

IIW Annual Assembly – Melbourne, Australia.

July 10th to July 13th, 2016

Summary of Commission V Activities.

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Summary

Dr. Eric Sjerve from Canada chairs this commission. The commission's 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 Commission V meetings were done in the form of updates by the Sub-commission chairmen on their work during the past year, presentation of papers, group discussion on topics and a joint session with Commission XVI on polymer joining and NDT. Descriptions of the papers and summaries of the group discussions are given. The full texts of the papers are available by contacting the CCIW.

July 11th, 2016 – Commission V Meetings

- **Presentation 1** – Commission V Annual Report, E. Sjerve, Canada, V-1704-16.
 - Eric Sjerve gave the opening remarks and the Melbourne agenda was adopted. The meetings this year will have Sub-commission VA and VF on Monday; Sub-commissions VC and VE on Tuesday; and the joint seminar with Commission XVI on polymer joining and adhesives on Wednesday. The commission V annual report was reviewed (V-1704-16) and updates on changes to IIW were given. A strategic direction of Commission V is to organize joint seminars with other commissions each year. It is the intention to try to organize a joint session with SC-AUTO and other interested commissions on joining and inspection of hybrid materials currently being used to reduce vehicle weight in the automotive industry. Eric Sjerve then talked about how Commission V needs to attract more young people and asked all Commission V members to work on this.
 - There were updates given on the standardization activities of Commission V. There was a special meeting on Sunday July 10th to discuss the three MMM ISO standards that are currently up for five year review. Comments were received from IIW and ISO. It was decided to form a working group chaired by Dr. Uwe Zscherpel to address outstanding comments. ISO 18211 on guided wave testing of above ground piping is now complete and it was published as an ISO standard. There is a group in the UK that intends to try to form a new method at ISO to deal with guided wave standardization. Commission V agrees with this, as the physics of guided wave inspection is fundamentally different than other NDT techniques. Short updates were also given on ISO/FDIS 19675 and the IIW Booklet of SHM papers.
 - SHM (structural health monitoring) is a topic that has growing interest for Commission V. SHM is when sensor(s) are mounted in-situ on a component to take continual measurements of some aspect of its health. There have been discussions for several years in Commission V about this topic and the joint seminar last year. Commission V feels that this is an important subject that warrants special consideration in Commission V. A resolution was put to Commission V to form a fifth Sub-commission to deal with SHM with Bastien Chapuis as the chairman. This resolution passed with strong support in Commission V.
 - Dr. Uwe Ewert is retiring from being chairman of Sub-commission VA since 2000. All wanted to thank Uwe for his dedication to IIW and wish him well in retirement. Mr. Pentti Kopiloff was also recognized since he has been the Finnish delegate for 39 years and he has attended 29 IIW Annual Assembly meetings in Commission V. Next year in Shanghai will be Pentti's last Annual Assembly before retirement.
- **Presentation 2** – Annual Report for Sub-commission VF (NDT Reliability Including Simulation of NDT Techniques), B. Chapuis, France, V-1727-16.
 - Bastien Chapuis gave the annual report. There are two main areas of work that were described: the French MOSAIC project to simulate ultrasonic propagation through coarse grained structures and the simulation assisted POD work. The MOSAICS work uses

CIVA as a simulation engine, and it provides an excellent framework for how to model coarse grained welds. Bastien presented the three different ways that the stiffness matrix can be modeled: piecewise description, parametric description and mapping description. Further information was given about when these different models should be used. Some description was then given on how simulation can be used for the TFM (total focusing method); this was provided as background information before the longer discussion of this technique in Sub-commission VC on Tuesday. Some short discussion on simulation assisted POD studies was given.

- **Presentation 3** – Update on publication of the use of simulation in POD curves estimation, B. Chapuis, France, V-1741-16.
 - Bastien Chapuis gave an update on this project. V-1730-16 is the updated document and it is now ready for publication. This update follows from the work presented in Helsinki last year on this topic. Previously, there were some outstanding comments that were received by experts in the area of NDT simulation that needed to be considered and integrated into this document. These comments are now resolved and there is good agreement within the experts on this working group. Bastien gave a summary of the different parts of this document, along with an explanation of how simulation affects the confidence interval of the POD curves. There was a vote in Commission V to forward this document for publication as an IIW Booklet, and all agreed it was ready for publication.
- **Paper 1** – Ultrasonic guided wave monitoring of composite repaired pipelines, D. Chauveau, France, V-1720-16.
 - Daniel Chauveau gave a presentation on using guided wave testing to monitor a pipeline section with a highly attenuate composite pipeline coating. This is a common way of strengthening a pipeline when there is a defect that exceeds the tolerance allowed for structural integrity, or when the growth of the flaw cannot be arrested with full certainty. This is a SHM application where a defect is monitored using a single placement of a guided wave sensor with repeated guided wave measurements. Modelling results were first presented using a number of different composite wrapping geometries, frequencies and wave modes. It was shown that the attenuation of the system is highly dependent on guided wave frequency. Some interesting results were then presented by adding an artificial defect into the ID of the pipe under the composite repair. Data was then gathered for multiple frequencies as the defect was enlarged. It was shown that the guided wave technique is sensitive to defect growth and that it can be used for SHM.
- **Paper 2** – The journey from standard change to implemented assessment, A. Ericson-Oberg, Sweden, V-1745-16.
 - Anna Ericson-Oberg gave a talk that is based on her research at Chalmers University and Volvo, and that builds on the paper presented at the Helsinki Assembly on a similar topic (see V-1684-15). This work draws on the experiences of a company building machines in which fatigue life is important. It was found that there was a lacking correlation between the weld class described in the weld standard and the fatigue life of the components. To improve this, the company decided to create its own weld standards where this link was better established. There was some discussion about the measurements that are ultimately required to ensure an acceptable fatigue life, and how the NDT techniques are not always well matched to these measurements. There was also discussion on the difficulties in implementing this type of change within an organization that is large and multi-national – it requires a change in culture.
- **Presentation 4** – Annual Report for Commission VA (Radiography Based Weld Inspection Topics), U. Zscherpel, Germany, V-1724-16.
 - Uwe Zscherpel gave the annual report. Uwe gave a detailed description current standardization activities, and he provided updates for both ASME and ISO. The standardization structure was presented with good visual linking between the standards. This was done with a radiography focus, but information about other NDT standards was also given. Special attention was given to standards used for radiographic testing of welds in German nuclear power stations. Some discussion about training was also given. Uwe then gave an update on the completion of the project to digitize the reference radiographs.

This has been a big success and the final product is now available on the Google store. The product is available in different versions at different costs, which was described. Some discussion was then done about digitizing the aluminum radiographs that were recently given to BAM by the IIW. There are some issues for this project in that the radiographs are quite old and it needs to be determined if they are relevant. This is future work for Sub-commission VA.

- **Paper 3** – Non-destructive neutron techniques for welding applications, A. Paradowska, Australia, V-1722-16.
 - Anna Paradowska from ANSTO in Australia gave a presentation about their neutron inspection capabilities. This organization has very strong capabilities in this area, including: a research reactor, centre for neutron scattering, synchrotron, a cyclotron imaging facility and an accelerator. Description of the ability to measure residual stress in components was given, along with a project that measured residual stress in a large pipe segment that would not be possible in most facilities. It is possible to provide different spatial resolutions for these measurements, down to voxels that are 1 mm on a side. Some good examples from additive manufacturing were provided. There were also some examples of tomography given for providing depth slices of different components.
- **Presentation 5** – The recent trends of NDT in Japan, Y. Ogino, Japan, V-1728-16.
 - Yuji Ogino gave an overview presentation of what types of NDT are typically performed in Japan. This presentation started with some of the economic drivers for NDT in Japan, including the positive and negative impacts of each driver. Some critical drivers are the high economic growth period of Japan in the 1960's, followed by some natural disasters that necessitated additional NDT. A quick description of the basic NDT techniques was given. Yuji also gave a detailed description of Japanese standards that are typically used for inspection, and how they correlate to ISO and ASME standards. Some discussion about the advanced NDT technique used in Japan was also provided.
- **Presentation 6** – New Zealand NDT requirements for steel structures, M. Karpenko, New Zealand, V-1723-16.
 - Michail Karpenko gave a presentation about a project to consider the NDT requirements for steel structures that is being done at HERA in New Zealand. An overview of current practices in New Zealand was given, and it was stated that much of the steel structures in New Zealand are built to be earthquake resistant. Some detailed information was given about the types and percentages of inspection required for different classes of structures. The objectives of this project are to better understand where these requirements originate from; i.e. are these requirements based in good scientific principles or are they based on best workmanship practices. Michail is looking for as much information about this as possible to try to build a case to modify these requirements, and he asked Commission V for help in this project. There was a discussion whereby some of the people in Commission V have some experience in this area and they will send Michail some information. This question is less about inspection methods and more about how much inspection is required to guarantee asset integrity of structures in earthquake zones.

July 12th, 2016 – Commission V Meetings

- **Presentation 7** – Commission V Update, E. Sjerne, Canada.
 - Eric Sjerne gave a quick summary of the minutes and resolutions from Monday. Uwe proposed two resolutions from the previous work on Monday, and both were passed.
- **Presentation 8** – Annual Report for Sub-commission VC (Ultrasonic Based Weld Inspection Topics), D. Chauveau, France, V-1725-16.
 - Daniel Chauveau gave the annual report. A description of the organization of EN and ISO standards for UT based techniques was given. There was also a good concise description of the different ISO standardization stages, which is quite relevant to Commission V. A history of the original IIW block was then given, including the dates that the initial ISO 2400 was prepared. Daniel showed conclusively that this development occurred in IIW Commission V. There were anisotropy problems with blocks made to this initial standard, which necessitated work to improve ISO 2400. Description of the new ISO 19675 PAUT block was also given; this project is now at the FDIS stage with

an expected publication in 2016. Lastly, some background was given on ISO-DIS 19285 for acceptance levels for PAUT testing and on ISO/NWIP 20601 on PAUT inspection of thin walled welds. Both of these standards are currently being worked on in ISO.

- **Paper 4** – Update on passive guided wave tomography, B. Chapuis, France, V-1729-16.
 - Bastien Chapuis gave an update on the project that he described in Commission V last year; reference IIW document V-1670-15. This is a novel technique whereby passive fibre Bragg sensors are used to detect guided waves propagating on a plate due to ambient noise in the structure. This is quite different than active SHM systems where energy is inputted into the structure. Bastien gave a good explanation of fibre Bragg gratings, and how they can be used in this configuration. This passive configuration is attractive for some applications where bulky sensors and driving electronics are not permitted. By using a cross correlation algorithm, it is possible to use the ambient noise inherent in the structure for monitoring for corrosion wall losses. Using the dispersion curves for guided waves it is possible to extract the material thickness in the areas of corrosion. Some practical examples of this technique were given with simulated corrosion flaws. Future work is expected to further commercialize this technique.
- **Presentation 9** – Application of total focusing method and comparison with phased array technology, L. Le Ber, France, V-1731-16.
 - Laurent Le Ber gave an update on the total focusing method (TFM) and full matrix capture method (FMC), which is an advanced phased array technique using the same PAUT probes as conventional PAUT inspection. In a conventional PAUT inspection, the focal laws are calculated first and then the probe is used to generate a specific sound beam. The power and flexibility of this technique is that the sound beam can be engineered to have a specific angle and focal properties. In FMC, single elements in the array are excited, and then all elements of the array are used to receive reflected signals. This is then done for all of the elements, which generates a large data set of received signals. TFM is then used to deconvolute these signals into a typical phased array display. Laurent explained that this technique gives better abilities than conventional PAUT testing in terms of its ability to provide a sharp focus over the entire inspection volume, near field resolution and off axis sensitivity. Examples of this were provided.
- **Paper 5** – A new method for the inspection of resistance spot welds using adaptive ultrasonic array, L. Le Ber, France, V-1724-16.
 - Laurent Le Ber gave an update on a new method for inspection of automotive spot welds using an adaptive phased array technique. Laurent first gave a description of the spot welding process, and the types of flaws that are possible: loose, stick, undersize and burnt nuggets. This new method uses a PAUT probe with a captive water column. The water column allows the probe to properly fit onto the spot weld, as it is often required to orient properly even if misaligned. The PAUT probe is first used with FMC/TFM to map out the OD surface of the spot weld, allowing the adaptive technique to be used to generate the correct ultrasonic beam in the spot weld. Once this is done, it is possible to generate good images of the spot weld and the back wall surface. Examples were given of what B-scan signals look like for different types of spot weld flaws, along with good spot welds. Special discussion of the case of a stuck spot weld was given; this defect is difficult to detect but it presents a problem for fitness for service.
- **Presentation 10** – Discussion about formation of a task group for methodology to use FMC and the TFM methods in the field, D. Chauveau, France, V-1732-16.
 - Daniel Chauveau gave a presentation that continued on the last two presentations by Laurent on the FMC and TFM methods. Daniel explained that these techniques are currently hot topics in NDT, and that there is much work and development being done. He then explained to the group that there is little standardization, or even best practices documents that are available. This situation is making it difficult for companies to implement these techniques fully for field inspections. Daniel then proposed that Commission V start a new working group in this area to draft some guidelines. His proposal is to involve experts from different industries and regions of the world to start working together on this task. There was strong support in Commission V for this work and the resolution passed.

- **Presentation 11** – Annual Report for Sub-commission VE (Weld Inspection Topics Based on Electric, Magnetic and Optical Methods), M. Kreutzbruck, Germany, V-1726-16.
 - Marc Kreutzbruck gave the annual report. This report focused on the MMM technique and the work that has been done at BAM in Germany on this topic. Marc stated that there have been over 20 people involved in investigating the MMM technique for a period of several years. There was background given on the basis of magnetic effects in steels, and comments made that these effects are very complicated and are often difficult to fully understand. Results were presented using GMR sensors that produce very high spatial resolution data on the magnetic fields on the surface of an object. It was shown that when considering the first derivative, it is important to properly control the lift off of the sensor. Similar results were shown with regards to the spatial resolution of the sensor. A detailed example was then given showing the surface magnetic effects on a tensile sample that had been pulled. There was a strong magnetic signature including Lüders bands. Some context was then given with respect to ISO 24497 on MMM. A short description of the meeting held on Sunday July 10th was given, and then Commission V took a resolution to form a working group to address the outstanding ISO and IIW comments.
- **Paper 6** – Non-destructive evaluation of welded joint quality by passive thermography, A. Klisch, Germany, V-1717-16.
 - Armen Klisch presented his work using passive thermography for detection of welding flaws. This technique is performed at the same time as the welding process, and it uses the heat dissipation from welding to detect flaws. The principle is that flaws will change the dissipation of heat away from the weld, which can be detected using an infrared camera. An example of an inspection done this way was given where there was a weld imperfection. This is an interesting technique as it is able to give direct feedback to the welding process in real time, unlike conventional NDT techniques. Some description of the advantages of this technique over other NDT techniques was given, but it has yet to gain widespread acceptance in industry. More work is required to better understand the POD for common weld discontinuities.
- **Paper 7** – Detection of local stress concentration zones in engineered products – the lacking link in the non-destructive testing system, S. Kolokolnikov, Russia, V-1740-16.
 - Sergey Kolokolnikov gave a presentation on stress concentration zones detection being the missing link in NDT. There was a short description of the MMM technique, including the physical basis for MMM. This was put into the context of existing Russian standards that present measuring the stress state of a component being part of the regular NDT process. Some background on the structure of ISO TC 135 was also given and how the MMM technique could fit. Examples were then given of the MMM technique being used on industrial components. Several of the examples given were of MMM being used for detection of metallurgical variations in materials, rather than macroscopic flaws. Detection of these variations is a different way to deploy NDT, in that it is detecting areas that could become a problem in the future. There was also an example of MMM used on a thick steel plate to detect flaws at the far surface; this led to a discussion about the physical basis of this and what difference there is in MMM sensitivity as a function of thickness.
- **Presentation 12** – IIW CEO update, C. Meyer, France.
 - Cecile Mayer was in the audience during the digital radiographs presentation by Uwe Zscherpel and she gave strong support for this project. Cecil provided updates in the following areas: the IIW Secretariat office is moving to Yutz in France which is close to the German border near Saarbrücken; there is a corporate brochure series that contains IIW technical outputs that she wants Delegates from Commission V to provide input into; and the IIW Web site is being upgraded to Office 365 in the coming year which will provide additional capabilities for all. Cecil also talked about how IIW is very appreciative with the efforts of Uwe Ewert and she stated that a plaque will be sent to him recognizing this. Eric Sjerne and Cecil then conducted an election in Commission VA, in which Uwe Zscherpel was elected chairman. Both Cecil and Eric thanked Uwe

Zscherpel for his good work with the reference radiographs and expressed that we are very happy with this election result.

July 13th, 2016 – Commissions V and XVI Joint Seminar on polymer joining and NDT

- **Presentation 13** – Commission V Update, E. Sjerve, Canada.
 - Eric Sjerve gave some opening remarks. The meeting minutes are posted on the IIW Web site and all are encouraged to review. A short summary of the resolutions from Tuesday was completed, and all agreed with the resolutions. An update to Commission V was given that the SHM Booklet will be published through Springer instead of an IIW Booklet as initially described.
- **Presentation 14** – Introduction, M. Kreutzbruck and D. Grewell, Germany and USA.
 - Marc Kreutzbruck gave an overview of Commission V activities for people in Commission XVI. He then gave background on the plastics industry and how it is moving towards lighter materials. This is a trend that is strong in both the automotive and aerospace industries. The driving trend with this is to lessen the weight of vehicles and planes to reduce fuel consumption, which in turn reduces carbon dioxide emissions. There are strong directions within national and international governments to reduce carbon emissions. Marc then stated that there is also a strong need for standardization in this area in order to allow industry to properly take advantage of these opportunities. There is a place for IIW Commission V in this process, and this seminar is hopefully the beginning of more collaboration in this important area.
 - David Grewell then gave an overview of Commission XVI for people in Commission V. This commission is relatively new and small compared to other more well established Commissions, and it is concerned with plastics and polymers. David talked about his background in welding and joining of plastics. David gave some examples of the importance of welding plastics, including: a Yoplait application where there are machines that weld the tops on yogurt containers at a rate of 120 per second; in the automotive industry where it is now common practice to weld two parts of glass reinforced intake manifolds together; and for wind turbines in Iowa where 80 - 100 m long blades are fabricated from thermoset glass reinforced composites where blade tips approach supersonic speeds when rotating and require strong NDT inspection before being put into service.
- **Paper 8** – Progress in nondestructive testing methods for the inspection of plastic components, M. Kreutzbruck, Germany, V-1733-16.
 - Marc Kreutzbruck gave a presentation describing some of the challenges and NDT techniques that are used for inspection of plastics and composites. He talked about CRFP, hybrid components that incorporate both metals and plastics, and adhesively joined parts. In many of these cases there are high anisotropy, scattering and attenuation when trying to apply conventional NDT techniques. Marc then gave a summary of the electromagnetic and acoustic spectrums and how they are used for inspection of these materials. There was then some detailed discussion about ultrasonic matrix arrays, air coupled ultrasound, ultrasonic birefringence and local defect resonance as applied to these materials. Examples of impact damage were given for composites, and for different types of defects in adhesively bonded materials such as kissing bonds, missing adhesive, decreasing bond width and porosity. Data was given on amplitude and phase shifts as a function of angle for birefringence measurements on CFRP showing the anisotropic effect of the fibres in the material.
- **Paper 9** – Evaluation of the integrity of polyethylene joint and piping systems by means of phased array UT, D. Chauveau, France, V-1721-16.
 - Daniel Chauveau presented work using phased array ultrasonic testing for inspection of electro-fusion joints in high density polyethylene piping systems. This was a project initiated by gas distribution companies in France that wanted a detailed study of electro-fusion welded pipe saddles and sleeves. Some discussion about the difficulties of HDPE inspection compared to conventional metallic inspection techniques was done. Many flaws were inserted into the welded joints by placing paper into the weld zone during heating. This resulted in a large series of flaws with different positions and sizes through

many welds; these flaws were close to the criteria of ISO 13596. These joints were then inspected and the results compared to destructive testing done to ISO 13956; this inspection procedure showed very impressive probability of detection results. Results were then presented using PAUT for detection of semi-elliptical defects and notches. This also showed good results, and it has resulted in the first field work being done in the Paris area.

- **Paper 10** – Laminographic testing of carbon fibre reinforced composites, U. Zscherpel, Germany, V-1735-16.
 - Uwe Zscherpel gave a summary of his work using radiography for detection of cracking in reinforced composites. X-ray planar tomography is a technique where the radiation source is moved parallel to the composite plate axis when acquiring radiographic images. A digital detector is placed behind and close to the composite to give good unsharpness. By moving the radiation source, it is possible using algorithms to compute a volumetric reconstruction of the composite showing the depths and shapes of defects. In this case, the composite panels were quite large, requiring design of specialized holding and movement fixtures. This inspection focused on stringers that were embedded in the composite material where there was the possibility of cracking developing at the interfaces. Some impressive planar tomographs were shown. Lastly, discussion and comparison to ultrasonic testing for another composite inspection of spars was presented.
- **Paper 11** – Crack growth monitoring at CFRP adhesive bondings, M. Kreutzbruck, Germany, V-1736-16.
 - Marc Kreutzbruck gave a presentation on an application for detection of cracking at adhesive bonds between two CFRP composite materials. For this work, a cyclic loading machine was designed to periodically load the adhesively bonded structure. The different NDT techniques were tested: an air coupled ultrasound system set at an angle to the component was used to generate guided waves, and thermography was used to detect the crack front as it propagated through and into the adhesive bond. It was shown that both NDT techniques are able to detect the crack front, but thermography is the technique that can be used during the loading process. Results were then presented showing the crack growth as a function of the number of cycles. In the parts being cyclically loaded, there is a crack stopper between the two composite plates whose purpose is to arrest cracking before it can lead to catastrophic failure. Marc presented graphs showing the crack length as a function of the number of cycles, and this data showed conclusively that the crack stoppers are working well. Once the crack propagates close to the crack stopper, crack growth rate dramatically slows down.
- **Paper 12** – Weld line characterization of plastic components using various contact and non-contact ultrasound techniques, M. Kreutzbruck, Germany, V-1737-16.
 - Marc Kreutzbruck gave a presentation about a project to characterize the stiffness of weld lines compared to the parent material in injection moulded components. In this process, thermoplastic materials are injected into moulds at high pressures, and for complicated designs there will be locations where molten streams come together from two directions. These are areas that can have poorer mechanical properties than the parent material, especially in the case where the materials are short fibre reinforced plastics. In this study, Marc presented results whereby air coupled ultrasound transmission, guided wave velocity, longitudinal waves and shear waves were all used for detection of weld lines. All of these techniques were able to detect weld lines by using C-scans, or measuring changes in ultrasonic velocities or phase shifts. However, it is unclear which NDT methods will be most appropriate for determining the possible strength reduction at weld lines. More work in this area is required before a technique can be commercialized.
- **Paper 13** – Non-Destructive characterization of hygrothermally aged polymers, I. Fiebig, Germany, V-1738-16.
 - Isabel Fiebig gave a presentation on the work that is being done at the University of Paderborn on aging of polymers, which can be divided into two categories: chemical aging that is an irreversible process and physical aging that can be reversed. This work used a chemical bath to immerse both polyamide samples and continuous glass fibre reinforced composite sheets to rapidly hygrothermally age them. Leaving the samples in

the bath different times resulted in different amounts of aging. Destructive testing was then performed to quantify the chemical, physical and mechanical properties of the aged samples. Ultrasonic NDT measurements were then performed and compared to the destructive results. It was found that there was a rapid decrease in strength and stiffness during the first week of aging, and then the properties didn't change as much. This was attributed to the water content in the samples. Future work is planned to implement a laser ultrasound system and investigate more materials using this technique.

- **Paper 14** – Use of active and passive thermography for non-destructive testing in the field of joining technology, S. Böhm, Germany, V-1739-16.
 - Stephan Böhm gave a presentation on this project. Some background was first given on both passive and active thermography, including lock-in techniques. A study was then presented on passive thermography for inspection of friction stir welding joints. Defects were introduced into the welds by changing the pin length, drilling holes, and inserting contaminants at the weld line. Thermographs were then presented of common friction stir weld flaws, such as porosity, wormholes, lack of fusion, lack of penetration and failure of the tool by the pin breaking. It was shown that thermography has good ability to detect these weld flaws but surface imperfections can lead to false calls. Thermography results were then presented for laser beam welding of double butt joints in steel sheets, where the study concentrated on flaw detection. In this case, active thermography was used. Lastly, results from thermography applied to adhesive bonding were presented with some results presented for detection of kissing bonds.