IIW Annual Assembly – Istanbul, Turkey **July 12th to July 14th, 2010**
Summary of Commission XI Activities
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Summary

Dr. Martin Prager from the USA chairs this Commission. The 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. The following includes short descriptions of the papers that were presented, and full versions of the papers are available by contacting the Canadian Council of the IIW.

July 12th, 2010 – Commission XI Meetings

The theme of the papers presented on July 12th was: "Evolving Codes and Standards Practices for Welded Construction".

Paper 1 – XI-931-10 "Why are Creep-Strength Enhanced Ferritic Steel Excessively Degraded in Elevated Temperature Pressure Vessel Cycle Service", M. Prager.

This paper was a review of creep and fatigue considerations for CrMoV alloys (such as alloy 22V, alloy 23, alloy 91, alloy 911, etc) used for pressure vessel applications in petroleum and power industries. The author discussed papers that have evaluated creep damage, including Type IV cracking in weldments that have led to pressure vessel weld failures prior to their intended design life. It was suggested that current laboratory tests that involved combined high-temperature creep and fatigue cycle testing may be misleading. This is important since cycle behaviour can influence design, welding, fabrication, stress state and inspection programs. The importance of time-at-temperature and strain-at-temperature on the weld properties (due to temper and phase transformations) were discussed. A model for creep-fatigue life damage assessment was presented, with consideration of current ASME Code, and correlations with testing data.

Paper 2 – XI-932-10 "Use of FEA for Design and Placement of Welds in Pressure Vessels Under ASME Code Case 2605", M. Prager, R. Brown, D.A. Osage

This paper discussed considerations of weld placement for pressure vessel design using FEA modeling. Background information was provided regarding strain rate and stress rupture variations across the weld zones. This is because the weld zone is non-homogenous and therefore different properties are achieved across the WM, C-HAZ, FG-HAZ and BM. ASME Code Case 2605 was introduced and the importance of weld placement (i.e., in locations with <50% creep damage) was discussed. Modeling must consider many factors, including (amongst others) the start-up and shut-down operations and the resulting stress cycling, the stress state and material properties (e.g. ductility). A review of modeling approaches and experimental data/literature was provided. Actual design cases were discussed, and the importance of proper weld location was emphasized, with examples of premature failure in the weld C-HAZ region.

- **Paper 3** – XI-933-10 "Implementing New Changes to ASME Section IX Heat Input Calculations (QW-409.1)", T. Melfi

  With advances in welding processes and equipment, there have been various additional procedure requirements mandated for complex waveform processes. Often these requirements are excessive and add very little value to the weld quality. To address this technology change, the ASME IX Code rules for heat input have been updated. The historical heat input equation was developed for "constant" welding processes. For complex waveform applications, there can be significant differences in the actual heat input (examples of ±10-30% were discussed). The changes to QW

409.1 were described, with the requirement for measuring instantaneous power or energy. Other changes to Code paragraphs were discussed. Strategies for implementing these Code changes were presented.

- **Paper 4** – XI-934-10 “Update on Component Testing for Validation of Life Assessment Rules for R5 and Other Standard Practices”, K. Nikbin

  This paper provided a thorough review of component testing for assessing the creep-fatigue crack growth mechanisms for materials, including considerations of modeling and predicting crack growth. Background information related to fracture mechanics and the parameters for consideration during crack growth prediction were discussed, including examination of the weld metal and HAZ. An overview of current testing programs around the world was provided, with a summary of different specimen geometries and materials. The influence of residual stresses on the crack growth mechanisms and remaining life assessments were discussed. Methods and data for introducing residual stresses during crack growth component testing were presented. It was emphasized that this work may be adopted into ASTM and ASME code/standards, and allow for future life assessments to consider the residual stress state of weldments

- **Paper 5** –XI-935-10 “Dealing with Growing Requirements for Higher Precision Impurity Analysis of Consumables – Do we need a round robin?”, T. Melfi

  An overview of the proposed program for completing a chemical analysis – round robin of laboratories was presented (note: completed by IIW Commission II). Some of the reasons for such testing include ensuring reproducibility of testing, evaluating current detection limits, development of guidance in specifications, assessing current chemical acceptance criterions, and reducing the conservative “cushion” in chemical specifications. Data was presented from three different labs that showed significant variations in max, min and average levels for various elements. The proposed round robin was presented, including elements to analyze and the analytical methods to be used. A discussion of alternative elements and test methods was presented.

July 13th, 2010 – Commission XI Meetings

The theme of the papers presented on July 13th was: Weld Failure Modes and Performance Enhancement

- **Paper 6** – Latest Improvements in the API/ASME Fatigue Master Curve, P. Dong, XI-936-10.

  This paper provided a review of a new stress analysis method for evaluating the fatigue performance of structures. Background to the development of this new methodology (over several years and multiple papers) was provided. In the past, the two main issues with fatigue analysis was (1) what stress concentration do you use (i.e. dependent on FEA mesh size/pattern) and (2) which S-N curve do you use (i.e. dependent on material grade, geometry, quality factor, etc). The solution developed is mesh-insensitive structural stress (or linear traction) extracted from modal forces from the FEA analysis. Using above, it is possible to determine an equivalent stress formulation. This method was presented in detail, with supporting validation data, and case study examples. Considerations for assessing weld quality and thermal behaviour were described. Areas of continued investigation/improvement were presented.

- **Paper 7** – Guidance for Local PWHT and Residual Stress Improvement and Using API/ASME Residual Stress Computations for Fitness-for-Service, P.Dong, XI-937-10

  This paper discusses techniques for local PWHT and other techniques for residual stress improvement. Background information related to uniform PWHT was provided. Unique considerations for local PWHT were also discussed, including issues related to creep relaxation and the development of thermal stress fields. Examples of FEA analysis of pipe weld joints illustrated that a local PWHT can result in a worsened stress state (i.e. in terms of tensile stress in the root) as compared to the as-welded condition. Localized techniques to reduce root tensile stress were discussed, including induction heating and specialized external heat – internal water cooling techniques. Other recommendations and considerations for local PWHT and residual stress improvement are discussed.

- **Paper 8** – Recognizing Weld Failure Modes in Practical Applications, C. Lundin, XI-938-10

  This paper provided a historical perspective of piping failures in power generation plants, with a focus on CrMo alloy piping produced with the SAW processes. The specific characteristics of the creep failure mode were discussed, with a focus on the metallurgical features and void coalescence mechanisms. The oxygen (oxide) content was identified as an important factor that was related to the flux used. The importance of using a basic flux and employing a normalizing and tempering PWHT was discussed.

- **Paper 9** – Test Methods for Simulating In-Service Weld Cracking, C. Lundin, XI-939-10

  This paper discussed the importance of considering all relevant factors when developing representative testing techniques that may duplicate actual failure modes. An overview of cracking test results for CrMo alloy weldments using the C-ring test, Gleeble test, and other test methods was presented. The influence of PWHT and chemistry (tramp elements) was discussed. Fractography case studies were provided to illustrate the differences in reheat cracking failures and hydrogen assisted cracking failure modes.

July 14th, 2010 – Commission XI Meetings

The theme of the papers presented on July 14th was piping and pipelines – welding and performance.

- **Paper 10** – Double Joint Pipeline Girth Welding, D. Yapp, XI-942-10

  This paper covered welding process technologies for double jointing of pipeline section. Background information related to double jointing pipeline sections for offshore and onshore applications was discussed. A dual torch tandem welding system (i.e. two torches with two wires each) that completes narrow-gap, girth welding in the 1G roll welding conditions was discussed. The 4 wires each use low heat input conditions (~0.4-0.6kJ/mm each) and therefore the weld undergoes rapid cooling and negates significant degradation of properties in the WM and HAZ (e.g. HAZ softening). Mechanical properties were provided and exceeded specification requirements. The productivity was comparable to the existing SAW systems it replaced, but the reduction in the heat input was desirable to optimize weldment properties (especially HAZ).

- **Paper 11** – Modern Pipeline Line Welding Processes Root Run Welding, D. Yapp, XI-949-10

  This paper discussed welding process developments for offshore J-lay pipeline welding. Historically, the root pass has been completed with the GTAW process, with good quality but low productivity. The investigators evaluated complex waveform variants of the GMAW process. Penetration maps for these variants were developed for different shielding gases and joint configurations. A ranking system of general weld quality was used to evaluate the different operating modes, and allowed for the root pass welding operation to be optimized.

- **Paper 12** – Development of Submerged Arc Welding Method in a Vertical-Up Position, R. Sakamoto, K. Kobayashi, T. Iijimal and Y. Mizo, XI-943-10

  The paper describes the development of a SubArc welding system for completing vertical welding. The application is the fabrication of LNG tanks; where SMAW is currently used for all vertical joints. The intent is to replace SMAW with a more efficient and productive process during field welding. A description of the system was provided, including equipment design and selection of welding parameters to optimize operation. Mechanical testing was completed, and the weldments achieved the required properties for the application. Full scale testing was also conducted.

- **Paper 13** – Development of Vertical Up SAW Welding Consumables for 9% Nickel Steel, M. Mizumoto and H. Nagasaki, XI-944-10

  The paper is a continuation of the work presented in paper XI-944-10 above, but a focus on the consumable developed. In this study, the softening of the flux as it melts to form slag was in-situ monitored/videoed using a high temperature microscope. This was done to optimize the melting "softening" temperature of the flux to achieve the optimized weld bead shape for vertical up welding. Consideration of the mechanical properties and deposition rates were provided.

Paper XI-943-10 and XI-944-10 were recommended for publication, endorsing the resolution in Commission XII.