



**P/T91: Welding, Heat Treatment, Oxidation, Damage Mechanisms,
Microstructure, Quality Control & Life Assessment
(Power, Petrochemical, and Refining Plants)**

Training Course

Kuala Lumpur 8 - 9 November 2010

Presenter: Prof F Masuyama, Kyushu Institute of Tech., Japan
and Dr D Robertson, ETD, UK

DAY 1

Module 1: **Material Properties and Heat Treatment**

0930 – 1300 h (with 30 minute break)

Objective

To develop a better understanding of the underlying concepts and basis of P91 development, its properties, the effect of heat treatment, chemical composition and understanding its weldment behaviour.

Specific topics will include:

- P91/ T91 specifications, inspections and control required during manufacturing and erection processes.
- Availability of material from various sources and quality control and checks required when purchasing and receiving material. Acceptance test of components, hardness, microstructure etc.
- The effect of heat treatment (austenitising/normalising and tempering) on microstructure and hardness and best available practices.
- The effect of heat treatment on material strength, creep strength, hardness and ductility etc.
- The effect of chemical composition details and what to look for.
- European, ASME and other codes, practices, recommendations, standards and their differences.
- Potential sources of materials data.

Lunch 1300 – 1400 hours

Module 2: **Steam-Side Oxidation of Thin Wall Tubing**

1400 – 1700 h (with 30 minute break)

Objective

To create a better understanding of the basic principles of oxidation in steam and its effect on tube over-heating and cracking/ failure.

Specific topics will include:

- Basic principles of P/T91 oxidation, research.
- T91 tubing demonstration and plant failure experience due to steam side oxidation.
- The effect of steam side oxidation on tube metal temperature for T91 tubing and its consequences.
- Effect of plant cycling on oxide spallation.
- Comparison of behaviour with traditional low alloy CrMoV steels.
- Damage effect of T91 spalled oxide on other plant components.
- Repair and replacement of failed tubes and issues involved.

DAY 2

Module 3: **Welding and Welded Component Behaviour**

0900 – 1300 h (with 30 minute break)

Objective

To create an understanding of the welding and pre- and post-weld heat treatment requirements and the criticality of the precise control required for this steel. These issues will refer to industrial experience to date.

Specific topics will include:

- Suitable welding procedures
- Pre-and post-weld heat treatment and Type IV failures in thick section components.
- Strength/ life reduction factors.
- Effect of plant cycling on cracking type, especially Type IV cracking.
- Weld repair issues.
- Dissimilar metal weld issues (P91 to low CrMoV steel welding, P91 to austenitic stainless steel welding), the effect of cycling and lessons from plant experience.

Lunch 1300 – 1400 hours

Module 4: **P91 Quality Control & Life Assessment**

1400 – 1700 hrs (with 30 minute break)

Objectives

To understand how P/T91 component integrity can be assessed. What are the available techniques and the advantages that they may offer. This includes a better understanding of the basic principles of oxidation in steam and its effect on tube over-heating and cracking/ failure.

Specific topics will include:

- Late cavitation development due to creep.
- Ductility and hardness issue.
- Type IV failures and their early detection.
- NDE techniques and their use for life assessment.
- Potential of the use of new NDE type techniques.
- Developments in Europe and Japan for life assessment of P91 component integrity / life assessment.



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