International Industry Seminar

Use and Abuse of P91 and P92 Steels

Dates: 16th – 17th October 2014  
Seminar Venue: ETD Training Centre  
Address: Fountain House, Cleeve Road, Leatherhead Surrey, KT22 7LX, UK

This brochure gives an outline of the seminar and the registration form, including hotel information in Leatherhead and central London

Preceded by: 2-day (14-15 Oct) Training Course on P91-P92 Issues

Sponsors

Delegates can attend all our events in person at our training centre near London, UK, or, by videoconference from your site around the world. Our state-of-the-art training suite means delegates can attend remotely and still fully interact with the speakers.
Seminar Committee
Dr A Shibli, ETD, UK – Chairman
Dr B Nath, GDF Suez, UK – Co-Chairman
Dr M Yaguchi, CRIEPI, Japan - Co-Chairman
Dr A Klenk, MPA Stuttgart, Germany
Dr D Allen, Consultant (Ex-E.ON), UK
Dr D Robertson, ETD, UK
Dr A Tonti, Inail, Italy

Background & Introduction
The relatively new 9Cr martensitic steels P91 and P92 have helped to increase power plant temperatures and pressures and thus efficiency mainly for new generation of plants but are also used as replacement components for older power plants. With older power plants the use of new steels has helped to increase plant flexibility by using thinner section components and reduced component fabrication, replacement and related costs. However, these steels can only achieve their design strength if they are heat treated strictly to their specified heat treatment temperature. As their high strength strictly depends on achieving ideal martensitic microstructure slight deviations from the specified temperatures can lead to disastrous consequences. This is equally true of post weld heat treatment temperature criticality. However, in these days of privatisation and competition and necessity to keep the manufacturing prices down, achieving such precision has often been difficult. As a result today P91 and P92 steel components are found in many power plants with various ‘aberrant’ or abnormal microstructures. As a result failures have occurred in power plants in the UK, USA, Japan, Korea, Asia and elsewhere.

The need now is not only to understand the behaviour of these steels in service but also to understand the fabrication and heat treatment issues fully and implications of deviations from precise specifications with a view to building better, more efficient and safe power plants in future.

The other factors that need special consideration are component inspection, monitoring and integrity/ life assessment. The last factor can be particularly problematic as micron size cavitation observed by traditional tools in these steels, which has been successfully used in low alloy steels for creep life exhaustion studies, appears late in life and therefore new concepts/ technologies/ techniques are required to enable plant operators to predict damage/ failure and make ‘run, repair or replace’ decisions.

Unlike most other ‘research’ conferences this 7th Seminar of ETD Consulting is aimed at industry. The objective is to bring together plant manufacturers, fabricators, operators, service providers and researchers on one platform and to learn from plant and research experience to date.

Information for Speakers
The presentations will be of 30 minutes duration.

All Technical Enquiries and new offers of presentations to:
Dr Ahmed Shibli
E-mail: ashibli@etd-consulting.com
Tel: +44 1372 363 111
Who We Are

ETD Consulting is a UK based engineering advisory and consulting company specialised in high temperature plant life assessment, maintenance, materials and other engineering issues in power generating and chemical processing plants. ETD has experience of organising workshops, courses and conferences in the UK, Europe, North America and Asia, on issues such as: plant life assessment, high temperature plant materials, component safety and durability, in-service weld performance, power plant cycling and risk based maintenance (RBM), Risk Centered Maintenance (RCM) etc. in power and petrochemical plants. Further information about ETD, its consulting projects for power and process plants, courses offered, conferences and other services we can offer is available at: www.etd-consulting.com

Who Should Attend The Seminar?

- Plant managers, operators and maintenance engineers of the HRSG/power plant using P/T 91 or intending/planning to use this material.
- Plant manufacturers and alloy producers who should be aware of the pitfalls and unsatisfactory practices and who wish to learn from experience.
- All those involved in P91- P92 component damage/ cracking assessment and wishing to know its behaviour in plant.
- Engineers from service providing / consulting companies.
- Inspection personnel seeking an appreciation of the problems and damage/ cracking behaviour of high temperature components using P91 and P92 steels.
- Planning personnel seeking a better understanding of the issues involved with the integrity of P91 and P92 components and required replacement / repair strategies.
- Researchers involved in developing P91 and P92 component integrity, life and crack assessment methodologies who need to know the industry experience and needs.

ETD Consulting’s two recently started Joint Industry or Group Sponsored Projects dealing with P91 and P92 issues include:

- **‘P91-P92 Inspection and Life Assessment’** – This 2- year duration project started in April 2014 and is aimed at the development of innovative inspection and life assessment techniques and methodologies. It involves testing of welded pipes and standard laboratory specimens and test pipe monitoring and periodic shut down and inspection.
  
  Existing sponsors include: (ETD-UK, MPA-Germany, TNB-Malaysia, ENEL-Italy, Electrabel/Laborelec Belgium).

- **‘Abnormal P91’** – This 5-year duration project started in April 2014. It is aimed at generating stress rupture data and estimating safe operating life of P91 welded components containing ‘aberrant’ P91 base or weld metals — the type often found in power plants and showing the risk of early stage damage and failure.
  
  Existing sponsors include: GDF Suez (UK/France)/Electrabel (Belgium) and a Group of Japanese utilities.

New sponsors are welcome/ expected to join both of the above projects.

Further information from: Dr A Shibli  
ashibli@etd-consulting.com  
Tel: +44 1372 363111
DAY 1 - Thursday 16th October

0900-1730h

Registration & Welcome: 0900 – 0930h

Session 1: P91 & P92 Fabrication and Plant Experience

1. Stress Corrosion Cracking risk of 9%Cr martensitic steels between welding and PWHT
   S Huysmans, Laborelec/ Electrabel / GDF Suez, Belgium

   Main points:
   - Untempered martensite is sensitive to SCC.
   - No definite standpoint on how long a weld can be left in the as welded condition.
   - Rule of thumb exist e.g. maximum 1 week.
   - Impact of different climatic conditions.

2. On site welding of small bore P91 piping - feedback and proposal for mitigation actions
   Thierry Le Guevel, EDF, France

   Main Points:
   - Presentation of the feedback we had with the explosion of a small bore piping.
   - Analysis of the associated causes: bad PWHT.
   - Proposal of acceptance criteria after control on site and of control ratio and of Improvement of the monitoring of the temperature.
   - Relevance of socket weld for High temperature and high pressure lines?.
   - Flexibility study be requested even for small bore piping.

Coffee Break – 1030 – 1100h
3. **E.ON experience with the use of P91**  
*Albert Bagaviev, Karl-Wilhelm Möller, E.ON, Germany*

**Main points:**
- Base metal heat treatment and aberrant microstructures.
- Problems experienced with thick section welded component.
- How do we deal with abnormal base and weld metal components.

4. **Failure of a main piping valve operating in a combined cycle power plant**  
*Michel Buzzi, Tirreno Power, Italy*

**Main points:**
- Two check valves of 2RH, from a 780 MW Combined Cycle (2TG + 1TV) Power Plant, suffered through structural failure after approximately 21,000 operating hours and nearly 500 start-up cycles. In October 2011, a steam leakage from the lid of one of the two valves (22", ANSI 600 F91), probably caused by the high number of work cycles, was detected. In fact, both valves showed permanent deformation of the neck and presence of cracks; they were observed with non destructive testing (magnetic particle inspection and replication testing). Hardness measurements on replicas areas showed values that were well below the minimum expected for this type of steel.
- Because of the lengthy delivery times for valves (8-10 months), the insertion of two temporary replacement logs (22", 24 mm thick, P91) was effected. The two removed valves were subjected to metallographic investigation in order to accurately identify the causes of the failure.

5. **Korean power plant and manufacturing industry experience with P91 and P92 steels**  
*Kee-Bong Yoon, Chung-Ang University, Seoul, Korea*

**Main points:**
- Will discuss experience in Korean power plants.
- Will also discuss experience of the Korean plant manufacturers.

**Lunch Break – 1230 – 1330h**
6. ASME Code Case 2179-6 and ASME/ANSI Code 2007 - Use of Gr. 92 material data and design consequences

*Dr Andrea Tonti, Inail, Italy*

**Main points:**
- ASME/ANSI Code 2007, dramatic drop in the allowable stress from ASME Code Case 2179-6 and implications for the components already designed or in use (for example, in one case the allowable stress dropped from 200,000 to 30,000 hours)!
- New investigations on such components after 30,000 hours of service to assess their state of creep damage/strain and assessment of life against ASME code 2007 and the ASME Code case.

7. ETD’s experience with aberrant P91

*Dr David Robertson, ETD Consulting, UK*

**Main points:**
- Examples of aberrant P91 base metal.
- Examples of aberrant material at P91 welded joints.
- Creep rupture strength of abnormal P91 material.
- Use of non-invasive sampling to differentiate aberrant P91 material from surface decarburization effects.

8. Experience with Aberrant P91 in Australian Power Plants

*Damien Charman, ALS, Australia*

**Main points:**
- Initial construction of P91 pipework not done to OEM specification.
- Potential fraudulent 3rd party checks hid poor manufacturing processes.
- Rectification of incorrect heat treated Main Steam and Hot Reheat Pipework.
- Significant In service creep damage due to HRSG operating at above design temperatures.
- Severe Cracking in P91 due to weld –o-lets welds being undersized.
- Rectification works being conducted to control superheater temperatures.

Coffee Break – 1500 – 1530h
9. Aberrant P91 materials and weldments that have entered service
   Birendra Nath, Irene Dimartino, GDF Suez, UK

   **Main Points:**
   - Various aberrant conditions of P91 parent metal.
   - Types of aberrations in welded joints.
   - Implications for life assessment.

10. Prediction of 9Cr steel creep performance using a Neural Network tool
    Andreas Klenk, MPA Stuttgart, Germany

   **Main Points:**
   - Neural Network Tool for prediction of the position of a specific melt within the creep rupture scatter band
   - Application of NN:
     - Influence of chemical composition (exemplarily) – the consideration of only one chemical element is not useful!
     - Influence of heat treatment

11. Experiences of application of P91 & P92 in coal fired power plant for 100,000 hours as a super heater tube and their new life assessment methods
    Yaushi Hasegawa, Nippon Steel & Sumitomo Metal Corporation, Japan

   **Main Points:**
   - The integrity and life P91 and P92 steels in service is now not only evaluated by the conventional methods such as hardness or creep void accounting, but also by the microstructure analyses through the new evaluation methods.
   - The new methods concern the relative crystal misorientation frequency and the precipitation of Mo or W in those steels as the important strengthening elements. The former method extracts the irreversible life consummation and the latter method reflects the accurate atmospheric or steam temperature history.
   - In this presentation, the life assessment methods based on the understanding of the microstructure development and the influence of chemical composition on precipitates will be discussed.

   **1700 – 1730h**

   Panel Discussion &
   Short (5-10 minutes) talks or presentations by the delegates on fabrication and plant experience
DAY 2 - Friday 17th October

Session 2: Damage, Cracking and Heat Treatment Issues

1. Weld "Type IV" cracking - An unavoidable problem?
   David Allen, IMPACT PowerTech Ltd (ex-E.ON), UK

   Main Points:
   - Recent research - TSB "VALID" project.
   - Recent research - EON heat treatment project.
   - Reducing the risks - By improving the weld.
   - Reducing the risks - By improving design.

2. Effects of some abnormal microstructures on hardness inhomogeneities in P91
   Zhifang Peng and Sheng Liu, Wuhan University, China
   Chao Yang, Jiangsu Frontier Electric Technology Co., LTD, China

   Main points:
   - Segregation and non-segregation regions of elements Cr and Mo.
   - Co-existence of martensite and ferrite structures.
   - Ferrite structures deformed along steel elbows.
   - Threadlike delta-ferrite and its boundary precipitates in weld structure.
   - Quantification of the abnormal microstructures and explanation for the hardness reduction of pipe components.

3. Influence of heat treatment on the microstructure and evaluation of creep damage in martensitic 9-10 Cr steels
   Andreas Klenk, Stefan Zickler, MPA Stuttgart, Germany

   Main Points:
   - Description of microstructure after different heat treatments.
   - Experimental evaluation of the development of creep damage.
   - New VGB rating charge for damage development and life assessment of 9Cr martensitic steels.

Coffee Break – 1030 – 1100h
4. **Review of Gr.91 steel specifications and requirements**  
*Fujimitsu Masuyama, Kyushu Institute of Technology, Japan*

**Main Points:**
- Chemical composition requirements.
- Effect of residual elements and Ni contents on the properties.
- Heating temperature effect on the softening and degradation.
- Cold forming/heating and mitigation rules.
- ASME Code.
- EPRI Guidelines.

5. **Microstructural evolution of P91 steel after long term creep tests**  
*Matteo Ortolani, Paolo Mariani, Tenaris, Italy*

**Main Points:**
- Importance of Long Term Creep rupture test at different temperatures.
- Testing results at 550, 600 and 650 °C above 100 thousand hours
- Evolution of microstructure and precipitation
- Nucleation and growth of new secondary phases

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**Session 3: Inspection and Life Assessment**

1. **Use of new tools for the inspection and quality check of 9Cr martensitic steels**  
*Ahmed Shibli, ETD Consulting, UK*

**Main Points:**
- Problems with the inspection of P91 and P92.
- Surface inspection issues.
- Inspection for below the surface damage/creep cavitation.
- Monitoring for early stage creep damage.
- Trials with new tools for inspection and monitoring.

**Lunch Break – 1230 – 1330h**
2. Life assessment of longitudinal welded joints of 9Cr steel pipe  
M Yaguchi, Criepi, Japan

Main Points:
- Creep damage of longitudinal welded joints.
- Analytical life assessment model for welded joints.
- Internal creep test with longitudinal welded pipe.
- Life assessment of USC boiler pipings.
- Database of damage and remaining life of USC boiler pipings.

3. Creep behaviour of longitudinally welded martensitic steel pipes  
Andreas Klenk, MPA Stuttgart, Germany

Main Points:
- Induction heat treatment for longitudinally welded pipes.
- Influence of shape imperfections.
- Long term creep behaviour of longitudinally welded pipes.

4. A demonstration of the Wilshire Equations of creep for NIMS Grade 91 steel data  
V A Gray, M T Whittaker, L Larocca-Savaris, R. Da Conceicao-Caneiro, Institute of Structural Materials, Swansea University, UK

Main Points:
- Wilshire Equations, like many other techniques, utilise the concept of region splitting in order to produce better long term creep life predictions. The advantage of the Wilshire approach is the use of normalised activation energies which for a number of other materials has provided significant insight into the underlying creep mechanism in comparison to traditional creep modelling methods.
- Wilshire Equations will be applied to NIMS Grade 91 steel in a demonstration of the power of this technique in predicting long term creep life and also creep mechanism.

1500 – 1530h

Panel Discussion
Issues with P91 and P92 steels in general and Aberrant Base and Weld Metal versions in particular
REGISTRATION FORM  

(Please copy and e-mail / fax / post)

P91/ P92 Training Course - 14-15 October 2014
P91-P92 Seminar - 16-17 October 2014
Venue: ETD, Leatherhead, Surrey, (south of London)

*Early registration discount extended to 26th September 2014*

REGISTRATION FEE: Please put ‘X’ in the box opposite the fee applicable and then show total fee. The fee below is shown in pound sterling and includes 20% UK Value Added Tax (VAT) which all delegates need to pay for events held in the UK.

Special reduction in Registration Fee for academic, research staff (not from industry) and students.
Please contact: enquiries@etd-consulting.com

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<th>Reduced Fee (if paying by 26th Sep. 14)</th>
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<tr>
<td>Training Course (14-15Oct)</td>
<td>900+180 = £1080</td>
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<tr>
<td>Seminar (16-17 Oct)</td>
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<td>Total fee = £</td>
<td>minus 10% reduction* (if applicable, please see below) = £</td>
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Total fee = £ (as an academic, researcher or student) = £

*Notes: 1) 10% reduction in fee for the 2nd, 3rd, 4th .. attendees from the same organisation.
2) 10% reduction if attending both the course and the seminar.
Only one reduction will apply.

PAYMENT: By UK bank cheque, bankers draft, or bank to bank transfer to ‘ETD Ltd.’
(For payment by bank to bank transfer, account details will be supplied on request to:
Mrs. K Mahoney kmahoney@etd-consulting.com)

Please quote reference ‘Oct 14 TC & Seminar’ with the payment and state here how you paid/ intend to pay:

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Accommodation: Information on hotel booking, with special concessions, will be provided on request. In central London (Leatherhead is a commuter area with frequent trains from London Victoria and Waterloo, the journey taking about 45 minutes) the accommodation could be in the region of £100 a night while in Leatherhead it could be about £70 a night.

Delegate Details: (Required for your badge)

Your title and name: Position (optional):

Company name & address:

Phone: Fax: E-mail:

REGISTRATION ADDRESS:

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