European Collaboration in Development of Creep Data for High Temperature Plant

NEWSLETTER April 2004

Newsletter of the EC supported Thematic Network 'Advanced Creep' (2001 – 2005)

INTRODUCTION TO ECCC

The European Creep Collaborative Committee (ECCC) is an industry led group of 44 organisations from 16 countries, representing the interests of high temperature plant manufacturers, plant operators and material producers. ECCC was formed in 1991 to co-ordinate creep data development activities throughout Europe. During the period 1993 to 1996, ECCC was supported by the EC Concerted Action programme (BE-5524 'CREEP') and developed recommendations for the generation, collation/exchange and assessment of creep rupture data for virgin parent materials. From 1997 to 2001 ECCC was supported by the EC Thematic Network programme (BET2-0509 'WELD-CREEP'), and the work was focused on weldments. Work from these projects resulted in the development and publication of European guidelines on data generation, exchange and assessment methods. Using these guidelines, ECCC has collated and assessed creep rupture data for a number of high temperature steels/alloys, resulting in the publication of approved data sheets on a scale that had not been possible before.

From 2001 to 2005 ECCC is being supported by the EC Framework V Thematic Network GTC2-2000-33051 'Advanced Creep'. This Thematic Network aims to bring together European industry and research expertise to devise and implement guidelines for the generation, electronic collation and application of advanced creep data for improving the effectiveness of high temperature plant design and component life assessment.

BACKGROUND (Advanced-Creep)

As a generality, the design of plant components and safety/performance assessment of materials used for high temperature applications in the power generation, nuclear, petrochemical, chemical process and other such industries is currently based on their tensile and creep rupture strength. Service experience has shown that the present design codes are very conservative and that the use of more sophisticated procedures based on 'advanced creep data' (such as strength at various levels of strain, creep ductility, stress triaxiality parameters, etc) could reduce this conservatism in both design and life extension of high temperature components. With this in view, in September 2001 the ECCC started a new 4-year duration Thematic Network 'Advanced Creep' aimed at bringing together European industry and research expertise to devise agreed rules and guidelines for generation, electronic exchange and use of such data for improving plant design and component life assessment. The following 'advanced creep' topics are being addressed:

1. Creep strain modelling (e.g. to give creep strength at various levels of strain)
2. Stress relaxation behaviour
3. Creep ductility
4. Multi-axial creep behaviour and notch sensitivity prediction
5. Creep property deterioration due to service exposure
6. Creep crack initiation from pre-existing defects
7. Creep data from component tests

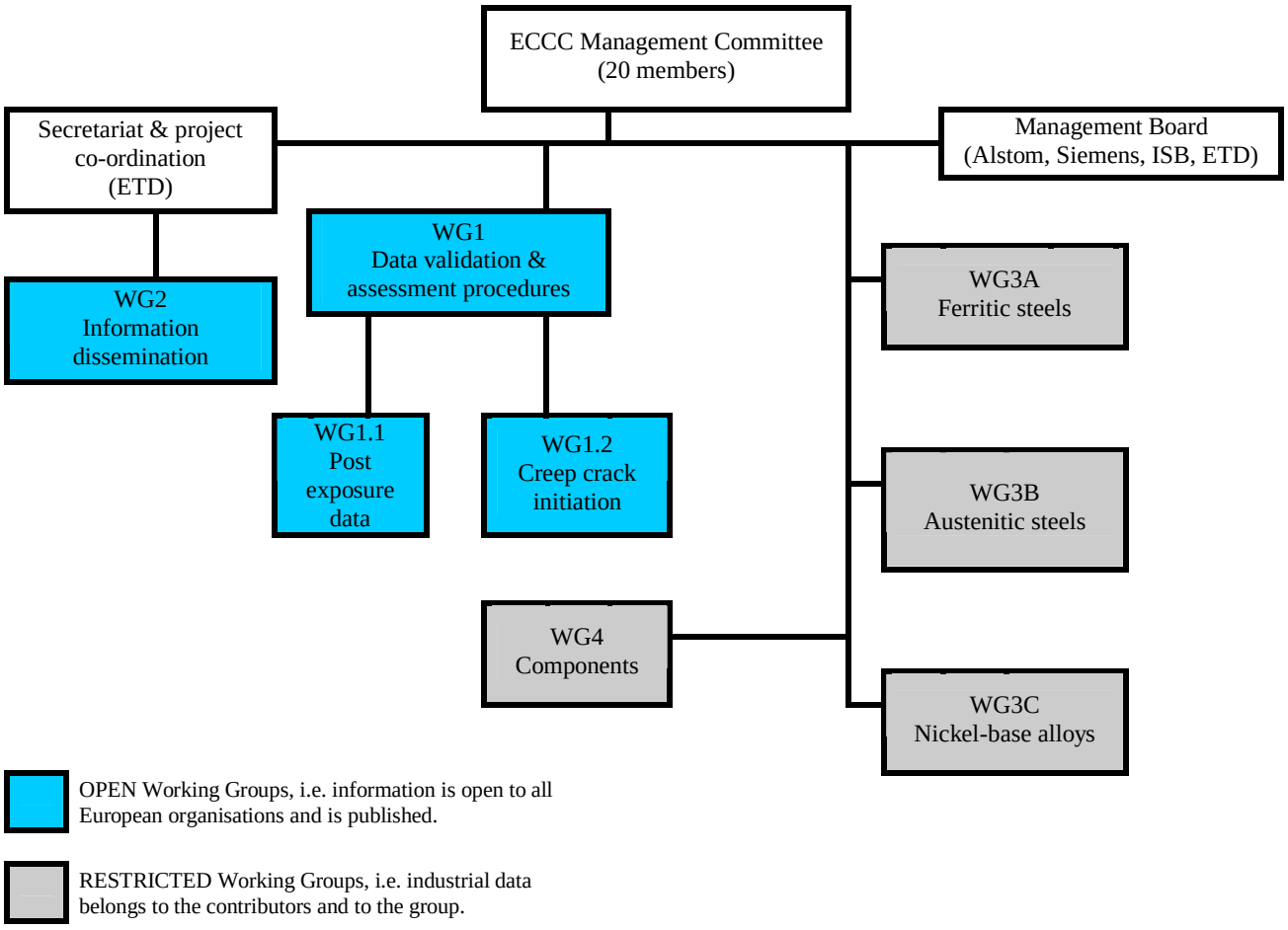
OBJECTIVES

This Thematic Network has set out to harmonise and rationalise the advanced creep data generated (being generated) within Europe. The project is also aimed at preparing European guidelines for the generation and analysis of such data in the future. Specific objectives are to:

- Co-ordinate output from European projects and industry and recommend optimised generation and assessment procedures for use within EC and non-EC (national or industry) funded projects dealing with advanced creep data on new and existing industrial plant materials.
- Identify gaps in European research and make recommendations for future work in this area.
- Publish datasheets on advanced creep data and provide support and information to European codes and standards bodies.

Supported by the Commission of the European Communities under the 'Competitive and Sustainable Growth' programme

ECCC / Advanced Creep Working Group Structure



Introduction to the ECCC Working Groups (WGs)

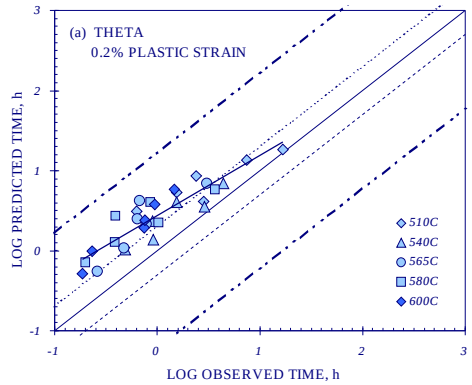
WG1: Data validation & assessment procedures

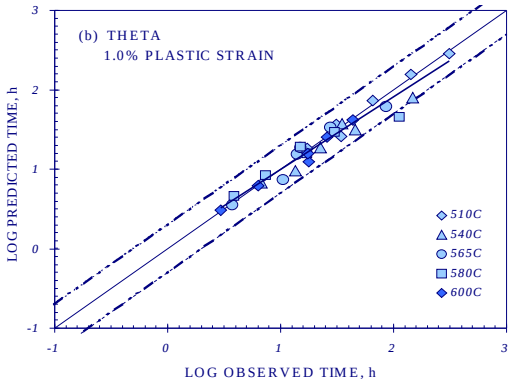
Convenor: S R Holdsworth (ALSTOM Power)

WG1 is responsible for the development of guidelines for creep data generation (i.e. testing), collation/ exchange and assessment, in order to provide the means for the WG3 groups to operate in a consistent way. During the earlier ECCC projects, five volumes of ECCC Recommendations were developed for this purpose. These recommendations are now being refined and expanded.

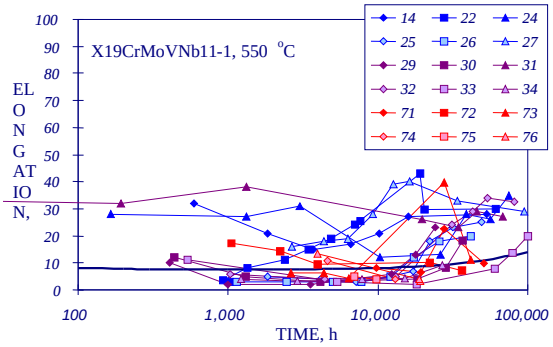
- **Assessment of creep strain data** - The model equations in common use for representing creep strain data have been collated and reviewed, and their effectiveness has been assessed for various materials (P22, P91, Type 316) and practical applications. A new method of qualifying the effectiveness of a creep strain equation for specific material types and applications has been introduced. Recommendations arising from the work have been published in the new ECCC Vol.5 Part Ib.
- **Assessment of creep ductility data** - The analytical representation of rupture ductility data is receiving focused attention for the first time in a collaborative activity and is providing a significant challenge due to the complexity of the problem.
- **Multi-axiality** – In a joint activity with WG4, WG1 is helping to establish a database of multi-axial test data.
- **Stress relaxation** – Recommendations arising have been published in the new Vol.5 Part Ic.
- **Creep rupture of welds** – Work on the assessment of DMWs has been completed; analysis of E911 welds and a survey of weld strength reduction factors are in progress.
- **Updating & maintenance of the ECCC Recommendations** - Revisions were issued at the ECCC Information Day in September 2003. Automation of the ECCC-WG1 Post Assessment Tests is currently being carried out.

Examples of WG1 technical work

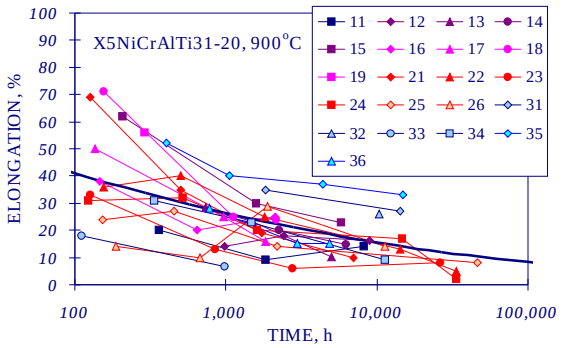




Example comparisons of predicted and observed times to 0.2% and 1.0% plastic strain for the Theta creep equations in the assessment inter-comparison



Comparison of Spindler model equation fit (B1, solid line) with X19CrMoVNb11-1 rupture elongation data at 550^{0}C



Comparison of Soviet model equation fit (B4, solid line) with X5NiCrAlTi31-20 rupture elongation data at 900°C

WG1.1: Post Exposed Materials

Convenor: G Merckling (Istituto Scientifico Breda)

This subgroup of WG1 considers post exposure creep testing and aims to improve the credibility and reliability of remaining life assessment (RLA) procedures. It considers the use of experimentally sound creep data derived from material of the component under investigation and checked against recommended acceptability criteria, and the use of post exposure creep data from different sources but on the same material to obtain a larger dataset.

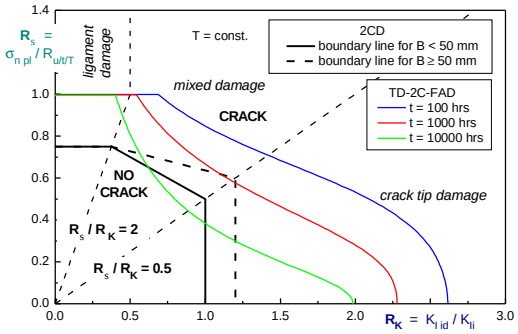
- **Remaining life assessment** - Working on the assessment of a pipe in 12Ch1MF steel, independent assessors have obtained credible and similar predictions for residual life due to the successful application of the modified Post Assessment Tests, particularly the dedicated PAT 1.1b, which checks credibility by comparing the predicted curves for the post exposure material with those for the virgin material.
- **Creep strain data** – 'Round-Robin' assessments of a PE dataset including creep strain data for the component itself and for other similar PE materials.
- **Terms and Terminology** - Prepared for post exposure specific testing techniques.
- **Data Generation** - Experience, rules and requirements for relevant data have been reviewed via a survey from the user's point of view of post exposure specific testing techniques, including small scale conventional creep, indentation creep and small punch creep testing. These techniques have been reviewed with regard to standardisation / harmonisation of testing practices, reliability and applicability of test results, and comparability of results with standard creep data.
- **Testing PE material** – A flow chart and logic path for defining and setting up a programme for post exposure testing and remnant life assessment are being established.
- **Data Collation and Exchange** – has involved further development of the PE creep data collation spreadsheet.
- **Review of RLA methodologies** which include evolution of microstructure and damage as a function of life fraction consumed.
- **Updating & maintenance of the ECCC Recommendations** - Revisions were issued at the ECCC Information Day in September 2003.

WG1.2: Creep Crack Initiation

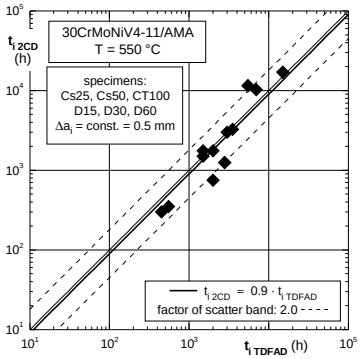
Convenor: A Klenk (MPA Stuttgart)

This subgroup of WG1, formed 2001, is specifically concerned with the generation (testing) and assessment of creep crack initiation data.

- **Development of ECCC Recommendations** – Terms and terminology for CCI have been defined, including the equations which are used to derive parameters like C* and creep toughness (Vol.2 Part IV). References have been collated to form a bibliography on testing and analysis. A Code of Practice for the determination of creep crack initiation has been prepared (Vol.3 Part IV). A spreadsheet for the collation and exchange of test data has been developed (Vol.4 Part IV).
- **Rationalisation of assessment methodologies** - Two main methods for assessment of CCI, namely the German 2-criteria approach and the UK R5-TDFAD, have been compared in a practical study. The two methods have been used to assess data for Type 316 and 1CrMoV steels. Comparison has provided a useful insight into the two methods and the differences between them. Although some differences in the principles of the approaches became obvious, the results obtained using the two methods were in reasonable agreement. Further work will focus on application of the methods to components.
- **Assessment of components** - Features tests and non-standard creep crack initiation test geometries.



Comparison of limit curves of different Two Criteria approaches



Comparison between predicted creep crack initiation times by using R5-TDFAD and 2CD on different specimen types for Da_i = 0.5 mm, 1CrMoV-steel at 550 °C

WG3x working groups co-ordinate the generation (testing), collation and assessment of creep data with the key objective of influencing high temperature property values in European Standards. These WGs are reviewing data contributed by member countries and partners on creep ductility, creep strain, notch ductility and rupture strength.

WG3A: Low and High Alloy Ferritic Steels

Convenor: J Hald (Elsam/Energy E2/TUD)

Current activities

- Co-ordination of the following ECCC test programmes:
- P92 parent and weldments
- P92 cast material
- 9/12Cr forged NF616, HCM12A, E911
- P23 (HCM2S) parent and weldment
- Mod. 2½CrMoV forged steel & weldments
- P91-P22 DMW
- P24 steel
- Data collation and assessment of creep strength, rupture strength and ductility for ferritic and martensitic steels, eg, rupture strength of P91 cross-weld, ½CrMoV cross-weld, E911 parent and cross-weld, P91 cast material and P92 parent, and creep strain of P91 parent.

WG3B: Austenitic Steels

Convenor: M W Spindler (British Energy)

Current activities

- Co-ordination of the following ECCC test programmes:
- NF709 parent & weld
- Super 304H parent & welds
- Alloy 800H parent materials
- Type 347HFG parent & welds
- Haynes HR120 parent
- Data collation and assessment:
- Rupture strength of HR3C parent, NF709 parent, NF709 weld metal, stabilized Alloy 800H
- Ductility of Type 316L(N) parent, Type 316H parent, Type 308 weld metal, Type 316 weld metal, Esshete 1250 parent & weld metal, HR3C parent, NF709 parent, NF709R parent
- Creep strength & creep strain model for Type 316L(N) parent, Type 316H parent, Type 316 weld metal, Esshete 1250 parent & weld metal
- Creep strength of Haynes HR120 & NF709R parent
- Multi-axial effects for Type 316H parent

WG3C: Nickel Base Alloys

Convenor: S Chandra (MAN Turbomaschinen)

This working group deals with turbine materials, particularly nickel-based alloys used mainly in gas turbines, but also being considered for use in future high temperature steam turbines.

Current activities

- Co-ordination of the following ECCC test programmes:
  - IN617 aged & welded materials
  - GTD111 DS
  - Rene 80
  - Nimonic 80A (smooth & notched)
- Assessment of creep strength and rupture strength values for superalloys, eg. two rupture strength assessments have been completed for IN617; and assessment of Nimonic 80A rupture strength.
- Assessment of ductility and notch sensitivity

WG4: Components

Convenor: P Auerkari (VTT)

Working group formed in 2001 to focus on the assessment of high temperature components and multi-axial features.

Current activities

- **Features testing** - Laboratories capable of carrying out features tests have been surveyed. A Code of Practice is being prepared.
- **Review of assessment procedures** - Design and assessment codes have been summarised, applications collated, and errors or conservatism assessed.
- **Ductility** - The effect of stress state on ductility is being investigated. Multi-axial creep tests for a wide range of materials have been identified. Test data for a small number of materials are being collated. The effect of ductility on behaviour such as notch strengthening / weakening is being investigated.
- **Assessment of features tests** - A number of features tests have been identified and candidate assessment procedures have been nominated. Input data for the assessment procedures are being collated. Assessments of some components are in progress.

WG2: Technology Transfer

Website

Further information on ECCC and the project 'Advanced Creep' can be seen at: www.etd1.co.uk/eccc/advancedcreep

Conferences

An ***International Seminar*** *'Advanced Creep Data for Plant Design & Life Extension'* was held in ***Prague*** in ***September 2003***. Delegates attended from Japan and various European countries. Two international experts delivered talks on the experience of their organisations in the use of advanced creep data for plant design and life assessment. The proceedings of the seminar have been published (contact the Secretariat for details), along with updated versions of the ECCC Recommendations Vols.1-5.

An ***International Conference*** on the topic and work of the Advanced Creep project is being organised in London in September 2005 (see more information later).

Publications

The ECCC Recommendations have evolved significantly since their first issue in 1994. The original five Volumes are currently being expanded into nine, covering terminology, testing practices and data acceptability criteria, electronic data collation and exchange, data assessment, remaining life assessment and component analysis. The Volumes consist of various parts covering generic issues, weldments, post-service exposed materials, creep crack initiation, multi-axiality and components. The expanded collection of Volumes will be as follows:

Vol.1 – Overview
Vol.2 – Terminology
Vol.3 – Data acceptability; material pedigree & testing practice
Vol.4 – Data collation / exchange
Vol.5 – Data assessment (uniaxial)
Vol.6 - Characterisation of microstructure and physical damage for remaining life assessment
Vol.7 - CCI – Data Assessment
Vol.8 - Multi-axial Data Assessment
Vol.9 - Component analysis

Enquiries on the Prague Seminar Proceedings and the five Volume publications may be addressed to: enquiries@etd1.co.uk

"ECCC CREEP CONFERENCE"

Creep & Fracture for High Temperature Plant Design & Life Assessment

12–14 September 2005, IMechE, Central London, UK

ECCC together with key experts from North America, Japan and elsewhere in a joint effort have decided to bring together researchers and industry from across the world to discuss the latest developments in all aspects of creep behaviour of high temperature materials. This international event is envisaged to cover the following three main themes:

- **Data assessment and modelling**
- **Materials microstructure and mechanisms**
- **Components**

The conference will contain less than 20% of papers from ECCC projects and thus the majority will cover the creep issues and findings of other projects from around the world.

For more information:

www.etd1.co.uk/eccc/advancedcreep

Or write to: enquiries@etd1.co.uk

Organisations participating in 'Advanced Creep'			
ETD	UK	Innogy	UK
MPA Stuttgart	DE	PowerGen	UK
Siemens	DE	SKODA	CZ
Alstom (Rugby)	UK	Corus	UK
ISB	IT	TU Graz	AT
CESI	IT	VDEh	DE
TU Darmstadt	DE	ESB	IE
ERA	UK	Siempelkamp PG	DE
British Energy	UK	VTT	FI
EDF	FR	WRI	SK
INASMET	ES	BZF	HU
SIMR	SE	Mitsui Babcock Energy	UK
Elsam A/S	DK	Dalmine	IT
CSM	IT	CEA	FR
Mannesmann F.I.	DE	Uni. Ancona	IT
VITKOVICE	CZ	GMS	NL
ISQ	PT	NLR	NL
SDF	IT	Laborelec	BE
SVUM	CZ	MAN Turbomaschinen	DE
IIS	IT	ISPESL	IT
Poli. di Milano	IT	Vallourec	FR
Alstom (Whetstone)	UK	GKSS	DE

TRAINING COURSE AND WORKSHOP

Innovative Approaches to Creep Data Assessment for Industrial Structures

21-22 October 2004, IOM3, Central London, UK

Leading industrial and research experts from the UK, Germany, Italy and many other European countries have been working for over a decade, under the umbrella of ECCC, on developing agreed guidelines for more reliable long-term extrapolation of rupture data and for accurate processing of large industrial data both for the base and weld metals. This has been done in an effort to improve plant design and the reliability of plant life assessment and extension.

The Workshop is designed to disseminate this know-how and make the newly developed data generation and processing techniques (some of which are now becoming/have become accepted by the European standards) become more widely recognised and accepted by the European and international industry and research. The training will be conducted through lectures and worked examples via four modules:

- **Introduction to Rupture and Creep Data Generation**
- **Creep / Rupture Data Assessment**
- **Procedures for Stress Rupture Data Assessment**
- **ECCC Post Assessment Tests (PATs)**

For more information visit:
www.etd1.co.uk/eccc/advancedcreep
Or write to: enquiries@etd1.co.uk

For further information please contact Dr D G Robertson, Newsletter Editor, at:
European Technology Development, 2 Warwick Gardens, Ashtead,
Surrey KT21 2HR, UK
Tel: + 44 (0) 1372 229 162 Fax: +44 1372 229 164
E-mail: drobertson@etd1.co.uk