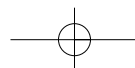
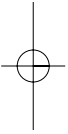
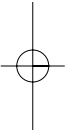
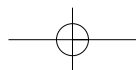
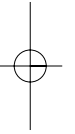
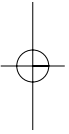




Plastic Pipe Systems





Plastic Pipe Systems

Failure Investigation and Diagnosis

Mehdi Farshad

Swiss Federal Laboratories for Materials

Testing and Research

EMPA, Switzerland

2006



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First edition 2006

ISBN-13: 978-1-85-617496-1

ISBN-10: 1-85-617496-4

©The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

Printed in Great Britain

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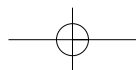
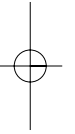
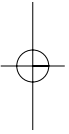
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About the author



Prof. Dr. Mehdi Farshad has academic degrees in civil engineering and engineering mechanics including B.S. from Tehran University, M.S. and C.E. from Columbia University, and Ph.D. in from Stanford University in USA. From 1971 to 1991 he was engineering professor at the University of Shiraz. During this period, he spent 2 years as guest professor at the University of Toronto, Canada. Since 1991, Prof. Farshad has been a Senior Research Scientist at EMPA (Swiss Federal Laboratories for Materials Testing and Research) in Switzerland and Titular Professor at ETH (Swiss Federal Institute of Technology) in Zürich, where he has been teaching courses in several branches of engineering sciences and conducting applied research and technical consulting activities. His areas of specialties include polymeric and composite materials, structural engineering, shell structures, stability, finite element simulations, biomechanics, and pipeline engineering. Prof. Farshad is the author of about 200 research papers and 30 books, including “Design and analysis of shell structures” and “Stability of Structures”. He has lead several international research programs and has been involved in conception, design, and realization of numerous professional engineering projects and technical expertise, failure investigations, and structural rehabilitation. He is the member of several international standardization committees, an external evaluator for SAS (Swiss Federal Accreditation) organization, a member of the Chamber of Swiss Experts, founding member of academy of sciences, and winner of several awards and honors. Prof. Farshad is the developer of the pipeline structural analysis and design program ADAP and the founder of an EMPA spin-off the *Farshad Technical Consulting* enterprise in Switzerland (www.farshad.ch).



Preface

Pipe systems are one of the most reliable and safest means of transfer of mater and energy. They are, in fact, the *lifelines* of communities. New materials such as plastic products and composites have enhanced the domain of application of material systems in pipelines. Plastic pipes have salient features such as low weight, ease of connection, and corrosion resistance. Like any other installations, however, statistical cases of malfunction and failure may occasionally occur in piping systems. An objective failure investigation of such incidents can prove to be very instructive for health monitoring, safety, maintenance, retrofitting, and life cycle management of pipelines. Hence, the knowledge gained from numerous failure investigations together with a sound scientific and engineering basis should become available to manufacturers, planers, users, and engineers dealing with piping systems. Due to ageing of the existing pipelines, this topic may gain more importance in the coming years. Therefore, the need for systematic investigation procedure, proper diagnosis, health monitoring, and decisions as well as the rehabilitation methods is expected to increase in the future.

In this book, a reference guideline dealing with the failure analysis of various pipes and in particular plastic and composite pipes is presented. The main motivations for composition of this book have been: (1) need of a wide class of users, planers, and engineers for a simple pipe diagnosis system and (2) availability of a fair amount of experience and data on the failure analyses in the part of the author and his colleagues. This book is the result of many years of research, teaching, and practice as well as the experience in various failure investigations. In the first chapter of this book, an overview of polymeric materials, their properties, and plastic pipes are presented. The second chapter deals with a systematic procedure for failure investigation of plastic pipes. In Chapters 3–9 various potential modes of failure in plastic pipes are discussed. These chapters include basic features and underlying mechanisms of failure modes including crazing, cracking, fracture, buckling and large deformations, changes of color and dimension, local damages, delamination, corrosion, and clogging of plastic piping systems. Each of the above-mentioned chapters includes several case studies related to actual failure cases occurred in practice. The last chapter of this book presents a knowledge base for the plastic pipe failure investigations. The skeleton of this knowledge base can be used to create an expert system for a systematic pipe failure diagnosis. A glossary of plastics pipes is also enclosed.

This book has a condensed and reference-type configuration enriched with numerous tabular and graphic and photographic representations. It also contains numerous examples of actual failure cases occurred in pipelines, photographs of the failed pipe system, and a condensed description and diagnosis of the failure event. These case studies can be used as sample procedural guidelines for other cases. This book can be used as a reference manual by a relatively wide spectrum of users including technical

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personal of communities responsible for pipelines, engineers and planers, pipe manufacturers, pipeline authorities, and standardization organizations.

I would like to thank the EMPA colleagues and organizations, who directly or indirectly contributed to the collection of data, the failure investigation reports, and the useful discussions and collaborations in joint failure investigation and also to Dr. Peter Richner from EMPA for his support of this publication. I would like to express my gratitude to my wife, Gowhartaj, for her several decades of support, love, devotion, and care.

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