AGING MANAGEMENT AT THE VVER-440/213 UNITS OF PAKS NPP

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Introduction

The owner's intention of WWER-440/213 units in Central Europe is to keep the plants in operation as long as technically feasible and reasonable from business point of view, e.g. to run NPPs at least 20 years behind the planned 30 years of operational lifetime. The preconditions of the long term operation are the safety and good plant condition. The first is ensured by the implemented safety upgrading programmes, commitment of operators and proper regulation. The last depends mainly on the past and recent practice of in-service inspection, maintenance, testing and recording the lifetime relevant data as well as on the knowledge of the design basis of the lifetime limiting structures, systems and components.

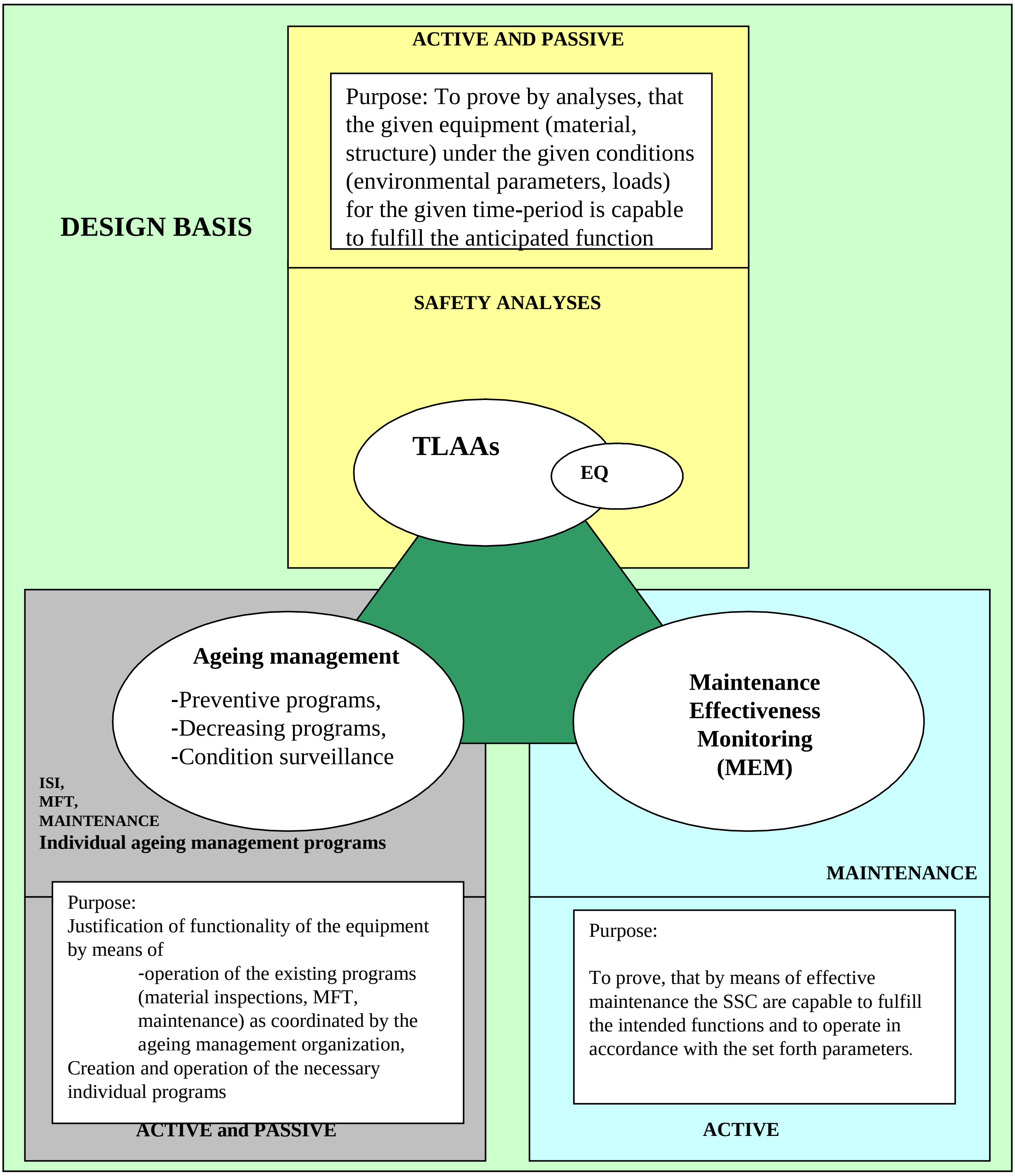
The design life of the NPP PAKS VVER-440/213 Units is 30 years .The Paks Nuclear Power Plant strategy is to extend the operational lifetime of the plant and renew the operational licence for 20 years over the designed and licensed lifetime. The possibility of the life extension is based on adequate aging management of safety related equipment.

A systematic ageing-management practice started approximately ten years ago. The most important AMP activities are performed at the plant from the very beginning of the operation. In the course of the Periodic Safety Review the ageing processes of the critical equipment were specified, and ways of tracing changes in status as well as possible correction measures were determined. In addition to ageing management and monitoring of the critical components of main equipment, a condition monitoring of structures, equipment and components is going on in the nuclear power plant, hereby ensuring the required performance of the large number of (although replaceable) components. In the NPPs systematic aging management monitoring database-expert system all critical degradation sites of safety related equipment are individually treated. Aging management programs are specified for the dominant degradation mechanisms of all critical component sites.

Required Scope of the Aging Management

The regulation background is based on the fact that the justification of performance of the safety functions stated in the FSAR is necessary in every phase of the life-time-cycle of the nuclear power plant in a continuous manner. The justification might be assured by means of coordinated execution of the activities indicated on Figure2.
For passive components of Safety Classes 1-3+ aging management requirements are in force. For passive/active components functioning in harsh environment Equipment Qualification Requirements are to be fulfilled. For all other safety related active components Monitoring of Maintenance Effectiveness (MEM) can be used instead of a regulated, systematic AMP.

Figure 1 Possible ways of justification of performance of the safety functions and of functionality in accordance with the required performance parameters
(SSC 1-3 +)



Organization of a systematic aging management program

Existing NPP programmes such as Preventive Maintenance, In-service Inspection, Equipment Qualification and component specific programmes contribute to the management of aging of all NPP systems, structures and components. Whereas utilities have made a significant start in implementing aging management systematic approaches, organizational problems may exist because the division of responsibility for relevant programmes is distributed among several NPP organizations including operations, maintenance, technical support and engineering. To effectively manage NPP aging the division of AMP responsibility requires co-ordination and integration mechanisms to facilitate the application of a systematic aging management process. For he example of a systematic aging management system, Figure 2. shows the (1) recommended approach for the AMP process.

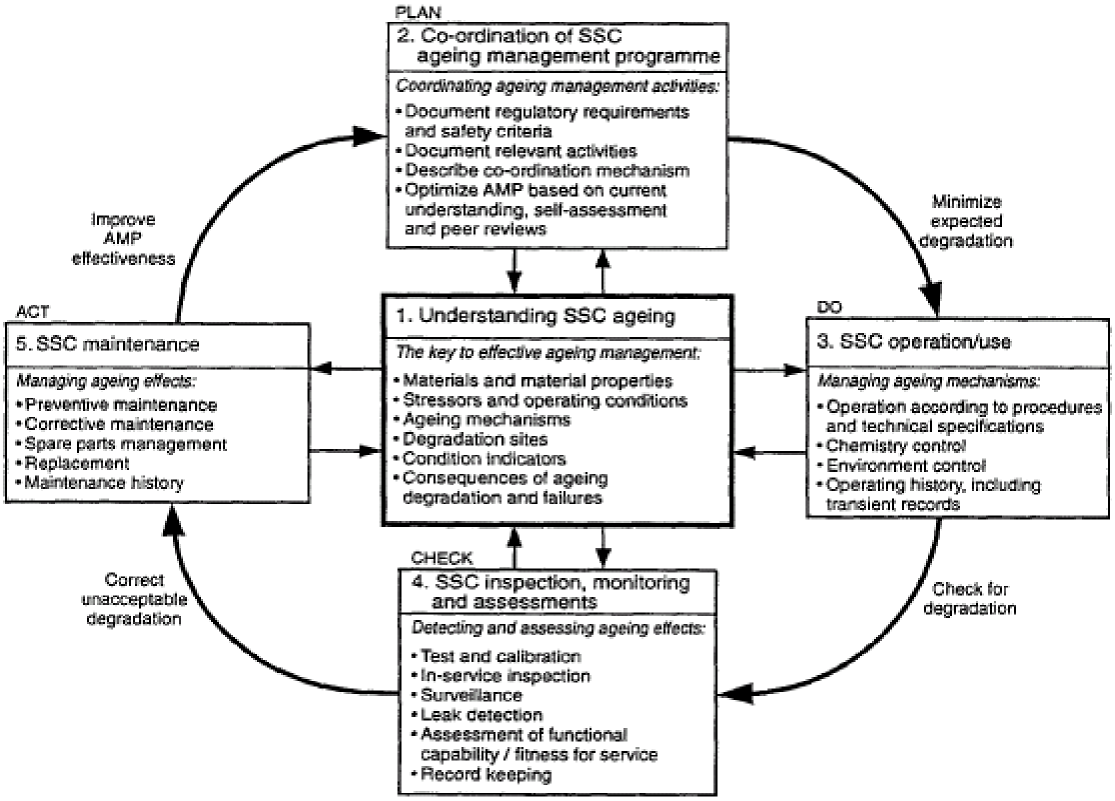


Figure 2.IAEA recommended example of a systematic aging management process

The aging management programmes of the Paks NPP are integrated in the activities of several operational units of the plant. Major units involved in the AMP are Maintenance Department, ISI Department, Technical Engineering Department, Operational department and Safety Directorate. The majority of ageing management activities are incorporated into operational, maintenance and inspection (ISI, IST, technical supervision etc.) procedures of Paks NPP accomplished in accordance with current operational license conditions.

The central AMP unit is responsible for the periodic assessment, review, modification and back fitting of the aging management programmes incorporating industry wide operational practice, results of the ongoing R&D activities and the Paks NPP’s own AMP experience. Replacement and refurbishment plans of the SSCs are prepared by the operational and maintenance department and controlled by the central AMP unit.

The generic and the degradation site specific AMP programmes and the related data collection/recording system are based on the suggestions of the AMP Regulatory Guides taking into account the relevant IAEA and US NRC approaches.

The AMP related data of high safety significant SSCs are collected and monitored in the NPP Systematic Aging Management database (DACAAM) which is an expert system operated by the central AMP coordination unit under the Technical Engineering Department.

AMP related database of high safety significant SSCs

The operation and maintenance of nuclear power plants requires the availability of timely, relevant, accurate and sufficiently complete information to make possible correct decisions which are essential for maintaining the safety and reliability of the aging plants throughout their service life.

The following safety significant SCCs are covered by the Paks NPPs DACAAM (Data Collection and Analysis for Aging Management) database/expert system: Reactor Pressure Vessels, Reactor Internals, Steam Generators, Main circulating piping, Pressurizers, Surge Pipelines, Main Circulating Pumps, Main Gate Valves, Main Feed Water Piping Main Steam Piping, Other safety related pumps and valves, Safety related heat exchangers, Containment penetrations, e.t.c.

The structure of the DACAAM system based mainly on the. IAEA AMP approach (Figure 2.)

Figure3. shows the DACAAM system main screen with all data-source and document links to be treated in a useful systematic AMP.

The data and documents collected in the frames of DACAAM are those, which are recommended to be recorded and frequently assessed.

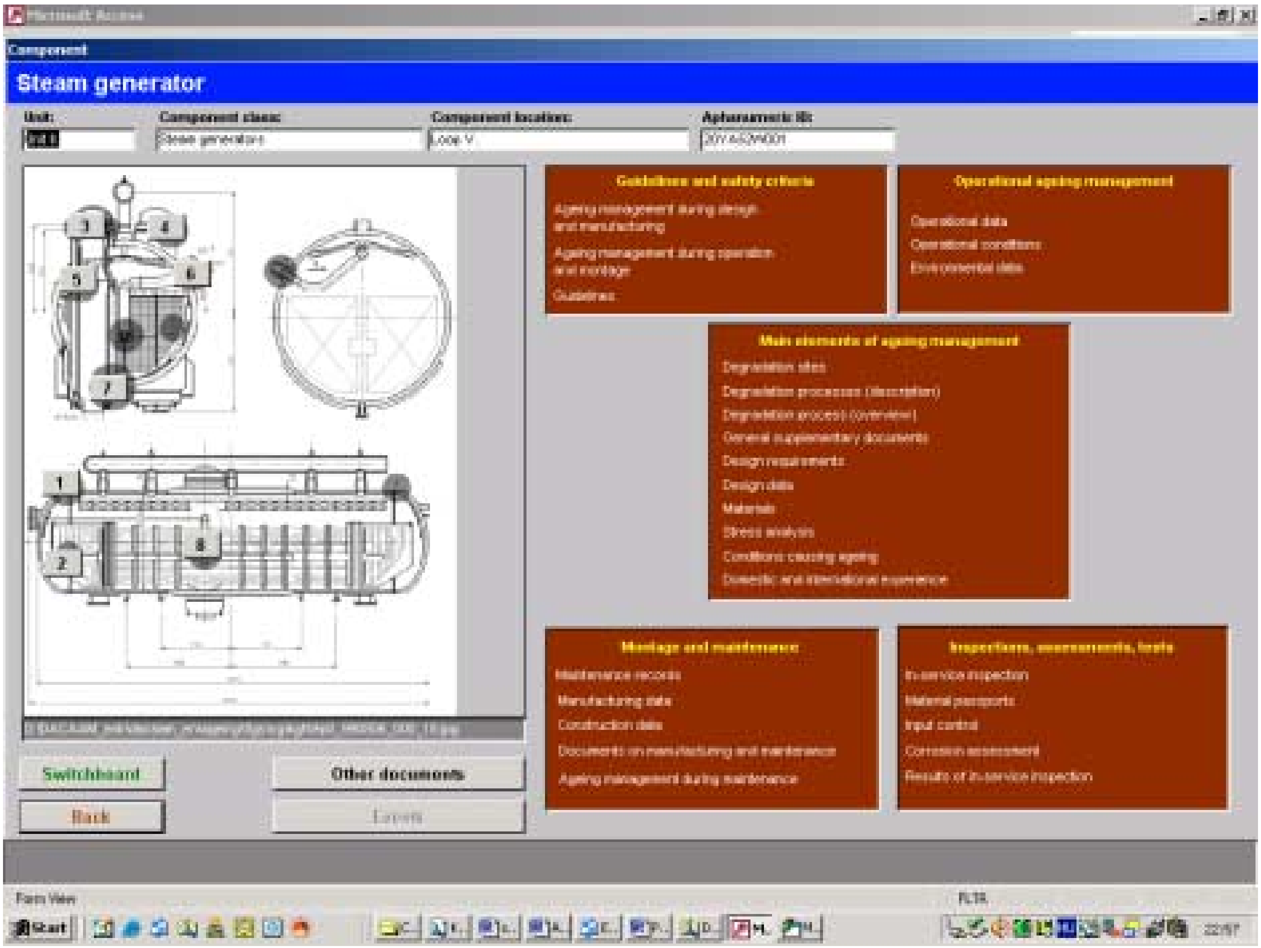


Figure3. Types of data belonging to the aging management of the critical components at Paks NPP taking into account the example of the Steam Generators

Typical data contained in the DACAAM System are as follows:

Regulatory requirements

- AMP related regulatory guide requirements
- Safety criteria
- Periodic assessment and reporting Requirements

Baseline information:

Baseline information is the broad category of nuclear power plant data which define a component and the plant and system in which it is located and describes its initial, un-degraded material condition and functional capability, as well as a limiting operating envelope represented by the design service conditions and other operational limits. The baseline data determine the design service life of components. Together with the actual operating experience data, they provide essential information for developing effective aging management strategies and for estimating remaining service life. In general, nuclear power plant AMP related baseline information exists, but it is usually dispersed in numerous reports and is rather difficult to retrieve. To ensure correlation of baseline data with operating and

maintenance history data, first of all a clear identification of a component in the plant and the system in which it is located is essential. Furthermore, it is important to make certain that all pertinent data are updated when the design is changed.
Typical AMP related baseline data are as follows:

- Construction data (e.g. dimensions, materials, material characteristics of the "as built" equipment, aging related manufacturing data, "0" condition defects/deficiencies data)
- Design information (e.g. expected neutron fluence, forecast for evolution of the toughness of irradiated materials, Design service transients/loads, Stress calculation results, Design safety margins)
- Design specifications (e.g. including design service conditions and design service life cycles)
- Degradation process forecasting information
- Component identification (including component type and location)
- Expected degradation mechanisms and potential critical sites descriptions (e.g. high CUF locations, high tensile stress locations, locations susceptible to local corrosion mechanisms)
- Data of component installation
- Design modification data

Operation history data

Operating history data describe the actual service conditions experienced by a component, including data on process conditions, chemistry and transients (e.g. pressure/temperature transients for pressure retaining components and the component's testing and failure data. Operating history data are essential to the effective management of aging and its effect on plant safety and reliability for the following reasons:

- Operating history data enable the comparison of a component's design life usage and the rate of the usage with the design basis and the prediction of lifetime. Thus, they provide documentation of whether and by how much the design bases have been ensured/exceeded.
- Operating history data allow aging related failures to be differentiated from other failures and specific environments favoring degradation and degradation mechanisms to be identified.

If all primary system pressure and temperature transients are identified right at the beginning and characterized for severity, the fatigue status and remaining fatigue lifetime of reactor coolant system components can be assessed under the AMP.

For the primary system pressure boundary components of a PWR, design rules require a fatigue assessment based on a list of transients which are supposed to represent the entire life of the plant. Of course, this assessment is meaningful only if during operation plant staff verify that all actual transients are not more severe or more numerous than assumed in the design analysis. When it is done properly, transient monitoring and documentation give, at any time, a clear view of where each component stands with respect to its fatigue margins.

Typical AMP related operational data are as follows:

- Process condition data (Pressure, Temperature, Flow rates
- Neutron fluence data (Calculated and measured)
- Water chemistry data (e.g. pH, concentrations of impurities)
- Material surveillance data (e.g. Charpy, Tensile and COD test data)

- Operational cycle counting data

Maintenance history data

Maintenance and testing personnel should understand that data collection after component inspection, testing is important. Even though results comply with technical specification criteria, they may be useful for trend analysis and ageing management. Such data will be correctly collected only as the result of interfaces between the AMP and the personnel in charge of data collection.

Routine information such as test results or monitoring data which is not directly related to an incident, failure, or degradation, can, nevertheless, provide insights into the material condition of the nuclear power plant. These data are generally collected by production personnel and evaluated by engineering personnel. Clear and detailed instructions should be provided so that the data can be processed accurately and according to a common format.

Typical maintenance history data:

- Component condition indicator data (e.g. results of in-service inspections used to monitor SCC's corrosion, wear or crack growth)
- Date, type and description of the maintenance/ISI program
- Degradation failure management description (e.g. Root cause, Repair, Back fitting)

AMP experience data

- Degradation process forecasting data
- Degradation process root cause analysis data
- Domestic and international aging related events data (e.g. degradation process resulting in failure event description, ,survey of the connected corrective activities)
- Construction materials/environment/degradation occurrences data trending

Practically all the above described data are covered by the DACAAM system. Some of the data are common for all safety significant SCCs, for example the AMP related regulatory requirements. Some of the data are related to the specific equipment type, for example the generic ISI, Maintenance, Test programs or the equipment design data. At the same time, there are numerous equipment/critical component related AMP data as well. For example the actual material data, actual operational data, the possible dominant degradation mechanism and the connected inspection/repair methods are typically component related.

The DACAAM system is structured to meet the above characteristics of the AMP data relations. The Equipment type level data are illustrated on the Figure 3., the typical critical component level data are shown on the Figure4.

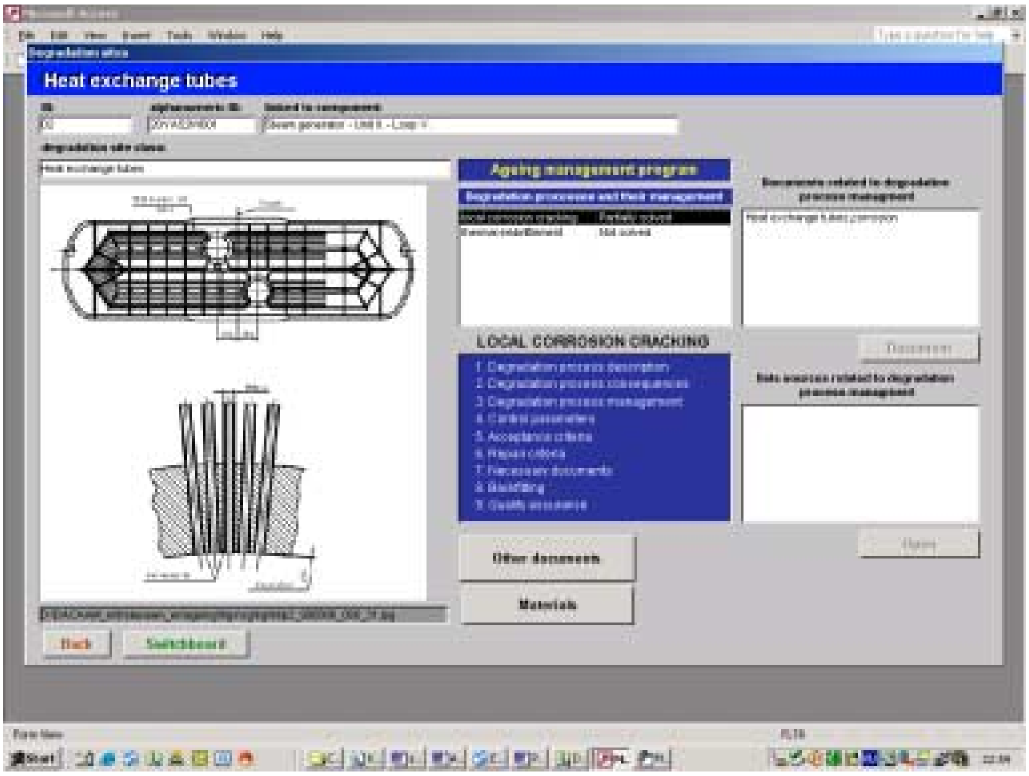


Figure 4: Critical component level AMP data on the example of the Steam Generator Heat Exchanger Tubes

The detailed component specific aging management programs are defined and reviewed for all critical sites and dominant degradation mechanisms of the equipment.

Typical examples of the maintenance history data record keeping forms are shown on the Figures 5 /a-b. Data on Indications/deficiencies found by the ISI/maintenance programs are precisely recorded in an easy retrievable way. For example the Steam Generator tube indications and the information about the plugged tubes, all the indications of the RPVs or the deficiencies found in the CRDM nozzles' lining of the RPV heads are stored and displayed with a special 3D data visualization tool.

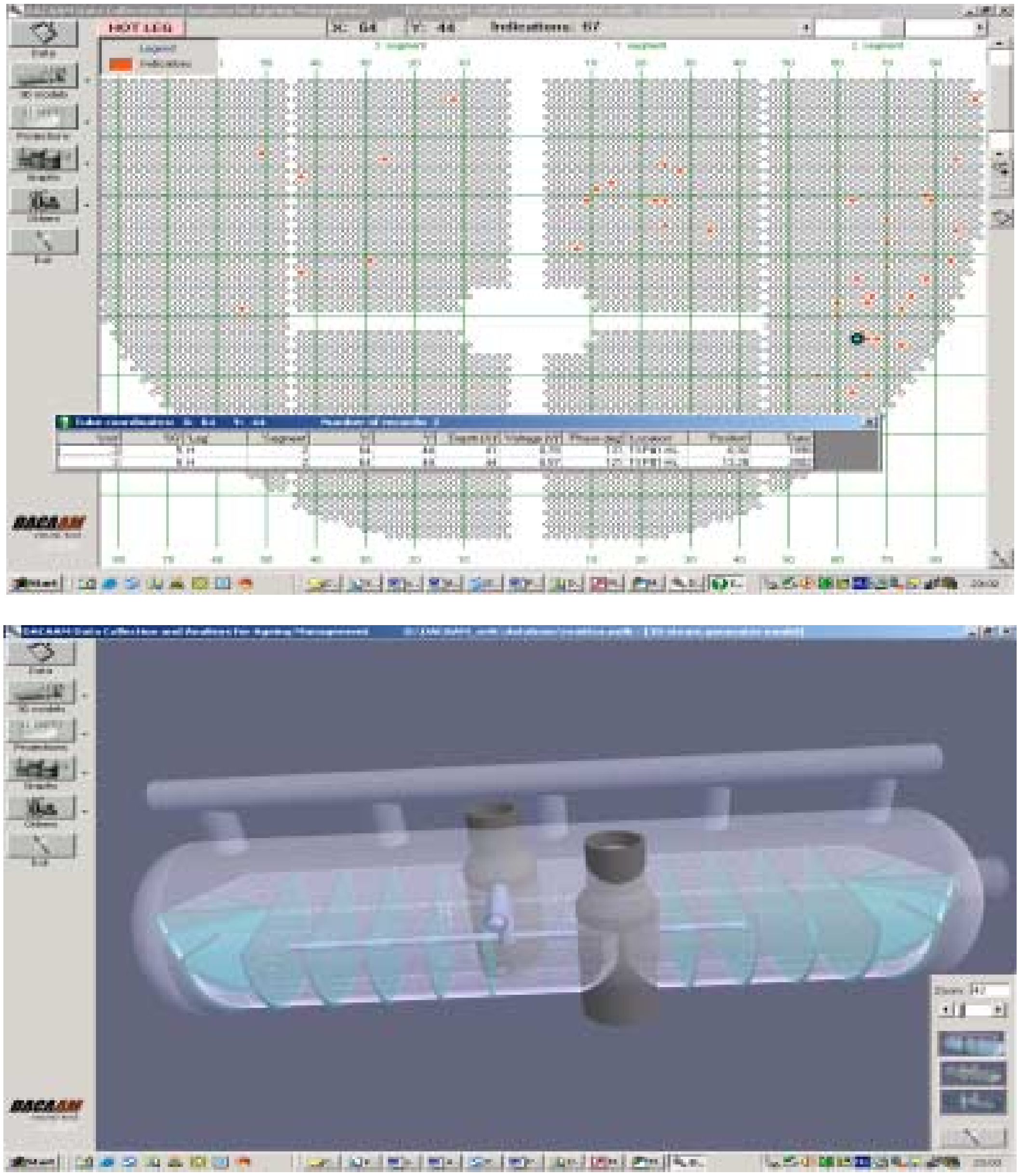


Figure 5 a/ b: Steam Generator tubes Maintenance history related data management and Visualization tools of the DACAAM system

Typical distribution map of the ODSCC indications in the horizontal steam generator tube bundles can be seen in Figure 5 b. More then 80% of the indications are originating from locations of tube supports plates, where the secondary circle corrosion products with concentrated corrosive agents are easily to be absorbed.

All the age related failures are documented by the maintenance, ISI and other specialists. These documents are stored or linked in the DACAAM system in a special format, enabling AMP related trend analysis and/or event reporting.

Aging Management Review

According to the License Renewal related Hungarian Atomic Energy Authority's Nuclear Safety Regulations and Guidelines based on the USNRC 10 attributes, a systematic review of the aging management programs, of all the safety related equipment, SSCs in safety classes 1-3+ has been performed at Paks NPP. The following main stages of the AMP were reviewed. 1. Identification of potential degradation mechanisms, 2.Identification of preventive or mitigating actions, 3.Identification of parameters to be controlled, 4.Detection of specified aging effects, 5.AMP related Monitoring and Trending, 6.AMP related Acceptance Criteria, 7. AMP related corrective actions, 8. AMP related operational history

The results of the AMP Review showed that the ageing management programs with some modifications and additional one time inspections of the safety related equipment ensures safe and presumable competitive basis for the future strategic plans of the Paks NPP units

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