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OECD  
NEA

Specialist Meeting  
on  
EROSION AND CORROSION  
of  
NUCLEAR POWER PLANT MATERIALS

Kiev (Ukraine)  
19-22 September 1994

**POOR QUALITY  
ORIGINAL**

Jointly organised by  
the OECD Nuclear Energy Agency  
and  
the International Atomic Energy Agency



**COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS  
OECD NUCLEAR ENERGY AGENCY**

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COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS  
PRINCIPAL WORKING GROUP No 3 ON PRIMARY CIRCUIT INTEGRITY

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1995

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- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
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### NUCLEAR ENERGY AGENCY

*The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all European Member countries of OECD as well as Australia, Canada, Japan, Republic of Korea, Mexico and the United States. The Commission of the European Communities takes part in the work of the Agency.*

*The primary objective of NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.*

*This is achieved by:*

- *encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
- *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
- *developing exchanges of scientific and technical information particularly through participation in common services;*
- *setting up international research and development programmes and joint undertakings.*

*In these and related tasks, NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.*

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## COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA), is an international committee made up of senior scientists and engineers. It was set up in 1973 to develop and coordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee's purpose is to foster international cooperation in nuclear safety among the OECD Member countries.

The CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of its programme of work. It also reviews the state of knowledge on selected topics of nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus on technical issues of common interest. It promotes the coordination of work in different Member countries including the establishment of cooperative research projects and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of cooperation, such as information exchanges, establishment of working groups, and organisation of conferences and specialist meetings.

The greater part of the CSNI's current programme of work is concerned with safety technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment, and severe accidents. The Committee also studies the safety of the nuclear fuel cycle, conducts periodic surveys of the reactor safety research programmes and operates an international mechanism for exchanging reports on safety related nuclear power plant accidents.

In implementing its programme, the CSNI establishes cooperative mechanisms with NEA's Committee of Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also cooperates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.

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OECD Nuclear Energy Agency  
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France

## Foreword

This Specialists Meeting was jointly sponsored by the IAEA International Working Group on Life Management of Nuclear Power Plant and by the Principal Working Group 3 (PWG-3) of the NEA CSNI, and hosted by the Institute for Nuclear Research of the National Ukrainian Academy of Sciences. PWG-3 deals with Reactor Component Integrity, and has a joint secretariat with the Commission of the European Communities. The activities of PWG-3 fall into three main areas: Non-Destructive Examination (NDE), fracture analysis and ageing/materials degradation. In NDE, the main activity has been the Programme for the Inspection of Steel Components (PISC), jointly with the CEC. In fracture analysis, the activities are organised by the Fracture Analysis Group, and include the round robins on Fracture Analysis of Large Scale International Reference Experiments (FALSIRE). In the area of ageing/materials degradation, PWG-3 considers case studies of operational experience, and sponsors Specialists Meetings and Workshops. This document is published under the responsibility of the Secretary-General of the OECD.

18 September 1994

Arrival and registration of participants  
Reception

19 September 1994

9:00 B R E A K F A S T

10:00 Opening Ceremony

Mr.Chebrov, Goscomatom, Head of the Sci.-  
Techn.Dept.

Mr.E.Grinik, Chairman of the Organizing  
Committee

Mr.L.Ianko, Scientific Secretary, IAEA

Mr.L.M.Davies, Chairman of the Meeting

K.Torronen, Chairman, PWG-3/NEA/OECD

Mr.V.Gavrilyuk, INR

11.00 SESSION A

CHAIRMEN: L.M.Davies

E.U.Grinik

1. K.Törrönen, P.Aaltonen, H.Hanninen (Finland) -  
Water Chemistry and Materials Degradation in LWRs. - p21
2. V.A.Fedorova, B.T.Timofeev, G.P.Karzov (Russia) - Analysis of  
corrosion damages of NPP equipment and corrosion- mechanical  
strength of RPV materials. - p37
3. D.R.Tice, I.L.Branwell, D.Worswick (UK) - Effects of  
Temperature on corrosion Fatigue Crack Growth of Pressure  
Vessel Steels in PWR Coolant. - p49
4. O.Hietanen, R.Korhonen (Finland) - Erosion - Corrosion of  
Parallel Feed Water Discharge Lines in Loviisa WWER 440. - p75

14.00 LUNCH

15.00 SESSION A (Contd)

CHAIRMEN: P.Tipping  
A.Zhidkov

- P87 1.K.A.Nikishina, N.G.Ziverdina.(Russia) - Effect of Ionizing Radiation on the Corrosion and Mechanical Behaviour of Dispersion hardened Copper Alloys.
- P103 2.V.I.Pokhmurskii, I.P.Gryp (Ukraine) - Influence of Metallurgical and Electrochemical Factors on Cracking of Steels in NPP under High Temperature.
- P113 3.V.A.Gashenko, O.N.Abakumova, I.S.Dudrovsky, V.L.Bogoyavlensky (Russia) - Influence of some Factors upon a Corrosive Behaviour of NPP Structural Material.

16.30 - 17.00 COFFEE BREAK

- P147 4. B.Centner (Belgium) - Steam Side Corrosion-Erosion Monitoring and Control Improvements Performed at the Kalinin NPP in TACIS'92 Programme.
- P163 5. V.G.Marinin (Ukraine) - Effects of Surface Treatment on the Cavitation Erosion of High-Chrome Steel, Zirconium, Titanium and their Alloys.
- P169 6. V.N.Belous, V.G.Denisov, A.I.Arzhaev, V.A.Shuvalov (Russia) - Corrosion Strength Monitoring of NPP Components Residual Lifetime.

19.00 WELCOME PARTY

20 September 1994

9.00 B R E A K F A S T

10.00 SESSION B

CHAIRMEN: D.Tice  
B.Timofeev

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- 1.A.A.Shinakov, L.I.Chirko, E.U.Grinik (Ukraine) - The Neutron Irradiation Influence on the Nodular Corrosion Development of Zirconium RBMK Reactors Canals.

p193

- 2.A.A.Shinakov, L.I.Chirko, E.U.Grinik, A.G.Krajny (Ukraine) - Influence of the Second Phase Interstitials on the Corrosion and Erosion of the Reactor Steels.

p199

- 3. A.Tannaro, J.Ortega (Spain) - Stress Corrosion Cracking in Vessel Penetrations. CRDH ISI Field Experience.

p203

- 3.I.P.Gnyp (Ukraine) - Corrosion Cyclic Cracking of Steels at NPP's under High Temperature Water Effects.

11.30 C O F F E E B R E A K

p219

- 4.M.Ruscak (CZR) - The Complex Approach to the Flow Assisted Cracking in Czech Nuclear Plants.

p235

- 5.Briceno Dolores Gomez (Spain) - Evaluation of the Susceptibility to Stress Corrosion Cracking of PWR Reactor Closure Head Penetrations.

p251

- 6.R.K.Meleshov, M.A.Fridman, O.D.Smian (Ukraine) - Stress Corrosion Cracking of Steam Generator Components of OSX18H10T Steel.

14.00 L U N C H

15.00 SIGHT- SEEING TOUR

19.00 D I N N E R



21 September 1994

9.00 B R E A K F A S T

10.00 SESSION C:

CHAIRMAN: K.Parczewsky  
V.Gavriluk

P 271

- 1.P.Tipping, U.Ineichen, R.Cripps (Switzerland) - Stress Corrosion Cracking Studies on Ferritic Low Alloy Pressure Vessel Steel-Water Chemistry and Modelling Aspects.

P 281

- 2.I.I.Ivanova, A.N.Demidik, V.V.Popovich, C.A.Kochtev (Ukraine) - Investigation of Corrosion Resistance of Ferrite Dispersion Strengthened Steels for the Hot Zone of Nuclear Reactors.

P 287

- 3.G.V.Stepanov, V.V.Kcharchenko, A.A.Shatko, V.V.Dranchenko (Ukraine) - Analysis of the Ways to Decrease Residual Stresses in Heat Exchanging Tubes and SG Collector Surfaces for Reducing Corrosion.

11.30 C O F F E E B R E A K

P 295

- 4. A.Tannarro, E.Gonzales (Spain) - Erosion Corrosion in Wet Steam and Single Phase Lines in Nuclear Power Plants.

P 305

- 5. A.G.Krajnij, V.V.Ogorodnikov, E.Grinik, L.I.Chirko (Ukraine) Swelling and Destruction of Borides under Neutron Irradiation.

14.00 L U N C H

14.30 SIGHT-SEEING TOUR

19.00 D I N N E R

22 September 1994

9.00

B R E A K F A S T

10.00

SESSION C (Cont) and PLENARY SESSION

CHAIRMEN: L.M.Davies

E.U.Grinik

- p 319 -
1. M.Bouchcourt (France)-Predicting Flow Accelerated Corrosion (Erosion-Corrosion) Damage in Power Plants with BRT-Cicero Code.
  2. V.N.Polyakov, D.Y.Iyubimov (Russia)- The Role of Hydrodynamics and Materials in Catastrophes of Reactors.
  3. L.Ianko (IAEA), L.M.Davies (UK)- Activities of the IAEA International Working Group on Life Management of Nuclear Power Plants.

C O F F E E B R E A K

PLENARY SESSION

14.00

L U N C H

19.00

F A R E W E L L D I N N E R

23 September 1994

9.00

B R E A K F A S T

Charter Bus to the Airport

Opening Speech - Specialists Meeting, Kiev  
L.M. Davies

Ladies and Gentlemen,

It was a pleasure for me to have been invited to this meeting in the Ukraine and in particular to Kiev. In particular I thank the Ukrainian hosts.

The topic of this Specialists Meeting is Erosion and Corrosion and it is a subject which comes into a number of areas in Nuclear Power Plant Life Management. Not only is it a consideration at the design stage and in the choice of materials but it is also a consideration during the operation of plants.

Aspect of corrosion and erosion therefore have an impact on plant outage and plant life.

The safety of nuclear power plants is permanent and the purpose of operating nuclear power plants is to produce electricity for sale.

Problems stemming from corrosion/erosion can therefore have an impact on the economics of nuclear power plants and in the safety assessment of nuclear power plants.

The last meeting on this topic was held in Vienna in September 1988. It is interesting to note that only two or three of the people who attended that meeting are present today.

As is usual for IAEA meetings the proceedings will be given a wide distribution, so Mr. Ianko will need to take the masters of papers with him from Kiev, so please hand them over to him as soon as possible.

Session Chairmen have been identified and their task will be to produce a short note summarising their session and drawing out any conclusions and recommendations. These will be discussed at the last session.

30 minutes has been allocated for each speaker and that includes time for discussion.

The session Chairmen will give notice at the end of 20 minutes with a card and also at 5 minutes.

At the end of the time the speaker will be given a "red card" and should finish immediately. This will impose a sense of fairness for all speakers.

For the last meeting it was felt that a glossary of terms should be included because of a conflict of definitions. I think this was a good idea and I have asked Dr. David Tice to consider that it should be included in the proceedings of this meeting.

I wish you a good and fruitful meeting.

## Opening Remarks

L. Ianko

Division of Nuclear Power  
International Atomic Energy Agency  
Vienna

It's my pleasure to greet all of you here in Kiev as participants of the Specialists' Meeting on "Erosion and Corrosion of Nuclear Power Plant Materials".

This meeting is convened in the framework of the activities of the Agency's International Working Group on Life Management of Nuclear Power Plants and represents an up-dating event which covers one of the regular topics within the framework of the activities of the IWG-LMNPP.

The IAEA pays a great deal of attention to different problems of reliable and safe operation of NPP's. The Agency's programme on the subject has been elaborated for all-time dependent factors affecting degradation of properties of material used as structural materials in NPP's systems and components. It is understood that corrosion/erosion problems could be considered both as degrading and time depending factor influencing the reliability and safety of NPP's component performance.

The reduced plant availability or loss of capacity in modern NPP's today can be significantly attributed to corrosion/erosion problems. The economic penalties that can result from this aspect show clearly that a prevention or regular monitoring could be an effective tool to handle the issue both now and in the future.

The latter shows an importance of the understanding of the mechanisms causing the phenomena. Taking into account the complexity of factors influencing corrosion/erosion processes one should thoroughly consider full interaction of parameters involved in the process and clearly define how to monitor every separately taken factor in order to prolong the lifetime or replace/repair a component on the economically favourable basis.

Up-to-date it should be recognized that there are still many questions left unanswered and practical solutions to be found regarding corrosion/erosion problems.

Variety of materials used combined with environments and loading conditions require a long term programme which could give a clear answer regarding the interaction of parameters involved and how one could monitor these parameters in order to achieve a longer safe and reliable component service.

Solutions to this problem could be different but the most important task is still existing: we should clearly define what the mechanism is and how it could be described qualitatively and quantitatively with regard of materials used, environmental and loading conditions.

The correspondence of those factors could provide operators with valuable information allowing to initiate the influence of corrosion/erosion phenomena on availability of NPPs.

The last meeting on the topic has recommended to develop and investigate some measures which should be developed to achieve concrete results. They have included proposals for more stringent material specifications, design improvements to reduce local stresses, improved quality control of materials and manufacturing processes, smooth operational procedures and condition, development of effective techniques to provide early corrosion crack detection and sizing, accumulation of experimental data for reducing uncertainties, suggestions for safe repair techniques of corrosion cracks and failures and so on.

It is expected that this meeting will serve as a practical tool for increasing the body of knowledge in the above mentioned area.

Presentations to be made at the meeting will serve as an updated information exchange in the area concerned, and could be used internationally.

I would like to wish you useful and fruitful work which would hopefully provide you with some new ideas for your future research work.

## OPENING REMARKS

Kari Törrönen  
Chairman of the PWG3 Reactor Component Integrity  
OECD Nuclear Energy Agency, Committee for the Safety of Nuclear Installations

### Specialists' Meeting on Erosion & Corrosion of Nuclear Power Plant Materials, Kiev, Ukraine

Ladies and Gentlemen,

I would like to reiterate the welcome of the previous speakers, this time on behalf of the OECD Nuclear Energy Agency, Principal Working Group 3.

This meeting on "Erosion and corrosion of nuclear power plant materials" is co-sponsored by IAEA and NEA, PWG-3 on Reactor Component Integrity.

Erosion and corrosion related phenomena are of utmost importance for both the safety and economy of nuclear power plants. We will have several examples of this during the meeting. Ageing and related materials degradation - also due to erosion and corrosion - are one of the main topics of the PWG-3.

As some of you may not be familiar with our group let me briefly describe our work. The input is coming from

- nuclear safety related occurrences
- new technologies for safety of components
- work of specialised international groups and
- national approaches in structural integrity issues.

This input is evaluated in our annual meetings with the help of invited experts and ad-hoc groups. We arrange also round robin exercises and specialists meetings and workshops. Output from our group is

- state-of-the-art -reports (SOARS)
- recommendations for further research
- recommendations for prevention and mitigation measures
- recommendations for safety measures and improvements

From this description you may understand that the outcome of this specialists meeting is very important to the PWG-3, especially the recommendations. My good friend Academician Myrddin Davies will guide you through the final session for formulating the recommendations, which I believe guarantees a good result.

As a chairman of a NEA working group I appreciate the possibility to work with the IAEA, which is especially beneficial in arranging and sponsoring meetings, and allows us to avoid unnecessary duplication.

NEA has lately also increased cooperation with non-OECD countries. Last February I had the pleasure to participate in a fact-finding mission to Ukraine and some other non-OECD countries. During this mission we visited also this beautiful city of Kiev, and had a very warm and friendly stay here.

As a result of this mission several concrete cooperation items were identified. These will be discussed by the PWG-3 during its annual meeting in this coming October and then proposed to the NEA Committee for the Safety of Nuclear Installations for approval. It is my firm belief that we may start some of the cooperative projects during this winter.

Finally, let me thank all the local organisers of this meeting for their efforts and hospitality and also Mr. Leonid Ianko for his excellent coordination.

I wish you all a successful meeting.

# SESSION A

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