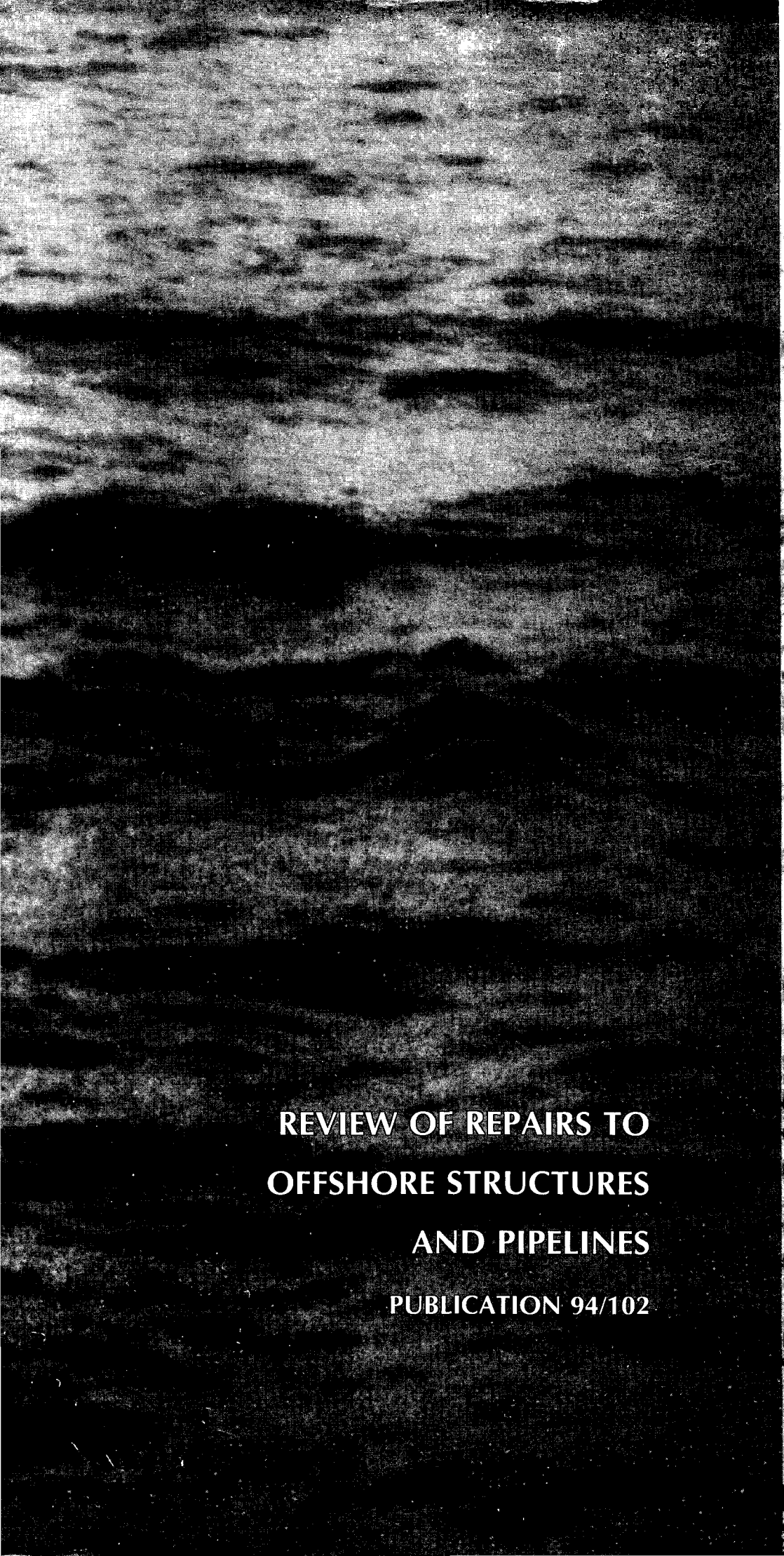

REVIEW OF REPAIRS TO OFFSHORE STRUCTURES AND PIPELINES

PUBLICATION 94/102

THE MARINE TECHNOLOGY DIRECTORATE LIMITED

ABOUT MTD

MTD (The Marine Technology Directorate Limited) is a UK-based international association of members having substantial interests and capabilities in ocean-related technology. The Members include industry, Government and other research establishments, academic institutions, the Engineering and Physical Sciences Research Council and the Royal Academy of Engineering. MTD advances research and development through its funding of marine technology in UK universities and polytechnics. It also initiates and manages *multi-sponsor projects* on behalf of groups of organisations requiring answers to problems common to the offshore and shipping industry.

The interests of MTD cover the whole field of marine technology (i.e. all aspects of engineering technology and science relating to the sea and to the exploitation and exploration of the sea, both below and above the seabed).

MTD operates programmes totalling over £6 million per year in three broad areas: research and development, education and training, and information dissemination.

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FOREWORD

This report results from a major review of repairs, which was initiated by The Marine Technology Directorate Limited as a multi-sponsor project funded by the organisations listed below.

A previous review, undertaken by the Underwater Engineering Group (UEG), was published in 1983, and many of the offshore operators and other organisations who found that review valuable supported the need for a new study to determine what repairs had been undertaken in the intervening decade.

The project was carried out under contract to MTD by Mr M Hordyk, Mr S Morahan and Dr C J Billington of Billington Osborne-Moss Engineering Ltd, with sub-contract work by Mr J J S Daniel of Jeremy Daniel and Co Ltd. Three of them were involved in the previous study, and their involvement in the new study provided continuity and a considerable understanding of the changes that had occurred.

The Project Manager at MTD was Mr R W Barrett.

The work was funded by the following organisations:

Amoco (U.K.) Exploration Co.	Phillips Petroleum Co UK Ltd
British Gas Exploration & Production Ltd	Texaco Britain Ltd
Elf UK plc	Total Oil Marine plc
Health and Safety Executive	Tecnomare SpA
Norwegian Petroleum Directorate	

The project was conducted under the guidance of a Steering Group which comprised:

Dr J V Sharp (Chairman)	Health and Safety Executive
Mr R W Barrett	MTD
Dr C J Billington	Billington Osborne-Moss Engineering Ltd
Ing R Brandi	Tecnomare SpA
Mr J J S Daniel	Jeremy Daniel & Co Ltd
Mr R Davies	Phillips Petroleum Co UK Ltd
Mr J P Derunes	Societe Nationale Elf Aquitaine
Mr M Hordyk	Billington Osborne-Moss Engineering Ltd
Mr T McIntyre	Texaco Britain Ltd
Mr D McShane	British Gas Exploration & Production Ltd
Mr N W Nichols	Marine Technology Support Unit
Mr K L Nilsson	Norwegian Petroleum Directorate
Mr J K Smith	Amoco (U.K.) Exploration Co.
Mr T Weir	Total Oil Marine plc

The raw data on repairs, collected from oil and gas operators as part of the project, remain confidential to the funding organisations listed above. However, a Lotus 123 disk version of the structural repairs data (not identifying any repair to a specific platform or operator) is available from MTD for those recipients of this report who require further statistical information from the survey. The report is a summary and analysis of those findings, and it has been released after a period of confidentiality to the sponsors, following completion of the project.

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SUMMARY

The study covered the sub-sea strengthening and repair of structures and pipelines used for, or associated with, the production, storage and transportation of hydrocarbons in the marine environment. This report therefore covers repairs on:

- fixed steel platforms (piled and gravity)
- concrete gravity platforms
- articulated or compliant structures
- floating production facilities (but not exploration drilling units or repairs carried out within a dock)
- sub-sea structures (including ancillary structures such as sub-sea valve housings).
- pipelines and flowlines.

The review is the most comprehensive study of its type yet undertaken with 172 repairs recorded, and it builds on the earlier 1982 review.

The data are analysed in various ways, including: cumulative total of platforms by construction material per installation year, cumulative repairs per national sector population, frequency of repairs per structure year versus water depth, causes of damage,repair types, number of repairs versus structure age, and reported costs.

The report contains conclusions and makes recommendations based on the findings. A Lotus 1-2-3 diskette, containing data on the structural repairs, is also available from MTD.

1. INTRODUCTION

In 1983, UEG published a review of repairs to structures in the North Sea[1]. This was the first comprehensive study on the causes of damage to offshore structures and it considered the various techniques used to repair the damage and the experience of using these techniques for some 60 underwater repairs which had been carried out up to that time.

The review was undertaken in 1982 at a time when the effects of fatigue loading on offshore structures were becoming apparent and were under active study. It was also at a time when the technology of repair systems was not widely understood and was held by only a limited number of engineering and technical contractors. The document was limited in a small way by a certain reluctance within the offshore industry to discuss publicly work on repair systems.

The review was widely circulated and received considerable acclaim. It was used by some operating companies as a primer upon which they developed a corporate strategy for offshore repairs.

By the end of the 1980s, a number of operating companies believed that it was time to undertake a second review. The intervening years had, for several reasons, produced a new crop of repairs. Many structures were approaching the end of their original design lives and might thus be more susceptible to damage. The fatigue design of structures had

become better understood, but older structures might now be suffering other problems such as corrosion. The newer structures with fewer bracing members and possibly with less structural redundancy, and with members being designed to more precisely defined design limits, might be introducing new problems. The new survey would be able to identify these. It would also be possible to review the performance of earlier repairs, some of which were themselves nearly 20 years old.

The Marine Technology Directorate Limited, who absorbed UEG, commissioned Billington Osborne-Moss Engineering Limited to undertake a new review of repairs with the objective of making available to designers, inspectors and operators of offshore structures and pipelines, a single reference document covering the industry experience of sub-sea strengthening and repairs.

The data gathering work for the new study was undertaken in 1992, and the project extended the first review in the following three ways:

- It assessed the performance of the repairs recorded in the 1983 review.
- It assessed the causes of damage to pipelines and the performance of pipeline repair systems.
- It investigated some repairs to structures outside the North West European Continental Shelf (NWECS).

2. SCOPE AND METHODOLOGY

2.1 Scope of the study

To be included in this review, the primary definition that a repair or strengthening system had to meet was that the remedial work was not planned during the design stages of the project. For example, if anodes were replaced as planned, the event was not included. However, if the anodes were found to be depleting faster than anticipated, the works required to correct the deficiency in the cathodic protection system would be included.

Although repairs to topsides were specifically excluded from the study, splash-zone damage was included, even when the repair was above the water line. The working definition adopted here was that the repair was included if sea conditions affected the repair activities. Thus some repairs to module support frames were included in the review. A problem of definition arose when a flare boom was damaged by a vessel impact, although in that case other structural damage ensured that the repair was included in the review.

Repairs to non-structural sub-sea elements were included, because they involve all the complexities of working at or below the sea surface. Often, there are structural consequences too (pile guides for example attract wave and current loadings, and caissons