

European Federation of Corrosion  
Publications

NUMBER 26

**Advances in Corrosion Control and  
Materials in Oil and Gas Production**

Papers from EUROCORR '97 and EUROCORR '98

*Edited by*

*P. S. JACKMAN AND L. M. SMITH*

*Published for the European Federation of Corrosion  
by IOM Communications*



Book Number 715  
Published in 1999 by IOM Communications Ltd  
1 Carlton House Terrace, London SW1Y 5DB

IOM Communications Ltd  
is a wholly-owned subsidiary of  
The Institute of Materials

© 1999 IOM Communications Ltd

All rights reserved

ISBN 1-86125-092-4

Neither the EFC nor The Institute of Materials  
is responsible for any views expressed  
in this publication

Design and production by  
SPIRES Design Partnership

Made and printed in Great Britain

---

**Part 6 – Corrosion Inhibitors** **399**

---

- 41.** Adsorption Isotherms for an Amine Based Fatty Acid Corrosion Inhibitor on Carbon Steel in CO<sub>2</sub>-Saturated Solutions 401  
*J. BUCHWEISHAIJA AND G. HAGEN*
- 42.** The Effect of Diamines on CO<sub>2</sub> Corrosion of Low Carbon Steel 410  
*T. BURCHARDT, T. VÅLAND AND J. KVAREKVÅL*
- 43.** Effect of Pre-Corrosion on the Performance of Inhibitors for CO<sub>2</sub> Corrosion of Carbon Steel 417  
*E. GULBRANDSEN, B. SUNDFÆR, S. M. HESJEVIK, S. SKJERVE, S. NESIC AND T. BURCHARD*
- 44.** Field Trials Using a New Generation of Electrical Resistance Probe for the Optimisation of Chemical Corrosion Inhibitors for Oilfield Applications 424  
*B. RIDD, R. JOHNSEN AND D. QUEEN*
- 45.** Inhibition of Vapour Phase Corrosion in Gas Pipelines 430  
*R. L. MARTIN*

---

**Part 7 – Non-Metallics** **439**

---

- 46.** Service Experience with Glass Reinforced Epoxy Pipelines and the Way Forward 441  
*S. R. FROST, M. R. KLEIN, S. J. PATERSON AND G. E. SCHOOLENBERG*
- 47.** New Ceramic–Metallic Materials for Choke Valves in Oil Production 453  
*J. H. AHLEN, E. BARDAL, L. MARKEN AND T. SOLEM*
- List of Abbreviations* 461
- Index* 463

33. Serviceability of 13% Chromium Tubulars in Oil and Gas Production Environments 332  
*M. S. CAYARD AND R. D. KANE*

---

**Part 4 – Corrosion Resistant Alloys** 341

---

34. Localised Corrosion of some Selected Corrosion Resistant Alloys in the Presence of Very High Salinity 343  
*T. CHELDI AND L. SCOPPIO*
35. High-Strength Corrosion Resistant Nickel-Base Alloys for Oilfield Applications 352  
*E. L. HIBNER, C. S. TASSEN AND P. W. RICE*
36. Effect of Alloy Nickel Content vs Pitting Resistance Equivalent Number (PREN) on the Selection of Austenitic Oil Country Tubular Goods for Sour Gas Service 358  
*E. L. HIBNER, C. S. TASSEN AND J. W. SKOGSBERG*
37. Effect of Grain Size on Stress Corrosion Cracking Resistance of Alloy G-3 (UNS N06985) OCTG in Sour Gas Environments 363  
*E. L. HIBNER AND C. S. TASSEN*

---

**Part 5 – Galvanic Corrosion** 367

---

38. Galvanic Corrosion — Principles and Practice for Use of Titanium 369  
*D. K. PEACOCK*
39. Performance of Cold-worked Duplex Stainless Steels in Oilfield Environments under Cathodic Charging Currents Appropriate to Galvanic Coupling Conditions 379  
*A. J. GRIFFITHS AND A. TURNBULL*
40. Galvanic Corrosion in Oil and Gas Environments 386  
*T. HARA, H. ASAHU AND H. KANETA*

---

<b>Part 3 – Martensitic Stainless Steels</b>	<b>217</b>
<hr/>	
22. Corrosion Resistance of Weldable Modified 13Cr Stainless Steel for CO <sub>2</sub> Applications <i>H. TAKABE, H. AMAYA, H. HIRATA AND M. UEDA</i>	219
23. Corrosion Performance of Weldable 12% Chromium Stainless Steel Seamless Line Pipes <i>Y. MIYATA, M. KIMURA, T. TOYOOKA, Y. NAKANO AND F. MURASE</i>	231
24. Corrosion Properties and Application Limit of Sour Resistant 13% Chromium Steel Tubing with Improved CO <sub>2</sub> Corrosion Resistance <i>H. ASAHI, T. HARA AND S. SAKAMOTO</i>	242
25. Weldable 13% Chromium Steel: The Development of the Components for a Wet Gas Piping System <i>I. J. DUFRANE, E. FRANCESCHETTI, J. HEATHER AND H. VAN DER WINDEN</i>	249
26. Fabricating Pipeline Bundles Using Modified Weldable 13% Chromium Stainless Steel Flowlines <i>TRICIA BARNETT</i>	259
27. Corrosion Resistance of 13% Chromium Stainless Steel Welded Joints in Flow Line Applications <i>M. UEDA, H. AMAYA, H. HIRATA, K. KONDO, Y. MURATA AND Y. KOMIZO</i>	267
28. Slow Strain Rate Testing of Low Carbon Martensitic Stainless Steels <i>T.H. BOELLINGHAUS, H. HOFFMEISTER AND S. DIETRICH</i>	274
29. On-line Sulfide Stress Cracking Monitoring of 13% Cr Pipe Welds at Realistic Weld Restraint Conditions in the Instrumented Restraint Cracking (IRC) Test <i>T.H. BOELLINGHAUS, H. HOFFMEISTER AND M. LITTICH</i>	286
30. Effect of Hydrogen Sulfide Partial Pressure, pH and Chloride Content on the SSC Resistance of Martensitic Stainless Steels and Martensitic Precipitation Hardening Stainless Steels <i>D. D. VITALE</i>	304
31. Evaluation of 13%Chromium Martensitic Stainless Steel in H <sub>2</sub> S-Containing Environments by using the Contact Electric Resistance and Impedance Techniques <i>K. SAARINEN AND J. HILDÉN</i>	314
32. Passivity and Passivity Breakdown of 13%Cr, 15%Cr and 13Cr5Ni2MoN Stainless Steels in Chloride-Containing Solutions <i>N. DE CRISTOFARO</i>	322

<b>8. Effect of Environmental Factors and Microstructure on CO<sub>2</sub> Corrosion of Carbon and Cr-bearing Steels</b> <i>M. UEDA AND H. TAKABE</i>	93
<b>9. Effects of Chromium Contents of Low-alloyed Steel and of Dissolved Oxygen in Aqueous Solution on Carbon Dioxide Corrosion</b> <i>K. NOSE, T. ISHITSUKA, H. ASAHI AND H. TAMEHIRO</i>	105
<b>10. The Influence of Small Amounts of H<sub>2</sub>S on CO<sub>2</sub> Corrosion of Iron and Carbon Steel</b> <i>J. KVAREKVÅL</i>	114
<b>11. Hydrogen-Related Stress Corrosion Cracking in Line Pipe Steel</b> <i>L. V. NIELSEN</i>	120
<b>12. The Role of Microstructure in Sulfide Stress Cracking Resistance of Thermomechanically Processed High Strength Low Alloy Steels</b> <i>A. GINGELL AND X. GARAT</i>	127
<b>13. The Effect of Microstructure on the <math>K_{ISCC}</math> of Low Carbon Low Alloy Steels</b> <i>G. ECHANIZ, C. MORALES AND T. PÉREZ</i>	135
<b>14. Coiled Tubing and Pipe for CO<sub>2</sub> and H<sub>2</sub>S Service</b> <i>R. P. BADRAK</i>	141
<b>15. Coiled Tubing Innovations for Corrosive Service</b> <i>R. P. BADRAK</i>	149
<b>16. Weld Corrosion — Chemical, Electrochemical and Hydrodynamic Issues, Inconsistencies and Models</b> <i>J. L. DAWSON, J. W. PALMER, P. J. MORELAND AND G. E. DICKEN</i>	155
<b>17. Experimental Simulation of Multiphase Flow for Assessing System Corrosivity</b> <i>S. SRINIVASAN AND R. D. KANE</i>	170
<b>18. Investigation of Premature Failure of a Well fluid Pipeline in an Indian Offshore Installation</b> <i>A. K. SAMANT, V. K. SHARMA, S. THOMAS, P. F. ANTO AND S. K. SINGH</i>	180
<b>19. Corrosion Resistance of Thermomechanical Control Process (TMCP) Steels for Cargo Oil Tanks of Very Large Crude Oil Carriers (VLCC)</b> <i>H. MIYUKI, A. USAMI, K. MASAMURA, Y. YAMANE AND Y. KOBAYASHI</i>	188
<b>20. Effect of Applied Potential on Cracking of Low-alloyed Pipeline Steel in Low pH Soil Environment</b> <i>M. TOUZET, N. LOPEZ AND M. PUIGGALI</i>	198
<b>21. Finding Optimum Positions for Field Signature Method (FSM) Corrosion Monitoring of Oil and Gas Pipelines</b> <i>P. O. GARTLAND</i>	210

## Preface

This EFC publication incorporates papers from the sessions at *EUROCORR '97* and *EUROCORR '98* dealing with Corrosion in Oil and Gas Production. These conference sessions, and attendant workshops, are run by EFC Working Party 13. This Working Party has over 200 members coming from 26 countries throughout the world. Over 80% of members are employed in the oil and gas producing industries, in engineering design houses, in industrial research laboratories or in manufacturing industries. As such the work of EFC Working Party 13 is led by the needs of industry rather than by academia. This is obvious from the content of the 47 papers contained in this publication.

The proceedings are opened by two keynote papers from leading experts in the understanding and control of Corrosion in Oil and Gas Production: Dr S. D. Kapusta, Shell International, The Netherlands and Professor G. Schmitt from Iserlohn University, Germany.

The remaining papers have been separated into six broad topics:

- Carbon and alloy steels
- Martensitic stainless steels
- Corrosion resistant alloys
- Galvanic corrosion
- Corrosion inhibitors, and
- Non-metallic materials.

Within these topics authors have explained new developments in the design of alloys, particularly in martensitic stainless steels, and have improved the understanding of corrosion, and corrosion mitigation, in a wide range of materials from carbon steels to corrosion resistant alloys, reinforced plastics and ceramics. Coming from the need to control corrosion in oil and gas production, the papers deal extensively with corrosion in carbon dioxide, hydrogen sulfide and chloride containing environments.

The contribution made by each of the authors represented here must be gratefully acknowledged. Without their willing help the *EUROCORR* conferences and this EFC publication would not be possible. The organising committees of *EUROCORR '97* and *EUROCORR '98* are also sincerely thanked.

Finally, thanks are due to Dr L. M. Smith. As previous chairman of Working Party 13 she organised the conference sessions at *EUROCORR '97*. She also reviewed the papers contained in this volume in order to write the Foreword.

**P. S. JACKMAN**

*Expert Metallurgy Services Limited, United Kingdom*

*Chairman of EFC Working Party 13 on Corrosion in Oil and Gas Production*