IIW Annual Assembly – Graz, Austria.
July 6th to July 9th, 2008.
Summary of Commission XI Activities.
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Summary

Dr. Martin Prager from the USA chairs this commission. Its focus is in the areas of pressure vessels, boilers and pipelines. The IIW meetings have two main purposes: to gather together experts from around the world to discuss welding related issues, and to allow the flow of information between the member welding societies in the parent countries. The meetings with commission XI were done in the form of papers given by experts in the field of welding. I will provide short descriptions of the papers given. The full texts of the papers are available by contacting the CCIIW. There will be an intermediate meeting in Cleveland 21-23 October 2008 for Commission XI.

July 7th, 2008 – Commission XI Meetings

The theme of the papers presented on July 7th was: Understanding the significance of toughness; testing, data and standards requirements with special emphasis on welding on pipelines.

- **Paper 1 –** Review of IIW Sub-Commission XI-E Meeting "Transmission Pipelines", D. Yapp, UK. An update on Commission XI-E attendance at the Hammerfest pipeline conference was presented. The Snohvit site is the most northernly gas processing plant in Europe that gathers gas from the northern North Sea and sends it to the northern part of Norway for processing. The paper discussed the underwater pipeline used to transport the product and provided details on how to perform a remote sub sea hot tap, the types of barges used to lay pipe and the welding processes used.
- **Paper 2 –** Application of Flaw Assessment Procedures to Girth Welds in Pipelines, H. Pisarski, UK. This papers deals with the criteria used to determine if flaws that has been found in sub sea girth welds must be repaired. Considers loading on girth welds in different configurations, and states that pipeline strains are subjugated to up to 2 – 3% of SMYS in some conditions, especially in the case of frost heave or ground movement. The codes do not address locally high stresses, but deal with overall (or global) stress levels (i.e. they do not consider the variation of stress around the circumference). There is interest in a reliable NDT technique that is able to locate and size flaws. A summary of various codes is given:
    - API 1104 – RT workmanship code. Appendix A provides alternative fracture mechanics based acceptance criteria.
    - API 1104 2007 Amendment – New fracture mechanics approach giving acceptable height versus flaw length for different loads.
    - CSA Z662-07 Annex K – CTOD design curves used to determine flaw acceptance criteria to prevent both brittle and plastic fracture.
    - BS7910:2005 and DNV RP F108 – Uses single edge notch tension specimens to produce simple verifiable flaw acceptance criteria for ductile material.

  There was also discussion about using SENB and SENT tests, and which one is better to use in this application. SENB is a technique that has been used historically, but a case is made for using SENT. However, there were some concerns raised: 1) SENT is not a standard test method and there is variability between testing labs, 2) the orientation of the notch is different between SENB and SENT and this will produce different results.
- **Paper 3** – Comments on Toughness Correlations and Strain Limits for Welded Components, M. Prager, USA. A very brief overview on modifying the K_{ic} versus Temperature curves, which applies to all ferritic materials. The entire curves were discussed, but the only modification was done in the lower shelf region, where the value was lowered.

- **Paper 4** – Hydrogen effects on Welded Components, B. Dogan, USA. In anticipation of a hydrogen infrastructure potentially replacing a fossil fuel one, there has been an ongoing discussion in Commission XI on how materials will perform under hydrogen service. Pipelines operating at high pressures are the only economical method of transporting hydrogen, which raises the question about whether the existing network of natural gas pipelines can be used for safely transporting hydrogen? There are similar issues with storage vessels for hydrogen. The main issue considered was hydrogen embrittlement at welded joints. There is also a potential corrosion issue with hydrogen. EPRI has put out a questionnaire , and has determined that there are a number of larger organizations working in certain areas of hydrogen research that are willing to collaborate. This could develop into a very important project if hydrogen becomes the energy of choice in the future. NIST is involved in this work also (see XI-898-08 for details).
- **Paper 5** – Automatic Welding System Characterized by High Speed Torch Oscillation and Hydraulic Internal Clamp of Offshore Pipelines, H. Hosoda, Japan, XI-899-08. Presentation on the development of high speed welding technology for offshore welding applications done in two parts: 1) the development of a two-torch GMA welding system with torch oscillation and seam tracking; and 2) the internal line-up clamp system. The welding system was novel in that it could perform at high travel speeds and high current, with minimal fusion flaw defects. The welding procedure was based on a narrow-gap design for pipeline grade materials. The internal clamp was able to reduce the "maximum misalignment" from 3.1mm to 0.9mm in practice while keeping the circumferential strain below 0.05%. Trial welding results were shown from off-shore pipeline work, but the system could be utilized in conventional pipeline welding applications also.

July 8th, 2008 – Commission XI Meetings

The theme of the papers presented on July 8th was: Fabrication problems with advanced ferritic steel pressure vessels with special emphasis on welding/cracking of 2¼ Cr-1Mo-V and similar alloys.

- **Paper 1** – Comments on Residual Stress Effects on Nozzle Weld Cracking, P. Dong, USA, XI-909-08. There are some special fabrication considerations in the new API 934B (07) modified Cr-Mo thick steel vessels, such as reduced weldability, high hardness and required heat treatments (preheat, ISR, PWHT). High residual stresses have also been stated as one of the major concerns. Stress modeling results are presented in both the longitudinal and transverse directions, for a variety of nozzle welded joint types. This modeling shows the magnitude and the direction of stresses, which is used to predict areas of potential in-service cracking. Comments are then made on the stress relief mechanisms and their effectiveness. Further work is required to better quantify the relationships between residual stresses and microstructures. There is a new PVRC JIP that will address some of these issues.
- **Paper 2** – A Vanadium Modified 2¼ Cr-1Mo Steel with Superior Performance in Creep and Hydrogen Service, M. Prager, USA, XI-900-08. This historical document was discussed by Prager to outline the original development work on this alloy. Experimental work was presented for this material such as: stress-rupture testing, weldability feasibility studies, filler metal development, weldment stress-rupture studies, base metal hydrogen attack studies, weldment hydrogen attack studies, exploratory hydrogen embrittlement research and elevated tensile strength trend curves. Comments are made regarding the relatively high concentration of Vanadium carbides that act as traps for hydrogen, which increases the solubility of hydrogen in the material and requires a higher PWHT temperature. Data is provided on a variety of material properties after lengthy service, and the conclusion is that this steel meets ASME Division 2 rules with superior resistance to hydrogen attack. This was the basis for which this alloy was introduced to the construction codes and accepted into industry. This was discussed to provide the background for current cracking problems, which are discussed in Paper 5.
- **Paper 3** – History and Development of 2¼ Cr-1Mo-V (22V) and Similar Alloys, M. Prager, USA, XI-897-08, XI-900-08, XI-910-08. Summary documents that provides a variety of historical data on the development and application of this material.
- **Paper 4** – Toughness Problems in Hydrogen Environments, M., Prager, USA. Tested microstructures in Cr-Mo steels in hydrogen service in similar conditions as in refineries. Graphs

are given of the Charpy values as a function of hydrogen concentration in the metal at different positions in the material – base metal, HAZ and weld metal. Results are given both before and after PWHT. A conclusion is made that Gr. 22V is, in every case, less susceptible to hydrogen embrittlement than Gr. 22. These complete results will be presented at NACE, New Orleans in March.

- **Paper 5** – Items Pertaining to Welding and Cracking of 2¼ Cr-1Mo-V Alloy as Reported at Petroleum Industry Meetings, M. Prager, USA, XI-895-08, XI-905-08, XI-907-08, XI-919-08. There is an appendix being worked on that deals with widespread fabrication problems that arose in January 2008 with SAW reheat cracking (also called stress relief or stress relaxation cracking) in some Cr-Mo welds. This appendix details an inspection plan to identify and characterize the possible transverse planar reheat cracking. This inspection procedure is expected to be updated next year as the NDT techniques are refined. The cracking appears in transverse clusters and can be at any lateral position in the weld.
- **Paper 6** – Development of GTAW System Using CO_2 Cooling for Reducing Residual Stress, Y. Ishizaki, Japan, XI-906-08. Presentation of a technique to reduce the potential of SCC in austenitic stainless steels by reducing residual stress of the HAZ during the welding process. The standard way of doing this is shot peening after the welding process. The described technique uses CO_2 cooling during the welding to control the temperature of the part. CO_2 fine power, regular powder and pellets were tested, with the best performance obtained using the fine CO_2 powder. Strain gauge testing was also completed that showed a reduction in longitudinal and transverse residual stresses for thick-plate welding applications. The technology is still in the development stage.

July 9th, 2008 – Commission XI Meetings

The theme of the papers presented on July 9th was: Failure prevention for welds in elevated temperature service, weld strength reduction factors, life prediction, extrapolation of strength properties and dissimilar metal welding.

There was a group discussion about writing a best practices document about welding and heat treatment for dissimilar metal welds. The chairman put forward the question about whether there is interest in forming a group that participates on writing such a document. The high level of interest in this document (almost an unanimous vote) will mean it is going to proceed, and there is an interim meeting planned in France to further discuss this topic.

- **Paper 1** – Annual Report for Sub-commission XI-C "Creep and Heat Resistance Welds", J. Hald, Denmark. Had one intermediate meeting in Holland at KEMA with a number of papers presented. The conclusion of these papers is that the advantages offered by creep strengthened materials can only be realized with careful quality control of fabrication, bending and heat treatment processes. There will be an intermediate meeting of this sub-commission in France in May, 2009.
- **Paper 2** – Long Term Creep Strength and Strength Reduction Factor for Welded Joints in ASME Grades 91, 92 and 122 Type Steels, K. Kimura, Japan. Description of a hot reheat piping (Grade 122) failure and subsequent steam leak in a power plant in Japan after only 33,000 hours. Graphs are shown that predict the creep life of these steels plotted against the stress value for a variety of operating parameters. New weld reduction factors for incorporation into Japanese Codes are proposed.
- **Paper 3** – Long Term Creep Behaviour of E911 Weldments Fabricated with Different Filler Metals, P. Mayr, Austria. Addressed what the weld metal strength level should be in order to get superior creep strength properties, i.e. should it be overmatched, under-matched or matched to the base material? A study with all three configurations on real welded samples showed that for the weld material that is overmatched, all of the failures were in the HAZ. For the other cases, at lower stresses the failures occurred in the HAZ, but at higher stresses there were failures in the weld material. Data is given on the damage mechanisms in all three cases.
- **Paper 4** – Effect of Specimen Size/Shape on Creep Life/Failure Mode, J. Masuyama, Japan, XI-918-08. Describes creep failure types and their locations in welds, both for standard size and large

weldments. A comparison is presented for large size specimens for both U (single V) and X (double V) type weld preparations, with data that shows that the U-groove weld lasted longer than the double V weld. With the exception of an internal pressure test for the double V weld, all welds failed along the HAZ. Some good information is given that shows the uncertainty in extrapolating the relatively low number of data points into long-term predictive creep curves.

- **Paper 5** – Discussion Document on Dissimilar Metal Welds, M. Prager, USA, XI-914-08. Provides some information on the general performance of a variety of DMW with different filler metals. There is also some data presented on the weld bevel preparations and how in some configurations (such as wide weld caps) they can arrest crack growth. There was interest in this document, so Prager will extract this information and present it at the next Annual Assembly.
- **Paper 6** – Best Practices Documents, M. Prager, USA, XI-915-08. This is a list of best practice documents from Commission XI over the lifetime of the IIW, that could be of broad interest to the welding community. This list is being given to Commission XI for comments and modifications and will be re-issued in the future.
- **Paper 7** – Application of Magnetic Stir Welding to Dissimilar Metal Structural Weld Overlay, T. Matsuoka, Japan, XI-902-08. There has been PWSCC (primary water SCC) in dissimilar metal nozzle components in Japanese nuclear service. The conventional method of mitigating this damage is to add a structural weld overlay over the cracked dissimilar metal weld, but this has problems with higher sulfur content in the old welds. In order to not contaminate the new weld with sulfur and lead to cracking problems, MSW (magnetic stir welding) is used. The stirring effects due to the Lorentz force causes a lower heat transfer into the existing weld, thus lowering the dilution and potential for PWSCC.

There were a number of papers archived in the IIW Web site that were not presented as part of the Commission XI meetings. These papers are as follows:

- **Paper 1 –** Development of a Filler Metal for Welding Vanadium Modified 2¼Chrome-1Moly Steel, M. Prager, USA, XI-901-08.
- **Paper 2 –** Hydrogen Induced Cracks in 2¼Cr-1Mo Welds, G. Prescott, USA, XI-903-08.
- **Paper 3 –** Weldability Assessment of 2¼Cr-1Mo-0.3V Pressure Vessel Steel, M. Prager, USA, XI-904-08.
- **Paper 4 –** Hydrogen in Heavy Wall SAW Joints of 2¼Cr-1Mo Steel After Different Dehydrogenation Heat Treatments, S. Dittrich, Germany, XI-908-08.
- **Paper 5 –** Examples of Repair Welding Procedures for Coke Drums, XI-911-08.
- **Paper 6 –** Stainless Steel Weld Metal – Prediction of Ferrite Content, XI-912-08.
- **Paper 7 –** Welding and Heat-Treatment of Joints Made of Dissimilar Metals, G. Gnirss, Germany, XI-913-08.