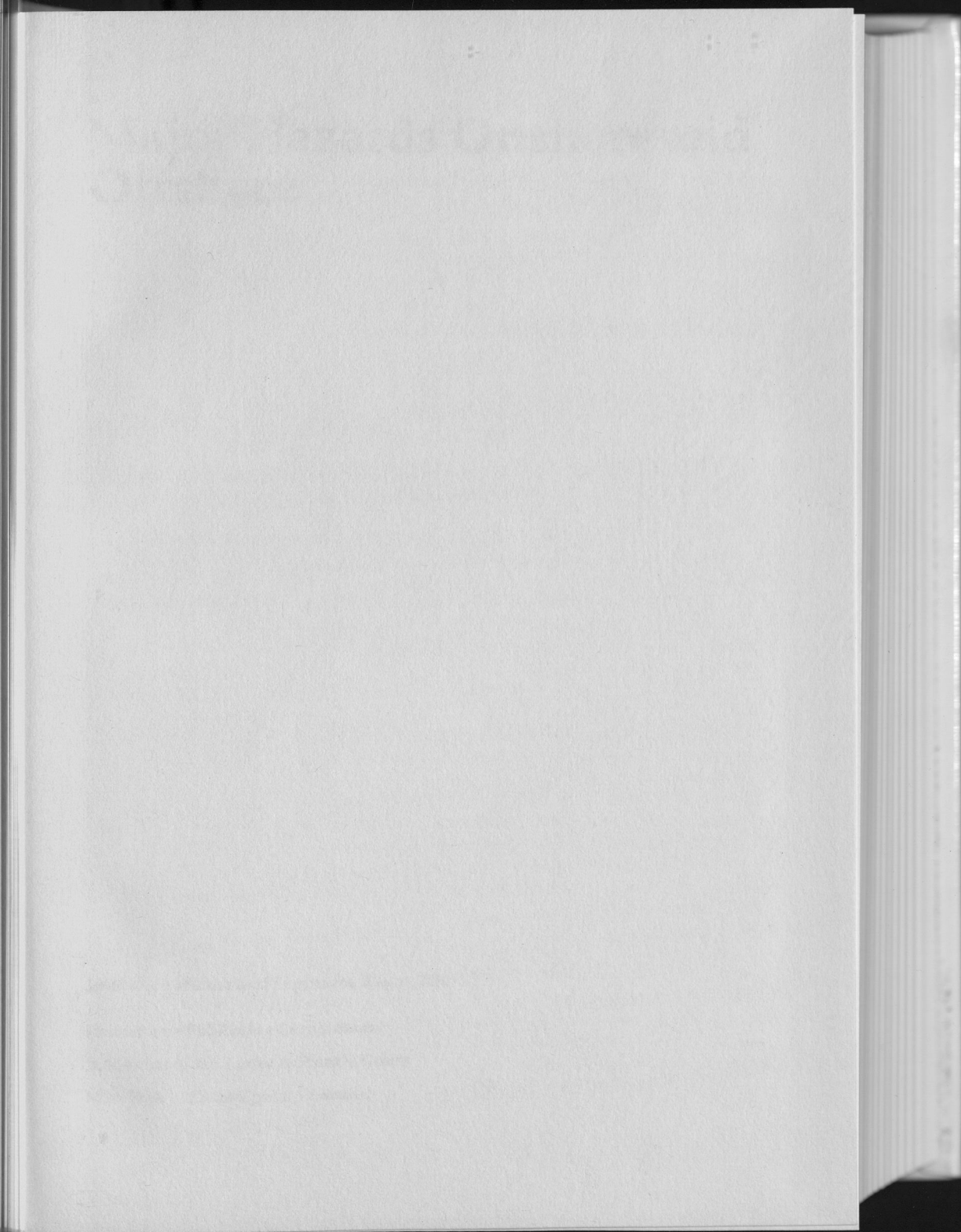
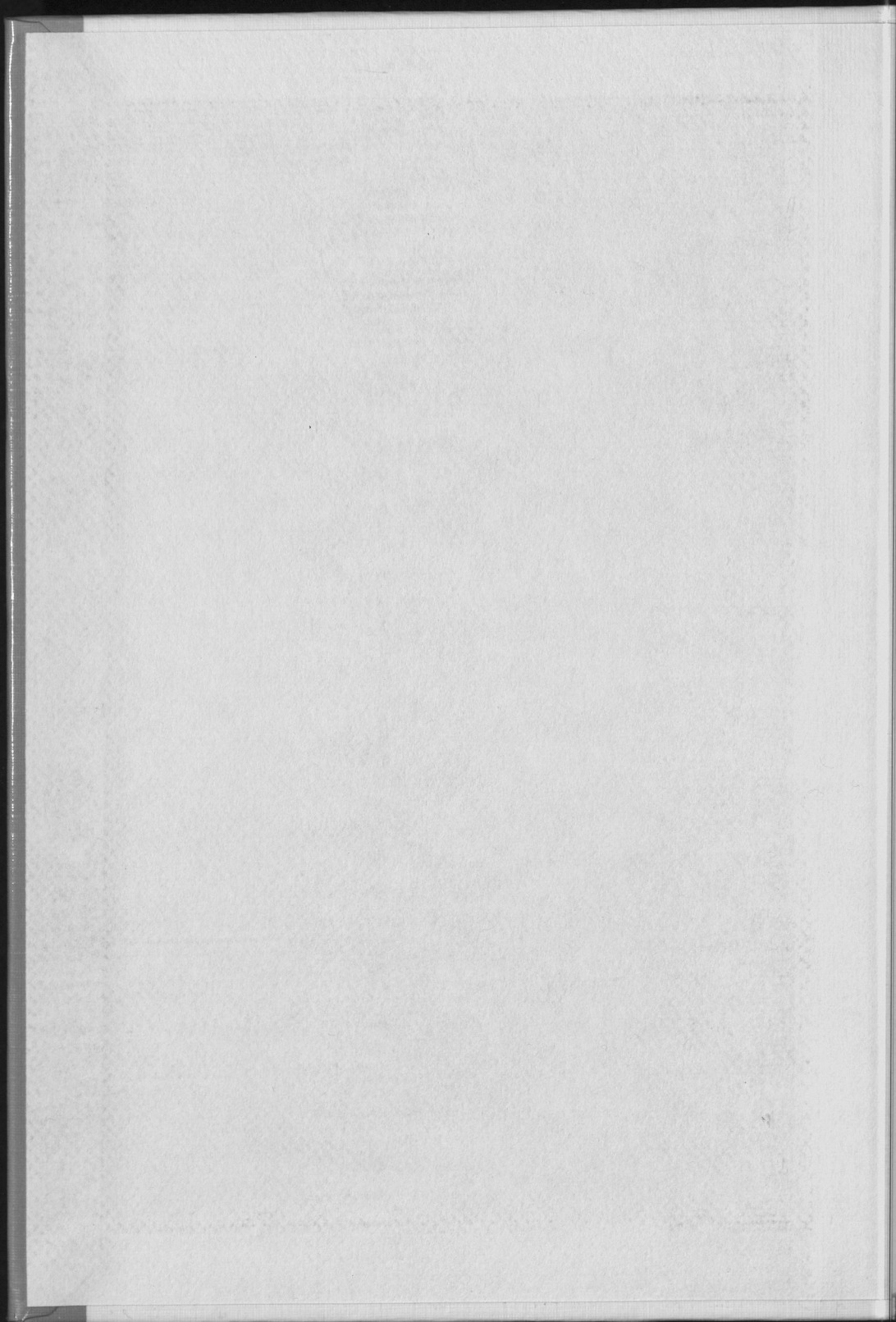


# Major Hazards Onshore and Offshore







# Major Hazards Onshore and Offshore

Institution of Chemical Engineers, Rugby, UK

Hemisphere Publishing Corporation

A Member of the Taylor & Francis Group

New York Philadelphia London

## Major Hazards Onshore and Offshore

Members of the Institution of Chemical Engineers should order as follows:

Worldwide Institution of Chemical Engineers,  
Davis Building,  
165-171 Railway Terrace, RUGBY,  
Warwickshire CV21 3HQ, UK

Non-members' orders should be directed as follows:

UK, Eire and  
Australia Institution of Chemical Engineers,  
Davis Building,  
165-171 Railway Terrace, RUGBY,  
Warwickshire CV21 3HQ, UK

or Taylor & Francis Ltd, Rankine Road, BASINGSTOKE,  
Hampshire RG24 0PR, UK

USA Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol,  
PA 19007, USA

Rest of the World Taylor & Francis Ltd, Rankine Road, BASINGSTOKE,  
Hampshire RG24 0PR, UK

### Library of Congress Cataloging-in-Publication Data

Major hazards onshore and offshore.

p. cm. — (Symposium series/Institution of Chemical Engineers; no. 130) (EFCE publication; no. 93)

"A three day symposium organised by the Institution of Chemical Engineers (North Western Branch) and held at UMIST, Manchester, 20-22 October 1992" — P. 111.

"EFCE event no. 470" — P. 111.

ISBN 0-85295-283-X (ICE). — ISBN 1-56032-259-4 (Hemisphere): \$195.00

1. Industrial safety — Congresses. 2. Offshore oil industry — Safety measures — Congresses.

3. Chemical engineering — Safety measures — Congresses. I. Institution of Chemical Engineers (Great Britain). North Western Branch. II. Series: Symposium series (Institution of Chemical Engineers (Great Britain)); no. 130. III. Series: EFCE publication series; no. 93.

T55. A1M34 1992

660'. 2804 — dc20

92-33319

CIP

### Copyright © 1992 Institution of Chemical Engineers

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any forms or by any means: electronic, electrostatic, magnetic tape, mechanical, photocopying or otherwise, without permission in writing from the copyright owner. Opinions expressed in the papers in this volume are those of the individual authors and not necessarily those of the Institution of Chemical Engineers or of the Organising Committee.

## Major Hazards Onshore and Offshore

A three day symposium organised by the Institution of Chemical Engineers (North Western Branch) and held at UMIST, Manchester, 20-22 October 1992.

### Organising Committee

N. Gibson (Chairman)	Burgoyne Consultants Ltd
A.C. Barrell	HSE
J.A. Barton	HSE
D.C. Bull	Shell Chemicals
J.H. Burgoyne CBE	Consultant
A.L. Clarke	Huntsman Chemical Company Ltd
K. Dixon-Jackson	Ciba-Geigy
R. Dooner	National Vulcan Engineering
T.A. Kletz	Consultant
G.S. Melville	Burgoyne Consultants Ltd
M.F. Pantony	HSE
R.L. Rogers	ICI plc
R.C. Santon	HSE
A.I. Thompson	Consultant

### INSTITUTION OF CHEMICAL ENGINEERS

SYMPOSIUM SERIES No. 130

EFCE Event No. 470

EFCE Publication No. 93

ISBN 0 85295 283 X



## Preface

This symposium continues the tradition of bringing together papers on a topic of current interest and importance in terms of process safety — in this case, Major Hazards Onshore and Offshore.

Lord Cullen in his report on the Piper Alpha disaster has, in effect, suggested that the experience gained in the control of major hazards onshore during the 1980s should be applied to improve safety offshore during the 1990s. This major three-day symposium reviews what has been learned so far with regard to major hazards and considers its present and future applications both onshore and offshore.

The topics covered in the programme are wide ranging and deal with all aspects of legislation, the application of regulations, techniques for evaluating hazards and prescribing safety measures in design, construction and operation, the importance of the human factors, and recent technical developments in protective measures, relief venting and predicting the consequences of fires and explosions.

The discussion sessions and informal contacts will provide an opportunity for participants from the regulatory authorities, industry and academia to exchange information on developments in safety both onshore and offshore.

Norbert Gibson  
(Chairman)

## Errata

Paper 33 (page 507): A model for predicting thermal radiation hazards from large-scale LNG pool fires (A.D. Johnson).

On page 522, the Y-axis for Figure 5 should read:

Total radiated power per unit pool area, MW/m<sup>2</sup>

## Contents

### Raising the Issues

- Paper 1 Control of major hazards offshore — implementing Lord Cullen's recommendations  
Page 1 A.C. Barrell (*Offshore Safety Division, HSE, UK*)
- Paper 2 Major hazards — the development of European and UK legislation over 20 years  
Page 15 A.J. Williams (*Hazardous Installation Policy Branch, HSE, UK*)
- Paper 3 Management responsibility for offshore safety  
Page 27 J. King (*Offshore Safety Division, HSE, UK*)
- Paper 4 Proposed offshore safety cases — a comparison with onshore CIMAH cases  
Page 39 D.P. Mansfield (*SRD, AEA Technology, UK*)
- Paper 5 One company's experience of formal safety assessment and preparation of offshore safety cases  
Page 49 M.J. Wendes (*BP Exploration, UK*)

### Management and Assessment of Risk

- Paper 6 Comparison of event tree, fault tree and Markov methods for probabilistic safety assessment and application to accident mitigation  
Page 59 H. James (*ICI, FCMO, UK*), M.J. Harris (*University of Manchester, UK*) and S.F. Hall (*SRD, AEA Technology, UK*)
- Paper 7 A comparative study of the management effectiveness of two technically similar major hazards sites  
Page 73 J.C. Williams (*DNV Technica, Norway*) and N.W. Hurst (*HSE, UK*)
- Paper 8 Assessment and management of risks to the environment  
Page 85 S. Welsh (*HSE, UK*)
- Paper 9 Performance of passive fire protection in jet fires  
Page 111 L.C. Shirvill (*Shell Research Ltd, UK*)



## Management of Hazards

- Paper 9 Cracking health and safety management  
Page 123 A. Bleeze (*Accident Prevention Advisory Unit, HSE, UK*)
- Paper 10 Research models of safety management of onshore major hazards and their possible application to offshore safety  
Page 129 N.W. Hurst (*HSE, UK*), L.J. Bellamy and M.S. Wright (*Four Elements Ltd, UK*)
- Paper 11 Safety management offshore system requirements  
Page 149 D.J. McKeever and R. Lawrenson (*SRD, AEA Technology, UK*)
- Paper 12 Management of safety — permit-to-work systems  
Page 171 S.Scott (*Chemical Manufacturing NIG, HSE, UK*)
- Paper 13 Protective device faults — vulnerability to management failure  
Page 183 A.G. Rushton (*University of Technology, Loughborough, UK*)

## Protective Measures and Relief/Venting

- Paper 14 Blowdown of vessels and pipelines  
Page 195 S.M. Richardson and G. Saville (*Imperial College, London, UK*)
- Paper 15 Some experimental aspects of transient releases of pressurised liquefied gases  
Page 211 R.G. Bettis and S.F. Jagger (*Explosion and Flame Laboratory, HSE, UK*)
- Paper 16 Pressure relief and two-phase flow  
Page 229 S. Selmer-Olsen (*DNV Technica, Norway*)
- Paper 17 Safe disposal of reactive chemicals following emergency venting  
Page 249 J. Singh (*Hazard Evaluation Laboratory, UK*)
- Paper 18 Security of electrical supply systems including standby supplies  
Page 275 J.A. McLean (*Technology and Health Sciences Division, HSE, UK*)

- Paper 19 The use of fire and gas detection systems as part of the safety control package  
Page 283 I.G. Buckland (*Technology and Health Sciences Division, HSE, UK*)

## Training and Human Factors

- Paper 20 Training process control skills  
Page 293 A. Shepherd (*University of Technology, Loughborough, UK*)
- Paper 21 A methodological approach to the development of an industrial emergency response system  
Page 307 P. Marsden, M. Ferrario and M. Green (*Human Reliability Associates Ltd, UK*)
- Paper 22 Human factors onshore and offshore  
Page 319 M.A. Needham (*HSE, UK*)
- Paper 23 Quantitative and qualitative prediction of human error in safety assessments  
Page 329 D.E. Embrey (*Human Reliability Associates Ltd, UK*)

## Protective measures and relief/venting — continued

- Paper 24 Advances in gas cloud dispersion modelling: heavy clouds on sloping ground  
Page 351 D.M. Webber, S.J. Jones and D. Martin (*SRD, AEA Technology, UK*)
- Paper 25 Computer simulations of wind and ventilation aid platform design and safety  
Page 375 A. Ronold (*DNV Technica, Norway*)
- Paper 26 Investigation into the use of active detonation arresters for solvent and waste gas recovery systems  
Page 385 S.P.Cooper, P.E. Moore (*Kidde-Graviner Ltd, UK*), B. Capp (*HSE, UK*) and J.Seneca (*Fenwal Combustion Research Center, USA*)
- Paper 27 Venting of gaseous explosions  
Page 411 W.P.M. Mercx, C.J.M. van Wingerden and H.J. Pasman (*TNO Prins Maurits Laboratory, The Netherlands*)

## Identification and Assessment of Risk

- Paper 28 Can we identify potential major hazards?  
Page 427 F.K. Crawley, M.M. Grant and M.D. Green (*W.S Atkins Safety and Reliability, UK*)
- Paper 29 Life cycle risk assessment and implementation on an expansion project for a hazardous facility  
Page 439 R.P. Argent, P. Cook and P. Goldstone (*Air Products plc, UK*)
- Paper 30 Loss estimation for refineries and chemical plant and risk improvement  
Page 459 R.T. Canaway (*Suregrove Ltd, UK*)
- Paper 31 Calibrating hazop studies  
Page 483 G.C. Stevens and A.M. Humphreys (*Arthur D. Little Ltd, UK*)

## Fire and Explosion

- Paper 32 FIRE 2: a new approach for predicting thermal radiation levels from hydrocarbon pool fires  
Page 491 M.J. Pritchard and T.M. Binding (*British Gas plc, UK*)
- Paper 33 A model for predicting thermal radiation hazards from large-scale LNG pool fires  
Page 507 A.D. Johnson (*Shell Research Ltd, UK*)
- Paper 34 Spherical explosions aggravated by obstacles  
Page 525 H. Phylaktou, G.E. Andrews, N. Mounter and K.M. Khamis (*University of Leeds, UK*)
- Paper 35 Explosion hazard assessment of offshore modules using 1/12 scale models  
Page 543 B. Samuel (*Shell Research Ltd, UK*)
- Paper 36 A method for preliminary design of fire protection requirements on an offshore oil production platform  
Page 559 G. Dalzell (*BP Exploration, UK*) and G.S. Melville (*Burgoyne Consultants Ltd, UK*)

## Assessment of Risk

- Paper 37 The role of QRA in offshore safety cases  
Page 593 R.P. Pape (*Offshore Safety Division, HSE, UK*)
- Paper 38 Health and Safety Executive's risk assessment tool  
Page 607 RISKAT  
C. Nussey (*Research and Laboratory Services Division, HSE, UK*), M.F. Pantony and R.J. Smallwood (*Technology and Health Sciences Division, HSE, UK*)
- Paper 39 An approach to the quantitative evaluation of safety on existing mobile drilling units  
Page 639 C.P. Sherrard (*Lloyd's Register of Shipping, UK*)
- Paper 40 Pipeline risk analysis  
Page 657 R.T. Hill (*Arthur D. Little Ltd, UK*)

## Emergency shutdown and escape

- Paper 41 Emergency shutdown systems in onshore and offshore process operations  
Page 671 J. Pearson (*HSE, UK*)
- Paper 42 Simulation of evacuation, escape and rescue  
Page 679 A. Førland (*DNV Technica, Norway*)
- Paper 43 Analytical methods and working experience with post-Cullen analysis of evacuation, escape and rescue  
Page 689 J.H. Forster (*SRD Oil and Gas, AEA Technology, UK*) and N. Wong (*Amoco UK Exploration Company, UK*)
- Paper 44 The assessment of evacuation, escape and rescue provisions on offshore installations  
Page 713 I.G. Wallace (*Neste Production Ltd, UK*)
- Page 729 Index