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NEA/CSNI/R(2000)15



PARIS

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

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

WORKSHOP ON THE INSTRUMENTATION AND MONITORING OF CONCRETE STRUCTURES

Workshop Proceedings

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

98963

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**NEA/CSNI/R(2000)15
Unclassified**

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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 meeting.

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

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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***SESSION 1a – Regulatory Considerations and State of the Art Chairman : Pierre Mignot****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)***SESSION 1b – Regulatory Considerations and State of the Art Chairman : Rüdiger Danisch****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

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

THURSDAY, 23 MARCH

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

SESSION 3 – Trends for the Future	Chairman : Luc de Marneffe
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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

SESSION 4 : Panel Discussion	Chairman : Les Smith
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14:15 - 16:15 Panel discussion

16:15 - 16:30 Closure of the workshop

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

SESSION 2 – DETECTING AGEING

SESSION 3 – TRENDS FOR THE FUTURE
--

SESSION 4 : PANEL DISCUSSION

D LIST OF PARTICIPANTS

BELGIUM

Mr. Luc DE MARNEFFE
Principal Engineer
TRACTEBEL
7, Avenue Ariane
B-1200 BRUSSELS

Tel: +32 2 773 81 48
Fax: +32 2 773 89 70
Eml: luc.demarneffe@tractebel.be

Mr. Roland LASUDRY
TRACTEBEL
7, Avenue Ariane
B-1200 BRUXELLES

Tel:
Fax:
Eml: roland.lasudry@tractebel.be

Mr. Pierre MIGNOT
Branch Head
Development, Analysis & Support Dept.
AIB-Vincotte Nuclear
Av. du Roi, 157
B-1190 BRUXELLES

Tel: +32 2 536 8343
Fax: +32 2 536 8585
Eml: pim@avn.be

Mr. Ir. Wim MOERMAN
Research Assistant
Magnet Laboratory for Concrete Research
(Ghent University)
Technologiepark-Zwijnaarde 9
B-9052 GENT

Tel: +32 9 264 55 23
Fax: +32 9 264 58 45
Eml: wim.moerman@rug.ac.be

Prof L. TAERWE
Magnet Laboratory for concrete research
Department of Structural Engineering
University of Ghent
Technologiepark 9
B-9052 Gent

Tel: +32 9 264 55 17
Fax: +32 9 264 58 45
Eml: luc.taerwe@rug.ac.be

CANADA

Mr. Claude SENI
MATTEC Engineering
359 Seaton Drive
Oakville
Ontario L6L 3X9

Tel: +1 (905) 827 2784
Fax: +1 (905) 827 2784
Eml: senic@istar.ca

CZECH REPUBLIC

Prof. Zdenek BITTNAR
Vice-dean for Research
Czech Technical University
Faculty of Civil Engineering
Department of Structural Mechanics
Thákurova 7

Tel: +420 (2) 2435 3869
Fax: +420 (2) 2431 0775
Eml: bittnar@fsv.cvut.cz

DENMARK

Mr. Peter Gunnar SHAW
Force Institute
Park Allé 345
DK-2605 Brøndby

Tel: +45 43 267208
Fax: +45 43 267011
Eml: psh@FORCE.dk

FRANCE

M. Bernard BASILE
FREYSSINET
1, bis rue du Petit Clamart
BP 135
78140 VELIZY

Tel: +33 1 46 01 85 09
Fax: +33 1 46 01 86 52
Eml: bbasile@freyssinet.com

Mr. Ban CHAU
Engineer
EDF-SEPTEN - Division Génie Civil
12-14 Avenue Dutriévoz
69628 Villeurbanne Cedex

Tel: +33 (0)4 72 82 77 90
Fax: +33 (0)4 72 82 77 07
Eml: ban.chau@edf.fr

Mr Jean-Baptiste DOMAGE
FREYSSINET
1, bis rue du Petit Clamart
BP 135
78140 VELIZY

Tel: +33 1 46 01 85 09
Fax: +33 1 46 01 86 52
Eml: jbdamage@freyssinet.com

Mr. Patrice GUINET
EDF SEPTEN Div. Génie Civil
12-14 Avenue Dutriévoz
69628 Villeurbanne Cedex

Tel: +33 + 33 4 72 82 71 60
Fax: +33 + 33 4 72 82 77 07
Eml: patrice.guinet@edf.fr

Mr Stephane HERPIN
EDF DTG
Lyon Monitoring center
12 rue St Sidoine
69003 LYON

Tel: +33 4 78 71 44 75
Fax: +33 4 72 33 55 49
Eml: stephane-s.herpin@edf.fr

Mr. Lionel LACROIX
Engineer
EDF - DTG - Service AO
12 Rue Saint Sidoine
69395 Lyon Cedex 3

Tel: +33 (0)4 78 71 65 57
Fax: +33 (0)4 72 33 55 49
Eml: lionel.lacroix@edf.fr

Mr. Bruno LANCIA
Directeur
Département Nucléaire et Travaux Spéciaux
FREYSSINET
141 Traverse le Mée, Bat. C6
13008 MARSEILLE

Tel: +33 (0)4 91 73 45 35
Fax: +33 (0)4 91 73 09 94
Eml: blancia@freyssinet.com

Mr. Jean Mathieu RAMBACH
DES/SAMS
CE FAR
CEA/IPSN
B.P. 6
92265 Fontenay aux Roses

Tel: +33 1 46 54 80 28
Fax: +33 1 47 46 10 14
Eml: mathieu.rambach@ipsn.fr

GERMANY

Mr. Dieter BUSCH
Junior Assistant Manager
RWE Energie AG Bereich Bau
Kruppstrasse 5
45117 ESSEN

Tel: +49 + 49 201 12 24 476
Fax: +49 + 49 201 12 22 486
Eml: dieter.busch@energie.rwe.de

Mr. Rüdiger DANISCH
Deputy Director
Civil Structures
Siemens AG, KWU NAD
P.O. Box 32 20
D-91050 ERLANGEN

Tel: +49 91 31 18 34 26
Fax: +49 91 31 18 33 74
Eml: Ruediger.Danisch@erl11.siemens.de

Mr. Peter EISERT
Gesellschaft für Anlagen-und
Reaktorsicherheit (GRS) mbH
Personalabteilung
Schwertnergasse 1
50687 Köln

Tel: +49 221 2068 741
Fax: +49 221 2068 888
Eml: eis@grs.de

Dr. Volker SCHMITZ
Head of Department Quantitative NDE
Fraunhofer IzfP
Universitaet, Geb 37
D-66123 Saarbruecken

Tel: +49 681 9 302 3870
Fax: +49 681 9 302 5930
Eml: schmitz@izfp.fhg.de

Dr. Friedhelm STANGENBERG
Stangenberg und Partner
Ingenieur-GmbH
Viktoriastrasse 47
D-44787 BOCHUM

Tel: +49 + 49 234 961300
Fax: +49 + 49 234 96130-48
Eml: spi_bochum.vo@t-online.de

GREECE

Mr Dimitris BAIRAKTARIS
BAIRAKTARIS AND ASSOCIATES LTD
Senior Partner - Technical Director
Structural Design Office
17, Pesmatzoglou Str.
145 61 Kifisia

Tel: +30 1 800 10 25
Fax: +30 1 807 99 88
Eml: baisteng@otenet.gr

HUNGARY

Mr. Oliver KAKASY
Resident Inspector
Hungarian Atomic Energy Authority
Nuclear Safety Directorate
H- 7030 NPP Paks
OAH NBI P.O.B. 71

Tel: +36 75 508 939
Fax: +36 75 311 471
Eml: kakasy@haea.gov.hu

Dr. Bela KOVACS
Head of Department
PLC for Quality Control and Innovation
in Building
H-1518 BUDAPEST, P.O.B. 69

Tel: +36 1 466 9854
Fax: +36 1 466 9854
Eml: bkovacs@mail.emi.hu

Prof. Dr. Peter LENKEI
Professor of Structural Engineering
PÉCS University, College of Engineering
H-7624 PECS
Boszorkany U.2

Tel: +36 72 224 268 ext 7237
Fax: +36 72 214 268
Eml: lenkeip@pmm.hu

Mrs. Eva SZONYI-KASZO
Researcher (Department for Structures and
CE works)
PLC for Quality Control and Innovation in
H-1518 BUDAPEST, P.O.B. 69

Tel: +36 1 466 9854
Fax: +36 1 466 9854
Eml: bkovacs@mail.emi.hu

ISRAEL

Mr. Gregory MURAVIN
Chief Scientist
Margan Physical Diagnostics
P.O. Box 8155
42160 NETANYA

Tel: +972 986 55510
Fax: +972 986 55514
Eml: margan@actcom.co.il

ITALY

Ing. Giuseppe PINO
ANPA
Department for Nuclear and Nuclear and
Radiological Risk
Via Vitaliano Brancati 48
I-00144 ROMA

Tel: +39 06 5007 2307
Fax: +39 06 5007 2292
Eml: gpino@anpa.it

KOREA (REPUBLIC OF)

Mr. Gye-hyun LEE
Principal Research Engineer
Structural Systems & Site Evaluation Dept
Safety Evaluation Division
KINS (Korea Institute of Nuclear Safety)
Kusung-dong 19-bungi, Yuseong-gu

Tel: +82 (0) 42 868 0203
Fax: +82 (0) 42 861 2535
Eml: k0791gh@kins.re.kr

NETHERLANDS

Ir. Louis VAN DER WIEL
Nuclear Safety Dept (KFD)
Ministerie van Sociale Zaken
an Werkgelegenheid (SZW)
Anna van Hannoverstraat 4,
P.O. Box 90801

Tel: +31 (0)70 3335234
Fax: +31 (0)70 3334018
Eml: Lvdwiel@minszw.nl

SLOVAKIA

Prof. Ing. Tibor JAVOR
Expertcentrum
Sulekova 8
811 06 BRATISLAVA

Tel: +421 (7) 54411738
Fax: +421 (7) 54411738
Eml: mslad@tuke.sk

SPAIN

Dr. Carmen ANDRADE
Director
Instituto de Ciencias de la
Construcción "Eduardo Torroja"
Serrano Galvache s/n - Aptdo 19 002
E-28033 Madrid

Tel: +34 91 302 0440
Fax: +34 91 302 07 00
Eml: andrade@ietcc.csic.es

Mr Juan ASENSIO
Almaraz NPP/Trillo NPP
Claudio Coello, 123
E-28006 Madrid

Tel: +34 91 431 4222
Fax: +34 91 435 7310
Eml: jav@cna.es

Mr. Jaime PALACIO
Mechanical Engineer
Geotecna Y Cimientos, S.A.
(GEOCISA)
Los Llanos de Jerez 10-12
28820 Coslada (MADRID)

Tel: +34 91 660 3104
Fax: +34 91 671 64 60
Eml: jpf-geocisa-madrid@dragados.com

Mr. Juan SABATER
Civil Engineer
C.N. ASCÓ / C.N. VANDELLÓS II
ct. n.340 km. 1123
Apartado de Correos 48
43890 L'Hopitalet de l'Infant

Tel: +34 977818700
Fax: +34977818720
Eml: jsabater@anacnv.com

Mr. Pablo ZULOAGA
Head
Construction and Projects
Department, ENRESA
Emilio Vargas 7
28043 Madrid

Tel: +34 9(1) 566 83 01
Fax: +34 9(1) 566 81 66
Eml: pzul@enresa.es

SWEDEN

Mr. Lars-Erik BERGLUND
Manager, Building Engineering
Engineering Department
Forsmarks Kraftgrupp AB
S-74203 ÖSTHAMMAR

Tel: +46 1 73 81484
Fax: +46 1 73 55116
Eml: leb@forsmark.vattenfall.se

Mr Christian BERNSTONE
Senior Researcher
Vattenfall Utveckling AB
Concrete Technology
S-814 26 Älvkarleby

Tel: +46 26 83 827
Fax: +46 26 83 630
Eml: christian.bernstone@utveckling.vattenfall.se

Dr. Arne ERIKSSON
Swedish Nuclear Power Inspectorate
(SKI)
Department of Structural Integrity
SE-106 58 STOCKHOLM

Tel: +46 (0)8 698 8695
Fax: +46 (0)8 661 9086
Eml: arne.eriksson@ski.se

Mr. Jan GUSTAVSSON
Manager Y2K Project
Ringhals Nuclear Power Plant
Vattenfall AB
Ringhals
S-430 22 VAROBACKA

Tel: +46 340 66 79 50
Fax: +46 340 66 83 89
Eml: jagu@ringhals.vattenfall.se

Mr. Jonas SVENSSON
Group Leader - Building Department
Oskarshamn Nuclear Power Plant
SE-572 83 OSKARSHAMN

Tel: +46 491 78 79 43
Fax: +46 491 78 60 38
Eml: jonas.svensson@okg.sydskraft.se

Mr. Thomas VIBERG
Building Engineer
Oskarshamn Nuclear Power Plant
SE-572 83 OSKARSHAMN

Tel: +46 78 62 05 491
Fax: +46 491 78 60 38
Eml: thomas.viberg@okg.sydskraft.se

SWITZERLAND

Mr. Daniel KLUGE
HSK
Division of Reactor Safety
CH-5232 VILLIGEN-HSK

Tel: +41 (56) 310 39 59
Fax: +41 (56) 310 38 54
Eml: kluge@hsk.psi.ch

UKRAINE

Prof. Yulii KLYMOV
State Research Institute of Building Cons
Building Construction
5/2 Kimenko str
KIEV 252680

Tel: +380 44 276 0366
Fax: +380 44 276 6269
Eml: klimov@kiev ldc.net

Mr. Volodymyr KRYTSKY
Head of Department - Struct. Int. & Stren
Ministry for Environmental Protection
and Nuclear Safety
35-37 Radgospna str.
Kyiv 03142

Tel: +380 44 452 6203
Fax: +380 44 452 6203 OR 452 8990
Eml: vb_krytskyy@sstc.kiev.ua

Dr. Olena MAYBORODA
State Scientific Tech. Centre on Nucl.&Ra
Ministry of Env. Protection&Nuclear Safet
35-37, Radgospna str
252142 KYIV

Tel: +380 44 452 62 03
Fax: +380 44 452 62 03
Eml: ee_mayboroda@sstc.kiev.ua

UNITED KINGDOM

Mr Paul FORREST
British Energy Generation (UK) Ltd
3 Redwood Crescent, Peel Park
East Kilbride G74 5PR
GLASGOW

Tel: +44 (01355)
Fax:
Eml: paul.a.forrest@snl.co.uk

Dr. Tony MCNULTY
NII, HSE
St Peter's House
Balliol Road
Bootle, Merseyside L20 3LZ

Tel: +44 151 951 3624
Fax: +44 151 951 3942
Eml: tony.mcnulty@hse.gsi.gov.uk

Dr. Leslie M. SMITH
Senior Civil Engineer
British Energy Generation (UK) Ltd
3 Redwood Crescent, Peel Park
East Kilbride G74 5PR
GLASGOW

Tel: +44 (01355) 262000
Fax: +44 (01355) 262459
Eml: les.smith@snl.co.uk

Mr. David YODAN
Regional Manager
PURE Technologies
16 Frogmore Road
Hemel Hempstead
Hertfordshire HP 3 9RW

Tel: +44 1442 437 543
Fax: +44 1442 437 551
Eml: david.youdan@soundprint.com

UNITED STATES OF AMERICA

Mr. Alan CHOCKIE
Chockie Group International
1201, Third Avenue, Suite 1790
Seattle, WA 98 101

Tel: +1 + 1 (206) 367 1908
Fax: +1 + 1 (206) 367 2205
Eml: chockie@chockiegroup.com

Dr. Herman L GRAVES
Senior Structural Engineer
US Nuclear Regulatory Commission
11545 Rockville Pike (TWFN 10L1)
North Bethesda, MD 20852

Tel: +1 301 415 5880
Fax: +1 301 415 5074
Eml: hlg1@nrc.gov

Dr. Dan NAUS
Oak Ridge National Laboratory
PV Tech Sect, Eng Tech Div
P.O. Box 2009, Bldg. 9204-1
OAK RIDGE
TN 37831-8056

Tel: +1 865 574 0657
Fax: +1 865 574 0651
Eml: djn@ornl.gov

Prof. Kwang-Chun PARK
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology
77 Massachusetts Avenue
Room 33-407A
Cambridge, MA 02139

Tel: +1 (617) 253 4519
Fax: +1 (617) 253 4196
Eml: kcpark@mit.edu

International Organisations

International Atomic Energy Agency, Vienna

Mr. Paolo CONTRI
International Atomic
Energy Agency
IAEA/NS/NSNI/ESS
Wagramerstrasse 5
P.O. Box 100 A-1400 VIENNA

Tel: +43 1 26000 26426
Fax: +43 1 26007
Eml: p.contri@iaea.org

OECD Nuclear Energy Agency, Issy-les-Moulineaux

Mr. Eric MATHET

OECD-NEA

Nuclear Safety Division

Le Seine St-Germain

12 bd des Iles

F-92130 ISSY-LES-MOULINEAUX

Tel: +33 1 4524 1057

Fax: +33 1 4524 1110

Eml: eric.mathet@oecd.org

Joint Research Centre, Petten

Dr Filippo SEVINI

European Commission

Joint Research Centre of Petten

Component ageing Sector

P.O. Box 2

1755 ZG, Petten

Tel: +31 (0)224 565 139

Fax: +31 (0)224 561 432

Eml: sevini@jrc.nl