Institute for Energy

IAEA / EC-JRC Regional Workshop

Advanced Methods for Safety Assessment and Optimization of NPP Maintenance

2-5 October, 2006

Institute for Energy, EC-JRC, Petten, Netherlands

Summary Report

Vesselina RANGUELOVA, Paolo CONTRI
DG JRC – Institute for Energy

Irina Kouzmina, IAEA

November 2006

SENUF

Safety of Eastern European Type Nuclear Facilities

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

EUR 22604 EN

Institute for Energy

INTERNATIONAL ATOMIC ENERGY AGENCY

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EUR 22604 EN
ISSN 1018-5593
Luxembourg: Office for Official Publications of the European Communities

Printed in the Netherlands

Report EUR **22604 EN**
2006/11

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Executive Sumary

This report presents the technical summary of the presentations and panel discussions in relation to the workshop on “Advanced Methods for Safety Assessment and Optimization of Nuclear Power Plant (NPP) Maintenance” which was organized in Petten (EC/JRC-IE premises) on October 2-5, 2006 by the JRC-IE (SENUF network), and the International Atomic Energy Agency (IAEA), Nuclear Safety and Security (NSS)/Technical Cooperation Departments.

The workshop intended to provide a forum for professional staff from utilities, regulatory authorities and technical support organizations from the Europe Region countries-recipients of the IAEA technical cooperation assistance and other EU countries to discuss on application of advanced methods to enhance safety during maintenance and optimize NPP maintenance programmes.

It was recognised that one of the methods for maintenance optimization that is being increasingly used in Member States is the Reliability-Centred Maintenance (RCM). Significant experience was also accumulated in the Nuclear Countries in relation to the practical use of Risk Monitors for maintenance optimization and enhancing safety during maintenance. Very often, insights from Probabilistic Safety Assessment (PSA) studies are taken into consideration in the process of maintenance programme optimization. In addition, the impact of organizational aspects and human factors in maintenance management, feedback from maintenance related events and root causes analysis are recognised as important components in the maintenance optimisation processes in place in many Countries.

The conclusions of the workshop were focused on the applicability of the PSA techniques to the maintenance optimization programs. Therefore, the conclusions of the workshop are presented in the two main areas: (a) Plant specific PSA models and techniques to optimize NPP maintenance planning and scheduling, b) Equipment reliability analysis as function of the Maintenance, Surveillance and Inspection (MS&I) programs.

The workshop also identified some issues that deserve additional research effort before a broad application of the RCM is proposed to the EU Members. In this framework, any future action in the EU/FP7 (EU framework programme 7) would be very welcome.

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1. Introduction

In the recent years substantial achievements have been accomplished by the nuclear power plants operators to improve plants safety and enhance plant operational performance. Among the many tasks addressed by this effort, many of the plants have used a number of advanced methods and techniques to optimize their maintenance activities looking for both enhanced nuclear safety and optimal use of financial and human resources.

To support the exchange of information and promote best practices for maintenance optimization, the Institute for Energy has established a working group on maintenance under its SENUF (Safety of Eastern European type NUclear Facilities) network.

The maintenance working group covers the following range of activities on NPP maintenance studies and expertise:

a) Review and identification of the most relevant (generic/specific) maintenance related issues,

b) Promotion of well designed and prepared maintenance plans for systems, structures and components,

c) Support to the network participants for the implementation of advanced maintenance approaches, including implementation of preventive (condition based) maintenance as well as preventive mitigation measures,

d) Evaluation of the advanced risk based maintenance approach and provision of assistance in its implementation.

To implement the last activity the IE has conducted a number of surveys and detailed research tasks in co-operation with the IAEA on the practices used in the Central and East European NPPs for risk informed maintenance optimization and promoted the know-how transfer from the most experienced EU nuclear power plants.
This report represents one of the SENUF deliverables under Task 3 " State of the art on Reliability Centered maintenance" (according to the SENUF Workplan for 2006 [1]).

This report also refers to the conclusions of the SENUF report for Task 1 (Reliability evaluation of systems and components, Optimisation of MS&I techniques) [2], where recommendations were issued on the continuation of the research in the field of the maintenance optimization, and in particular in the application of PSA techniques to maintenance optimization. That report also represents an useful background on the whole topic.

To collect the most recent advances in the above mentioned field and to support up-to-date conclusions, a workshop on "Advanced Methods for Safety Assessment and Optimization of NPP Maintenance" was organised in Petten (JRC-IE premises) on 2-5 October, 2006. The organisation effort was shared between the IE and the IAEA/TC and NSS Department. The IAEA funded the participation of some representatives of Eastern European Countries and invited two international experts. The JRC-IE funded some participants, provided the logistic support and invited three international experts.

This report collects the outcome of the IE/IAEA meeting in the two main areas of discussion: (a) Plant specific PSA models and techniques used to optimize NPP maintenance planning and scheduling, b) Equipment reliability analysis as function of the MS&I programs). The report also includes some additional sections on the following:

- State-of-the-art on the quality of plant specific PSA models needed to support advanced RCM application
- Regulatory aspects on evaluation of maintenance optimization
- Analysis of the applicability of the overall workshop conclusions to the WWER plants

A comprehensive list of references [1-13] in the field of maintenance optimization is provided at the end of the report, mainly from IAEA documents, USA and EU Countries practice.

2. Summary of the workshop

1.1 Participants

About thirty delegates from European Organizations attended the workshop. They came from Central and East Europe countries: Armenia, Bulgaria, Czech Republic, Hungary, Lithuania, Romania, Russian Federation, Slovakia & Ukraine. The Western European utilities/suppliers were represented by Finnish, German, Spanish, and Swedish experts.

1.2 Objective

The objective of the workshop was to provide a forum for professional staff from Nuclear Power Plants, NPP design and engineering companies, regulatory authorities and technical support organizations from the Europe Region countries-recipients of the IAEA technical cooperation assistance and other EU countries to discuss on application of advanced methods to enhance safety during maintenance and optimize NPP maintenance programmes.

Over the past years significant effort was spent world wide to optimise the safe operation of NPPs and their regulatory control taking into account different operational issues including maintenance optimization. At present, approaches and practices for enhancing safety during maintenance and increasing its efficiency are subject of high interest in the engineering community and both the IAEA and the EC/JRC-IE devoted considerable efforts to support national research and developments in this field. The current maintenance optimization practice differs from country to country, and the workshop was an opportunity to discuss the existing methods, clarify the differences and identify advantages and disadvantages of each of the approaches.
For instance, one of the methods for maintenance optimization that is being increasingly used in Member States is the Reliability-Centred Maintenance (RCM). Sharing practical experience on the use of RCM is very helpful for the countries that consider introducing this method in the operational practice or are willing to enhance the existing procedures. Another example includes a wider use of Risk Monitor tools to enhance operational safety both at power or shut down operational modes.

Other aspects that deserve additional research are the impact of organizational aspects and human factors in maintenance management, feedback from maintenance related events and root causes analysis.

1.3 Organization

The workshop was organized in the following sessions:

1) Application of advanced methods to enhance safety at maintenance
- Reporting and Assessing Maintenance Related Events/ Root Cause Analyses
- Organizational Aspects and Human Factors in Maintenance Management
- Implication of Long Term Operation Aspects on Maintenance
- Use of Risk Monitor for Optimization of Safety During Maintenance
- Use of Insights from PSA to Identify Safety Significant Maintenance Activities
- Quality of PSA Models Needed to Support Maintenance Optimization

2) Advanced methods for optimisation of corrective/predictive/condition based maintenance
- Definition of the Scope of the NPP Equipment Subject to Maintenance Optimization
- Analysis of Components Criticality/ Safety Significance/ Failure Modes
- Maintenance Plan Definition, Implementation, Monitoring and Updating Process (Feedback)
- Optimization of Maintenance through Introducing Reliability-Centered Maintenance Programmes.

3) Regulatory aspects in assessing of NPP maintenance programmes
- Guidance for review and assessment of maintenance optimization studies
- Licensing requirements for approval of modifications to NPP maintenance practices related to System Structures and Components important to safety.

An interactive session with two working groups enabled a broad exchange of experience among the participants. The two parallel group sessions addressed regulatory aspects in maintenance optimization and use of PSA for maintenance optimization (Group 1), and RCM main features and optimal choice of the scope of maintenance optimization (Group 2), respectively.

A questionnaire was distributed to the participants prior to the workshop. The analysis of the Country experience was used for the development of the special sections of this report. The response to the questionnaire is collected in Appendix 1, which includes also some comments developed during the plenary discussion at the workshop.

Proceedings were issued in a CDRom by the EC/JRC-IE. In the following, the most important issues addressed at the Workshop are presented and discussed.

2 Comments from the working groups

2.1 Regulatory aspects of maintenance optimization

Changing the maintenance strategy, practice and/or documentation at the NPPs very likely would undergo a new licensing process in most of the countries, regardless of whether the country nuclear regulation includes requirements on the application of maintenance optimization methods, or risk-informed applications.

In most of the countries the change in the maintenance practices and documentation, and especially the changes in Technical Specifications, would be considered as modification of the licensing basis and would therefore require licensing. It was recognized that in most of the cases the change in the maintenance strategy would require communication with the regulatory body and its consequential approval.

Therefore, the two following issues were identified as urgent needs in this field:

- Need to establish regulatory body capability to review licensees' submittals dealing with maintenance optimization based on the application of advanced methods for maintenance optimization
- Need to establish tasks for the regulatory body in relation to the licensing of the change in maintenance practice

The current regulation in some countries may not be flexible enough to allow easy and timely licensing of the maintenance programmes based on advanced optimization methods. It does not mean that it is impossible to license such programmes, but it may pose some overburdens to both regulators and utilities in a way that the licensing efforts make the application not beneficial for the licensee. Moreover, some of the optimization actions may not be allowed by the regulation in some countries, if they lead even to negligible increase in plant risk profile.

In relation to the mechanisms of cooperation between Regulator and Utility, good examples and practices, and Utility expectations, the workshop noted that the utilities expect that the regulatory body appreciates the objectives of the maintenance optimization efforts, and is prepared for the licensing process in terms of review expertise and positive attitude to the application to be licensed. Also to avoid problematic licensing process, the regulatory body is expected to issue guidelines to facilitate the licensing process. To this concern, assistance may be required by the International Organizations to assist in the development of some regulatory review guidance and provide for professional training in the field.

There is a variation of approaches in different countries in relation to the regulatory acceptance of advanced maintenance optimization methods. The approaches may vary from the total resistance to accept new methods to the openness of the regulatory body to discuss and issue the license for such applications. Even inside the same country there can be differences in the treatment of the license applications from different NPPs. It is important to continue the international efforts to seek further harmonization on the subject.

2.2 Use of PSA for maintenance optimization

In case the maintenance optimization is supported by the application of PSA results and models, the quality of the PSA becomes an important issue for the success of the maintenance optimization. As any PSA application, the maintenance optimization has crucial requirements for the PSA quality. The scope, completeness, modelling details and used data should be such that allow the PSA to be used for adequate support of maintenance optimization. Not suitable PSA should not be used for this purpose.

In order to ensure an appropriate PSA quality, as minimum the following actions should be implemented:

- Use appropriate guidelines during development of PSA and review of PSA
- Involve both PSA experts and NPP maintenance staff in the development of PSA models
- Keep in mind the intended applications at the time of scope definition and if possible take into account the available standards.
- Perform PSA regulatory review before maintenance optimization is implemented.

Basically two guidance for qualification of PSAs for specific applications are available, namely: the ASME RA-S-2002 Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications the IAEA TECDOC 1511 - Determining the Quality of Probabilistic Safety Assessment (PSA) for Applications in Nuclear Power Plants, 2006. These documents facilitate determining how suitable a given PSA is for a specific application and in particular for supporting maintenance optimizations. The workshop participants were encouraged to give feedback to the IAEA on the IAEA PSA quality guidelines.

Which PSA and which attributes (level, scope, etc.) are suitable to a maintenance optimization program? It depends on what plant and respectively PSA elements are affected by the maintenance optimization: the PSA containing the affected PSA elements should be used. It is important to have good understanding also of the limitations of the PSA models and the assumptions made when developing these studies to avoid misinterpretation of PSA results.

PSA risk measures and quantitative and/or qualitative criteria used to support the maintenance optimization decision should be well identified. In some cases PSA Level 1 may be enough to justify those decisions, however in some countries the licensing requires the demonstration of the risk changes in terms of Large Early Release Frequency (LERF), and therefore Level 2 PSA results are to be submitted for licensing the modifications.

Maintenance related special PSA needs may include the following:

- Separation of the maintenance related basic events in the component unavailability models, like unavailability due to repair, planned maintenance, test, human errors etc.
- Modeling of maintenance activities in each of the safety system trains to correctly reflect actual maintenance activities
- Use of more detailed reliability models for modeling of PSA basic events, e.g. to identify failure modes of components affected by different type of maintenance
- Additional special models to support ISI, On-line maintenance, RI configuration control, etc...

In addition, it was noted that risk monitors are useful tools to support maintenance planning off-line and on-line restoration strategies in case of equipment failures during the plant operation.

2.3 The RCM programs in the experience of the European Countries

The objectives of the RCM were listed as in the following (with some differences according to the country framework):

1) Need to control the maintenance cost, particularly in liberalized energy markets, through reduction of unnecessary tasks and optimized maintenance periodicity
2) Improvement of plant safety through better scheduling of maintenance activities
3) Optimization of the management organization, more suitable to control plant safety
4) Development of pre-conditions for the plant life extension
5) Support the production through minimization of outages duration and optimized work control
6) Minimization of the radiation doses
7) Optimized integration among existing safety programs, such as: ISI, AMP, configuration management, design basis reconstruction, etc.

In relation to the operating cost reduction as a consequence of RCM application, the participants highlighted the following reductions:

- In SWE, 10 - 20% of the effort, especially for I&C calibration intervals
- In SP, 20% in work, 30% in number of tasks
- In HUN, expected, not quantified
- In CZ, 30% on a restricted number of systems selected for a benchmark (according to the implemented Phare project in Dukovany NPP)
- In SKR, expected, not quantified.

Despite of that, a generic reluctance was recorded in some Countries by the Regulatory Body in the modification of the maintenances policy on the basis of RCM.

The following difficulties and challenges were identified during the RCM implementation:

1) The regulatory body acceptance of the changes in the maintenance program as a result of component reliability analysis may play a crucial role
2) The RCM increases the amount of paper work: if it is not well driven, it may represent a useless burden on the operators
3) The RCM requires an optimized management of the interfaces between departments and safety programs: a bad coordination may prevent a successful implementation of the RCM
4) There are objective difficulties in the implementation of the RCM due to the required change in mentality of the personnel and amount of extra work in some cases (particularly when the RCM is not fully computer assisted)
5) The quality of the maintenance record sheets is crucial to feed the system with a proper feedback

The main steps of the establishment of the RCM at the site were identified as in the following: goal setting, definition of the steering group, definition of the case studies, training of personnel, benchmarking the foreign experience, procedure development, appropriate software development or adaptation, interfaces with the management system of the plant (for spare parts, work order, etc.), definition of the peer review mechanisms.

In relation to the Project management for a maintenance optimization project, the group identified the need for a steering group, which should be settled at the beginning for the project (lasting usually for 3 years) startup. The implementation of an RCM program should start from a special project team, with a limited number of people, dealing with a selected limited set of sample systems (4-6 people can manage up to 200-300 components). After that, the RCM should be incorporated into the maintenance department. In most of the plants that have introduced RCM successfully this latter step proved to be easy. In the RCM, the system engineers play a crucial role is the assessment of system reliability and operational requirements, as well as in the management of all the interfaces with ISIS, AMP, configuration, etc.

Many references are available for implementation of RCM optimization programs particularly from the USA, SWE, CZ, HUN (also included in the workshop proceedings and reference literature). The equipment reliability program (as defined for example in the INPO AP913 guide) is attracting more and more attention, however, some adaptations may be necessary at plant specific level.

In conclusion, some terminology issues were identified, namely the concept of component/system reliability should be better qualified for an appropriate use in the engineering community. In general terms, reliability is used as synonymous of “safety margin”.

2.4 Main technical features of the RCM programs

In relation to the Scoping process applied in the RCM, it was noted that the approaches are quite different in the Countries:

- In SWE RCM is applied only to non-safety related SSCs. Safety SSCs are analyzed only to get a documented base for the preventive maintenance (PM) program. Analyzes of safety system seldom result in any changes of the existing PM-program. The process to get a change of the Technical Specification requirement are very strict and in most cases not worth the effort.
- In HUN RCM is applied to 70% of the safety related SSCs and to 30% of other systems
- In SKR RCM is applied to 44 systems (100-500 components) selected on the basis of different criteria, including safety significance.

The quality of the maintenance documentation was recognized as crucial to feed a proper feedback mechanism. The culture of communication (including the “no blame”) may play a major role in ensuring all failure mechanisms have been properly identified and all actual equipment failures have been recorded.

It was noted that in the current dynamic industry an optimized maintenance system should be adaptive. In particular mechanisms should be put in place to deal with configuration changes, changes of suppliers, emerging results from the aging management programmes (AMP), etc. The need for implementation of a living RCM program under the responsibility of the system engineer was highlighted.

Performance Indicators for maintenance effectiveness are considered very useful and welcome, however it was recognized that some research work is still needed in this field. It was felt important for the International organization to provide assistance in this field and set up some benchmarking studies.

The exchange of experience with the conventional industry, particularly the aerospace proved very beneficial in some countries (HUN, SLR) and the group recommended the participants to apply this practice extensively.

The implementation of optimized maintenance programs should include specialized training to many involved people. Two levels of training are needed: a specialized one to the directly affected people (6 months, retrained every 3 years) and a more generic on the objectives to the staff at large. RCM-Methodology Training for the project team before starting the case study or pilot project is essential for a successful project. To get maintenance management to promote and accept an RCM-project they also need some training before the project starts.
To this concern, the importance of the availability of state-of-the-art training centers, maintenance manuals and procedures was highlighted. In some cases (HUN) the training of the contractor's personnel is controlled by the plant, in other cases (SWE) it is audited. The Country tradition and labor market suggest to develop tailored solutions. Training is also carried out on-the-job, through continuous exchange of experience and periodic meetings of the steering project team.

The group identified a number of issues in the field of the component integrity and reliability of SSCs. It was recognized that data banks are available with failure data at the plant level (SP), at the utility level (SWE, FI), but they are mainly used for PSA input. The consequences of a failure are often evaluated with POA (Probabilistic Operational Assessment): however, these tools are usually expensive and therefore their use is limited to very exceptional cases. The equipment reliability to be used in the RCM is still evaluated in most cases by expert judgments and by analysis of the feedback experience.

2.5 The future of the RCM programs

The workshop identified two areas where some effort is needed to support the full implementation of RCM models in European Countries. These areas cover research tasks and call for an initiative at the International Organizations level.

In the field of regulatory practice, support would be needed in the licensing of advanced maintenance optimization applications and information on the regulation in the countries with good practices in the field. In particular, the following recommendations for future support from international organizations were identified:

- Develop detailed guidelines for regulatory review of specific maintenance optimization applications such as: RI TS, RI ISI, On-line maintenance, etc.
- Provide training and/or training material, tutorials for regulatory review of maintenance optimization applications.
- Promote benchmark exercises.
- Expand the scope of the IAEA safety review missions to specific maintenance optimization applications.

In relation to the PSA quality issues, need for support was identified in the following tasks:

- Extend the IAEA PSA quality guidelines (i.e. TECDOC-1511) towards

Level 2 PSA and at least internal floods and fires in order to facilitate the regulatory use of the PSAs
- Extend the IAEA IPSART scope to review PSA applications
- Provide support for establishment of WWER specific component reliability database

In terms of research tasks able to make the RCM more broadly applied, the following was identified:

- Clarification of the reliability target for the different groups of components and reliability parameters calculation
- Integrated management of the data bases available at the plants: many sources of data are available at the plants (ISI, maintenance, AMP, PSA, operation, etc.) but often they are not integrated and they do not support an integrated approach to component reliability.
- Development of criteria for "good" performance of SSCs (acceptance criteria)
- Identification of representative maintenance effectiveness indicators
- Understanding of the impact of the RCM on the workforce: in relation to different competencies needed and overall reduction of the workforce at the sites
- Comparison of the available methodologies for RCM: the available proposals are very much affected by the national frameworks where they have been developed. Benchmarking on selected systems and commodity groups would be very useful to this concern
- Exchange of information at the EU level, despite of the national differences and plant issues, would be very useful in the following areas:
    - Methodologies for RCM
    - Organizational aspects
        - Failure rates for commodity groups (with some assumptions on anchoring, environment, etc.)
        - Training of personnel and use of training centers

3 Analysis of the questionnaire

Eleven Organisations participated to the survey on maintenance practice through the questionnaire jointly prepared by the JRC/IE and the IAEA. The most relevant comments are collected in the following:

- Almost all countries are implementing projects on maintenance optimisation, though with different approaches and scope. Extensive maintenance optimization projects are ongoing in BUL, ROM, SLR, SP, SWE, GER;
- RCM is formally implemented in SP, SWE, SLR, while LIT is concentrated on ISI and GER on outage optimisation.
- Few countries have specific regulatory requirements in the field of maintenance optimisation: SP and US apply the Maintenance Rule; SLR is developing regulatory documents on integrated maintenance approaches.
- No data are provided in relation to costs of maintenance optimisation programs; only Spain presented data in relation to the implementation of the RCM.
- LIT provided specific details on benefits from RI-ISI; GER on the outage optimisation, and SP on qualitative insights. However, no quantitative

evaluation of the benefits coming from the maintenance optimisation were provided.
- Almost all Countries have computerized in-house system to record component failures and maintenance events.
- Not sufficient information was provided on PSA quality and requirements on PSA models used for RCM justification.
- Quantitative criteria in the PSA application to maintenance are applied by BUL and LIT; qualitative in GER and SP.
- Data were provided on reliability data only by UKR, SP, LIT.

In conclusion, the questionnaire provided a first insight in the Country practice in relation to maintenance optimisation and in particular in application of RCM methodologies. In general, it can be concluded that for most of Central and East Europe countries these programs are still at the beginning and more analysis is needed to capture the differences in the Country approaches and to promote harmonization and application of best practices. Dissemination of the lessons learnt from the maintenance optimization in experienced countries like Spain and Sweden can further facilitate this process.

4 Conclusions and acknowledgment

The workshop concluded that there is a potential, very important role for both the IE network on safe operation of nuclear installation (in the research field) and the IAEA (in the support and training) in the coordination of the efforts among the European Countries to promote a full implementation of maintenance optimization programs.

In fact the implementation of RCM methods requires the availability of component data, well established probabilistic techniques of appropriate quality etc. that cannot be developed at the Country level only. In this framework, any future action in the EU/FP7 and in the IAEA/TC program would be most probably very welcome.

It is suggested to maintain the exchange of information amongst EU utilities through IE networks on operational safety to support harmonization of the maintenance practices in EU countries.

The IE and IAEA appreciate the work of all participants in the “Advanced Methods for Safety Assessment and Optimization of NPP Maintenance” workshop and wishes to thank those of them who contributed to the workshop discussions and preparation of this report.

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6 List of Abbreviations

AMP	Ageing Management Program
CFR	Code of Federal Regulations
CM	Corrective Maintenance
EPRI	Electric Power Research Institute
EU	European Union
IAEA	International Atomic Energy Agency
IE	Institute for Energy
ISI	In-Service Inspection
I&C	Instrumentation & Control
LTO	Long Term Operation
MS&I	Maintenance, Surveillance and Inspection
NPP	Nuclear Power Plant
PLEX	Plant Life Extension
PLIM	Plant Life Management
PM	Preventive Maintenance
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
RBI	Risk Based Inspection
RCM	Reliability Centred Maintenance
RG	Regulatory Guide
RIM	Risk-Informed Maintenance
SENUF	Safety of Eastern European Type Nuclear Facilities
SSC	Systems, Structures and Components
TS	Technical Specifications
VVER (or WWER)	Water-Cooled Water-Moderated Power Reactor

7 Appendix 1 – Synthesis of the responses to the questionnaire

QUESTIONNAIRE ON NPP MAINTENANCE OPTIMIZATION (EXPERIENCE AND PLANS FOR THE FUTURE)

PART I (general)

1) Participants' name:

1	**UKR** KhNPP	Valeriy Viktorovich Lysenko
2	**BUL** RiskEng	Marinela Ilieva
3	**ROM** CernNPP	Gabriel Strasser
4	**BUL** KNPP	Emil Kichev
5	**SLR** UJD	Peter Uhrík, Miloš Žužo
6	**RUS** Gidropress.	Alexander Tribelev
7	**SP** Iberinco	Mariano Fiol
8	**HUN** Paks	Gábor Nemeth, Béla Nagypal
9	**LIT** EnInst	Robert Alzbutas
10	**GER** Areva	Norbert Lügger
11	**SWE** Ringhals	Mats Jonsson

2) Organizations

1	**UKR**	Khmelnitsky NPP
2	**BUL**	Risk Engineering Ltd
3	**ROM**	CNE PROD CERNAVODA
4	**BUL**	Kozloduy NPP, Bulgaria
5	**SLR**	Úrad jadrového dozoru SR (UJD SR) - Nuclear Regulatory Authority of the Slovak Republic
6	**RUS**	FSUE OKB "GIDROPRESS", Russia
7	**SP**	IBERDROLA
8	**HUN**	Paks Nuclear Power Plant Ltd.
9	**LIT**	Lithuanian Energy Institute

10	**GER**	AREVA NP I'm employee of AREVA NP GmbH since 2004. I'm responsible for International Outage Service, Outage Optimization and Consulting. From 1988 until 2004 I was working in a German NPP (BWR). From 1996 I was head of Mechanical Department and the responsible Outage Manager and responsible for Outage Optimization Programs in this NPP. The following answers are a mixture of results of these functions.
11	**SWE**	Ringhals NPP

3) Relevant experience in use of maintenance optimization tools:
(Please give details of a project on maintenance optimization in which you have/are or planning to participate - e.g. plant unit site, reactor type, goals of the project on maintenance optimization, scope of the reactor systems subjected to maintenance optimization, reasons for selection of one or another maintenance optimization methodology, etc.)

1	**UKR** KhNPP	I have work experience in improvement of maintenance planning and maintenance management at Khmelnitsky power units.
2	**BUL** RiskEng	Since the beginning of 2005 we are working on an "Optimisation of operations, technical service and repair of Units 5&6 of Kozloduy NPP" , WWER 1000/320, the final goal of the project is to reduce the outage duration and revise Technical Specification of the Units. Several tasks are included in the project – RI ISI, RI Technical Service and Repair, RI Testing, Risk Monitoring, Change of Technical Specification to reflect the new requirements for AOT and STI, Cost Benefit Analysis. The project is performed with Westinghouse as a Subcontractor for some of the applications; the project is expected to be competed in the middle of 2008. 7 systems are selected for analysis for each of the Risk Informed Applications based on risk ranking
3	**ROM** CernNPP	Cernavoda NPP operates one 700 MW CANDU type reactor (PHWR). Maintenance and Operation Practices at Cernavoda NPP • In respect of Basic Safety Principles for Nuclear Power Plants 75-INSAG-3 and Safety Culture 75-INSAG-4, by use of specific reference documents and procedures • Use of early planning of the work to be done, by 13 weeks, 2 weeks and daily plan schedule

		• Previous assessment of the work to be done, by establish the specific needs of instructions, tools, spare parts, manpower • Yearly management assessment of the total plant maintenance performed, based on performance indicators: unavailability of NSS, unplanned outages or SS plant trips due to maintenance activities, undertaken radiation doses, preventive maintenance percentage over the total of maintenance activities. The Preventive Maintenance activity is currently a subject for thorough re-evaluation, follow equipment failures which led to several unscheduled plant shutdown. A PM tool was made available by EPRI to the utility members of this organization. Includes: **-** Electronic database of PM information on more than 60 major component types used in US NPP, which directs engineers to PM tasks and task intervals recommended by panels of utility experts and provides the technical basis for why these are sound recommendations. **-** Plant PM Program Builder, provide the workspace for the user to analyse the own PM program using component lists downloaded from plant sources and data automatically drawn from the PM Basis database. Approach: Expert panel formulate the criteria for equipment screening and produce an essential equipment (EE) list. Main criteria: Dynamic equipment which, if failed to perform its function and the failure cannot be mitigated by control action, would cause a unit transient/ shutdown or a level 1 or 2 impairment (as per TS). CNE PROD also initiated the "Essential Equipment Project". The project consists of the following steps: - Identification of the Essential Equipment (EE) that cause an immediate effect such as shut down of the plant or a level 1 or 2 impairment (equivalent to TS violation). - Identify the preventive maintenance program which has been applied to the EE. - Determine the vulnerability of the selected EE using the EPRI PM Basis Database 6.0. Follow-up on the as-found condition of the inspected equipment.
4	**BUL** KNPP	**Plant:** Kozloduy NPP, Bulgaria

		Units: • Six Units; • Four units with reactor type WWER-440/B230 (Unit1 1-2 have been shut down in 31 December 2001); • Two units, with reactor type WWER 1000-B-320 **Project title:** Risk Informed Maintenance Optimization of Units 5,6 at Kozloduy NPP **Project Goal:** To Reduce the Unit Outage for Refueling, Equipment Maintenance and Testing through Risk Informed Performance Based Approaches in Decision Making **Scope of the System, Subjected to Maintenance Optimization:** The following systems are included in the scope of the pilot study: • Spray System (TQ1) - • Low Pressure Injection System for Emergency and Planned Cooling (TQ2) • High Pressure Injection System for Emergency and Planned Cooling (TQ3) • High Pressure Injection System for Emergency Boron Injection (TQ4) • Emergency Feedwater System (TX) • Emergency Diesel Generator System (DG) • Technological Protection and Interlock Circuits System (YZ) • Service Water Supply System to Group A Consumers (QF/VF) • Ventilation and Cooling of Safety Systems (TL/UV) **Criteria for System Selection:** The selection of equipment (SSE) covered by RCM is based on identification of its risk significance and the requirements of maintenance and testing at Kozloduy NPP. The key points in the equipment selection are as follows: • For risk categorization process is used an approach, described in the US NEI document "10 CFR 50.69 SSC Categorization Guideline" – NEI 00-04 (January 2005); • Equipment with low safety significant is a leading candidate to be included in the scope of maintenance

		optimization; • Information on current maintenance and tests activities at Kozloduy NPP.
5	**SLR** UJD	There are two maintenance optimisation projects running at this time at NPPs in Slovakia. One of it at Bohunice NPP- units 3 and 4 and the other one at Mochovce NPP - units 1 and 2. Both of them have started last year only (in 2005), both of them are RCM projects and both of them are still in the process of preparation and authorisation. These two projects are the first activities related to maintenance optimisation at NPPs in Slovakia. According to this UJD SR does not have much relevant experience in use of maintenance optimisation tools from the previous.
6	**RUS** Gidrop .	1 Balakovo NPP Unit 1, WWER-1000.There is a program of maintenance optimization. The purpose of optimization program: to increase the periodicity of repair and maintenance service till 18 months. The following systems and equipment RS are included in the program: - Reactor vessel; - Upper block; - Control rod tubes; - Main circulation pipelines; - Hydroaccumulators including pipelines and valves; - Pressurizer system including bubble, pipelines and valves; - MCPs, including pipelines and valves; - The steam generators; - Electrical equipment of RCPS; - Neutron Flux Monitoring Equipment; - Process Parameters Protection Equipment; - Equipment of In-core Instrumentation System; - Channels of the RS thermometrical equipment, including thermocouples and converters. Basing methods of optimization: Deterministic ones (the analysis of operating experience, cyclic resource durability, requirements of regulatory documents, etc.); Probabilistic ones (reliability analyses on the operating experience basis). 2 The purpose of optimization: scheduled repair of a single safety system train during the reactor operation.

<table>
<tr><td></td><td></td><td>Basing methods of optimization: PSA (comparison of results of probabilistic safety assessment for the reactor in operation and shutdown modes).</td></tr>
<tr><td>7</td><td>SP
Iber</td><td>

Implementation of RCM programs in all Spanish NPP and most of conventional power plants.
Implementation of a Risk-Informed On-Line preventive maintenance program

<table>
<tr><td>Cofrentes NPP</td><td>BWR-6</td><td>1996</td><td>13 safety systems</td></tr>
<tr><td>Garoña NPP</td><td>BWR-3</td><td>2001</td><td>All safety systems</td></tr>
<tr><td>Trillo NPP</td><td>KWU</td><td>2000.</td><td></td></tr>
</table>

Implementation of Risk Monitor in Cofrentes NPP since 1997. In Garoña NPP since 1999. In Ascó and Vandellós NPP since 2001.
Implementation of a risk-based in service testing program in Cofrentes NPP since 2000.
Implementation of a Risk-Informed in service inspection program in Cofrentes NPP since 2003.
TACIS SOFT OSA activities in Kola NPP (Russian federation) and Khemelnitsky NPP (Ukraine) related with Outage Optimization.

</td></tr>
<tr><td>8</td><td>HUN
Paks</td><td>Mr. NÉMETH
<u>Personal experiences:</u>
WWER-440 Russian designed reactors, 21 years at the NPP, 18 years at the maintenance field.
2004- Advisor of The General Director
2003-2004Head of Maintenance Training Section
2001-2003 Maintenance Director
1999-2001 Head of Maintenance Department
1996-1999 Chief Engineer of the Mechanical Maintenance Department
<u>Projects:</u>
Implementation of the Maintenance Training Centre (company level – finished)
Implementation and 3rd party qualification of Maintenance Division’s Q.A. system (maintenance level – finished)
Different IAEA projects (e.g. RER/4/025, UKR4012-004-003A)
FORATOM
NUMEX</td></tr>
</table>

		Mr. NAGYPÁL Personal experiences: WWER-440 Russian designed reactors, 15 years at the NPP, 13 years at the maintenance field. 2003- group leader of the Independent Q.C. Group of the –Maintenance Division 2001- Q.A. Manager of the Maintenance Division 2001-2003 Chief Technologist of the Maintenance Division, 1997-2001 Lead Technologist of the Electrical Maintenance Section, 1993-1997 Technologist of the Electrical Maintenance Section, 1991-1993 Instructor of the Paks NPP's High School at the electrical and I&C filed. Project experiences: Renew of the Paks NPP's Maintenance Strategy (maintenance level - finished) Implementation of the Equipment Responsibility System (maintenance level - finished) Development of Organization and Improvement of Safety Culture (company level – under process) "Fundamental Safety Messages" Team (company level - finished) Implementation and 3rd party qualification of Maintenance Division's Q.A. sytem (maintenance level – finished) Participation of maintenance optimization NUMEX courses (continuously) Different IAEA projects (e.g. RER/4/025, UKR4012-004-003A)
9	**LIT** EnInst	A project with the acronym IRBIS (Ignalina NPP Risk Based Inspection pilot Study) has been performed with the objective to perform a quantitative risk minimisation of austenitic stainless steel welds (of 325 mm outside diameter pipes, total 1240 welds) in Ignalina NPP, Unit 2 (RBMK-1500). The considered damage mechanism was IGSCC. The failure probabilities were quantified by using probabilistic fracture mechanics. The conditional core damage probabilities were taken from the plant PSA. ISI program provided a framework for allocating inspection resources in coast effective manner and helped focus the inspection and maintenance activities where they are most needed.
10	**GER** Areva	• Introduction of planning tool „Primavera" with the understanding: Outage planning and Outage performance as a „year-round job" with long-term planning, annual milestone planning and detailed outage planning and controlling. The task is to ensure that there is no prolongation of the planned outage duration.

		• Development and introduction of a year-round outage organization with the understanding „a year-round job needs a year-round professional leadership“ – of course with using the plant and the utility resources.
11	**SWE** Ring	Ringhals site contains 4 plants, one ASEA BWR and 3 Westinghouse PWR. The objective for the SRCM-project is to get an optimized maintenance programme and to get it documented. The scope is to analyze aprox. 50 systems at each plant i.e. total 200 systems. The systems to analyze was selected from 2 criteria's 1:st safety or safety related systems 2:nd maintenance intensive systems. The selection of methodology was made in a pilot study were several options was evaluated.

4) Are there any requirements specified by your regulatory authority which are relevant to maintenance optimization, and in particular to reliability centered maintenance (RCM) – if yes, please give some details (e.g. title and status of the regulatory documents, areas of application, specific content of the statements, etc.):

1	**UKR** KhNPP	There no such requirements at present.
2	**BUL** RiskEng	No
3	**ROM** CernNPP	Maintenance related requirements are defined in plant reference document Operating Policies and Principles and detailed in plant procedures. For the moment there are no specific RCM requirements imposed by CNCAN regulatory authority.
4	**BUL** KNPP	There are general requirements of the Bulgarian Nuclear Regulatory Agency (BNRA) which are relevant to maintenance optimization. The requirements are stated in the following regulations and instruction: • Act on the Use of Nuclear Energy (AUNE) • Regulation for providing the safety of Nuclear Power Plants (NPPs) • Regulation for the procedure for issuing licenses and permits for safe use of nuclear energy • BNRA Instruction for In-Service Inspection There are no specific requirements of the BNRA, which are in particular relevant to Reliability Centred

		Maintenance (RCM).
5	**SLR** UJD	There are general requirements related to the maintenance of systems and components given by the generally binding legal documents, namely by the Act on peaceful use of nuclear energy (No. 541/2004), by the regulation on Safety documentation of nuclear installations (No.56/2006), and by the regulation on Nuclear safety assessment (No.50/2006). These documents do not deal explicitly with neither maintenance optimization nor with RCM. Apart from these UJD SR develops its own Safety Guide (PSA and Integrated Decision Making Process) which deals with assessment process of PSA application projects. The first draft version of the Safety guide has been prepared recently and is expected to be issued for a trial period soon. Even though this document does not refer explicitly to the maintenance optimization issues it should be applicable for the assessment of all changes that result from PSA and its applications (i.e. including maintenance optimization). This safety guide is based on the analogous international documents as Risk informed regulation of nuclear facilities: Overview of the current status (IAEA-TECDOC-1436, Vienna, February 2005), PSA quality for applications (IAEA-TECDOC, Vienna, November 2003) and An approach for using probabilistic risk assessment in risk-informed decisions on plant-specific changes to the licensing basis (US NRS Regulatory Guide 1.174, Revision 1, November 2002).
6	**RUS** Gidrop .	The general regulatory document is OPB-88/97 (General Safety Requirements). It has the status of the Federal Normative Document. According to the requirements, the Technological Regulations are developed for each Unit of NPP and must be agreed with Regulatory Authority. Any changes in TR including service optimization are limited by regulatory requirements to the safety and reliability parameters of the RS equipment and systems. PSA tools is applied for a substantiation of safety and reliability indices. According to OPB 88/97: - Before input the NPP in operation, and also periodically during the operation (according to requirements of the project and regulatory documents) should be carried out the testing of availability of safety systems, safety related systems (elements), instrumentation and control systems, monitoring of basic metal and welds of safety related systems and elements. - Frequency and volume of a periodic testing should be established by the schedules developed by administration the NPP.

		The schedules should correspond to requirements of regulatory documents and should be depended on importance of the tested system (element) for the NPP safety taling into account the quantitative analysis of the systems (elements) reliability.
7	**SP** Iber	Spanish regulatory authority has implemented in all Spanish NPP the Maintenance Rule, based in 10CFR50.65. This rule requires the monitorization of the performance of systems and the analysis and correction of possible problems. This regulation actually provides the regulator the means for inquiring about all the maintenance practices of the Plant. If these practices do not include the proper analysis, or do not focus in the risk significant equipment items, the Plants can be sanctioned. The best way to fulfill this regulation avoiding possible regulators problem is the implementation of a Risk-informed maintenance program, that may include all the activities described in the previous question. There are not any regulatory requirements about RCM. Anyway, this is a methodology that has been implemented in all Spanish NPP through a voluntary initiative of the Plants.
8	**HUN** Paks	Not yet.
9	**LIT** EnInst	Requirements of State Nuclear Power Safety Inspectorate: “Requirements for Safety Assessment of Austenitic Components with IGSCC Cracks for RBMK-1500 Reactors (2004)“. The requirements include the procedures for safety assessment and the procedures for determination of In-Service Inspection extent and frequency. According to the requirements the extent of the inspection should be the 100% or defined according to the RISK ranking of the system under consideration. Such RISK is assumed to be calculated multiplying PSA Consequences and Damage Indexes (defect occurrence frequency).
10	**GER** Areva	Requirements for German NPP are specified for the safety related components in the KTA rules, the plant’s operating manual (Tec spec) and the testing manual. If there is the need or the wish to change the operating manual or the testing manual the agreement of the authorities is to be needed. The method of Reliability Centered Maintenance (RCM) is not specified in the KTA rules.
11	**SWE** Ring	The requirement from the regulatory body is that we shall have a analyzed and documented maintenance program. This requirement was enforced 1998.

5) Resources spent for the implementation of a maintenance optimization programme (MOP):
(If possible, please give details of the resources spent for the implementation of MOP, i.e. staff-time, duration of the project, installation of computerized information systems, consultant support, etc.)

1	**UKR** KhNPP	There are no data on the resources spent for the implementation of MOP.
2	**BUL** RiskEng	Duration of the project is 3,5 years, the software used is: Saphire v. 6.75 – used for PSA modelling and quantification of CDF; Safety Monitor v.4 used for risk monitoring; Win SRRA code, @Risk software; Perdue Model – all used for RI ISI application. Westinghouse methodology is used for RI ISI application.
3	**ROM** CernNPP	Plant staff from various departments (Operation, Maintenance, Technical / Engineering, Safety & Licensing) with external contractor support was involved in MOP since 2000 year. The project is currently undergoing.
4	**BUL** KNPP	**Project Duration:** 36 months **Contractor:** Risk Engineering Ltd and Westinghouse Electric Company LLC **Supporting Software:** • System Analysis Program for Hands-on Integrated Reliability Evaluation (SAPHIRE) • Structural Reliability and Risk Assessment software (Win-SRRA) • Safety Monitor
5	**SLR** UJD	As has been already mentioned, both projects related to MOP in Slovakia have started last year only (in 2005) and are still in the process of preparation and authorisation. Since the implementation process has not been finished yet, it is not possible to estimate resources spent for the implementation.
6	**RUS** Gidrop.	
7	**SP** Iber	• Reliability Centred Maintenance: strongly depending on scope: o 82 systems (41 for each Unit) o 3 years-man

		o RCM Management database named 'HAMA', developed by IBERDROLA S.A. o Project developed by power plant and IBERDROLA S.A. personnel • Risk Monitor: around 200.k€, strongly depending on scope and current status of PSA • On-Line preventive program: around 300k€ also depending on scope and previous development of Risk Monitor • Maintenance Rule: 400k€, plus 100k€/each year • Risk Informed In-Service Inspection: 450k€ • Risk-Informed Testing of valves and pumps: 180k€
8	**HUN** Paks	Forced participation of courses, workshops, conferences which are relevant with the MOP. We've started to train our staff – at first at the manager levels – to be suitable for the new methodologies.
9	**LIT** EnInst	Information is not available.
10	**GER** Areva	By need
11	**SWE** Ring	With our scope we are 5 full time equivalent analyst, 1 project manager on 25 % of FTE and 1 administrator on 75 % FTE. The plan is to spend 4 years finishing the project. We got training and support from the vendor of the tool we use "ERIN-Engineering". The time schedule is made with the assumption that each component takes about 20 minutes to analyze.

6) Benefits of the implementation of MOP:
(Please provide details on what particular benefits have been achieved by the implementation of a MOP, e.g. percentage of saving time for maintenance, indicators of higher availability of the plant, indicators of more safe plant unit operation, compliance with the regulatory requirements, etc.)

1	**UKR** KhNPP	It is not possible to report for the benefits for the moment because the project is under development – expected benefits: reduction of the outage duration; extension of AOT and STI; economical benefits; increase of power production
2	**BUL**	

	RiskEn g	
3	**ROM** CernN PP	Currently under evaluation since both PM Program and EOOS Risk Monitor are under field trial implementation.
4	**BUL** KNPP	The project is under development. Expected benefits can in several areas: • Balanced extension of AOT and STI; • Reduction of the unit outage duration; • Support to the optimization of the existing Technical Specifications (TS) for units 5 and 6 at Kozloduy NPP taking into account international accepted standards. It is a basis for the management of Kozloduy NPP to operate the units in compliance with the safety requirements of Bulgarian Nuclear Regulatory Agency (BNRA), so as in competitive way in the environment of a free energy market in Bulgaria.
5	**SLR** UJD	See question No.5. These details we will received after implementation MOP
6	**RUS** Gidrop .	**1. Expected effect from realization MOP** - decreasing of periodicity of repairs and maintenance service till 18 months; - scheduled repair of the safety systems trains during the reactor operation; - increase of average availability factor by the safety guarantee.
7	**SP** Iber	1) Safety of the Plant is improved through •Focus of the resources in the most significant equipment •Safety Culture improvement by introducing risk concepts in the organization, self assessment of maintenance practices, performance monitoring,… •Definition of new maintenance tasks over significant equipments and continuing Adjustment to Maintenance Tasks •Increase in Equipments Availability •Reduction in Programmed Unavailabilities •Plant Risk Minimization •Human Error Probability Minimization.

		•Evidence of design deficiencies •Better control over the components life cycle. 2) Economical benefits by •Potential reduction of Outage duration. •Reduction of corrective maintenance caused by better maintenance. •Reduction of Maintenance tasks. •Reduction of regulatory problems caused by maintenance.
8	**HUN** Paks	We have got a new, up-to-date maintenance strategy
9	**LIT** EnInst	Using a quantitative risk-informed analysis for INPP unit 2, it is possible to combine a 44% reduction of the number of future inspections with a 35% reduction of overall risk. This is possible mainly due to a proposed shorter inspection interval for the high risk welds. In the higher risk levels, a shorter inspection interval than 4 years is recommended for 205 welds. Many low risk welds are suggested not to be included in the selection according to new ISI program. This means that the radiation exposure to plant personnel can be reduced (56 %) and resources can be redirected to other safety related issues. The reduction of accumulated future radiation exposure for the suggested program case is more than 3300 mSv compared to the current pipelines in service inspection program. After completing of IRBIS project the Ignalina NPP have take advantage on the pilot study results and prepare the new Inspection Program focusing on the highest risk locations. The amount of inspection was not reduced, but the risk was reduced significantly.
10	**GER** Areva	f.e. the above mentioned tools are necessary to plan the outages more detailed to ensure that there is no prolongation of the planned outage duration (1 more day of outage duration = 1 Mio. €)
11	**SWE** Ring	Not so much saving of time for PM was found but we found a lot of inconsistencies and plant documentation that wasn’t updated. In the long term we expect to save time due to optimization.

7) If you have any further plans in relation to maintenance optimization or use of the results achieved, please provide details:

1	**UKR** KhNPP	
2	**BUL** RiskEng	Based on the results of the project and after implementation of the recommendations KNPP may wish to implement the methodologies on an extended number of systems at Units5&6.
3	**ROM** CernNPP	Start the Predictive Monitoring Pilot Project with support from external contractor, in extension to EPRI PM Basis. Based on evaluation of pilot project results, an on-line predictive monitoring project could be developed (Equipment Health Monitoring). The effective use of predictive monitoring techniques has the potential to accurately predict equipment failure degradation and provide early warning of failure prior to affecting plant operation. This can result in increased production and reduced maintenance costs for consequential damages associated with major equipment failures.
4	**BUL** KNPP	Maintenance optimization activities to be extended for all equipment of units 5 and 6.
5	**SLR** UJD	Our primary focus will be put on the two running RCM projects. Due to lack of previous experience in this area UJD SR has started to prepare a certain number of specialists for this kind of projects (common trainings with the utilities specialists' in this area, visiting workshops, learning from international experience, studying relevant literature) Apart from that UJD SR develops its own Safety Guide (PSA and Integrated Decision Making Process) which deals with assessment process of PSA application projects as has been mentioned in question No.4. This guide should help us to assess projects related to maintenance optimization.
6	**RUS** Gidrop.	
7	**SP**	We are working in the extension of Risk-Informed inspection to pipes of safety Class 3. We are analyzing the

	Iber	impact of the Shutdown PSA (and resulting Risk Monitor) in Maintenance practices. This will significantly influence in Outage planning, preventive scheduling and technical specifications requirements. We are also complementing the current Risk Monitor to include LERF monitorization.
8	**HUN** Paks	Our plans contain some implementation for the higher volume CBM, our strategy is contains the RCM.
9	**LIT** EnInst	The Lithuanian regulatory body (VATESI) in general agree to use RI-ISI program for austenitic pipelines, and waiting for Ignalina NPP proposal. If the number of inspections are reduced, the compensating actions should be taken, i.e. if some of low risk welds in the future is not periodically inspected, the more precise Leak Detection System are necessary. After 3 years of operation, updating of RI-ISI was performed by taking into account new statistical data on pipe defects. Comparison with previous RI-ISI program was performed. An additional RI-ISI program based on large release frequency is defined using information from Level 2 PSA. However, as Level 2 PSA study was performed for the first time for this type of reactors, it contains a lot of uncertainties and at this stage of development the results should not be used directly in risk applications. The RI-ISI team supports the use of Level 2 PSA results as risk data input to determine RI-ISI strategy in the future, when uncertainties of this level of risk study are reduced considerably.
10	**GER** Areva	Risk Minimizing Programs to ensure that there is no prolongation of the planned outage duration and no forced shutdowns during operation period of the plant.
11	**SWE** Ring	

PART II (Reliability Centered Maintenance)

1) Project scope - please describe the scope of an RCM project you are concern with:

a. How the scoping/selection of the components/systems to be covered by RCM was (or are planned to be[1]) carried out? What were (or would be) the main principles/ideas for components/system selection?

[1] The answer may concern either the experience acquired or plans for the future if there is no experience.

1	**UKR** KhNPP	The project "Reliability Centered Maintenance" has been started at Khmelnitsky NPP under OSA TACIS 2003 Programme. The planned project scope covers adaptation of Western methodologies to the level of detailed working manual for KhNPP, performing required analyses for two pilot systems, development of optimised maintenance strategies for these pilot systems, agreement of approaches and results with Ukrainian Regulatory Body. Upon the completion of TACIS 2003 project it is planned to perform activities for all plant systems.
2	**BUL** RiskEng	RCM is partially implemented under the scope of RI Technical Service and Repair task –Categorization process generally follows the guidance provided in Nuclear Energy Institute Document NEI 00-04, "10 CFR 50.69 SSC Categorization Guideline".
3	**ROM** CernNPP	CNE PROD Cernavoda has no RCM in place. Cernavoda NPP started to implement a Maintenance Enhancement Project intended to put in place a systematic and comprehensive maintenance program. The direction taken and process used are based on the recommendation of WANO and IAEA-April 2000 international missions for Maintenance Management. The Maintenance Enhancement Project objective by means of this systematic approach is to improve power production by increasing the reliability and performance of equipment while lowering costs. The criteria used to identify critical systems are: • Safety criteria – Protective nature – Remove decay heat and limit radioactive release in normal operating condition – Remove decay heat and limit radioactive release in abnormal operating condition – Support system for any of the above • Production criteria – It may cause unit trip – It may cause unit derate (Setback / Setback) – It may cause unit power reduction with more than 10% – It may cause indirect loss of production

		• The criteria used to identify critical components are: – Existence of redundancy – Time from failure to the loss of system function – Possibility to implement mitigating or corrective action – Impact on system operability
4	**BUL** KNPP	The selection of equipment (SSE) covered by RCM is based on identification of its safety significance and the requirements of maintenance and testing at Kozloduy NPP. The key points in the equipment selection are: • For risk categorization process is used an approach, described in the US-NEI document "10 CFR 50.69 SSC Categorization Guideline" – NEI 00-04 (January 2005); • Equipment with low safety significant is a leading candidate to be included in the scope of maintenance optimization; • Information on current maintenance and tests activities at Kozloduy NPP.
5	**SLR** UJD	
6	**RUS** Gidrop .	
7	**SP** Iber	Systems selection is carried out considering the following criteria: • Significant systems for the Plant Safety and Availability • Systems with a high maintenance work load • Systems with high corrective maintenance work load
8	**HUN** Paks	We just plan to implement RCM.
9	**LIT** EnInst	The research considers risk measures that help to define risk informed inspection program and to focus the inspections on the more important locations of considered systems. Such approach allows an optimization of inspection program while the probabilistic and fundamental deterministic safety requirements are maintained. This will provide a good basis in order to develop guidance document and to draw conclusions about the inspection priorities, to evaluate inspection interval influence and to compare alternative inspection programs.

		The incorporation of plant risk information in the ISI programs can provide a useful focus of inspections on the most “risky” locations. The new risk informed ISI programme can be based on ranking of the elements for inspection according to their risk significance. When risk for all components are calculated, a procedure for risk ranking can be applied in order to identify components with the highest risk. The objective of the risk ranking process is to form component groups with similar risk factor and focus the inspection activities on the risk significant components. A number of risk categories can be used for this purpose, based on risk magnitude. The severity of consequence can also be used to classify the component failures in different categories of safety significance. The risk categories are then used to make an ISI selection.
10	**GER** Areva	The Reliability Centered Maintenance (RCM-Method) is not used in Germany as a systematic method due to the fact that EPRI is not responsible for German NPP. In General you classify the systems and the components in • Safety related components and systems • Non safety related components and systems. During erection phase of the plants a PSA analysis had to be done for the safety related components with the result of testing procedures and intervals which are fixed in the testing manual. If you want to change the interval of the testing procedure or the testing procedure itself (f.e. change from inspection to function test) you have to show by PSA that there is no loss of safety level and… you need the agreement of the authorities. For this reason there is no need to use the RCM method. For the non safety related components and systems RCM similar approaches are done, the RCM method would be very useful, but at the moment RCM methodology is not in use (and should/will be changed).
11	**SWE** Ring	Safety systems and maintenance intensive systems.

b. How many components/systems have been (or are planned to be) covered by the RCM project?

1	**UKR** KhNPP	Upon the completion of TACIS 2003 project it is planned to optimise maintenance strategies for all plant systems.
2	**BUL** RiskEng	Seven systems were selected based on safety significance component and system selection.
3	**ROM** CernNPP	An expert panel composed by system engineers, maintenance engineers and licensed operators identified 65 systems important for nuclear safety, 26 systems important for production and approximately 6100 critical components. The systematic approach consists of the following steps: – Group critical components per type (MOVs, PVs, Pumps, etc.) by families of design and manufacturers – Identify the duty cycle and operating conditions – Identify the "leader" for each family with the most severe duty cycle and conditions – Identify tasks / intervals as per EPRI recommendations – Identify manufacturer recommended tasks / intervals – Identify mandatory requirements (EQ, OMT, etc.) – Identify tasks / intervals performed at Cernavoda NPP and look for internal / external OPEX – Tasks / intervals evaluated by an expert panel group joined by system engineers and maintenance specialists – Issue the Preventive Maintenance template for the component – Identify procedures, spare parts, tools needed – Issue and approve call-ups and introduce them in the planning system The list of critical components has been compared with the list of PSA components (2863). PSA components not initially considered critical were included in the list, thus the number of critical components rose to a total of 8113.

		The total number of EE identified is 456 components.
4	**BUL** KNPP	It is a pilot project. That is why limited equipment was selected based on its risk significance categorization to verify the applicability of the chosen Risk Informed (RI) methods for maintenance optimization in the area of In-Service Inspection and Testing (ISI/IST) and overall maintenance activities (optimization of the scope and type of testing and maintenance). The equipment (SSC) selected to maintenance optimization is as following: • Spray system (TQ1) • Low Pressure Injection System for Emergency and Planned Cooling (TQ2) • High Pressure Injection System for Emergency and Planned Cooling (TQ3) • High Pressure Injection System for Emergency Boron Injection (TQ4) • Emergency Feedwater System (TX) • Emergency Diesel Generator System (DG) • Technological Protection and Interlock Circuits System (YZ) • Service Water Supply System to Group “A” Consumers (QF/VF) • Ventilation and Cooling of Safety Systems (TL/UV)
5	**SLR** UJD	
6	**RUS** Gidrop .	
7	**SP** Iber	82 systems are have been covered by the CN Almaraz Project (41 for each Unit)
8	**HUN** Paks	
9	**LIT** EnInst	The considered RI-ISI study investigates 300 mm diameter piping ISI strategies with respect to risk and required resources. In total 1240 stainless steel welds were analyzed, assuming IGSCC to be the main damage

		mechanism.
10	**GER** Areva	
11	**SWE** Ring	It's a great variation from very small to big systems.

c. Does the plant have a computerized in-house system for registering component failures and maintenance events? If yes, please provide the following details:

- When the system was put in operation (year)? :
- Which plant department inserts the information in the data collection system? :
- Which departments use the information? :
- Is the data collection system available in the main control room? :
- Is the information periodically analysed and used for maintenance planning? If yes, please provide details:

1	**UKR** KhNPP	At Khmelnitsky NPP there is a plant system for registering component failures that is in operation since plant commissioning. It registers the failure and its causes including maintenance events. - The last modernization of the system was completed in 2005. It comprised transfer to Oracle software and currently its title is Ukrainian Reliability Database. - Plant departments who are the owners of equipment insert information into data collection system including the information on defects. The personnel of Reliability and Life Time Management Department perform engineering support. - All departments-owners of the equipment and engineering services use the information for various purposes (e.g. reliability and life time management, equipment registration, equipment qualification, PSA, etc.). - It's planned to make the system available in the Main Control Room in the near future. - The information is continually analyzed and periodic reports are issued. Information is used for outage planning: - Issuing Annual Outage Schedule; - Issuing schedules for life management (replacement of equipment with expired life time or activities on life time

		extension).
2	**BUL** RiskEn g	The plant has a database for registering component failures since 1994-1995. A new integrated information system is under implementation which covers – recording and tracking of component failures; registering, planning and reporting of maintenance events; work order system; lifetime of the important equipment tracking - Which plant department inserts the information in the data collection system? : all departments are involved in data entry depending on the data, which have to be collected - Which departments use the information? : - Is the data collection system available in the main control room? : No - Is the information periodically analysed and used for maintenance planning? If yes, please provide details: No information
3	**ROM** CernN PP	- When the system was put in operation (year)? : Starting middle of April, 2005. - Which plant department inserts the information in the data collection system? : Operations Department (Work Requests / Work Permits / Control Room Logs), and Maintenance / Scheduling Department (Work Reports / Work Schedule). - Which departments use the information? : Technical Department, Maintenance Department, OPEX, Safety & Licensing. - Is the data collection system available in the main control room? : Only for maintenance events. - Is the information periodically analysed and used for maintenance planning? If yes, please provide details: Component failures and maintenance activities are assessed by Operation, Maintenance / Scheduling, OPEX, Safety & Licensing joint working team and feedback is used in preventive maintenance scheduling. Mothly reports are provided to plant management through Plant Safety Oversight Committee.
4	**BUL** KNPP	There is a computerized system for registration of the equipment failures and maintenance activities. • **Year of operation:** - since 1995 with input of previous existing information **Note:** A new integrated information system is under development and implementation. It incorporates all information concerning the lifetime of equipment (including design data, operation and maintenance data,

		failures; events, work order system, etc.) • **<u>Department, which is in charge to input information:</u>** - Operational Department Maintenance Department Technical Support Department • **<u>Department, user of information:</u>** - Operational Department Maintenance Department Technical Support Department • **<u>Access to the data collection system:</u>** - Different levels of access is available from all working places with PC, including **<u>Main Control Room (MCR)</u>** • **<u>Periodicity of information analyses and usage:</u>** - At least once per year Used for planning of the unit annual outage
5	**SLR** UJD	
6	**RUS** Gidrop .	
7	**SP** Iber	Yes, SIGE • At the beginning of the operation, in 1981 • MTO • Maintenance, Engineering and Safety-PSA • Yes This information is analysed monthly by the Data Analysis Group, to monitor component performance, to define failures or un-availabilities and to achieve the performance criteria defined by the MR.

8	**HUN** Paks	
9	**LIT** EnInst	Computerized system (database) for registering component failures are available, however the historical data inclusion is still in progress and the system application process is not specified precisely.
10	**GER** Areva	
11	**SWE** Ring	Does the plant have a computerized in-house system for registering component failures and maintenance events? If yes, please provide the following details: - When the system was put in operation (year)? : In the early 80's Ringhals used a in-house developed system, and in the late 90's we moved the data to a SAP/R3 platform. - Which plant department inserts the information in the data collection system? : Maintenance. - Which departments use the information? : Maintenance and operations. - Is the data collection system available in the main control room? :Yes. - Is the information periodically analysed and used for maintenance planning? If yes, please provide details: Not at the moment but we are planning to do so using a tool called "Bicycle".

2) General methodology:

a. What methodology has been (or are planned to be) used in the RCM project? Please give reference, if applicable, to the applied RCM methodology.

1	**UKR** KhNPP	Methodology will be based on RCM general provisions. Detailed working manual is being developed at present.
2	**BUL** RiskEng	The methodology is developed based on Westinghouse input and using the following references: 1. NEI 00-04 (Prepublication Rev. 0), "10 CFR 50.69 SSC Categorization Guideline", January 2005. 2. 10 CFR 50.69, Final Rule, "Risk-Informed Categorization and Treatment of Structures, Systems, and Components for Nuclear Power Reactors", November 22, 2004. 3. Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications". August 1998.

		4. Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis”, Revision 1, November 2002.
3	**ROM** CernNPP	The Maintenance Enhancement Project is developed based on EPRI experience and methodology in an effort to shift from traditional time-directed tasks to condition-based maintenance.
4	**BUL** KNPP	**Risk categorization of equipment:** – based on US NRC and US NEI method: • Document 10 CFR 50.69, Final Rule, “Risk-Informed Categorization and Treatment of Structures, Systems, and Components for Nuclear Power Reactors”, November 22, 2004. • Document NEI 00-04 (Prepublication Revision 0), “10 CFR 50.69 SSC Categorization Guideline”, January 2005. **RI optimization of ISI/IST:** – based on Westinghouse method and US NRC regulations: • US NRC Regulatory Guide 1.178, “An Approach for Plant Specific, Risk-Informed Decisionmaking for Inservice Inspection of Piping”, September 1998; • US NRC Regulatory Guide 1.175, “An Approach for Plant Specific, Risk-Informed Decisionmaking: Inservice Testing”, August 1998 **Overall maintenance optimization:** – based on US NRC methods: • US NRC Regulatory Guide 1.160 Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NRC, March 1997; • Document NUMARC-93-01, Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, Revision 03, July 2000; • US NRC Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis”, Revision 1, November 1998. • US NRC Regulatory Guide 1.177, “An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications”. August 1998.
5	**SLR** UJD	
6	**RUS**	

	Gidrop .	
7	**SP** Iber	Simplified methodology developed by IBERDROLA S.A. and adapted of American Plants
8	**HUN** Paks	
9	**LIT** EnInst	The used RI-ISI methodology is related to WCAP-14572: Westinghouse Owners Group Application of Risk-Informed Methods to Piping In-service Inspection, Topical Report, Rev. 1, Westinghouse Energy Systems.
10	**GER** Areva	
11	**SWE** Ring	SRCM from ERIN-Engineering

b. Please list 5 main advantages and disadvantages of the used methodology (from your point of view):

1	**UKR** KhNP P	The main disadvantage is extremely big scope of preventive maintenance without performing actual assessment of equipment significance for plant safety and reliability.
2	**BUL** RiskEn g	Advantages foreseen: - Provide a set of criteria in evaluation of the vulnerability of equipments towards various failure mechanisms. - Establish a comprehensive maintenance plan (priorities, spare parts necessary, etc.) for equipments which do not benefit by adequate preventive maintenance. - Evaluate the optimum task interval by the trade-off reliability versus unavailability. Disadvantages foreseen: - Long term process involving significant work effort / costs.
3	**ROM** CernN	

	PP	
4	**BUL** KNPP	**<u>RCM Advantages</u>** <u>(based on the own experience)</u>**<u>:</u>** • N/A – the project is under development **<u>RCM Disadvantages</u>** <u>(based on the own experience)</u>**<u>:</u>** • N/A – the project is under development
5	**SLR** UJD	
6	**RUS** Gidrop .	
7	**SP** Iber	Advantages: • Increase in Equipments Availability • Human Error Probability Minimization • Evidence of design deficiencies • Continuing Adjustments to Maintenance Tasks • Best knowledge of the facility • Decrease in Reduction of Outage duration Disadvantages • Difficulty on the Feedback Process • High consumption of resources in the detailed methodology
8	**HUN** Paks	
9	**LIT** EnInst	The risk informed methods are efficient tools to identify the relative importance of the system components. Therefore, deterministic assessment supported by risk-informed insights can be used to evaluate risk significance of inspection activities, focus the analysis and activities on the key components and to optimize inspection and maintenance both from the safety and the radiation exposure standpoints. The total amount of inspection sites

		and the cumulative radiation exposure to the NPP personnel can be reduced at the same level of total risk. It should be remembered that if the uncertainty of an input parameter is biased at the same direction for all welds, the risk ranking order is in most cases preserved. This also implies that one should not rely on absolute values of the CDF for individual welds and treat them only in relative sense.
10	**GER** Areva	
11	**SWE** Ring	The tool contains a database with many years of experience. It will give clear recommendation for changing the PM programme. The streamlined approach make the scope manageable. The user interface is not user friendly. It's not so easy to make plant specific changes to the database templates.

c. Please list issues where the main difficulty was experienced in applying the selected methodology:

1	**UKR** KhNPP	Methodology is only being developed.
2	**BUL** RiskEng	• gathering plant specific data • breaking down a component to subcomponents • breaking down maintenance activity to sub-activities with their specific times for completion
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	Some difficulties, based on the on going project, where defined: • Gathering plant specific data; • Breaking down the equipment into components based on the project needs; • Breaking down maintenance activities to sub-tasks and definition of their specific times for completion.
5	**SLR** UJD	
6	**RUS** Gidrop.	

7	**SP** Iber	• Plant Documentation Management • Maintenance Historic Plant Management and Support to analyze it. • Support, Feedback and Compromise of Plant Staff. • Maintenance staff traditional Culture
8	**HUN** Paks	
9	**LIT** EnInst	Even if the RI-ISI programs suggest only 10% extent of inspection in the low risk welds, there should be an element of continuous plant feedback based on the inspection findings. This means that if new cracks are detected even in the low risk welds, it may be wise to increase the extent of inspection and shorten the inspection interval for this group of welds. One way of assuring that information of this kind is treated in an appropriate manner is the formation of an expert panel. The task of the expert panel is to review new proposed inspection programs and suggest possible changes and additions, which perhaps are not coming out from a RI-ISI analysis. The expert panel should include people with different experiences; plant operation, material data, inspection, strength of materials, probabilistic methods and PSA.
10	**GER** Areva	
11	**SWE** Ring	

3) If PSA models were used in the RCM project please specify:

a. What was the scope of PSA used for the RCM project (hazards analyzed, operational modes, and analysis level, i.e. Level-1 or -2)?

1	**UKR** KhNPP	**2. Khmelnitsky-2** PSA Level 1 for internal events has been developed and agreed with Regulatory body; PSA for internal fires is being developed and it's to be finalized in November 2006; PSA for internal floods has been developed,

		PSA for external impacts has been developed; PSA for outage has been developed; PSA for Spent Fuel Pond has been developed; PSA Level 2 has been developed.
2	**BUL** RiskEn g	Level 1 full power PSA + fire, seismic and flooding analyses
3	**ROM** CernN PP	CNE Cernavoda Unit 1, PSA Level 1 Internal Events 100% FP, Fire, Flood and Seismic completed with Shutdown PSA, currently under development.
4	**BUL** KNPP	PSA, Level 1 for full power, including internal event, fire analysis, seismic and flooding analyses is used for maintenance optimization
5	**SLR** UJD	
6	**RUS** Gidrop .	
7	**SP** Iber	PSA is not necessary for RCM Analysis, although it is useful as information supply.
8	**HUN** Paks	
9	**LIT** EnInst	The considered RI-ISI uses the conditional core damage probabilities (as sometimes called consequences) for different postulated LOCA events. The safety barriers were provided by Ignalina PSA study. The project team considered Level 1 PSA results (core damage frequency) to be sufficient for the RI-ISI purposes.
10	**GER**	

	Areva	
11	**SWE** Ring	

b. Were there any specific RCM-related requirements to the PSA model quality/attributes (i.e. PSA models, data, documentation)? If yes, please provide details:

1	**UKR** KhNPP	Methodology is only being developed.
2	**BUL** RiskEng	Change of beta factor model for CCF with MGL for reduction of the conservatism, improvement of data analysis using more plant specific values, application of Bayesian approach
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	The project is under development. Up to now the following changes into the PSA model are made towards reducing the conservatism of analysis: • Replacing some generic data with plant specific data based on Bayesian method; • Changing of Beta factor model for Common Cuase Failure (CCF) with Multiple Greek Letter (MGL) factor.
5	**SLR** UJD	
6	**RUS** Gidrop.	
7	**SP** Iber	No
8	**HUN**	

	Paks	
9	**LIT** EnInst	Consequences of the selected pipe systems are determined and quantified by probabilistic safety assessment study of Ignalina NPP. The PSA project started as Level 1 study in 1991 and was continuously developed and improved until 2002 during 5 development phases. The Level 1 PSA was reviewed several times by IAEA missions (IPSART, 1999 and 2001) and other international review teams, which concluded that current plant risk model represents fairly complete internal event risk topography. The first approach for Level 2 PSA study was also completed in 2001, providing estimates for radioactive release frequencies.
10	**GER** Areva	
11	**SWE** Ring	

c. Which RCM-related changes have been implemented to the standard/living PSA models and data and if non, what was the main reason for this? Please provide details:

1	**UKR** KhNPP	Methodology is only being developed. If it is required to introduce some changes into PSA model, such changes will be made.
2	**BUL** RiskEng	Listed above requirements were implemented before start of using PSA model
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	For updating the existing PSA model the following changes have been implemented: • Replacing some generic data with plant specific data based on Bayesian method; • Changing of Beta factor model for Common Cuase Failure (CCF) with Multiple Greek Letter (MGL) factor.
5	**SLR** UJD	
6	**RUS**	

	Gidrop .	
7	**SP** Iber	It affects decreases of availability or exposure times to the basic issue failure associated to modifications in maintenance task.
8	**HUN** Paks	
9	**LIT** EnInst	When using RI-ISI to define new future inspection program, there should be an element of continuous updating of RI-ISI analysis as new information develops. This could mean for example introducing new inspection methods, new information on pipe stresses, unexpected cracking occurrence, updating of the PSA study or replacement of piping to materials not susceptible to IGSCC. The latter action may very well be an attractive alternative to performing inspections, especially for the high risk welds.
10	**GER** Areva	
11	**SWE** Ring	

d. Which quantitative risk measures/metrics have been used in the equipment categorisation/ RCM optimization process?

1	**UKR** KhNP P	Methodology is only being developed.
2	**BUL** RiskEn g	The risk characterization uses two PSA importance measures to identify potentially safety-significant components/systems. These are the risk achievement worth (RAW) and the Fussell-Vesely (F-V) measures. Risk reduction worth (RRW) can be used in place of F-V. The following importance measure criteria are used to identify possible safety significant components/systems: • Sum of F-V for basic events of interest including common cause > 0.005 • RAW for basic event of interest > 2

		• RAW for corresponding common cause failure basic event > 20
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	The risk measures, which have been used to identify equipment (SSC) candidate safety significance, are based on the document US NEI 00-04 (Prepublication Revision 0), "10 CFR 50.69 SSC Categorization Guideline", January 2005. They include • Risk Achievement Worth (RAW); • Fussell-Vesely (F-V) Importance; • Risk Reduction Worth (RRW). The chosen quantitative criteria are as follows: • **Sum of F-V for all basic events modelling the SSC of interest,, including common cause events: - > 0.005** • **Maximum of component basic event RAW values: - > 2.0** • **Maximum of applicable common cause basic event RAW values: - > 20.0**
5	**SLR** UJD	
6	**RUS** Gidrop.	
7	**SP** Iber	Any
8	**HUN**	

	Paks	
9	**LIT** EnInst	The considered Global system Risk reflects the total System Conditional Core Damage Frequency (CCDF). It takes into account each component influence to CDF considering probability for a component to failure due to degradation per year and probability for a component to degrade the safety of whole system, expressed as Safety barrier (Probability of Safety Systems Failure).
10	**GER** Areva	
11	**SWE** Ring	

e. How were the components not included in the PSA models treated for the RCM purposes? Please provide details:

1	**UKR** KhNPP	Methodology is only being developed.
2	**BUL** RiskEng	
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	N/A – the project is under development
5	**SLR** UJD	
6	**RUS** Gidrop.	
7	**SP**	Component classification criteria are based on concepts related with availability, safety, facility and environment

	Iber	protection, without using quantitative measures, except those that can be specifically related to the component reliability
8	**HUN** Paks	
9	**LIT** EnInst	The non RI-ISI selection is doing a good job in the sense that the highest risk levels are covered by 100%. On the other hand, locations representing low and very low risks are also selected in the non RI-ISI program. Inspection of these low risk welds does not significantly affect the total CDF. This indicates that there are possibilities for optimization.
10	**GER** Areva	
11	**SWE** Ring	

f. If results are available, could you please give some qualitative/quantitative information on the actual modifications made to the maintenance programmes? Please provide details:

1	**UKR** KhNPP	Methodology is only being developed.
2	**BUL** RiskEng	not available yet
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	N/A – the project is under development
5	**SLR** UJD	

<table>
<tr><td>6</td><td>RUS
Gidrop
.</td><td></td></tr>
<tr><td>7</td><td>SP
Iber</td><td>
<table>
<tr><th colspan="9">GLOBAL RESULTS FROM PHASES I AND II IN A PWR</th></tr>
<tr><td></td><td>Analysed components</td><td>Critical components</td><td>Former tasks</td><td>Final tasks</td><td>Former hours</td><td>Final hours</td><td>%Tasks reduction</td><td>%Hours reduction</td></tr>
<tr><td>Phase I</td><td>5,226</td><td>1,017</td><td>2,798</td><td>1,889</td><td>8,140</td><td>6,306</td><td>32%</td><td>23%</td></tr>
<tr><td>Phase II</td><td>10,218</td><td>3,264</td><td>5,213</td><td>3,151</td><td>15,940</td><td>12,898</td><td>40%</td><td>19%</td></tr>
<tr><td>Mean</td><td>15,444</td><td>4,281</td><td>8,011</td><td>5,040</td><td>24,080</td><td>19,204</td><td>37%</td><td>20%</td></tr>
</table>
</td></tr>
<tr><td>8</td><td>HUN
Paks</td><td></td></tr>
<tr><td>9</td><td>LIT
EnInst</td><td>After completing of IRBIS project the Ignalina NPP have take advantage on the pilot study results and prepare the new Inspection Program focusing on the highest risk locations. The amount of inspection was not reduced, but the risk was reduced significantly.
With a quantitative RI-ISI-analysis for Ignalina NPP unit 2, it is possible to combine 44% reduction in number of future inspections and 35% reduction in risk. This is possible due to proposed shorter inspection interval for high risk welds. Shorter inspection interval is suggested for 205 welds in the higher risk locations. Less than 100% extent of inspection in the lower risk levels is well compensated by the choice of a shorter inspection interval for the higher risk locations.</td></tr>
<tr><td>10</td><td>GER
Areva</td><td></td></tr>
<tr><td>11</td><td>SWE
Ring</td><td></td></tr>
</table>

g. Were these modifications approved by the regulator?

1	**UKR**	The Regulatory body participates in the project. Appropriate working communication has been established. All

	KhNPP	modifications shall be agreed with the Regulatory body.
2	**BUL** RiskEng	Not yet presented
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	No - the project is under development
5	**SLR** UJD	
6	**RUS** Gidrop.	
7	**SP** Iber	The Spanish regulator controls maintenance activities efficiency and not the maintenance plan. The maintenance activities required by regulation are not modified.
8	**HUN** Paks	
9	**LIT** EnInst	The Lithuanian regulatory body (VATESI) in general agree to use RI-ISI program for austenitic pipelines, and waiting for Ignalina NPP proposals. There is an opinion, that if the number of inspections are reduced, the compensating actions should be taken, i.e. if some of low risk welds in the future is not periodically inspected, the more precise Leak Detection System are necessary.
10	**GER** Areva	
11	**SWE** Ring	

h. Which were the main difficulties experienced when using PSA models for RCM purposes? Please provide details:

1	**UKR** KhNPP	Methodology is only being developed
2	**BUL** RiskEng	
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	N/A – the project is under development
5	**SLR** UJD	Due to the reasons explained in the first question, we are currently not able to answer questions related to the PSA models used.
6	**RUS** Gidrop.	
7	**SP** Iber	It is not applicable
8	**HUN** Paks	
9	**LIT** EnInst	The practical experience indicates that IGSCC is the most important damage mechanism in RBMK plants. Very few failures have actually occurred, however, and this state of affairs precludes any estimation of the failure probability based on observed data, other than perhaps small leak probabilities. To estimate the failure probability, analytical methods have to be used instead. In such a case the uncertainty of estimates is one of the biggest issues.
10	**GER**	

	Areva	
11	**SWE** Ring	

5) Please specify <u>Maintenance Optimization related areas</u> where future international cooperation might be useful:

1	**UKR** KhNPP	I can't specify such areas at the moment.
2	**BUL** RiskEng	
3	**ROM** CernNPP	- Use of Risk Monitors for optimization of safety during maintenance - Optimization of maintenance through introducing RCM programmes - Definition of plant performance indicators to evaluate achievement in maintenance optimization - Ageing impact on components reliability
4	**BUL** KNPP	Areas, where future international cooperation might be useful: • Treatment of the equipment (SSC), not included in the PSA models, for the RCM purposes • The role of RCM among the other NPP maintenance activities in order to enhance overall NPP safety and competitiveness.
5	**SLR** UJD	From the regulators' point of view we would appreciate to have an international forum (in the form of workshops, seminars, trainings, etc.) for exchanging knowledge and experience in authorization and regulation of maintenance optimization projects. Requirements for safety systems as international rules
6	**RUS** Gidrop.	

7	**SP** Iber	Define standards of preventive and corrective maintenance for every type of component according to its failure modes.
8	**HUN** Paks	
9	**LIT** EnInst	Identification of a good basis (from the point of RI-ISI needs and PSA supporting studies) to draw conclusions about the inspection priorities, and to evaluate inspection interval influence and to compare alternative inspection programmes. Investigation of the uncertainty related to PSA supporting studies and PSA application for RI-ISI purposes.
10	**GER** Areva	
11	**SWE** Ring	

PART III (use of generic probabilistic concepts in maintenance optimisation)

1) How do you define the performance criteria for the components covered by the RCM project (please provide at least one example)?

1	**UKR** KhNPP	Methodology is only being developed
2	**BUL** RiskEng	The criteria for selection of the critical components are: RRW > 1.005; RAW > 2.
3	**ROM** CernNPP	N/A
4	**BUL**	N/A – the project is under development

	KNPP	
5	**SLR** UJD	Question not applicable to the regulatory body.
6	**RUS** Gidrop.	
7	**SP** Iber	The performance criteria are based on maintenance history considering industry experience, validated by an expert team and PSA.
8	**HUN** Paks	
9	**LIT** EnInst	The following criterion was considered: ΔCDF < 0 or possibly only a small increase in CDF in case of reducing inspection costs. Here ΔCDF = CDF(new inspection program) – CDF(current inspection program). Acceptance criterion also can be based on relative values ΔCDF/CDF << 1.
10	**GER** Areva	See comment of PART II Every failure in German NPP is notified and written down by the shift. All failures are analyzed concerning PSA relevant aspects. PSA relevant aspects for safety related components and systems or criteria can be: o Internal leakage o External leakage o Loss of function o Without loss of function o …..
11	**SWE** Ring	

2) How do you define the performance goals for the components covered by the RCM project (please provide at least one example)?

1	**UKR** KhNPP	Methodology is only being developed
2	**BUL** RiskEng	
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	N/A – the project is under development
5	**SLR** UJD	Question not applicable to the regulatory body.
6	**RUS** Gidrop.	
7	**SP** Iber	Specific objectives are established when the component performance is not appropriate because it doesn't meet the performance criteria.
8	**HUN** Paks	
9	**LIT** EnInst	The most important goal of a non-destructive examination (NDE) is to be able to detect possible degradation at an early stage in order to prevent the damage to cause to a possible failure. There is a need for an In-Service Inspection (ISI)-program that has the capability of more accurately finding the components where the probability of degradation is the greatest. ISI program should provide a framework for allocating inspection resources in coast effective manner and help focus the inspection activities where they are most needed.
10	**GER**	

	Areva	
11	**SWE** Ring	

3) Which techniques are applied for the monitoring of the component reliability in time/ revealing ageing effects?

1	**UKR** KhNPP	Periodic analysis of equipment reliability is performed outside the project scope, especially for equipment with extended operation life. Reliability analysis is mandatory for all equipment with expired design life. The plant has special engineering service to control these aspects
2	**BUL** RiskEng	
3	**ROM** CernNPP	N/A
4	**BUL** KNPP	N/A – the project is under development
5	**SLR** UJD	Question not applicable to the regulatory body.
6	**RUS** Gidrop.	
7	**SP** Iber	Condition based maintenance with methodologies adapted from INPO AP-913
8	**HUN** Paks	
9	**LIT** EnInst	The statistical data analysis was used for revealing ageing effects. Up to 2000, a total of 278 cases of IGSCC have been found in unit 1 with 17 years of operation. The corresponding number for unit 2 is 57 cases of IGSCC

		with 13 years of operation. The deepest cracks reached about 12 mm. However, no leaks have been experienced so far for this type of piping. After 3 years from the Pilot study, updating of RI-ISI was performed by taking into account new statistical data on pipe defects. Comparison with previous RI-ISI program was performed. For certain degradation mechanisms, such as thermal fatigue (which is not covered in this pilot study) and vibration fatigue (as a single damage mechanism), it can be difficult to use the considered inspection techniques to reduce the risks. This is because that they sometimes can develop degradation faster than proposed inspection intervals to deal with IGSCC. In such cases, a continuous monitoring technique (related to LBB) may be a better strategy for risk reduction.
10	**GER** Areva	
11	**SWE** Ring	

European Commission

EUR 22604 EN – DG JRC – Institute for Energy
Advanced Methods for Safety Assessment and Optimization of NPP Maintenance – Summary report of the Workshop held at the Institute for Energy, EC-JRC, Petten, Netherlands on 2-5 October, 2006

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Luxembourg: Office for Official Publications of the European Communities
2006 – 64 pp. – 21 x 29.7 cm
EUR - Scientific and Technical Research Series; ISSN 1018-5593

Abstract
This report presents the technical summary of the presentations and panel discussions in relation to the workshop on "Advanced Methods for Safety Assessment and Optimization of NPP Maintenance" which was organized in Petten (EC/JRC-IE premises) on October 2-5, 2006 by the JRC-IE (SENUF network), and by the International Atomic Energy Agency (IAEA), Nuclear Safety/Technical Cooperation Dept.
The workshop addressed the application of advanced probabilistic methods to the optimisation of the maintenance programmes at the European NPPs.
The conclusions of the workshop are presented in two main areas: (a) Plant specific PSA models and techniques to optimize NPP maintenance planning and scheduling, b) Equipment reliability analysis as function of the MS&I programs.
The workshop also identified some issues that deserve additional research effort and international support before a broad application of the RCM is proposed to the EU Members.

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