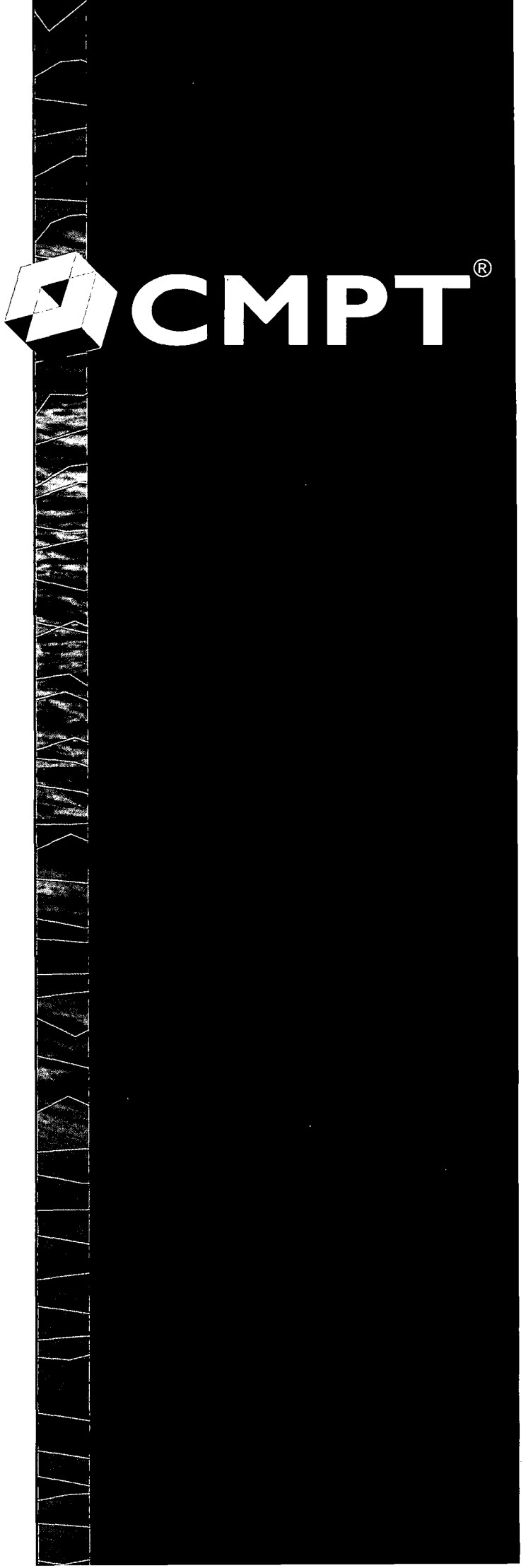

Defect Assessment in Offshore Structures

A Procedure

by

F M Burdekin FEng, FRS and M J Cowling

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ABOUT CMPT

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CMPT operates a virtual "research and innovation trading floor" dealing in information that will connect what industry needs with what the research community and technology companies can provide, and with what the public sector can do to assist.

ABOUT THE OFFSHORE SAFETY DIVISION OF THE HEALTH AND SAFETY EXECUTIVE

The responsibilities for regulating health and safety offshore were unified in a single body - the Health and Safety Executive - as a result of the recommendations of the Lord Cullen enquiry into the Piper Alpha disaster. A new Offshore Safety Division was set up as a result.

Research has played an important part in ensuring safety in the North Sea and will continue to do so. A major aim is to undertake an integrated programme of projects which address both the strategic or generic investigation of offshore hazards and the related short term needs, for example to support safety case assessment. A risk-based research strategy has been developed by HSE with input from the Division's Research Strategy Board to provide a means of prioritising research effort and helping to ensure that value for money is obtained.

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Most of the research in the Managed Programme was carried out at eight universities with the majority of the development of this Procedure being performed at UMIST and the University of Glasgow. Sponsors of the Managed Programme include AEA Technology, BP, British Gas, British Steel, Brown & Root, Conoco (UK), Earl & Wright, the Health & Safety Executive, the Ministry of Defence, Mobil North Sea, River Don Castings, Shell Exploration and Production, Sir William Halcrow and Partners, The Welding Institute, and Veritec.

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Note

The Offshore Safety Division of the Health and Safety Executive has supported publication of this report to encourage dissemination of the results of research that has received public funding. This support does not imply automatic endorsement by the HSE of any of the technologies described.

Every reasonable effort has been made to ensure that this document is based on the best knowledge available up to the time of finalising the text. However, no responsibility of any kind for any injury, delay, loss or damage whatsoever, however caused, resulting from the use of the Procedure presented can be accepted by CMPT, the sponsors or others involved in its publication.

SUMMARY

This review provides an assessment methodology procedure for defects in offshore structures, to supplement the procedure given in BSI document BS 7910:1998, *Guidance on methods for assessing the acceptability of flaws in fusion welded structures*. It is presented in a similar format. The Procedure is a set of routines for establishing the structural integrity of welded joints in steel offshore structures, based on current research and best industry practice. It is offshore specific in that it deals with the special characteristics of such structures in terms of detailed design and the nature of the loading in such applications.

Routines for assessment of individual joints are combined into system reliability assessments and an overall scheme for inspection and repair. The Procedure is supported by a Commentary that gives the background to sections of the methodology.

1.0 INTRODUCTION

BS 7910:1998 (derived from PD 6493:1991) *Guidance on methods for assessing the acceptability of flaws in fusion welded structures* (ref 8) contains well established routines for the assessment of the significance of defects in welded structures.

The present Procedure document has been produced to provide more detailed and offshore specific guidance, including a background Commentary, than can be included in BS 7910:1998. This Procedure is based on a programme of six years' joint government and industry funded research (The Defect Assessment in Offshore Structures Managed Programme) under the auspices of MTD. It has been extended to include subsequent work sponsored by HSE at UMIST and recent developments associated with the latest revision of BS 7910:1998.

The Procedure presented in Sections 2 to 7 is a specific set of routines for establishing the structural integrity of welded joints in steel offshore structures. It is offshore specific in that it deals with the peculiar characteristics of such structures in terms of detailed design and the nature of the loading in such applications.

The features of the Procedure which contribute to this approach include:

i) Results from a very large number of additional stress analyses of various (particularly tubular) joints commonly found on offshore structures.

ii) An in-depth study of the influence of detailed weld geometry and its effect on local stress distributions and hence integrity.

iii) Unique treatments of residual stress distributions in appropriate joints.

iv) New information on the ultimate load carrying capacity and hence reserve strength of tubular welded joints commonly found on offshore structures.

v) The use of reliability-based routines which enable structural integrity to be assessed against target levels of performance, which are geared to the consequences of failure.

vi) General compatibility with BS 7910:1998.

The Procedure itself is not founded simply on the results of the recent sponsored research but draws together appropriate information from a wide range of relevant sources. To this extent the Procedure aims to be the best currently available in terms of the overall knowledge base. General structural engineering guidance is published on methods for assessing defects in welded structures, in the form of BSI Document BS 7910:1998. This document was updated from the previous BS PD6493:1991 and provides a useful comparison with the Procedure described here. Given that the revision of BS PD6493:1991 has been known of (and contributed to) for some time, and now includes an offshore specific Annex, it seemed sensible to present this Procedure in a format similar to BS 7910:1998. This provides users with a reassuring familiarity and permits detailed direct comparison. This Procedure refers to BS 7910:1998 at several points, recommending the use of clauses in the BSI document in some cases, but gives more specific guidance where appropriate for other cases. This is an example of bringing together the results

from the Defect Assessment in Offshore Structures Managed Programme with information from elsewhere to produce a unified, but much improved, comprehensive approach. An important feature of the Procedure is the accompanying detailed Commentary which provides background information for the specific guidance given in the Procedure.

Section 2 of this Procedure represents standard industry practice for structural analysis, with additional warnings regarding obscure factors of safety. This is important to ensure that the resulting data are in a satisfactory and uniform form for the subsequent assessment procedures.

Section 3 incorporates the traditional fatigue endurance (S-N) design routines with options to allow the user to include a reliability based analysis. These options vary from a simple application of partial safety factors (multipliers) to, for example, the assumed stress range, to more complex routines allowing the user to estimate the effects of uncertainties in the various inputs to the analysis. The overall objective is to provide the user with a tool to calculate a fatigue lifetime for a predetermined level of reliability. Guidance is given on the selection of this predetermined level of safety and the effects of structural redundancy in the relationship between individual welded joint and structural system reliability.

Section 4 incorporates the latest fracture mechanics based assessment for fracture in welded joints in offshore applications. The sequence of the individual steps in the analysis follows the pattern of BS 7910:1998 but includes the evaluation of much greater detail in the stress distributions in the vicinity of a defect.

Section 5 gives a step-by-step description of the fracture mechanics based fatigue assessment for tubular welded joints containing a crack-like defect. This part of the Procedure is supported by a specially developed software package. This software is recommended because of the repetitive nature of the calculations and the size of the data sets which are accessed. Section 5 accesses a large amount of new data generated during the Defect Assessment Managed Programme.

Section 6 gives guidance of the assessment of system reliability, appropriate target levels and the relationships to individual component (welded joint) reliability.

Section 7 describes how to combine the routines within Sections 3 to 6 to produce a scheme of inspection and repair.