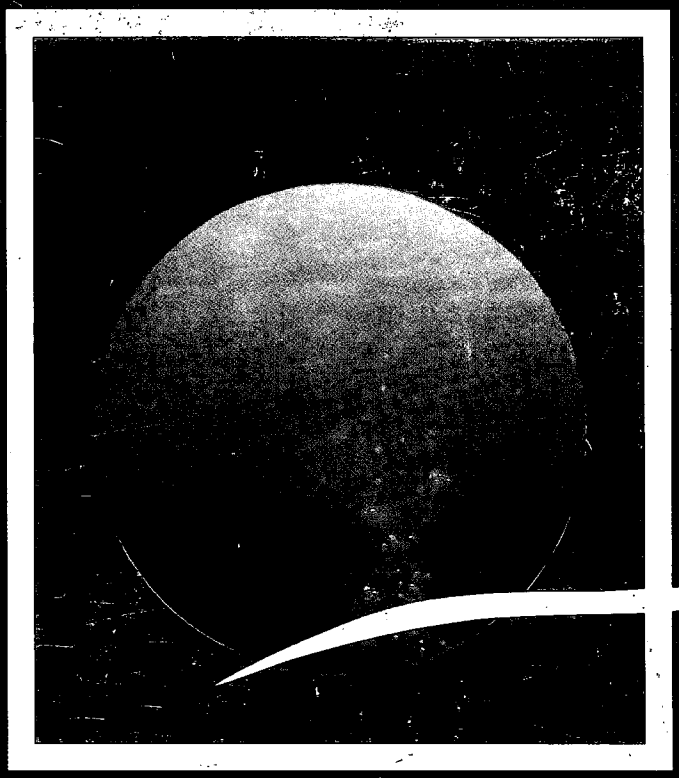
Probability-based fatigue inspection planning



THE MARINE TECHNOLOGY DIRECTORATE LIMITED

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MTD Ltd advances marine research and development, primarily by means of its research activities in Higher Education Institutes and partly funded by SERC. MTD Ltd also provides an interface between such research and the requirements and expertise of its members. Since its absorption of UEG, the research and information group for the offshore and underwater engineering industries, MTD Ltd has expanded its interests to include multi-sponsor projects.

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FOREWORD

This report results from one of seven individual projects that made up a major joint industry programme on underwater inspection of steel offshore structures. The programme was initiated by UEG and transferred to MTD Ltd as a part of the takeover arrangements. The overall report from the programme: "Underwater Inspection of Steel Offshore Installations: implementation of a new approach" was published as MTD Ltd Publication 89/104. However, in the absence of any significant advances in some of the material prepared during the course of the programme, selected reports, such as this one on probability-based fatigue inspection planning, are being published separately.

The project leading to this report was undertaken under contract to UEG (and transferred to MTD Ltd) by Dr H O Madsen of Det norske Veritas. The Project Manager responsible for its publication was Mr R W Barrett.

The original project was funded by the following participants:

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1. INTRODUCTION TO THE PROBABILISTIC APPROACH

Until now, structural reliability methods have been mainly applied to individual failure modes of single elements in a structure. In recent years, an increased interest in system reliability has arisen. It is now possible to compute failure probabilities for general systems – the difficult, and as yet not fully-solved, part is to model a structure with its failure modes as a system in reliability analysis terms. The objectives of this study were:

- To demonstrate the applicability of probabilistic methods to inspection planning
- To ascertain the importance of the principal input parameters for the probabilistic analysis and the sensitivity of the results to changes in these input parameters
- To investigate the effect of the use of different inspection techniques on the perceived reliability of a structural component
- To identify shortcomings in currently available probabilistic methods applied to real structures.

The study relates to the inspection of existing platforms, and it does not cover cases where, during design, an initial inspection plan is decided upon, together with materials, dimensions, etc.

The use of probabilistic methods in structural design is growing rapidly. There is now a general agreement on the approach behind the use of probabilistic methods in decision making: uncertainty modelling tools are accepted and unified. In addition, numerical techniques have been developed to efficiently compute failure probabilities and sensitivity factors. Such computer programs are now commercially available, and they are easily accessible to engineers. A general overview and introduction to the probabilistic approach to structural design is presented here, while a more detailed account of the available methods is presented in Madsen *et al*[1].

A probabilistic approach is applied to different aspects of design. Probabilistic methods are used for the determination of safety factors in structural codes and technical standards. The first such analysis was performed for the 1974 Canadian Standards Association Code, and since then almost all major codes for land-based and offshore structures have been through a formal calibration process. In recent years, probabilistic methods have also been directly used as a design tool, particularly to examine severe and rare failure modes, structures with severe failure consequences and for structures which are produced in large numbers. Very recently, the probabilistic method has been further developed to incorporate new information becoming available after the design process. Such information may become available during fabrication (e.g. compliance control of materials, and from service experience). Inspection and monitoring, as well as proof loading tests, provide important additional information. With the additional information, some of the uncertainty present at the design stage is removed, and improved decisions on repair, strengthening, inspection plan and change of use can be made. This is generally not possible to nearly the same extent using deterministic methods. Updating of design methods may be required, for example in bridge design, where loads may increase if heavier vehicles are subsequently allowed.