF STEEL IN SEA WATER

K.P. Fischer
Norwegian Marine Technology Research Institute A/S
POBox 173
N-3201 Sandefjord, Norway

W.H. Thomason
CONOCO Inc.
POBox 1267
Ponca City, OK 74601

J.E. Finnegan
CONOCO Norway Inc.
POBox 1752
0122 Oslo 1, Norway

ABSTRACT

The electrochemical behaviour of the flame sprayed aluminium coating (FSA) exposed in natural sea water has been studied both at ambient and high temperatures in the laboratory. The tests have shown that FSA generally performs very well both in submerged and splash zone exposure. The prime effect of the FSA coating in sea water is as a very strong barrier type coating. The free corrosion potential of the FSA coating in strongly flowing sea water will be about -930 to -950 mV Ag/AgCl at ambient temperature. Here the use of a silicone sealer paint on the FSA coating will increase the service life of the system. An FSA coating with a silicone sealer paint will have some reduced anodic capabilities giving a current density output of about 30 to 200 mA/m^2 in a potential range of -950 to -850 mV. For FSA coating without a sealer the current output can be up to about 500 mA/m^2 in an initial exposure period. However, at a high, constant current density the Al-coating will be consumed during a few months exposure. These laboratory test data are compared with the performance data from the Hutton TLP platform.

INTRODUCTION

Flame sprayed aluminium coating (FSA) has been used for the corrosion protection of the high strength steel tension legs and risers on the Hutton TLP platform in the North Sea. This first time application of FSA for corrosion protection of a major offshore construction has stimulated interest for its future use. The selection and evaluation of FSA coatings for the Hutton TLP have been described in several papers (1, 2, 3). Flame sprayed aluminium coatings have several advantages for the protection of submerged steel structures. Its prime function is as a very strong barrier type coating. Additionally, the coating has significant anodic capability. This capability is limited by the anodic properties of the 99.5% Al used and by the thickness of the

PAPER NUMBER

408

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

RECENT PROGRESS IN ATMOSPHERIC CORROSION TESTING *

M. Pourbaix and A. Pourbaix
Belgian Center for Corrosion Study CEBELCOR
Av. Paul Héger, grille 2
B-1050 Brussels, Belgium

ABSTRACT

An accelerated electrochemical test with cyclic immersions and emersions, and electrode potential measurements during the periods of immersion, helps to assess the corrosion behavior of metallic material under different climatic conditions, and to understand the mechanism of atmospheric corrosion or passivation.

Results of both natural exposure tests and laboratory tests may often be expressed by the linear bilogarithmic law $\log p = A + B \log t$, where A measures the initial corrosion intensity and B measures the passivating action of the atmosphere. Correlations between electrode potential measurements and the values of parameters A and B are discussed.

INTRODUCTION

In the present paper, reference will be made to two relatively recent progresses relating to natural exposure tests and to laboratory work performed for selecting and setting-up steels and other metals and alloys resisting to atmospheric corrosion under given climatic conditions. Special reference will be made to "weathering" low-alloy steels where corrosion may lead, under certain conditions, to the formation of a rust layer which becomes progressively protective.

NATURAL EXPOSURE TESTS. THE LINEAR BILOGARITHMIC LAW (2,3)

Results of natural exposure tests are usually expressed by diagrams, such as figure 1, where one plots the weight loss as a function of the exposure time.

Already in 1934, R.F. Passano (4) observed that the results of such tests could sometimes be expressed by straight lines instead of curves if one plots, instead of these two data, their logarithms. N.B. Pilling and W.A. Wesley

* The present text is a summarized version of two lectures delivered on June 25, 1981 in Mexico and on May 27, 1986 in Barcelona (1).

PAPER NUMBER

420

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

CORROSION RESISTANCE OF ALUMINUM ALLOY PLATE IN RURAL, INDUSTRIAL, AND SEACOAST ATMOSPHERES

B. W. Lifka
Aluminum Company of America
Alcoa Technical Center
Alcoa Center, PA 15069

ABSTRACT

Stress corrosion and exfoliation corrosion test specimens from aluminum alloy plates have completed five years of a scheduled 20 year exposure program in rural atmosphere at Alcoa Center, PA, industrial atmosphere at Los Angeles, CA, and seacoast atmosphere at Point Judith, RI. The materials being evaluated are 19 mm and 64 mm thick plates of the following nine alloys and tempers: 2024-T351 and T851, 5456-H116, 6061-T651, 7050-T7651 and T7451 and 7075-T651, T7651, and T7351. Test data are presented for 6 months, and 1, 2, and 5 years of exposure. In general, the effects of corrosion were most pronounced in the seacoast atmosphere and least in the rural atmosphere. An exception was more severe stress-corrosion cracking (SCC) of the 7xxx alloys in T7 type tempers in the high NO_x industrial atmosphere.

In addition, accelerated, laboratory tests to determine resistance to stress-corrosion cracking were conducted in 3.5% NaCl by alternate immersion according to ASTM G44. Likewise, resistance to exfoliation was evaluated by the "EXCO" procedure, ASTM G34, except that the "ASSET" procedure, ASTM G66 was used for the 5456 Al-Mg alloy plates. Results obtained in these laboratory tests are compared with those observed in the natural atmospheres.

INTRODUCTION

"The proof of the pudding is in the eating." Likewise, the proof of an alloy is in its performance. The accepted basis on which to judge the corrosion resistance of aluminum alloys is long-term performance in outdoor atmospheres. A recent publication by Sowinski and Sprowls[1] presents a critical summary of worldwide weathering tests of aluminum and its alloys, including a bibliography extending back to 1946. Their summary includes the three geographical test sites used in this current test program.

Accelerated laboratory tests do not precisely predict long-term corrosion behavior. However, early answers are

PAPER NUMBER

421

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

TWENTY-YEAR ATMOSPHERIC CORROSION TESTS OF HOT-DIP COATED SHEET STEEL

H. E. Townsend
Bethlehem Steel Corporation
Homer Research Laboratories
Bethlehem, PA 18016

A. R. Borzillo
BIEC International, Inc.
Steel Group Offices
Bethlehem, PA 18016

ABSTRACT

Steel sheets coated with hot-dip aluminum, zinc, and a series of binary aluminum-zinc alloys have been tested for corrosion resistance in marine, industrial, and rural environments for twenty years. The results of these tests show that, compared to zinc coatings, a 55% Al-Zn alloy coating is several times more durable. Compared to aluminum coatings, the 55% Al-Zn coating provides superior galvanic protection in industrial and rural environments, and has much better resistance to crevice corrosion in marine environments. These tests demonstrate conclusively that, among alloy coatings within the Al-Zn binary system, the 55% Al-Zn alloy coating provides the best combination of durability and galvanic characteristics for long-term corrosion protection of sheet steel.

55% Al-Zn alloy coatings produced on a large-scale commercial coating line exhibited greater durability than those produced earlier on a pilot laboratory facility. This difference is attributed to decreased corrosivity of the test environments and to improvements in the coating process. These improvements include faster cooling of the coating during solidification and application of chromate passivation.

INTRODUCTION

The purpose of this paper is to present results of 20 years of atmospheric corrosion testing of steel sheet protected with hot-dip coatings based on zinc, aluminum, and their alloys. Hot-dip coatings are applied to steel sheet in coil form by dipping in a bath of molten coating metal in a continuous process. They are an effective and economically sound means of providing long-term protection to steel against atmospheric corrosion. Steel sheet protected by hot-dip coatings are used for a wide variety of applications in the construction, automotive, and appliance industries.

PAPER NUMBER

427

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

STEEL STRUCTURES COATING WITH ZINC METALLIZING

Pierre Grenon, ing.

Ministère des Transports

2700, rue Einstein

Sainte-Foy, Québec, CANADA

G1P 3W8

ABSTRACT

In Quebec, because of our climate, the bridges and structures maintenance constitutes a serious and costly problem. The period for the application of corrosion protective coatings is rather short: the working season starts with May to finish with the end of October, from which we must subtract the days of raining and severe humidity. The large temperature variation between the winter and the summer, - 30 C to +30 C, has a disastrous effect on certain coatings that have contraction and expansion coefficients quite different from the steel coefficient, which results in coating cracking and peeling. Moreover, the industrial pollution and above all the application of de-icing salts on the traffic lanes strongly damage the corrosion protective coatings and consequently reduce the steel structure useful life.

We have tried to solve that problem by using a type of coating that could resist corrosion during a longer period. On quite a few bridges and overpasses, we have used zinc coatings by metallizing. This discussion of our field experiences for different type of environments, tells how the application of a sealer over the zinc coating improves substantially the corrosion resistance longevity.

INTRODUCTION

This study comes from the observations of the main structures in Quebec which were coated with zinc by metallizing (1). The report includes photos (all taken in July 85) in order to allow a good comparison between all the structures, relativeto the actual coating time, the type of environments and the way the coating process was realized .

First, we divide the metallized structures into two groups: structures metallized between 1971 and 1974, without any protection over the zinc coating, and the structures metallized between 1977 and 1984 with a wash primer and two coats of vinyl paint over the zinc.

STEEL STRUCTURES STATE

During the construction period and the field erection, most generally, these structures had been coated with two layers of basic lead silico-chromate paint and sealed with a layer of enamel paint.

PAPER NUMBER

431

Corrosion 87

March 9-13, 1987
Moscone Center / San Francisco, California

TWENTY YEARS OF

WEATHERING STEEL PERFORMANCE

R. Heidersbach
Metallurgical Engineering
California Polytechnic State University
San Luis Obispo, CA 93407

W. Paden and R. Erbar
Chemical Engineering
Oklahoma State University
Stillwater, OK 74078

ABSTRACT

This paper discusses how weathering steels have been used for buildings, highway structures, and similar applications. The problems which have developed after twenty years of use are discussed along with suggestions on how they could have been avoided.

INTRODUCTION

Weathering steels are a special class of high strength, low alloy (HSLA) structural steels which were developed for their resistance to atmospheric corrosion (1). They were developed using standard test procedures for determining the relative atmospheric corrosion resistance of alloys. Figure 1 shows a typical atmospheric exposure test site with flat panel specimens exposed at an angle (neither vertical nor horizontal). While a number of other arrangements are possible, the specimen geometry and exposure methods shown in Figure 1 were used for most of the research and development testing for weathering steels (2-4).

Test panels exposed to atmospheric corrosion in racks like those shown in Figure 1 can be analyzed in a number of ways. Corrosion products can be analyzed (5-6). More often, these corrosion products are stripped from the sample and the remaining metal is weighed. Weight loss data can be reported directly, but more often it is converted to average penetration rates. This is the type of information reported in most