WORKING GROUP

EQUIPMENT AND BUILDING STRUCTURES AGEING MANAGEMENT FOR WWER TYPE NPPS

CONTENTS

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INTRODUCTION

The decision about organisation of the Working Group "Ageing Management of Equipment and Structures of NPPs with WWER" in the frames of the Co-operation Forum of WWER Regulators was made at the 6th annual meeting in St. Petersburg, Russia, on 24-27 June 1999. Ukraine assumed the chairmanship of the working group.

A main tasks of WG was agreed by 7th annual meeting of WWER Regulators Forum in Odesa, Ukraine, on 11-13 October 2000.

Members of the Working Group are

Mr. Robert Harutjunov, ANRA, Armenia
Mr. Dimitar Vasilev, BNSA, Bulgaria
Mr. Petr Tendera , SONS, Czech Republic
Ms. Agnes Janosine Biro, Institute for Electric Power Research Co, Hungary
Mr. Matti Ojanen , STUK, Finland
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Mr. Zdenek Mokersky, SONS, Czech Republic

The IAEA supported two meeting of WG the period after 7-th Forum, Mr. Paolo Contri and Mr. Jaroslav Pachner of IAEA actively participated in the Group's work as an observers and contributors, for which the Working Group wishes to express them deepest gratitude.

WG ACTIVITY. MEETING IN KIEV.

- The first meeting of the Group was held on 30, 31 October and 1 November 2000 in Kiev with participation of representatives of all WWER countries and Mr. Paolo Contri from IAEA Department of Nuclear Installation Safety.

At the first meeting all participants of the working group presented experience in their countries in the following areas:

- Evaluation of quantity, quality and reliability of available data on equipment and structures relevant to different WWER plants;
- Examples of fulfilment and practical implementation of projects related to ageing of equipment and structures in their countries;
- Ageing management requirements issued from regulatory guidelines in force in countries - participants.

- Two examples of regulatory requirements have been handed out: the first from

Russian regulator (oriented to life extension), the second from Lithuania (oriented to the management of safety) through IAEA. The following two case studies have been selected:

- Integrity of WWER440 SG heat exchangers tubes: inspection methodologies, their frequency and their impact on the safety margin and residual life evaluation;
- Functionality of the prestressing system for the WWER1000 containment: forecasting of prestressing losses and control of the safety margin.

- The workplan of WG activity that was established in Minutes of the 1-st meeting.

WG ACTIVITY BETWEEN 1-ST AND 2-ND MEETINGS

According to the workplan of WG activity in the period between 1-st and 2-nd WG meeting the following activities were performed:

- At the 1-st meeting it was agreed to develop a short state of the art of the experience in AMP, including the references to the documents issued by the WWER Countries. The summary table was updated by the Country representatives and sent back to Ukrainian co-ordinator for inclusion in the WG final document. This summary table was agreed at 2-nd meeting and will be presented below.
- Two documents – Russian acting regulatory guide NP-017-2000 and draft of Lithuania requirements getting though IAEA as example of regulatory approaches were translated and delivered to the participants .
- The first draft common regulatory approach based on Russian regulatory guide NP-017-2000, draft of Lithuania requirements getting though IAEA and IAEA documents were developed and distributed to IAEA and WG participants for comments and remarks.
- Results of Mr.Pacher's review of this draft were taken into account in draft of WG recommendation which will be presented as basis of this WG meeting discussion.
- For both selected case studies – integrity of WWER 440 SG heat exchangers tubes and functionality of WWER 1000 containment pre-stressing system format of ageing management data submission was defined. The drafts of data formats were sent to WG participants for comments, proposed changes were included in final data formats which were distributed to all for completing.
- WG participants performed assessment of both case studies and results were send to Ukrainian co-ordinator for generalisation. All this data were delivered among WG participants to study information from WWER countries and to discuss during 2-nd meeting.
- Ukrainian team collected and summarised received data and national regulatory

requirements for two case studies, prepared summary reports for WWER 440 SG and WWER 1000 containment PS which were presented by Mr. Zaritsky and Mr. Krytskyy as basis of discussion at 2-nd WG meeting.

- Preliminary assessment of applicability of developed common regulatory approach to the WWER 440 and WWER 1000 on examples of two case studies in co-operation with reference plant technical team was performed by Mr. Pogorelov who visited the reference plant for case study n.1 - Novovoronezh Units 3 and 5. He presented the plant's practice at 2-nd meeting as basis for discussion.
- Proposals to communication channels among Regulatory bodies for ageing related data exchange were preliminary adopted during the WG activity.
- All participants presented to the WG their experience in the development of ageing management programs (AMP) in their Countries.

WG ACTIVITY. MEETING IN MOSCOW.

The second meetings was held in Moscow, Russia at 2 - 5 April, 2001 under IAEA support with participation of representatives of all WWER countries and Mr. Jaroslav Pachner from IAEA Department of Nuclear Installation Safety.

At the 2-nd meeting was discussed the developed materials and performed the following:

- Agreement on the state of the art of ageing management in the WWER countries;
- Definition a WWER regulatory approach to ageing management;
- Evaluation the results of the case studies: identify the implementation problems;
- Definition suitable communication channels among regulators for ageing related data;
- Development Proposals for future WG activity.

For organising fruitful work during 2-nds meeting representatives of the Regulatory Bodies of countries operating WWER presented:

- comments and correctives to the Draft of WG recommendations on regulatory requirements which was sent round early;
- conclusions and recommendations to the case (cases) study in order that the Working Group should formulate appropriate statements;
- proposals to communication between Regulatory bodies for ageing related data exchange with taking into account results of WG activity and to future WG activity.

WG RESULTS

Results obtained by WG are presented in the WG report which provides a summary

of the national contributions in the field of equipment and building structures ageing management, in first chapter- introduction, five technical chapters and conclusion.

- The second chapter discuss national experience (in the first place - regulatory experience) in the field of ageing management. All countries operating WWER type plants provided contributions in the form of national reports, which were distributed among the group members. The reports were so detailed that it was decided on the first WG meeting to generalise national experience in summary table for inclusion in final report.
- The third chapter is dedicated to development a detailed concept of the regulatory approach to ageing management. WG summarise regulatory positions and recommendations in unified version of regulatory guidelines on ageing management of SSCs of NPP with WWER type reactors.
- Results of investigation of selected case studies - integrity of WWER 440 steam generator heat exchangers tubes and functionality of WWER 1000 containment pre-stressing system are presented in the forth chapter.
- The fifth chapter discuss questions connected with ageing related data exchange and suitable communication channels between WWER countries Regulator's based on WG experience.
- Proposals for Working Group (WG) future activity are placed in the end of report.

Six appendixes include additional materials such as Agendas and Minutes of WG meetings, comparison of ageing related regulatory requirements, data formats and database for WG cases studies - Integrity of WWER440 SG heat exchangers tubes and functionality of the prestressing system for the WWER1000 containment. Appendixes 5 and 6 are included information on ageing related data for both case studies presented by WG participants.

The Working Group found this form of technical co-operation very fruitful and rewarding. Working Group present to WWER countries Forum assessment following results of its work :

- table of state of art in the ageing management;
- common approach to AM presented in the WG recommendations for regulatory guidelines on ageing management of SSCs and applicability of this recommendations for the specific WWER SSCs. In developing their national requirements WWER countries are recommended take into account the agreed approach.
- Generalisation and database for SG heat exchange tubes integrity and containment pre-stressing system. WWER countries might then analyse or modify and improve national requirements in line with agreed approach, but also consistent with their national policy.
- Proposals for data exchange mechanism among WWER countries on the basis of

WG experience.

- Proposals for future WG activity.

ANALYSIS OF EXPERIENCE IN AGEING MANAGEMENT

The analysis of the experience in WWER countries (Table 1) suggested the following conclusions which were agreed at the 1-st meeting (see - Minutes):

- The most of the Countries ageing management aspects are included in existing programs for maintenance, surveillance and inspection (MS&I), improving their coverage of ageing aspects, but without an additional program for ageing;
- Ageing evaluation is often a prerequisite for licensing. In some other cases operator considered it as a condition for life extension and part of the periodic safety review (PSR);
- Some plants have already implemented ageing related measures. Few regulatory bodies issued formal requirements on ageing management and therefore few experiences of extensive implementation of ageing programs are available;
- All countries have included the same tasks in selected ageing issues;
- Most WWER plants were designed with the same standards (USSR): now different procedures for maintenance and residual life evaluation are in force in different Countries;
- No regular exchange of operating experience has been recorded in general among all WWER regulators concerning ageing related data. Some cases of information exchange have been recorded for specific items and in few Utilities;
- Few ageing oriented data bases are available: in general information are stored in paper or in many dedicated data bases not fully integrated with design data, operation data, maintenance data. There are few examples of good integration which could be used as a basis for the development of the case studies.

Summary Table of experience in WWER Countries in relation to ageing management

Country	Ageing related tasks addressed with major emphasis	Regulatory aspects, ageing related	Availability of ageing related data	Documents issued by the Regulator
1	2	3	4	5
Armenia	Material analysis Improved ISI. SG plugging tubes. Erosion-corrosion analysis on SG level meter nozzles and SG studs. Thermal fatigue on austenitic cladding of PV flange. Guide vane of main circulation pump (thermal fatigue). Corrosion on concrete of cooling towers.	Russian standards for maintenance	Statistics No DB presented	No requirements for AMP.
Bulgaria	All 1 and 2 class components (pressure retaining boundary): Vessel embrittlement Conceptual study for LBB Improved ISI Structural analyses Containment prestressing Monitoring of containment deformations.	No specific requirements for AMP. Regulatory requirements for both ageing management and assessment of residual life time of some components are often set down in the permission issued by ISUAE for annual outage of the NPP units. Extended scope of MS&I during annual outages. AMP for units 1-4 is going to be elaborated by the Kozloduy NPP.	Statistics No DB presented Only few departments of the NPP Kozloduj have already elaborated DB which are not fully integrated in a local computer net, e.g. DB for containment prestressing.	No requirements for AMP. Internal regulatory guide has been prepared and it has been submitted for approval.
1	2	3	4	5

Czech Republic	There exist a special ageing management programme for some SSC selected on the basis of the IAEA methodology (IAEA TRS No. 338).	• General requirement on maintaining safety margin in determined limits. • Living SAR (yearly). • Living PSA. • Report on ageing of selected SSC (yearly). • Some safety indicators ageing related used by both the NPP and the SUJB. • Emphasis on reliability of ISI/IST results, on- and off line diagnostics and other means of condition monitoring.	Data, records, test reports, etc. Are collected and stored by NPP according QA programme.	SUJB guidelines (recommendations) : • for lifetime evaluation of RPV and its internals • for ISI qualification, • for equipment qualification of WWER 440/213 plants • erosion-corrosion monitoring programme • detection methods for leakage monitoring final drafts of guides for IST of valves, IST of pumps, lifetime evaluation of SG and pressurizers (pressure compensators), etc.
Hungary	All class 1,2,3 components Cables Concrete	PSR mandatory every 10 years AMP mandatory Large attention to public acceptance	Large and detailed DB Data available for 23 most important components	Requirements for AMP 4 guidelines: design, operation, regulatory control of AMP, QA

1	2	3	4	5
Finland	Vessel embrittlement, Erosion-corrosion on SG feed water distributors and feed water piping, Qualification of NDT-systems, Structural analyses, Thermal stratification, Electrical cables, Protection automation, Actuation systems	AMP included in MS&I, Staff training, Living PSA (1&2), Living FSAR, Living QA, Selection of SSCs for ageing management ; followup by STUK's annual inspection programme. Annual report on ageing of electrical and I&C systems and components	Annual, monthly and event related reports, results of ISI/IST, DB presented in FSAR and other plant documentation	General requirements for AM in YVL 1.0, General AMP requirements for pressure equipment in YUL 3.0 (to be revised). YVL 5.2 Electrical systems and equipm. and YVL 5.5 I&C systems and comp. contain requirements for AMP, AM evaluated during PSR
Russian Fed.	Emphasis on non-replaceable components Improved ISI and calculation methodology Settlements of buildings LBB Containment prestressing Corrosion	Focussed to life extension Annual report to GAN on ageing of components	DB operated by TSOs	No requirements for AMP Requirements for safe operation (8-89) Requirements in view of life extension (17-2000) Guidelines: Life time management (39-95), Maintenance and repair (69-97), other methodologies by operators for evaluation of equipment

1	2	3	4	5
Slovak Rep.	Vessel embrittlement Improved monitoring Calculation of usage factors Corrosion / erosion programmes LBB concept application Leaktightness of confinement Improved NDT	No specific req. for AMP Everything inside maintenance, surveillance, QA, ISI, PSR procedures Annual report on ageing presented to NRA SR	Statistics DB sufficient, operated by licensee	No requirements for AMP Specific ageing related requirements issued by regulatory decisions
Ukraine	Prestressing tendons I&C ageing Valves and devices	PSR according to operation time	DB with failure data for 9 units, for main equipment	No requirements for AMP Requirements for safe operation (PNAE G -7-008-89) Industrial standard Requirement for valves (OTT -87) Requirement for I&C life extension (ND 306.711-96)

RECOMMENDATIONS FOR REGULATORY GUIDELINES ON AGEING MANAGEMENT

The Working Group recommendations for regulatory guidelines on ageing management of SSCs of NPP with WWER type reactors was developed in following way:

1. Analysis existing documents:
- Document of GOSATOMNADZOR of Russia "The basic requirements to prolongation of operating term of the nuclear station unit" (NP-017-2000)
- Draft VATESI requirements on ageing management of systems, structures and components important to safety in nuclear power installations (Lithuania)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation and Review of Nuclear Power Plant Ageing Management Programme, Safety Report Series No. 15, IAEA, Vienna (1999).
- AMAT guidelines, Reference document for the IAEA Ageing Management Assessment Teams. IAEA Services Series No.4

2. Preparation of Table on ageing related regulatory requirements comparison and development Draft of WG recommendations.

3. Distribution 1-st draft of WG recommendations to WG participants for comments and correctives.

4. Correction the Draft recommendations with taking into account results of review of document by IAEA consultant Mr. Pachner.

5. Discussion the Draft recommendations, and agreement the 2-nd Draft recommendations during 2-nd WG meeting.

6. Development final version of WG recommendations based results of discussion.

RECOMMENDATIONS

for regulatory guidelines on ageing management of systems, structures and components (SSCs) of NPP with WWER type reactors

Introduction

Implementation of a systematic ageing management process for SSCs is needed for maintaining safe NPP operation during the whole service life.

Regulations of maintenance, inspection, testing, repair and replacement of equipment as well as the range of monitored parameters and monitoring and diagnostic tools were identified on the basis of design and manufacturing recommendations.

Regulatory requirements and guidelines on ageing management have been implemented or are being implemented into practice in several countries with WWER-type NPPs on the basis of IAEA recommendations and the positive experience which was obtained for different types of NPPs.

This document is aimed to provide recommendations for regulatory requirements and guidelines on ageing management of SSCs in WWER type NPPs based mainly on generalisation of the following documents:

- Document of GOSATOMNADZOR of Russia "The basic requirements to prolongation of operating term of the nuclear station unit" (NP-017-2000)
- Draft VATESI requirements on ageing management of systems, structures and components important to safety in nuclear power installations (Lithuania)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation and Review of Nuclear Power Plant Ageing Management Programme, Safety Report Series No. 15, IAEA, Vienna (1999).
- AMAT guidelines, Reference document for the IAEA Ageing Management Assessment Teams. IAEA Services Series No.4
- Glossary of Nuclear Power Plant Ageing, OECD/NEA.
- Summary Table of experience in WWER Countries in relation to ageing management. Appendix to Minutes of the meeting of WG "Equipment and Building Structures Ageing Management of WWER Type NPPs" in Kiev, 30 Oct. – 1 Nov. 2000.

Content

Terms and definitions

Acceptance limit: specified limit of a functional or condition indicator used to assess the ability of an SSC to perform its design function.

Ageing: general process in which characteristics of an SSC gradually change with time or use.

Ageing degradation: ageing effects that could impair the ability of an SSC to function within acceptance criteria (limits).

Ageing effects: net changes in characteristics of an SSC that occur with time or use and are due to ageing mechanisms.

Ageing management: engineering, operations, and maintenance actions to control within acceptable limits ageing degradation and wearout of SSCs.

Ageing management programme (AMP): organisational structure, responsibilities, procedures, processes and resources for co-ordination of ageing management.

Ageing mechanism: specific process that gradually changes characteristics of a SSC with time or use.

Condition: the state or level of characteristics of a SSC that can affect its ability to perform a design function.

Residual lifetime: actual period from a started time to retirement of an SSC.

PSA: probabilistic safety analysis

Service life: actual period from initial operation to retirement of an SSC.

SSCs: systems, structures and components.

Wearout: failure produced by an ageing mechanism.

1. Scope

These recommendations for regulatory requirements and guidelines on ageing management of SSCs in WWER type NPPs cover the following aspects:

- introduction (implementation) of ageing management in NPPs;
- forming guidelines on ageing management programs (AMP) in NPPs;
- AMP assessment.

2. Objective of ageing management

The objective of ageing management implementation in NPP is to control that ageing degradation and wearing of SSCs important to safety are in acceptable limits during the entire NPP service life.

3. Recommendations on implementation of ageing management in NPPs

3.1 The licensee should take into account regulatory policy and guidance when setting up and implementing the ageing management. Any regulatory requirements or guidelines should be regarded as minimum criteria.

3.2 Due account should be taken of any available national or international guidance and good practice in the field of ageing management.

Procedures of co-operation and information exchange between Regulatory Bodies of countries with WWER type reactors are recommended as well as procedures of interaction between national regulators and licensees aimed to obtaining of information about NPP in sufficient scope for regulatory decisions making.

3.3 Regulatory body should determine content and frequency of licensees reporting on results of maintaining ageing management.

Ageing processes for SSCs important to safety should be evaluated in frames of periodical safety review of NPP and in the frames of the licensing process.

In case if an unforeseen ageing mechanism is identified and/or a significant deviation from foreseen operation parameters is observed, licensee should fulfil a specific analysis of new data and send it to Regulatory Body for review.

3.4 Licensee should collect and process all data important to ageing management. This should include development of an appropriate database on ageing management and should ensure application of relevant information to other important operational activities e.g. programmes of technical maintenance, in-service inspection programmes, surveillance programmes and updating or development of appropriate operational procedures.

Licensee should ensure quality of the information relevant to the components concerned.

3.5 To facilitate the introduction and maintaining of systematic approach to ageing management in NPPs it is recommended to establish the following regulatory guidelines, in accordance with which licensee should:

(1) Officially establish ageing management policy and objectives.

The ageing management policy should show licensees' commitment to ensure the adequate safety level of NPP unit during its whole service life. Policy document should reflect commitments on:

- maintenance of safety margins in SSCs;
- AMP implementation;
- conducting of AMP regular reviews and self-assessment;
- continuos updating of AMP;

as well as to share information related to ageing of SSCs important to safety.

(2) Conduct the activity on ageing management in the frames of specially developed ageing management programme in NPP.

AMP should provide a link of existing programmes such as preventive maintenance, in-service inspection, equipment qualification and component specific programmes etc.

Recommended version of regulatory requirements on AMP is shown in part 4.

(3) Provide an organisation structure for the systematic management of ageing.

This structure should have sufficient number of competent staff, necessary authority and resources.

(4) Regularly analyse the effectiveness of the AMP, apply appropriate measures for elimination of any deficiencies and for continuos updating and backfitting of the AMP.

(5) Arrange sufficient exchange of experience with other licensees of similar NPP.

(6) Periodically submit to Regulatory Body information about AMP implementation and effectiveness.

4. Recommended version of regulatory guidelines on AMP in NPPs

Objective of AMP

The aim of AMP is to provide for timely detection and mitigation of significant ageing degradation in SSCs important to plant safety so as to ensure their integrity and functional capability (in excess of the normal operating requirements), and thus the availability of required safety functions throughout NPP service life.

Systematic ageing management process

Effective ageing management requires an SSC specific application of a systematic ageing management process. This generally applicable process is illustrated in Fig. 1, which is an adaptation of Deming's "PLAN-DO-CHECK-ACT" cycle to the ageing management of an SSC.

A comprehensive understanding of an SSC, its ageing degradation and the effects of this degradation on the SSC's ability to perform its design functions is the basis and a prerequisite for a systematic ageing management process. This understanding is derived from a knowledge of the design basis (including applicable codes and regulatory requirements); the design and fabrication (including the material properties and specified service condition); the operation and maintenance history (including commissioning and surveillance); inspection results; and generic operating experience and research results.

Deming's "PLAN" activity in the ageing management process is aimed at maximizing the effectiveness of ageing management through the co-ordination of all programmes and activities that relate to managing the ageing of an SSC. It includes the identification and documentation of applicable regulatory requirements and safety criteria, relevant programmes and activities and their respective roles in the ageing management process, as well as a description of the mechanisms used for programme co-ordination and continuous improvement. The "DO" activity of the ageing management process is aimed at minimizing expected SSC degradation through the operation\use of the SSC in accordance with operating procedures and limits. The goal of the "CHECK" activity in the ageing management process is the timely detection and characterization of any degradation through SSC inspection and monitoring and the assessment of observed degradation to determine the type and timing of any corrective action. The "ACT" activity in the process is aimed at the timely mitigation\correction of SSC degradation through appropriate maintenance, including SSC repair and replacement.

The closed loop of the generic ageing management process indicates the need for continuos improvement of an SSC specific AMP based on the current understanding of SSC ageing and on the results of self-assessment and peer reviews. Such a programme is a mixture of SSC specific ageing management actions designed to minimize, detect and mitigate ageing degradation before SSC safety margins are compromised. This mixture reflects the level of understanding of SSC ageing, the available technology , the regulatory\licensing requirements and plan life management considerations and objectives. The timely feedback of experience is essential in order to provide for ongoing improvement in the understanding of SSC ageing and in the effectiveness of the AMP.

Recommended requirement

To ensure the availability of required safety functions throughout NPP service life, the licensee shall provide for timely detection and mitigation of ageing degradation of SSCs important to safety by implementing SSC-specific ageing management programmes that utilize the systematic ageing management process.

Note: This objective is achieved through the co-ordination and appropriate integration of existing NPP and external programmes that contribute to ageing management, such as operations, surveillance, maintenance, technical support, and research and development

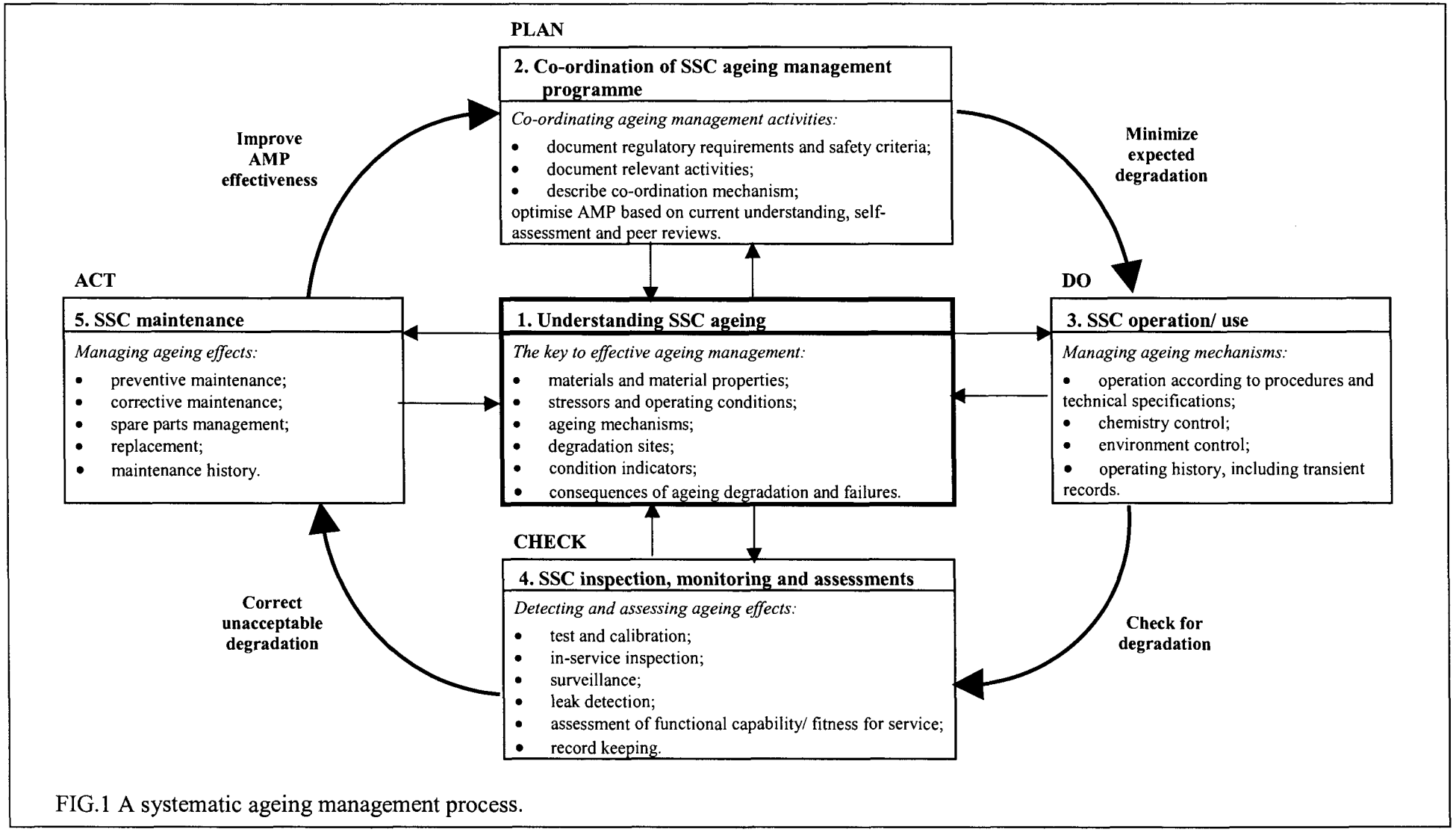


FIG.1 A systematic ageing management process.

Recommended practices

AMPs are different for different SSCs. The ageing management programme should cover:

- Selection of systems, structures and components, making use of PSA information as appropriate;
- Monitoring and evaluation of SSCs technical condition and prediction of its change in relation to safety functions affected by ageing;
- Optimisation of systematic plant surveillance programme (including testing, inspection and monitoring) with the purpose to ensure that degradation of SSCs important to safety will be detected before their integrity and functional capability is impaired;
- Development of technical and organisational measures to control ageing degradation of SSCs through optimisation of operating parameters, maintenance procedures and design modifications;
- Establishing an efficient data collection system and record-keeping of SSCs parameters;
- Performing assessment of current and future functional capability of SSCs important to safety based on collected information;
- Introduction of spare parts programmes to ensure their availability and prevention degradation during the storage.

Selection of systems, structures and components

AMP should include all SSCs important to safety.

Non-replaceable SSC should be included in AMP at the time of AMP introduction.

Priority of recoverable/replaceable SSCs for including in AMP is determined in NPP based on their safety significance, technical conditions, known degradation processes, repair ability, expediency of replacement.

Ageing related acceptance criteria

An ageing criteria in comparison with which a quantifiable acceptable safety margin can be shown, should be determined on the basis of requirements of actual norms and rules in the field of atomic energy use for all SSCs to be included in AMP or potentially could be included in AMP.

Methodology

The methods, used for safety assessment, should be conservative in order to compensate uncertainty of the available information.

The efficiency of methods and tools for monitoring of technical condition of SSCs important to safety has to be sufficient for timely detection of degradation.

Assessment of SSC's residual lifetime should be conducted on the basis of methods approved (agreed) by Regulatory body; the used software should be qualified.

Note: For many SSCs it is neither practical nor necessary to determine their residual life; it is sufficient to demonstrate required SSC integrity/functional capability until the next inspection or testing.

AMP documentation

All actions conducted in NPP in the frame of AMP as well as results of APM should be documented according to quality assurance.

The following items are recommended to be included into AMP documentation:

- description of the AMP structure and functions;
- SSC selection procedure and methodology;
- list of SSCs covered by AMP;
- the technical specification (limits and conditions);
- operating conditions and procedures;
- programmes and procedures of testing, surveillance and monitoring;
- maintenance procedures;
- remedial and mitigating actions adopted;
- description of results on SSCs qualification;
- documentation of the assessment methods for SSCs;
- description of data collection and record-keeping system and procedures;
- feedback of operational experience;
- spare parts programme procedures;.
- reports on the AMP results.

It is recommended to carry out the database for efficient documentation of AMP results.

5. Assessment of AMP effectiveness

5.1 The indicators of AMP effectiveness are:

(a) the actual condition (i.e. integrity and functional capability) of SSCs covered by the AMP (which shall meet the applicable safety requirements);

(b) the programmatic arrangements to maintain the required integrity and functional capability of SSCs in future.

As indicators of AMP effectiveness could be used following:

- forced outage rate owing to ageing related failures of SSCs;
- preventive and corrective maintenance work burden and its ratio;
- chemistry control parameters deviation;
- compliance with inspection and surveillance programmes.

5.2 The conduction of the periodical AMP review aimed to its optimisation is the responsibility of the NPP. The review should include:

- the self-assessment;
- the peer review of AMP and relevant existing programmes important to ageing management (e.g. with involvement of Technical Support Organisations);
- the comprehensive AMP review (for example, in the frame of periodic safety review of NPP unit);
- other appropriate managerial techniques.

5.3 The scope, frequency, procedures and indicators of the review of AMP effectiveness should be presented to Regulatory body.

INVERSTIGATION OF CASE STUDIES

Goals of studies:

- to assess applicability of general provisions of IAEA concerning management of aging and provision for integrity of heat exchanging tubes of SG WWER-440 and containment PS WWER -1000;
- to disclose potential issues which could arise under management of aging of heat exchanging tubes of SG WWER-440 and containment PS WWER -1000 and cause necessity to undertake regulatory actions;
- to provide the informational basis for the WG under development of the regulatory requirements on management of aging equipment and building structures of reactor facilities of WWER type.

Data formats for case studies

In the 1-st WG meeting in Kiev it has been observed that a general exchange of data bases of ageing related data among different countries would be rather difficult due to the different formats and content. In connection with this it was decided that data collection needs for using a common data format.

For selected case studies – integrity of WWER 440 steam generator heat exchangers tubes and functionality of WWER 1000 containment pre-stressing system format of ageing management data submission was defined. The drafts of data formats were sent to WG participants for comments, proposed changes were included in final data formats which were distributed to all for completing.

Case study 1: Integrity of WWER440 SG heat exchangers tubes: inspection methodologies, their frequency and their impact on the safety margin and residual life evaluation

The information on heat exchanging tubes of SG WWER-440 was collected concerning the following issues:

- background (term of operation, replacement and modernization of SG: general parameters of SG operation);
- data on materials and processes of manufacturing heat exchanging tubes;
- water chemistry (controlled parameters of water; methodology of water chemistry monitoring; history of water chemistry);
- inspection: methodology, frequency, scope (criteria on safety margins and measures to keep them; requirements to inspection of heat exchanging tubes; description of individual programs on inspection of tubes (if available); modifications of in-service inspection programs);
- types and location of defects (description of defect, method of detection, mechanism of degradation);
- plugging heat exchanging tubes (data on plugging before and during operating, criteria and methods for plugging);
- mitigation measures (methodology and history of rinsing, blow-down, impact of

upgrading measures).

Under analysis the following statistical data were used:

- Number of power units – 24;
- Number of SG – 144;
- Term of SG operation: since 2 years (Mochovce-2) through 30 years (NVNPP-3);
- Total service time of SG: ~ 470 years.

Conclusions of 1-st case study analysis

1. Analysis of the data on heat exchange tubes integrity has shown that WG recommendations for regulatory guidelines on ageing management are applicable for ageing management of the specific WWER SSCs but it is necessary to implement additional regulatory actions taking into account specifics of individual SSCs.

2. In WWER countries regulatory bodies establish different safety criteria for SG heat exchange tubes integrity.
In most of the countries there are regulatory requirements on:

- radioactivity of blow down water, radioactivity of secondary water or radioactivity of fresh steam;
- leak rate from I to II side.

Plugging criterion based on wall thickness reduction in some countries is used as regulatory criterion and in other countries as licensee criterion.

3. WG determined important ageing related problems which need attention of regulators:

3.1 Monitoring of water chemistry
The on-line monitoring of water chemistry and immediate corrective actions are important for maintaining quality of secondary circuit water. The on-line monitoring facilitates timely corrective actions for corrosion mechanisms.

3.2 In-service Inspection
The In-service Inspection of heat-exchange tubes is an important contributor to ageing management process based on following aspects:

- determining defect locations;
- contributing to identification of degradation mechanism;
- identification of damaged tubes;
- grouping of tubes on the basis of the degree of damage.

In arrangement of heat-exchange tubes ISI special attention should be paid to the qualification of ISI systems and ISI program optimisation with regards to frequency and scope of inspection.

3.3 Degradation mechanism study
To manage the ageing of heat-exchange tubes it is recommended to carry out laboratory studies as well as simulation research of the degradation mechanisms.
It should be noted that the representative statistic data of the laboratory studies could be used for ISI system qualification.

3.4 Heat-exchange tubes plugging

Plugging criteria must be well justified. Plugging criterion has significant influence on necessary volume of inspection.

The procedure of heat-exchange tubes plugging shall be qualified.

3.5 Corrective measures

Appropriate corrective measures can mitigate the influence of stressors to the heat-exchange tubes ageing.

Presented examples of corrective measures are connected with replacement of main condenser and high pressure heater materials. The aim of such measures is to provide better compatibility of secondary circuit materials.

Also it is recommended to use accepted methodology of SG pollution assessment as a corrective measure. Problem of application of chemical cleaning methodology could be solved by implementation of well justified technologies

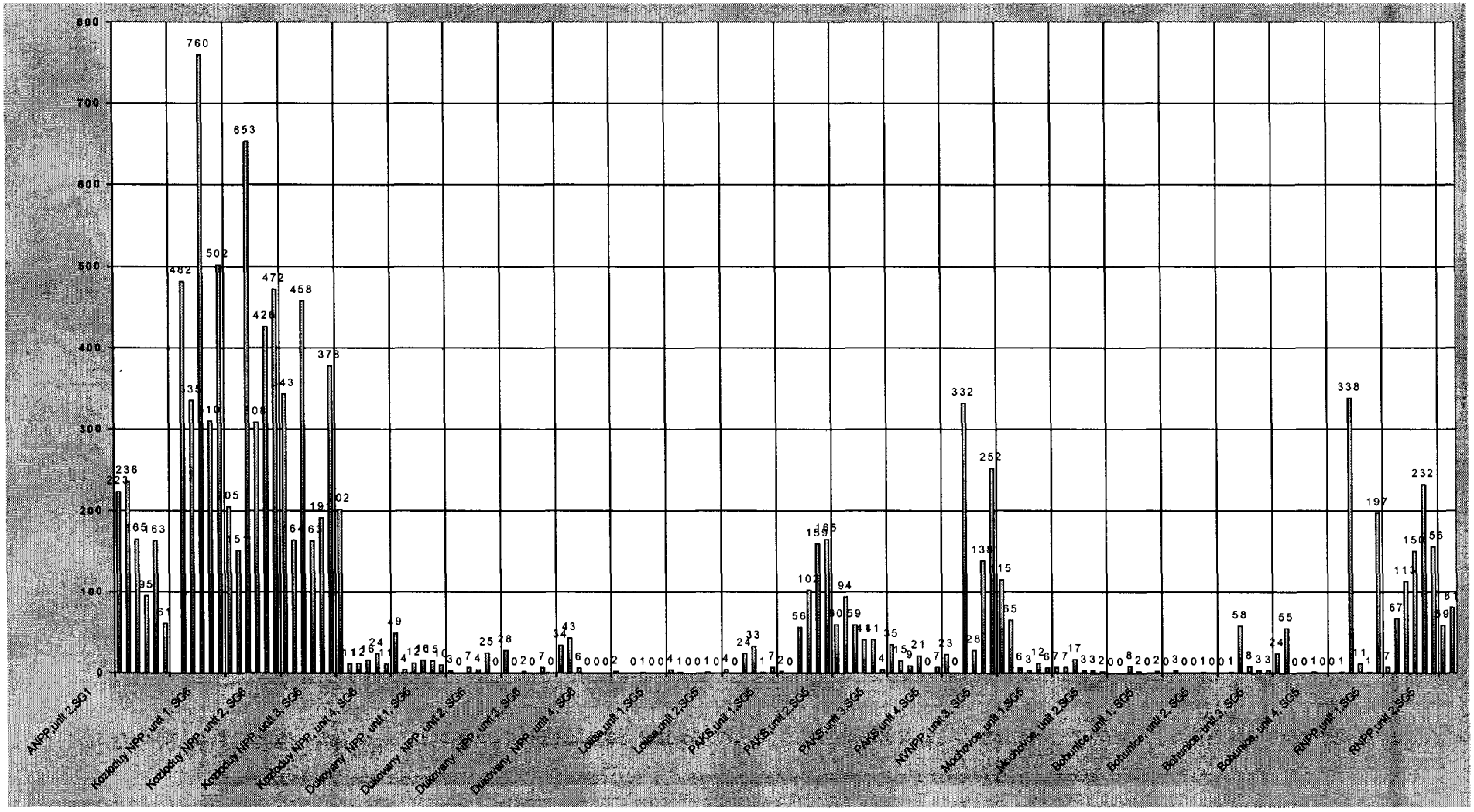
ANALYSES OF WATER CHEMISTRY

Country	Armenia	Bulgaria				Czech Republic				Finland		Hungary				Russia	Slovak Republic						Ukraine	
NPP	ANPP	Kozloduy				Dukovany				Loviisa		PAKS				NVNPP	Mochovce		Bohunice				RNPP	
Unit	2	1	2	3	4	1	2	3	4	1	2	1	2	3	4	3	1	2	1	2	3	4	1	2
online analysers	-	x	x	x	x	-	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-
number of control (diagnostic) parameters	-	5	5	5	5	-	-	-	-	9	9	4	4	4	4	3	5	5	3	3	4	4	-	-

PLUGGING CRITERIA, VOLUME AND TIME OF ECT IMPLEMENTATION

Country	Armenia	Bulgaria	Czech Republic	Finland	Hungary	Russia	Slovak Republic	Ukraine
Plugging criteria (wall thickness)	≥40%	Till 1996 ≥40% . After 1996 ≥60% .	20 % reduction – registration level 50-80 % reduction individual assessment 80% reduction reduction – repair	≥50%	≥50% (without proper justification)	≥80%	≥80%	≥60%
EC inspection volume	100% inspection of Unit 2 all Stream Generator heat exchanging tubes	For Units 1,2,3 - 300%; For Unit 4- 200%;	100 %	Average 7000 half tubes every 2 years. From 2002 appr. 20000 half tubes every 2 years.	Min 11% 100%	No less than 10-15% but not less than 500 tubes every year from one SG	100 %	100 %
Time of ECT implementation	From 1994 ECT is used	From 1995 the inspection frequency is once per 4 year	From 1990 ECT is used	ETC used since plant startup	ECT in use for 11% since 1988.Since 1997 once every SG is checked in 100%	Since 1994 eddy-current inspection is performed	Since 1979 regular Eddy current inspections. Since 1999 regular 4-year inspection cycle in 100% volume	Since 1999, eddy-current inspection is used.

DIAGRAM ON PLUGGING TUBES



ANALYSES OF INSPECTIONS DATA: SAFETY MARGINS CRITERIA

Country	Armenia	Bulgaria	Czech Republic	Finland	Hungary	Russia	Slovak Republic		Ukraine
NPP	ANPP	Kozloduy	Dukovany	Loviisa	PAKS	NNPP	Bohinice	Mochovce	RNPP
Wall thickness	≥40% (in case of ECT)	Till 1996 ≥40% . After 1996 ≥60% .	20 % reduction – registration level 50-80 % reduction individual assessment 80% reduction reduction – repair	≥50%	≥50% (without proper justification)	≥80%	≥80%	≥80%	≥60%
No flaws from I to II side of SG	≤ 5 litre/h	≤ 5kg/h for each SG determined by $Na^{24}(K^{42})$	max 1 l/hour permanently or 2 l/hour max 72 hours	≤ 2 kg/h	≤ 5 dm^3/h	≤ 5 dm^3/h	-	5 l/h/1SG 20 l/h/6SGs	≤ 5 kg/h
Specific radioactivity of J^{131} in blow down water of each SG	-	≤ $2*10^{-8}$Ci/l	-	Limits for plant total radioactivity release defined in Technical Specifications-	Total gamma activity of K^{42} and Na^{24}<4000 Bq/dm3	≤ $2*10^{-8}$ Ci/l	-	< 740 Bq/l	≤ $2*10^{-8}$ Ci/l
Specific radioactivity of J^{131} in blow down water of all SGs	-	≤$5*10^{-9}$Ci/l	-	-	-	-	-	-	≤ $5 * 10^{-9}$ Ci/l
Activity of TG main ejectors blow-up	-	≤$1*10^{-7}$Ci/l	-	-	-	≤ $1 * 10^{-8}$ Ci/l	-	-	≤ $1 * 10^{-8}$ Ci/l
Radioactivity of secondary water	ΣÀ less 2E-10 curie/litre (operation limits: 1E-9)	-	max. total volume gamma activity of blow down water expressed as activity ^{137}Cs 7.10^5 Bq/m^3 or 1,5 MBq/m^3 max 72 hours	-	Total of Beta activity < 10 Bq/dm3 max. tritium activity < 1000 Bq/dm3	-	total β-activity of dry rest of blowdown water <370 Bq/l	-	-
Fresh steam activity	-	-	-	Continuous N16 monitoring during stable operating conditions	-	-	150 kBq/m^3 200 kBq/m^3	-	-

Case study 2: Functionality of the prestressing system for the WWER1000 containment: predicting loss of prestressing forces and control of the safety margin

The information on containment pre-stressing system (CPSS) of the WWER-1000 was collected concerning the following issues:

- general information (lifetime, general parameters, absent tendons (NPP, unit, number of absent tendons and cause of absence));
- data on tendon's material and technology of manufacturing;
- maintenance: frequency, methodology, volume (safety margins criteria, inspection and maintenance requirements, methodology and equipment for tension force control, modification of inspection and maintenance programs during lifetime, frequency of control-preventive works (CPW));
- statistic of tendons' failures (breaks of tendons during operation and during CPW, replacement of tendons);
- results of broken tendons investigation;
- pulling up of tendons and relevant regulations and regulatory actions;
- mitigation measures (impact from modernisation measures, etc.).

WG had collected information about CPSS of following units:

- Zaporozhzhe NPP (ZNPP) units 1-6, type V-320; units was put into operating at 12/1983, 01/1985, 09/1986, 08/1987, 09/1988 and at 08/1992 correspondingly.
- Kozloduy NPP (KNPP) units 5-6, type V-320; units was put into operating at 01/1987 and at 11/1987 correspondingly;
- Balakovo NPP (BNPP) unit 4, type V-320; unit was put into operating at 05/1993;

Novovoronezh NPP (NVNPP) unit 5, type V-187; units was put into operating at 05/1980.

Conclusions of 2-nd case study analysis

1. Analysis of data of CPSS operation has shown that WG recommendations for regulatory guidelines on ageing management for VVER SSCs are applicable in general to CPSS but it is necessary to implement additional regulatory actions for taking into account CPSS specifics.

2. There are differences in regulatory requirements in VVER countries:

- on minimal and maximal levels of pre-stress forces in tendons;
- in maintenance and in-service inspection program;
- in program for independent checking of actual level of pre-stress force and tendon technical condition, etc.

3. WG determined important ageing related problems which need attention of regulators:

3.1. Acceptance of justified criteria on operational capability for whole CPSS and their components according to design safety functions (i.e. defining of minimal and maximal levels of pre-stress forces in tendons for whole containment and its different zones);

3.2. Collection and review of data about degradation of CPSS elements;

3.3. Define NDE program for independent checking of actual level of pre-stress force and tendon technical condition in different zones of containment;

3.4. Develop procedures and establish organizational structures on justification of

applied methodologies, instrumental and calculation methods, codes, data, equipment;

3.5. Defining optimal program on in-service inspection and maintaining CPSS as well as providing minimal necessary pre-stress forces in tendons for CPSS operation in optimal regime;

3.6. Assess effectiveness of results of maintenance and modernization measures.

SAFETY MARGINS CRITERIA FOR CPSS

Criterion	Ukraine Zaporozhzhe NPP	Russia - Balakovo NPP, Novovoronezh NPP	Bulgaria Kozloduy NPP
Number of absent tendons	1 tendon in dome and 1 tendon in cylinder	-	2 (continuing of the operation of the containment is coordinated with the designer)
Minimal pre-stress force in tendons (for cylinder/dome), tons	1. 784 / 762 (V-320) 2. 722.8 / 696.7 (V-302, V-338)	1. 785.7 / 772.3 (V-320) 2. 705.8 / 696.7 (V-187, V-302,V-338)	850 / 850 (V-320)
Maximal number of broken wires in tendon	2 wires	not more then 2	2 wires in field of anchor
Corrosion zones in tendon	1. Corrosion in more then 10% of wires with metal breaking depth over 0.8 mm. 2. Corrosion in more then 1% of total wires cross-section.	1. Corrosion of wire metal with size 0.5 mm in depth. 2. Corrosion with reference area more then 1 mm^2 at 4 wires.	1. Lubrication and measures for protection against water and humidity during operation
Arragements of installation anchor strings	-	-	Should be avoided knitting of wires
Maximum DL on screw	-	-	No more than 66 thread loops to remain over the nut

SCOPE OF TENDONS CONTROL VOLUME DURING CPWS

Scope of tendons were controlled in dome, %.

Year	Zaporizhzhe NPP						Kozloduy NPP		BNPP	NV NPP
	1	2	3	4	5	6	5	6	4	5
1983										
1984										
1985										
1986										
1987										
1988	97.1									
1989		100								83.6
1990			100	22.2	100		100			94.5
1991	100			100						6.8
1992							100	100		27.4
1993		100						100		90.4
1994		33.3	97.2			100			11.8	94.5
1995	97.1		33.3	100	100	47.2	100			
1996	31.4	97.2	61.1	25.0					14.2	
1997	31.4	69.4	61.1	38.9	13.9	69.4	100	100	22.0	
1998	77.1	100	58.3	97.2		36.1	100		11.4	13.7
1999			22.2		100	50.0	100		9.1	
2000	31.4								2.9	

Scope of tendons were controlled in cylinder, %.

Year	Zaporizhzhe NPP						Kozloduy NPP		BNPP	NV NPP
	1	2	3	4	5	6	5	6	4	5
1983										
1984										
1985										
1986										
1987										
1988	74.7									
1989		98.9								84.7
1990			98.9	25.0	100		100			60.1
1991	95.8			100						2.7
1992							100	100		29.0
1993		100						100		100
1994		40.0	97.9			100			14.6	79.8
1995	100		18.9	100	100	43.2	100			
1996	40.0	96.8	70.5	38.5					12.8	
1997	51.6	69.5	50.5	42.7	25.3	64.2	100	100	16.7	
1998	43.2	97.9	32.6	99.0		38.9	100		14.6	14.2
1999			51.6		100	29.5	100		0.0	
2000	63.2					9.5			0.0	

SCOPE OF PULLED UP TENDONS DURING CPWS

Scope of pulled up tendons in cupola, %.

Year	Zaporizhzhe NPP						Kozloduy NPP		BNPP	NV NPP
	1	2	3	4	5	6	5	6	4	5
1983	100									
1984		100								
1985										
1986			100							
1987				100			100			
1988	97.1				100					
1989		97.2						100		0.0
1990			50.0	19.4	86.1		100			89.0
1991	42.9			69.4					100	0.0
1992						100	100	100		0.0
1993		0.0				0.0		11.1		0.0
1994		33.3	16.7			0.0			5.9	0.0
1995	88.6		19.4	19.4	2.8	47.2	27.8			
1996	14.3	55.6	33.3	0.0					2.9	
1997	5.7	11.1	19.4	0.0	0.0	5.6	0.0	11.1	0.0	
1998	5.7	16.7	8.3	13.9		0.0	0.0		2.9	0.0
1999			11.1		0.0	2.8	0.0		9.1	
2000	8.6					2.8			2.9	

Scope of pulled up tendons in cylinder, %.

Year	Zaporizhzhe NPP						Kozloduy NPP		BNPP	NV NPP
	1	2	3	4	5	6	5	6	4	5
1983	100									
1984		100								
1985										
1986			100							
1987				100			100			
1988	75.8				100					
1989		100						100		0.0
1990			72.6	24.0	96.8		100			96.0
1991	84.2			69.8					100	0.0
1992						53.7	100	100		0.0
1993		21.9				45.3		12.5		0.0
1994		38.9	16.8			0.0			2.1	0.0
1995	75.8		5.3	24.0	11.6	38.9	62.8			
1996	20.0	65.3	37.9	3.1					0.0	
1997	13.7	16.8	14.7	3.1	4.2	8.4	7.4	25.0	0.0	
1998	11.6	20.0	9.5	35.4		2.1	31.9		0.0	0.0
1999			9.5		5.3	5.3	16.0		0.0	
2000	9.5					1.1			0.0	

MITIGATION MEASURES FOR CPSS

Country	Description of measure	Operation condition changed
Ukraine	Technical Specifications on tendon had been developed, namely, "Reinforcing tendon for Containment Pre-stressing System of NPP, Technical Specifications TS U 0249543-037-96	Using for CPSS the tendons with improved properties. Number of wires increased from 450 till 456. Maximal pre-stress force was decreased from 1000 till 875 ton-forces.
	Technical Specifications on wire had been developed, named "Wire round with diameter 5 mm from carbon steel for NPP Containment pre-stressing, Technical Specifications TS U 00191046.14-95"	Using for CPSS tendons the wire with improved properties.
	Technical Decision "On changing of forces of Containment Pre-Stressing System tendons ..."	Minimal pre-stress force in tendon decreased from 850 till 784 / 762 ton-forces in cylinder/dome
	Methodology of prognosis of forces in CPSS tendons of Ukraine NPP GND 306.7.02/3.006-98	More precise prognosis of pre-stress force in tendon and determination of necessary volume of maintenance
	Development of test bench for taking of more precise graduate characteristics of hydro-jacks	More precise determination of pre-stress force during CPW and minimal pulling up of tendons
Bulgaria	The principal structure modernization of CPSS take plase on Kozloduy NPP. Modernization includes the replace of tendons 450∅5 B-II on new ones 55 ∅15.2 B7 with new type of anchors.	Improvement of CPSS serviceability.
	For reduce the bend deformation of wire the following measures are implemented: - installation bend with reduced length is made; - after passing through the rolls of the special-warping machine the installation bends are removed down and working bends are made.	Using for CPSS tendons the wire with improved properties.
	Number of wires in tendon changed from 450 to 459.	Using for CPSS the tendons with improved properties.
	The more precise hydro-jacks are used (after modernisation – exchanging – of tendons and anchor units on new type ones);	More precise determination of pre-stress force during CPW and minimal pulling up of tendons
	Automatic control system was developed for the containment stressed state output data reading. Computerised program was developed for processing the data obtained by automatic control system for stressed state of the containment.	More precise determination of pre-stress force during CPW and minimal pulling up of tendons
Russia	Number of wires was increased from 450 till 456.	Improve of tendons properties.
	Maximal pre-stress force was decreased in cylinder/dome from 1000 till 785.7/772.3 (V-320) and 705.8/696.7 (V-187,V-302,V-338) ton-forces.	Optimisation of operation conditions for tendon.
	Development of guides "Requirements to Maintenance of WWER-1000 CPS", "Assessment of strain-stress state ... of containment on the basis of instrumentation indications", "Estimation of minimum required pre-stress level ..."	Implementation of CPSS operation and maintenance.

DEFINITION SUITABLE COMMUNICATION CHANNELS AMONG REGULATORS FOR AGEING RELATED DATA

The problems related to data exchange were analysed during WG activity in between Kiev and Moscow meetings. It was determined:

- Identification of data format to exchange information about ageing and related mitigation measures for SSCs is recommended.
- Data collection gives possibility to analyse data of total service life of all considered units. For example data are available for 240 operating years of heat exchange tubes of SG WWER 400.
- Most NPPs in WWER countries which submitted their information to WG show a high interest to have materials prepared by WG. However, some data could have some confidentiality restrictions.
- Exchange of information about regulatory requirements and safety criteria for SSCs gives possibility to identify good practices and common challenges of WWER regulators.

The analysis of the experience of WG members suggested the following conclusions which was agreed at the 2-st meeting :

- The ageing related data exchange is important for ageing management. It is proposed to consider the possibility of organisation of data exchange on permanent basis.
- It is recommended that national regulatory requirements, safety criteria, regulatory decisions, technical information for both case studies collected by WG be transformed to an electronic database for annual updating. Available IAEA data bases for materials and components should be considered in this process and integrated as far as practicable.
- WG framework seems to be a suitable communication channel for WWER ageing related data exchange.

CONCLUSIONS

- WG developed Recommendations for regulatory guidelines on ageing management summarising the WWER Countries approach to the AMP, based on the Russian acting regulatory guide NP-017-2000 and draft of Lithuania requirements getting though IAEA as example of regulatory approaches and the IAEA documents.
  WWER countries might then develop national requirements in line with the agreed approach, but also consistent with their national policy.

- Unification of the approaches to ageing management in the different countries has been considered very useful, to guarantee the exchange of data and of the results of ageing evaluation. The ageing related data exchange is important for ageing management. It is proposed to consider the possibility of organisation of data exchange on permanent basis.

- Analysis of the data of two case studies - heat exchange tubes integrity and functionality of prestressing system has shown that WG recommendations for regulatory guidelines on ageing management are applicable for ageing management of the specific WWER SSCs but it is necessary to implement additional regulatory actions taking into account specifics of individual SSCs. WG determined important ageing related problems which need attention of regulators for both selected case studies

- The data exchange is a key task of the ageing management for its safety implications in the development of statistically significant data bases. Identification of data format to exchange information about ageing and related mitigation measures for SSCs is recommended.
  WG framework seems to be a suitable communication channel for WWER ageing related data exchange.

PROPOSALS FOR FUTURE WG ACTIVITY

At the 2-nd WG meeting were defined the following directions to continuation of the WG activity in 2001/2002:

- Compare AM scope in WWER countries;
- Exchange requirements to identify critical nodes of SSC according to their ageing impact on safety functions;
- Continue analyzing the ageing conditions of new selected types of SSCs. For data exchange with licensees it is proposed to develop standard form of letter from WG to operators in order to have their agreement.

According to recommendations of Mr. Paolo Contri proposals of future WG activity could not limited of short term activity (for 2001/2002) and below is presented long term tasks for Working Group.

Results of WG activity show that it is advisable to concentrate efforts on:

- Set up of the permanent communication channel among regulators.

In the Minutes of both WG meetings and in the report was stress that communication channel is very important for ageing management. WG framework seems to be a suitable communication channel for exchange of WWER ageing related regulations and data. But establishing a permanent communication channel is outside of WG competence.
For achievement this aim WG suggest to the Forum members to consider advisability of organisation of permanent communication channel and in case of positive decision to give a task for WG to prepare in details how it can be realised.

- Collection of regulatory criteria for WWER type NPP key components based on understanding of ageing mechanisms and data collection.

WG collection of data on SG heat exchange tubes and containment prestressing system has shown that it is useful to compare a ageing related regulatory criteria for individual SSCs and discuss methodology of this criteria justification. WG collected data, made statistics what the NPPs did in the past through their maintenance programs. Continuation of ageing data collection for new selected types of SSCs should be aimed to extend understanding of the ageing mechanism and their impact of safety margins. In this work it seems helpful to use information from research tools, analysis, simulation etc. in order to predict the degradation in a more reliable way and use this information in regulatory practice.

- Collection, analysis and co-ordination of research results aimed at the interpretation of the ageing mechanisms.

The interpretation of the ageing mechanisms require availability of research tools, numerical models, software tools that have to be collected and applied to the cases of interest for a better prediction of the degradation in time. Usually research results and tools are property of NPP or research institutes but WG framework take possibility to collect information about carrying out of ageing mechanisms research in WWER countries, determine of urgent directions and help in information exchange.