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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2002)4
Unclassified

CNRA/CSNI WORKSHOP ON LICENSING AND OPERATING EXPERIENCE OF COMPUTER-BASED I&C SYSTEMS

SUMMARY AND CONCLUSIONS

Hluboka nad Vltavou, Czech Republic
25th-27th September, 2001

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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), Korea (12th December 1996) and the Slovak Republic (14th December 2000). 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.

COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency (NEA) is an international committee made up primarily of senior nuclear regulators. It was set up in 1989 as a forum for the exchange of information and experience among regulatory organisations and for the review of developments which could affect regulatory requirements.

The Committee is responsible for the programme of the NEA, concerning the regulation, licensing and inspection of nuclear installations. The Committee reviews developments which could affect regulatory requirements with the objective of providing members with an understanding of the motivation for new regulatory requirements under consideration and an opportunity to offer suggestions that might improve them or avoid disparities among Member Countries. In particular, the Committee reviews current practices and operating experience.

The Committee focuses primarily on power reactors and other nuclear installations currently being built and operated. It also may consider the regulatory implications of new designs of power reactors and other types of nuclear installations.

In implementing its programme, CNRA establishes co-operative mechanisms with NEA's Committee on the Safety of Nuclear Installations (CSNI), responsible for co-ordinating the activities of the Agency concerning the technical aspects of design, construction and operation of nuclear installations insofar as they affect the safety of such installations. It also co-operates with NEA's Committee on Radiation Protection and Public Health (CRPPH) and NEA's Radioactive Waste Management Committee (RWMC) on matters of common interest.

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.

CNRA/CSNI WORKSHOP ON
LICENSING AND OPERATING EXPERIENCE OF
COMPUTER-BASED I&C SYSTEMS
Hluboká nad Vltavou, Czech Republic

25th-27th September, 2001

Summary and Conclusions

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CNRA/CSNI WORKSHOP ON
LICENSING AND OPERATING EXPERIENCE OF
COMPUTER-BASED I&C SYSTEMS

EXECUTIVE SUMMARY

The OECD Workshop on Licensing and Operating Experience of Computer-Based I&C Systems, was held from 25th to 27th September, 2001, in Hluboká nad Vltavou, Czech Republic, sponsored by both the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA). It was organised in collaboration with the Czech State Office for Nuclear Safety (SÚJB), the Czech Power Board CEZ a.s., I&C Energo a.s. and the Nuclear Research Institute, Rez near Prague.

The objectives of the Workshop were to exchange the experience gained by both the regulators and the industry in different countries in the licensing and operation of computer-based I&C systems, to discuss the existing differences in their licensing approaches in various countries, to consider the safety aspects of their practical use, and to discuss the ways of promoting future international co-operation in the given area.

The scope of the Workshop included:

- review of the progress made since the CNRA/CSNI workshop which was held in 1996
- current and future regulatory needs and/or requirements for the computer-based I&C systems
- progress made in software life cycle activities, including verification and validation, and safety/hazards analysis
- benefits of applying the computer-based I&C systems to improve plant performance and safety.

The Technical Sessions and Discussion Sessions covered the following topics:

Opening Session: Advances made in the use and planning of computer-based I&C systems
Topic 1: National and international standards and guides for computer-based safety systems
Topic 2: Regulatory aspects
Topic 3: Analysis and assessment of digital I&C systems
Topic 4: Software life cycle activities
Topic 4: Experience with applications, system aspects, potential limits and future trends and needs
Final Session: Workshop summary.

The workshop provided a unique opportunity for people with experience in licensing, developing, manufacturing, implementing, maintaining or researching computer-based systems important to safety to get together and to discuss their insights learned from their actual activities. The Workshop was successful in this point. It was attended by 65 people from 15 countries and by 2 international organizations.

Progress since the previous workshop

At the first workshop the basic concern was whether it is possible to safely implement and operate software-based systems in nuclear power plants. During the 5 years following the first OECD workshop, computer-based I&C systems have been installed and operated in both safety and non-safety systems in a number of nuclear plants all over the world. These countries have developed the systems in their own manner and universal measures to implement computer-based safety systems have not yet been obtained. This status has not changed since the previous Workshop. In parallel, the nuclear industry (consisting of the utilities, vendors, designers, and constructors) and the regulators have universally reached a somewhat stable state in addressing the issues and concerns which were identified during that first workshop. This state was achieved by accepting, in principle, that a computer-based safety system designed, implemented and reviewed based on a structured life-cycle process would provide an acceptable safety system.

The life cycle processes adopted by most of the countries are based on the requirements of national or international standards which have similar structures and methodologies. The process consists of a series of hardware- and software- related activities including design, review, tests, verification and validation, configuration management, safety analyses, and associated documentation.

In comparison with the last meeting, it is evident that great progress has been made in the application of digital computer-based I&C systems. At the same time, it was reported in several papers that new problems had emerged during these five years, for example, COTS, certification of software, obsolescence of digital spare parts, re-classification of some computer-based systems (for example, overall plant computer that controls main control panels or consoles), regulatory efficiency and effectiveness on computer-based systems important to safety, etc. Future problems from the regulatory point of view refer to both the adoption of the established qualification methods for software-based I&C systems to new developments in software technology and to the improvement of the licensing procedures.

As the progress of digital technology is very rapid from day to day, there is a need to continue following the progress of digital technology and surveying the measures for application with accumulating operating experience of previous installations. Collecting and evaluating operational experience of computer-based systems as initiated by the CSNI Task Force on Computer-Based Control Systems Important to Safety (COMPSIS) will be essential for the evaluation of reliability characteristics of such systems and devices.

Findings and Recommendations

The purpose of this Workshop was to recognize the progress of technology concerning the items that the previous Workshop and the CNRA Special Issue Meeting had indicated.

In this context, the insight from this Workshop can be summarized as follows:

Complexity: The complexity of functions required of the modern computer systems and its basic elements (cpu, graphic tools, compilers, etc.,) is increasing with technological advances. As a consequence, there are two diverging trends which need to be addressed - added functionality and capability of the system versus verifying that adequate safety is maintained. Methodologies for demonstrating software safety, including the issue of verification and validation are still controversial.

Reliability: Many papers indicated that simplicity was most important to assure the reliability of computer-based systems important to safety, but did not indicate "how simple is simple enough for safety application". At the same time, some analytical approaches were introduced but did not succeed in showing quantitative values. This status has been left unchanged since the previous Workshop. International co-operation should help in obtaining the analytical measures.

Diversity: The functional diversity is considered in most of the applications which were presented at this Workshop, while some indicated other digital diverse systems.

Digital technology evolution**:** The rapid pace of the digital technology evolution has identified the need for addressing obsolescence of components, equipment, and tools; consideration of spare parts, human resources and expertise for operating and maintaining NPP digital systems for the life of the systems. Suggestions made at the workshop, such as sharing resources and knowledge base through some vehicles like Owner's Groups, are worthy of consideration.

International and national standards: Considerable progress has been achieved on this issue. Many international standards and guides covering software lifecycle were developed and revised during these five years, while many countries have developed their own standards or guides.
Some people felt that there are too many standards that are often complex, inconsistent, and misleading. As stated in the papers at this workshop, the various standards committees are aware of these shortcomings and co-ordination activities between the various national and international standards organizations have been initiated. Such efforts should be encouraged so that the fundamental requirements and acceptance criteria for all computer system life-cycle activities in both national and international standards are clear and consistent.

Independent V&V: All of the presentations related to this issue indicated that they followed the similar style of V&V as the ones endorsed in IEC 880 and also reported that it cost too much time and human resources, with a large amount of documentation. Meanwhile, many approaches on independent V&V were reported but the insights on the degree of independence were divided. It seems difficult to reach a general consensus on the degree of independence. In particular, the independent V&V performed in NPP Temelin gave the impression that "independence" is a very costly and time-consuming activity. It seems that we stand at a turning point, that is, which way should we adopt. One way is to produce a complex system and to perform cost-ineffective independent V&V on it. The other is to pursue simplicity that does not need to perform independent V&V. For some systems, such as French SPIN/SPINELINE3, German Teleperm-XS, Japanese POL, and American Eagle it was shown that they have been already verified and moved to the stage of design certification or product certification for reuse in safety application. The

approach "Independent V&V for first application and certification of design or product for second use" is expected.

***Maintaining human competencies*:** An area of concern expressed during the workshop was that the human resources and competencies necessary to maintain the current computer-based safety and non-safety systems is not likely be available in the near future. Most of the participants agreed that addressing the problem on human resources is essentially important as well as the development of safety critical digital systems. Methods and policies for retaining the knowledge, expertise and competencies should be initiated in the industry and regulatory bodies.

COTS, PDS, PES: The use of commercial off-the-shelf (COTS) products, previously developed software (PDS), and previously existing software (PES) and other legacy systems in safety system applications is an issue that was identified as an immediate concern. Standards addressing the requirements and acceptance criteria and detailed guidance on how to implement them in a manner that is internationally applicable are needed immediately.

Conclusion

As a general conclusion, the Workshop can be considered representative of the progress made towards reaching the targets set at the Munich workshop almost five years ago. The Munich workshop had identified areas where further development and specific improvements were needed. The Hluboka workshop has reviewed the development achieved since then. Based on the papers presented at this workshop and on the discussions by the workshop participants, it is evident that the details of the life-cycle activities and the associated acceptance criteria are still in flux and have yet to be universally acceptable. The basic trends from Munich still hold and are reaffirmed in the frame of evolving regulatory and commercial environments.

Future international co-operation should strive to reach universally acceptable positions in the above areas.

OECD/CSNI WORKSHOP ON
LICENSING AND OPERATING EXPERIENCE OF
COMPUTER-BASED I&C SYSTEMS

MEETING SUMMARY

Sponsorship

The OECD Workshop on **Licensing and Operating Experience of Computer-Based I&C Systems,** was held from 25h to 27th September, 2001, in Hluboká nad Vltavou, Czech Republic, it was sponsored by both the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA). It was organised in collaboration with the Czech State Office for Nuclear Safety (SÚJB), the Czech Power Board CEZ a.s., and I&C Energo a.s.

2. Background:

In March 1996 the CNRA and CSNI organised a Workshop on Technical Support for Licensing Issues of Computer-Based Systems Important to Safety. The workshop was hosted by GRS/ISTec in Munich, Germany. The main purpose of the Workshop was to provide a forum for the exchange of information on the technical issues of computer-based systems important to safety. In June 1996 there was a joint CNRA/CSNI Special Issue meeting to discuss the technical support required for licensing issues of computer-based systems important to safety, utilising the results of the workshop. Follow-up activities were discussed at the December 1996 annual meetings of the CNRA and CSNI. Both meetings confirmed the general recommendations of the workshop, such as:

- Digital systems can be used in safety systems provided that they meet local regulatory requirements
- A wide spectrum of licensing approaches exists
- Further co-operation between the regulatory bodies is necessary to understand the regulatory basis for differences
- It is important to collect information on actual experience in utilising software systems.

In response to the CSNI and CNRA annual meetings in 1996, a Task Group on Computer-Based Systems Important to Safety was established under the CSNI Working Group on Operating Experience. The Task Group has developed a database (COMPSIS) on operational experience related to computer-based systems and follows up on the state of knowledge on the issues. Also, a guideline document, NEA/CSNI/R(99)14 "COMPSIS, Computer-based Systems Important to Safety, Reporting Guidelines", was issued in 1999. The data collection has already been initiated by the Task Group under a trial experiment.

The use of digital systems in NPPs is expanding rapidly. As this technology improves, more and more of these systems are being installed at existing and new plants. The most extensive applications of digital I&C systems have been made at the Darlington NPP in Canada, Sizewell B NPP in the UK, Chooz B1 (France), Kashiwazaki-Kariva 6,7 in Japan, Wolsong 2,3,4 (Korea) and Temelin NPP in the Czech

Republic. Recently, partial refurbishment of the obsolete I&C systems at some VVERs, e.g. Bohunice 1,2 (Slovakia) or Paksh 1,2 (Hungary) by digital ones was done, as well.

At the present time, there is generally a greater experience with computer-based I&C systems on both sides, the industry and among regulators, than there was five years ago. Progress has also been made in developing international regulatory guides and recommendations related to the digital I&C systems.

Based on the progress made in the development of digital I&C systems in recent years and their practical applications in many NPPs in NEA member states, the two committees, CNRA and CSNI, decided to organise a joint CNRA/CSNI Workshop in the second half of 2001 on "Licensing and Operating Experience of Computer-Based Systems Important to Safety", as a follow-up to the one which was held in 1996. The purpose was to exchange the experience gained by both the regulators and the industry in different countries in the licensing and operation of computer-based I&C systems, to discuss the existing differences in their licensing approaches in various countries, to consider the safety aspects of their practical use and to discuss the ways of future international co-operation in the given area.

3. Scope and Technical Content of the Workshop

The scope of the Workshop included:

- review of the progress made since the CNRA/CSNI workshop in 1996
- current and future regulatory needs and/or requirements for the computer-based I&C systems
- progress made in software life cycle activities, including verification and validation, and safety/hazards analysis
- benefits of applying the computer-based I&C systems to improve plant performance and safety.

The Technical Content of the Workshop included:

Opening Session: Advances made in the use and planning of computer-based I&C systems
Topic 1: National and international standards and guides for computer-based safety systems
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Topic 3: Analysis and assessment of digital I&C systems
Topic 4: Software life cycle activities
Topic 4: Experience with applications, system aspects, potential limits and future trends and needs
Final Session: Workshop summary.

In general terms, the Workshop attempted to give answers to questions in the following areas:

- What are the benefits of using computer-based I&C systems?
- What national and international standards and guidance could be universally acceptable from the safety perspective?
- What are the regulatory requirements for the current and future generations of digital I&C systems?
- What are the major technical issues and challenges associated with applications of digital technology in I&C systems?

4. Programme Committee of the Workshop

For the preparation of the workshop, its agenda and all the other organisational aspects, the existing CSNI Task Force on Computer-Based Control Systems Important to Safety (COMPSIS) set up the core of the workshop Programme Committee (PC). It was the responsibility of the Programme Committee to evaluate the abstracts of the proposed papers, select the papers for presentation, organise the Sessions, develop the final programme of the workshop, appoint the Session Chairmen, etc. The members of the Programme Committee were:

Mr. Jean-Paul BOUARD, EdF, France
Mr. Matthew CHIRAMAL, NRC, USA ,(COMPSIS Chairman)
Mr. Pierre J. COURTOIS, AVN, Belgium
Mr. Gustav DAHLL, OECD Halden Project
Mr. Karoly HAMAR , HAEC, Hungary
Mr. Hartmuth HEINSOHN, GRS, Germany
Dr. Marja-Leena JÄRVINEN, STUK, Finland
Mr. Karel KRIZEK, CEZ a.s., Czech Republic
Mr. Petr KRS, SÚJB, Czech Republic (PC Chairman)
Dr. Arndt LINDNER, ISTec, Germany
Mr. Bo LIWÅNG , SKI, Sweden
Mr. Zen-ichi OGISO, NUPEC, Japan
Mme. Brigitte SOUBIES , DSIN, France
Prof. Björn WAHLSTRÖM, VTT, Finland
Mr. Bob Yates, NII, United Kingdom
Mr. Miroslav Hrehor, OECD/NEA, (Scientific Secretary).

On the occasion of the Workshop there was an opportunity for participants to visit NPP Temelin with its VVER-1000 reactors equipped with the Westinghouse's digital I&C system.

OPENING SESSION : ADVANCES MADE IN THE USE AND PLANNING OF COMPUTER-BASED I&C SYSTEMS

Session Chairmen: M. Chiramal, P. Krs

Electricité de France Experience of computer-based I&C systems

Poizat Francois, EdF , France

The presentation focused on the experience gained by EdF in the transition from the electro-magnetic relay-based analog I&C systems in the 34 900 Mwe NPP units (commissioned during 1977 to 1983) to the first digital integrated protection system (SPIN) based on Motorola 6800 microprocessors in the 20 1300 Mwe P4 ad P'4 units (1984 - 1991) to the fully computerized I&C system in the 4 1450 Mwe N4 units (1997) in which the protection system (SPIN), control systems (Contronic E and uREC), control room (KIC) including plant operating procedures are computerized.
To revamping/refurbishment of the steam generator level control system, and the nuclear instrumentation system at the oldest 900 Mwe units during 1998 -99.

The presentation traced these changes, discussed the problems encountered, and the lessons learned. As NPPs trend towards more computerization and reliance on digital components, consideration should be given to the short life cycles of these products and difficult-to-maintain software skills. The presentation concluded that the trend towards the use of COTS to develop NPP I&C systems is a viable solution, provided that safety requirements are met in a cost-effective manner.

The Evaluation on Applying the Digital Safety System to Existing PWR Plants in Japan

Yoichi Mito, The Kansai EP Co., Inc.
Masafumi Utsumi, Mitsubishi HI Ltd., Japan

The presentation addressed the problem now facing the Japanese nuclear power plants of aging, obsolescence, and the high cost of maintenance of conventional analog I&C system components and equipment. The industry is studying and developing long-range plans for systematic maintenance and replacement of the analog I&C components and equipment. The latest generation of NPPs in Japan are designed with digital safety and non-safety I&C systems. The study considers the differences between the existing plants and the new plants in the area of system safety functions, redundant architecture, interfaces. Included in the study is the consideration of upgrading the main control room boards with advanced computer-based Human-machine Interface systems.

Independent Assessment of the Temelín Safety System Software

Petr Závodský, CEZ a.s., Czech Republic

The presentation covered the activities carried out by Data System and Solutions LLC (DSAS), under contract to the utility CEZ , for the independent assessment (IA) of the Temelin Plant's safety I&C system software.

The I&C system for the Temelin Nuclear Power Plant was designed and implemented by Westinghouse Electric Co. Westinghouse had performed independent verification and validation of the safety I&C system software in accordance with the requirements of standards IEC-880/1986, IEEE Std. 7-4.3.2/1993,

ANSI NQA-2a/1990 Part 2.7. In addition, to provide confidence in the integrity of the safey system software, SUJB required that independent assessment be performed on the safety system software that included independent verification and confirmation that the software design met the requirements of the standards, and an independent review and evaluation of the system software.The presentation included accounts of the following tasks performed by DSAS and its sub-contractors, and the lessons learned from these activities:

Independent audit of the software development process
Assessment of system software tools
Verification of system and software requirements
Verification of software design
Static analysis of source code
Dynamic testing
Assessment of system common mode
Verification and validation of configuration and calibration data

Based on the IA program it was concluded that there were no findings to undermine the confidence in the quality of the software design implementation process and the system software, and that the processes used by Westinghouse were generally in compliance with the requirements of the reference standards.

Regulatory Review of the Digital Plant Protection System for Korea Next Generation Reactor
D. I. Kim, B. R. Kim and S. H. Oh,
Korea Institute of Nuclear Safety

The presentation provided the regulatory review approach and results of an interim evaluation by the KINS staff with regard to the review of the standard safety analysis report of the Korea Next Generation Reactor (KNGR -AP1400).
The review raised new issues related to the system architecture of the KNGR digital plant protection system (DPPS) regarding the integration of the DPPS bistable processor and the local coincidence logic processor in each of the redundant protection channels. Another item of concern identified is the use of soft controllers in the plant digital engineered safety features actuation system (DESFAS) and the classification and qualification of such controls. The presentation also provided details the of defense-in-depth and diversity analysis for the postulated common mode/cause failure of software, and of the design of the diverse manual controls for DPPS and DESFAS.

Decision Support for Approval of Safety Critical Programmable Systems
Gustav Dahll, Bjørn Axel Gran, OECD Halden Reactor Project
Bo Liwång, Swedish Nuclear Power Inspectorate

The subject of the presentation was the application practices of the three principles of licensing and regulatory requirements - rule-based, consensus-based, and risk-based - as they pertain to software-based NPP I&C systems. The Swedish nuclear regulatory body is drafting a new inspection handbook, where these principles are applied to the lifecycle activities of the software-based system. The presentation provided a methodology for systematically combining the three principles using Bayesian Belief Nets. An experimental study that used the BBN method in combination with a software safety standard was applied to a safety critical software-based system - a computerized system for aiding helicopter landing in various locations during rescue operation. The project consisting of several tasks was discussed during the presentation.

TECHNICAL SESSION 1: NATIONAL AND INTERNATIONAL STANDARDS FOR COMPUTER-BASED SAFETY SYSTEMS AND GUIDES

Session Chairmen*:* J.P. Bouard, Z. Ogiso

International Standardisation in Nuclear I&C Engineering

Bouard Jean-Paul, EdF, France

The presentation on international standardisation in nuclear I&C, first introduced the global context and the international and regional relationships developed by the International Electrotechnical Commission (IEC), which, together with the International Standards Organisation (ISO) are responsible for the preparation and maintenance of many of the world's International Standards. Then it focuses on standardisation in the nuclear instrumentation and control sector and highlights the work currently being done within IEC SC45A (Instrumentation reactor). More particularly, on projects dealing with software for computer in the safety systems of NPP, classification, the sector translation of the generic standards for the nuclear domain.

Comparison of IEC and IEEE Standards for Computer-Based Control Systems Important to Safety

Gary Johnson, Lawrence Livermore National Laboratory, USA

The presentation comparing IEC and IEEE (Institute of Electrical and Electronics Engineers) standards, recognises that, if in the past the IEC and IEEE developed two sets of standards for I&C used in NPP, today, due to the shrinking of the market, the nuclear business is a global one and thus in this environment the harmonisation of the activities of these two bodies is vital. The contents of the two sets of standards are surveyed and opportunities to improve consistency between the two sets are identified.

The New IAEA Safety Guide and the Common Position of European Regulators on Software for Systems Important to Safety

Courtois Pierre-Jacques, Association Vinçotte Nuclear, Belgium

The presentation introducing the new IAEA safety guide on software important to safety and the European report on the common position of European regulators on the same subject gave an overview of some of the distinctive aspects of those two international documents which provide guidance on the design and licensing of computer based systems. It focused on their coherence and complementarities, on their strong and original points and on the issues left open.

Approach to the Application of the State Requirements, Legislation and Standards in Modernization of I&C Systems, Concerning Especially the Digital Computer-Based Systems
J. Zatloukal, P. Krakora, NRI Rez, Czech Republic

The licensing base for computer-based systems important to safety in NPP Temelin and NPP Dukovany was introduced in this presentation. The regulatory requirements for NPP Temelin were based on the US standards related to computer-based safety systems. The adoption of US standards came from the fact that Czech standards were addressed only to analog systems and not to the digital systems at the time when digital safety systems in NPP Temelin were decided to be adopted and subsequently US standards were introduced with the adopted digital system. Meanwhile, the regulatory requirements for NPP Dukovany were based on the Czech standards namely, "Set of USJB Positions" which was developed as the licensing base for implementation of digital safety systems. The licensing stage for digital safety systems in NPP Dukovany is still under way.

Standard Base for Regulatory Activity in NPP I&C Systems Area
M. Yastrebenetsky, V. Goldrin, Yu. Rozen, S. Vinogradskaya
State Scientific Technical Center on Nuclear and Radiation Safety, Ukraine

The standard base for regulation on digital I&C systems in Ukraine NPP was introduced, together with some samples of digital systems. The Ukraine standards are basically based on 3 dominant documents but these were harmonized with international standards and some foreign national standards. The criteria for digital application in I&C systems and the main features of the assessment methods for compliance with the criteria were also introduced.

During the **panel session** some important points were brought up:

First, the ***complexity of modern basic components*** (micro processors, compilers, graphic tools etc.) and the power of the tools used for safety demonstration of computer based systems (CBS) are increasing. Those two antagonist trends maintain the situation of balanced nuclear safety when introducing CBS in NPP. Today, as always, the absolute demonstration of safety of software is out of reach, the V&V of CBS is still an open and controversial question. Over the past ten years, CBS have been introduced in many NPPs in numerous countries without any major problems. This introduction was done using basic design rules (determinism proven by design, restricted use of component, rigorous QA…) to use generic component and it appears that this sound approach can be used and trusted to face the accelerating evolution of IT.

Secondly, the ***international context of standardisation*** is deemed to be complex, misleading and even disconcerting. Co-ordination between the different bodies would be valuable. In a first step the inconsistencies should be identified, a roadmap proposing the way to deal with them could be drawn. The responsibilities and relationships between the different bodies should be clearly defined.

Finally the problem of ***maintaining human competencies*** was raised. It appeared during the debate that there was no general consensus to answer that question and to guarantee that the skills necessary for the maintenance, the licensing activities related to the modifications concerning the CBS currently in operation will be there in the future. Nevertheless, some examples of measures taken by industrial companies are given based on defining long term contract to address the problem or in recruiting staff in different domain, automation for example and training them to IT.

TECHNICAL SESSION 2 REGULATORY ASPECTS

Session Chairmen: A. Lindner, K. Hamar

In the Technical Session 2 “Regulatory Aspects” four papers were presented. They dealt with the different aspects of regulations for digital safety I&C. The first paper describes the activities and the status of the generic pre-qualification of a digital platform, the second one includes an approach to investigate several licensing procedures and to derive from this investigation improved licensing procedures, the third paper deals with the collection of data from the operational experience of computer-based I&C systems and the last one describes digital projects in Hungary and their consequences with respect to safety regulation.

Pre-Qualification of Digital Platform – U.S. NRC Regulatory Review of the Common Q Platform

W. K. Mortensen, M. Chiramal

The Common Q platform is a computer system consisting of a set of commercial-grade hardware and previously developed software components dedicated and qualified for use in nuclear power plants. The Common Q platform is to be loaded with plant-specific application software to implement various nuclear plant safety system applications. The basis of pre-qualification is compliance with the NRC-approved EPRI Topical Report TR-106439, "Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications". The NRC staff reviewed the basic operation of the system, life cycle process and documentation associated with the Common Q hardware and software. The procedure was introduced by the lecturer as a type testing procedure, where the outcome also declares legal statements about the compliance with key requirements in the US, 10CFR50 appendix “B”, about quality assurance. The staff has completed the review of the qualification of nearly all of the Common Q platform components and the staff’s evaluation of the completed activities has been documented in the safety evaluation report (SER) issued on August 11, 2000.

Survey and Evaluation of Digital I&C Licensing Experience

Swu Yih, Chin-Feng Fan, Chan-Fu Chuang

This paper describes the licensing experiences of digital I&C systems based on USNRC regulations for Taiwan’s fourth NPP (Lungmen Project). The contents consist of three parts. In the first part, it is described how the licensing process was conducted, how the licensing strategy was adopted, and how the manufacturers, utility, consultant companies and regulators interact. Some statistics of licensing- related activities and events listed in chronological order are also presented to help understand the scope and complexity of this licensing. In the second part, the paper describes an in-depth analysis of USNRC digital I&C regulations. The internal logical structure, strengths and weaknesses of those regulatory codes, guides, and standards are investigated to identify the efficiency shaping factors. In the third part, modifications are proposed for the current regulation structure and regulation practice. These modifications may improve the current digital I&C licensing efficiency and effectiveness. There was a presentation of a licensing process model which can be used to evaluate the effectiveness of different licensing approaches. The original USNRC regulations and proposed modifications are then evaluated under this model to show the improvement of efficiency.

Collecting Data from Operational Experience of Computer-Based I&C Systems – A Regulatory Perspective on Goals and Tasks
G. Schnürer, F. Seidel

The paper deals with the methods and goals of the collection of data from computer-based I&C systems which are developed, qualified and maintained using a unique platform. The main goal of the data collection is to contribute to the further qualification of these systems by the evaluation and optimization of the qualification procedure, demonstration of the achieved systems' dependability and utilizing the experience of the system applications of lower safety significance within the licensing procedure for computer-based systems important to safety. The content of the records and the evaluation methods for operational experience should have been agreed by the involved experts of the licensees, manufacturers, technical support organizations and regulatory bodies. Not only the failures and the reported events are of interest, but also periods of operation without significant failures. As a long-term goal of the collection of operational experience, the achieved performance of the system might be estimated in quantitative terms. To calculate the reliability, it is crucial to establish an evaluation model in order to identify the necessary parameters as early as possible and to collect them continuously during the operation.

Digital Projects In The Near Past And Their Consequences In Safety Regulations In Hungary
K. Hamar

The paper describes from the regulatory point of view the operational experiences with digital I&C systems in Hungary. There are systems with different importance to safety used like reactor protection systems, core monitoring systems, process computers and others. Errors and problems of the digital systems and related components are listed. The lecturer emphasises the great importance of type testing for the successful licensing of the Teleperm XS system as a reactor protection system for the NPP Paks. From the ongoing licensing processes it can been seen that qualification of class "B" (following IEC 61226) may be more difficult, because of more complex static and dynamic system properties of class "B" systems. As the most important system property, the deterministic behaviour is identified. The existing experiences will be addressed in the new Hungarian safety regulations.

Discussions and Conclusions, Session 2:

During the discussion of the papers, questions regarding some of the details of the presentations were dealt with. In particular, several aspects of the model for the licensing process, presented in the second paper, were discussed. Establishing a model of the licensing process seems to be an interesting approach, but further work is necessary.

Compared to the last meeting in 1996 in Munich the great progress in the application of digital computer-based I&C systems was evident. Future problems from the regulatory point of view refer to both the adoption of the established qualification methods for software-based I&C systems to new developments in software technology and to the improvement of the licensing procedures. Collecting and evaluation of operational experience of computer-based systems will be helpful for the evaluation of reliability characteristics of such systems and devices.

The following conclusions could be drawn:

1. Type testing is an important and desired institution in licensing, beneficial for licensees, and regulatory bodies, and hopefully for developers and manufacturers, too.

2. The efficiency of the licensing process may promote or suppress the utilization of digital technology.

3. The regulator behaves as a transformer between the ”evidence” and the “confidence”.

4. The conservative approach is still present in the licensing, and the licensees and the developers are not satisfied with it. They are waiting for relaxation, and searching for the feasible techniques to support it.

5. Safety is manifest in a set of system properties, like deterministic behaviour, constant system load, simplicity, transparency, etc. At the same time, these are the “easy to license” system properties. The simplicity is in contradiction with nearly all of the another system characteristics: functionality, testability, diversity.

6. The SW reliability data collection suffers that loss, if the reported events and error cases are dependent on the licensee event reporting systems. If reporting criteria do not meet, the result is that the statistically valuable cases remain hidden.

7. From the aspect of data collection efficiency, the comparable operational profile and the unique platforms are desired.

TECHNICAL SESSION 3 ANALYSIS AND ASSESSMENT OF DIGITAL I&C SYSTEMS
Session Chairmen: M.L. Järvinen, M. Kersken

The following five papers were presented:

Preliminary Evaluation of computerized procedure from safety viewpoints
Yun H. Chung, Sung N. Choi, Bok R. Kim, KINS

The paper presents the preliminary safety assessment made to the Computerized Procedure Systems (CPS) to be implemented at the Korean Next Generation Reactor, which is planned to start commercial operation in 2010. The computer-based procedures are being used at various nuclear power plants. This change can support and enhance the operators' performance and safety. However there are safety issues which should be discussed when implementing these systems such as the impact on operators and shift performance, situation assessment and response planning, handling of complex situations particularly in failures of the CPS and change over to paper-based procedures, design for navigation and communication and software quality. The paper presents the preliminary assessment results.

Modernization of the I&C system for ANP Dukovany by the use of computer-based equipment

Jean Pierre Burel, Schneider El., F. Dalik, K. Wagner, M. Říš, ŠKODA
Jean-Paul Mauduit, Framatome-ANP

The paper describes the replacement of existing systems important to safety (category A and B) by computer based systems which are realized by SPINELINE 3 technology. Special parts of the system are units executing functions connected directly with the VVER reactor technology; these are developed by means of an industrial microcomputer-based system as used by Skoda. The features of SPINLINE 3 and Skoda technology are described with emphasis on their contribution to safety.

FMEA performed on the SPINLINE 3 operational system software as part of the Tihange 1 NIS refurbishment safety case

L. Ristord, C.Esmenjaud, Schneider El. Industries

The paper presents the FMEA analysis made for the new Tihange 1 Nuclear Instrumentation System which became operational in March 2001. The choice of the software based technology raised the issue of the risk of a CCF due to the use of the same software in redundant independent units. In addition to the demonstration of the application of the safety requirements for the software in safety systems, a FMEA oriented towards the significant CCF risk was required as part of the safety case. The paper presents the FMEA experience, including the adaptation of the principles of FMEA to the analyses of the software, an approach to identify the components to be analyzed, definitions of the software failure modes associated with the components, examples of the analyses performed on the operational system software and feedback of the experience. Performing the FMEA has proven to be a good way to discuss in depth safety aspects of software based systems.

Qualification of pre-developed software for safety-critical I&C application in NPP's

M. Kersken, ISTec Garching

Implementation of I&C functions important to safety in nuclear power plants are increasingly realized with computer-based systems, i.e. by its software. These so called equipment families are often used to develop these I&C functions. Extensive research work has been made, mainly during last ten years, to tackle the problem of qualifying pre-developed software to be included in the systems important to safety. Due to the great variety of software types and differences in the applications, no unique solution has yet been developed. The objective of the paper is to provide a set of staggered criteria for the qualification of pre-developed software to be used in different categories for the safety critical I&C. An attempt is made to demonstrate an exemplary procedure as to how the different approaches can be brought together, to form a useable set of staggered criteria for the acceptance of the pre-developed software. The first examples show that there will be no principal difficulty for a unified approach, because there are no major contradictions in the requirements or recommendations of the analyzed documents. The acceptance of such a unified procedure, however, needs the involvement of a broad international group of experts.

A Bayesian approach to risk informed performance based regulation for digital I&C QA programs

Swu Yih, Sun-Li Chyou, Li-Sing Wang, AEC INER,
Chin-Feng Fan, Yuan-Ze University

A proposal for a systematic way to reduce unnecessary conservatism in regulatory processes is given. Bayesian Belief Networks BBN are applied as a modelling technique to describe the assessment processes as e.g. independent V&V.
The method first enumerates major influence factors, and constructs the BBN for system risk; an event tree based on same influence factors is then generated. Tree trimming is performed to delete the impossible branches and thus control the exponentially explosive problem in the event tree construction. The numbers of occurrences of final outcomes of the tree are then counted to draw the risk profile graph. The graph can help in identifying the potential areas of unnecessary conservatism. It can also help in determining whether the resulting outcomes of proposed QA program changes are acceptable or not.

Conclusions from session 3

As can be seen from these topics, the session comprised a quite large variety of analysis techniques which can be applied to computer-based systems in I&C important to safety. These reached from review and evaluation of computerized operating procedures for future reactors (Korea) to constructive and analytical techniques which are applied at the moment during the replacement of systems important to safety in an actual plant (Czech Republic). The application of FMEA to computer based technology (Belgium), especially to software, is quite innovative, and has been used in a safety demonstration to show low risk of common cause failure due to software.

A practical systematic approach for an acceptance procedure for pre-developed software was proposed. This approach was based on widely discussed international documents concerning this topic. Another proposal which dealt with the assessment of the effectiveness of regulation procedures based on modeling via Bayesian Belief Networks is highly interesting, because this may be a sound basis for directing the limited resources which can be spent during the development and safety demonstration of computer-based systems important to safety into the most effective combination of techniques which should be applied.

The session did not focus so much on an independent verification and validation IV&V. Discussions after this and other sessions showed, however, that IV&V has an important role in the safety demonstration, but

the focus and methods can still be further developed. The application of different tools and methods - as against those which are used in V&V during development – can bring additional assurance to the safety demonstration. The use of pre-qualified software and the associated IV&V can be one of the ways of reducing the costs of the safety demonstrations. Also in this area future work is needed in the international community.

With respect to this variety of techniques which were presented in the session and their actual or envisaged application in the near future, the session reflects an image of the whole workshop. In most of the sessions there were possibilities to exchange experience of applying well known constructive and analytical techniques to actual implementations of computer based technology. Other contributions, however, were more directed towards opening the door for new applications by providing proposals for their assessment. This mixture of direct application-oriented presentations on the one hand and others oriented towards the near future on the other side, made the workshop very valuable for the experts working in the field of I&C important to safety.

The information also provided new guides and standards for computer-based technology important to safety, which was very helpful, because this gives a better feeling of the internationally agreed principal regulatory requirements.

TECHNICAL SESSION 4: SOFTWARE LIFE CYCLE ACTIVITIES

Session Chairmen: G. Dahl , F. Krizek

The overall theme of the session was the description of the V&V methods used in the licensing process for NPPs. This includes both the methods which have been used and methods planned to be used in NPPs in Taiwan, the Czech Republic and Ukraine. Four papers were presented:

Implementation of Software Independent Verification and Validation for Lungmen Distributed Control and Information Systems
Jiin-Ming Lin, Jeen-Yee Lee, Taiwan Power Company

Static Analysis of the Software Used in Safety Critical System of the NPP Temelin
Piroutek Z., Roubal S., Rubek J., I & C Energo a.s., Czech republic

Assessment Methodology of the Temelin NPPControl System Performance and Quality
Ivan Petruzela, Karel Bednarík, CEZ a.s., Czech republic

Methodology of NPP I&C System Algorithms and Software Expert Analysis
V.S. Kharchenko, L.M. Lyubchik, M.A., Yastrebenetsky State Scientific Technical Center on Nuclear and Radiation Safety, Ukraine

The first paper, presented by Jeen-Yee Lee from Taiwan Power Company (TPC), dealt with the implementation of the software independent verification and validation (IV&V) for the Distributed Control & Information Systems of the Lungmen NPP. It covered the codes and standards as applicable, the scope of the software IV&V and the documents reviewed, the organisational structure and activities for performing the IV&V work. Teams from GE and TPC performed software V&V for the Lungmen project, based on the USNRC Standard Review Plan Chapter 7, BTP-14 and USNRC Regulatory Guide 1.168 respectively. Two recommendations for performing future software IV&V activities can be made on the basis of the experiences so far. One is to fully understand the regulatory requirements on software IV&V before an IV&V project gets started. The other is to establish a tracking system for IV&V activities in IV&V project to facilitate control and monitoring of the issues identified.

The next two papers described the methods used in the evaluation of safety critical software at the Temelin NPP. The first paper, presented by J. Rubek from I & C Energo s.r.o, gave an overview over the static analysis methods used in this process. The method used was influenced by the one used for the licensing of the Sizewell B protection system, although it is not a direct copy. For the analysis they used the tool MALPAS for analysis of control flow, data use, information flow and semantic compliance. The approach used was cost consuming, but made it possible to discover software anomalies which could be not found in manual check.

In the other Temelin paper, presented by I. Petruzela, also from I & C Energo, described assessment methodology of the control system performance and quality. A methodology has been developed in I&C

Energo for the test assessment of the control process quality. This is based on the evaluation of the behaviour of the main controlled quantities in the course of transients of the test. A set of criteria is defined which serve to check the performance of the Temelín NPP unit control against the design. They determine the borders of the area in which the numeric values of the assessed parameters should vary if the work is made in compliance with the design. The fulfillment of the criteria makes it possible to determine the achieved quality of the NPP Temelín unit major controllers after the completed test.

The fourth paper, presented by V. Kharchenko from the State Scientific and Technical Center on Nuclear and Radiation Safety in Ukraine, described a methodology for verification and validation and expert analysis of algorithms and software in I&C systems. The method was approved for application in Ukrainian NPP, and was in particular applied during the evaluation of the computer-based control system ASUT-1000M for Zaporozhey NPP.

These papers gave a valuable contribution to the workshop as they presented methods actually applied in the licensing of safety critical I&C systems in different NPPs, and that they cover complementary aspects of the licensing process, from general principles to more detailed techniques.

TECHNICAL SESSION 5 EXPERIENCE WITH APPLICATIONS, ASPECTS, POTENTIAL SYSTEM LIMITS AND FUTURE TRENDS AND NEEDS

Session Chairmen: B. Liwång, M. Hrehor

Operating Experience of Digital Safety-Related System of Kashiwazaki-Kariwa Unit No. 6 and 7

Makino Shigenori, Tokyo Electric Power Company

The paper presented the development of digital safety systems for the Kashiwazaki-Kariwa Unit 6 & 7. Digital control and network systems has been applied to the I&C systems of Japanese BWR's since the 1980s. The introduction has been stepwise and the scope of the application has been widened gradually. Based on the experience almost all of the I&C systems, including the safety-related systems, were finally digitised in K-6/7. The system consists of 4 divisions with a 2 out of 4 logic. As for the consideration for common mode failures, some hard-wired back-up countermeasures were installed.

In the paper the development process and the different activities for the V&V were presented. In the validation process, the semi-dynamic simulation tests were also performed additionally to investigate the integrity for system requirement.

The NUREG/CR-6430 introduced several techniques for the hazard analysis. TEPCO performed the hazard analysis utilising the FTA methodology.

For the top hazard two events was defined; failure to initiate trip signal on request and unnecessary (erroneous) trip signal without request. For each of these the underlying structures were developed step by step until the bottom hazard elements were identified. Each of the identified bottom elements were examined against their verification process.

The conclusions from the experience from the performed development, installation and operation is that the following policies should be applied to digital safety systems:

- utilisation of digital systems with good performance and operating experience
- simple software architecture
- static memory allocation, avoidance of external interrupts etc.
- use of graphical language in order to keep transparency and traceability
- modularization of the software for its reuse and effective V&V
- considerations for common mode failures and suitable backup measures

Technical Requirements on Maintenance of Digital I&C Systems Important to Safety
G. Schnürer, ISTec, Garching
F. Seidel, BfS, Salzgitter, Germany

The paper presents work which has already started in Germany.

The paper deals with the necessity of requirements on maintenance and upgrading of safety relevant digital I&C systems as a basis for the elaboration of proper maintenance and upgrade guidelines. Requirements which are treated and discussed are technical solution-oriented versus guidelines so as to have an overall general character. The adoption of existing rules and guidelines is also taken into account for the definition of these additional requirements for safety relevant I&C.

The goal of the paper is the introduction of possible safety relevant requirements with respect to
- maintenance of digital safety relevant and safety I&C
- tracing and route cause analysis of incidents caused by I&C maintenance
- support the regulatory body as well as technical experts concerning state of the art

In the paper it is shown that the international standard IEC 60880 contains the necessary elements for an acceptable modification process and discussed some areas of special interest for handling modification requests, including the configuration management system.

As a summary the following aspects are to be considered:

- Completeness and applicability of the existing requirements concerning maintenance and upgrading of digital safety systems.

- Software maintenance requirements for systems of lower safety categories.

- Maintenance requirements concerning automatically generated software.

Requirements Management of I&C System Refurbishment of NPP Dukovany
Jiri Pliska, I&C Energo a.s., Czech republic

Using an example of the Requirements Management System as implemented in the project "I&C System Refurbishment for NPP Dukovany" the paper presented the system analysis methods and the corresponding tools – generally designed CASE systems as a necessary preconditions for the organisation, management, co-ordination, inspection and evaluation of the extensive project, both from the viewpoint of the contractor and customer, as well as from the viewpoint of the national regulatory body. It is a tool for systematic identification, requirement structuring, communication, control, monitoring and verification of user requirements.

The system is based on a list of individual requirements. The user requirements are organised within a hierarchical structure which observes the structure of the application area. Individual requirements are mutually interrelated in various ways. Each requirement is expressed in the form of a written description. Some significant features of the requirements are clearly and simply expressed with a set of assigned attributes. The practical experience has proven that a good CASE system provides many more options for solutions in Requirements Management Systems than common specialised tools.

The entire system of requirements is in the HTML format represented with 14 000 files with the total size of 50 MB. Any evaluation or sorting takes from several seconds to several minutes. The most time-

consuming is fulltext search, taking less than 10 minutes in the whole system. When limiting conditions are used, the search is significantly faster.

Licensing Process of the Digital Computer-based I&C Systems to be Implemented within the NPP Dukovany I&C Refurbishment Project
Ceslav Karpeta, Scientech Inc. - CR, Josef Rosol, CEZ a.s., Czech republic

The paper provided a brief outline of the NPP Dukovany I&C system refurbishment project with a particular focus on specific regulatory requirements related to the digital I&C systems and ways which the utility has adopted in order to ensure that these requirements are met. The licensing process applied to the refurbishment of the Dukovany NPP I&C system is structured to the several stages with the final objective of obtaining the regulatory permission for permanent operation of the refurbished unit. Also, an overall quality assurance programme was established in line with the regulatory requirements covering processes, activites, products, organizations, personnel, etc. The utility intends to perform various audits in order to ensure that the installed equipment will operate as intended, and to provide information needed to support the licensing process. An Audits Plan has been developed to provide the basis for those activities.

Temelin Nuclear Power Plant Westinghouse -I&C Change Process
Dennis M. Popp, John. L. Duryea, USA

During the course of the I&C Systems upgrade at Temelin NPP numerous engineering changes were incorporated in the design and then implemented onsite. From the early stages of installation, Westinghouse has implemented a controlled process to manage these changes. Since the onset of commissioning, Westinghouse has adapted a flexible approach to managing this change process so as to be responsive, during various upgrade efforts, to the needs of the Czech design organizations, as well as those of the start up team. The paper provided an outline of the development of this process.

Under the change process, all modifications to the various digital systems are reviewed to ensure that correct system functionality is maintained and integrated with other plant systems, regulatory requirements, commitments and software configuration controls.

PROGRAMME

CNRA/CSNI WORKSHOP ON

LICENSING AND OPERATING EXPERIENCE OF COMPUTER-BASED I&C SYSTEMS

Hluboká nad Vltavou, Czech Republic
25-27 September, 2001

Tuesday, 25 September 2001

08:00 - 09:00	**Registration and Coffee**	
09:00 - 09:10	**Welcome**	**P. Krs** **SUJB, Deputy Chairman** **Mr. Krizek - CEZ a.s.**
09:10 - 09:20	**Introductory Remarks** **OPENING SESSION:** **ADVANCES MADE IN THE USE AND PLANNING OF COMPUTER-BASED I&C SYSTEMS**	**M. Hrehor -OECD/ NEA** **Chairmen:** **M. Chiramal** **P. Krs**
09:20 - 09:50	**Electricité de France Experience of computer-based I&C systems** Poizat Francois, EdF	**FRANCE**
09:50 - 10:20	**The Evaluation on Applying the Digital Safety System to Existing PWR Plants in Japan** J Masafumi Utsumi, Mitsubishi HI Ltd Yoichi Mito, Kansai Electric Power	**JAPAN**
10:20-10:40	**Coffee Break**	
10:40 - 11:10	**Independent Assessment of the Temelín Software Safety System** Petr Závodský, CEZ a.s.,	**CZECH REPUBLIC**
11:10 - 11.40	**Regulatory Review of the Digital Plant Protection System for Korea Next Generation Reactor** D. I. Kim, B. R. Kim and S. H. Oh Korea Institute of Nuclear Safety	**REP. OF KOREA**

11.40 - 12.10	**Decision Support for Approval of Safety Critical Programmable Systems** Gustav Dahll, Bjørn Axel Gran OECD Halden Reactor Project Bo Liwång, Swedish Nuclear Power Inspectorate	**OECD/HALDEN/SWEDEN**

TECHNICAL SESSION 1

	NATIONAL AND INTERNATIONAL COMPUTER-BASED STANDARDS AND GUIDES FOR SAFETY SYSTEMS	**Chairmen:** **J.P. Bouard** **Z. Ogiso**
14:00 - 14:30	**International Standardisation in Nuclear I&C Engineering** Bouard Jean-Paul, EdF	**FRANCE**
14:30 - 15:00	**Comparison of IEC and IEEE Standards for Computer-Based Control Systems Important to Safety** Gary Johnson, Lawrence Livermore National Laboratory	**USA**
15:00 - 15:30	**The New IAEA Safety Guide and the Common Position of European Regulators on Software for Systems Important to Safety** Courtois Pierre-Jacques, Association Vincotte Nuclear, Brussels	**BELGIUM**
15:30-15:50	**Coffee Break**	
15:50 - 16:20	**Approach to the Application of the State Regulatory Requirements, Legislation and Standards in Modernization of I&C systems, Concerning Especially the Digital Computer-Based Systems** J. Zatloukal, P. Krakora, NRI Rez	**CZECH REPUBLIC**
16:20 - 16.50	**Standard Base for Regulatory Activity in NPP I&C Systems Area** V. Goldrin, M. Yastrebenetsky Yu. Rozen, S. Vinogradskaya State Scientific Technical Center on Nuclear and Radiation Safety	**UKRAINE**
16:50 - 18:00	**Discussion Opening Session & Session 1**	

Wednesday, 26 September 2001

TECHNICAL SESSION 2 **REGULATORY ASPECTS** — **Chairmen: K. Hamar, A. Lindner USA**

09:00 - 09:30 **EMI/RFI and Power Surge Withstand Guidance for the U.S. Nuclear Power Industry** — **USA**
Christina Antonescu, U.S. NRC
Paul D. Ewing, Richard T. Wood
Oak Ridge National Laboratory

09:30 - 10:00 **Pre-Qualification of Digital Platform - U.S. NRC Regulatory Review of the Common Q Platform** — **USA**
W. K.Mortensen, M. Chiramal**,** US NRC

10:00 - 10:30 **Survey and Evaluation of Digital I&C Licensing Experiences** — **CHINESE TAIPEI**
Swu Yih, INER, AEC
Chin-Feng Fan,Yuan-Ze University
Chan-Fu Chuang,, Nuclear Regulation Division, AEC

10:30-10:50 Coffee Break

10:50 - 11:20 **Collecting Data from Operational Experience of Computer-Based I&C Systems- A Regulatory Perspective on Goals and Tasks** — **GERMANY**
G. Schnürer, ISTec, Garching
F. Seidel, BfS), Salzgitter

11:20 - 11:50	**Digital Projects in the Near Past and their Consequences in Safety Regulations in Hungary** K.Hamar, HAEC	**HUNGARY**
TECHNICAL SESSION 3	**ANALYSIS AND ASSESSMENT OF DIGITAL I&C SYSTEMS**	**Chairmen:** **M.L. Järvinen** **M. Kersken**
13:30 - 14:00	**Preliminary Evaluation of Computerized Procedures From Safety Viewpoints** Yun H. Chung, Sung N. Choi, Bok R. Kim, KINS	**REP. OF KOREA**
14:00 - 14:30	**Modernization of the I&C System for ANP Dukovany by the Use of Computer-based Equipment** Jean Pierre Burel, Schneider El., F. Dalik, K. Wagner, M. Říš, ŠKODA Jean-Paul Mauduit, Framatome-ANP	**CZECH REPUBLIC/ FRANCE**
14:30 - 15:00	**FMEA Performed on the SPINLINE3 Operational System Software as Part of the TIHANGE 1 NIS Refurbishment Safety Case** L. Ristord, C.Esmenjaud, Schneider El. Industries	**FRANCE**
15:00-15:20	**Coffee Break**	
15:20 - 15:50	**Qualification of Pre-Developed Software for Safety-Critical I & C Application in NPP's** M. Kersken, ISTec Garching	**GERMANY**
15:50 - 16:20	**A Bayesian Approach to Risk Informed Performance Based Regulation for Digital I&C QA Programs** Swu Yih, Sun-Li Chyou Li-Sing Wang, AEC INER, Chin-Feng Fan, Yuan-Ze University	**CHINESE TAIPEI**
16:20 - 17.30	**Technical Discussion Sessions 2& 3**	

Thursday, 27 September 2001

TECHNICAL SESSION 4	**SOFTWARE LIFE CYCLE ACTIVITIES**	**Chairmen:** **G. Dahl** **F. Krizek**
09:00 - 09:30	**Implementation of Software Independent Verification Distributed Control and Information Systems and Validation for Lungmen** Jiin-Ming Lin, Jeen-Yee Lee, Taiwan Power Company	**CHINESE TAIPEI**
09:30 - 10:00	**Static Analysis of the Software Used in Safety Critical System of the NPP Temelin** Piroutek Z., Roubal S., Rubek J. I &C Energo a.s.,	**CZECH REPUBLIC**
10:00 - 10:30	**Assessment Methodology of the Temelin NPP Control System Performance and Quality** Ivan Petruzela, Karel Bednarík I &C Energo a.s.,	**CZECH REPUBLIC**
10:30-10:50	**Coffee Break**	
10:50 - 11:20	**Methodology of NPP I&C System Algorithms and Software Expert Analysis** V.S. Kharchenko, L.M. Lyubchik M.A., Yastrebenetsky State Scientific Technical Center on Nuclear and Radiation Safety	**UKRAINE**

TECHNICAL SESSION 5	**EXPERIENCE WITH APPLICATIONS SYSTEM ASPECTS, POTENTIAL LIMITS AND FUTURE TRENDS AND NEEDS**	**Chairmen:** **B. Liwång** **M. Hrehor**
11:20 - 11:50	**Operating Experience of Digital Safety-Related System of Kashiwazaki-Kariwa Unit No. 6 and 7** Makino Shigenori Tokyo Electric Power Company,	**JAPAN**
11:50 - 12:20	**Technical Requirements on Maintenance of Digital I&C Systems Important to Safety** G. Schnürer, ISTec, Garching F. Seidel, BfS, Salzgitter	**GERMANY**
13:30 - 14:00	**Requirements Management of I & C System Refurbishment of NPP Dukovany** Jiri Pliska, I&C Energo a.s.,	**CZECH REPUBLIC**
14:00 - 14:30	**Licensing Process of the Digital Computer-based I&C Systems to be Implemented within the NPP Dukovany I&C Refurbishment Project,** Ceslav Karpeta, Scientech Inc. - CR Josef Rosol, CEZ a.s	**CZECH REPUBLIC**
14:30 - 15:00	**Temelin Nuclear Power Plant Westinghouse -I&C Change Process** Dennis M. Popp, John. L. Duryea	**USA**
15:00 - 16:00	**Technical Discussion Sessions 4 & 5**	
16.00 - 16.20	**Coffee Break**	

16:20 –17:20	**FINAL PLENARY SESSION/ Workshop Summary Conclusions by Session Chairmen**	**Chairman: M. Chiramal**
17:20 - 17:30	**Concluding Remarks & Adjourn**	**P. Krs (SÚJB)**

19:00 - 21:00 Meeting of the Session Chairmen to summarize conclusions and recommendations

Friday, 28 September 2001

09:00 - 12:00 Visit of NPP Temelin

LIST OF PARTICIPANTS

♠ - visit of NPP Temelin

BELGIUM

COURTOIS, Pierre J.
Advanced Technologies Dept.
AIB-Vinçotte Nucleaire
Avenue du Roi, 157
B-1060 Brussels

Tel: +32 2 536 83 22
Fax: +32 2 536 85 85
Eml: courtois@info.ucl.ac.be

CHINESE TAIPEI

♠JEEN-YEE LEE,
Taiwan Power Company
20F, 242, Roosevelt Road
Sec. 3. Taipei, Taiwan

Tel.: +886 2 23667156
Fax: +886 2 23671675
Eml.: *D02705*@taipower.com.tw

♠SWU YIH,
Institute of Nuclear Energy Research
PO Box 3-11
Lung Tang, Taiwan

Tel: +3-4711400-6335
Fax: +3-4711400-6335
Eml: syih@iner.gov.tw

♠DER-JEH SHIEH
Institute of Nuclear Energy Research
PO Box 3-11
Lung Tang, Taiwan

Tel: 886-3-4711400-6300
Fax: 886-3-4711415
Eml: djshieh@iner.gov.tw

♠CHANG-FU CHUANG
Nuclear Regulation Division
Atomic Energy Council Taiwan
67, Lane 144, Keelung Rd., Sec. 4
Taipei, Taiwan 106

Tel.: +886 2 23634180, ext. 307
Fax.: +886 2 23635377
Eml.: chuang@aec.gov.tw

CZECH REPUBLIC

KRIZEK, Karel
Head of I&C Operation
NPP Temelin .
CEZ A.S
373 05 Temelin

Tel: +420 334 422 223
Fax: +420 334 422 3815
Eml: Krizek_Karel/4430/ETE/CEZ@mail.cez. cz

KRS, Petr
State Office for Nuclear Safety
Senovazné Square, 9
110 00 Prague 1

Tel: +420 2 216 24 206
Fax: +420 2 216 24 396
Eml: petr.krs@sujb.cz

PETRUZELA Ivan
I&C Energo s.r.o.
Areál VÚ
190 16 Praha 9 - Bechovice

Tel.: +420 2 6706 2181
Fax: +420 2 6706 2182
Eml.: ipetruzela@ic-energo.cz

BEDNARIK Karel
I&C Energo s.r.o.
Areál VÚ
190 16 Praha 9 - Bechovice

Tel.: +420 2 6706 2185
Fax: +420 2 6706 2182
Eml.: kbednarik@ic-energo.cz

PIROUTEK Zdenek
I & C Energo s.r.o.
190 11 Praha 9 – Bechovice

Tel.: +420 2 67062182
Fax: +420 2 67062182
Eml.: zpiroutek@ic-energo.cz

ROUBAL S
I & C Energo s.r.o.
190 11 Praha 9 – Bechovice

Tel.: +420 2 67062182
Fax: +420 2 67062182
Eml.: sroubal@ic-energo.cz

RUBEK J.
I & C Energo s.r.o.
190 11 Praha 9 – Bechovice

Tel.: +420 2 67062183
Fax: +420 2 67062182
Eml.: jrubek@ic-energo.cz

ZAVODSKY Petr
CEZ, a. s.
Division of Construction
NPP Temelín

Tel: +420 334 78 2151
Fax: +420 334 78 3815
Eml: Zavodsky_Petr@mail.cez.cz

PLISKA Petr
I & C Energo s.r.o.
Prazska 684
67401 Trebíc

Tel.: + 420 618 893 300
Fax: + 420 618 893 999
Eml.: jpliska@ic-energo.cz

WAAGE Herbert
CEZ, a. s.
Division of Construction
NPP Temelín

Tel: +420 334 78 3560
Fax: +420 334 78 3815
Eml: waage_herbert@mail.cez.cz

CENDELÍN J.
West Bohemian University in Pilsen
Faculty of Applied Sciences
Department of Cybernetics
Univerzitní 22,
30614 PLZEN

Tel.: + 420 19 7491 155
Fax: + 420 19 279 050
Eml: cendelin@kky.zcu.cz

♠KRYL Petr
Orlík 266
Nuclear Engineering SKODA
316 06 Plzen
Tel.: +420 19 704 2825
Fax: +420 19 75 20 600
Eml.: pkryl@jad.in.skoda.cz

ZATLOUKAL Jan
Nuclear Research Institute Rez a.s.
250 68 Rez
Tel.: +420 19 7441099
Fax: +420 19 7441097
Eml.: zat@ujv.cz

KRÁKORA Petr
Nuclear Research Institute Rez a.s.
250 68 Rez
Tel.: +420 19 7441098
Fax: +420 19 7441097
Eml.: krakora@ujv.cz

KUBÍNOVÁ Jana
Schneider Electric CZ, s.r.o.
Thámová 13
186 00 Praha 8
Tel.: +420 2 810 88 634
Fax : +420 2 248 10 849
Eml.: jana_kubinova@cz.schneider-electric.com

♠ KARPETA Ceslav
Scientech, inc. - CR
A. Staška 30
146 00 Praha 4
Tel.: +420 2 22 13 53 38
Fax : +420 2 22 13 53 37
Eml.: scikar@mbox.vol.cz

KUBANOVÁ Iva
I&C Energo a.s.
Husova 17
370 05 Ceské Budejovice
Tel.: +420 38 510 23 11
Fax : +420 38 534 49 17
Eml.: ikubanova@ic-energo.cz

FINLAND

♠REIMAN Lasse
STUK
P.O.Box 14
FIN-00081 Helsinki
Tel.: +358 9 7598 8379
Fax : +358 9 7598 8382
Eml: lasse.reiman@stuk.fi

♠JÄRVINEN, Marja-Leena
Finnish Centre for Radiation
and Nuclear Safety (STUK)
P.O. Box 14
FIN-00881 Helsinki
Tel: +358 (9) 759 88 304
Fax: +358 (9) 759 88 382
Eml: marja-leena.jarvinen@stuk.fi

♠LINDEN Ulf
Fortum power and Heat Oy
Loviisaa Power Plant
P.O. Box 23
07901 Loviisa
Tel.: +358 10 45 53800
Fax:
Eml.:ulf.linden@fortum.com

FRANCE

♠BOUARD, Jean-Paul
Division Contrôle Commande
E.D.F. - SEPTEN
12-14, avenue Dutriévoz
F-69628 Villeurbanne Cedex
Tel: +330472 82 71 66
Fax: +330472 82 77 04
Eml: jean-paul.bouard@edfgdf.fr

SOUBIES, Brigitte
IPSN/DES/SAMS
Centre d'Etudes Nucleaires
60-68 ave General Leclerc
Batiment 08, BP 6
92265 Fontenay-aux-Roses CEDEX
Tel: +33 1 46 54 84 06
Fax: +33 1 47 46 10 14
Eml: brigitte.soubies@ipsn.fr

♠POIZAT Francois,
EDF Industry/Basic Design Department,
12-14 avenue Dutrievoz,
69628 Villeurbanne Cedex
Tel.: +33 4 72 827 479
Fax: +33 4 72 82 77 04
Eml.: francois.poizat@edf.fr

♠ESMENJAUD Claude
Schneider Electric Industries M3
38050F Grenoble
Tel.: +33 476 605 860
Fax: +33 476 606 462
Eml.:claude_esmenjaud@mail.schneider.fr

BUREL Jean-Pierre
Schneider Electric Industries M3
Safety Electronics and Systems, Usine M3
23 Chemin du Vieux Chene
F-38240 Meylan
Tel.: +33 476 606 884
Fax: +33 476 606 992
Eml.:jean-pierre_burel@mail.schneider.fr

MOSIO Bernard
Nuclear International Project Manager
Schneider Electric Industries M3 plant
23 Chemin du Vieux Chene
F-38240 Meylan
F-38050 Grenoble cedex 9
Tel.: +33 476 60 55 90
Fax: +33 476 60 63 52
Eml.:bernard_mosio@mail.schneider.fr

LAPASSAT Anne-Marie
DSIN/SD2
F92266 Fontenay-aux -Roses
Tel.: 33 1 43 19 71 03
Fax : 33 1 43 19 70 66
Eml: anne-marie.lapassat@industrie.gouv.fr

GERMANY

♠LINDNER, Arndt
Institute of Safety Technology (ISTec)
P.O. Box 1213
85 740 Garching
Tel: +49 89 32004 529
Fax: +49 89 32004 300
Eml: lia@grs.de

♠SCHN•RER G•nter
Institute of Safety Technology (ISTec)
P.O. Box 1213
85 740 Garching

Tel.: +49 89 32004 523
Fax: + 49 89 32004 300
Em.: sgu@ grs.de

♠KERSKEN Manfred
Institute of Safety Technology (ISTec)
P.O. Box 1213
85 740 Garching

Tel.: +49 89 32004 546
Fax: + 49 89 32004 300
Eml.: ker@ grs.de

♠SEIDEL Freddy
Federal Office for Radiation Protection (BfS)
P.O. Box 100149
D-38201 Salzgitter

Tel.: +49 5341 885 863
Fax: +49 5341 885 865
Eml.:fseidel@bfs.de

HUNGARY

HAMAR, Karoly
Nuclear Safety Inspectorate, I & C Sec.
Hungarian Atomic Energy Comm.
Nuclear Safety Inspectorate
P.O. Box 676
H-1539 BUDAPEST 114

Tel: +36 1356 5566-2221
Fax: +36 1355 1591
Eml: hamar@haea.gov.h

JAPAN

♠OGISO, Zen-ichi
Manager, Nuclear Power
Engineering Corp. (NUPEC)
Fujitakanko Toranomon Bldg.
17-1, 3-chome, Toranomon
Minato-ku, Tokyo 105

Tel: +81 3 3435 3427
Fax: +81 3 3435 3428
Eml: ogiso@nupec.or.jp

♠MAKINO Shigenori
Tokyo Electric Power Company
1-3 Uchisaiwai-cho
1-chome Chiyoda-ku
Tokyo 100-0011

Tel.: +81 3 3501 8111
Fax: +81 3 3596 8562
Eml.: Makino.S@tepco.co.jp

♠MITO Yoichi
The Kansai Electric Power Co. Inc.
Nuclear Power Division
3-3-22, Nakanoshima Kita-ku
OSAKA 530-8270

Tel.: +81-70-5938-2709
Fax: +81-6-6444-6279
Eml: K576277@kepco.co.jp

♠UTSUMI Utsumi,
Mitsubishi Heavy Industries Ltd
Nuclear Energy Systems Engineering Center
1-1-1, Wadasaki Hyogo-ku
KOBE 652-8585
Tel.: +81-78-672-3305
Fax: +81-78-672-3268
Eml: utsumi@atom.hq.mhi.co.jp

♠MIYAUCHI Katsumi
Design Section Nuclear Power Department
Hokkaido Electric Power Co.,Inc.
Higashi 1-Chome , Ohdori
Chuo-ku , Sapporo , 060-8677
Tel.: 81-11-251-1111
Fax: 81-11-218-5786
Eml: 1998088@epmail.hepco.co.jp

♠YAMAGISHI Hitoshi
Design Section Nuclear Power Department
Hokkaido Electric Power Co.,Inc.
Higashi 1-Chome , Ohdori
Chuo-ku , Sapporo , 060-8677
Tel.: 81-11-251-1111
Fax: 81-11-218-5786
Eml: hitoshi-y@epmail.hepco.co.jp

♠FUJII Sumio
Design Section Nuclear Power Department
Hokkaido Electric Power Co.,Inc.
Higashi 1-Chome , Ohdori
Chuo-ku , Sapporo , 060-8677
Tel.: 81-11-251-1111
Fax: 81-11-218-5786
Eml: s-fujii@epmail.hepco.co.jp

KOREA (REPUBLIC OF)

Yun H. CHUNG
Korea Institute Of Nuclear Safety
19 Guseong-Dong Yusung-Gu
Taejon, 305-338
Tel: +82 42 868 0245
Fax: +82 42 861 9945
Eml.: yhchung@kins.re.kr

D. I. KIM
Korea Institute Of Nuclear Safety
19 Guseong-Dong Yusung-Gu
Taejon, 305-338
Tel: +82 42 868 0246
Fax: +82 42 861 1700
Eml.: dikim@kins.re.kr

♠TAEYONG SUNG
Integrated Safety Assessment Team
Korea Atomic Energy Research Institute
P.O. Box 105 Yusung, Taejon, 305-600
Tel.: 82-42-868-8923
Fax : 82-42-868-8256
Eml.: tysung@kaeri.re.kr

SLOVAK REPUBLIC

♠SÚKENÍK Peter
Nuclear Power Plant Bohunice
919 31 Jaslovské Bohunice
Tel.:+421 33 597 2808
Fax:+421 33 597 4720
Eml.:sukenik_peter@ebo.seas.sk

♠BÁNOVCOVÁ Mária
Nuclear Power Plant Bohunice
919 31 Jaslovské Bohunice
Tel.:+421 33 597 2356
Fax:+421 33 597 4720
Eml.:banovcova_maria@ebo.seas.sk

♠LIBOSVAR Kamil
Nuclear Power Plant Bohunice
919 31 Jaslovské Bohunice
Tel.:+421 33 597 2356
Fax:+421 33 597 4720
Eml.:libosvar_kamil@ebo.seas.sk

♠ARBET Ladislav
Nuclear Power Plant Research Institute
Okru ná 5
918 46 Trnava
Tel.:+421 33 599 1726
Fax:+421 33 599 1153
Eml.:arbet@vuje.sk

♠GESE Augustín
Nuclear Power Plant Research Institute
Okru ná 5
918 46 Trnava
Tel.:+421 33 599 1105
Fax:+421 33 599 1153
Eml.:gese@vuje.sk

SLOVENIA

♠ Pecek Vladimir
Nuclear Regulatory Authority
Vojkova 59
1000 Ljubljana
Tel.: (+386) 1 472 11 42
Fax : (+386) 1 472 11 99
Eml: vladimir.pecek@gov.si

SWEDEN

LIWÅNG, Bo
Deputy Head
Dept. of Plant Safety Assessment
Swedish Nuclear Power Inspectorate
S-106 58 STOCKHOLM
Tel: +46 (0)8 698 84 92
Fax: +46 (0)8 661 90 86
Eml: bo.liwang@ski.se

♠ANDERSSON Jan-Ove
IoC, research and Development
Barsebäack Kraft AB
Box 524
SE-246 25 Löddeköpinge
Tel.: +44 46 72 41 48
Fax: +46 46 72 46 93
Eml.:jan-ove.andersson@barsebackkraft.se

♠JONSSON Nils
Engineering department
Barsebäck Kraft AB
Box 524
SE-246 25 Löddeköpinge
Tel.: +44 46 72 40 00
Fax: +46 46 77 48 58
Eml.:nils.jonsson@barsebackkraft.se

♠ERIKSSON Karl-Erik
OKG Aktiebolag
Oskarsham NPP
SE-572 83 Oskarsham

Tel.: +46 491 78 76 82
Fax: +46 491 78 68 65
Eml.:karl-erik.eriksson@okg.sydkraft.se

SWITZERLAND

REDDERSEN Hans-Georg
Colenco Power Engineering
Mellingerstrasse 207
CH-5405, Baden

Tel.: +41 56 483 1563
Fax: +41 56 493 7356
Eml.:hans-georg.reddersen@colenco.ch

UKRAINE

♠ YASTREBENETSKY Michael
State Scientific and Technical Center
on Nuclear and Radiation Safety
17 Artema str.
Kharkov 6100

Tel.: +38 0572 471 700
Fax: +38 0572 471 700
Eml.: rel@online.kharkiv.com

♠ KHARCHENKO V.
State Scientific and Technical Center
on Nuclear and Radiation Safety
17 Artema str.
Kharkov 6100

Tel.: +38 0572 471 700
Fax: +38 0572 471 700
Eml.: rel@online.kharkiv.com

UNITED STATES OF AMERICA

♠CHIRAMAL, Matthew
Senior Advisor for Digital Technology
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
M.S. 0-11D 19
20555 Washington DC

Tel.: +1 301 415 2845
Fax: +1 301 415 2444
Eml: mxc@nrc.gov

DURYEA John Luis
Westinghouse Electric Co.
Nuclear Automation,
P.O. Box 355, Pittsburg PA 15230

Tel.: +420 334 77 34 46
Fax:+420 334 77 34 49
Eml.: Duryeljl@notes.westinghouse.com

International Organisations

OECD/Halden Reactor Project, Institutt for Energiteknik, Halden

♠DAHLL Gustav
Institut for Energiteknik
OECD - Halden Reactor Project
Os alle 13, P.O. Box 173
N - 1751 Halden

Tel: +47 69 21 22 00
Fax: +47 69 21 24 40
E-mail: dahll@hrp.no

OECD/Nuclear Energy Agency

♠HREHOR Miroslav
Nuclear Safety Division
12, boulvard des Iles
92 130 Issy-les-Moulineaux
France

Tel: +33 1 45 24 10 58
Fax:+33 1 45 24 11 10
Eml:miroslav.hrehor@oecd.org