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NEA/CSNI/R(2000)15



Organisation de Coopération et de Développement Economiques  
Organisation for Economic Co-operation and Development

OLIS : 10-Jan-2001  
Dist. : 15-Jan-2001

English text only

PARIS

NUCLEAR ENERGY AGENCY  
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2000)15  
Unclassified

## WORKSHOP ON THE INSTRUMENTATION AND MONITORING OF CONCRETE STRUCTURES

### Workshop Proceedings

Brussels, Belgium  
22,23 March 2000

98963

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Incomplete document on OLIS

English text only

## ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

## 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 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has 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 NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers. It was set up in 1973 to develop and co-ordinate 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 co-operation in nuclear safety amongst the OECD Member countries.

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 in different projects and International Standard Problems, and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups and organisation of conferences and specialist meetings.

The greater part of 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 fuel cycle, conducts periodic surveys of reactor safety research programmes and operates an international mechanism for exchanging reports on nuclear power plant incidents.

In implementing its programme, CSNI establishes co-operative mechanisms with NEA's Committee on 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 co-operates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.



## FOREWORD

### Introduction

The Committee on the Safety of Nuclear Installations (CSNI) of the OECD-NEA co-ordinates the NEA activities concerning the technical aspects of design, construction and operation of nuclear installations insofar as they affect the safety of such installations. In 1994, the CSNI approved a proposal to set up a Task Group under its Principal Working Group 3 (recently re-named as the Working Group on Integrity of Components and Structures (IAGE)) to study the need for a programme of international activities in the area of concrete structural integrity and ageing and how such a programme could be organised. The task group reviewed national and international activities in the area of ageing of nuclear power plant concrete structures and the relevant activities of other international agencies. A proposal for a CSNI programme of workshops was developed to address specific technical issues which were prioritised by OECD-NEA task group into three levels of priority:

### First Priority

- Loss of prestressing force in tendons of post-tensioned concrete structures
- In-service inspection techniques for reinforced concrete structures having thick sections and areas not directly accessible for inspection

### Second Priority

- Viability of development of a performance based database
- Response of degraded structures (including finite element analysis techniques)

### Third Priority

- Instrumentation and monitoring
- Repair methods
- Criteria for condition assessment

The working group has progressively worked through the priority list developed during the preliminary study carried out by the Task Group. Currently almost all of the three levels of priority are effectively complete, although in doing so the committee has identified other specific items worthy of consideration. By working logically through the list of priorities the committee has maintained a clarity of purpose which has been important in maintaining efficiency and achieving its objectives. The performance of the group has been enhanced by the involvement of regulators, operators and technical specialists in both the work of the committee and its technical workshops and by liaison and co-operation with complementary committees of other international organisations. The workshop format that has been adopted (based around presentation of pre-prepared papers or reports followed by open discussion and round-table development of recommendations) has proved to be an efficient mechanism for the identification of best practice, potential shortcomings of current methods and identification of future requirements.

### OECD-NEA Workshop on the Instrumentation and Monitoring of Concrete Structures

OECD-NEA IAGE held an international workshop on the Instrumentation and Monitoring of Concrete Structures in Brussels, Belgium in March 2000. During previous workshops, the importance of instrumentation and monitoring was demonstrated as it became clear that these interface with each of the subjects covered. An increased need to address the ageing of concrete structures is now a commonly accepted idea within the nuclear community, primarily because these are the longest lasting structures and also because after decommissioning, inspection programs are likely to be down-scaled putting greater demands on instrumentation. As a consequence, the ageing of

instrumentation (including loss of instrumentation and/or retrofitting issues) is an important subject that needs to be addressed. Since the definition of the original priorities by the OECD-NEA Task Group, the importance of instrumentation and monitoring has been more widely recognised (although it should be noted that even at the time that the priorities were determined the representatives from Belgium and Spain recommended that instrumentation and monitoring should have a higher priority; possibly first priority rather than third priority). This was reflected in the participation in the workshop with 64 participants from 19 countries taking part and 20 papers being presented making it the largest workshop run so far.

The objective of the workshop was to assess the capability of current instrumentation and monitoring systems to describe the actual state of structures and detect ageing problems. The workshop focused on experience of current instrumentation and monitoring systems with a view to detecting trends for the future. The three sessions of the workshop covered a broad range of activities and issues within the framework of monitoring instrumentation for concrete structures with work from both nuclear and non-nuclear industries being presented.

**OECD-NEA WORKSHOP ON THE  
INSTRUMENTATION AND MONITORING OF CONCRETE STRUCTURES,**

**22-23 March 2000, Brussels, Belgium**

- A      CONTENTS**
- B      PROGRAMME**
- C      PAPERS**
- D      PARTICIPANTS**





## A. TABLE OF CONTENTS

	PAGE
<b>B. PROGRAMME.....</b>	<b>13</b>
<b>C. PAPERS.....</b>	<b>17</b>
<b>SESSION 1a – REGULATORY CONSIDERATIONS AND STATE OF THE ART.....</b>	<b>17</b>
Chairman : Pierre Mignot	
<b>Detection of Aging of Nuclear Power Plant Structures.....</b>	<b>19</b>
D.J. Naus - Oak Ridge National Laboratory (USA)	
H.L. Graves, III, U.S. Nuclear Regulatory Commission	
<b>Results and Problems of Monitoring of Prestressed Containment of Nuclear Power Plants.....</b>	<b>59</b>
Prof. Y.Klymov - State Research Institute of Building Construction (Ukraine)	
<b>Instrumentation and Monitoring of Belgian Containments.....</b>	<b>81</b>
L. de Marneffe – TRACTEBEL (BE)	
<b>The Use and In-service Performance of Instrumentation on Civil Engineering Structures at UK Nuclear Power Plants.....</b>	<b>89</b>
LM Smith, J.P. McFarlane - British Energy Generation (UK)	
<b>SESSION 1b – REGULATORY CONSIDERATIONS AND STATE OF THE ART.....</b>	<b>103</b>
Chairman : Rüdiger Danisch	
<b>Using and New Technologies in Ukraine for Monitoring of Prestress Containment and Other NPP Concrete Structures.....</b>	<b>105</b>
Volodymyr Krytskyy - State Scientific and Technical Center on Nuclear and Radiation Safety (SSTC NRS), (Ukraine)	
<b>Monitoring and Control-Preventive Works Optimization of VVER-1000 Containment Pre-stressing System.....</b>	<b>113</b>
O.Mayboroda - State Scientific and Technical Center on Nuclear and Radiation Safety (SSTC NRS), (Ukraine)	
<b>Behaviour of Inner Containment Dome of an Indian PHWR during Prestressing and Proof Testing.....</b>	<b>125</b>
Raghupati Roy - Nuclear Power Corporation of India Limited (India)	
<b>CANDU 6 containment instrumentation and its use.....</b>	<b>139</b>
Claude Seni - Mattec Engineering Ltd. (Canada)	

**MAEVA containment mock-up Concrete behaviour observed by the instrumentation.....167**  
 Patrice Guinet, Lionel Lacroix, Ban Chau - EdF (France)

<b>SESSION 2 – DETECTING AGEING .....175</b> Chairman : Dan Naus
---

**UPUS® : Ultrasonic Load Measurement for prestressed Bars.....177**  
 Bernard Basile, Bruno Lancia – Freyssinet (FR)

**SCANPRINT : Inspection and Maintenance Computer Program for Structures.....183**  
 Jéôme Stubler, Bernard Basile, Jean Baptiste Damage – Freyssinet (FR)

**Instrumentation and Monitoring of Natural Draught Cooling Towers in Belgium .....189**  
 R. Lasudry - TRACTEBEL (BE)

**Assessment of the Monitoring Results recorded by the Measuring Devices of the THTR  
 Prestressed Concrete Reactor Vessel with respect to Ageing.....201**  
 M. Borgerhoff, K. Schimmelpfennig - Stangenberg und Partner Ingenieur-GMBH (GER)

**Ageing and long-term monitoring of concrete structures .....217**  
 Tibor Jávör - Expertcentrum (Slovakia)

**Electrochemical techniques to detect corrosion in concrete structures in  
 Nuclear Installations.....231**  
 Pablo Zuloaga - ENRESA , Carmen Andrade -I.E. TORROJA,  
 Jesús Rodríguez, Marta García, Jaime Palacio - GEOCISA(SPAIN)

**Embedded sensors for the instrumentation of concrete structures.....249**  
 Pablo Zuloaga -ENRESA, Carmen Andrade - I.E. TORROJA  
 Jesús Rodríguez, F. Jiménez, Jaime Palacio - GEOCISA(SPAIN)

**Evaluation of reinforced concrete structures degradation.....257**  
 Prof. Gregory Muravin , Dr. Ludmila Lezvinsky, Mr. Boris Muravin- Margan Physical Diagnostics Ltd,  
 (ISRAEL)

<b>SESSION 3 – TRENDS FOR THE FUTURE.....271</b> Chairman : Luc de Marneffe
--

**Intelligent Monitoring of Seismic Damage in Reinforced Concrete Tunnel Linings.....273**  
 Dimitris Bairaktaris - Bairaktaris and Associates, Ltd.,(Greece)

**Optical Fiber Sensors in the Construction Industry.....283**  
 Ir. W. Moerman - University of Ghent. (BE)

**The Use of Acoustic Monitoring to Manage Concrete Structures in the Nuclear Industry.....289**  
 David Youdan - Pure Technologies

**NDE as a means of determining as-built conformity of concrete structures and comparison of NDE-techniques for inspection of a pre-stressed cable.....299**  
 Peter Shaw - Force Institute(Denmark)

**Trends in the development of Non-destructive Testing Methods to assess the actual State of Structures.....321**  
 V. Schmitz - Fraunhofer Institut for Nondestructive Testing (GER)

<p><b>SESSION 4 : PANEL DISCUSSION .....337</b>                  Chairman : Les Smith</p>
---

**Panel discussion.....337**

**Conclusions and Recommendations.....343**

**D. LIST OF PARTICIPANTS.....345**



**B PROGRAMME**

**OECD-NEA Workshop on the Instrumentation and Monitoring of Concrete Structures,  
22-23 March 2000, Brussels, Belgium**

**WEDNESDAY, 22 MARCH**

**9:00 - 10:00** Registration

**10:00 - 10:20** Introduction

*J. Van Vyve – TRACTEBEL/ELECTRABEL/BELGATOM*

*P. Govaerts – AVN*

*E. Mathet - OECD*

<b>SESSION 1a – Regulatory Considerations and State of the Art</b>	<b>Chairman : Pierre Mignot</b>
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**10:20 - 10:40** Detection of aging of Nuclear Power Plant structures

*D.J. Naus - Oak Ridge National Laboratory (USA)*

**10:40 - 11:00** Results and Problems of Monitoring of Prestressed Containment of Nuclear Power Plants

*Prof. Y.Klymov - State Research Institute of Building Construction (Ukraine)*

**11:00 - 11:20** Coffee break

**11:20 - 11:40** Instrumentation and Monitoring of Belgian containments

*L. de Marneffe – TRACTEBEL (BE)*

**11:40 - 12:00** The Use and In-service Performance of Instrumentation on Civil Engineering Structures at UK Nuclear Power Plants

*LM Smith - British Energy Generation (UK)*

<b>SESSION 1b – Regulatory Considerations and State of the Art</b>	<b>Chairman : Rüdiger Danisch</b>
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**12:00 - 12:20** Using and New Technologies in Ukraine for Monitoring of Prestress Containment and Other NPP Concrete Structures

*Volodymyr Krytskyy - State Scientific and Technical Center on Nuclear and Radiation Safety (SSTC NRS), (Ukraine)*

**12:20 - 12:40** Monitoring and Control-Preventive Works Optimization of VVER-1000 Containment Pre-stressing system.

*O.Mayboroda - State Scientific and Technical Center on Nuclear and Radiation Safety (SSTC NRS), (Ukraine)*

- 12:40 - 13:00** Behaviour of Inner Containment Dome of an Indian PHWR during Prestressing and Proof Testing  
*Raghupati Roy - Nuclear Power Corporation of India Limited (India)*
- 13:00 - 14:30** Lunch
- 14:30 - 14:50** CANDU 6 containment instrumentation and its use  
*Claude Seni - Mattec Engineering Ltd. (Canada)*
- 14:50 - 15:10** MAEVA containment mock-up Concrete behaviour observed by the instrumentation  
*Lionel Lacroix - EdF (France)*
- 15:10 - 15:30** Coffee break

<b>SESSION 2 – Detecting Ageing</b>	<b>Chairman : Dan Naus</b>
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- |                      |  |
|----------------------|--|
| <b>15:30 - 15:50</b> | UPUS® : Ultrasonic Load Measurement for prestressed Bars<br><i>Bernard Basile – Freyssinet (FR)</i>  |
| <b>15:50 - 16:10</b> | SCANPRINT : Inspection and Maintenance Computer Program for Structures<br><i>Jean Baptiste Damage – Freyssinet (FR)</i>  |
| <b>16:10 - 16:30</b> | Instrumentation and Monitoring of Belgian cooling towers<br><i>R. Lasudry - TRACTEBEL (BE)</i>   |
| <b>16:30 - 16:50</b> | Assessment of the Monitoring Results recorded by the Measuring Devices of the THTR Prestressed Concrete Reactor Vessel with respect to Ageing<br><i>M. Borgerhoff - Stanganberg und Partner Ingenieur-GMBH (GER)</i> |
| <b>16:50 - 17:10</b> | Ageing and long-term monitoring of concrete structures<br><i>Tibor Javor - Expertcentrum (Slovakia)</i>  |
| <b>19:00 - 22:00</b> | Banquet  |

## THURSDAY, 23 MARCH

<b>SESSION 2 - continued Detecting Ageing</b>	<b>Chairman : Dan Naus</b>
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|---------------------|---|
| <b>9:30 - 9:50</b>  | Electrochemical techniques to detect corrosion in concrete structures in Nuclear Installations<br><i>Pablo Zuloaga - ENRESA (SPAIN)</i> |
| <b>9:50 - 10:10</b> | Embedded sensors for the instrumentation of concrete structures<br><i>Pablo Zuloaga -ENRESA (SPAIN)</i>                                 |

**10:10 - 10:30** Evaluating of reinforced concrete structures degradation  
*Prof. Gregory Muravin - Margan Physical Diagnostics Ltd,  
 (ISRAEL)*

**10:30 - 11:00** Coffee break

<b>SESSION 3 – Trends for the Future</b>	<b>Chairman : Luc de Marneffe</b>
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**11:00 - 11:20** Fibre optics based detection and assessment of deformation due to ageing and seismic forces in reinforced concrete tunnel linings

*Dimitris Bairaktaris - Bairaktaris and Associates  
 Ltd.,(Greece)*

**11:20 - 11:40** Strain Monitoring of Concrete Elements by means of Fiber Optic Bragg grating sensors: comparative measurements

*Ir. W. Moerman - University of Ghent. (BE)*

**11:40 - 12:00** The Use of Acoustic Monitoring to Manage Concrete Structures in the Nuclear Industry

*David Youdan - Pure Technologies*

**12:00 - 12:20** NDE as a means of determining as-built conformity of concrete structures and comparison of NDE-techniques for inspection of a pre-stressed cable

*Peter Shaw - Force Institute(Denmark)*

**12:20 - 12:40** Trends in the development of Non-destructive Testing Methods to assess the actual State of Structures

*V. Schmitz - Fraunhofer Institut for Nondestructive Testing  
 (GER)*

**12:40 - 14:15** lunch

<b>SESSION 4 : Panel Discussion</b>	<b>Chairman : Les Smith</b>
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**14:15 - 16:15** Panel discussion

**16:15 - 16:30** Closure of the workshop





**C. PAPERS**

**SESSION 1a – REGULATORY CONSIDERATIONS AND STATE OF THE ART**

**SESSION 1b – REGULATORY CONSIDERATIONS AND STATE OF THE ART**

**SESSION 2 – DETECTING AGEING**

**SESSION 3 – TRENDS FOR THE FUTURE**

**SESSION 4 : PANEL DISCUSSION**

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