IIW Annual Assembly – Singapore.
July 12th to July 15th, 2009.
Summary of Commission V Activities.
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Summary

Dr. Philippe Benoist from France chairs this commission. Its focus is in the areas of quality control and quality assurance of welded products, and as such it deals with NDT techniques. 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 V were done in the form of updates by the Sub-commission chairmen on their work during the past year, presentation of papers and group discussion on topics. Descriptions of the papers and summaries of the group discussions are given. The full texts of the papers are available by contacting the CCIIW.

July 13th, 2009 – Commission V Meetings

- **Presentation 1 –** Commission V Annual Report, P. Benoist, France, V-1464-09.
    - Benoist presented the annual report for Commission V. There was one interim meeting in Paris.
    - The average attendance in Graz at the 2008 IIW Annual Assembly was 14 people from 17 countries.
    - The new Sub-commission VF is now formed and is active.
    - We discussed the document DVS 0703 Technical Bulletin in the meeting, which is a best practices document. This document is an interpretation of EN/ISO 5817, which is used in the German industrial community. There are concerns that any changes to EN/ISO 5817 would then require changes to be made to other standards. The resolution was to form a small group of experts to read the document and prepare to discuss it at the 2010 IIW Annual Assembly.
- **Paper 1 –** Acoustic Emission Monitoring of High Energy Piping, B. Ham et al, Australia, V-1431-09.
    - Discussed a project in Australia applying AE (acoustic emission) to high energy piping. PAC (physical acoustics) hardware was used for this work.
    - AE was applied to hot reheat, HP (high pressure) bypass and LP (low pressure) bypass, all of which operated at 540 ºC. The piping did not have any existing cracking, but locations were chosen that were expected to be susceptible to cracking.
    - They used AE wave guides welded onto the piping with an axial spacing no less than 5 m. System loading was accomplished at turn on after shutdown.
    - They detected a total of seven strong AE signals; analysis revealed that three were flow induced, two were due to hanger noise, one was extraneous and one occurred before any significant stress was applied. None of the AE signals was due to flaws, as determined by applying conventional NDT and replication to the AE locations.
    - They used some advanced signal processing that lowered the false call rate of the technique, which in the past has been the main problem with this application.
- **Paper 2 –** Quality Enhancement in Case of Friction Stir Welding by Online Monitoring NDT, G. Dobmann et al, Germany, V-1433-09.
    - Friction stir welding does not use a filler metal, but has a fast spinning tool that joins the two sides. It is done in three stages: friction heat when the tool touches the material, plastification when the tool is part way into the material, and then material transport when the tool is fully immersed.
    - One of the flaws that can be present in friction stir welds is joint line remnants, which are oxides that are stirred into the weld. These can have irregular shapes in the weld nugget.
    - IZfP has implemented on-line monitoring into the welding process in a closed loop control that is meant to provide quality information back into the welding process.

- The joint line remnants are spatially periodic with a frequency that dependents on the FPR (feed per revolution of the friction stir bit). There are a number of other frequencies that are present within the system that indicate other process quality factors.
- Using these ideas, it is possible to detect early in the process when there are going to be weld quality issues.
- Dobmann then described a high power ultrasound tool (actually used for friction welding of plastics – 20 KHz, 3kW unit) that is used in conjunction with friction stir welding to improve weld quality.

- **Presentation 2** – Annual Report for Sub-commission VA (Radiography Based Weld Inspection Topics), U. Ewert, Germany, V-1427-09.
  - Ewert presented the annual report for Sub-commission VA. This group is active with standardization and harmonization of radiography standards, with special focus on the transfer of film RT to digital RT.
  - There were no intermediate meetings this year.
  - The working group on Digital Industrial Radiology was not active over the past year, nor has not been since 2007. Dr. Uwe Zscherpel from BAM has taken over this group, and he wants to join it with existing standards committees.
  - There is ongoing work for film classification systems. ISO 11699 is harmonized with CEN 584 for film classification, but these differ from ASTM E1815.
  - A discussion of general rules for weld inspection was published under EN 12062, which will become ISO 17635 when revised. This will include digital radioscopy, computed radiography and TOFD, as well as standard NDT techniques. The concept is to have B quality level (highest quality) for dynamically loaded vessels, C quality level (middle quality) for statically loaded vessels and D quality level when there is agreement between the parties on this quality level. The quality level A is reserved for special applications. This represents a significant departure from the ASME philosophy.
  - Data was presented on the image improvement when using lead screens with CR. Lead screens can reduce the exposure times significantly when using film, but only make roughly a 40% difference with CR imaging plates (IP). The lead screens also cause edge unsharpness and reduce the lifetime through mechanical damage on the IP. It is unclear on whether lead screens should be used when doing weld quality CR work.
  - There were good results presented on the intensity of radiation incident on IP for corrosion measurements. There is an asymmetric effect with the width of the notches being exposed – the added effect of the lead intensifying screen effect gets smaller as the notch width gets smaller. This will have an effect for techniques that use film density to estimate wall loss in areas of corrosion pitting.
  - Handling of CR IP causes mechanical damage, which reduces their effectiveness and operational life. The relevance of this is for weld quality CR, when the IP are used in flexible cassettes. There is work being done to see if using an IP in a flat hard cassette can produce good weld quality images.
  - There is a strong effort in Europe to move the EN standards to ISO, which is something that must be considered in North America. If this process proceeds, then the ISO standards will be essentially German standards that have been transferred to EN, and then into ISO standards. This will result in the ASME standards not being represented within ISO to any significant degree.
- **Paper 3** – Nondestructive Inspection of Iter PF Jacket Welds, L. Silva et al, Portugal, V-1434-09.
  - Iter is a European experimental thermo-nuclear reactor that has a complicated coil and solenoid design that make up the reactor.
  - A summary of previous NDT work done by other organizations on similar geometry was provided. The results of this past work are: ET (poor depth penetration), conventional UT (poor performance for curved geometry), x-ray (poor detection in some locations) and TOFD (deterioration of signals at welds).
  - Current NDT requirements for jacket inspection are the standard NDT techniques of RT, LPI and VT. The Iter quality rules call for EDM notches and pin holes to be cut into the longitudinal seams for qualification of NDT procedures.

- Based on this, they decided to initially evaluate the following NDT techniques: RT with high sensitivity film (D2 film), CR (Durr equipment) and computed tomography (Yxlon equipment). Details of these techniques are provided in the paper.
- The results of all techniques were good. Both film and CR had difficulty detecting the smallest flaw positioned in the corner transition. Computed tomography detected all flaws with high POD and was subsequently used for this work.

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- **Paper 4** – Compensation Principles in Digital Radiology for Weld Inspection, U. Ewert et al, Germany, V-1438-09.
    - Digital detectors were developed for medical applications, and thus have high sensitivity and high unsharpness compared to industrial x-ray films. This paper discussed how to compensate for these issues using other methods.
    - Had a discussion on the S/N ratios and how they affect the ability of a system to detect small signals. The noise sources are the result of photon noise (dependent on exposure dose), structure noise (roughness of sensitive IP layer), crystalline noise (due to structure of part being exposed) and surface roughness (of the part being exposed).
    - Photon noise is reduced by increasing the exposure time. There is a good graph that describes a number of different IP compared to DR and film. The DR detector provides the best image quality. Ewert presented an equation that compares IQI visibility with a contract parameter times the SNR ratio to get the 2T ASME requirements. A lower tube voltage allows better contrast, and a higher tube voltage allows a better SNR.
    - DDA (digital detector arrays) are able to detect signals that are sub-pixel size. This effectively allows a DDA to function at a resolution level less than their pixel size.
    - ASTM guidelines were discussed on how to handle the following for DDA: dead pixel, over responding pixel, under responding pixel, noisy pixel, non-uniform pixel, persistent lag pixel and bad neighbourhood pixel. Guidelines are also given about the number of pixels that are required for detecting a flaw.
- **Paper 5** – Assessment of Hot Cracking Resistance of Welded Material Using Planar X-ray Tomography, U. Ewert et al, Germany, V-1440-09.
    - This paper describes how some advanced welding processes can lead to hot cracking. This paper presents some results about how the hot cracking process occurs.
    - There are three kinds of hot cracking: solidification cracks (formed during solidification), liquidation cracks (formed by liquidation of the HAZ) and ductility dip cracks (due to a reduction in the hot ductility). The reason for these three types of cracking is described.
    - Planar computed tomography was used to image cracking, which can be oriented in many different directions. The principle of this technique is to move the x-ray source across the weld with a stationary detector, thus providing information in many different incident planes. Standard radiography will not work due to the crack orientation. Destructive testing is not a great option, as it only captures the cracking in the cutting plane.
    - There are a number of images presented that show in detail the ability of planar computed tomography to image cracking. There are videos that show depth cross sections through the welds in the vertical direction.
- **Presentation 3** – Annual Report for Commission VC (Ultrasonic Based Weld Inspection Topics), E. Sjerve, Canada, V-1428-09.
    - Sjerve presented the Annual report for Sub-commission VC. There were four interim meetings of this group.
    - The Handbook on the Ultrasonic Examination of Austenitic and Dissimilar Welds has now been published.
- **Presentation 4** – Handbook for Phased Array Inspection, E. Sjerve, Canada.
    - Sjerve presented the state of the Handbook for Phased Array Inspection. The resolutions from Graz were shown and discussed (one to publish the Handbook through IIW after external editors comments are addressed, and one on copyright).
    - The main part of this update was a description of the external editor's comments and how they have been addressed. Comments were received from CEA (France), IZfP

    (Germany), NIST (USA) and BAM (Germany). All comment have been addressed with appropriate modifications to the Handbook. These changes were approved, with some small outstanding modifications that need to be done.
  - The phased array glossary was discussed, and it will be reviewed it one more time to ensure consistency with the CEN phased array glossary.
  - Dr. Drinkwater from the UK has agreed to be an external editor for the Handbook.
  - The Handbook has been submitted to IIW to start the publication process. IIW has offered another route to publication through a technical report in ISO. This was discussed in the commission and it was decided to pursue both publication routes.
  - The Acknowledgments section is still being formatted. The Handbook working group will submit the desired format for this section to the commission for approval.
  - A resolution to publish the Handbook was agreed upon, so this document will proceed to publication. Editorial issues and some small modifications will be done.
- **Presentation 5** – Guided Wave Inspection of Pipelines: An Advanced Diagnostic Tool that is Spreading Quickly, F. Brecciaing, Italy, V-1440-09.
  - Bresciani is the leader of the IIW working group on LRGW. There were difficulties in getting the equipment manufacturers involved in this working group in the past year as they are reluctant to participate.
  - Bresciani provided a good summary of LRGW. The applications and the basics of the LRGW technique as applied to piping were discussed. Included in this was: penetration distance, attenuation issues, wave modes, how the technique handles fittings and the minimum cross sectional wall loss that can be detected.
  - Training difficulties were discussed. This technique is more like manual ultrasonic inspection, as it relies heavily on operator interpretation. It is common to have a wide variation in the interpretation of signals for operators that do not have enough field experience. Normally, interpretation is done at the same time as data acquisition, resulting in poor results for some inspections.
  - LRGW is a screening tool, and cannot determine the remaining wall thickness of a corroded area. Bresciani discussed other NDT techniques that could be used to determine remaining wall thickness after LRGW identifies an area of corrosion. The difficulties in getting good data for some corrosion morphologies of corrosion were discussed.
  - A detailed account of current Italian LRGW standards and best practices documents occurred.
  - There was an open discussion on LRGW. There were some people in the Commission that have done good work in both field inspection, qualification of LRGW vendors and modelling of LRGW behaviour. There was a consensus in the Commission that this inspection technique has much potential in the future, but has some deployment difficulties. There are also many LRGW advances that will become available in subsequent versions of the commercial systems.
  - The decision was to translate the Italian LRGW documents into English and then circulate them to the Commission. In parallel, the working group will be staffed with people that are end users of this technology. A number of national representatives in the Commission will go back to their respective countries and solicit people who are willing to contribute. The composition of the working group should have people with both practical and theoretical LRGW experience.
- **Presentation 6** – Phased Array Calibration Block, E. Sjerve, Canada.
  - Sjerve presented a short overview of the motivation behind starting this project. He also presented the various factors that need to be considered when fabricating such a block.
  - An open discussion in the Commission occurred regarding how to move this project forward. There were several national groups that have shown interest in this. It is likely that we will have a first meeting at the 2009 ASNT conference.

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- **Presentation 7** – Annual Report for Commission VE (Weld Inspection Topics Based on Electric, Magnetic and Optical Methods), G. Dobmann, Germany, V-1429-09.

  - Dobmann presented the Annual report for sub-commission VE. No interim meetings were held.
  - An update on the MMM work was presented. There is a MMM Handbook that is being published through IIW. There are some problems with this document now since there is only one equipment manufacturer.
  - There is ongoing work in materials characterization using magnetic NDT methods.
- **Paper 6 –** Development of the Technique for Gas Pipeline Girth Welded Joints Inspection Based on MMM, S. Kolokolnikov, Russia, V-1441-09.
  - MMM functions by detecting residual stresses in welded joints as a determination of potential flaw locations. These areas are called SCZ (stress concentration zones), and sometimes correspond to micro flaws that are not detrimental to service, and in other cases correspond to macroscopic flaws detrimental to service.
  - MMM can detect damage in its early stages before it grow into flaws. This is unlike other NDT techniques that only detect flaws when they are macroscopic.
  - A comparison between standard NDT techniques and MMM was presented for girth welds on in-service pipelines. MMM was done through the pipeline coating, which was then removed for conventional NDT. Destructive testing on some samples was done.
  - There was development of the field gradient magnitude that corresponds to rejectable flaws in girth welds. This allowed a screening field gradient level to be established, above which conventional NDT would be applied.
  - The resolution is to do comprehensive round robin trials to produce good statistics on: POD for flaws, POD for certain types of flaws and false call rate. There was a detailed discussion on how this is the next step required for MMM to be recognized within a wider audience.
- **Paper 7** – Real Time Monitoring of Weld Pool Using Infrared Thermography – Estimate of Weld Beam Width and Depth of Penetration and Detection of Weld Defects from Thermal Image of Weld Pool, A. Bhaduri et al, India, V-1432-09.
  - This is a robotic welding application where welders have no physical access to the welds. This then requires a real time quality control feedback process during welding, which this paper describes. They have developed all of the hardware, feedback control, infrared gear and software themselves.
  - The application is TIG welding of 316LN SS plate. Details of the infrared imaging system were provided.
  - Real time images of the thermal profile of the weld pool are presented. Emissivity was estimated using thermocouples and modelling, and integration times on the infrared measurements were optimized. Work was then done to estimate the width of the weld pool based on thermal measurements.
  - Once this was done, thermal profiles of the weld length were gathered for welds with no flaws. They were then gathered for a variety of weld flaws – IP, LOF, tungsten inclusions, etc. The main flaw indication parameter used is the width of the molten weld bead.
  - Bhaduri has demonstrated that it is possible to measure in real time the width of a molten weld bead during welding, and have shown some level of correlation of these images to certain weld flaws. They are now in the process of getting better statistics in the correlation to weld flaws and to build the system into a closed feedback loop.
- **Paper 8** – Micro-Magnetic Non-Destructive Evaluation of Micro Residual Stresses of the IInd and IIIrd Order, G. Dobmann et al, Germany, V-1436-09.
  - In Germany, there are WB 36 steels in service that have good mechanical properties, but degrade over time (decrease in toughness, increase in mechanical hardness and increase of brittle-ductile transition temperature).
  - The changes that occur with age are operation induced copper precipitation of small coherent Cu particles. Since Cu has a greater atomic radius than iron, the copper precipitates cause a local distortion of the iron lattice causing tensile residual stress fields (these are 3^{rd} order). There is also a different a difference in thermal expansion of the copper precipitates and the iron matrix, which result in compressive stress on the iron matrix (these are 2^{nd} order). These two effects compete with each other.

  - The goals of the work are: characterization of micro residual stresses and NDT measurement of them. Samples were prepared for this technique development and then magnetic measurements were done using Barkhausen noise techniques while putting the sample under tensile and compressive loads. A theoretical description of the magnetic effects at the grain structure level is given.
  - There are also residual stresses of the first order, which are due to stresses inherent in the lattice due to material processing. A discussion was presented regarding the different types of heat treatments done and the resulting first order residual stresses.
  - With the presence of Mn in the metal matrix, it is possible to limit Cu precipitation and thus minimize the risk of material degradation. Graphs of micro residual stress in the material as a function of different material compositions and thermal aging time were presented to support this thesis.
- **Presentation 8** – Annual Report for Commission VF (NDT Reliability Including Simulation of NDT Techniques), P. Benoist, France, V-1430-09.
  - Benoist presented the Annual report for sub-commission VE. One interim meeting was held.
  - The objectives of the work are:
    - Guidelines for simulation use in NDT, including model validation.
    - International database and benchmarking; comparison with reference data. This will bring together companies that are currently doing simulation work.
    - Guidelines in the area of POD and extension of existing documents.
    - Have a framework to continue some new aspects in progress (multi-parameter, mixing empirical/simulated data, etc)
  - The IIW work will act to bring many groups together in this important area of work. Canadian companies that are working in this area should join the initiative in order to have access to these results.
  - This is important in order to be able to extend fitness for service work. The FFS people need to know the accuracies and confidence intervals of NDT techniques as inputs to their models. This is very difficult data to obtain, because there is such a wide variation between NDT techniques, human factors in applying the techniques, the types of flaws in certain geometries, etc.
- **Paper 9** – Recent Advances on the Ultrasonic Examination of Austenitic Welds, P. Benoist et al, France, V-1435-09.
  - When performing inspection of austenitic materials, there are some significant issues that must be solved. There is anisotropy in the weld (variation in weld parameters depending on position), coarse grained structures (high attenuation and low SNR) and heterogeneity (beam splitting).
  - This paper describes a research project that was done in Europe to deal with these issues. CEA was involved in modelling the behaviour of ultrasound propagating through the welds. It is important to understand this issue in a broad context, since there can be significant differences in the behaviour depending on material, type of welding process, type of ultrasound used and the types of flaws present.
  - Dendritic grain structures in these welds can cause beam steering, which results from a difference in the phase and group velocities of the ultrasound. In order to better understand the weld structures, electron backscattering diffraction was used. This information was then used as an input to the modelling work.
  - A software package called MINA was developed to handle the complex anisotropic structures found in austenitic welds. There is another software package called Athena to do finite element modelling of the beam propagation, and CIVA which is the overall driving software.
  - Some interesting results are presented that show the beam skewing effects that are possible for austenitic welds. Further results are presented for a wide variety of different configurations.
- **Paper 9** – POD in NDT Based on Simulated Data, P. Benoist et al, France, V-1437-09.
  - Need to find a way of evaluating the quality of the inspection technique. In the past, these were done using expensive and time consuming experimental work. There is also

the problem of never being sure that the manufactured defect is representative of the flaw that will be found in the actual in-service component.

- The idea is to replace some of the need for experimental work with simulation. The paper gives a number of factors that affect these results – both the deterministic factors and the random ones.