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INTEGRATED MAINTENANCE PROGRAM AT CERNAVODA NPP – UNIT 1

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ABSTRACT

The purpose of this paper is to provide the information related to the integrated maintenance program in the Cernavoda Candu plant. The integrated maintenance strategy is the one to provide guidance that can be used to enhance an existing maintenance program by improving the responsibility for plant components and systems maintenance while optimizing resources. The implementation of this guidance will help ensure that tasks for important components are applicable for the types of expected failures and are effective in controlling the failures.

This document is showing how the maintenance program is controlled, integrated, enhanced and optimized in Cernavoda NPP.

The content of the paper includes:

A. The general description of the maintenance program including the main phases as follows:

I. MAINTENANCE STRATEGY
II. MAINTENANCE PROGRAMS
III. MAINTENANCE PLANS
IV. INTEGRATED MAINTENANCE
V. MAINTENANCE EXECUTION
VI. MAINTENANCE OPTIMIZATION

B. **Maintenance Program Objectives**

C. **Maintenance Performance Indicators**

The paper also presents how technical assessment programs can be optimized and interfaced with the executions programs.

It also includes a detailed one page description of the strategy plan (appendix one).

The final conclusion of this paper is that only a complex comprehensive and integrated maintenance program as it was started and will be applied in NPP Cernavoda is assuring a safe and reliable production for the unit.

1.0 *Introduction*

Today, when nuclear generated electricity is not universally accepted nor is it not always the most inexpensive option, the program of Cernavoda NPP in the field of nuclear power should reflect and sustain the major attitude and interests.

Now, the Cernavoda NPP program has its emphasis on improving safety in the operation of nuclear power plants, promoting the safe management and disposal of radioactive waste, and assessing the benefits, risks and costs of the nuclear business.

The economic competitiveness can be achieved by improving performance of the NPP that consists of improved plant productivity and reliability.

The basic elements of improved productivity are more competent management, a strict plant configuration control and more effective support of plant operation. Improved reliability can be achieved through effective maintenance program, plant life management, better operation support and provision of competitive and training personnel.

1.1 Maintenance of NPP – Principles

The maintenance activity has its historical evolution, developing from the concept "**fix it when broke**" (~1950's) through the preventive maintenance (from early 1950's to end of 1970's) until its optimized versions (condition based maintenance, reliability centered etc.). The several approaches based on different philosophies are followed around the world. There is a permanent development in techniques and institutional matters being applied or considered in the field of NPP maintenance.
However, the essential role of maintenance is the long term, safe, reliable and cost effective operation of NPP's.

The primary purpose of maintenance is to allow nuclear operators to use all functions for safe and reliable power production by keeping then functions available. In order to keep these functions provided by systems available the maintenance tasks have to be achieved on components related to the systems that are achieving the necessary functions.

NPP maintenance requires special attention because of:

- Limitations set by requirements that a minimum number of components remain operable even when the plant is shutdown in order to ensure that all necessary safety functions are guaranteed.
- Difficulty to access to some plant equipment even when the plant is shutdown, due to radiation protection constraints.

Experience has showed that efforts to improve the efficiency and effectiveness of NPP maintenance programs have moved to improvements in safety and reliability of NPP operation. This is the case because improvements in efficiency and effectiveness:

- Focus maintenance and other resources based on their importance to safety and availability.
- Organize maintenance activities in such a way as to make the best use of limited resources.
- Provide an objective basis for decisions (ex.: which components should be included in preventive maintenance programs).
- Make the best use of tools such as "information technology", to provide more accurate and useful information to all levels and parts of organization, thus improving the quality and safety of plant activities.
- Measure performance in areas such as safety, reliability and quality and use this information to identify areas of improvement

Reducing workload is a permanent target for the maintenance program. Identifying and eliminating or modifying maintenance activities that have a small (or no) effect on safety can reduce workload.

Such areas are: reducing the regulatory, optimizing the preventive maintenance program based on (RCM) or similar methods and eliminating preventive maintenance activities through advanced condition monitoring, or monitoring component's is also an essential tool for improving the assessment of remaining lifetime and optimizing the maintenance actions. Using conditioned based maintenance (predictive), unnecessary costly maintenance actions and associated maintenance errors reduced failures can be avoided.

This is that different maintenance specific programs have been developed in NPP Cernavoda as the commissioning, initial and commercial operation has been going. This is the reason the integrated "environmental (Romanian) adapted" maintenance program at year 2000 high standard have been imposed and developed for NPP Cernavoda.

The general maintenance program has been created for developing, integrating, scheduling, planning, assessment and optimization of the existing specific maintenance programs developed on different criteria as they were mentioned in the introduction.

In this paper will be presented the following:

A) Integrated Maintenance Program Objectives

B) General Description of Integrated Maintenance Program

C) Integrated Maintenance Program Performance Indicators

A) Integrated Maintenance Program Objectives

Integrated Maintenance Program is meant to meet the following generic objectives. These objectives represents the management goals to achieve needed improvements as maintenance goals are clearly identified and controlled.

The objectives are:

- Minimize the number of unplanned reactors/ turbogenerator trips due to maintenance activities
- Maximize safety systems availability
- Minimize the number of forced outages
- Minimize the station and equipment downtime
- Minimize unplanned challenges to safety related systems
- Minimize personnel errors
- Minimize radiological exposure
- Reduce repeat work (rework)
- Complete scheduled system surveillance and preventive activities in timely manner
- Manage the corrective maintenance backlog to minimize the backlog and completion time of outstanding deficiencies
- Minimize work on hold for parts
- Maximize worker productivity

B) General Description of Integrated Maintenance Program

Integrated Maintenance Program (see app. 1) is formed of:

I. Maintenance Strategies
II. Maintenance Specific Programs
III. Maintenance Specific Plans
IV. Integrated Maintenance
V. Maintenance Execution
VI. Maintenance Optimization

I. Maintenance Strategies

Maintenance strategy specific to every program represents the entire criteria, principles, conditions and responsibilities for defining a specific maintenance program. Specific maintenance strategies are or will be defined in "Station Reference Documents" (RD) for every program.

The specific strategies are:

- Outage strategy (planned/ unplanned)
- MCCR (ISCIR) strategy (pressure boundary/ pressure protection, lifting device)
- Metrology strategy (calibration and calibration verification for regulated and non-regulated equipment)
- Preventive Maintenance strategy for components (pumps, motors, MOV, AOV)
- Operating testing strategy (mandatory/ non-mandatory)

- "In service inspection" strategy
- "Chemical Analysis" strategy (oil analyze, etc)
- Maintenance Modification strategy
- "Obsolete" and "Life Time Replacement" strategy
- Spare parts strategy

II. **Specific Maintenance Programs** represent the result of applying the Maintenance strategy on the plant systems, based on technical analyses, according with the established principles and criteria.

Every specific maintenance program is (or will be) detailed in a "Station Instruction" which consists as a minimum of:

- Specific Program Principles
- Program Responsibilities and Criteria
- Applicability Limits
- Systems/Equipment on which specific maintenance program applies
- Maintenance frequency / periodicity
- Tests, verification and types of materials needed for the program
- Acceptance Criteria

Every specific program will be finalized by issuing specific call-up / work request / work plan.

Specific maintenance programs:

- Outage Programs (Planned & Unplanned) – is taking over specific activities from other program
- MCCR (ISCIR) Program (relief values, lifting devices, pressure boundary components)
- Metrology Calibration Programs
- Components Preventive Maintenance Program (pumps, motors, MOV, AOV, etc) includes time based maintenance as well as predictive maintenance
- "In service" Testing Program
- Chemical Program
- Modification Design Program – includes "obsolete" & "Life time Replacements Program (as-it is requested by operating experience or regulatory body)
- Corrective Maintenance Program – includes all maintenance activities as they are related to defective components or other deficiencies (material conditions status)
- Spare Parts Program - as it contains all the identification stock control and optimization of spare parts and materials necessary for plant maintenance accordingly with the defined maintenance program

III. Maintenance Plans

Specific Maintenance Plans are implemented by issuing specific call-up, work request by applying the program on the specific system component and they include as a minimum:

- Systems/ equipment including in program
- Planning (scheduling), the frequency of activities inside the program
- Estimation for necessary parts, materials and manpower needed.
  They are realized by coding the call-up/ Work Request/ Work Plans with the specific code for each specific program.

IV. Maintenance Program – Integrated

Plant Maintenance Program (PLMC) is a yearly program as a result of 3 plans information based on 3-5 years periodic analysis.

a) Preventive Maintenance Plan – PLMP

b) Modification Plan – PLMOD

c) Corrective Maintenance Plan (Activities)

a) Preventive Maintenance Plan is the heart of the integrated plant maintenance plan and is issued in 5 steps as follows:

1) Specific Maintenance Plans issue – issue Work Request/ call-up/OMT

2) Specific Maintenance Plans Integration at system/ equipment level (based on code sorting)

3) Integrated Technical Analysis of the Preventive Maintenance Plan

4) Technological Integrated Analysis (technology, manpower, material)

5) Preventive Maintenance Plans Issue

b) **Modification Plan is the approved modification to be implemented in the defined period.**

c) **Corrective Maintenance Activities (Plan) will be divided in:**

- Backlog (to be followed-up to be close to "0" and activities to be scheduled as the preventive maintenance – is planned)
- Daily corrective maintenance is the flexible component of the plan (as it includes the daily emergency work)

V. Maintenance Execution

Maintenance execution will be clearly defined in:

1) **Introduction** (when will be according with I→IV plan)

2) **Assessment** – all activities will be evaluated as support documentation materials, manpower etc. is available

3) **Planning** – all maintenance activities will be planned according with priorities and resources in the 13 weeks, 2 weeks and daily maintenance schedule

4) **Execution** – represents the effective field work implementation

5) **Reporting** – complex reports will be developed to assists in confirming and optimizing the activity

6) **Accepting/closing** – represents the formal confirmation of the technical and quality of work

VI. Integrated Maintenance Plan Optimization

The Integrated Maintenance Plan Optimization is realized in 2 phases:

1) **Optimization before execution** – which is done as the specific plans are issued and approved (including WR / WP / Call-up) and is based on:

- Integrated planning of different specific plans
- Technical optimization as the different activities necessity and benefits
- Manpower and estimated cost

2) **Optimization after execution** - which is based as a minimum:

- Preventive – Corrective percentage status
- Final costs
- Technical and technological optimization according with the field status reports (ex.: replacement of preventive with predictive maintenance)

C. Integrated Maintenance Program Performance Indicators

Plant Integrated Maintenance Plan (PLMC) will be periodically checked by plant management (weekly, monthly, yearly – on the case) as will have to be confirmed as efficient and continuously optimized.

For PLMC general efficiency will be continuously monitored: systems and equipment surveillance, spare parts stock and procurement, personnel training, equipment calibration status, budget validity and applicability.

Based on this, corrective actions will be taken as:

- Preventive maintenance frequency modification,

- Predictive maintenance improvement,
- Design modifications,
- Spare parts stock change,
- tools & technology improvements,
- manpower & productivity improvements,
- budget revision,
- maintenance procedure improvement, etc.

During and after implementation maintenance program will be continuously monitored the following:

- Safety systems availability (unavailability)
- Unplanned outages (for plant and safety systems, etc.)
- Systems and equipment downtime
- Lost time accident rate
- Radiation doze
- Backlog level and reduction
- Productivity and overtime control
- Preventive maintenance effectiveness and % of preventive maintenance to total maintenance activity
- Etc.

The entire program is surveillance (or should be sustained) by complex software databases as:

- work management systems;
- master equipment list;
- planning systems and databases (including different programs coding);
- functional equipment group.

The optimization of the entire process can be done by an "critically" and "priority assessment" based on engineering judgement criteria.

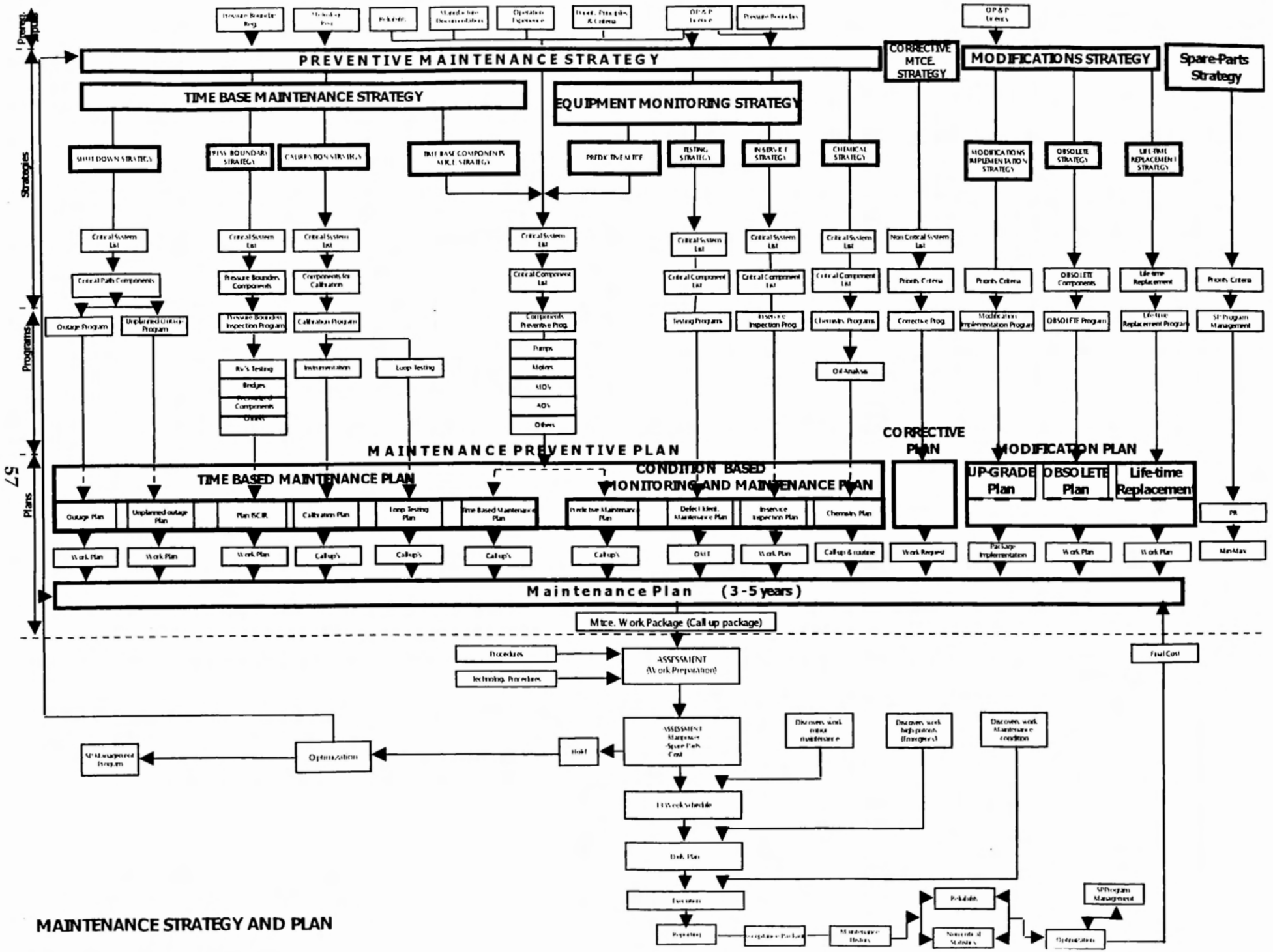
Everything can be finally revised or sustained by P.S.A. – Probabilistic Safety Assessment program.
And this should not fail.

Conclusions

As the last up-to-date policies in Nuclear Power Plant maintenance are that, corporate and station policies should reflect a philosophy of "**striving for excellence**" in station operation and maintenance.

The final conclusion is that Cernavoda NPP "Integrated Maintenance Program" is an "year 2000" program adapting the up-to-date technology to Romanian Environment for developing a flexible and actively optimized maintenance system which allows for any future easy improvement and optimization. It is considered a specific new model which prove the advanced organization and technology already in place or in progress at Cernavoda NPP Unit 1.

This is one of the main elements in supporting its safe and efficient operation.


Strategies
Programs
Plans
PREVENTIVE MAINTENANCE STRATEGY
TIME BASE MAINTENANCE STRATEGY
EQUIPMENT MONITORING STRATEGY
CORRECTIVE MTCE. STRATEGY
MODIFICATIONS STRATEGY
Spare-Parts Strategy
SHUT DOWN STRATEGY
PRESS. BOUNDARY STRATEGY
CALIBRATION STRATEGY
TIME BASE COMPONENTS MTCE STRATEGY
PREDICTIVE MTCE
TESTING STRATEGY
IN-SERVICE STRATEGY
CHEMICAL STRATEGY
MODIFICATIONS IMPLEMENTATION STRATEGY
OBSOLETE STRATEGY
LIFE-TIME REPLACEMENT STRATEGY
Critical System List
Non Critical System List
Critical Path Components
Pressure Boundary Components
Components for Calibration
Critical Component List
Priority Criteria
OBSOLETE Components
Life-time Replacement
Outage Program
Unplanned Outage Program
Pressure Boundary Inspection Program
Calibration Program
Testing Programs
In-service Inspection Prog.
Chemistry Program
Corrective Prog.
Modification Implementation Program
OBSOLETE Program
Life-time Replacement Program
SP Program Management
RV's Testing
Bridges
Instrumentation
Loop Testing
Oil Analysis
Pumps
Motors
MOV's
AOV's
Others
MAINTENANCE PREVENTIVE PLAN
CORRECTIVE PLAN
MODIFICATION PLAN
TIME BASED MAINTENANCE PLAN
CONDITION BASED MONITORING AND MAINTENANCE PLAN
UP-GRADE Plan
OBSOLETE Plan
Life-time Replacement
Outage Plan
Unplanned outage Plan
Plan ISCIR
Calibration Plan
Loop Testing Plan
Time Based Maintenance Plan
Predictive Maintenance Plan
Defect Elimt. Maintenance Plan
In-service Inspection Plan
Chemistry Plan
PR
Work Plan
Call-up's
OMT
Call-up's & routine
Work Request
Package Implementation
Man-Max
Maintenance Plan (3-5 years)
Mtce. Work Package (Call up package)
Procedures
Technolog. Procedures
ASSESSMENT (Work Preparation)
Final Cost
Optimization
Hold
Discovers work minor maintenance
Discovers work high priority (Emergency)
Discovers work Maintenance condition
Dwk Plan
Execution
Preparation
Maintenance History
Probabilistic
Non-probabilistic Statistics
SP Program Management
MAINTENANCE STRATEGY AND PLAN
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