EGF Newsletter

Official Newsletter of the European Group on Fracture Nr. 5, Winter 1987/88

ECONOMIC CONSEQUENCES OF FRACTURE IN EUROPE

Contents on page 3

A Study Contract of EGF with the Commission of the European Communities at Joint Research Centre Petten,The Netherlands

CEC-JRC Petten Establishment, The Netherlands, offered EGF through its Strengthening and Liaison Committee with Prof.Faria (CEMUL-IST., Lisbon, Portugal) as chairman, a 24 months "study contract" on the "Economic Consequences of Fracture in Europe".

December 1987 this contract was signed with the "Foundation for Application of Materials" at Delft, The Netherlands, which acts as the legal representative for EGF and manages the official EGF Office at Delft. General objectives of the study are:

1) Assessment of the total cost by fracture in Europe per annum.
2) Indication of the future potential for reduction in cost as caused by fracture, identifying – in order to achieve this relevant R & D priorities for themes and their subjects in the field of fracture to advance the understanding of material fracture and of fracture control technology – where firstly required for this.

Further, with regard to 2):

3) statement of requirements for improvement and development of codes of practise, norms, specifications, standards, guidelines and recommendations to prevent fracture with respect to materials, manufacture of appliances and their use, design of structures and their operation – including maintenance prescriptions – allowing assessments of reliability for envisaged purpose and service.

An evaluation of the European situation with regard to fracture control a decade later should demonstrate economic benefits of these efforts.

Continued on page 3

The Price of Fracture

Alongside you can read that EGF has concluded a study contract with CEC. This is, however, not only to study a scientific or technical problem – as one would expect at a first glance – but to find out the economical consequences of fracture and how these can be reduced.

I am very glad that it proved possible to find persons within EGF who are willing to contribute to this study, because most engineers and scientists involved in fracture are less experienced in solving economical problems. Speaking for myself, I can reasonably estimate the costs of tearing things apart and of the computations required to explain why it did, but I am sure that this is not intended.

The study will most probably result in an impressive damage figure for fracture, but I fear that reducing this significantly will be a long term operation. The danger is then that budget keepers will tend to support activities promising short term successes, being insufficiently aware of the fact that the impact of fracture is more than a figure on a balance sheet. First of all the human suffering which may be caused by accidental fracture – can we set a price for casualties? The same applies to the possible pollution caused by it – do we really know the price for damaging the nature? A completely different aspect is that fracture can also be an economically favourable event. A consumers society is not served by products with an infinite life, and products are hence designed to fail after their economic life is expired. The better you can predict the lifetime of a product, the cheaper it will be, and the better you can compete.

It is the task of EGF to inform the right people and bodies on all possible impacts of fracture, to assure that the right policy is followed. Let us remember in doing this that the economics of fracture is only one aspect of it, and not the only one....

the editor

EGF ADDRESSES

Executive Committee

President
Drs. H.C. van Elst
(see Secretary General)

Secretary General & EGF Office
Prof. A. Bakker
Delft Univ. of Technology
Faculty of Materials Science
P.O. Box 5025
2600 GA Delft
the Netherlands
Tel. (31)15-785418
Telex 38151

ECF7 Organizer
Dr. E. Czoboly
Institute for Technology and Materials Science
Techn.Univ. Budapest
1521 Budapest, Hungary
Tel. (36)1-665011 ext. 23-00

ASFM Seminars

Organizer
Dr. L.H. Larsson
CEC, D.G. XII/D/1
ARTS 3/39
1049 Brussels, Belgium
Tel. (32) 2-2354065
Telex comeu b 21877
Fax (32) 2-2358046

Secretarial office
Secretariat "Ispra Courses"
CEC-JRC,Ispra Establishment
21020 Ispra (Varese), Italy
Tel. (39)332-789819/789839
Telex 380043/380058

ECF7 Conference

Scientific Secretariat
Dr. E. Czoboly
(see Executive Committee)

Secretarial office
Mrs. I. Soltész
Society of Mech. Engineers
P.O. Box 451
1372 Budapest 5, Hungary
Tel. (36)1-530-749
Telex 225792

Strengthening Committee

Chairman
Prof. L. Faria
CEMUL-IST
Avenida Rovisco Pais
1096 Lisboa, Portugal
Tel. (351)19-803486
Telex 63423

Publications Committee

Chairman/Editor Fatigue section FFEMS-Journal
Prof. K.J. Miller
University of Sheffield
Dept. of Mech. Engineering
Mappin street
Sheffield S1 3JD, UK
Tel. (44)742-768555 x 5160
Telex 54348

Editor Fracture section FFEMS-Journal
Dr. L.H. Larsson
(see Seminar Organizer)

Task Group Micromechanisms

Chairman
Prof. W. Dahl
T.H. Aachen
Inst. für Eisenhüttenkunde
Intzestr. 1
5100 Aachen, FRG
Tel. (49)241-805782
Telex 832704 thac d

Secretary
Dr. K.E. Hagedorn
Max Planck Institut für Eisenforschung
Postfach 140 260
4000 Düsseldorf 1, FRG
Tel. (49)211-67921
Telex 8586762

WP Ductile Crack Growth Round Robin
Dr. D. Curry
Schlumberger Cambridge Res. Ltd., P.O. Box 153
Cambridge CB2 3BE, UK

WP Stretched Zone Round Robin
Mr. A. Halim
T.H. Aachen
Inst. für Eisenhüttenkunde
Intzestr. 1
5100 Aachen, FRG

Dr. K.E. Hagedorn
(see secr. TG Micromech.)

WP Micr. Cleavage Fracture Stress Round Robin
Mrs. H.Dürnewald-Arfmann
T.H. Aachen
Inst. für Eisenhüttenkunde
Intzestr. 1
5100 Aachen, FRG
Tel. (49)241-805831

Task Group EPFM

Chairmen
G. Angelino
CISE, Materials Department
P.O.Box 12081
2034 Milano, Italy
Telex 311643 cise i

Prof. D. Firrao
Politecnico di Torino
Instituto di Chimica Applicate e di Metallurgia
Corso Duca degli Abruzzi 24
10129 Torino, Italy
Tel.(39)11-5566763/5567777
Telex 220646

WP Numerical Round Robin
Dr. W. Schmitt
Fraunhofer Institut für Werkstoffmechanik
Wöhlerstr. 11
7800 Freiburg, FRG
Telex 041-17761159 fhiwmfr

WP R-Curves and Tearing Instability
Dr. I. Milne
CEGB-CERL
Kelvin Avenue
Leatherhead
Surrey KT22 7SE, UK
Tel. (44)372-374488
Telex 917338

WP Crack Growth Round Robin
Dr. M.I. de Vries
ECN
P.O. Box 1
1755 ZG Petten
the Netherlands
Tel. (31)2246-4949
Telex 57211

WP High Temp. Crack Growth Round Robin
Dr. Th. Hollstein
Fraunhofer Institut für Werkstoffmechanik
Wöhlerstr. 11
7800 Freiburg, FRG
Tel. (49)761-5142-121
Telex 041-17761159 fhiwmfr

WP Fracture Mech. Testing Standards
Prof. K.-H. Schwalbe
GKSS-Forschungszentrum
Max Planck Straße
2054 Geesthacht, FRG
Tel. (49)4152-12979
Telex 218712 gkss-g-d

Task Group Polymers and Composites

Chairmen
Prof. J.G. Williams
Dept. of Mech. Engineering
Imperial College of Science and Techn.
Exhibition Road
London SW7 2BX
UK
Tel. (44)1-5895111
Telex 261503
Telefax 01-584-7596

Prof. H.M. Kausch
Polymer Laboratory
École Polytechnique Fédérale de Lausanne
1007 Lausanne
Switzerland
Tel. (41)21-472841
Telex 454478

Task Group Fatigue

Chairman
Prof. K.J. Miller
University of Sheffield
Dept. of Mech. Engineering
Mappin street
Sheffield S1 3JD, UK
Tel. (44)742-768555 x 5160
Telex 54348

WP Multiaxial Fatigue
Dr. M.W. Brown
University of Sheffield
Dept. of Mech. Engineering
Mappin street
Sheffield S1 3JD, UK
Tel. (44)742-768555
Telex 54348

Task Group Fracture Dynamics

Chairmen
Prof. J.F. Kalthoff
Ruhr University
Experimental Mechanics
Bochum, FRG

Dr. Z. Bilek
Inst. of Physical Metallurgy
Czechoslovakian Academy of Sciences
Ziskova 22
61662 Brno, CSSR

WP Crack Arrest
Dr. E. Roos
MPA
Pfaffenwaldring 32
7000 Stuttgart 80, FRG

Economic Consequences of Fracture in Europe

cont'd from page 1

It was concluded that this study could be performed by EGF after receiving positive reactions for co-operation from F.R.G., France, Hungary, Italy, Portugal, U.K., The Netherlands, and Switzerland.

Not all national and (or) individual EGF members could be contacted before as to their possible willingness for participation in this study.

With this Newsletter communication co-operation to this study is solicited among all those within EGF, who are in a position to contribute to it. Parties interested in this can so inform the EGF Office or Prof. Faria.

Besides ideas conjecturing "what and how" (and "when and by whom") for research on fracture prevention – including among many things also non-destructive testing techniques on site for detection of flaws and other manifestations of material damage or detrimentation – possible information on (national) failure cases and their implied cost, will be most welcome.

An entry to such information might be national certifying authorities, usually supervising reliability of performance of structures and bodies confronted with loss of production by failure of applied material or manufacturing equipment; further bureaus charged with economical statistics.

The work for this study will be carried out in consultation with Commission representatives of JRC Petten Establishment; Prof. Faria proved willing to act as "project leader".

A supervising committee is being formed within EGF to follow progress; a first meeting to arrive at a preliminary working scheme meanwhile took place at Brussels, 28th January 1988.

A limited amount of money is at disposal from this study contract to be used for contributions in proportion to quantity and quality (as to be judged by the mentioned committee), while travelling expenses as for meetings of participants and the committee, etc.can be met to a certain extent; guidelines for these matters are the concern of the project leader, prof. Faria.

A similar study in the United States was performed by the National Bureau of Standards together with Battelle Columbus Laboratories in 1978. The results were published in an NBS reports: "The Economic Effects of Fracture In the United States", Special Publications 647-1 and 647-2, NBS, 1983 (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; price $ 11.00 + ca. 25% mailing per report).

Other studies on the effect of failure have been performed earlier – in particular with respect to corrosion – both in Europe and U.S.; the corrosion aspects of failure will be (mostly) left outside consideration in the present planned study.

CONTENTS

Economic consequences of Fracture in Europe 1
The Price of Fracture 1
EGF Addresses 2
Task Group News
- Announcement 16th plenary meeting Task Group EPFM 4
- New round robin activity on local approach to fracture 4
- Quantitative Fractography, *letter received from L.Wojnar* 4
- EGF round robin on ductile crack growth measurement, *final report by D. A. Curry* 7

Call for papers:
European Symposium on Elastic-Plastic Fracture Mechanics 6
Stress corrosion from a view-point of Fracture Mechanics, *by J. Spiekhout* 13
DVM honorary membership for L.F. Coffin and K. Iida 18
Agenda of Fatigue and Fracture Events 21

Production

EGF Office
Edited by A. Bakker
(see address section, page 2)
Printed at Delft University
Circulation 2500

EGF ADDRESSES *Cont'd*

Publishers

EGF Publication series
M.E.P.
P.O. Box 24, Northgate Avenue
Bury St. Edmunds
Suffolk IP32 6BW
UK

EGF Journal FFEMS
Pergamon Press
Headington Hill Hall
Headington
Oxford OX3 0BW
UK

Proceedings ECF4/5/6/7
EMAS
339 Halesowen Road
Cradley Heath
Warley
West Midlands B64 6PH
UK

Task Group ELASTIC–PLASTIC FRACTURE MECHANICS

16th Plenary Meeting, 21-22 April 1988
FRAMATOME, la Défence - Paris, France

TRANSFERABILITY OF TOUGHNESS DATA OF LABORATORY SPECIMENS TO ASSESS STRUCTURAL INTEGRITY

Proposals for presentations on this subject should be sent as soon as possible, but not later than April 1, to:

Mr. F. Mudry
École des Mines de Paris
60, Boulevard Saint-Michel
75272 PARIS Cédex 06, France

The provisional program is:

- Thursday morning – Size effects on toughness measurements (J_c, COD_c).
- Thursday afternoon – Local criteria.
- Friday morning – Problems of transferability for assessment for components.
- Friday afternoon – Other topics, and EGF discussion on round programs.

Further information will be mailed with the final program.
The local organization will be taken care of by FRAMATOME.
If you plan to come to this meeting, please contact :

Mr. A. Pellissier-Tanon
FRAMATOME
Tour Fiat
92084 PARIS la Défense Cédex 16, France

New Round Robin Activity on LOCAL APPROACH TO FRACTURE

A new Round Robin activity is proposed on the "Use of local Criteria to Fracture". It involves both numerical and experimental work on notched tensile bars and later, on cracked CT specimens. The Working Party "**Numerical Round Robin**" of the Task Group EPFM will give administrative support.
The activities will directly be organized by F. Mudry. The participants of the last numerical Round Robin will automatically receive information about this activity.

Persons or institutions interested to participate should write directly to :

Dr. F.Mudry
École des Mines de Paris
60, Boulevard Saint-Michel
75272 PARIS Cédex 06
France
Phone : 42.34.90.14.

or to :

Dr. W. Schmitt
Fraunhofer Institut für Werkstoffmechanik
Wöhlerstraße 11
7800 FREIBURG
FRG
Phone : 761-51.42.104

Quantitative Fractography

Letter recieved from L. Wojnar, Cracow, Poland:

The European Group on Fracture shows increasing activity and supports several scientific initiatives. It encouraged me to write to you in order to explain my own ideas.

Analysis of fracture surfaces is an important part of many fracture toughness tests. Moreover, the fractographic analysis is sometimes the only key to understand the micromechanism of rupture or the effect of microstructure on the fracture process. Fractographs are very often published in scientific works but they are in general described only qualitatively.

In my opinion the present situation should be changed as quantitave fractography can be helpful in the study of fracture mechanisms, verifying fracture models and algorithms for computer simulation etc. There are worked out several methods of quantitative fractography (see Metals Handbook, 9th edition, Vol. 12, pp. 193-210) but these methods are used by stereologists rather than by engineers working in fracture mechanics.

The main reason for the small progress in practical application of quantitative fractography is the lack of experience and suitable efficient methods. For example, the main measure in quantitative fractography seems to be the fracture surface area. This quantity is rather laborious to estimate and in practise one can observe changes in fracture behaviour without changes in the fracture surface area. In other words, the problem is how to choose fracture surface parameters sensitive to the changes in fracture toughness, crack growth etc. To make things more complicated these parameters should be chosen individually for each type of material.

Taking into account all these facts I propose the creation of a Task Group Quantitative Fractography. The aim of the Task Group activities would be as follows:

FRACTURE CONTROL OF ENGINEERING STRUCTURES

Proceedings of the 6th Biennial European Conference on Fracture – ECF6 – held at the RAI-Congress Centre, Amsterdam, The Netherlands, June 15-20, 1986

Editors: H.C. van Elst and A. Bakker

●

The proceedings are contained in three volumes, case bound at 225 mm by 125 mm with 2,220 pages and over 600 illustrations

ISBN 0 947817 18 2

The major topics considered by the Conference included:

- BASIC FRACTURE CONCEPTS AND MODELS
- TOUGHNESS ASSESSMENT AND MATERIAL RESPONSE
- NUMERICAL METHODS
- FATIGUE
- CRACK PATHS AND CRACK BRANCHING
- MICRO-MECHANISMS
- NON-METALS

Requests for books and further information should be sent directly to:
Engineering Materials Advisory Services Ltd.
339, Halesowen Road, Cradley Heath,
Warley, West Midlands, B64 6PH, U.K.
Price: £ 150 U.K., $ 240 U.S. OVERSEAS

- evaluation of quantitative fractographic methods applicable in research and engineering practice;
- simultaneous measurement in different laboratories in order to establish the scatter of results and difference in feature recognition;
- application of the elaborated methods in fracture research.

I am prepared to try to create such a Task Group and organize its work. My university has promised to support such kind of activity.

Please keep me informed if this initiative is interesting for EGF. If so, I think it could be mentioned in the next issue of the EGF Newsletter. In my opinion the final work program of this Task Group could be fixed during the ECF7 Conference in Budapest, so the work could start next year.

Leszek Wojnar

We answered dr. Wojnar that his initiative seems to fit well within the scope of EGF, but that forming a separate Task Group on the subject of quantitative fractography is not really necessary, since we have an active Task Group on Micromechanisms of Fracture. The suggestion is therefore to investigate whether there is enough interest to justify the formation of a new Working Party within this Task Group. Everybode who is willing to take part in the activities of such a Working Party is therefore invited to state this to the EGF Office (address see page 2).

CALL FOR PAPERS

European Symposium on

Elastic-Plastic Fracture Mechanics:
Elements of Defect Assessment

October 9-11, 1989
Freiburg, FRG

The European Symposium on Elastic-Plastic Fracture Mechanics: Elements of Defect Assessment, will be organized by Deutscher Verband für Materialprüfung and sponsored by the **European Group on Fracture (EGF)**, Deutsche Forschungsgemeinschaft and others.

The objectives of the Symposium is to review recent theoretical and experimental developments in elastic-plastic fracture mechanics for structural assessment. On the various elements needed for structural assessment, the following topics will be particularly addressed:

- **Crack tip constraint; size and geometry effects on elastic-plastic fracture;**
- **Ductile to brittle transition: - microstructural,**
  - mechanical,
  - statistical aspects;
- **Theoretical treatment of stationary and growing cracks using J or CTOD;**
- **Flaw assessment concepts and verification.**

Particular emphasis should be placed on comparison of experiment with analysis.

The symposium will consist of invited lectures and original contributions. Prospective authors are requested to submit a 500 word abstract with one or two key illustrations to either of the Symposium chairmen by

October 1, 1988

A Symposium Committee – formed by the Symposium co-chairmen J. G. Blauel and K.-H. Schwalbe, and G. Angelino, A. Bakker, H. Clausmeyer, W. Dahl, D. François, J. Gudas, G. Irwin, J. Merkle, A. Wells and others – will decide on the acceptance for presentation and publication in the proceedings. Authors will be informed of acceptance for presentation by

January 15, 1989

For more information contact the Symposium co-chairmen:

J. G. Blauel
Fraunhofer Institut für Werkstoffmechanik
Wöhlerstraße 11
D-7800 Freiburg, FRG
phone : (0)761/5142-101
telex : 17761159 fhiwmfr d
telefax : (0)761/5142-147

K.-H. Schwalbe
GKSS-Forschungszentrum Geesthacht
Max-Planck-Straße
D-2054 Geesthacht, FRG
phone : (0)4152/12-979
telex : 0218712 gkssg
telefax : (0)4152/12-618

Proceedings based on this Symposium are anticipated by EGF. Deadline for all manuscripts is

September 1, 1989

Papers not submitted by the deadline will not be accepted for the Proceedings. Papers submitted after the deadline will be forwarded to the EGF Journal

Fatigue and Fracture of Engineering Materials and Structures

to be considered for publication. Please contact one of the Symposium co-chairmen if you cannot meet the deadline.

EGF Round Robin on
DUCTILE CRACK GROWTH MEASUREMENT

D.A. Curry
Schlumberger Cambridge Research Ltd.
P.O. Box 153
Cambridge CB3 0HG, UK

Introduction

Most methods of determining a material's resistance to ductile crack growth require the measurement of crack growth on the fracture surface of tested fracture toughness specimens. A number of different techniques have been proposed for making these measurements. These techniques include direct measurement of the fracture surface using travelling microscope or scale rule, and indirect measurements made on fractographs using travelling micro scope, scale rule, planimeter or weighing. Ductile crack growth is rarely uniform across the thickness of a fracture toughness specimen. Consequently, its extent is usually represented by some average crack extension. Different definitions of the average crack growth have been proposed, some being multipoint averages [1] [2] and others being area based [3].

Little is known of the accuracy or reproducibility of ductile crack growth measurement, or how these might be influenced by the definition of crack growth or indeed by the technique employed in making the measurements. The EGF Task Group on the micromechanisms of fracture organised a round robin programme to investigate the measurement of ductile crack growth for crack growth resistance testing. The aim of this programme was to compare the different crack growth measurement definitions and techniques with the hope of being able to recommend one definition and technique as the most suitable. This paper reports the results of the round robin.'

Definition and Measurement of Ductile Crack Extension

One approach to the definition of average crack growth is to take the average of a number of measurements of crack extension made at different points through the specimen thickness. Both the ASTM [1] and the BSI [2] proposals require measurements to be made at regular intervals of 1/8th of the specimen thickness. The ASTM practise is to define Δa as a weighted average of all nine measurements:

$$\Delta a_{ASTM} = \frac{1}{8}\left[\Delta a_2 + \Delta a_3 + \Delta a_4 + \Delta a_5 + \Delta a_6 + \Delta a_7 + \Delta a_8 + \frac{\Delta a_1 + \Delta a_9}{2} \right] \quad (1)$$

where Δa_n is the measured crack extension from the initial fatigue crack front to the the of the ductile crack at the n th measurement station. In contrast, the BSI definition of Δa is the simple mean of the seven inner measurements, ignoring entirely the crack growth at the specimen surfaces. The stretch zone is not included in the ductile crack growth measurements of this definition:

$$\Delta a_{BSI} = \frac{1}{7}\left[\Delta a_2 + \Delta a_3 + \Delta a_4 + \Delta a_5 + \Delta a_6 + \Delta a_7 + \Delta a_8 \right] \quad (2)$$

An alternative approach to the definition of ductile crack extension [3] is to take an area based average for which the crack area is measured and divided by the specimen thickness:

$$\Delta a_{area} = \frac{A}{B} \quad (3)$$

where A is the measured crack extension area, including any stretch zone, and B is the specimen thickness.

The techniques for measuring ductile crack growth are here characterised as direct or indirect. Direct measurements are made directly from the fracture surface whereas indirect measurements are made on photographs of the fracture surface. For multipoint average definitions of crack extension both direct and indirect measurements can be made with a travelling microscope or a scale rule. The area based average crack extension can only conveniently be measured indirectly. (This position is now changing with the increasing availability and success of video image-analysing equipment) The area of crack extension is measured on a fractograph either with a planimeter or by cutting out and weighing the appropriate portion of the fractograph.

Round Robin programme

Six different steel fracture toughness specimens were selected with average crack growths ranging up to approximately 2.5 mm. The ductile crack growth that occurred during testing was marked by heat tinting.

All participants in the programme were to measure the crack growth on the same set of fracture toughness specimens using as many as possible of a range of different measurement techniques and crack growth definitions. Table 1 gives the complete list of measurements techniques and crack growth definitions to be examined, together with the abbreviations used to refer to them when the results are presented. After each participant had made their measurements, they were to send the specimens on to the next participant for them to make their measurements, and so on. All measurements were then to be collated for comparison.

Measurement Technique	Δa Definition	Abbreviation
Direct, travelling microscope	ASTM	DM TrvMic (ASTM)
	BSI	DM TrvMic (BSI)
Direct, scale rule	ASTM	DM ScaRul (ASTM)
	BSI	DM ScaRul (BSI)
Indirect, travelling microscope	ASTM	IM TrvMic (ASTM)
	BSI	IM TrvMic (BSI)
Indirect, scale rule	ASTM	IM ScaRul (ASTM)
	BSI	IM ScaRul (BSI)
Indirect, planimeter	Area	IM Planim (Area)
Indirect, weighing	Area	IM Weight (Area)

Table 1: Crack growth measurement techniques and definitions examined

A total of 21 laboratories agreed to take part in the programme. Unfortunately, the specimens were lost in transit after 16 of the participating laboratories had made their measurements. The loss of the specimens and the time spent in trying to locate them contributed to the long time taken for the completion of the round robin. Nevertheless, at the time the specimens were lost a total of 24 sets of measurements had been made - in some laboratories more than one person made measurements. Note that in many cases not all measurement techniques and definitions were employed by each participant. As a result, the number of data differ for the different techniques and definitions. They range from 4 only in the case of the least frequently used technique and definition to 21 for the most popular.

Results

The measurements made on each of the six samples by each technique and crack growth definition have been grouped together. The mean and standard deviation of each set of measurements have been calculated. Table 2 lists the mean crack growth measured for each sample according to the measurement technique and crack growth definition. The corresponding standard deviations are given in Table 3.

The results for each sample are presented graphically in Figure 1. Here the mean crack growth is plotted for each measurement technique and crack growth definition. The error bars extend to 1.96σ from the mean, where σ is the standard deviation for that particular technique and definition applied to that sample. Also shown on each Figure is the overall mean crack growth computed by grouping together all measurements for that sample.

	Sample						
Technique	1	2	3	4	5	6	Data
DM TrvMic (ASTM)	.892	***2.35***	.107	***1.72***	***1.36***	.481	21
DM TrvMic (BSI)	.949	***2.63***	***.070***	***1.95***	***1.50***	.480	15
DM ScaRul (ASTM)	.946	***2.28***	.109	1.76	1.35	.465	11
DM ScaRul (BSI)	***1.06***	2.50	.120	***1.94***	***1.57***	.504	8
IM TrvMic (ASTM)	.869	2.35	***.130***	1.76	1.40	.533	4
IM TrvMic (BSI)	.905	***2.60***	.095	***1.93***	***1.57***	.524	4
IM ScaRul (ASTM)	***.843***	***2.33***	.089	***1.72***	***1.31***	.455	16
IM ScaRul (BSI)	.921	2.63	.085	***1.99***	***1.47***	.495	9
IM Planim (Area)	.894	2.50	***.120***	1.75	***1.24***	.424	8
IM Weight (Area)	***.744***	2.38	***.177***	1.74	***1.32***	.474	10
All Techniques	.895	2.43	.103	1.80	1.39	.474	

Table 2: Mean of crack growth measurements (in mm) for each technique and sample. Values in bold/italic type differ significantly from mean for all techniques and that sample

	Sample						
Technique	1	2	3	4	5	6	All
DM TrvMic (ASTM)	.080	.148	.039	.064	.063	.053	.447
DM TrvMic (BSI)	.112	.217	.034	.139	.074	.044	.620
DM ScaRul (ASTM)	.133	.156	.060	.135	.073	.077	.634
DM ScaRul (BSI)	.186	.140	.072	.162	.193	.076	.829
IM TrvMic (ASTM)	.069	.219	.023	.046	.064	.113	.534
IM TrvMic (BSI)	.115	.306	.026	.058	.123	.084	.712
IM ScaRul (ASTM)	.090	.098	.029	.090	.081	.063	.451
IM ScaRul (BSI)	.107	.154	.038	.157	.100	.044	.600
IM Planim (Area)	.171	.287	.035	.104	.068	.102	.767
IM Weight (Area)	.179	.176	.079	.099	.111	.084	.728
Mean Δa All Techniques	.895	2.43	.103	1.80	1.39	.474	

Table 3: Standard deviation (in mm) of crack growth measurements for each technique and sample

Discussion

Differences between measurement techniques and crack growth definitions

It should be recognised at the outset that comparison of the mean crack growth results will not allow any best or worst technique to be identified.There is no absolute "correct" crack growth measurement against which to assess the others. But consistent differences between techniques and crack growth definitions can be detected if present. A knowledge of these will

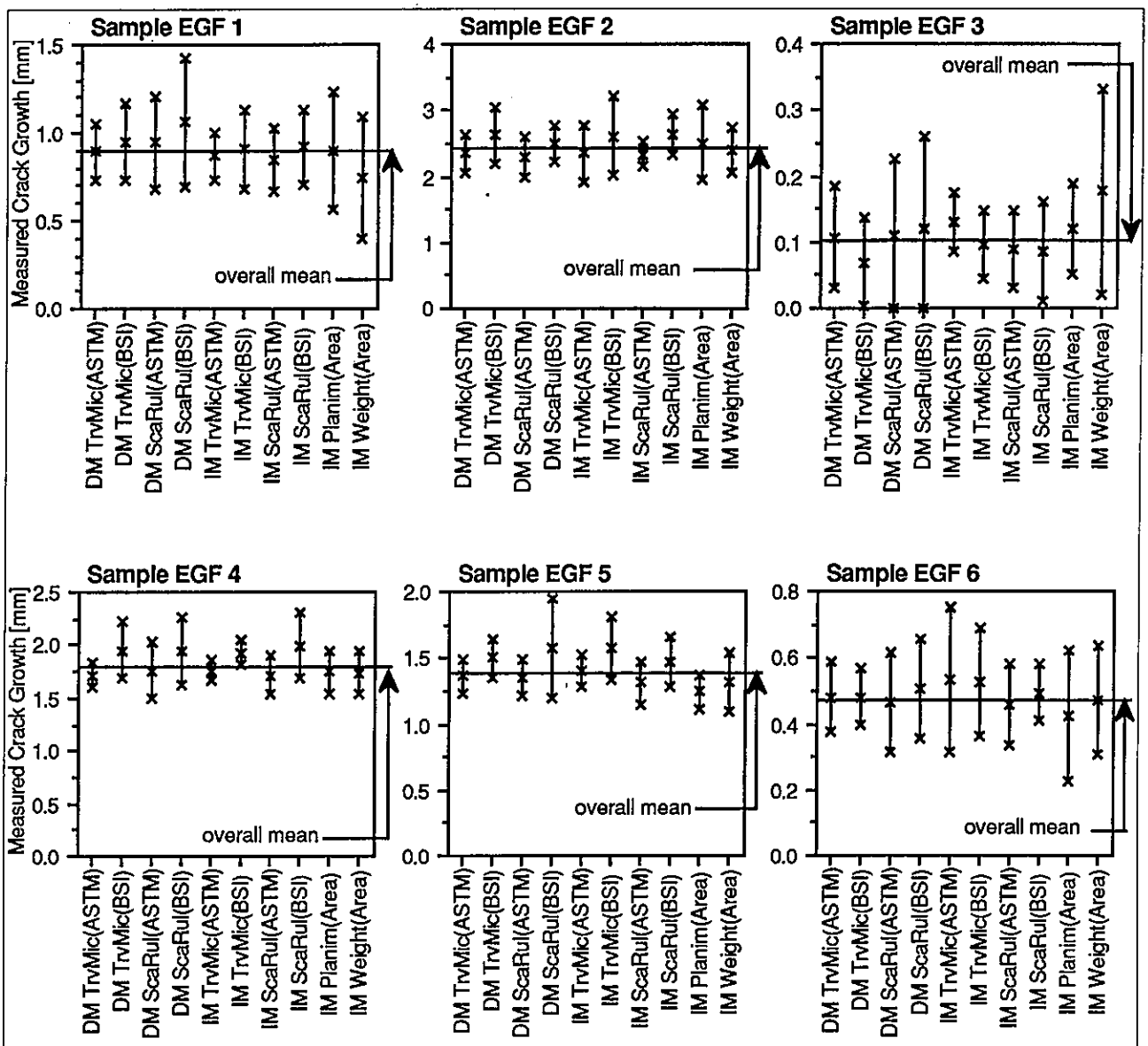

Figure 2: Influence of measurement technique and crack growth definition on measured crack growth.

be useful when comparing crack growth resistance data based on different crack growth measurement techniques and definitions.

Examination of Figure 1 and Table 2 shows that the differences between the mean crack growths measured on any one sample by the different techniques and definitions are small. The greatest difference between smallest and largest mean crack growth measurements for any one sample was 0.32 mm. This was observed for the sample with the largest crack growth, and in general the spread in mean crack growths for the range of techniques and definitions tended to decrease with decreasing crack growth.

An approximate test of the significance of differences between the measurements of mean crack growth for one sample can be made by comparing the mean for each technique and definition with the overall mean. The overall mean, Δa, and standard deviation, σ, for all techniques and definitions are first computed. Then the standard error, *s.e.* is estimated for each individual set of measurements:

$$s.e. = \frac{\sigma}{\sqrt{n_i}} \qquad (4)$$

where n_i is the number of measurement available for that particular sample, technique and definition. If the mean crack growth for that sample, technique and definition differs from the overall mean by less than ± 1.96 *s.e.* then the difference is probably insignificant (This test is only approximate, and may be misleading in the case of large differences between the techniques. Furthermore, it should be noted that the test becomes more stringent as the number of measurements in a set increases). In Table 2, mean crack growth values in bold/italic print do not meet this criterion for insignificant difference from the overall mean.

It can be seen that there are some consistent differences between mean crack growth values. The mean crack growth for the BSI definition is generally higher than the equivalent ASTM defined value, except at the lowest crack growth when the position is reversed. Indeed, BSI defined crack growth measurements tend to be higher than the overall mean at all except the lowest crack growth. Of the ASTM defined crack growth measurements, those made directly with travelling microscope and indirectly with scale rule tend to be lower than the overall mean. Finally, both area based crack growth definitions tend to be lower than the mean for all apart from the lowest crack growth; then they were higher than the mean.

The comparison of ASTM and BSI multipoint averages suggests that the exclusion of the stretch zone is more significant than the inclusion of the outermost crack growth measurements at low crack extensions, making the BSI average lower then. Conversely, at high crack growths the inclusion of the outermost measurements reduces the mean by more than the exclusion of the stretch zone, which is presumably a smaller fraction of the total crack growth now, so that the ASTM average becomes the lower of the two.

Repeatability of measurements

Possibly the most important aspect of any procedure for measuring crack growth is its repeatability, particularly if that procedure is to be part of a standard test technique for determining crack growth resistance. Without knowing the repeatability, it is not possible to make valid comparisons of data for different materials or from different laboratories. The standard deviation of the crack growth computed for each set of measurements, that is of all measurements made on one sample by one technique and definition, gives an indication of the reproducibility of that technique and definition- the smaller it is, the higher the reproducibility. Considering any one sample, the differences between standard deviations for different techniques and crack growth definitions are not very great. Typically the largest standard deviation is two to three times the smallest. No one measurement technique and crack growth definition gives the smallest standard deviation for all samples - in some cases the limited number of measurements reduces the significance of the standard deviations for individual samples.

One way of overcoming this problem of representing the overall repeatability is to sum over all samples the standard deviation for each technique and definition. The resultant value is not the overall standard deviation of all measurements, but it does provide a comparitive indication of repeatability. The summed standard deviations are presented as the last column in Table 3.

A simple way of comparing the repeatability of the different techniques and definitions is to rank them according to the size of the standard deviations. This has been done in Table 4. Here for each of the six samples a number between 1 and 10 has been ascribed to each technique and definition. 1 indicates the lowest standard deviation for that sample, 2 the next lowest and so on with 10 being the highest. As in the case of the absolute standard deviations, the rankings have been summed over all samples and this sum used to establish another overall ranking. These overall rankings are also given in Table 4.

	Sample						
Technique	1	2	3	4	5	6	All
DM TrvMic (ASTM)	2	3	7	3	1	3	1
DM TrvMic (BSI)	5	7	4	8	5	2	4=
DM ScaRul (ASTM)	7	5	8	7	4	6	6=
DM ScaRul (BSI)	10	2	9	10	10	5	10
IM TrvMic (ASTM)	1	8	1	1	2	10	3
IM TrvMic (BSI)	6	10	2	2	9	8	6=
IM ScaRul (ASTM)	3	1	3	4	6	4	2
IM ScaRul (BSI)	4	4	6	9	7	1	4=
IM Planim (Area)	8	9	5	6	3	9	8
IM Weight (Area)	9	6	10	5	8	7	9
Mean Δa All Techniques	.895	2.43	.103	1.80	1.39	.474	

Table 4: Ranking of techniques for each sample according to standard deviation – lowest ranking corresponds to lowest standard deviation

Examination of Tables 3 and 4 shows that direct measurement with a travelling microscope and the ASTM definition gave lowest overall standard deviation in crack growth and had therefore the best repeatability of the techniques and definitions examined. Indirect measurement with a scale rule and, again, the ASTM definition gave an overall repeatability which was only slightly poorer. Using a travelling microscope instead of a scale rule plainly decreased the standard deviation and hence increased the repeatability of crack growth measurements made direct on the fracture surface. Conversely, it increased the standard deviation and so reduced the repeatability of measurements made indirectly on fractographs. Considering any one measurement technique, the ASTM definition of crack growth gave a consistently lower standard deviation than did the BSI definition. This no doubt reflects difficulty in defining unambiguously the transition from stretch zone to true ductile crack growth. Neither of the two area based measurement techniques did particularly well, but the least reproducible measurements overall were provided by direct measurement with a scale rule and the BSI definition of average crack growth.

There was no clear dependence of the ranking of standard deviations on the crack growth being measured. That is to say, in general, a technique and definition giving good repeatability for small crack extensions also gave good repeatability at large crack extensions. The one exception to this was with the smallest crack growth examined. Then direct measurement by travelling microscope with the ASTM definition gave lower repeatability than other techniques to which it was superior at higher crack extensions.

Influence of crack growth on repeatability

As can be seen in Table 3, there was a general trend for the standard deviation in the crack growth to increase with increasing crack growth. In all cases the lowest crack growth sample displayed the lowest standard deviation. The overall standard deviation for all measurement techniques and definitions has been calculated for each sample. This is plotted against the overall mean crack growth in Figure 2. This shows clearly the increase in standard deviation, and hence in uncertainty of crack growth measurement, with increasing crack growth. It is also apparent that the standard deviation is not directly proportional to the crack growth. Instead the fractional standard deviation, that is the standard deviation divided by the mean, decreases with increasing crack growth. This can be interpreted as indicating two contributions to the standard deviation, the first being independent of crack growth and the second directly proportional to crack growth.

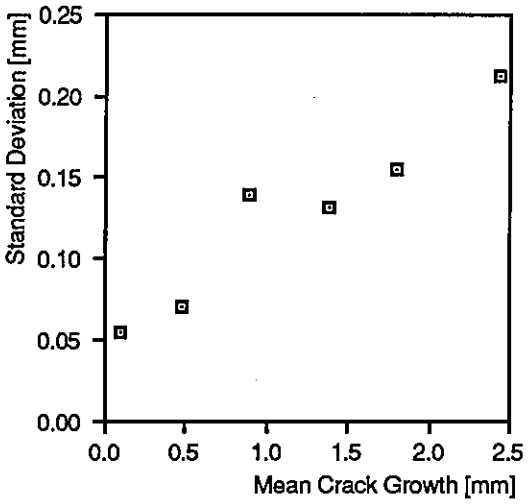

Figure 2: Relationship between mean crack growth and standard deviation of crack growth measurements.

Uncertainty in one measurement

Finally, these results can be used to give an indication of the possible error or uncertainty in crack growth when only one measurement is made. With one measurement, the 95% confidence limits to the true crack growth value are ±1.96 times the standard deviation for the technique and definition employed. The best overall repeatability was given by direct measurement with a travelling microscope and the ASTM crack growth definition. This technique and definition had confidence limits of ±0.08 mm at a crack growth of 0.1 mm, rising linearly with crack growth to ±0.29 mm at 2.5 mm crack growth.

Conclusions

1) All crack growth measurement techniques and definitions gave rather similar mean crack growth values. The BSI definition of crack growth gave values that were higher than the overall mean crack growths, except at vary low crack growth (c. 0.1 mm), when they tended to be smaller than the overall mean. When applied to direct measurements with a travelling microscope and indirect measurements with a scale rule, the ASTM definition of crack growth gave values that tended to be lower the overall mean.
2) The most reproducible measurement procedures overall were direct measurement with a travelling microscope and indirect measurement with a scale rule, both using the ASTM definition of average crack growth. The ASTM definition of average crack growth gave consistently better repeatability than did the BSI definition.
3) Overall, the standard deviation in crack growth and hence the uncertainty in crack growth increased with increasing crack growth.
4) The uncertainty in any one crack growth measurement made with the most reproducible technique and definition was ±0.08 mm at 0.1 mm crack growth, rising to ±0.29 mm at 2.5 mm crack growth.

Acknowledgements

Thanks are due to all who participated in this round robin programme, both for their efforts in making the measurements and for their patience in waiting for this analysis. Special thanks go to Dr. Detlev Dormagen and Mr. Gordon Lindsay for assisting in the collation and analysis of the data.

References

1 Annual Book of ASTM Standards, E813-81,"J_{Ic}, a measure of fracture toughness", Section 3, vol. 03.01 (1983) 762-80.
2 British Standards Institution, BS 5762, "Methods of crack opening displacement (COD) testing", 1979.
3 B.K. Neale, D.A. Curry, J.R. Haigh and K.N. Ackhurst, "A procedure for the determination of the fracture resistance of ductile steels", Int. J. Pres. Ves. & Piping, vol 20 (1985) 155-179.

FATIGUE 87

THIRD INTERNATIONAL CONFERENCE ON FATIGUE AND FATIGUE THRESHOLDS

JUNE 28th - JULY 3rd 1987

UNIVERSITY OF VIRGINIA

CHARLOTESVILLE, U.S.A.

The major topics reported in the Proceedings include,

- **CRACK INITIATION.**
- **CRACK CLOSURE.**
- **SMALL CRACKS.**
- **VARIABLE AMPLITUDE LOADING.**
- **FATIGUE AND MICROSTRUCTURE**
- **FATIGUE THRESHOLDS.**
- **RESIDUAL STRESS.**
- **HIGH TEMPERATURE FATIGUE.**
- **ENVIRONMENTAL EFFECTS AND ADVANCED MATERIALS.**

The Proceedings consist of 3 volumes case bound 2.25 mm by 155mm with 1870 pages and over 610 illustrations.
ISBN 0 9 4787 23 9

EMAS

EDITORS:
R. O. RITCHIE
E. A. STARKE Jnr.

OVERVIEWS

An Overview of Fatigue.
A. J. MCEVILY.

Deformation Mechanisms and Crack Initiation in Fatigue.
V. GEROLD and B. MEIER.

Environmentally Assisted Fatigue Crack Growth.
R. P. WEI.

Deformation, Fatigue, and Fracture Behaviour of Two Cast Anisotropic Superalloys.
WALTER W. MILLIGAN, ERIC S. HURON and STEPHEN D. ANTOLOVICH.

Applications of Fatigue Analyses: Transportation. - R. W. LANDGRAF.

Fatigue Crack Growth. - C. J. BEEVERS.

Applications of Fatigue Analyses: Aircraft Engines. - A. C. PICKARD, M. A. HICKS and R. H. JEAL.

Application of Fatigue Analyses: Airframes. - G. LUTJERING and H. J. SCHMIDT.

Fatigue Crack Growth Predictions for Variable - Amplitude and Spectrum Loading. - J. SCHIJVE.

Applications of Fatigue Analyses: Energy Systems. - P. L. ANDRESEN, R. P. GANGLOFF, L. F. COFFIN and F. P. FORD.

Substructural and Microstructural Influence on Crack Closure.
W. W. GERBERICH.

The Micromechanisms of Small Fatigue Crack Growth and the Influence of Metallurgical Factors. - J. LANKFORD and D. L. DAVIDSON.

Requests for books and further information should be sent directly to:

Engineering Materials Advisory Services Ltd., 339, Halesowen Road, Cradley Heath, Warley, West Midlands, B64 6PH, U.K.

Price: UK £130, Overseas $260 U.S.

STRESS CORROSION FROM A VIEWPOINT OF FRACTURE MECHANICS

Where Fracture Mechanics and Corrosion Specialists Meet

J.Spiekhout
N.V. Nederlandse Gasunie, Groningen, The Netherlands

SUMMARY AND CONCLUSIONS

This article deals with the use and limitations of fracture mechanics in the assessment of stress corrosion. Fracture mechanics up till now deals primarily with fracture behaviour under quasi-static load (no environmental influences and creep) as well as fatigue and corrosion fatigue.

With regard to the use of fracture mechanics in the assessment of stress corrosion, it is concluded that:

- determining the allowable defect dimensions in order to prevent stress corrosion is possible provided a reliable K_{Iscc} value is available for the material/medium combination in question at the applicable temperature;
- assessing the risk of unstable fracture due to a known stress corrosion crack at the time of its detection, on the basis of crack geometry, can be more difficult than for other kinds of defects, quite apart from the normal problems of a purely fracture mechanics nature;
- detection of stress corrosion cracks can be difficult and determining the shape and dimensions of stress corrosion cracks using NDT techniques is often more difficult than with other kinds of defects;
- it is not possible to express uniform crack growth relations and the possibility of defects propagating into each others interaction zone must be taken into account. Crack growth relations must be determined on an empirical basis in each case and must make allowance for the uncertainties concerning the correlation between test conditions and conditions in practice.

By way of elucidation of a fracture mechanics approach to stress corrosion, a few cases from the literature are also briefly discussed.

INTRODUCTION

Both fracture mechanics and stress corrosion are relatively young disciplines in which development is still continuing.

Stress corrosion is defined as the initiation and propagation of a crack under the simultaneous influence of a medium and tensile stress. This tensile stress can be present as a result of external loads or residual stresses in the material, or both. As far as the corrosive medium is concerned, it is a question of an electrolyte.

It is basically possible to say something about the likely time to failure provided the relevant crack growth relations are known.

It is useful to know the K_{Iscc} threshold for the different possible materials as this parameter provides an indication of the resistance to stress corrosion of various material/medium combinations. However as is generally known that when determining the fitness for purpose of a structure, it is always necessary to take uncertainties into account with respect to the correct value for the K_{Iscc} threshold. Beside the recognized uncertainties, ageing and creep may lower the threshold, as can cyclic loading over and above the level of quasi-static loading. In the latter case, this is referred to as non-classical stress corrosion.

When determining the life of the structure and calculating on the basis of growing cracks in addition to the problems from a fracture mechanics point of view, which are discussed next, the interpretation of the results of stress corrosion tests again gives rise to inevitable problems. For instance, the incubation period depends on the material, conditions of stress (K_I) and load history. In the process of crack propagation, much more so than in the case of fatigue, it is possible for numerous cracks to develop and cracks to become branched.

FRACTURE MECHANICS APPROACH TO STRESS CORROSION IN THE VARIOUS CODES

PD6493 [1] devotes one article (art. 18.4) to stress corrosion. In specific cases, involving material-environment combinations with which sufficient experience (also in practice) has been built up, it can be assumed that failure will not occur as long as $K_I < K_{Iscc}$. In all other cases of possible stress corrosion, not a single defect is acceptable. Nothing is said on the matter of operating in conjunction with growing stress corrosion cracks. At present, there is no information to indicate that this will be changed in the next revision of PD6493.

R6, rev. 2 [2] only concerns fracture behaviour under quasi-static load. In rev. 3 of R6 [3], appendix 6 is entirely devoted

to fatigue, corrosion fatigue, stress corrosion and interaction between the latter two phenomena. In this appendix, provision is made for controlled operation in conjunction with growing stress corrosion cracks. A formulation in the form:

$$\frac{da}{dt} = C'K^n$$

is proposed for the crack growth, in which C' and n are constants which are to be determined from stress corrosion tests on notched test specimens.

Article IWB-3641.1 in ASME XI [4] mentions operation of vessels with growing stress corrosion cracks. However the way in which to treat stress corrosion is left to the user.

PRACTICAL PROBLEMS RELATED TO THE FRACTURE MECHANICS APPROACH OF STRESS CORROSION

A stress corrosion crack is a sharp defect just like fatigue crack, for example. Regarding the fracture mechanics assessment of a detected stress corrosion crack, as to whether the crack represents a hazard or not, it is basically possible to treat such a crack in the same way as any other defect.

Apart from the problems of a purely fracture mechanics nature, there is the problem of detecting defects. In particular, establishing the precise depth of a defect using NDT techniques is not easy. In the case of stress corrosion cracks, there is additional problem of the often erratic course of the very fine crack, the possibility of branching of the crack and of several cracks in close proximity to each other. Detecting stress corrosion cracks on the metal surface is difficult enough. In order to do so, the surface of the metal has to be treated in the correct manner. Grit blasting, for example, can "hammer closed" any stress corrosion cracks which are present, rendering it impossible to detect them.

The question of branched cracks, assuming that the course of the crack is known, is in fact answered by fracture mechanics. The stress intensity factor of a branched crack and also that of a curved crack, is smaller than that of a straight crack.

For more than one adjacent crack, as can occur with stress corrosion, it is possible to apply interaction rules for adjacent defects to evaluate whether they should be treated as individual defects or as one single composite defect. The interaction rules for stress corrosion cracks running parallel to each other lead to conservative results. This is because, for parallel cracks, in the same way as for branched and curved cracks, the stress intensity factor is 30-70% lower than for a single straight crack (see [4]-[16]).

Another favourable effect with parallel cracks is that they reduce the residual stress. To what extent such a reduction takes place is not known, however. The necessary overestimation of the residual stress can therefore make the calculation unnecessarily conservative in such cases.

When stress corrosion cracks occur at the surface of the material, after a certain amount of lengthwise growth, they will begin to counteract each other. The stress intensity factor at the crack tips at the surface will decrease and, at a certain stage, crack propagation will become predominantly depthwise. This is schematized in figure 1.

With the aid of fracture mechanics, it is possible to determine the seriousness of a detected crack and also to say something about the critical crack dimensions. The time taken for a detected crack to grow to critical dimensions can also be determined

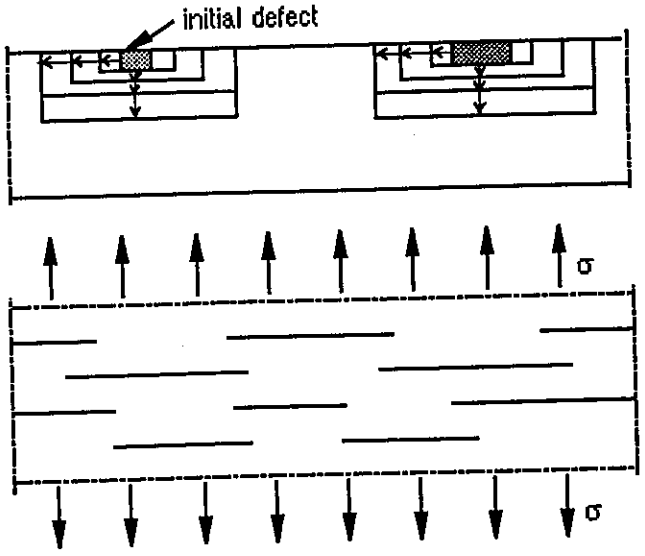

FIGURE 1: Crack growth schematized

if the crack growth relation is known. This crack growth relation has to be derived from tests on notched test specimens of the material concerned, conducted in the appropriate medium and at the relevant temperature. The problems implied by such tests have already been indicated.

Another important aspect to consider when conducting crack growth tests is the necessary time involved. The duration of a fatigue test compared with the design life of a structure can be reduced by increasing the cyclic loading frequency. In the case of stress corrosion crack growth tests (or large scale tests with more complicated geometries), this is not possible. The effects of increasing the stress, increasing the ion concentration in the medium or increasing the temperature are generally not sufficiently well-known, so that one has no alternative but a long test duration.

An uniform relation for the stress corrosion crack growth with concentration factors, electrochemical constants etc. is not available (although in ref. [9], an attempt is made to provide such a relation in the description of J_{SCC} for H_2 stress corrosion of pipeline steel and, in ref. [10], K_{SCC} for H_2 stress corrosion of Cr-Mo steel is written as a function of the carbon content among other things). One of the reasons for the absence of an uniform relation is that from a corrosion point of view there is no single straight forward mechanism at work in stress corrosion: for example, there is the classical stress corrosion which occurs in austenitic stainless steel in the presence of chlorine ions, stress corrosion in a hydrogen environment or the non-classical stress corrosion such as carbonate-bicarbonate stress corrosion, which can only occur under quasi-static load cycles, added to which there is the fairly strong influence of inhomogeneities on stress corrosion crack growth and the path along which the crack will propagate.

The crack growth relation must also make provision for the effect of quasi-static cycling on top of the level of constant load, as this is a fairly common occurrence in practice (e.g. filling and emptying).

Stress corrosion cracks in close proximity to each other can extend into each other's interaction zones and suddenly form one long crack. In making calculations of expected service life, this must be taken into account. It is equally possible for a stress corrosion crack to grow out of an area of high stress concentration into one of lower stress levels where crack growth stops. In a deformation controlled situation it is also possible for the stress to diminish as the size of the crack increases and, again, the crack growth can slow down and even halt as a result. These latter effects are of course favourable.

In the above, we have proceeded on the basis that the shape and position of the stress corrosion cracks are known. In practice, this may be the case if it is known that stress corrosion cracks can only occur in certain parts of the structure, for example at the site of welds. The situation is quite different, however, if one has discovered a number of small cracks and therefore suspects that similar cracks are likely to occur in the rest of the structure but does not know where. This is like looking for the proverbial needle in a haystack. However, by applying the principles of fracture mechanics, it is possible to determine what the maximum size of a defect is, which will just survive the test load. In the same way, it is possible to determine what size of defect would lead to failure under operating conditions. The difference between the defect sizes under operating conditions and under the test load can then be used to determine the life of the structure, or the period which can be allowed to elapse before the next test loading. It should be noted, however, that there are disadvantages to test loading as such.

The test load can in fact cause a certain amount of stable crack growth of what are termed sub-critical defects (this can be detected on the basis of acoustic emissions, provided it is possible to filter out any interference from background noise, such as from running machinery) and can then lead to re-initiation of stress corrosion cracks which had in fact ceased growing when operating conditions are resumed. But in this case, the remedy is perhaps worse than the disease. Test loading does not provide an answer to the problem of possible interaction of propagating cracks in close proximity to each other, however.

A FEW CASES

Ref. [11] reports on the stress corrosion and fatigue of steel grades used for gas bottles for storage of hydrogen. The results of tests on steels with a hardness of approximately 310 HB gave a K_{SCC} value of approximately 50 $MNm^{-3/2}$. The conclusion was that the critical defect size appropriate to this K_{SCC} value was clearly larger than the criteria of good workmanship applied in the factory.

The results of fatigue tests gave acceleration factors ranging from 20 to in excess of 100, depending on hardness, compared with the crack growth rate in an inert medium. Also measured were the effect of type of test specimen and the effect of load cycling frequency.

In ref. [12], a whole session was devoted to stress corrosion. This mainly concerned the determination of the threshold value for stress corrosion,the investigation of the influence of load application rate, of rate of strain and pre-loading on the test results and the investigation of the influence of alloy elements and manufacturing operations on the susceptibility to stress corrosion, for specific material-medium combinations in each case. Practical applications and the evaluation of crack growth relations are not covered.

Ref. [8] reports on a case of failure due to carbonate-bicarbonate stress corrosion of carbon steel and describes the steps taken to prevent further damage. During tests under simulated operating conditions, crack growth rates of up to $2x10^{-7}$ mm/s were found at the surface. The rate of growth through the thickness was approximately 4 times slower. On the basis of this crack growth rate, a life of over 5 years was calculated. The failure had occurred 6 years after construction. The steps taken consisted in replacing the most suspect section of pipe and altering the operating conditions (lowering the maximum operating pressure, permitting smaller pressure fluctuations and lowering the maximum operating temperature) with a view

to preventing any further growth of stress corrosion cracks in the pipeline.

A fracture mechanics underpinning for the expected life and necessary inspection intervals has been provided for the rotating parts of steam turbines of NiCrMoV turbine steels coming into contact with water or steam under conditions which can lead to stress corrosion [16]. The crack growth (da/dt in mm/h) is expressed as a function of temperature (T in °Celsius) and the 0.2%-yield stress ($R_{p0.2}$ in N/mm²) as follows:

$$\ln da/dt = -1.7 - 4056.7/(T+273) + 0.004032\, R_{p0.2}$$

In the assessment of stress corrosion cracks in spherical tanks for the storage of ammonia, use is made of a "leak-before-break" concept which depends on the toughness of the material. Cracks which are likely to fail are ground out and filled by welding. Small cracks are ground out to produce a smooth profile so as to reduce the stress concentration (see [5] and [17]).

LITERATURE

1 PD6493: 1980: "Guidance on some methods for the derivation of acceptance levels for defects in fusion welded joints", British Standards Institution, UK.

2 R.P. Harrison, K. Loosemore, I. Milne, A.R. Dowling: "Assessment of the Integrity of Structures Containing Defects", Central Electricity Generating Board, R/H/R6-Rev. 2, UK.

3 I. Milne, R.A. Ainsworth, A.R. Dowling, A.T. Stewart: "Assessment of the Integrity of Structures Containing Defects", Central Electricity Generating Board, R/H/R6-Rev. 3, UK.

4 "Pressure Vessels", ASME Boiler and Pressure Vessel Code, Section XI, Division 1, "Rules for In-Service Inspection of Nuclear Power Plant Components", ASME, USA.

5 O.L. Towers: "SCC in welded ammonia vessels", Metal Construction, August 1984.

6 "Corrosion - Volume 1 - Metal/Environment Reactions", edited by L.L. Shreir, Newness-Butterworths, UK.

7 R.N. Parkins: "An overview - Prevention and control of stress corrosion cracking", Materials Performance, August 1985.

8 T.N. Baker, C.G. Rochfort, R.N. Parkins: "Pipeline rupture 1, 2 and conclusions", Oil and Gas Journal, January 12, January 26 and February 2, 1987.

9 A.N. Kumar, R.K. Pandey: "Process and mechanism of fracture in a pipeline material", in "Fracture Prevention in Energy and Transport Systems", Proc. Rio de Janeiro, Brasil, 1986.

10 Hong Youshi, Liang Kiaming: "An Investigation on Stress Corrosion Cracking (SCC) Behaviour of Cr-Mo Steels", in "Advances in Fracture Research", Proceedings of the 6th International Conference on Fracture (ICF 6), New Delhi, India, 1984.

11 D. Harris, A.H. Priest, J. Davenport, P. McIntyre, E.A. Almond, B.Roebuch: "Hydrogen-assisted cracking of gas container steels", in "Integrity of gas containers: Materials Technology" NPL (National Physical Laboratory) Teddington, UK, 1984.

12 " Advances in Fracture Research", Vol. 4, "Environmental Effects", Proceedings of the 6th International Conference on Fracture (ICF 6), New Delhi, India, 1984.

13 "Sub-critical Crack Growth due to Fatigue, Stress Corrosion and Creep", Course, Ispra, Italy, October 1981, ed. L.H. Larsson, Elsevier Applied Science Publ., The Netherlands, 1984.

14 C. Berger, G. Mundt: "Fracture Mechanics Behaviour of Stress Corrosion Cracks", Proceedings of the 5th European Conference on Fracture (EGF5), Lisbon, Portugal, 1984.

15 C. Berger: "Fracture Mechanics Behaviour of Stress Corrosion Cracks", Int. Conf. and Exp. on Fatigue, Corrosion Cracking Fracture Mechanics and Failure Analysis, Salt Lake City, USA, 1985.

16 C. Berger: "Bewertung von Fehlern in Bauteilen des Turbogeneratoren-haus" (Assessment of defects in turbogenerator construction components), DVM AK "Bruchvorgänge" (Fracture Processes), Aachen, February 1986, (in German).

17 D.P. Peng: "Fracture prevention for ammonia storage facilities", 27th Symposium on Safety in Ammonia Plants and Related Facilities, American Institute of Chemical Engineers, Los Angeles, California, November 1982.

ICAF

NEW MATERIALS AND FATIGUE RESISTANT AIRCRAFT DESIGN

EDITOR
David L. Simpson

The Proceedings of the 14th Symposium of the International Conference on Aeronautical Fatigue, 8 - 12 June, 1987, Ottawa, Canada.

629 pages with 410 illustrations and case bound 255mm x155mm
ISBN O 947817 29 B

This publication contains a major paper by Tom Swift, his 11th Platema Memorial Lecture on **DAMAGE TOLERANCE IN PRESSURISED FUSELAGES.** The new materials receiving particular attention with respect to fatigue behaviour include **ALUMINIUM LITHIUM ALLOYS, POWDER METALLURGY ALUMINIUM ALLOYS, METAL MATRIX COMPOSITES ALLOYS, NEW MECHANICALLY ALLOYED ALUMINIUM** and **CARBON FIBRE COMPOSITES.** Theoretical and experimental studies are also presented on spectrum loading, rain flow counting and composite structure fatigue assessment. Sandwich and cold worked structures are also highlighted as well as environmental aspects such as temperature and aggressive atmospheres.

EMAS

Requests for books and further information should be sent directly to:

Engineering Materials Advisory Services Ltd., 339, Halesowen Road, Cradley Heath, Warley, West Midlands, B64 6PH, U.K.

Price: UK £58, Overseas $115 U.S.

DVM Honorary Membership for
Dr. Louis Coffin *and* Prof. Dr. Kunihiro Iida

On the occasion of the 2nd International Conference on **Low Cycle Fatigue and Elasto-Plastic Behaviour of Materials**, held in Munich (FRG) from September 7-11, 1987, the Deutscher Verband für Materialprüfung (German Association for Testing ofMaterials) – DVM – awarded the Honorary Membership to Dr. Louis F. Coffin (USA) and Prof. Dr. Kunihiro Iida (Japan). Below follow the laudations delivered on this occasion.

Laudation for
Dr. Louis F. Coffin
by H. Nowack

Ladies and Gentlemen, the Deutscher Verband für Materialprüfung (DVM) and the organizers of the present Conference want to honour **Dr. Louis F. Coffin**, an eminent person in the field of Low Cycle Fatigue (LCF).

Although Dr. Louis F. Coffin is well-known to all of you, I should like to briefly commemorate his most important efforts in the field of LCF. Dr. Coffin is a pioneer of LCF and the visible manifestation of his significant role in this field is the famous Coffin-Manson relationship. This relationship has been published 33 years ago, and this idea initiated a new age and a new type of thinking in the field of fatigue.In a review lecture which Dr. Coffin gave in 1985 in the Sagamore Hotel at Lake George, he pointed out that at that time – that means 33 years ago – the conventional fatigue prediction methods had no longer been sufficient. New types of pressure vessels and equipments for nuclear power plants had to be realized,where stresses above the elastic limit and very often extremely severe thermal stresses were present. Once the foundation stone for the treatment of such conditions was set up by the introduction of the Coffin-Manson relationship, the building of LCF started to develop.

From left to right: Dr.-Ing. H. Nowack, Prof. Dr.-Ing. D. Aurich, Dr. L.F. Coffin, Prof. Dr. K. Iida and Dr.-Ing. E. Haibach

There were again and again most essential ideas, pulses and contributions by Dr. Louis F. Coffin: Whether it were the experimental techniques, where complicated testing requirements had to be realized, whether it were efficient and reliable damage monitoring systems, or whether it were his ideas which motivated the researchers in the field of materials to explore the LCF mechanisms on a microstructural level, or whether it was his theoretical thinking, which led to the development of most essential prediction methods, in all these fields Dr. Louis F. Coffin acted as a most important pacemaker. One of the LCF prediction methods, which I should like to specially mention, is the frequency separation method to describe the interaction of time dependent and of time independent deformation components under complicated creep-fatigue conditions.

During the past ten years some tendency developed together with the progresses in elastic-plastic fracture mechanics to consider the field of LCF from two different points of view, from the traditional LCF viewpoint and from a fracture mechanics point of view. Dr. Coffin has placed always much emphasis into bringing these two diverging directions again closer together and to develop unifying concepts.

It is impossible to give a complete record of the innumerable highlights of his work and of his thinking. Moreover, Dr. Coffin has also a clear opinion about that how the future developments in the field of LCF should go. He suggests that – since the lifetime of technical components is steadily increasing – the corrosion influences should be more intensively investigated. Since the uncertainties of prediction methods for engineering components also increase as the lifetime of the components is increased, sensitive and reliable in-service damage monitoring systems have to be developed. He also recommends the extensive use of computers in order to reduce the expenses for testing and for fatigue life prediction.

Besides being an extremely engaged and successful researcher and engineer, there exists also another very important side of Dr. Louis F. Coffin. He is an excellent teacher. In numerous seminars, courses and lectures he transferred his unique knowledge and experience to other engineers and scientists. Especially also the young engineers took an immense profit from learning from him. I myself, when I had started my research work in the field of fatigue and had the opportunity to visit Dr. Coffin at General Electric about 15 years ago, remember the exciting atmosphere in his surrounding and the extremely informative technical discussions.

Dr. Coffin's career of life is full of highlights. He received his Science Doctor in Mechanical Engineering from the MIT. He was also Assistant Professor at the MIT. Later on he became an employee of the Atomic Power Laboratory and from there he went to General Electric Research and Development Centre. This is the place where most of his pioneering efforts in the field of LCF took place.

During his research and development work he published more than 130 papers and he is also holder of about 10 important patents. His outstanding successes in his work were honoured by 10 awards and honours. Dr. Louis F. Coffin is also fellow and member of nearly all renowned American societies and he is affiliated with numerous institutions.

Today Dr. Louis F. Coffin has excellent relationships to all colleagues in the field of Low Cycle Fatigue around the world. On the "First International Conference on Low Cycle Fatigue and Elasto-Plastic Behaviour of Materials" in Stuttgart Dr. Coffin gave the introductory lecture, and it was the spirit coming from his lecture, which introduced extremely fruitful communications between engineers and scientists.

The Chairman of the Conference, Prof. Rie, the Head of the DVM, Prof. Aurich, and we all other organizers of the present Conference thank Dr. Louis F. Coffin deeply for his substantial support. In order to express his gratitude to Dr. Louis F. Coffin, the DVM should like to award the honorary membership to him.

Laudation for Professor Dr. Kunihiro Iida by E. Haibach

Ladies and Gentlemen, some prominent person gave the following definition of the term 'colleague':"A colleague is a dispensable competitor. " Now I could enter into a long discussion about arguments supporting or opposing this statement. But I won't and better leave the term 'colleague' un-commented:

I would rather like to speak of a friend we have among us. He is well known, either personally or through literature, to every one working in the field of fatigue, in particular low cycle fatigue, of fatigue of welded joints, or of fatigue and structural safety of nuclear power plants.

The Deutscher Verband für Materialprüfung would be proud to have this personality as a member and, therefore, asks for his willingness to accept a honorary membership on occasion of this conference. With his kind permission I may, so to say, fill in the application form of DVM membership on his behalf which then will read as follows:

Name : **Kunihiro Iida**
Borne : 1926 in Tokyo
Nationality : Japanese

Main positions held:

- Professor Emeritus of the University of Tokyo.
- Professor, Department of Mechanical Engineering, Shibaura Institute of Technology, Tokyo.
- Chairman of the Technical Advisory Committee on Nuclear Power Plant Operation, established by the Japan Ministry of International Trade and Industry.
- Vice-Chairman of Commission XIII, Fatigue Behaviour of Welded Components, of the International Institute of Welding.

Academic and professional career:

- Graduated at the Department of Naval Architecture, faculty of Engineering, The University of Tokyo, the department he worked later on for almost 17 years.
- Degree of Doctor of Engineering on a thesis Discontinuities on Initiation and Propagation of Low Stress Brittle Fracture".
- For 13 years he worked on welding and strength of ship structures.
- For another 7 1/2 years he then was Associate Professor, first at the department of Nuclear Engineering and the at the Department of Naval Architecture. In 1971 he became Professor at the Institute of Naval Architecture, from where he retired 1986, but continuing teaching at Shibaura Institute of Technology since then.

There are several good reasons to support the suggestion of having our friend Professor Iida offered a honorary membership of DVM:

First, I would like to mention his merits as an author or co-author of a highly impressive number of publications, a good part of which written in English. And it is through these papers, many of those he personally presented at conferences, that Professor Iida provided us an immense amount of valuable information on research work carried out in Japan, which otherwise we hardly would have any knowledge of because of our difficulties with the Japanese language and writing. The paper being presented at the session tomorrow morning may be referred to as pretty good example of the services our friend has provided over many, many years; most of the work referred to in his present paper was published in Japanese language only. Hence we would like to show our appreciation as to his unique function of keeping us informed of what was and what is going on in fatigue research in Japan and to honour him as one of the first who bridged the language barrier and who continued to do so over many years of contacts on various occasions.

Secondly, I would like to mention his ability of bringing together those people from his and our country that work in the field of fatigue research and hence may benefit from such personal contacts by better understanding the findings and the background of the other's work. And again, the mission of Professor Iida's present visit is not just to participate in this Second International Conference on Low Cycle Fatigue and Elasto-plastic Behaviour of Materials. In fact, a parallel mission of his visit is to discuss the arrangements of the next German-Japanese Joint Seminary with Professor Kussmaul, an event that results from friendly connection existing since more than 20 years, as well.

Among all these activities we must not forget the successful research work Professor Iida did and still does himself, and the way of how he fruitfully influenced the research work of others. For instance, he arranged for the biggest low cycle fatigue testing machine of ± 3.000 t capacity to be installed and operated at his laboratories at the University of Tokyo.

Last, but not least, however, I would like to point out the fact that this conference is organized by Deutscher Verband für Materialprüfung and that the attribute "Deutsch" has a special recognize, who has the privilege to talk with him on subjects other than technical matters. Frankly speaking, I honestly admire his profound knowledge of German literature, music and culture. And maybe the understanding of German mentality he gained from there explains why he is friend with so many of us here in Germany.

Ladies and Gentlemen, in summarizing my arguments I may state that there are good reasons and great merits for which the Deutscher Verband für Materialprüfung wants to express the warmest thanks to Professor Iida by offering him a honorary membership. And, dear Professor Iida, may this award make you aware of the great number of friends you have in German and their great respect for you honest personality and for your meritorious professional work.

AGENDA of Fatigue and Fracture Events

Agenda items are placed free of charge. Inform the editor about any fatigue and/or fracture related meeting of interest for the readers of this Newsletter.

March 17-18, 1988
20. Sitzung des DVM-Arbeitskreises Bruchvorgänge "Corrosion and Fracture"
Location : DECHEMA, Frankfutt/Main
Organizer : DVM and DECHEMA
Language : German
Deadline : Nov. 13, 1987
Inquiries : Dr. Christina Berger
Kraftwerk Union AG, Dept. TWMF
P.O. Box 10 11 53
D-4330 Mülheim-Ruhr, FRG

April 5-15, 1988
NATO ASI Residential Advanced Course on ADVANCES IN FRACTURE SCIENCE AND TECHNOLOGY
Location : Hotel Joao, Alvor Beach, Algarve, Portugal
Organizer : CEMUL/IST, Lisbon, Portugal
Sponsor : NATO Scientific Affairs Division
Inquiries : Prof. Carlos Moura Branco
NATA ASI Fatigue/CEMUL IST
1096 Lisboa, Portugal
Tel. (1) 80 35 80/80 50 63
Telex 63 423 istutl p

April 12-14, 1988
International Conference on Environment-Assisted Fatigue
Location : Sheffield, UK
Organizer : Univ. of Sheffield, UK
Sponsor : EGF
Deadlines : Dec. 1, 1987 - Abstracts (500 words)
Inquiries : Dr. P. M. Scott
Materials Development Division
Building 393, Harwell Laboratory
Oxfordshire OX11 0RA, UK

April 21-22, 1987
16th Plenary Meeting of the EGF Task Group on Elastic-Plastic Fracture Mechanics
Location : FRAMATOME, Paris, France
Sponsor : European Group on Fracture
Deadlines : April 1, 1988 - announcement of contributions
Inquiries : Mr. A. Pellissier-Tanon
FRAMATOME
Tour Fiat
92084 Paris la Défence Cédex 16, France

April 25, 1988
Symposium on Surface Crack Growth: Models, Experiments and Structures
Location : Las Vegas (Nevada), USA
Sponsor : ASTM Committee E-24
Deadlines : Jul 1, 1987 - Abstracts (extended)
Mar 1, 1988 - Full manuscripts
Inquiries : W.G. Reuter (symposium co-chairman)
Idaho National Engineering Lab.
P.O. Box 1625
Idaho Falls, ID 83401
USA
Tel. 208/526-1708

April 25-26, 1988
9th Symposium on Composite Materials
Location : Las Vegas (Nevada), USA
Sponsor : ASTM Committee D-30
Deadlines : Jun 1, 1987 - Abstract (500-1000 words)
Jan 31, 1988 - Full manuscripts
Inquiries : S.P. Garbo (Symposium chairman)
United Technology, Sikorsky Aircraft Division
6900 North Main Street
Stratford (Connecticut) 06601-1381, USA
Tel. 203/386-4576

April 27, 1988
Symposium on Fatigue and Fracture Testing of Materials
Location : Las Vegas (Nevada), USA
Sponsor : ASTM Committees E-9 and E-24
Deadlines : Jul 1, 1987 - Abstracts (300-500 words)
Mar 1, 1988 - Full manuscript
Inquiries : H.I. McHenry (symposium co-chairman)
National Bureau of Standards
Boulder, Colorado 80303
USA, Tel. 303/497-3268

May 10-11, 1988
CEGB Structural Integrity Symposium
Location : CERL, Leatherhead, Surrey, UK
Organizer : Structural Integrity Unit of the C.E.G.B.
Inquiries : Dr. I. L. Mogford
C.E.R.L.
Kelvin Avenue
Leatherhead, Surrey KT22 7SE, UK
Tel (0372)374488 Ext. 2400, Telex 917338

May 17-20, 1988
Short Courde on High Temperature Component Life Assessment
Location : Imperial College, London, UK
Organizer : Imperial College, London, UK
Inquiries : Dr. G. A. Webster
MED, Imperial College
Exhibition Road
London SW7 2BX, UK
Tel 589-5111 x6183, Fax 5847596, Telex 929484

June 8, 1988
12. Sitzung der SVMT-Fachgruppe Bruchmechanik und Ermüdung
Location : Ecole Polytechnique Fédérale de Lausanne, Switzerland
Organizer : SVMT
Language : German and French, others ask dr. Prodan
Deadlines : May 1, 1988 - announcements of contributions and registration
Inquiries : Dr. M. Prodan
Gebr. Sulzer AG
Abt. 1502
8401 Winterthur, Switzerland

AGENDA cont'd

June 13-15, 1988
International Conference on Life Assessment and Life Extension of Thermal Plants
Location : The Hague, the Netherlands
Organizer : NIL, the Netherlands
Sponsor : KEMA, VGB, EPRI, CRIEPI
Deadlines : to be announced later
Inquiries : NIL
Laan van Meerdervoort 2b
2517 AJ The Hague
The Netherlands
Tel. (31)70-600937

June 15-17, 1988
Third International Spring Meeting on FATIGUE CRACK GROWTH UNDER VARIABLE AMPLITUDE LOADING
Location : Paris, France
Organizer : Fatigue Commission of the French Metallurgical Society
Sponsors : ASTM et al.
Inquiries : Dr. J. Petit
ENSMA
86034 POITIERS Cedex
France

June 28-30, 1988
21st National Symposium on Fracture
Location : Annapolis MD, USA
Sponsor : ASTM Committee E24
Deadlines : August 1, 1987 - Abstracts (300-500 words)
Nov. 1, 1987 - Acceptance notice
April 1, 1988 - Final manuscripts
Inquiries : Dr. J. P. Gudas
David Tayler Naval Ship R&D Center
Metals and Welding Division, Code 281
Annapolis, MD 21402-5067
USA, Tel. (1)301/267-2841

July 4-6, 1988
International Conference on Fracture and Damage of Concrete and Rock and Special Seminar on Large Concrete Dam Structures
Location : Vienna, Austria
Organizer : TU Vienna, Institute of Mechanics
Deadlines : Nov. 30, 1987 - Abstracts (300 words)
March 31, 1988 - Full Papers
Inquiries : Doz. Dr. H. P. Rossmanith
Institute of Mechanics
Technical University Vienna
Karlsplatz 13
1040 Vienna, Austria
Tel. (43) 222-58801-3121,Telex 3 222 467 tuw

September 6-8, 1988
VIII. Symposium on Deformation and Fracture
Location : Magdeburg, G.D.R.
Organizer : Univ. of Technology "Otto von Guericke"
Language : German, English, Russian
Inquiries : Prof. H. Blumenauer
Tech. Universität "Otto von Guericke"
PSF 124
3010 MAGDEBURG, DDR

September 6-9, 1988
Fourth Int. Symposium on Spacecraft Materials in Space Environment
Location : Toulouse, France
Organizer : CERT, CNES, ESA
Deadlines : Feb 1, 1988 - abstracts (300 w)
Mar 21, 1988 - notification
Sep 6, 1988 - camera readey man.
Inquiries : Centre d'Études et de Recherches
de Toulouse, Symposium Secr.
Ghyslaine PICCHI
B.P. 4025, 31055 Toulouse Cedex, France
Fax 61557172, Telex 521596 f

September 11-15, 1988
Sixth International Conference on Pressure Vessel Technology, ICPVT-6
Location : Beijing, China
Organizer : Chinese Pressure Vessel Inst.
Sponsor : Int. Council for Pressure Vessel Technology
Deadlines : Feb 2, 1987 - Abstracts
Sep 5, 1987 - Full papers
Inquiries : Mr. C.B. Corbett
Manager Process Ind. Devision
Inst. of Mechanical Engineers
1 Birdcage Walk, Westminster
London SW1H 9JJ, UK

September 19-24, 1988
Seventh European Conference on Fracture, ECF7
Location : Budapest, Hungary
Organizer : Scientific Society of Mechanical Engineers (GTE), Hungary
Sponsor : European Group on Fracture (EGF)
Deadlines : Sep. 30, 1987 - Abstracts (500 words)
Dec. 31, 1987 - Acceptance notice
March 31, 1988 - Full papers
Inquiries : Dr. E. Czoboly
Technical University Budapest
Inst. for Mechanical Technology and Materials Science
P.O. Box 451
1372 Budapest, Hungary

September 19-22, 1988
Second International Symposium on Brittle Matrix Composites
Location : near Warsaw, Poland
Deadlines : Dec. 31, 1988 - Abstracts (500 words)
Apr. 31, 1988 - Final draft of papers
Inquiries : Prof. Dr. A. M. Brandt
Polish Academy of Sciences
Inst. of Fundamental Technological Research
Swietokrzyska 21
00 049 Warsaw, Poland
or
Dr. I. H. Marshall
Paisley College of Technology
Dept. of Mechanical and Production Engineering
Highstreet
Paisley PA1 2BE, Scotland

AGENDA cont'd

September 26-30, 1988
20th Europhysics Conference on Macromolecular Physics
3rd Lausanne Polymer Meeting
Physical Mechanisms in Polymer Failure
Location : Lausanne, Switzerland
Organizer : European Physical Society
Section of Macromolecular Physics *et al.*
Deadlines : Dec 31, 1987 - preregistration
Inquiries : Prof. H. H. Kausch
Laboratoire de Polymères
32, chemin de Bellerive
1007 Lausanne, Switzerland
Tel. (021) 472847,Telex 450676

September 29, 1988
Symposium on Contact Fatigue
Location : Cambridge, UK
Sponsors : Cambridge Univ. Eng. Dept.
Int. Journal on Fatigue
Inquiries : Mr. A. Burrows
Int. Journal of Fatigue
Butterworth Scientific Ltd.
P.O. Box 63, Bury Street
Guildford, Surrey GU2 5BH, UK
Tel. (0463)300966 Fax (0463)301563
Telex 839556 scitegg

November 22-25, 1988
WELDTECH 88
Location : Ramada Inn, West London, UK
Organizer : The Welding Institute, Cambridge, UK
Deadlines : Dec 18, 1987 - Abstracts (500 words)
June 17, 1988 - Final manuscripts
Inquiries : Mr. Tony Gray
The Welding Institute, Abington Hall
Abington, Cambridge CB1 6AL, UK
Tel. 0223 891162 Telex 81183 weldex g
Telefax 0223 892588

November 1988
Symposium on Thermal and Mechanical Behaviour of Ceramic and Metal Matrix Composites
Location : Atlanta, Georgia, USA
Sponsor : ASTM Comm. D-30 & E-24
Deadlines : April 15, 1988 - abstracts (300-500 w)
Sep 1, 1988 - full papers
Inquiries : Dr. J. M. Kennedy
Dept. of Mech. Engineering
Clemson Univ.
Clemson, SC 29634-0921, USA
Tel. (803)656-5632

March 16-18, 1989
ICF7 Satellite Workshop on Advanced Composites
Location : Beach Hotel, Santa Barbara
California, USA
Organizer : Univ. of California, Santa Barbara
Sponsor : The Int. Congress on Fracture
Inquiries : Prof. A. G. Evans
Materials Department, Univ. of California
Santa Barbara, Ca 93106, USA

March 20-24, 1989
Seventh International Conference on Fracture, ICF7
Location : University of Houston, Texas, USA
Organizer : University of Houston
Sponsor : The Int. Congress on Fracture
Deadlines : April 1, 1988 - Full papers (±8 p.)
Aug 1, 1988 - acceptance not.
Oct 1, 1988 - Camera ready man.
Inquiries : Dr. Kamel Salama
Mechanical Engineering Dept.
Un. of Houston, University Park
Houston, Texas 77004, USA
Tel. (713)749-4455 Telex 556475

April 2-7, 1989
8th Int. Conference and Exhibit on Offshore Mechanics and Arctic Engineering - OMAE Europe 1989:
- **8th Offshore Mechanics and Arctic Eng. Symposium**
- **2nd OMAE Materials Technology Symposium**
- **2nd OMAE Pipeline Symposium**
- **2nd OMAE Computer Symposium**

Location : Euginio Costa, Genoa, Italy
Organizer : OMAE Conf. Committee
Sponsor : ASME OMAE Division
Deadlines : May 1, 1988 - abstracts (300-400w)
May 15, 1988 - Tentative acc.
Aug 30, 1988 - Manuscripts
Dec 1, 1988 - Final acceptance
Inquiries : Prof. Jin S. Chung
Int. OMAE Conf. Committee
c/o. Colorado School of Mines
1500 Illinois Street
Golden, Colorado 80401, USA
Tel. (303) 420-8114

October 9-11, 1989
European Symposium on Elastic-Plastic Fracture Mechanics: Elements of Defect Assessment
Location : Freiburg, FRG
Organizer : DVM
Sponsors : European Group on Fracture *et al.*
Deadlines : Oct 1, 1988 - Abstracts (500 words)
Jan 15, 1989 - Acceptance notice
Sep 1, 1989 - Manuscripts for proceedings
Inquiries : J. G. Blauel
Fraunhofer Institut für Werkstofmechanik
Wöhlerstraße 11
D-7800 Freiburg, FRG
phone (0)761/5142-101, telex 17761159 fhiwmfr
fax (0)761/5142-147
or
K.-H. Schwalbe
GKSS-Forschungszentrum Geesthacht
Max-Planckstraße
D-2054 Geesthacht, FRG
phone (0)4152/12-979, telex 0218712 gkssg
fax (0)4152/12-618

PLEASE HELP US with keeping this Agenda up-to-date

Conference Proceedings from the European Group on Fracture – EGF

THE BEHAVIOUR OF SHORT FATIGUE CRACKS (EGF 1)

Edited by K.J. Miller and E.R. de los Rios

This book is a collection of 34 paper read at the first international conference devoted to this important development in the understanding of metal fatigue. It has important implications for engineering designers, manufacturing engineers, material scientists, consultants, insurance assessors, and those responsible for evaluating the integrity of existing engineering plant.

0 85298 615 7/234 x 156mm/hardcover/568 pages/1986 · *UK £39.00* Export *£49.00*

THE FRACTURE MECHANICS OF WELDS (EGF 2)

Edited by J. G. Blauel and K. H. Schwalbe

Compared to the parent material, weldments have to be considered as locations with a higher probability for the occurance of cracks or crack-like defects and of impaired toughness properties. It follows that the modelling and assessment of welds is a significant problem in fracture mechanics.
Topics discussed in this excellent volume include: the characterization of welded joints and the necessity of modifying the conventional parameters to take account of specimen geometry, heat input, post weld heat treatment, and residual stresses; the possibly misleading nature of conventional welding procedure qualification tests; the occurence of low toughness values in connection with pop-in events; and the value of wide-plate testing.
These ten papers represent very recent work and will ensure that THE FRACTURE MECHANICS OF WELDS will be of great interest to all involved in this important area.

0 85298 644 0/234 x 156mm/hardcover/223 pages/1987 · *UK £28.00* Export *£35.00*

Orders and enquiries to:
Sales Department, Mechanical Engineering Publications Limited,
P.O. Box 24, Northgate Avenue, Bury St. Edmunds,
Suffolk, IP32 6BW, England

MEP

Please return the form below when you want to be kept informed on EGF's activities and:

- **you did not return a form before,*or***
- **the address on the evelope is in error, *or***
- **your address has been changed.**

EGF

EGF Newsletter - Subscription form

Please mail the coming **cost-free** issues of the EGF Newsletter to:

Full Name : MRS ANĐELKA MILOSAVLJEVIĆ

Full Address : 27. MARTA 80
11000 BEOGRAD
YUGOSLAVIA

Mail to : EGF Office
c/o Delft University of Technology
Faculty of Materials Science
attn. prof. A. Bakker
P.O. Box 5025