

EUROPEAN FITNESS-FOR-SERVICE PROCEDURE FITNET AND ITS APPLICATION TO WELDED AEROSPACE STRUCTURES

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ABSTRACT

The FITNET fitness-for-service (FFS) procedure is newly developed to provide rules for the design, fabrication, and flaw (or degradation during the service) assessment aspects of the metallic load-bearing structures with or without welds. The FITNET FFS Procedure provides assessment rules for flaws or damage due to fracture, fatigue, creep and corrosion to demonstrate the structural integrity of the component.

This paper presents validation examples of the fracture module of the FITNET FFS procedure using thin-walled panels with laser beam welded (LBW) stiffeners. The panels were made of high strength aluminum alloys A6013-T6 and A6156-T6. These structure-like laboratory specimens were used to investigate the residual strength behaviour of the fuselage components within the framework of the damage tolerance analysis. The stiffened panels contained two, three and four welded stringers. The stringers oriented in loading direction and panels contained a single center crack artificially introduced between the stringers into the skin material. Additionally, some of the four-stringer panels contained welded clips (short T-joint attachments) located between the stringers. The experimental results of the panels were compared with the predictions of the FITNET FFS procedure. Hence, this paper focuses on the use of this new procedure or the predictions of the critical conditions of these complex thin-walled panels.

The analysis results have shown that the FITNET FFS fracture module can successfully be used for the prediction of the residual strength behaviour of the thin-walled airframe components.

The content of this manuscript was presented at the FITNET final conference, 17-19 May 2006, Amsterdam.

INTRODUCTION

The aircraft fuselage structures are predominantly thin-walled metallic components and damage tolerance behaviours are stringently assessed for postulated or real flaws for fatigue and fracture. Damage tolerance evaluation procedures are partly used to develop optimized inspection and maintenance guidelines for existing structures to operate safely. Furthermore, it provides technically sound remaining life predictions to enhance economic life of the structures while ensuring the safety. Commonly used structural integrity procedures [1-7] are the techniques used to demonstrate the fitness-for-service of engineering components (with and without welds) transmitting loads. FFS procedures have important implications for economic development in assuring the quality of engineered goods and services. Used correctly, they can increase efficiency by preventing over design and unnecessary inspection and repair. Additionally, they can provide a balance between economy and concern for individual safety and environmental protection, where these are affected by component failure. They have been developed and validated using cases of the general engineering structures rather than thin-walled airframe components. However, FFS procedures such as SINTAP [4, 5] and FITNET [8] are of value at the design stage to provide assistance for new constructions, particularly where these may be innovative in the choice of materials or fabrication methods, and at the operation stage to provide assistance throughout the life of the airframe structures.

The application of FFS procedure during the pre-development or design stage of a new aircraft component using a new material or fabrication method (such as welding instead of riveting) can provide significant help for prediction of allowable stresses for a given material, fabrication method and flaw size. Evaluation of the strength and fracture behaviours of the flat technological panels with structural details is of great value, if experimental findings can be predicted using engineering flaw assessment procedures such as FITNET. However, there is a lack

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IIW Guidance on Assessment of the Fitness for Purpose of Welded Structures, 1990 **IIW Guidance on Assessment of the Fitness for Purpose of Welded Structures** International Institute of Welding, 1990 **Fatigue Strength of Welded Structures** S J Maddox, 2014-03-14 The key to avoidance of fatigue which is the main cause of service failures is good design In the case of welded joints which are particularly susceptible to fatigue design rules are available However their effective use requires a good understanding of fatigue and an appreciation of problems concerned with their practical application Fatigue strength of welded structures has incorporates up to date design rules with high academic standards whilst still achieving a practical approach to the subject The book presents design recommendations which are based largely on those contained in recent British standards and explains how they are applied in practice Attention is also focused on the relevant aspects of fatigue in welded joints which are not yet incorporated in codes thus providing a comprehensive aid for engineers concerned with the design or assessment of welded components or structures Background information is given on the fatigue lives of welded joints which will enable the engineer or student to appreciate why there is such a contrast between welded and unwelded parts why some welded joints perform better than others and how joints can be selected to optimise fatigue performance **Fracture and Fatigue of Welded Joints and Structures** K Macdonald, 2011-04-19 The failure of any welded joint is at best inconvenient and at worst can lead to catastrophic accidents Fracture and fatigue of welded joints and structures analyses the processes and causes of fracture and fatigue focusing on how the failure of welded joints and structures can be predicted and minimised in the design process Part one concentrates on analysing fracture of welded joints and structures with chapters on constraint based fracture mechanics for predicting joint failure fracture assessment methods and the use of fracture mechanics in the fatigue analysis of welded joints In part two the emphasis shifts to fatigue and chapters focus on a variety of aspects of fatigue analysis including assessment of local stresses in welded joints fatigue design rules for welded structures k nodes for offshore structures and modelling residual stresses in predicting the service life of structures With its distinguished editor and international team of contributors Fracture and fatigue of welded joints and structures is an essential reference for mechanical structural and welding engineers as well as those in the academic sector with a research interest in the field Analyses the processes and causes of fracture and fatigue focusing predicting and minimising the failure of welded joints in the design process Assesses the fracture of welded joints and structure featuring constraint based fracture mechanics for predicting joint failure Explores specific considerations in fatigue analysis including the assessment of local stresses in welded joints and fatigue design rules for welded structures Fitness for Purpose of Welded Structures American Welding Society, International Institute of Welding, 1991 Welded Structures L. Lobanov, 1997 *Fitness for Purpose of Welded Structures* American Welding Society, 1991* **Fracture Mechanics, Nineteenth Symposium** Thomas A. Cruse, 1988 **Fatigue Assessment of**

Welded Joints by Local Approaches Dieter Radaj,C M Sonsino,W Fricke,2006-10-30 Local approaches to fatigue assessment are used to predict the structural durability of welded joints to optimise their design and to evaluate unforeseen joint failures This standard work provides a systematic survey of the principles and practical applications of the various methods It covers the hot spot structural stress approach to fatigue in general the notch stress and notch strain approach to crack initiation and the fracture mechanics approach to crack propagation Seam welded and spot welded joints in structural steels and aluminium alloys are also considered This completely reworked second edition takes into account the tremendous progress in understanding and applying local approaches which has been achieved in the last decade It is a standard reference for designers structural analysts and testing engineers who are responsible for the fatigue resistant in service behaviour of welded structures Completely reworked second edition of a standard work providing a systematic survey of the principles and practical applications of the various methods Covers the hot spot structural stress approach to fatigue in general the notch stress and notch strain approach to crack initiation and the fracture mechanics approach to crack propagation Written by a distinguished team of authors Assessment of Materials in Ageing Offshore Structures John V. Sharp,John Wintle,2025-04-17 This book provides essential knowledge and techniques required to assess materials for extending the life of ageing offshore structures used for energy production With over half of these structures currently in a life extension phase the effects of ageing and degradation are at the forefront of the industry The book presents the changes in industry practices and key technological advancements that have shaped the field since its inception It reviews the original properties of the materials employed in offshore structures and provides a deep understanding of their behaviour as they age over time The relevant degradation processes are investigated for offshore structural materials such as steel welds bolted joints concrete grout reinforcement pre tensioning and non metallic materials including coatings and composites Materials engineers will be equipped with the necessary tools in this book to evaluate materials in existing ageing structures The book goes beyond theoretical knowledge providing practical insights into assessing the performance of materials in ageing structures With a focus on ensuring the efficient and safe continued use of existing infrastructure engineers will find useful guidance to inform decision making and facilitate the assessment process The book brings together a wide range of research findings relevant to the topic and offers an updated summary of material assessment techniques that are largely difficult or even impossible to access publicly This book is an invaluable resource for practising materials engineers offshore engineering professionals or materials engineering students *Handbook of Structural Welding* J. F. Lancaster,1997-08-07 This handbook provides a comprehensive analysis of the current state of welding technology as applied to large structures and process plant The author takes account of the increasing necessity for engineers at all levels to be aware of problems such as fatigue failure and provides advice *Stress Determination for Fatigue Analysis of Welded Components* E. Niemi,1995-04-30 This report introduces definitions of the terminology relevant to stress determination for fatigue analysis of

welded components The various stress concentrations stress categories and fatigue analysis methods are defined Fatigue analysis methods considered are nominal stress hot spot stress notch stress notch strain and fracture mechanics approaches The report also contains comprehensive recommendations concerning the application of finite element methods and experimental methods for stress determination It is intended for fatigue design of common welded structures such as cranes excavators vehicle frames bridges ship hulls offshore structures etc fabricated from materials at least 3mm thick In general attention is focused on weld details which give rise to fatigue cracking from the surface notably from the weld toe

Design, Fabrication and Economy of Welded Structures K Jarmai,J Farkas,2008-04 These proceedings cover the fields of different materials and fatigue of welded joints thin walled structures tubular structures frames plates and shells and also incorporate special optimization problems fire and earthquake resistant design special applications and applied mechanics and thus provide an important reference for civil and mechanical engineers architects designers and fabricators Proceedings cover the fields of different materials and fatigue of welded joints thin walled structures tubular structures frames plates and shells Also incorporate special optimization problems fire and earthquake resistant design special applications and applied mechanics Provide an important reference for civil and mechanical engineers architects designers and fabricators

Advances in Fatigue Science and Technology C. Moura Branco,L. Guerra Rosa,2012-12-06 This volume contains the edited version of lectures and selected research contributions presented at the NATO ADVANCED STUDY INSTITUTE on ADVANCES IN FATIGUE SCIENCE AND TECHNOLOGY held in Alvor Portugal 4th to 15th of April 1988 and organized by CEMUL Center of Mechanics and Materials of The Technical University of Lisbon The Institute was attended by 101 participants including 15 lecturers from 14 countries The participants were leading scientists and engineers from universities research institutions and industry and also Ph D students Some participants presented papers during the Institute reporting the state of art of their research projects All the sessions were very active and quite extensive discussions on scientific aspects took place during the Institute The Advanced Study Institute provided a forum for interaction among eminent scientists and engineers from different schools of thought and young researchers The Institute addressed the foundations and current state of the art of essential aspects related to fatigue science and technology namely Short Cracks Metallurgical Aspects Environmental Fatigue Threshold Behaviour Notch Behaviour Creep and Fatigue Interactions at High Temperature Multiaxial Fatigue Low Cycle Fatigue Methodology of Fatigue Testing Variable Amplitude Fatigue Fatigue of Advanced Materials Elastic Plastic Fatigue and several engineering applications such as welded joints energy systems offshore structures automotive industry machine and engine components This book is organized in three parts Part I Fundamentals of Fatigue Part II Engineering Applications Part III Research Contributions The research contributions covered most of the areas referred above

Pressure Vessel And Piping Technology - Proceedings Of The Seminar John Shing Tai Cheung,Lin Seng Ong,1993-05-11 This last decade has seen remarkable growth in the Asian Pacific region in

the off shore oil petrochemical power and process industries and the rapid change in these fields requires constant updating and reappraisal of the available and new technologies The proceedings of the seminar will contain papers from representatives from many countries to address current technological issues and discuss engineering development and operating experiences The proceedings will therefore greatly benefit those who wish to learn about the new developments in the areas of application of pressure vessels and piping technology Tubular Structures XI Jeffrey A. Packer, 2017-10-02 This topical book contains the latest scientific and engineering developments in the field of tubular steel structures as presented at the 11th International Symposium and IIW International Conference on Tubular Structures The International Symposium on Tubular Structures ISTS has a long standing reputation for being the principal showcase for manufactured tubing and the prime international forum for discussion of research developments and applications in this field Various key and emerging subjects in the field of hollow structural sections are covered such as novel applications and case studies static and fatigue behaviour of connections joints concrete filled and composite tubular members earthquake resistance specification and code developments material properties and structural reliability impact resistance and brittle fracture fire resistance casting and fabrication innovations Research and development issues presented in this book are applicable to buildings bridges offshore structures entertainment rides cranes towers and various mechanical and agricultural equipment This book is thus a pertinent reference source for architects civil and mechanical engineers designers steel fabricators and contractors manufacturers of hollow sections or related construction products trade associations involved with tubing owners or developers of tubular structures steel specification committees academics and research students The conference presentations herein include two keynote lectures the International Institute of Welding Houdremont Lecture and the ISTS Kurobane Lecture plus finalists in the CIDECT Student Papers Competition The 11th International Symposium and IIW International Conference on Tubular Structures ISTS11 took place in Quebec City Canada from August 31 to September 2 2006 *Welder (Theory) - II* Mr. Rohit Manglik, 2024-05-18 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels **Metal Fatigue Analysis Handbook** Yung-Li Lee, Mark E. Barkey, Hong-Tae Kang, 2011-10-06 Understand why fatigue happens and how to model simulate design and test for it with this practical industry focused reference Written to bridge the technology gap between academia and industry the Metal Fatigue Analysis Handbook presents state of the art fatigue theories and technologies alongside more commonly used practices with working examples included to provide an informative practical complete toolkit of fatigue analysis Prepared by an expert team with extensive industrial research and professorial experience the book will help you to understand Critical factors that cause and affect fatigue in the materials and structures relating to your work Load and stress analysis in addition to fatigue damage the

latter being the sole focus of many books on the topic How to design with fatigue in mind to meet durability requirements How to model simulate and test with different materials in different fatigue scenarios The importance and limitations of different models for cost effective and efficient testing Whilst the book focuses on theories commonly used in the automotive industry it is also an ideal resource for engineers and analysts in other disciplines such as aerospace engineering civil engineering offshore engineering and industrial engineering The only book on the market to address state of the art technologies in load stress and fatigue damage analyses and their application to engineering design for durability Intended to bridge the technology gap between academia and industry written by an expert team with extensive industrial research and professorial experience in fatigue analysis and testing An advanced mechanical engineering design handbook focused on the needs of professional engineers within automotive aerospace and related industrial disciplines Fracture 84 S. R. Valluri,2013-10-02 **Power Generation** Gyoujin Cho,2000-02 Contains the following reports A review of techniques to manage penetration variability during TIG welding An appraisal of methods for quantifying the performance of ultrasonic inspection techniques for detecting and sizing weld flaws Real time defect assessment from ultrasonic test data Heat affected zone hydrogen cracking of C Mn steels when welding with tubular cored wires

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