



Sixth World Conference on Neutron Radiography

Review by J. P. Barton

1. Introduction

The use of neutrons for radiography, radioscopy and complementary inspection methods was reported in 84 papers presented at the Sixth World Conference on Neutron Radiography held in Osaka, Japan, May 17-21, 1999. The proceedings are to be published by Gordon and Breach, Science Publishers. Numerous neutron radiography applications for nondestructive evaluation are now established and routinely used. Engineering design applications include ensuring that jet engine fuel injector nozzles do not become blocked by coking, quality control applications include checking the coolant channels in each individual engine blade. Such contributions to air worthiness were, no doubt, appreciated by the 95 participants who flew into the new Kansai Airport from 18 countries and from many parts of Japan.



The universe of neutron radiology, like our cosmological universe, appears to be expanding at an ever-increasing rate. Several dimensions are apparent. The neutron source dimensions include reactors ranging from the high flux 20 MW JRR-3M reactor in Japan to the new dedicated 30 kW Kamini reactor in India. The accelerators include the large SINQ spallation source in Switzerland, and the small, but transportable, plasma-focus tubes from Russia. The isotopic source systems discussed range from 150 milligram to 0.1 milligram Cf-252 for proposed inexpensive in-house systems.

Concerning the imaging dimensions of the neutron radiology universe the conference sheds little light on previously hot areas, such as track etch imaging, but photo-stimulated luminescent phosphors feature prominently, as do electronic imaging methods. Neutron energy or wavelength is another dimension of the neutron radiology universe, and while thermal neutron methods predominate there are important reports on cold neutron, epithermal and fast



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neutron techniques. A fourth, dimension is time. Techniques reported ranges from 10^4 frames per second (30,000 MW reactor pulse) to one frame per day (small Cf-252 source), but most reports feature 30 frames per second imaging using a beam flux of about 10^8 n/cm²-s.

For an applied neutron physics field such as neutron radiology one can ask the question whether applications should be identified before technique development or vice-versa. The conference indicates that the space is curved, and that the synergistics or feedback between the dimensions means that either applications or technique development could lead the progress.

2. Applications of Established Radioscopy

The Mechanical Engineering Department of Kobe University presents a spectacular set of five papers on dynamic thermal hydraulic applications of neutron radioscopy. The applications include water cooled nuclear fuel assemblies, steam generators using spiral tubes, cryogenic-fluid heat exchangers (liquid nitrogen), refrigerator components (freon), liquid metal based steam generators, accelerator spallation targets, space rocket heat exchangers (freon) and fluidized beds. In an invited paper, Professor Takenaka presented visually stunning neutron radioscopy giving details of two phase flow, bubble formation, void fraction distribution, and flow vectors for various material combinations in controlled temperature and pressure. A high-resolution video movie shows processes at actual speeds (30 frames per second) with rotation to provide analog three-dimensional viewing and color contouring to dramatize detail.

The application of Dynamic Neutron Radioscopy to fluidized bed technology is expanded by other mechanical engineers from Kansai University, Kobe University, and JAERI, working cooperatively. Studies of fluidized beds (such as coal and sand particulates) relate to furnace performance and pollutant emission control. Two other application papers focus on quantitative measurements: gas-liquid two phase flow in spiral tube heat exchangers, and two-phase flow in water-cooled nuclear fuel assemblies. These mechanical engineering results show the value of extensive teamwork over many years of previously published technique development. The neutron facility used is the JRR-3M beam 7 at the Japanese Atomic Energy Research Institute (JAERI). Both electrical engineers at the Musashi Institute of Technology and nuclear engineers at Kyoto, Nagoya, Rikkyo, and other universities have contributed much to the capabilities now available for such applications at JAERI.

Thermal-hydraulic design applications are also reported by a team at Kyoto University employing high frame rate dynamic neutron radioscopy of 1,000 frames per second with the JRR-3M nuclear reactor beam. Measurements include the void fraction of sub-cooled boiling under high heat conditions for applications such as cooling spallation solid targets or fusion reactors.

Dynamic Neutron Radioscopy applications are featured in five papers from Europe. From Budapest, Hungary, Dr. Balasko working with engineers from refrigeration design companies, reports on methods used to inspect calorimetric devices for flow of fluids, evaporation, condensation, segregation and clogging. A second paper discusses the application of Dynamic Neutron Radiology to thermostat design. In a third application reported from Budapest, agriculture specialists have joined the group at the 10 MW reactor to model oil infiltration and flow in sandstone. In a separate paper, M. Middletown, a professor of

applied geology in Australia, combines with staff at Chalmers University in Sweden to explore neutron imaging applied to dynamics of fluid-filled porous rocks. Parameters of interest in petro-physics include porosity, field saturation, permeability, and flow velocity in reservoir rocks.

A fifth European application of Dynamic Neutron Radioscopy is reported by G. Bayon, at the Orphee reactor in France with staff of the Mineralogy Institute, University of Kiel, Germany. For geological purposes measurements of viscosity and density of granite and silicate melts at high temperature and pressure are analyzed.

From the U.S.A., a report on application of Dynamic Neutron Radioscopy by Dr. Lindsay of the University of Michigan is co-authored by mechanical engineers from the Ford Motor Company and an associated hydraulic company. Fifteen years of automobile transmission systems design studies are reviewed.

3. Applications of Established Radiography

Applications for static neutron radiography are discussed in twelve papers. Three of these applications utilize the Kyoto University Reactor. The Materials Science Department at Tottori University report on cold NR use for trace hydrogen evaluation in Mg₂Ni hydrogen storage alloys. The Engineering Department at Tottori University describes studies of lithium ion diffusion in batteries. The Environmental Engineering Department at Kyoto University describes the application of neutron radiography to measurements of sludge drying. From South Africa a paper describes how the 20 MW reactor SAFARI-1 is being used for neutron radiography applied to aircraft, automotive, pyrotechnic, and general engineering. Ancient fossil bones are also being studied there using NR. The much lower power Slowpoke 2 reactor in Canada is being applied to aircraft corrosion inspection. From Taiwan, a paper describes how the application of neutron radiography to inspection of engine blades and explosive cords has passed quality certification requirements.

The Graduate School of Agriculture at the University of Tokyo presents a study showing living root activity related to water movement in soil. The Agriculture University at Godollo in Hungary report on application of the Budapest reactor to studies of rare earth transport in plant tissues. From Nara, Japan the Gangoji Institute for Research of Cultural Property cooperated with Kyoto University to apply neutron radiography for study of ancient museum items. Museums in Berlin, Germany, together with the HMI reactor staff, provide two excellent papers on neutron auto-radiography, one applied to paintings and one applied to studies of ancient marble.

The Institute of Medical Science at the University of Tokyo cooperated with three other institutions to report on measurements of boron compound uptake in tumors of mice using neutron capture auto-radiography. This application is related to the Boron Neutron Capture Therapy (BNCT) program for cancer treatment. The potential of photo-luminescent imaging plates for similar BNCT applications is evaluated by J. Rant of Slovenia, working in collaboration with authors in four other countries.

4. Research into New Radioscopy Imaging Technology

In addition to the papers on applications of Dynamic Neutron Radiography discussed above there are a further eleven papers on research and development of improved radioscopy-imaging

techniques.

Seven different papers with authors from the Department of Electrical and Electronic Engineering at Musashi Institute of Technology report progress on different aspects of electronic imaging. Professors Murata, Mochicki and colleagues describe techniques to enhance signal to noise ratio and multi-channel filtering. They also describe simultaneous neutron-gamma radioscopy using a double layer scintillator. The first layer Gd_2O_2S (Eu) gives a red light signal due to neutron conversion and the second layer Gd_2O_2S (Tb) gives green light for predominantly gamma radiography. Two other papers co-authored with scientists from Toshiba Corporation evaluate specific aspects of the red-green double scintillator technology.

The extension of the Dynamic Neutron Radiography capability at JRR-3M from 30 frames per second (fps) to over 1000 fps is described by Dr. Matsubayashi in collaboration with staff from the Kyoto University Reactor. Other reports on Dynamic Neutron Radiography equipment characterization or technology advances are presented, one from the USA (Bettis), one from India (400 kW Trombay reactor), and one from Brazil (2MW, Sao-Paulo reactor).

5. Research into New Radiography Imaging Technology

Ten years ago, at the Third World Conference on Neutron Radiography (WCNR-3), which was also held in Osaka, the majority of radiographic imaging research papers were on film methods or track-etch methods. There was only one paper on what is now termed Neutron Imaging Plates (NIP). In this process a photo stimulated luminescent phosphor serves as sensor, to be later read with a laser scanner for digital image processing. The early paper by K. Okamoto et al, in fact, listed fourteen co-authors from Kyoto University, Kinki University, Osaka University, and Osaka Radiation Research Institute. From that one paper in WCNR-3 and one paper by J. Stade et al in WCNR-5, the interest in imaging plates has rapidly expanded. The Third International Topical Meeting on Neutron Radiography in 1998 had five papers on Neutron Imaging Plate technology. At WCNR-6 out of eleven papers on imaging for static neutron radiography ten papers are on Imaging Plate technology.

A paper by S. Fujine et al from Kyoto University and staff from FUJI Photo Film Co. Ltd evaluates a high resolution ($25 \times 25 \mu m^2$ 16 bits/pixel) computed tomography plate containing Gd_2O_3 or LiF as neutron converter. The photo-stimulated luminescence is shown to be a linear function of neutron fluence over the range 10^5 to $3 \times 10^9 n/cm^2$ and the thermal neutron component (NC) of the image quality as measured by the beam purity indicator type ASTM-75 is over 74 percent. Independently, Professor Kobayashi of Rikkyo University has evaluated the desirable NIP features of high sensitivity, high linearity, high resolution and the potentially undesirable features of gamma sensitivity, image fading, and radiation damage.

Professor M. Tamaki of Nagoya University, with twelve colleagues, presents five papers on separate aspects of imaging plate technology. Dysprosium activation is proposed to overcome gamma fogging. Imaging is also evaluated for thermal and cold neutron energies, epithermal neutrons (indium or resonance), and fast neutrons (cadmium threshold converter). The potential of imaging plate technology for backscatter imaging, autoradiography, computer tomography, and dynamic imaging (radioscopy) has been recognized by several authors. K. Kato of the Fujita Health Institute and Y. Ikeda

of the Japan Fine Ceramic Center detail an image subtraction method for pseudo-real time neutron radioscopy. Finally, a paper from India describes the use of the image plate process for dysprosium activation transfer neutron radiography. The 15 MeV Linac radiation source produces both neutrons and unwanted gamma, which the dysprosium foil transfers eliminates.

6. High Yield Neutron Sources and Beams

The capabilities of several major facilities are described. They include the spallation (accelerator) neutron source at PSI, Switzerland, the 1 MW TRIGA reactor at Pennsylvania State University in the USA and the Uranium 233 fueled Kamini reactor recently operational at the Indira Gandhi Centre, Kalpakka, India. Capabilities of the 20 MW reactor SAFARI-1, in South Africa are described in the paper previously mentioned under applications. In addition, T. Matsumoto (Musashi Institute of Technology) discusses computer methods as used for medical BNCT beam design and H. Kobayashi (Rikkyo University) describes the relationship that neutron radiography beam geometry holds with the neutron energy spectrum.

W. Whittemore points out that most TRIGA reactors could be pulsed many times each minute, thus increasing the neutron fluence per frame for certain electronic imaging applications. To produce a cold neutron beam J. Barton compares the merits of a beryllium-bismuth filter with a long beryllium filter. A separate paper by Barton analyzes filters to transmit thermal neutrons for radiography while reducing fast neutrons and gamma. A beam filter for epithermal neutron radiography consisting of cadmium and indium is described by M. Balasko for the 10 MW Budapest reactor.

7. Low Yield Neutron Sources

Lessons from the new Cf-252 system at Pantex Plant, USA are drawn by J. Barton. He points out that a very low yield source (0.1 milligram) could provide an inexpensive in-house system capable of occasional neutron radiographs. A paper by A. Yamaji and colleagues of the Musashi Institute of Technology describes sensitive electronic imaging tested with neutron beams of only 200 n/cm^2 -s from a small Cf-252 source. Another paper by R. Taniguchi et al of Osaka Prefecture University demonstrates a pulse counting technique capable of imaging at even lower neutron fluxes.

8. Neutron Radiography using Fast Neutrons

Two papers are presented by V. Mikerov et al on transportable fast neutron capabilities provided by various small accelerator or plasma focus tubes. Both continuous neutron sources and pulsed sources have been evaluated at VNIAA, Moscow using CCD type imaging devices. A single set of equipment can provide for both neutron radiography and x-radiography. A paper by H. Kobayashi from Rikkyo University, with colleagues from five other institutions, evaluates fast neutron radiography using tracking etch imaging. The results indicate both industrial and biomedical potential. Photo-luminescent imaging plates have been demonstrated as an alternative method for fast neutron radiography in two papers, one by J. Rant et al and one by M. Tamaki et al mentioned previously.

9. Neutron Computed Tomography

A paper from the Musashi Institute of Technology addresses signal processing for three dimensional computed tomography. Two reports on neutron computed tomography are presented by B.

Schillinger working at the Technical University of Munich, Germany. The first paper shows how the effective collimator and image unsharpness can be determined for guide tube beams of neutrons ranging from thermal to cold energy, The second paper gives examples of the effect of different neutron spectra on actual three dimensional neutron tomographs. Another paper by T. Funahashi of Nagoya University applies neutron computed tomography to a simulated nuclear fuel element.

10. Miscellaneous Reports

A modified umbra method for quantitative two dimensional void fraction measurements in two-phase flow is presented by N. Takenaka et al. A double beryllium filter neutron energy gain method for screening hydrogen content inconsistencies in identical objects such as turbine blades is presented by J. Barton.

The relationship between neutron beam energy spectrum, neutron transmission and an effective total macroscopic cross section is analyzed in a paper by H. Kobayashi. In a separate basic study, J. Lindsay analyses factors effecting resolution in radioscopy involving scintillator or solid state device electronic imaging. The advantages of B-10 over Li-6 or Gd are discussed.

In another valuable presentation E. Heiberg reminds us that neutron radiology might have much in common with medical radiology. Each November the Radiological Society of North America meets in Chicago with the latest equipment exhibited and seminars involving 60,000 participants. This venue might be considered for a future meeting of neutron radiographers.

In addition to the papers of original work this conference featured four special review papers, each of which were allotted fifty minutes for oral presentation. The review papers were by invited experts and were of extremely high quality. They were as follows: Neutron sources by W.L. Whittemore, Neutron Imaging by J. Rant, Image Quality Interpretation by H. Kobayashi and Multiphase Flow Dynamic Imaging by K. Mishima.

Professor P. Chirco of the University of Bologna, Italy described a new program to assist co-operation between neutron imaging projects in individual countries. The funding is for three years but covers only coordination expenses such as travel. The official title is "Neutron Imaging Techniques for the Detection of Defects in Materials". Included with neutron radiology are complementary neutron techniques such as scattering or diffraction. At present, neutron groups from ten countries in east and west Europe have joined. Funding could be open to other European countries, and non-European teams are invited to participate but at their own expense.

The Sixth World Conference on Neutron Radiography included simultaneous Japanese-English translation services and was organized in every way in luxurious and highly appreciated style. The host chairman Professor K. Kanda and S. Fujine, Kyoto University, and colleagues are to be congratulated and thanked. Proceedings are to be published by Gordon and Breach Science Publishers.

The next World Conference on Neutron Radiography is planned for Rome, Italy in 2002. Dr. P. Chirco, who was elected president of the International Society for Neutron Radiology, will form the organizing committee.

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WCNR-6 Opening Address

THE SIXTH WORLD CONFERENCE ON NEUTRON RADIOGRAPHY (WCNR-6) Reported by S. Fujine

The Sixth World Conference on Neutron Radiography was held at the Hotel Nikko Kansai Airport, Osaka, Japan, May 17-21, 1999. About 100 participants from 18 countries came together at the conference and 84 papers were presented in oral and poster session.

The scientific program covered all topics of neutron radiography research from basic to application and provided not only oral and poster presentations including seven invited papers and four topics titled as "Neutron Radiography: Status of Art and Future" but also a panel discussion as "Future of Neutron Radiography Research".

Numbers of participants and papers were 95 and 84, which were 67 and 39 from Japan, 7 and 12 from USA, 4 and 5 from Germany, 2 and 1 Canada, 2 and 5 Hungary, 1 and 1 Australia, 1 and 0 England, 1 and 1 France, 1 and 6 India, 1 and 1 Italy, 1 and 1 Korea, 1 and 2 Russia, 1 and 5 Slovenia, 1 and 1 South Africa, 1 and 0 Sweden, 1 and 3 Switzerland, 1 and 1 Taiwan, and 1 and 0 Thailand, respectively.

Although from final registration, 107 participants from 25 countries were supposed to come to present 98 papers, no one except one from India came from India, Bangladesh, Pakistan, The Netherlands, Austria, Brazil, Iran and Israel and many papers were canceled. The canceled presentations in oral session were replaced by the papers in poster session.

On May 20, afternoon after taking the group picture, an excursion to the Research Reactor Institute, Kyoto University was executed, 29 people visited the reactor.

At the end of the WCNR-6 on May 21, the new board members for the International Society for Neutron Radiology (ISNR) were elected. They were P. Chirco (Italy) as President, J.T. Lindsay (USA) as Vice President, S. Fujine (Japan) as Secretary, M. Balasko (Hungary), G. Bayon (France), L.G.I. Bennett (Canada), J.S. Brenizer (USA), E.H. Lehmann (Switzerland), V. Mikerov (Russia), K. Mishima (Japan), K. Mochiki (Japan), B. Schillinger (Germany), N. Takenaka (Japan) and R.R. Tsukimura (USA) as the Board Members and President P. Chirco appointed Roberto Rosa as Deputy President.

The next Conference (WCNR-7) will be held in Rome, Italy in 2002.

During the post conference tour, 18 people enjoyed Inland Sea 4-day Tour.



Impressions from the 6th WCNR

Imre Pazsit

Department of Reactor Physics
Chalmers University of Technology
SE-412 96 Goteborg, Sweden



The 6th World Conference on Neutron Radiography was held between 17-21 May at the Hotel Nikko of the new Kansai Airport, Osaka. This venue provided a very comfortable and convenient place for a conference at a time of the year when the climate is still quite comfortable for foreign participants.

The conference was indeed truly international, with participants from all continents. The organisers managed to collect most leading experts from the field, providing thereby a very good technical standard for the conference.

Not surprisingly, the Japanese participants were by far the largest group, not only because of being the hosts, but also because Japan is one of leading countries regarding research in radiography. As a consequence, several talks were given in Japanese with simultaneous interpreting provided. For the sake of the Japanese participants, all English talks and all discussion was also translated on-line. Not seldom such a circumstance leads to difficulties in understanding and cause delay, but here none of them were present. The translation was professional and the technical facilities good and easy to handle. The hosts have organised a large and efficient technical staff to help with all arrangements.

All talks went nearly on time, sometimes to the expense of shortening the discussion, but that was the best trade-off one could attain. The thematic grouping of the talks was excellent, and so was the idea of arranging a number of "Lectures" - invited topical talks on certain basic aspects of radiography, given by acknowledged expert in each field. The organisers also were alert on inviting participants of from the user community, since, as it was also emphasised at the conference, the future of radiography is largely dependent on extending applications from laboratory tests to industrial production and research, geophysics, process control etc.

All participants were given at the beginning of the conference a copy of a combined final program and book of abstracts, which was very useful. Publishing of this booklet on time, despite the usual slips from authors all over the world, is the feat of Dr. Fujine, the Conference Secretary. Another useful document was the list of participants with photos, which was very useful, not the least for first-time participants like myself.

As usual, on-line rearrangement of the program was also necessary due to some cancelled talks. This was also made very effectively and with clear information to all participants on both a bulletin board and in the spacious lecture room.

Last but not least, the organisers succeeded to give a very relaxed and informal touch to the meeting through a number of social events. Apart from the conference banquet (traditional Japanese food with clear orientation signs, dance performance, tea ceremony with cute Japanese girls in kimono) there was a welcoming banquet, a mid-week party mostly for the foreign participants, and a closing party for the chairmen, panelists and invited speakers. This aspect of the conference was a demonstration of the Japanese hospitality at its best and the hosts of the next World Conference in Italy will not have an easy task to match this standard.

INTERNATIONAL SOCIETY FOR NEUTRON RADIOLOGY

Minutes of the session of the Board Members

May 17th, 1999 (by J.J. Rant)

The ISNR Board Members elected for the period June 1996-may 1999 reconvened on the regular session at the beginning of the WCNR-6 on May 17th, 1999.



Present were:

Prof. Dr. K.Kanda (President), Dr. S.Fujine (Deputy President), Dr. J.Lindsay (VicePresident), Dr. J.Rant (Secretary) and members Dr. M.Balasko, Mr. G.Bayon, Prof. Dr. J.Brenizer, Dr. P.Chirco, Prof. Dr. H.Kobayashi, Dr. E.Lehmann, Dr. V.Mikero, Prof. Dr. Y.Murata and Missing members: dr. C-O.Fischer, Prof. Dr. R.Lanza and Dr. H.U.Mast. As invited observers attended the meeting Dr. J.Barton and Dr. P.Kalyanasundaram India as deputy of Dr. Viswanathan.

Agenda of the Board meeting:

1. Venue and time of the next 7.WCNR
2. Proposals for the next presidency and members of the ISNR Board For the period 1999(June)- 2002
3. Publication activity
4. Diverse

Minutes:

Ad. 1: The candidacy to host the next WCNR-7 in 2002 announced :India (P.Kalyanasundaram, place Bombay or Kalpakkan near Madras) instead of previously withdrawn regular turn of USA to host WCNR-7,

USA(J.Lindsay, U.of Michigan, Ann Arbor), who again put forward the candidacy,

Italy in the name of the EC COST Action 524 (Neutron Imaging Methods to Detect Defects in Materials) and ENRWG (P.Chirco and J.Rant, place Rome).

The members from ENRWG asked dr.Lindsay to exchange his otherwise regular term in 2002 for the term of WCNR-8 in 2005. In 2002 there will be official end of the COST 524 action and EC requires the presentation of the COST results on a major conference in Europe. After consultation and hearing of all arguments of ENRWG board members dr.Lindsay agreed to exchange the candidacy and wait until 2005.

The candidacy of India encountered serious objections (lack of activity at WCNR conferences and ISNR, etc) and the voting unanimously decided Rome will be next venue of WCNR-7.

Ad.2: According to the rule that the next ISNR president is from the country hosting also the next WCNR Dr. P.Chirco was proposed as candidate for the next president. For the candidacy of the Vice **President and Secretary** the following members were proposed:

Dr. J.Lindsay for Vice President and Dr. S.Fujine as Secretary.

Proposal for the Board Members:

USA: Prof. J.Brenizer and Dr. R.Tsukimura

Japan: Dr. N.Takenaka, Dr. M.Tamaki, Dr. K.Mochiki, Dr. M.Kamata, Prof.K.Mishima

Canada: Dr. L.Bennett

Europe: Dr. M.Balasko, Dr. G.Bayon, Dr.E.Lehmann, Dr. V.Mikero, Dr. J.Rant and Dr. B.Schillinger

India: Dr. K.Viswanathan

Ad.3: In the proceedings of present WCNR (blue book) all papers will be published. However, in addition Gordon and Breach publishers will be asked to publish as many reviewed papers as are found acceptable in Journal of Nondestructive Testing and Evaluation.

PROCEEDINGS OF THE THIRD INTERNATIONAL TOPICAL MEETING ON NEUTRON RADIOGRAPHY

Lucerne, Switzerland March 16-19, 1998

Proceedings of the Third International Topical Meeting on Neutron Radiography have been published as *Nuclear Instruments and Methods in Physics Research - A, Vol. 424, No. 1* (1999) (ISSN 0168-9002) by Elsevier Science B. V., edited by E. Lehmann, H. Pleinert and S. Körner.

SATELLITE MEETING OF THE "INTERNATIONAL CONFERENCE IN CENTRAL EUROPE '99", September 7, 1999

Embedded Conference "Neutron Imaging to Detect Defects in Materials", Session B

Dr. Márton Balaskó, Boad Member of ISNR and Vice-chairman of COST 524 Project



Preliminary Programme

September 7, Tuesday

- Characterisation of NR Facilities and Mobile Sources

Chairman: **P. Chirco**, Co-Chairman: **H. Yanagie**

1. **H. Kobayashi** (Japan); Invited Paper; "Signal and Information on Neutron Radiography, A Proposal of Characterisation Method on Neutron Beams for Radiography"

2. **P. Bach** (France); "Performances of Some Mobile Neutron Radiography Systems"

- Facilities

Chairman: **S. Cluzeau**, Co-Chairman: G. Swallowe

3. **J. Brenizer** (USA); "Characterization of the Penn State NR Facility"

4. **R. Rosa et al.** (Italy); "A Renewd NR Facilities at the ENEA-Casaccia TRIGA Reactor"

5. **V. Mikero et al.** (Russia); "Investigation of Perspectives of FNR on Basis Non-traditional Neutron Sources"

- Applications

Chairman: **H. Kobayashi**, Co-Chairman: **J. Stade**

6. **G. Bayon et al.** (France); "Application of Dynamic Neutron Imaging in Earth Sciences"

7. **M. Balasko et al.** (Hungary); "Investigation of Microporosity in Die-Cast AlSi₁₂(Cu) Alloys by NR and XR as Complementary Radiographic Methods"

8. **E. Lehmann et al.** (Switzerland); "Application Fields for Neutron Radiography and Tomography in Industry and Technological Development"

- New Methods, New Equipment and Calibration

Chairman: **V. Mikerov**, Co-Chairman: **R. Rosa**

9. S. Koerner et al. (Austria); "A New CCD Camera NR Detector at the Atominstitut of the Austrian Universities"

10. T. Nemeč (Slovenia); "Calibration of Quantitative NR Method for Moisture Measurement"

11. G. Swallowe (United Kingdom); "Neutron Diffraction Studies for the Measurement for Strains and Stresses"

12. J. Rant et al. (Slovenia); "Transfer Technique for FNR Using Photoluminescent Imaging Plates"

- Medical Applications

Chairman: **R. Ilic**, Co-Chairman: **E. Lehmann**

13. H. Yanagie et al. (Japan); "Application of B-10 Entrapped Peg-Liposome to BNCT for Pancreatic Cancer Model in Vivo"

14. J. Rant et al. (Slovenia); "Detection of B¹⁰ Distributions in Histological Samples by NCAR Using Photoluminescent and Cold Neutrons: New Results"

- Closing Remarks: J. Rant

Poster Session

Chairman: **M. Balasko**

15. G. Po'r (Hungary); "Radiography Based on Scattered Neutrons Camera Obscura"

16. M. Balasko (Hungary); "X-ray Radiography Inspection of the Core Model of the CODEX AIT-2 Facility"

17. F. Peterka (Czech Republic); "NR for Applications in Civil Engineering"

18. V. Mikerov (Russia); "Artefacts of FNR Concerned with Neutron Scattering"

J. Rant, Organizing Committee Session B, Chairman

M. Balasko, Organizing Committee Session B, Secretary

SUMMARY REPORT OF THE EUROPEAN CONFERENCE ON NON-DESTRUCTIVE TESTING

Dr. Márton Balaskó, KFKI Atomic Energy Research Institute, Chairman of ENRWG.

During May 26th-29th, 1998, Copenhagen was the centre of specialist of Non-destructive Testing. The 7th ECNDT meeting attracted 875 experts from 55 countries of the world. The largest delegations arrived from Germany(146), Sweden(100), France(95) and the hosting country Denmark(79). The scientific program was organized in 25 sessions. During the three days 301 papers were orally presented. This giant program was completed by a poster session containing 241 posters. Eight papers were contributed by Neutron Radiography. They are:

- **W.J. Lewis, L.G.I. Bennett**; "Results Achieved Inspecting Composite Flight Control Surfaces Using Neutron Radiography"

- **M. Balaskó, G. Endröcz, G. Makai, I. Járkás**; "Study of Complex Composite-Metal Structure with Dynamic Neutron Radiography and Vibration Diagnostics"

- **T. Nemeč, J. Rant, V. Apih, M. Kaling**; "Monitoring of Moisture Transport in Building Materials by Neutron Radiography"

- **M. Balaskó, E. Sváb, G. Endröcz, A. Péter, I. Szikra**; "Radiography Investigations Combined with Vibration Diagnostics and Acoustic Emission in the Development of Refrigerators"

- **G. Rihar, J. Rant**; "The First Application of Imaging Plates to an Examination of Welded Joints"

- **M. Balaskó, E. Sváb, I. Cserhádi**; "Combined Dynamic Neutron Radiography and Thermovision in Development of Absorption-Type Aggregators"

- **S. Gangotra, P.M. Ouseph, K.C. Sahoo, D.S.C. Puroshotham**; "Detection of Hybrid Blisters in Irradiated Zircaloy Pressure Tubes by Neutron Radiography"

- **J. Rant, J. Stade, M. Balaskó, M. Kaling**; "New Possibilities in Neutron Radiography with Imaging Plates"

COST ACTION 524 STARTED

Dr. Piero Chirco, The Chairman of this action, wrote editor:

A new European-wide cooperative action was started on July 1998 aimed to study the use of advanced neutron imaging technique for the development of improved materials. This cooperative action is started under the COST framework, a programme funded by the European Union open to about 30 countries in Europe. The action will end on September 2002. The Chairman of this action Dr. Piero Chirco, from Italy; the Vice-Chairman is Dr. Márton Balaskó, from Hungary. Actual member states are Italy, Hungary, France, Spain, Germany, United Kingdom and Austria. Other European countries are joining. Each European country involved in COST may join the Action through its National COST Office. This cooperation is opened to non-European countries as well. More information is available on the Internet at the URL. (<http://bofi87.df.unibo.it>)



Dr. M. Balaskó also reported to editor:

The No.524 COST project was signed by Austria, Germany, France, Hungary, Italy, Spain, Sweden, and United Kingdom at the end of March 1998. Its title is "Neutron Imaging Techniques for the Detection of Defects in Materials". Dr. Serge Cluzeau was the first who propounded the importance of the common work in the frame of the COST on the 3rd ENRWG Meeting (Budapest) in 1995. Professor Franco Casali and Dr. Piero Chirco are praised for the establishment of this project. Their founder work was contributed by the leadership of the ENRWG.

The first Management Committee Meeting of the project was organized on July 10, 1998 in Brussels. The main points of the agenda were the following:

- Agreement on the internal rules of procedure for the COST 524.

- Election of chairperson and vice-chairperson.

- Working plan for the implementation of the COST 524.

In the first year Dr. Piero Chirco was elected for chairperson and Dr. Márton Balaskó for vice-chairperson.

Dr. M. Balaskó's letter dated December 10, 1998:

The 6th ENRWG Meeting and Management Committee Meeting of the COST 524 project were organized in Prague between November 30 and December 2, 1998.

I would like to give a survey about the ENRWG Meeting Briefly. Even participants arrived from Austria, Czech Republic, Hungary, Italy, Russia, Switzerland, France and Slovenia. In the frame of the round table presentation the information were known by:

- **Serge Cluzeau**: He is in pension. He has begun to organize an NR project in the Aeronautic Maintenance Institute of Bordeaux (IMA). This organization will be contributed by SODERN.

Zone d'Activités Aéroportuaries

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- **Guy Bayon**: 8000 parts of ARIANA rockets were examined. They have a viscosity study project. They prefer to establish the neutron tomography facility. He was appointed as the Head of Laboratory. CONGRATULATIONS !

- **Joze Rant**: He is in pension. He is a consultant of Microfit company and he deeded the large field of NR - from IP work at the TRIGA reactor in Ljubljana to FNR and Rezonacy NR at Budapest reactor.

- **Roberto Rosa**: They began the preliminary experimental work on the TRIGA reactor in Casaccia. The power is only 100kW, neutron flux: 10^5 n/(cm s), L/D=70.

- **Eberhard Lehmann**: The NEUTRA station is very busy at the SINQ. They have film, IP and CCD detector systems. An attractive demonstration was given about the different parameters of detectors. New application is a fry facility for analysis of fuel elements by indium and dysprosium foils.

- **Vitali Mikerov**: He is in pension. They developed FNR and Laminography methods on the basis of portable neutron source. By the way he is working in Munich as cooperation worker of his German colleagues. He is a participant in the "Bulk hydrogen analysis, using neutrons" project, which is organized by IAEA.

- **Márton Balaskó**: He continued his activity comparison of NR with other NDT methods (thermovision, vibration diagnostics and acoustic emission). He designed a new neutron beam diameter changer and filter unit. The HYSEN technique is planned to apply. They increased their activity in biological application. He is taking part in "Bulk hydrogen analysis, using neutrons" project of IAEA.

- **Frantisek Peterka**: He is very busy as a businessman. He is a member of Advanced Technology Group too. It has been dealing with different kind of NDT. The leadership of ATG plan to buy a portable neutron source.

- **Piero Chirco**: He gives lectures in Velence and he travels many times from Bologna. He is the Chairman of the COST 524 and he makes very much administrative works. He hardly has time for the experimental activity.

- **Pierre Bach**: He declared the SODERN company continues its function in the field of neutrons. They intend to cooperate with the Bordeaux NR Group.

- **Michael Zawisky**: The NR station works well at the TRIGA reactor of the Technical University of Vienna. They have some civil engineering application.

Márton Balaskó summarized the activity of ENRWG from Bologna to Prague regarding the NR publication on ITMNR-3, 7th ECNDT. The actuality of COST 524 project was mentioned by

him. He highlighted the "Bulk hydrogen analysis, using neutrons" project of IAEA. Its subtopics are the following:

1. Neutron transmission, scattering and activation techniques, coordinated by Dr. M. Bartle (New Zealand).
2. Digital neutron imaging, coordinated by Dr. R. Lanza (USA).
3. Hydrogen detection by epithermal neutrons, coordinated by Dr. P. Shaikh (India).
4. Microscopic behaviour of hydrogen in bulk materials, coordinated by Prof. J. Csikai (Hungary).

The list of the participant countries is: Australia, Canada, Cuba, Hungary, India, New Zealand, Nigeria, Poland, Russia, Japan, South Africa, Thailand. The web side for more information: BULKH-N@UNB.CA

The ENRWG prefers to participate on 6th WCNR in Osaka. Hungary will present five papers, Slovenia by three, Switzerland by three, France by two, Italy by two, Czech Republic by one. Márton Balaskó resigned from the presidency of ENRWG regarding his vice chairman role in the COST 524 project, and many other tasks. After the election of the new leadership:

Joze Rant (Slovenia) was voted to chairman of ENRWG, Eberhard Lehman (Switzerland) Co-chairman, Piero Chirco (Italy) Secretary.

The 7th ENRWG Meeting will be organized in Portose (Slovenia) at the end of September, 1999.

The representative of Austria, Czech Republic, France, Germany, Hungary, UK, Italy, Spain, Slovenia and Switzerland took part on the 2nd session of COST 524 project. They briefly made a survey about the works of the past half year. Dr. Piero Chirco review his evaluation work about the neutron sources of the project. The membership established the following working Groups:

1. Standardization - coordinated by Dr. E. Lehmann.
2. Civil engineering - by Dr. F. Peterka.
3. Aerospace - by G. Bayon.
4. Comparison of NR with other NDT - by Dr. M. Balaskó.
5. Non radiography techniques - by Dr. Gerard Swallowe (UK).
6. Tomography and computation analysis - by Dr. E. Lehmann.

An editorial board was organized to publish some information about the establishment and target of COST 524 project in INSIGHT journal and in COST's bulletin. Its members are: Dr. P. Chirco, Dr. M. Balaskó and Dr. Federico J. Mompean (Spain).

ABOUT PUBLICATIONS OF THE ENRWG AND COST ACTIONS

in a letter from **J. Rant**;

As agreed in Prague I established a contact with the INSIGHT journal and the editor is willing to provide us space in the forthcoming issues in 1999. The March 1999 issue of INSIGHT will be devoted to Aerospace NDT, however it seems that this issue might be unsuitable as the deadline to submit manuscripts is January 15th, too early perhaps. It seems that issue in June or in July might be more convenient. The July issue will be devoted to NDT in civil engineering. More about publishing in INSIGHT and my call for papers I will issue in circular in the first week of January. We have to prepare also a separate COST introductory publication on the status and perspective of the COST action. I derived some ideas and will discuss them with the leaders of our Wgs immediately after the New Year.

The Nuclear Society of Slovenia (NSS) agreed to host our annual ENRWG meeting and associated COST 524 MC meeting in Portorose, from 6-9 September, 1999. The first circular and the call for the conference will be issued within a week.

Associated with the NSS/ENS conference "Nuclear Energy in Central Europe" there will be a satellite conference for presentations of authors, not limited only to COST members. In a separate session the reports on the COST action could be presented. The proceedings are registered as ENS publications and are included in the INSPEC register. I hope that we shall meet in Portorose and that it will be a fruitful event.

Jack S. Brenizer has moved from University of Virginia to Pennsylvania State University as Professor since January, 1999. His New Address is:
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Pennsylvania State University
Breazeale Nuclear Reactor Building, University Park
PA 16802, USA
Tel: 1-814-865-6351, Fax: 1-814-863-4840
e-mail: brenizer@enr.psu.edu

J.F.W. Markgraf was retired in March, 1999, from his duty at the JRC, PETTEN, The Netherlands.

Burkhard Schillinger, Technischen Universität München, won the doctorate (Doktors der Naturwissenschaften) early in 1999. **CONGRATULATIONS on winning the doctor's degree!** The title of his thesis was "Neue Entwicklungen zu Radiographie und Tomographie mit thermischen Neutronen und zu deren routinemäßigem Einsatz" in German.

RESEARCH COMMITTEE ON NR IN JAPAN

The 58th meeting, organized by Radiation Application Development Association, was held at the JAERI meeting room in Tokyo on 31 August, 1998. At this meeting Dr. T. Hibiki of KURRI gave a lecture entitled "Visualization and Measurement Thermal-Hydraulic Phenomena Using Thermal Neutrons as Microscopic Probes". At the 59th meeting, 30 November, 1998, Prof. Y. Murata of Musashi Institute of Technology gave a lecture about Advanced Radioscopy System Displaying Neutron-Gamma Radioscopic Images Using a Two Color Luminescent Scintillator. The 60th meeting was held on March 4, 1999.

THE SECOND SPECIALISTS' MEETING ON NEUTRON RADIOGRAPHY TECHNIQUES FOR APPLICATIONS AND UTILIZATION

2nd Specialists' Meeting on **Neutron Radiography Techniques for Applications and Utilization** was held at KURRI (Research Reactor Institute, Kyoto University) on 18-19 in November, 1998. The Proceedings of this Meeting was published as KURRI-KR-27 (ISSN 1342-0852), edited by S. Fujine and H.

Kobayashi, including following 17 papers in Japanese except one paper: No. 16:

1. **K. Nittoh** et al.: Discriminated Neutron and X-ray Radiography Using Multi-color Scintillation Detector.
2. **K. Mochiki** et al.: Advanced Radioscopy System Displaying Neutron-Gamma Radioscopic Images.
3. **M. Matsubayashi** et al.: Emission Spectrum Measurement of Fluorescent Converters for Neutron Radiography.
4. **Y. Ikeda** et al.: Flat Panel-Typed Amorphous-Silicon Imaging Device.
5. **S. Fujine** et al.: Characterization of Imaging Plate Neutron Radiography System and its Applications.
6. **H. Kobayashi**: Basic Parameters and Problems on Neutron Sensitive Imaging Plate.
7. **M. Tamaki**: Neutron Radiography Techniques Extended by Using Imaging Plates.
8. **Y. Masunaga** et al.: Characteristic of Imaging Plate on Quantitative Neutron Radiography.
9. **O. Nishiguchi** et al.: Application of Imaging Plate in Thermal and Cold Neutron Radiography.
10. **Y. Murata** et al.: A Research on a High Speed Reconstructing Engine for Three Dimensional Computed Tomography.
11. **R. Taniguchi** et al.: Spectroscopical Neutron Imaging System.
12. **F. Masuzawa** et al.: Neutron Radiography Application to Ancient Arts (V) - A Quantitative Trial to Correlate Intensity Values and Thickness of Silk and Japanese Paper on Metallic Plates (1).
13. **M. Hayashi** et al.: Visualization and Analysis of Lithium Ion Motion in Solid Oxides by Neutron Radiography.
14. **N. Takenaka**: Toward Quantitative Measurement of Void Fraction by Thermal Neutron Radiography.
15. **M. Mizubata** et al.: Application of Fast Neutron Radiography to Thermal Hydraulics Phenomena.
16. **K. Mishima** et al.: Study on Flow Characteristics in Gas-Molten Metal Mixture Pool.
17. **T. Onodera** et al.: Large Particles and a Bubble Movement in Fluidized-bed.

Any news about neutron radiography in your countries is cordially welcomed. Please send them to editor.

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WCNR-6 Home Page: <http://www.rii.kyoto-u.ac.jp/WCNR6/>

International Society for Neutron Radiology

CONSTITUTION

Name:

International Society for Neutron Radiology

Purposes:

World Conference on Neutron Radiography
NR Newsletter
NR Directory
Electronic Communication - Client/Server
Other, as may be proposed and voted.

Membership:

All interested attendees to WCNR. All others whose application form is submitted by mail and approved by the "Board".

Fees:

No fees for membership. Costs such as conference organization, and mailing will be covered by volunteers.

General Election:

A general election to elect the Board and also to elect the Officers shall be held amongst those members present on the closing day of each WCNR.

The Officers:

- Shall consist of President, Vice President and Secretary.
- Shall serve until the close of next WCNR.
- Shall be Board Members.

President:

The president shall be responsible for and ensure satisfactory organization of the next WCNR (WCNR N+1). The President shall chair the Board and shall preside over WCNR N+1. Immediately after election the President shall appoint a deputy with whom to work together in preparing the next WCNR.

Vice President:

- Shall be from a different geographical region and shall assist in identifying candidates for election to President at WCNR N+1 in order to host WCNR N+2. Note, however, that because of the long 6 or 8 year interval likely before WCNR N+2 the elected Vice President is not automatically President Elect for WCNR N+2.

The Board (composition)

- Shall consist of up to 12 persons, plus the 3 officers. From the 12 one shall be the President of the present WCNR (or appointed by that person), and one shall be appointed by the President elected to host the next WCNR. For the remaining 10 who are elected, no more than 3 may be from the country with most papers at the present WCNR, no more than 2 may be from the next country in terms of papers, and no more than 1



elected person shall be from each other country.

The Board (function)

- Shall replace the provisional steering committee.
- Shall serve until close of next WCNR and meet the day before that WCNR.
- Shall organize and supervise the next general election.
- Shall motion and vote on changes to constitution (2/3 majority).
- Shall motion and vote on other specific proposals (simple majority).

Operation of Constitution:

This constitution has become operational since June, 1996.

Officers (1999.5-2002):

President: Piero Chirco (Italy)
Deputy President: Roberto Rosa (Italy)
Vice President: John T. Lindsay (USA)
Secretary: Shigenori Fujine (Japan)
Board: Márton Balaskó (Hungary)
Guy Bayon (France)
Les G.I. Bennett (Canada)
Jack S. Brenizer (USA)
Eberhard H. Lehmann (Switzerland)
Vitali Mikerov (Russia)
Kaichiro Mishima (Japan)
Koh-ichi Mochiki (Japan)
Burkhard Schillinger (Germany)
Nobuyuki Takenaka (Japan)
Ray R. Tsukimura (USA)
Adviser: John P. Barton (USA)
Keiji Kanda (Japan)

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