LCC™

LWR Chemistry and Component Integrity Programme

The LCC12 deliverables.
For information on earlier published LCC Special Topic Reports please see *page 16*.

The annual LCC Programme is focused on reactor coolant, secondary chemistry and RCS material issues and open to nuclear utilities, manufacturers and vendors, research and engineering organisations as well as regulatory agencies. In the LCC11 Programme, currently 18 organisations in North America and Europe, representing 33 nuclear plants, are members. The Programme was started in 2004.

Deliverables

ANT International will provide the LCC Members with the following:

- Searchable CD-ROM(-s) with the following contents:
  - High-resolution pdf files with the complete LCC Special Topic Report and the Annual Reports in colour
    - > The files can be copied to a company server, with full read access for everybody with access to the server.
    - > The contents from the LCC Special Topic Report and the Annual Reports in pdf-format can be printed.
      Also, the contents from the pdf-files can be copied and pasted electronically into other documents, e.g. Word files.

  The CD-ROM(-s) of the LCC STR and of the ARs will be provided before the Seminar in March (see below).
- Optional reports printed in four-colour. The printed LCC Special Topic Report and the Annual Reports will be provided as soon as they are printed with the aim of delivery before the Seminar in March.
- A Seminar will be held in Europe to present the results of the LCC Programme.
  The number of full time employees per Member that may attend meetings is limited to eight (8) people per organisation. The language of the LCC Programme will be English.
- The authors will be available for consulting throughout the year. A few telephone or e-mail consultations requiring no additional work are provided at no additional cost to Members.

Listen to Juan de D. Sanchez Zapata, Iberdrola.

Listen to Niels van Dijke, EPZ

Listen to Ana Isabel Muñoz and Carlos Arias, CNAT

LCC Programme Content and Description

Nuclear utilities have to reduce costs for operation, maintenance and fuel, keep the highest level of safety and lowest possible level of radiation exposure to employees and the general public and minimize environmental impact of liquid and solid effluents and wastes. Emphasis is put on safety, longer fuel cycles, higher burnup of fuel, increased fuel duty with more nucleate boiling in Pressurised Water Reactor (PWR's) and plant power uprates as well as more technical issues like Axial Offset Anomaly (AOA also called Crud Induced Power Shift/CIPS), Stress Corrosion Cracking (SCC) all point to the increased importance of high quality water chemistry and control.

It is our goal that the LCC Programme shall assist the LCC Members in meeting all these water chemistry and material related challenges in a most efficient way. This Programme reviews and evaluates the developments and trends in Light Water Reactor (LWR) primary coolant and secondary side chemistry and also structural materials technology (excluding fuel materials). This is accomplished by identification of relevant information and a discussion of its significance for the Programme. The Programme reviews all relevant information through publications and international conferences and, when necessary, comments and background information are added.

Additional benefits for the LCC Members can be seen in the fact that the Members gain an increased understanding of power plant water chemistry and material integrity to facilitate more efficient plant operation. Furthermore, the LCC Members can be assisted in the training and education of a new generation of chemistry and material experts in their organisations.

The overall objectives of the LCC Programme are to enable the LCC Member to:

- Gain increased understanding of reactor water chemistry related to a successful plant operation and continued integrity of Reactor Coolant System (RCS) materials while keeping radiation exposure low
- Guiding the plant operators to apply adequate PWR secondary side chemistry for safe, economical and environmentally friendly plant operation with high availability and without significant steam generator degradation or fouling problems or carbon steel Flow Accelerated Corrosion
- Assist in the training and education of a new generation of chemistry and materials experts
- Establish an independent meeting point for experts to enable free and critical discussions and experience exchange

These objectives are met through critical review and evaluation of the most recent data related to reactor water and secondary side chemistry, identification of the most important new information, and discussion of its significance in relation to water chemistry now and in the future.

The evaluations are based on the large amount of non-proprietary data presented at technical meetings and published in the literature.

LCC12 Programme

Reports will be prepared within the LCC12 Programme as follows:

- Annual Reports (ARs) on Key Emerging Issues and Recent Progress Related to Structural Material Degradation and Plant Chemistry/Corrosion
- Special Topic Report on "Environmentally-Assisted Degradation of Structural Materials in Water Cooled Nuclear Reactors – An Introduction.

At the LCC12 Seminar, the Annual Reports will be presented. Additional presentations will be given on the following topics:

Evolution of the PWR Water Chemistry Guidelines and Specifications
Worldwide in PWR plants the primary and secondary side water chemistry is controlled based on guideline specifications. There exist three to four guidelines given by EPRI, EDF, VGB and MHI that are mainly used worldwide by almost all PWR plants. The selection to apply these guidelines depends on the vendors of the plants, plant design and used structural materials and finally on utilities experience. All these guidelines have the objective of improving the plant thermal and corrosion performance. Accordingly, they give recommendations how to apply the water chemistry at different plant operation modes. Many of these recommendations of different guidelines are comparable and similar, whereas some of them are completely different.

In this presentation the reasons for these differences will be explained and basis of the specification values in the guidelines discussed. The information given in this presentation has the aim to help the understanding of the water chemistry application at different plant operation modes and hence, supports the plant chemists to establish and/or modify their own plant specific chemistry programs if desired.

The content of the presentation is also useful for the authorities supporting their approval decisions for the individual plant specific water chemistry programs.

BWR Water Chemistry Specifications and Guidelines Evolution
BWR water chemistry specifications have evolved over the years in order to mitigate SCC of reactor internal materials, radiation field reduction and eliminate fuel performance issues. The water chemistry guidelines have been tightened to control impurity inputs into the reactor, cobalt reduction, iron reduction to minimize cobalt transport and copper reduction to eliminate crud induced localized corrosion of fuel cladding materials.

The presentation will address the issues involved, the reasoning behind establishing the guidelines with supporting data and how BWR owners managed to maintain plant operations within established industry guidelines.

The presentation will highlight the BWR water chemistry guidelines evolution and the current guidelines in place in the US, in Europe and in Japan. The presentation will also address any differences and similarities in the guidelines between BWRs 2 through 6, ABWR and yet to be commissioned ESBWR.

Radiochemistry of Failed Fuel
The subject of failed fuel will be presented from a radiochemistry perspective. The types of leaks will be described and the use of radionuclides to characterize the type of leak, its possible location and the amount of leakage. Iodine and xenon spiking after a power transient will be described and some examples provided. This presentation will help plant chemists and engineers who involved in characterizing a fuel failure to evaluate its potential origin or managing its consequences.

Steam Generator Primary to Secondary Leaks

Primary to secondary leaks will be discussed. The background and justification for the limits and guidelines will be provided. Actions will include how to detect leakage and calculation methods to determine the leak rates. Types of leaks will also be described and some examples given. This will assist plant chemists and engineers who are involved in managing a primary to secondary leak in the steam generator to evaluate its importance and consequences.

The Materials Concept in German LWR – Contribution to Plant Safety, Efficiency and Failure Provision

Already during the design stage of a nuclear power plant a well-balanced materials concept is very important for later plant operation with regard to safety, availability, efficiency and failure provision. According to the German basis safety concept for components belonging to the highest safety class 1 an optimised design in conjunction with founded material selection, manufacturing and testing techniques has been developed. A prominent example deals with the RPV for PWR. Technical manufacturing capability of optimised ingot melting up to 570 tons had to be qualified followed by forging processes of semi products with homogeneous microstructure and warranty of mechanical properties over the cross section. Furthermore, resistance against neutron irradiation far beyond design limit as well as corrosion resistant welds of the compound tubes into the closure head for control rod drive bars had been realised. One special design feature refers to the inner cladding of the main coolant lines with seamless elbows and integrated nozzles made from bainitic steel.
Other examples are relating to the well-founded choice of Incoloy 800 for steam generator tubes and to substitute hard facing alloys formerly containing Co. For BWR a Nb-stabilised low carbon stainless steel had been used for the core shroud which was manufactured under optimised conditions. The same material had been used for refurbishing of piping systems in BWR which formerly were made of a non optimised Ti-stabilised stainless steel in conjunction with inadequate manufacturing procedures.

Invited presentation

(To be defined later)

Report on Key Emerging Issues and Recent Progress Related to Structural Material Degradation

During operation, the materials used for the construction of components react with light water reactor environment and cause component degradation, including cracking at welds and piping. Such degradation is due to irradiation, corrosion, fatigue, and other damage mechanisms, and has remained a severe operational challenge for utilities. Details on such degradation are regularly reported and published in scientific journals and at utility workshops and conferences. Foremost in the latter category are those organized since 1983 by NACE, TMS, ANS and CNS in the Environmental Degradation of Water Reactor Materials.

The Annual Report will contain highlights from the 17th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, which was held in Ottawa, Canada in August 2015. It will cover PWRs, VVERs, CANDUs and BWRs.

Over 150 papers were published at this conference and this Report cover diverse topics touching on specific degradation modes in various alloys, such as:

- PWSCC of cold worked Alloy 690 and its weld metals
- Corrosion fatigue of stainless steels in PWRs and BWRs
- Fuel cladding materials
- Cracking of Alloy 718 and X750
- Flow assisted corrosion
- Oxide films and characterization in PWR Secondary systems
- SCC of Alloy 82 and 182 welds
- IASCC of stainless steels
- Irradiation studies involving ion and neutron irradiation
- Synergistic effects of thermal ageing and neutron embrittlement
- Alloy 600 oxidation and mechanisms in PWRs
- PWR Field experience
- Advances in in-situ monitoring and ex-plant and mockup component evaluation
- Generation IV materials research
- Fundamental studies involving new state-of-the-art microscopy and other techniques
- Fukushima accident related research on SS corrosion in sea water
- Dry Cask Storage System and Waste Container Corrosion

Reports on Key Emerging Issues and Recent Progress Related to Plant Chemistry/Corrosion

The 20th Nuclear Plant Chemistry (NPC) International Conference, which started in Bournemouth (UK) and held every other year, will be held in Brighton (UK) in October 2016. It is the most important conference related to chemistry in Nuclear Power Plants, and covers many new results in this area. The key information presented at this Conference will be covered in two separate Reports: One on PWRs, VVERs, CANDUs, PHWRs and auxiliary systems issues. The other on BWRs and Fukushima response.

Report on PWRs, VVERs, CANDUs, PHWRs and auxiliary systems

This first Report on PWRs, VVERs, CANDUs, PHWRs and auxiliary systems issues will not only summarise but analyse the results to assess in which specific situation the results are applicable and give the point of view of experts of ANT International that will attend the Conference.

This is of significant interest, considering their long experience and expertise, to give the LCC customers how to consider different presentations that may sometimes give contradictory or conflicting results. A past example explained in which PWR units' hydrogen should be increased (proposed by some US papers), which should be decreased (Japanese papers) or kept as in the past (some other papers). The advantages, disadvantages, questions or limitations of new solutions will be explained. More specifically, the following oral and poster sessions from the Conference will be covered in this Report:

PWRs, VVERs, CANDUs and PHWRs: Operating Experience: Primary coolants, including efforts of dissolved hydrogen (DH), pH, lithium, boric acid, enriched boric acid, potassium, ammonia, zinc, activity build-up and radiation control

Pressurized Water Scientific Studies: Fundamental and laboratory studies, and computer modelling

LWR Secondary Water Chemistry (Steam Cycle): Steam generator degradation, flow-accelerated corrosion, effects of amines and dispersants, sludge management, and lay-up optimization

Auxiliary Systems, Water and Waste Treatment System: Water purity control and advanced processes and monitoring technology, resin and filter optimisation, scale mitigation in condensers and cooling towers, chemistry control in auxiliary systems, and waste water management

Life Time Management and Plant Aging: Chemistry and corrosion issues related to lifetime management and countermeasures

Chemistry for Nuclear New Build: Water chemistry plans for new nuclear power plants, commissioning strategies, passivation optimisation and experience, developments in LWR plant design and materials, and improvements and challenges for the operation of new plants such as expended cycles and load following

Water Chemistry in Alternative Reactor Designs: R&D for Generation IV and other alternative reactor designs, operating experience with existing high temperature reactors and prototype reactors, and water chemistry strategies in alternative reactor designs

Report on BWRs and Fukushima

BWRs have undergone a variety of important and improved water chemistry evolutions over the past few decades addressing issues relating to stress corrosion cracking of reactor materials, BWR fuel performance, radiation fields and personnel exposure. Among the key water chemistry advancements include hydrogen water chemistry, noble metal chemical addition, on-line noble metal chemical addition, non-hydrogen technologies for SCC mitigation, iron reduction, cobalt reduction, zinc addition and improved filtration technologies. In addition, many BWRs have performed power uprates as well.

BWR owners are striving for excellence with the use of these technologies towards improving capacity factor, seeking inspection relief, minimizing fuel leakers, minimizing personnel exposure, while facing demanding cost reductions but still maintaining safe operation of BWR plants.

The subject Report summarizing the BWR related papers from the NPC 2016 conference is designed to provide updated information with the author's critique and analysis for the benefit of the ANT International/LCC customers. The Report is expected to be a comprehensive document summarizing the latest information on BWR water chemistry that would benefit the BWR operators and regulators.

The following oral and poster sessions will be covered in this Report:

BWR Operating Experience: Hydrogen water chemistry, noble metal chemical addition, zinc addition, transient chemistry, issues of corrosion, radiolysis, and combustible gas management, activity build-up and radiation control.

Boiling Water Scientific Studies: Fundamental and laboratory studies, computer modelling.

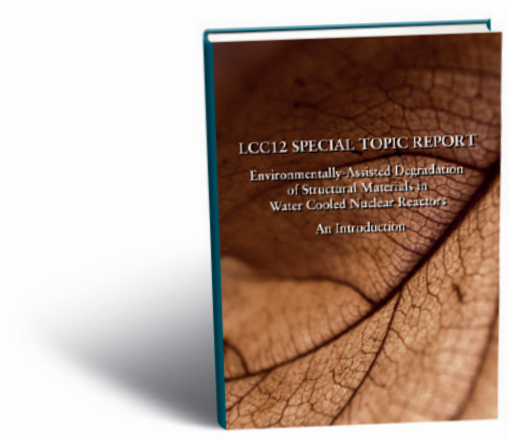
Auxiliary Systems, Water and Waste Treatment System as Applied to BWRs: Water purity control and advanced processes and monitoring technology, resin and filter optimisation, scale mitigation in condensers and cooling towers, chemistry control in auxiliary systems, waste water management.

Life Time Management and Plant Aging as Applied to BWRs: Chemistry and corrosion issues related to lifetime management and countermeasures.

Chemistry for Nuclear New Builds –BWR Related Topics: Water chemistry plans for new nuclear power plants, commissioning strategies, passivation optimisation and experience, developments in LWR plant design and materials, improvements and challenges for the operation of new plants such as expended cycles and load following.

Fukushima response: Implementation of resilience enhancements, chemistry management during and following severe accidents, assessment of chemistry impacted hazards, modelling and R&D studies.

Environmentally-Assisted Degradation of Structural Materials in Water Cooled Nuclear Reactors – An Introduction



The Report is intended for people new to the subject, or who need a "refresher" on the essential factors behind component failures and the subsequent mitigation actions. Such a focus is critical at this time, given the ongoing retirement of experienced personnel and the loss of "corporate memory" relating to the management of materials degradation. This loss is being felt in areas of reactor license renewal, power uprates, load following, and the certification and construction of advanced designs of both BWRs and PWRs.

Environmentally-Assisted Degradation of Structural Materials in Water Cooled Nuclear Reactors – An Introduction, is an updated and expanded version of the previous ANT International Report authored by Dr. Peter Ford and published in 2006.

1 General introduction
  1.1 Definition of the problem
  1.2 Organization of report
2 LWR designs and initial material choices
3 Basic principles of physical metallurgy
  3.1 Carbon and low-alloy steels
  3.2 Stainless steels
  3.3 Nickel-base alloys
  3.4 Embrittlement issues
4 Basics of aqueous corrosion of metals
  4.1 Introduction
  4.2 Different forms of corrosion
  4.3 Main factors affecting corrosion
  4.4 Basics of electrochemistry
  4.5 Aqueous
  4.6 Localised
  4.7 Microbially induced corrosion (MIC
  4.8 Stress corrosion cracking – general

"The long experience of the LCC Expert Team provides useful information for 'sunny and cloudy days' of a chemist's job!"

MICHAEL BOLZ
NPP Philippsburg

Report authors

The authors are: Dr. Francis Nordmann, formerly at Électricité de France, Dr. Samson Hettiarachchi, formerly at GE Hitachi, Mr. Dewey Rochester, formerly at Duke Energy, Mr. François Cattant, formerly at Électricité de France, Dr. Peter Ford, formerly at General Electric, Dr. Peter Scott, formerly at AREVA, Dr. Pierre Combrade, formerly at AREVA NP, and Mr. Claude Amzallag, formerly at Électricité de France.

Dr. Francis Nordmann has over 40 years of experience in power plant chemistry. He is retired from Électricité de France (the French Utility) in 2007, where he was an international expert in charge of chemistry and corrosion in the corporate offices. He was in charge of managing the engineering studies for the French fleet of 58 PWR units and of several international programmes. His Ph. D degree was obtained at the French Atomic Energy Commission, in connection with the University of Mulhouse in 1973. He also worked for 8 years within the French manufacturer Framatome (now Areva). He has been active for example in the following areas:

- Water Chemistry evolution and studies for the various systems (primary coolant, secondary steam-water system, condenser cooling systems, and intermediate circuits)
- Developing the Chemistry Specifications for the French NPP and some others
- Interface with Manufacturers and Regulatory Body
- Chemistry and corrosion Training
- Steam Generator blowdown and condensate polishers strategy
- Optimisation of secondary water chemistry for various objectives
- Steam Generator experience feedback and relation with chemistry
- International projects with various countries and organisations
- Organising Committee of several International Conferences on Chemistry for Nuclear Reactors

Dr. Samson Hettiarachchi has 33 years of experience as a college lecturer, researcher, innovator and a technologist. He has held a variety of technical positions at GE Nuclear Energy as Chief Engineer/Physical Sciences, Chief Technologist/Chemistry, Engineering Fellow and Principal Engineer prior to his retirement from GE in February 2011. Prior to joining GE, he held the position of Electrochemist/Senior Electrochemist at SRI International (formerly Stanford Research Institute) and the position of Lecturer/Senior Lecturer in Chemistry at the University of Colombo, Sri Lanka. Two of his innovations at GE Nuclear Energy, NobleChemTM and On-Line NobleChem are widely used in the US, Japan, Spain and Switzerland to extend the life of Boiling Water Nuclear Reactors. Dr. Hettiarachchi's research experiences include Physical Chemistry, Electrochemistry, Surface Chemistry, Catalysis, Corrosion and Mitigation of materials, Battery Technology, Sensor Technology, and In-situ Generation of Nano-particles. He has worked in the nuclear power industry related work for about 25 years. His specific experiences in the nuclear industry include, Development of ECP sensors, ECP monitoring, High Temperature pH Measurements, Zeta Potential Measurements, HWC Benchmark Tests, Water Chemistry Guidelines, Dose Reduction, Fuel Corrosion, SCC Mitigation, NobleChem Applications, On-Line NobleChem Applications, Inspection Relief Criteria Development, and Plant Chemistry/Materials Education and Training. For many years he has participated in EPRI BWRVIP Mitigation Committee Meetings and several IAEA Meetings. He has over 100 publications in International Journals and International Conference Pro-

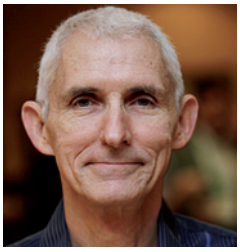
ceedings and holds 27 issued US patents. He has been a peer reviewer for the Corrosion Journal and the Journal of Nuclear Science and Engineering.

Mr. Dewey Rochester retired from Duke Energy Carolinas LLC in June 2010 after working for thirty six years in the field of nuclear power plant chemistry. He began his career in May 1974 at Duke's Oconee Nuclear Station as a Junior Chemist. He was promoted to site Chemistry Manager in February 1978. In September 1984 he transferred to the corporate office to lead the process qualification programme for the steam generator chemical cleaning at Oconee. From 1989 until 2003 he worked on a variety of projects dealing with primary and secondary water chemistry, and steam generator corrosion issues as well as performing assessments of plant chemistry performance. In February 2003 he was promoted to Duke Energy's Corporate Nuclear Chemistry Manager, where he led the group responsible for the development of the site chemistry programmes at Duke's three nuclear sites. During his career he has worked in all phases of nuclear power plant chemistry including makeup water production, primary and secondary chemistry, radwaste processing and steam generator chemical cleaning and corrosion. He has authored and co-authored several papers on steam generator chemical cleaning, radwaste processing, steam generator corrosion issues, and the use of dispersants to mitigate steam generator deposition. He also made numerous presentations at various conferences and seminars.

Some of his interests include:

- Chemical cleaning processes and corrosion monitoring
- Core design impact on corrosion product releases
- The use of dispersants for steam generator deposition mitigation
- Post accident sampling systems
- Steam generator corrosion issues
- Primary and secondary water chemistry guidelines
- Zinc addition to mitigate plant dose rates

He served twice as Chairman of the Babcock & Wilcox Steam Generators Owner's Group, Chairman of the EPRI Chemistry Subcommittee and a member EPRI Steam Generator Owner's Group Technical Support Subcommittee and Integration Committee.



Mr. François Cattant graduated in chemical engineering in 1974 and joined Electricity of France (EDF) in 1975 as chemist engineer at the chemical department of the corporate laboratories (Plants Operation Division). At that time, he was involved in power plants water and steam conditioning.

Up to 1995 he worked in the following technical fields as an expert:

- Failure root cause analysis of gas-cooled reactors components, including fuel
- Water & steam chemistry, chemical cleaning and NDE for fossil fired stations
- Failure root cause analysis of nuclear power plants irradiated or contaminated parts & components and reactor pressure vessel (RPV) irradiation programs monitoring
- Examination of Dampierre 1 retired steam generator, to the examination of RPV head penetrations, to the study of thermal embrittlement, to the analysis of wear

Between 1995 and 1998 he was loan-in to the Nuclear Maintenance Application Center at EPRI Charlotte (NC, USA). He was involved in various maintenance guides such as those of pumps or diesel generators. He also acted as EPRI expert for the examination of Ringhals 3 retired steam generator.

In 1998 he moved back to France, at the R&D Materials and Mechanics of Components department where he stayed until his retirement in 2009. He served there as scientific advisor and senior engineer. His area of expertise was again chemistry, corrosion, and metallurgy, with special attention to primary water chemistry, source term reduction, primary water corrosion (Alloys 600/182/82, SSs), PWSCC mitigation and repair, fuel cleaning, innovation strategy. He also served as the EDF representative to the EPRI Materials Reliability program. During this period:

- he was under contract with EPRI, being EPRI technical expert regarding several destructive examinations such as North Anna 2 RPV head penetrations, South Texas Project 1 Bottom Mounted Instrumentation, Braidwood 1 pressurizer heater #52, San Onofre 3 CEDM #64...
- he was the President of the "Materials, Non Destructive Testing and Chemistry" section of the "French Nuclear Energy Society" (from 2004 to 2008);
- he was also the Materials Ageing Institute (MAI) International Partnership Manager.

During his carrier, he made many presentations and papers in international conferences and scientifics journals.

In 2010, he was sponsored by the MAI to write a "Handbook of Destructive Assays", a 1100 pages document putting together extended summaries of hundreds of destructive examinations performed on LWRs' NSSSs, in France, US, Japan and Sweden.

Dr. Peter Ford received his doctoral degree from Cambridge University. He has been associated with the nuclear power industry for over 35 years with a focus on, first, understanding the factors controlling materials degradation and then, developing mitigation methods. He worked initially with the Central Electricity Generating Board (UK) and then for 23 years with the General Electric Corporate Research and Development Center (GE-CRD) where he was manager of the Corrosion Mitigation and Coatings Laboratory. This laboratory interacted closely with General Electric Nuclear Energy, with seminal contributions to a wide range of materials-related problems including: Choice of structural materials for current and future reactors; Fuel cladding degradation; Radioactivity build-up; Life prediction codes for environmentally-assisted cracking of materials both in and out of core; Water chemistry mitigation methods including Noble Metal Technology and finally, underwater repair and cladding techniques.

Since retirement from GE, he served for 4 years as a member of the Advisory Committee for Reactor Safeguards at the US Nuclear Regulatory Commission.

Dr. Ford is active in various societies and international cooperative groups in the field of nuclear materials degradation, including consultancies with reactor vendors, utilities, universities and national labs, etc. He has authored or co-authored 90 papers and patents and is a Fellow and recipient the Willis Rodney Whitney Award from NACE-International for "outstanding contributions to the science of corrosion".

Dr. Peter Scott received his B.Sc. in chemistry from the University of Sheffield in England in 1965 and then his Ph.D. in physical chemistry from the same university in 1968. He spent two years as a Post Doctoral Fellow in the Department of Applied Chemistry of the National Research Council of Canada before starting his career in the nuclear industry in the Materials Development Division at the Harwell Laboratory of the UKAEA. During 18 years at Harwell, he became a section head and a recognised expert in corrosion of metallic materials, particularly concentrating on the phenomena of corrosion fatigue and stress corrosion cracking in thermal and fast reactor systems. He entered the Framatome Group (now AREVA NP) in 1989 and was named 'Expert Principal' (or Senior Corrosion Consultant) in 1993 and AREVA International Expert

in 2003. In this capacity, he represented the company on several international working groups dealing with problems of stress corrosion cracking of materials mainly in light water reactors. During his period with Framatome/AREVA NP he also served as a member of the editorial board of the NACE Corrosion Journal. He is the author or co-author of over 100 scientific publications and in 2000 he received the F. N. Speller Award from the NACE for outstanding contributions to the practice of corrosion engineering.

Dr. Pierre Combrade received his first degree from the Ecole Nationale Supérieure des Mines de Paris,in1967 and earned his doctorate degrees with a thesis on solidification of refractory eutectic alloys for aero engine turbine blades in1972.

He spent 22 years in Creusot-Loire (then Usinor) company where he was involved in the study of stress corrosion cracking and localized corrosion of corrosion resistant alloys as well as in the development of a laboratory devoted to the study of corrosion problems in light water reactors.

With his team, he joined FRAMATOME (now AREVA NP) in 1994 as Head of the "Corrosion and Chemistry Department" in the Technical Center in Le Creusot and, since 2003, was an AREVA "International Expert". He retrired from AREVA NP in January 2007.

His main field of activity regarding light water reactors are:

- IGSCC of Ni-base alloys in caustic solutions, and in primary and secondary PWR coolants.
- Corrosion-fatigue of low alloy steels.
- Oxidation of Ni-base alloys in high temperature water.
- Formation of deposits in high temperature water.
- Electrochemistry in high temperature water.

He is the author of over 50 technical papers and several reviews as well as book chapters on stress corrosion cracking and crevice corrosion. He is co-author of a book of metallurgy published in 1997 and re-edited in 2002.

He has also been involved in teaching activities in the Ecole des Mines de Paris and in the Ecole des Mines de Saint Etienne, as well as directing several thesis students working on SCC, oxidation in HT water and fretting-corrosion problems.

Mr. Claude Amzallag retired from Electricity of France (EDF) in June 2010 after working for 37 years in the field of nuclear energy. He began his career in November 1973 at the Research Center of CREUSOT-LOIRE Steel Company, Firminy. He was in charge of the Fatigue Laboratory from November 1973 to June 1994.

The main achievements in CREUSOT-LOIRE include:

- Development and characterization of materials for nuclear, mechanical and aircraft industries,
- Realization and Management of Research and Development Programs on Fatigue and Rupture Behaviour of Materials,
- Coordination of Materials Handbooks [Fabrication, Materials Behavior (Fatigue, Corrosion, Rupture and Constitutive Laws), Field Experience],
- Standardization of Fatigue and Rupture Tests in FRANCE (AFNOR) and USA (ASTM),
- Organization of International Seminars, Workshops and Conferences – Editor of the Proceedings (ASTM Special Technical Publications, SF2M-FRANCE).
- Management of Projects for Nuclear, Mechanical and Aircraft Industries.

From July 1994 to June 2010, he worked at the Basic Design Department of Electricity of France (EDF - SEPTEN), Villeurbanne, as Materials Expert.

The main achievements in EDF include:

- Management of the EDF Scientific Program on Components made of Nickel Base Alloys,
- Responsible of the EDF Research and Development Program on Fatigue of Austenitic Stainless Steels,
- Collection and Analysis of International Service Experience in Fatigue and Corrosion,
- Coordination of Materials Handbooks,
- Assistance and Technical Support in Materials (fatigue, rupture, corrosion, constitutive laws, disposition and reference curves) for EDF,
- Review and Justification of fabrication problems.

He has authored and co-authored over 100 technical publications on Fatigue and Corrosion and made numerous presentations at various conferences. He has coordinated several international standards on Fatigue and Rupture Tests and edited several books. He has also been involved in teaching activities in the frame of permanent formation of nuclear engineers.

Price and Terms of Payment

The fixed nominal price for the LCC Membership appears in the associated Proposal.

Terms and Conditions

The term of LCC12 Programme starts from the date of the purchase order and lasts 12 months onwards.

ANT International shall exercise its best efforts to meet the objectives in this assignment and shall apply to the work professional personnel having the required skills, experience and competence. If the assignment is found to be significantly deficient by the customer within 6 months of its completion, ANT International shall modify the work done within this assignment in such a way that it will become satisfactory to the customer. This modification shall be done without incurring any additional costs to the customer. The total amount of such additional costs due to the modification shall be limited to be less or equal to the amount originally paid to ANT International for this assignment.

It is understood that ANT International is not responsible for any damage, incurred to the customer, their employees, or their plants or to a third party due to the use of the information or the recommendations given within this assignment.

The compiled information and the conclusions, as a result of this work, may be used by the purchasing party for its own use for any purpose provided that the source is given. ANT International retains the rights to the compiled information and the conclusions for other uses.

Nuclear Liability

ANT International and its sub-suppliers, including also suppliers of information and services, of every tier and kind, and everyone engaged by any of them, shall have no liability whatsoever (irrespective of negligence or gross negligence) for any damage or loss whatsoever (including also consequential and indirect loss) resulting from a nuclear incident (as such term is defined in the Paris Convention on third party liability in the field of nuclear energy, as amended from time to time). This shall apply for damage or loss suffered by third parties or the owner and for damage and loss to the nuclear installation, on site property and any other property of any kind, and until the nuclear installation has been definitely decommissioned and irrespective of any termination or cancellation of the proposed work.

Insurances of the owner and of others in respect of a nuclear incident shall exclude any right of recourse against the supplier and his sub-suppliers of every tier and kind.

Contact

For more information and/or an offer welcome to contact us at sales@antinternational.com

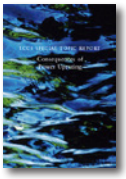
Please also visit our website for the latest updated information, www.antinternational.com

Earlier published LCC Special Topic Reports

Available in hard copy

Available on CD/DVD

LCC2 STR
CRUD in PWR/VVER and BWR Primary Circuits



LCC3 STR
Consequences of Power Uprating

LCC4 STR
Environmentally-Assisted Degradation of Carbon and Low-Alloy Steels in Water Cooled Nuclear Reactors

LCC5 STR
Decontamination and Steam Generator Chemical Cleaning

LCC5 STR
Start-up and Shutdown Practices in BWRs as well as in Primary and Secondary Circuits of PWRs, VVERs and CANDUs

LCC6 STR
Radiochemistry in Nuclear Power Reactors (Light Water Reactors) Volume I

LCC6 STR
Incoming Goods, Hazardous Materials and Aging of Plant Chemicals

LCC6 STR
Effect of Zink in BWR and PWR/VVER on Activity Build-up, IGSCC and Fuel Performance

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Key Results from Recent Conferences on Structural Materials Degradation in Water Cooled Reactors

LCC7 STR
Introduction to Boiling Water Reactor Chemistry Volume I

LCC7 STR
PWR/VVER Primary Side Coolant Chemistry, Volume I – Technical Basis and Recent Discussions

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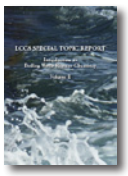
Operational Issues and Practices



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Introduction to Boiling Water Reactor Chemistry Volume II

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Effects of Coolant Chemistry on Fuel Performance

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