REVIEW OF THE USE OF NEW HIGH STRENGTH STEELS IN CONVENTIONAL AND HRSG BOILERS

R&D AND PLANT EXPERIENCE

(*Acronym*: New Steels Review**)**

Final Report

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Management Overview

This review deals with the status and use of modern high strength steels (in particular P91, P92, E911, P122 and T/P23, T/P24). This is the second review of its kind, the first was conducted in the year 2000. Both reviews were sponsored by international industry, from Europe, USA, Canada, Middle East and Asia. The first review had looked at the use of mainly 9Cr martensitic steels, the findings from research and very limited plant experience available at that time. This second review, in addition to the above, covers other high strength steels for high temperature application and the very important aspect of ***integrity and life assessment*** of these steels now that they have seen 15 to 20 years of service and cracking and failures are being reported from plants around the world.

A few years ago (at the time of the first P91 review) ***failures*** in e.g. P91 components were still relatively new and were attributed to weaker or suspect casts. A number of new failures have occurred since then and therefore interest in integrity/life assessment and monitoring of these components has become acute. This is especially so because the traditional NDE methods of replication and early damage detection in these steels have been found to be less than satisfactory and therefore there is a need to study, develop and establish new methodologies and techniques for life assessment of these steels. A number of new developments in this area have been reviewed and more promising techniques highlighted. The study has brought together research and plant experience from Japan, Europe and North America to throw light on potentially successful techniques that should be adopted.

The ***welding and heat treatment*** of many of these steels is critical in that small deviations from ideal practices can result in devastating consequences. In this era of competition, manufacturers and service providers are keen to save costs and therefore may look for lower cost sub-contractors for component fabrication and welding. However, some of these sub-contractors may not always be aware of the criticality of welding and heat treatment of these steels and incidents are known where this has resulted in problems with plant even before their fully fledged operation. Similarly choosing a ***welding process*** and ***welding consumables*** also requires the knowledge of what is available and the effect of these on the performance of the components. This issue has therefore been dealt with in some detail in this report and guidance provided.

Dissimilar metal welds is always a problem area in high temperature plant due to, amongst others, different heat treatment requirements for the two adjoining metals. In the case of the high Cr martensitic steels this situation becomes even more demanding and this has been discussed in this report together with the actual experience to date.

As the service life of P91 reaches the mid-life stage and the material shows signs of cracking and failure, it is important to understand the issues involved with ***weld repairs***. This aspect has been researched particularly in Europe and is discussed in this review.

More recently, new light has been thrown on the ***steam side oxidation*** and this has proved to be not so good for steels, especially for superheaters, with less than about

10.5 to 11%Cr. The consequences of this in terms of tube life, damage to turbine blades etc. have been discussed in this report together with the alternatives available. This has been preceded by the science of various types of oxides that form on these steels and their behaviour and effect on the rise in metal temperature.

It is important to understand the process of creep strengthening in the new high strength steels and how their strength is affected by actual material chemical composition within the standards' specification, fabrication and exposure at high temperatures and pressures. Therefore this review discusses the ***microstructure*** details of these steels and their behaviour and integrity under creep and creep-fatigue (particularly for cycling plant) conditions.

The development of new low alloy bainitic steels such as T23 and T24 is now catching attention in many quarters. These were originally developed for boiler furnace tubing for ultra supercritical plants but can now be used, and indeed are being used, for superheater tubing for lower temperature boilers especially in HRSGs. Their main advantage is that thin sections can be welded without PWHT. Further developments are taking place regarding the use of these steels for thick section components. These aspects have been discussed in detail in this report.

Finally, it is important for the plant operators to know important ***inspection and quality control*** criteria when buying plants and components made from these steels. Here we have interviewed plant managers with most successful experience and the report provides guidance on what to ask for and look for when buying new plant or replacement components.

So much research has been going on these steels for the past ten years or so and so much has been published that it was important to synthesise this in to a useful and user friendly document which can be easily followed by plant engineers without getting lost in the details of the research itself. It was also important to bring together research findings and plant experience so that a comprehensive and comprehensible guide can be provided which relates to plant experience and works as a guide for plant manufacturers, service providers and plant operators. This report attempts to achieve these objectives.
