Good practices for outage management in nuclear power plants
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FOREWORD

As a follow-up to an earlier Technical Document on Good Practices for Improved Nuclear Power Plant Performance (IAEA-TECDOC-498), the Agency has produced a more focused technical report on good practices associated with nuclear power plant outage planning and execution. As with the earlier document, the overall aim is that by identifying good practices in the key aspects of outage management, overall world nuclear performance will improve and the gap between excellent performers and operators with developing programmes will be narrowed. The outage period is one of heightened maintenance activity and work hazards where interrelated and complex tasks must be co-ordinated. An excellent programme is one which accomplishes this in a timely manner but with its central objectives being:

- maintenance of plant and employee safety; and
- long-term component and plant reliability.

This document has been produced through the contributions of numerous operators and government agencies. It aims at minimizing text and focusing on actual good practices in use which can be found in the annexes.

While not complete or in order of priority, the following list summarizes the key factors in ensuring good performance in outage management.

- Utilities must have a long-term outage strategy in order to:
  - ensure efficient use of resources
  - meet changing regulatory requirements (this document could serve as an aid in preparing for discussion of commitments with authorities)
  - limit the rate and extent of changes.

- The long-term outage strategy must include:
  - a thorough documentation of the process itself and responsibilities for the plan
  - resource allocation
  - major outage content
  - integration with other stations/utilities
  - a process allowing routine update.

- An outage organization must exist with a clear structure and well defined responsibilities for planning and executing the outage process.

- The planning period must include a systematic identification and documentation of all outage activities and detailed planning well in advance with a specific focus on the critical path.

- There must be a timely provision of good procedures, tools and equipment, spare parts and manpower planning for specialty skills and necessary training.
Outage execution management focus on integrated co-ordination between maintenance, operations and contract support staff in order to promote team work and smooth work flow.

An effective feedback and work control process must exist.

A rigorous programme of ensuring quality work performance must be in place.

Post-outage reviews must be conducted in order to:

- assess outage performance vs. expectations
- identify problem areas
- amplify successful strategies

thereby improving future performance. This review represents the start of the next outage planning phase.

While the specific methods used to achieve excellence in maintenance/refuelling outages may differ, the above points represent the fundamental requirements of outage management. In addition, continuing a high level of performance requires a culture which examines all aspects of activities with a view to self-improvement. Only in this manner can opportunities for improved results be fully exploited.

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EDITORIAL NOTE

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Chapter 1

INTRODUCTION

Nuclear power plant outage management is a key factor in successful utility performance. It constitutes a period of time where significant resources (station and external) are expended at the plant while replacement power must be purchased to meet the utility's supply obligations. The purpose of this technical document is two-fold. First, it is hoped that by reviewing basic outage management it can provide guidance to utilities seeking to develop or improve their maintenance programs; as well, by illustrating a number of good practices employed by world Nuclear Operators, it will lead to an experience transfer between electrical utilities.

This document has been prepared through the contributions of numerous operators and government agencies, as is evident from the good practices identified. It is not meant to be prescriptive, as it is not an exhaustive review of all issues, related to outage preparation and execution. It does, however, provide specific examples of successful strategies in most key areas of outage performance.

Plant activities can be subdivided into three major areas. These are:

1. full power plant operation and maintenance
2. outage/refuelling activities
3. emergency response operations.

While it is recognized that procedures and policies may overlap considerably, this report will concentrate on outage-related activities. As well, while good practices in such areas as those dealing with training, procedure acquisition, and work control may have benefits to other plant activities, the linkages are left to the reader to make.
Plant outages are planned actions in which work activities are carried out between disconnection and reconnection of the unit to the electrical grid. A maintenance outage is characterized by preventive and breakdown maintenance as critical path activities, whereas in refuelling outages, all maintenance work is kept to a shorter duration than refuelling/pressure vessel testing. In either case, the period of time constitutes a majority of the plant annual incapability, and its successful completion will contribute significantly to subsequent unit reliability.

The following represent the main objectives of outage management.

(1) **Restore Plant Quality/Performance**

Both Safety Analysis Report and Life Assurance Programme identify specific components as critical to plant safety and operation. Outage inspection work must determine plant status and ensure any degradation is eliminated or analyzed for its impact on both safety and performance. Trends must be evaluated both prior to and during outages to ensure that timely corrections can take place. Beyond inspections, known deficiencies must be eliminated as part of the breakdown maintenance effort.

(2) **Implement Plant Modifications**

Due to the nature of the work, some plant modifications can only be performed safely when the plant is in a cold shutdown condition. With aging plants, these activities may constitute a significant proportion of the maintenance carried out in the planned outage.

(3) **Optimize Outage Duration**

A certain optimum exists between complete inspection and component replacement and a minimal outage programme. Given a reactor design, equipment duplication, accessibility and proven reliability, an optimal programme can be struck. As equipment and system performance is highly dynamic, a comprehensive surveillance programme is necessary to confirm assumptions and to update the inspection/repair schedule. Only in this manner can a utility ensure a cost effective and thorough outage
programme. A key concept in this objective is that of minimizing risk to both public and employees, through an inspection/repair outage scope which includes all critical components; as well, given a need for reliable on power operation, essential maintenance may not be deferred, possibly extending the planned outage.

(4) Minimize Outage Extensions

Once the outage programme has been developed, a major success criteria is the meeting of outage duration targets. This can only be achieved through extensive pre-outage planning, a rigorous content control programme, and a comprehensive review of work activities.

(5) Minimize Conventional and Radiological Hazards

During a maintenance or refuelling outage, both conventional and radiological hazards may be significantly greater than during operating periods. The possible combination of:

- open radioactive systems
- increased field activity and personnel concentration
- inexperienced, outside contractor staff
- transportation of heavy equipment
- housekeeping and cleanliness problems

dictate that a conscious and extensive outage safety programme be in place to maintain good performance (ie, low accident rate and ALARA exposures).

(6) Minimize Waste Generation

Periods of increased plant activity such as outages place a major strain on active waste minimization and material wastage reduction efforts. The cost and labour requirements of handling active waste as well as the environmental impact of both active and conventional wastes require a comprehensive education and control programme. Waste targets provide both visibility and incentives for waste control efforts during outage periods. Good housekeeping standards rigorously applied will assist waste reduction efforts.
(7) Improve Future Performance

Successful Nuclear Operators show increased outage efficiency over time indicating an active and effective post outage review process. This can only be achieved by station dedication and a desire to provide and receive constructive criticism subsequent to the outage period. Beyond this, a thorough documentation and easy retrieval of both successes and failures must be available and make up the experience loop used by successful utilities (see Annex 1.1).

In order to meet the above objectives, a utility must possess an effective outage management system. Subsequent chapters will review in detail those elements of outage management dealing with:

- Long Term Outage Strategies
- Outage Planning and Preparation
- Outage Execution and Control
- Post Outage Review

Clearly, attention to these key factors will lead to improved performance. That a point is reached beyond which, cost effective improvements cannot be made is also undeniable. The management of maintenance/refuelling outages is so complex, however, that this point is unlikely to be reached in all areas and must be continuously reviewed to ensure that new equipment strategies and concerns have been included. Beyond this, turnover of key personnel, regulatory changes, and evolving environmental factors dictate the need for an ongoing learning process and programme updating.
Chapter 2
LONG-TERM OUTAGE STRATEGY

This chapter deals with the long-range outage planning process. While the number of factors to be included and the rigor of application may vary between utilities, all accept that this is a key step in ensuring effective planned outage management. Aside from giving specific examples of comprehensive long-term strategies, this chapter will review some of the key factors requiring consideration. These are not meant to be all inclusive, but rather, to document practices followed by the most successful utilities.

In order to understand the process there are two fundamental questions to be addressed. These are:

- What is a long-range outage plan?
- Why must a utility have one?

The long-range outage plan produced by most Nuclear Operators is a forward looking document covering at least the next five years and often as much as ten years (see Annexes 2.1 and 2.2). Many incorporate this process into their business plan as most factors are common to both. In terms of content, it will generally include a schedule of outages, their proposed duration and the major work activities. As well, it will examine all key issues surrounding outage content and timing (see Annex 2.3).

Beyond this, there is always a process in place to ensure its review and update on at least an annual basis.

The preparation of long-term plans by utilities allows them to meet some basic strategic objectives, namely:

- effectively using critical resources,
- meeting regulatory requirements, and,
- limiting the rate and extent of plant changes.
The execution of a maintenance or refuelling outage has a major impact on a utility. In most cases, additional resources must be brought into the plant to deal with the increased workload. This may necessitate:

- staff hiring (regular and/or temporary) and training,
- off-site staff provision,
- extensive contract negotiations with contractors and vendors.

In order to properly alert all support groups and allow for long lead time preparations to be carried out, a long-term plan must be available.

In most countries, the nuclear industry operates under considerable scrutiny. Whether public at large or regulator, everyone has a keen interest in the operation of the maintenance programme. A long-term strategy allows the utility to project completion of key commitments and to assess impact on electrical supply and cost.

Finally, the long-range plan, through its consideration of key factors, places boundaries around outage duration and content. This ensures that any additional tasks identified are scrutinized with these limits in mind. This provides for more effective control of outage work and plant modifications.

2.1 Factors in Preparing the Long-Range Outage Plan

This section deals with the most commonly considered factors in preparing an outage strategic plan. They are subdivided into those which a power station has some control over, i.e., internal factors and those which are set by environmental considerations, i.e., external factors.

2.1.1 Internal Factors

Outage Content

The factors discussed below will generally dictate the outage duration. The specific allocation of time to each factor will vary greatly due to both reactor design and other internal and external factors. For example, CANDU as well as GCR stations perform refuelling activities at power and so need not conduct any refuelling
during unit shutdowns. For BWR/PWR plants, however, this constitutes the critical path activity of many annual shutdowns. As well, the extent of component duplication and the general accessibility of equipment will dictate the level of breakdown maintenance which will be carried out during the unit outage. While the specific content may vary greatly, the factors constitute the mix of tasks which must be considered to ensure an accurate assessment of outage duration.

Refuelling

For all PWR/BWR operators, a refuelling outage is required in a 12 to 24 month time period. The exact frequency of outage is generally dictated by fuel economy considerations, and overall economics. Annex 2.4 reviews a 12/24 month strategy used in Sweden. Annex 2.5 defines the refuelling outage as part of that strategy. Finally, Annex 2.6 examines a rationale for altering fuel management use at EDF in France.

Periodic Inspection

Component non-destructive examination is carried out by all nuclear plant organizations. Its motives are generally broken down into four major groups, namely:

- Operating Safety Assurance
- Nuclear Plant Life Assurance
- Life Extension Inspections
- Preventive Maintenance Program.

To operate the nuclear power plant safely and without trouble during the planned operating period is the first motive for the operator. Periodic inspection of the plant systems/components is the way to assure such safety operation of the nuclear power plant.

Most new facilities licensed to operate in the last ten years, require a formal Quality Assurance Program which dictates not only the standards of fabrication of all major components but
also a periodic requirement for non-destructive evaluation. This inspection schedule forms part of the outage package. In addition, as it generally constitutes a condition of the operating licence, there is little flexibility in its execution.

For economic reasons, nuclear operators, in the design phase of a reactor system will identify critical life components which establish the expected life of the station. Deterioration of these key areas will, therefore, also form part of the inspection programme. Unlike the mandated life assurance inspections, there is greater flexibility in their execution and they may be scheduled during a longer maintenance outage.

Finally, based on maintenance experience, specific equipment not normally accessible at power will be targeted for inspection. Here, the focus is on increasing future plant reliability by eliminating potential key systems failures. Again, in these inspections, some timing flexibility exists and based on past results may be deferred from year to year striking a balance between excessive inspections and unacceptable forced outage rates is the aim of all nuclear operators.

Breakdown Maintenance

The repair of defective equipment, while sometimes identified late in the planning process for an outage, can be assessed on the basis of past resource utilization and trends which may be evident from plant or component aging. While this factor should not become the outage duration setting parameter, its potential impact should be factored into the establishment of the outage length. Most successful utilities not only consider this factor in long term planning but work aggressively at ensuring that it plays as small a role in outage content as possible. An example of the results of this approach on reducing breakdown maintenance is provided in Annex 5.2. Reduction of breakdown maintenance can generally be achieved by:

- Forced outage pre-planning
- Designing out known problems.
Most successful operators anticipate the possibility of unexpected forced shutdown. An accurate and frequently updated work list allows the station to take advantage of the occurrences and to keep breakdown maintenance as part of the planned outage under tight control (see Annex 2.7).

In addition, high frequency breakdowns should be identified through technical surveillance. Where economic justification can be made, equipment modification will result in lower breakdowns and further reduce its contribution to planned outages.

Modifications

This factor often plays a critical role in setting outage duration. Most nuclear facilities have a significant programme of installing retrofit equipment or systems into existing units.

In order to estimate its impact, known activities are input into the outage programme and historical workload trends are reviewed.

If necessary, a contingency may be added to ensure that an accurate evaluation of the expected workload exists.

Testing

Several systems associated with safety/shutdown mechanisms cannot be tested while at full power. The unit outage, then, provides an opportunity to verify the functionality of critical components. Containment testing and hydro testing of the reactor pressure vessel are typical activities.

While in some cases, the activity may only be a small part of an outage programme, the failure of any test may significantly impact on the nuclear operator. Annex 2.8 and 2.9 provide examples of typical testing schedules.
**Preventive Maintenance**

While periodic inspection and testing are in fact forms of preventive maintenance, this section was added to address additional activities; such as:

- vibration monitoring
- equipment disassembly and inspection
- thermographical scans.

These are beyond the non-destructive examination (NDE) carried out as part of periodic inspections but are an essential element of maintenance reliability.

A successful long-term strategy will give high priority to the execution of this form of outage maintenance but will limit its length to the other work activities.

**Resources**

Once outage content and their duration has been established, the availability or provision of resources must be considered. Lack of preparation in this area will lead to resource limited outage duration and is unlikely to be cost effective. The long lead time required for acquisition and training of corporate resources make this a long-term strategy issue. Annex 2.10 deals with one utility’s attempt at quantifying ongoing maintenance needs.

**Station Staff**

The execution of a unit outage requires the dedication of significant station staff. Typically, the following groups are involved:

- Operating group,
- Mechanical Maintenance,
- Instrumentation and Control,
- Electrical Maintenance,
• Planning,
• Stores/Supply,
• Building Maintenance,
• Technical Support,
• Site Inspection Group,
• Administrative Support,
• Chemical Group,
• Radiation Protection.

• Reactor physics

Depending on the number of units on site and the management structure, the outage planning and execution may involve the redeployment of resources or the use of dedicated staff from a long-range planning process, the key issues to consider are:

• staff needs based on outage content,
• special skills involved and source of staff,
• competing requirements for station resources.

Outside Support Groups

These are highly variable in both numbers and composition amongst all utilities and constitute a product of both political realities and sound economic judgement. Specific support services are provided for:

• maintenance and modification activities
• inspection
• technical support
• administrative support
• design.

Many organizations rely heavily on contractor maintenance support. The long-range plan must make allowance for this by identifying outage content and timing well in advance of the shutdown. This permits utilities to seek support commitments for outage work. The same can be said about all support services listed above.
Material Availability

The execution of outage maintenance results in considerable strain on material inventory. This can be particularly significant for a multi-unit operator. Inventory levels must be kept high enough on all high movement items to ensure that material availability does not extend outage duration.

As well, specific materials with long lead times must be identified and controlled to minimize impact of outage work. Past problems can be reviewed to ensure that in the longer term, they will not adversely effect the plant.

A key strategic issue which must be considered by the station is the overall infrastructure required for executing an outage. Plans must be made and reviewed frequently to ensure that:

- Facilities are in place for station staff and contractors (office space, laundry, work shops, cafeteria, change rooms).
- Adequate supervision is established with clear reporting lines and accountability.
- Administrative support has been adequately provided (clerical, telephone system, work management systems, payroll system).

The smooth functioning of the outage relies on these factors and as many involve large advance expenditures, they must form part of the long-range planning process.

Labour Relations

Disruption of station or support resources may be caused at any time by labour relations issues. Collective Agreement expiration should be anticipated, if appropriate to the utility circumstance, and accounted for in the long-term outage strategy.
Facility provision has a significant impact on employee working conditions and as such every attempt should be made to maintain high standards, especially during the outage period.

**Funds Availability**

While a review of outage content and station resources will improve the likelihood of a match, contingencies have to be built into the planning process to ensure that outage schedules can be maintained. Staff overtime must be allocated and projected into outage periods. Sufficient project funds must be available to account for:

- work delays
- additional contractor labour
- additional material needs.

The execution of the long-term outage strategy requires the commitment of significant funds. This must form part of station's business plan and be supported by a stable equity base.

2.1.2 **External Factors**

The consideration of outage content and resources will in itself generate an outage schedule which includes duration as well as timing. The additions of external factors such as supply/demand will force, primarily, a review of the outage timing. In addition, where severe shortages or large surpluses exist, work not associated with the refuelling element may be deferred or moved forward to alter proposed outage length. The section that follows, discusses the factors involved in assessing electrical production and consumption for a utility which helps shape the long-term outage plan (see Annex 2.11).
Supply

Capacity

Most nuclear utilities have a mix of electrical generation, namely:

- Thermal
- Hydraulic
- Nuclear.

In addition to these self generated forms other options exist:

- non-utility generated power
- purchased power.

Beyond this, the long-term generation plan may include:

- units under design or construction
- recommissioning mothballed or reserve units.

The above will allow an organization to establish its current total production capability, future potential based on both self generated and purchased power options.

Regulatory Limits

While this area varies considerably throughout the world, most nuclear operators have production limits imposed directly or indirectly upon them. These normally fall into the following groups:

- thermal emissions
- toxic gas levels (Thermal Generation)
- operating power restrictions/shutdown frequency
- radiological emission limit
- employment standard law
- health and safety law
In terms of the long-term outage plan, these limitations will simply reduce the generated power available to the electrical grid and potentially imposed timing and duration limits on planned outages.

Demand

The assessment of demand for electrical supply is crucial to a utility. While minor variances can be easily rectified through interconnections, major miscalculations can be both expensive and system threatening. The identification of a significant excess demand above supply may lead to some major alterations to the long-term outage plan.

A thorough review of electrical consumption in the area of interest to the utility will generally show the following:

- seasonal nature of demand (especially in northern climates)
- any impact of conservation initiatives
- a trend roughly aligned with the economic outlook of the region.

Beyond this, export agreements may lead to increased utility demands as well as a more variable ongoing requirement. These should be factored into the long-range outage strategy to ensure that significant shortfalls or excesses are not created.

2.2 Long-Term Outage Plan Preparation and Maintenance

The complexity of the long-term plan as well as the diversity of issues considered make it unlikely that its generation is vested in only one person. The internal factors are often evaluated by local staff, while the external issues are dealt with by headquarters support individuals.

As a result, in order to be effective all groups involved in its preparation must have a clear understanding of their role in its generation and upkeep.
Secondly, in order to carry out its intended purpose, the long-term outage strategy must be frequently updated. Most organizations carry out annual business planning. This, thus, necessitates an update of the corporate outage plan.

Finally, the factors identified are not to be considered all inclusive. Most have simply been defined rather than analyzed as strategy formulation would require. These factors, however, do constitute a common set of issues employed by a number of good performers in outage management in generating a long-term outage strategy.
Chapter 3
PLANNING AND PREPARATION OF OUTAGES

An effective system for planning and preparation of outage work is a major factor in achieving a good outage performance.

Good practices which have been proved effective for planning and preparation have shown following common features:

• clearly structured outage organization with well defined responsibility and authority for planning, preparation work and coordination function.
• systematic identification of all outage activities required, detailed planning well in advance and more focus on the critical path.
• timely provision of good procedures, tools and equipment, spare parts, manpower planning for the required skills and the appropriate training.

In the following sections each of the important elements is discussed.

3.1 Outage Organization

The effective implementation of outage work requires the establishment of an "outage organization". This is due to the complexity of outage work and interfaces with all work groups involved in the planned outage, it should be well defined and structured to handle:

• outage planning and preparation,
• outage execution,
• post outage review.

It is considered a good practice to use the same organization for all these important phases of the outage management, rather than "handing over" from a planning organization to an execution organization.
The outage organization should be set up with well defined responsibility and authority for each functional group to implement individual tasks and achieve overall outage goals. The responsibility for directing all the associated outage activities and coordinating with various groups should be assigned to an individual as the Outage Manager.

The detailed planning and extensive coordination service for the planned outage requires the establishment of a Planning Group. The responsibility for providing such a service is usually delegated to one of the functional groups within outage organization. In order to enhance planning and coordination effort, many operating organizations establish a separate working group from the planning stage to completion of outage. This is usually staffed by deploying knowledgeable and experienced personnel from the relevant plant groups such as operations, maintenance and radiological protection, etc. The Planning Group can be formed for each outage or permanently. An example of a permanent "Outage Coordination Group" organized for this purpose by one operating organization is given in Annex 3.1.

The composition and number of the working group may vary, depending on the outage work load and tasks of the group.

The tasks of the Outage Planning Group basically include:

- Identifying all pre-outage activities to ensure preparedness well ahead of outage start.
- Making work schedule for planning and preparation.
- Identifying all the work to be done during the outage.
- Long term planning.
- Developing main outage schedules.
- Reviewing all plans and schedules according to technical specifications.
- Preparing information material.
- Planning "infrastructure" such as food, housing, transports, etc.
- Start-up and coordinating the planning and preparing work in the organization according to the work schedule.
- Providing information to authorities about the outage planning and execution.
• Coordinating, monitoring and following to completion of activities during outage execution.
• Making notes in a log book during outage execution.
• Monitoring work programme and updating work schedule.
• Safe and proper handling of "last minute changes" in schedules during outages.
• Preparing the outage report.
• Evaluating outage effectiveness after outage and identifying improvements for future outage.

The Outage Planning Group should have the overall responsibility for the outage being executed in an acceptable way according to safety and efficiency.

Each functional group in the outage organization should have the responsibility that their own specific work will be executed in a skillful manner and according to the overall plans and schedules made by the Planning Group in cooperation with the functional groups.

3.2 Outage Planning

Outage planning should be done well in advance so that adequate time can be allowed for extensive review and appropriate preparation work.

3.2.1 Safety and Procedures

It is important to establish planning routines which always ensure the reactor safety and personnel safety during outages.

A typical process used by Nuclear Operators to ensure a thorough review of outage activities with reference to nuclear safety is by the existence of a "Safety Review Committee" which oversees all significant safety related maintenance initiatives proposed for the outage.

The authorities' rules and regulations, for example the technical specifications, should be followed at all times. It is a good practice to promote good communications with the authorities. This means a lot of information exchange that will create a mutual understanding of the day to day problems.
It is also important that all the outage planning and preparation are done according to well established and documented internal procedures at the plant.

3.2.2 Planning Start-up

Immediately after the completion of that unit's outage, the planning for its next outage should start. Two examples of outage planning and preparation process are shown in Annex 3.2.

The first thing to do is to as soon as possible make a first rough preliminary main time schedule defining:

- outage start date,
- major activities,
- estimated outage length and critical path.

Inputs to this first schedule are information from long-term planning and leftovers from the outage just completed.

Reasons for this early scheduling are:

- outage length and main activities normally have a major impact on the economical budget and thus an estimate of resources is needed at an early stage.
- it is important to, as early as possible, get information of planned major activities that can affect the critical path. This is to decide how to allocate the planning resources.

A good practice is to make a work schedule for the planning and preparation period. The schedule should identify all pre-outage activities necessary to ensure preparedness well ahead of outage start. Important target dates along the way should be clearly marked. To be functional a work schedule must be accepted in the organization. A good idea is to let all the involved managers review the schedule and sign it to indicate that they and their departments are ready to work according to it. Examples of work schedules are given in Annexes 3.3 and 3.4.
A parallel activity at this stage is the post-outage review (described in Chapter 5). The result must of course be taken into consideration for the next outage as the planning proceeds.

All plans are prepared with the following principal steps:

- Identification of the outage work to be performed during a specific outage.
- Development of a preliminary time schedule defining critical path.
- Development of a detailed time schedule and individual work plan.

3.2.3 Identification of Outage Activities

A proposed maintenance worklist should be available on the site. The list includes all required work such as refuelling, preventive and corrective maintenance, in-service inspections and modifications.

There are many ways of identifying outage activities. The Planning Group can choose among the following methods:

- Ask for written information (lists, descriptions, etc) from the organization.
- Call for meeting with the functional groups responsible for outage activities.
- Interview functional groups, modification planners and project leaders.
- Use computer systems.

The best way is probably to use a mixture of all these methods.

A computerized maintenance system with the ability to sort work orders by priority and coordinated with the component data system is much useful in managing the maintenance work backlog. (See brief descriptions of computerized outage systems in Annex 3.5.)

Beside the outage activity itself, information must be gathered about:
• the required time and manpower, radiological conditions,
• certain conditions necessary (systems in or out of operation, etc),
• required means of assistance and service, spare parts and material.

A review of each major job should be performed to determine if the work must be done during the outage or, if the work can be deferred to the next outage. The review should be based on operational and technical judgement of the plant management. However, the decision should be made with highest priority to plant safety to ensure that the outage work preserves adequately the safety status of the plant after completion of the planned outage.

Except for safety, another important factor to consider is the "operation risk" during the next operation period. After an outage the plant must be in a condition to be able to perform high availability and efficiency which is required by all utilities.

Mandatory maintenance requirements including regulatory inspections and other operating licensing conditions should be carefully reviewed and factored into the list of the proposed work to be performed.

A forced outage work list should be maintained to ensure that some work items can be performed in the event of unscheduled plant shutdown so as to reduce the maintenance efforts during planned outage.

Close monitoring of outstanding maintenance work should expedite jobs which can be performed with unit on-line in order to reduce maintenance efforts during outage as much as possible.

The list of the outage work to be done during the outage should be periodically refined through regular planning meetings. The identification of outage work should be completed well in advance to outage start for preparing a time schedule.

Additional outage work should require an approval process with consideration of impact on outage resources or critical path time.
The Planning Group should inform the organization that late alternations in the plans and schedules could cause major disturbances and extra costs.

It is generally a good practice to let those parts of the organization which are responsible for maintenance, modifications, operations, inspections, etc, decide what to do during the outage and also how to do it. It should then be the responsibility of the Planning Group to decide when to do it, that is to coordinate all activities so that all the work groups can cooperate in the best possible way to get the job done. The Planning Group should only interfere with the decision of what to do if the activity considerably affects the overall outage goals.

3.2.4 Preliminary Time Schedule

As soon as the major jobs to be done are identified, a preliminary time schedule should be prepared, using a standard reference schedule for a specific outage as a guide. The reference schedule provides a basis for preparation of the preliminary time schedule. It evolves and changes as experience is gained.

The preliminary time schedule presents a clear picture of the outage showing the major activities with target dates. Time scheduling is not limited to the outage work. Scheduling for outage prerequisite work, plant shutdown and startup programme are also prepared at the preliminary scheduling phase.

The preliminary main schedule shows the major outage activities between disconnection from and reconnection to the electrical grid, and is a refinement of the very first schedule discussed earlier.

The critical path should be calculated with clear definitions of the critical activities and target time periods for these. Much effort should be made in developing the critical path. It should be based on system logic network and a realistic time schedule without float time since a proper sequence of the critical activities is determinant of the total duration of the outage time.
The critical path calculation may be assisted by a scheduling system as one part of the computerized maintenance programme. As the critical path by definition is the sequence of activities which decide the outage length, it is necessary to pay extra attention to it in order to make the outage short.

A lot of planning effort should be given the critical activities to minimize the time needed and to reduce any uncertainty that might exist.

The shortest possible time is allocated to each activity. The time schedule for critical activities is usually based on shift work, 24-hours a day, including weekends. However, the resources, particularly experienced manpower should be considered to match the work schedule.

The amount of resources given to critical activities depends of course on the outage policy of the utility, that is how much a short outage is worth compared to other important outage goals.

Realistic time and manpower estimates for critical path work are improved by the involvement of experienced staff, lessons learned from previous outage experience and the use of enhanced information system. Peak workloads can be avoided by optimized simulation of shutdown activities.

A refuelling outage for off-load fuelling reactor is one of planned outages. In this context, "Refuelling Outage" is identical to "Periodic Inspection". Critical path of the refuelling outage is mainly correlated to the sequence of work on the reactor.

Typical critical path work for refuelling outage may include:

- shutdown and cool down of reactor including tests,
- removal of reactor vessel head,
- refuelling (fuel unloading, fuel inspection, fuel loading and core mapping),
- inspection of reactor vessel,
- mounting of reactor vessel head,
• containment leak rate test,
• major component inspection,
• startup tests.

Typical time schedules of refuelling outages are exemplified in Annex 3.6. The duration of each schedule varies somewhat, depending on respective maintenance philosophy and the plant maintenance capacity.

For on-power fuelling reactors, there is more flexibility in outage scheduling and a scheduled maintenance always dictates outage duration.

The time schedule which is determined by critical path work provides the time slots available for all the non-critical work to be done. If special work such as extensive modifications should extend beyond the available time slots, these are then worked out in detail for the period where these activities are on the critical path or can be deferred to next outage.

It is important to identify the "semi-critical path" in the time schedule. This means the sequence of non-critical activities which is closest to become critical, if anything goes wrong during outage execution.

Proper attention should be paid also to the "semi-critical" activities in parallel with the critical path during planning.

There are many ways of producing time schedules, for example:

• drawing by hand with pen and paper,
• drawing with CAD techniques,
• using computerized project planning tools.

Many types of schedules are used, for example:

• Bar chart schedules (see Annex 3.3),
• network schedules (see Annex 4.1).
Whatever technique is used, schedules must be easy to understand, easy to handle and contain just enough information to be of best use for planning and controlling outage activities.

Checks and inspections on complex equipment/components should be arranged as early as possible after plant shutdown in order to make available more time for unforeseen corrective action.

Progress of non-critical path work is periodically reviewed against planned objectives to re-allocate resources as necessary and/or take prompt corrective actions in case of unforeseen problems.

3.2.5 Other Useful Schedules

The Planning Group should be responsible for the overall planning and coordination of outage activities and leave the detailed work planning to those functional groups responsible for the actual work performance.

The Planning Group should give clear and precise information about available time frames, that is start and end times for the individual tasks to be performed, but should not interfere with the detailed work planning as long as it indicates that the work can be done properly within the set time frames.

It is important that an open dialogue between the Planning Group and functional groups is maintained at all times.

(A) "Umbrella" Schedule

A good practice used by some operating organizations is the pre-determined system clearance tag-outs, which makes it possible to group much of the outage work into well defined portions.

An example is the "umbrella" system at Barsebeck, Sweden (described in Annex 3.7). The system clearances are marked in an "umbrella" schedule with start times and end times.
The advantages of "umbrellas" and "umbrella schedules" are to:

- improve the planning overview,
- make it easier to do "last minute changes" in planning without loosing control,
- simplify the planning and keeping of safe reactor shutdown conditions,
- simplify detailed work planning,
- simplify work permit handling.

(B) Outage Start and Finish Schedules

The outage start and finish are particularly critical moments of the outage. A good practice is to describe them in schedules as more detailed parts of the main schedule including specific testing subsequent to maintenance activities (see Annex 4.1).

(C) Special Work Schedules

For special major outage activities with a large part of the outage organization involved such as turbine replacing, building project, etc, it is useful to make special work schedules at the overall level.

Ensuring Safe Shutdown Conditions

Keeping safe shutdown conditions during outage is essential. The complexity of safety planning is dependent on the degree of redundancy in the safety related systems and the extent of the technical specifications for the plant.

Good practices are:

Barsebeck, Sweden makes an operating plan which describes the availability of safety system components such as pumps for reactor flooding and residual heat removal, diesel generators, and important electricity supply bus bars. It is a time schedule and it also
describes how the unavailability of electrical supply affects the pumps. The operating plan is a practical method for safety review both during planning and outage execution.

With the operating plan as a base Barsebeck makes schedules showing the planned operational status at all times during outage. Three types of schedules are made:

- reactor flooding schedules,
- reactor cooling schedules,
- electrical supply schedules.

The schedules and how they are used are described in Annex 3.8.

3.2.6 Review of Time Schedules

The preliminary schedules should be completed through a strict review process in the outage organization.

It is important that all schedules are accepted in the organization. They should:

- be realistic and achievable,
- not contain contingency time,
- be the best estimate.

The schedules should be submitted for review well in advance of the more detailed work planning.

The following aspects need special attention in reviewing the schedule:

- Guarantee of "safe shutdown" conditions during outage according to technical specifications.
- Assurance of personnel safety including radiation protection and industrial safety.
- Regulatory inspections and all licensing requirements to be factored in the outage schedule.
• Identification of the critical resources such as manpower, specialized tooling, spare parts, supporting facilities, equipment accessibility, etc.
• Availability of qualified contractors personnel, other off-site support and training requirements.

After review and necessary adjustments, every schedule should be approved and authorized, according to well established procedures, with dates and signatures. The same procedures should be also applied for any later revisions.

To avoid mistakes it is necessary to mark all schedules with revision number and date. It is a good idea to regularly give information about the numbers of latest issues.

3.2.7 Detailed Work Planning

According to the time schedule approved, detailed work plans are prepared. These should be detailed enough to direct and control individual task execution.

The detailed work planning is done in the functional groups and is the base for preparation of work orders. If the detailed planning does not comply with the overall schedules and the time frames set by the Planning Group, immediate feedback is necessary.

The following details of each task should be included in work planning:

• work description,
• work procedure and relevant documents,
• system or component to be isolated,
• number and qualification of required personnel,
• protection and measures for radiation, industrial safety and fire protection and working conditions (lighting, noise, vibration, etc.),
• supporting service (scaffolding, insulation, etc),
• specialized tooling and relevant spare parts,
• estimation of working hours and radiological dose,
• functional tests after maintenance.
• quality control activities.

All these work plans are integrated on the basis of system or component for overall review and analysis. Resource levelling should be performed on the basis of plant limitations such as outage budget and outage duration, to determine an optimum outage schedule.

Post maintenance test is an important part of this stage. Post maintenance tests would be performed as soon as components/systems are ready for testing.

In the process of review and analysis of work plans, a task analysis should be performed to ensure successful result of the work. This analysis is particularly necessary where the tasks are complex and have previously led to repeated failures. According to the task analysis, special job instruction and training may be required and should be prerequisite to work scheduling.

3.3 Outage Preparation

All necessary preparations to perform outage work should be identified, authorized and followed to completion prior to work start. These can be provided in a safer and more economical manner beforehand rather than in an ad hoc manner during outage.

To this effect, the personnel responsible for this should ensure that all necessary provisions are made for the procurement of the outage resources so that any delays and/or work interruptions can be avoided, inclusive of interactions with authorities.

Preparation activities should be focused on factors ensuring that outage tasks can be performed successfully within time allotted.
Reactor safety and personnel safety must always be taken into highest consideration in preparing for outage work.

### 3.3.1 Work Orders and Work Permits

One important result of the detailed work planning discussed in Section 3.2.7 is the generation of work orders.

The normal procedure is that work orders are written by engineers responsible for plant maintenance. The work orders are then sent to operations personnel or another functional group assigned for preparation of work permits.

Since there in most cases is a substantial number of work orders and work permits to handle before and during an outage, a computerized administration system is necessary. Examples are shown in Annex 3.5.

A good practice is to prepare radiation work permits and fire protection work permits in connection with the normal routine. This is practised at Barsebeck, Sweden in order to state the pre-requisite conditions for work causing increased radiation or fire hazards.

### 3.3.2 Hardware Preparation

The timely availability of special equipment on-site is one of the most important factors in ensuring successful performance of outage work. Early action must be taken for this hardware, particularly when requiring long lead-time for procurement. The on-site availability should be ensured and confirmed well before outage start.

**Spare Parts and Material**

Regarding the type and number of spare parts kept on-site, it is generally better to have too many spare parts than to have too few. However, a cost/benefit analysis on high investment for spare parts, compared with the economic merits of plant availability, may be required.
The following actions should be taken during preparation period:

- Condition of spare parts to be used should be checked. This includes material condition and quality assurance records for qualified parts and material.
- A process for acceptable substitution should be provided for parts which are no longer available from original supplier.
- Emergency procurement and expediting process should be made available to obtain parts or specialized service from vendor or supplier on occurrence of unforeseen problems.

A good practice is to use a computerized system to keep track of spare parts and material quality records.

Any unforeseen problems can be alleviated by the provisions of:

- "Emergency call agreements" with the original vendors/suppliers to provide specialized services, beyond the capability of the on-site, at short notice. These services may include engineering support, technical advice, special tooling and extra manpower.
- "Spare part pooling agreements" with sister units to permit prompt exchange of spare parts not available on site.

**Tools and Equipment**

A detailed list of tooling required for the outage must be assembled and checked.

- Some of the tools and equipment to be used on critical path work should be inspected and approved prior to the outage.
- Test and inspection equipment for non-destructive examination should be tested prior to the outage. Provisions for test result analysis such as chemical or other laboratory level evaluations should be made available on site or off site with rapid turnaround time.
- Extensive training and demonstration by mock-ups is necessary beforehand for complex equipment handling tools.
3.3.3 Supporting Facilities and Services

Careful preparation for on-site support should be made to provide the workers with good working conditions.

All support requirements identified at the detailed work planning should be prepared well ahead of outage start. Examples are:

- scaffolding,
- insulation,
- radiation protection,
- fire protection,
- housekeeping,
- transports,
- fencing in dangerous areas,
- opening of concrete barriers and hatches,
- painting, etc.

The equipment needed for these facilities should be checked, qualified and completed.

Good working conditions also mean a well prepared "infrastructure" for contractor personnel. Examples are:

- food and coffee/tea,
- housing,
- lockers and showers,
- telephones,
- offices,
- personal calling devices ("beepers")
- copying machines,
- computers,
- dose meters,
- free time activities,
- transports to and from the plant, etc.
Special attention should be given to access points to the controlled area. Provision of additional access points and additional monitors may be required to reduce time required for passing access controls.

Adequate provisions for safe movement of equipment and workers should be checked and made available. These include ladders, platforms, cranes, elevators and chain hoists, etc.

In confined areas where repeated outage work is performed, permanent lifts and platforms should be provided instead of scaffolding, reducing time and effort during subsequent outages.

Spare requirements should be checked. Additional storage areas can also be designated for equipment material storage for contractors.

Preparations should be made for quick handling of security checks, badging and passing in and out of plant area.

Availability of service areas is important. These concern workshops and laboratories close to the process, storage areas for disassembled equipment in controlled areas and special rooms for work permit handling and radiation control.

3.3.4 Contractors

Contractor related practices and criteria for systematic job supervision and monitoring, and recording of work performance must be well established and updated.

When contractor services are used for specialized maintenance work, practices which proved effective in obtaining good quality service include:

- Long-term contracts with the original equipment manufacturers/suppliers or specialized maintenance service organizations for inspection and maintenance work on specific equipment (e.g., steam generator tube inspection, tube plugging,
reactor vessel inspection, etc) would ensure satisfactory performance of maintenance work and benefit of long term plant specific experience.

- Provisions for incentive/penalties would prompt service supplier to perform high quality of work and encourage to develop improved work techniques and tooling.
- Staff continuity, competence and familiarity with the plant are important factors in producing consistently successful results. These factors apply for contractor personnel as well as inhouse staff.
- It is a good practice to involve contractors and suppliers at an early date in planning and preparations so as to understand the outage goals and to be encouraged to suggest improvements.

3.3.5 Dose Budget

Review of the detailed work planning with the purpose of estimating radiation doses is an important part of the outage preparations.

Doses should be calculated as a best estimate and put together in a dose budget for the whole outage. If calculated doses tend to exceed the outage goals, measures should be taken to reduce doses, for example, extra shielding or replanning of work in high radiation areas.

Utilization of automated equipment for maintenance work is highly recommended to reduce accumulated dose of individual maintenance staffs and also reduce required time for maintenance works. Frequent periodic inspection sometimes results high accumulated dose of experienced maintenance staffs and limits their participation to the required maintenance works.

Automated equipment for maintenance and inspection of the nuclear power plant components is widely used in the periodic inspection in Japanese nuclear power plants for this reason.

Examples of the automated equipment are shown in Annex 3.9.
A good practice, established at Leibstadt, Switzerland, is the implementation of compulsory dose calculations as a part of the computerized work order system. These methods ensure the radiation exposure is kept as low as reasonably achievable (ALARA).

3.3.6 Personnel Qualification and Training

Intensive personnel and equipment handling training is a key element to decrease working time in high radiation zones.

For each task to be performed, an assessment should be made of the type and depth of the training required. Some may require qualification of the process and the workers. All training requirements should be identified and met fully before outage start.

- Training of workers including contractors for the complex tasks and their skill must be accomplished well ahead of outage start. In addition to this, the demonstration for this type of work is preferably rehearsed immediately before work start.
- Use of full scale mockups of the components to be worked on is very beneficial in developing confidence that workers can do the task in the time allotted. This is particularly important where the work has to be done in confined areas with high radiation dose rate such as inside steam generators.

An example of a mock up facility is the CETIC used by EdF in France. Annex 3.10 gives a brief description of CETIC.

One kind of personnel qualification is the radiation protection information which is given to all contractors on arrival to Barsebek, Sweden. The half hour information deals with:

- what is radioactivity?
- how to read warning signs,
- how to use dose meters,
- how to use protection equipment; etc.
Another example from Barsebeck is the one day information to all new (at Barsebeck) contractor foremen on arrival to the plant. They are informed about all important procedures and routines used. The information is mandatory and is a requirement to be authorized to receive work permits and work as a foreman.

- All maintenance personnel, particularly contractors should be familiar with system operational characteristics so that they can readily recognize potential hazards to themselves and the equipment.

3.3.7 Procedures

Applicable procedures for all tasks to be done must be completed, updated and assembled. The procedures should include all the tools and parts necessary and also clear instructions on how post-maintenance tests and inspections should be done.

The procedure should include "hold points" for inspection at the important steps. One key element of procedure is the removal of temporary devices (plugs, jumpers, etc.) often used in maintenance and testing. Procedures should be readily available and clearly understood by the workers involved.

3.3.8 Modifications

It is normal that a substantial part of outage work is the implementation of modifications.

To keep up or improve plant safety, modifications must be processed according to routines which guarantee:

- skillful design,
- proper safety reviews and approvals,
- updated documentation and well informed operators at start up after the outage; etc.

This means that handling of modifications should be part of outage preparations and start as early as possible.
3.3.9 Information

An essential part of planning and preparation for outage is information.

It is important that the whole organization is well informed about the progress of the planning work and goals and expectations.

Regular distribution of meeting minutes and schedules is a good practice.

Information to give to contractors on arrival should be well prepared. A good practice at Barsebeck, Sweden, is the production of a four page leaflet containing, for example:

- main schedules,
- organization (with photos and phone numbers),
- info about food and housing,
- emergency procedures,
- important phone numbers,
- outage goals; etc,

Another example from Barsebeck is the Outage Handbook (Annex 3.11).

Good and timely information to everyone involved in outage activities is the basis for successful performance.
In the execution of a maintenance or refuelling outage, many of the processes initiated during outage preparation will carry on. Of critical importance at this stage are:

- A clearly defined and appropriate organization (with a focus on work accountability).
- An effective feedback and work control process.
- A rigorous programme of ensuring quality work performance.

This Chapter will review the above considerations in some detail and where possible, provide examples of successful strategies employed by various nuclear plant operators.

The outage period is characterized by three distinct phases. These are:

- Reactor shutdown/testing.
- Outage maintenance/refuelling.
- Reactor startup/testing.

Depending on the type of reactor, the shutdown phase may vary from a few hours to several days (eg, PWR/BWR). This time period is characterized by extensive safety and support systems testing along with the application of equipment isolations for subsequent maintenance. Most utilities review the work lists thoroughly to ensure that activities which may be carried out at full power are executed in order to minimize the burden of both Operator and maintenance forces during the shutdown.

The second period is where the bulk of maintenance is carried out. Extensive planning prior to this time will improve work flow and performance vs expectations.
Finally, the startup period is required to confirm the functionality of all safety systems which may have had extensive maintenance, prior to return to high power operation. Coordination between maintenance and operations is particularly critical at this stage and is greatly assisted by extensive pre-planning. Annex 4.1 provides an example of a standard startup procedure used by Barsebeck.

4.1 Organization

There are a wide variety of organizational structures used effectively in order to manage maintenance outages. In general, a larger or multi-unit station may gain by having a permanent organization to manage outage activities as routine work. A small, single-unit station may function well with a temporary organization for an outage execution management. All, however, have specific common elements, namely:

- Clearly established responsibilities and work group interfaces at all plant levels.
- A good understanding, shared by all staff (including peripheral and contract employees) of individual roles in the execution of the outage.
- A clear emphasis on maintaining a focus on the critical path schedule in the control of outage work.
- Well established process of work documentation, supporting accountability for work progress.

Examples of detailed structures used successfully are included in Annexes 4.2 A, B, C.

Outage execution is carried out on both "strategic and work conduct" levels. The strategic aspects of the outage, typically deal with:

- technical decisions on inspection results,
- additional work control,
- overall outage performance.

Most utilities provide an overview organization to set policy and provide guidance to the outage execution team. While the participants may be largely
the same in both groups, maintenance and plant managers normally form part of the strategic committee.

The work conduct level of outage management has a daily work focus and will ensure:

- compliance to the existing plan and revision as necessary,
- realignment of resources to maintain critical path,
- establishment of short-term goals (24 to 48 hours) for outage execution,
- detailed work preparation and execution.

Annex 4.3 gives an indication of these two outage conduct levels applied at PAKS nuclear plant, Hungary.

4.2 Outage Execution Control and Monitoring

The keys to an effective programme in this area is the provision of accurate and timely information to both work supervisor (foreman) and coordinators. In order to achieve this, a number of factors must be considered. The more critical are as follows:

• work group interfaces,
• information management systems,
• work planning tools.

The relationships between and within work groups dictate to a large extent, the ease with which quality information flows during maintenance/refuelling outage. Each group relies on others to prepare job sites, to isolate equipment, or to carry on complete ongoing tasks. Effective team work will only be achieved if responsibilities are clearly laid out and understood and considerable effect expended to communicate expectations to all involved. Mechanisms must also be put in place to ensure that team building and group performance is rewarded. Again, effective communications and group goal setting foster this environment. Much of the employee/supervisory attitudes will be dictated by the efforts made in pre-planning the outage, further underlining the significance of Chapter 3 in successful outage management. The following section will review the key interfaces typically required in any maintenance/refuelling outage.
The essential interfaces to be discussed are as follows:

- Worker/Foreman
- Foreman/Foreman
- Foreman/Work Coordinator
- Work Coordinator/Work Coordinator
- Foreman/Support Services
- Foreman/Operations

The most fundamental relationship is that between the foreman and his subordinate on a daily basis job expectations must be identified, work hazards highlighted and progress documented and assessed. As with other interfaces, it must be clearly documented and understood by all plant staff. The above is generally accomplished through a number of basic steps; namely:

- pre-job briefing,
- supervisory field visits/verification,
- work reporting.

An example of pre-job briefing expectations are provided in Annex 4.4.

The interface between foremen can be broken into two general areas:

- shift to shift,
- between different work groups.

In both cases, a turnover of equipment status and work progress takes place. Where a 24 hour operation is in progress, one shift will pass on work to another to continue or complete. Here, the status of work protection, any needed support work and work site accessibility must be accurately transmitted. This permits the incoming shift to quickly deploy its resources and minimize "dead time" between one shift and another. Many shift operations overlap their supervisory staff to further reduce non-productive staff time.

The turnover between work groups need not take place at the beginning or end of a day, but still requires timely and accurate information transfer. In both cases, all supervisors should understand both the quality and quantity of information transfer expected of them. Annex 4.5 describes the turnover process used at the PNGS, Canada.
The work group coordinators in a maintenance/refuelling outage provide a link between work execution and planning. Frequent and detailed discussions must take place with field supervision in order to permit the anticipation of potential conflicts and the revision of work plans and/or direction. A comprehensive work management system assists in both evaluating plant and work status as well as in making necessary changes. A daily meeting between work group coordinators and line staff is used to supplement work updates and review additional work.

In all nuclear facilities, the operations department plays a key role in facilitating maintenance activities. The operations department is responsible for monitoring system performance and establishing a safe work environment for maintenance forces. For its part, maintenance supervisors must keep the operations department aware of maintenance progress and of any actions which may impact on equipment or personnel. As with most areas, a wide variety of methods are employed successfully. The essential components are generally:

- Complete documentation of the expectations on both groups.
- A comprehensive equipment/work status information management system.

An example of maintenance facilitation and operation/maintenance interface used by the Embalse, Argentina, is provided in Annex 4.6.

Finally, a number of support services (as described in Section 3.3) are required to ensure the smooth execution of any reactor outage, whether carried out as a prerequisite to the work activity or as an integral part of the work itself, coordination of the support service activity with those of field maintenance forces is critical. Effective and timely communication is ensured through dedicated contacts and work status updating on a frequent basis. Annex 4.7 provides an example of a Service Centre approach used at the Barsebeck Plant.

Another area of major importance to successful outage execution is that of work control. Documentation must exist to cover such areas as:

- work requests
- work orders
- work permits.
These tools provide for good definition for the interfaces described earlier, as well, as enabling the controlling authority to ensure an appropriate and safe sequencing of maintenance execution. The general work order procedure used in outages by the PAKS Nuclear Power Plant is shown in Annex 4.8. Most Operators have detailed procedures starting with equipment deficiency identification right on to work documentation for equipment history records. Here again, an integrated work management system provides considerable assistance in achieving the above. Suitable examples have been shown in Chapter 3.

The review of outage progress on a daily basis is required to ensure that a focus on the critical path is maintained. This will ensure that:

- Additional work identified is discussed thoroughly in terms of potential impact on outage duration.

- Work status can be verified to avoid potential delays.

- Required technical input is timely and properly scrutinized.

An example of additional measures for individual job dose control is provided in Annex 4.11, showing the radioprotective ticket in use at Leibstadt, Switzerland.

The above is normally accomplished by daily planning meetings and the issuance of a revised 24/48 hour plan. Other mechanisms can also be used to monitor outage progress. Annex 4.9 shows a weekly review of work orders initiated as a function of time, while Annex 4.10 provides an indicator of radiological exposure during the outage. All of these help both plant supervisors and managers focus on key performance objectives.

4.3 Quality Programme

While this is an area of tremendous scope, its inclusion in outage execution recognizes that attention to quality is more important than ever during this period of high activity. Key areas which must be addressed in any programme are as follows:
• adequately trained staff,
• use of specialist maintenance crews,
• housekeeping standards,
• strong technical presence,
• procedural compliance,
• QC inspections/supervisory verification, and testing,
• high level of management involvement.
• review to ensure removal of all temporary devices used during outage.

The safe and timely execution of outage work relies on both resident and contract staff being adequately trained to perform their assigned duties. The use of pre-job training involving classrooms, mock-ups and simulations, all have a role to play in ensuring quality execution.

In the execution of intricate work activities, it may be appropriate to provide rehearsals for every step to be completed. Chapter 3 dealt at some length with needed employee orientation. Annex 4.12 provides an example of requirements set out by EDF to ensure quality with its contract staff. Annex 4.13 describes the management of quality used at KEPCO in Japan.

The use of specialist maintenance crews is of particular importance for multi-unit stations and those operators maintaining a round the clock shift organization. Certain tasks such as welding, electronics repairs, computer maintenance and vibration monitoring applications are well suited to specialist crews. While their existence may vary significantly from one Operator to the next, issues dictating their use are generally:

• consequence of rework,
• need for 24 hour execution (ie, critical path),
• level of expertise required,
• frequency of execution,
• complexity of the tasks.

The high level of activity which exists during the outage places considerable stress on housekeeping at the plant. Temporary work stations are often set up and waste generation is above normal levels. Concentration of both in house resources and contractor staff further aggravates this issue.
In order to maintain a hazard free environment which encourages quality workmanship, rigorous control must be exercised. Specific measures helpful during this period include:

- A formal control process over temporary work stations.
- Frequent supervisory field housekeeping visits.
- Clear accountability for both work area cleanup and routine pickup of waste from the site (as well as routine contamination checks).
- The use of special clean areas for work where conditions must be closely monitored (e.g., turbine generator work areas, see Annex 4.15).

Annex 4.14 summarizes good housekeeping practices.

During the course of any maintenance/refuelling outage, a number of technical decisions are required, based on both inspection results and problems with work execution. Technical support must be available to ensure that valuable time is not wasted awaiting analysis or review. Rework can also be avoided by ensuring a close link between the maintenance forces and technical resources. Specific jobs, which involve the interpretation of inspection data to direct further maintenance work may dictate the provision of dedicated technical staff.

Chapter 3 dealt with the preparation of extensive plans and procedures detailing all key aspects of maintenance work. Compliance to these procedures, therefore, plays a major role in ensuring both quality of work and safety of employees. Line managers must instill in their subordinates a culture of procedural compliance and insist on accountability for results. Considerable thought has been placed into the production of detailed procedures and at the peak of maintenance activity is no time to deviate from calculated work direction. Deviations must carry an appropriate review level equal to or beyond that needed to produce the work procedure.

The execution of some maintenance activities requires extensive testing by quality control staff. The maintenance personnel may themselves, require special licenses (e.g., welders) and these should be centrally coordinated to ensure valid and up to date tickets. Beyond this, calibrated and tested tools are required for maintenance on safety and safety related systems.
Once maintenance has been carried out, radiography on other QC verification may be required. In terms of general work verification, two philosophies are prevalent in world Operators. These are:

- line supervisory staff verification,
- QC staff verification.

In either case, roles and responsibilities must be clearly laid out to ensure compliance. Where QC staff are relied upon, these must be made readily available to ensure a minimum of work flow disruption. Line verification clearly has an advantage in this respect. As part of work verification, detailed testing procedures are often required to ensure that any system which may have been affected by maintenance is proven fully operational.

Finally, all of the above are driven by the management organization. The success of efforts to ensure quality will be dictated by the support provided in clarifying individual accountability and field presence in ensuring line compliance. No one area will have a more significant role to play in effective outage execution.
Chapter 5
POST-OUTAGE REVIEW

The post-outage review is the final element of ensuring an effective outage management programme. In order to improve future outage performance, its main objectives are generally to:

- assess outage performance vs. expectations,
- identify problem areas,
- revise inspection and future maintenance programme based on as found conditions,
- amplify successful strategies.

In terms of performance evaluation, different measures of outage performance may be usefully evaluated with relevant goals and objectives being assigned. These measures are typically:

- duration,
- costs,
- personnel exposure and injuries,
- waste,
- short term quality effects (no immediate or subsequent delay due to improve work execution),
- long term quality effects (improvement of equipment reliability based on as-found conditions),
- safety plant status.

This Chapter will review those factors impacting directly on the above performance elements. In addition, it will examine common aspects of successful processes used for collecting information, identifying improvements, implementing them and evaluating their effectiveness. The establishment of such a programme will lead to reinforcing a continuous improvement in the work ethic of the station staff.
5.1 **Performance Assessment**

While not providing a complete assessment of the conduct of the outage, specific performance measures provide the basis for which further evaluations may be conducted. As well, while absolute values may not be directly comparable from one Operator to the next (eg, reactor design and regulatory environment), trends may offer insight into developing problems or into how the scope of effective changes made can be broadened to other areas.

The following are the most commonly used outage performance measures.

**Personnel Radiological Exposure and Conventional Safety**

- Individual and collective exposure of personnel broken down into:
  - job
  - work group
  - crew.
- Reported injuries or lost time injuries.
- Overall comparison to past performance or that of industry in general (ALARA). (See Annex 5.1 for dose reduction.)

**Outage Duration**

- Actual vs. assessed task duration including operations tasks.
- Critical path review.

**Cost**

- Manpower requirements (in house and contractor)
- Overtime worked.
- Material charges.
- Support services costs (administration, housing, meals).

**Waste Generation**

- Quantity of liquid and solid wastes.
- Active/Inactive waste breakdown.
Quality Effects

- Reactor trips, outage extensions, forced outages or power reductions from power operations attributable to outage activities.
- Deviations by contractors and utility workers from QA requirements.
- Safety related events, especially abnormal plant safety status.
- Maintenance rework incidents (regardless of impact on outage duration).

Beyond the above primary indicators, specific areas should be formally added to the post outage review as they may signify root cause issues for problem indicators.

Methods and Means

- Desirability of automated or special tooling development programmes to speed work and/or reduce personnel exposure.
- Adequacy of procedures and work techniques including technical documentation and time-to-repair estimates.
- Need for more training on, or acquisition of, new mock-ups and rehearsal facilities.
- Need for special plant modifications to improve equipment maintainability such as permanent access platforms, additional shielding, installation of inspection ports.
- Adequacy of scheduling including tests or inspections for detection of anticipated problems.

An example of the reduction of number of work orders during outage due to pre-planning efficiency is shown in Annex 5.2.

Resources

- Need to readjust on-site and/or off-site spare parts inventory.
- Adequacy of manpower and manpower skills.
- Adequacy of available industrial resources versus utility needs.
Organization

- Coordination and communication between different work teams and between these teams and operations where their roles are established by documentation.
- Outage scope modifications.
- Assessment of ideas applied to the outage from the critique of previous outages.

Equipment Condition

- Need to change preventive or predictive maintenance policies based on review of as found conditions.

5.2 Process

Responsibility

As with all aspects of outage management, responsibilities must be clearly assigned for all aspects of the post outage review. These include:

- establishing a programme for identification and application of outage lessons learned, including methods for gathering and reporting relevant information,
- collecting information,
- conducting the review,
- implementing corrective actions,
- writing reports.

Where separable the last four areas may be more effectively grouped into the following categories:

- organization and coordination related data (planning or coordination group for example),
- work execution related data,
- equipment conditions related data.
Programme

A well documented programme should be established describing methods for implementing, scheduling and assigning responsibilities for each of the areas mentioned below. Completion of this programme can even become one of the outage objectives itself.

Outage objectives

Evaluation of outage performance requires that planned goals and objectives be compared to those actually achieved (a sample of outage objectives from CP&L is included in Annex 5.3). Additionally, trends and effectiveness of previous corrective actions should be assessed by comparing them to prior outage performances.

Information gathering

Most of the required information is potentially available for review but it may be necessary to:

- establish requirements concerning the nature of information to be found in existing reporting,
- structure input sheets and use computerized checking to make data more usable,
- create additional forms (Annex 5.4 is a sample form; it is filled in if a job procedure deficiency related to documentation, parts, tools or procedure steps is found).

Critical path analysis requires an ongoing recording of information so that the correct reason for each delay is known. For this purpose, a logbook should be kept and entries made by the outage coordinator when a delay of over eight hours is incurred or other significant events occur.

Information review

Critique meetings should be held by each group as close as possible to the end of their outage activities. The meetings should:
• systematically address the main elements of the key performance indicators to cover all areas of potential improvement,
• solicit ideas for improvements from all of the staff,
• point out successful implementation of work activities and good ideas, but on the other hand, first try to make self criticism,
• distinguish between recommended improvements which are internal to the group and those which are external and require the action of higher authority to implement,
• develop a prioritized listing of recommended actions and initiatives. The listing should be included in the group's report,
• investigate and determine the root cause of all significant problems and delays, even those that had been solved as best as possible within planned outage constraints.

Nevertheless all this will not guarantee to get the "whole picture" about difficulties and good practices and to ensure that objectives have been understood. Feedback is filtered, stakes are different for contractors and utility staff. So independent review or cross interviews may be worthwhile. For example, every second or third year a sample of the contractors at Barsebeck are interviewed during the outage. About 20 - 30 contractors, both foremen and workers, are selected by the outage coordination group and given a list of questions concerning the working conditions at the plant.

Corrective action

A corrective action plan identifying actions to be taken, the responsible individuals or organizations for the action and a target completion date, should be promulgated and its progress monitored. For example, Barsebeck uses "experience list" handled by the outage coordination group and regularly updated and Pickering an "action list".

Promotion of good practices

Recognition of groups or individuals for significant contribution to the success of the outage should be given.
Group rewards such as T-shirts and hats are often given to all station staff for achievement of overall outage targets. This encourages group goal setting, represents an inconsequential cost, and significantly reduces the change of discouraging specific excluded groups by ensuring that all staff are recognized.

Reports

Finally, successful practices should be described and fully documented to ensure that they can be repeated and examined by other Operators for potential implementation.

One or several outage reports should be written to document the work accomplished and significant lessons learned ensuring that pertinent outage experience is distributed to appropriate personnel and departments. The following should be included:

* an overall report addressing the comparison of planned versus achieved outage goals, critical path analysis and outage organization,
* a technical report addressing the major items work list, modifications and outage scope additions, major anomalies detected on equipments and those to be first investigated,
* an execution report addressing means, methods and resources.

Each report should include particularly successful ideas used, action items to be resolved and an assessment of ideas applied to the outage from the critique of previous outages. (See Annex 5.5)

Whenever possible the reports should be analyzed by the utility and relevant portions distributed to sister plants. For example EDF issues a yearly summary of all outage reports and national level actions to be taken. Also included is a summary of good practices for the outage co-ordinator's review.

Finally, a specific report is often issued to the Safety Authorities and any related feedback integrated into the process. This provides a vital communications link between regulators and utility.
Annexes

EXAMPLES OF GOOD PRACTICES

The Annexes contain examples of various practices and procedures currently used by numerous operating organizations.

The page numbers under the titles refer to the pages in the main text.
EXTERNAL Experience
e.g. Databank

DEVIATION
IS ≠ SHOULD
(Problem)

OWN Experience

INTERNAL LOOP

First time

Solution for Problem

IS = SHOULD

EXTERNAL LOOP

a: Time to write Protocol

b: Time to work out LEARNEFFECT

OUTPUT to EXTERNAL
e.g. Databank
## Annex 2.1

### ONTARIO HYDRO LONG TERM OUTAGE STRATEGY

1995 outage plans for all reactors (NGS)

<table>
<thead>
<tr>
<th>STATION</th>
<th>UNIT</th>
<th>START DATE</th>
<th>END DATE</th>
<th>DURATION (DAYS)</th>
<th>MAJOR ACTIVITIES</th>
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<tr>
<td>PNGS-A</td>
<td>2</td>
<td>18 AUG</td>
<td>27 OCT</td>
<td>70</td>
<td>Maintenance, Generator Core C/O</td>
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<tr>
<td></td>
<td>3</td>
<td>02 JUN</td>
<td>02 JUL</td>
<td>30</td>
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<tr>
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<td>5</td>
<td>03 NOV</td>
<td>03 DEC</td>
<td>30</td>
<td>Maintenance</td>
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<td></td>
<td>7</td>
<td>24 MAR</td>
<td>23 MAY</td>
<td>60</td>
<td>Maintenance, Main Cond. retube</td>
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<tr>
<td>BNGS-A</td>
<td>1</td>
<td>01 JAN</td>
<td>17 DEC</td>
<td>351*</td>
<td>Continuation of LSFCR outage</td>
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<tr>
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<td>3</td>
<td>05 MAY</td>
<td>06 AUG</td>
<td>93</td>
<td>Maintenance</td>
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<tr>
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<td>4</td>
<td>15 SEP</td>
<td>17 DEC</td>
<td>93</td>
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<td>6</td>
<td>10 MAR</td>
<td>02 MAY</td>
<td>53</td>
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<tr>
<td>DNGS</td>
<td>1</td>
<td>19 MAY</td>
<td>29 MAY</td>
<td>10</td>
<td>Containment Test</td>
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<td></td>
<td>2</td>
<td>01 MAY</td>
<td>29 MAY</td>
<td>28</td>
<td>Containment Test, Maintenance, Inspections (PT, Generator, PHT System, Boilers)</td>
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<td>Containment Test, Inspections</td>
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<td>Containment Test</td>
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<td>BHWF</td>
<td>E3</td>
<td>30 APR</td>
<td>30 SEP</td>
<td>153</td>
<td>Economic Outage</td>
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<tr>
<td></td>
<td>E4</td>
<td>15 APR</td>
<td>15 SEP</td>
<td>153</td>
<td>Maintenance, Economic Outage</td>
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* - INDICATES CONTINUATION OF OUTAGE FROM PREVIOUS CALENDAR YEAR

** - INDICATES CONTINUATION OF OUTAGE INTO THE NEXT CALENDAR YEAR
### SIX YEAR PLAN (the first two years)

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<tr>
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<tr>
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<td>- OVERHAUL LP TURBINES 1, 2</td>
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<td>- INSULATION OF EXTRACTION LINES IN CONDENSOR</td>
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<td>- OVERHAUL DIESEL GENERATOR</td>
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<td>- TESTING OF CRD-NOZZLES</td>
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<td>- PAINTING IN REACTOR AND TURBINE BUILDINGS</td>
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<td>- PIPE INSULATION IN CONTAINMENT</td>
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<td>- MODIFICATION OF CABLE LINES IN WETWELL</td>
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<td>- INSTALLATION OF MOISTURE MEASUREMENT IN WETWELL</td>
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<td>- SEISMIC PROTECTION OF ACCUMULATOR BATTERIES</td>
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<td>BARSEBECK 2</td>
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<td>- REPLACEMENT OF SIGNAL Transformers</td>
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<td>MAINTENANCE JULY 2 – JULY 31</td>
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<td>- INSPECTION OF TURBINE BEARINGS</td>
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<td>- LARGE CONTAINMENT LEAKAGE TEST</td>
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</table>
The Swedish nuclear power operators:
- Vattenfall
- Sydkraft AB
- OKG AB

have decided to cooperate in their planning of nuclear power outages in an organization called KAS.

In order to ensure resources for outage work, the companies act together towards the major vendors in Sweden. Long-term agreements are made by all the companies together.

Long-term scheduling of outages is made by KAS according to:
- resources available
- power demand

Three years ago TVO in Finland joined KAS. The outages are scheduled for five years ahead. The above is the schedule for 1990.
ELECTRICAL ENERGY PRODUCTION IN SWEDEN

OUTAGES - SUMMER 1988
In the Barsebeck NPP different production cycles have been tested in order to shorten the outage periods. Earlier there were both 12 and 18 months production cycles. Due to positive experiences regarding production and maintenance, our operation philosophy has been changed once again. 12/24 months operation philosophy means:

- 12 months: refuelling and minor outage works are performed every year.
- 24 months: replacement of fuel elements and major outage and modification works are performed every second year.

The 12/24 months operation philosophy mean that we have a long outage period of four weeks for one unit, when fuel elements are replaced, outage and modification works are performed. For the other unit there is an outage period of two weeks, when fuel elements are replaced, minor maintenance and modification works are performed.

We started this year new operation philosophy in 1986. Over the years we have learned to execute more work at the same time, and also realized that more space is needed for canteen, dressing rooms, and desks for the managing people, etc.
Barsebeck Nuclear Power Plant Planning Strategy

- Refuelling activities = length of outage
- Corrective maintenance
- Preventative maintenance with priority
- Inservice inspections – one year interval
- Plant modifications with priority for safety
- Minimizing the number of contractors
- Large scaffolding and other large service activities should be avoided
- All testing and other operational activities should be performed as they are during a normal outage
Annex 2.6

EDF RATIONALE FOR ALTERING FUEL MANAGEMENT STRATEGY
(page 7)

How to reduce fuel costs?

By increasing fuel element burn up

How to use such an increase?

By increasing core partition
1/3 → 1/4 → 1/5

By extending cycle duration
with identical core partition (1/3)

Overall cycle duration can be
adjusted to 12 months to prevent
outages from drifting from
summer to winter

Outage frequency ↓
yearly outage cost ↓
availability ↑

Fuel Cost Saving = 12% When
Enrichment 3.25% → 3.7%
Cycle Duration 290 → 275 FPED

Fuel cost saving = 4.5% when
Enrichment 3.25% → 3.7%
Cycle Duration 290 → 340 FPED

Note:
OVERALL CYCLE DURATION = fuel cycle duration + stretch out + power modulation
availability factor

FPED = Full Power Equivalent Day
## UNIT 5 POISON OUTAGE WORK PROGRAM

**Next planned outage is May 1991**

<table>
<thead>
<tr>
<th>INDEX</th>
<th>PAGE</th>
<th>TARGETS</th>
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</thead>
<tbody>
<tr>
<td>POISON OUTAGE</td>
<td>2</td>
<td>SYNCHRONIZE 36 HRS AFTER POISON OUT</td>
</tr>
<tr>
<td>POISON OUTAGE LOGIC</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>WORK PERMIT STATUS</td>
<td>4-5</td>
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<td>ROUTINES</td>
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| HIGHLY DESIRABLE NUCLEAR MTCE | 6    |                                            |
| HIGHLY DESIRABLE CONVENTIONAL MTCE | 6    |                                            |
| START-UP & SYNCHRONIZE      | 7    |                                            |

### RESOURCE CODE-NAME

<table>
<thead>
<tr>
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<tr>
<td>C1</td>
<td>CONTROL MAINTENANCE</td>
</tr>
<tr>
<td>CM</td>
<td>CONTROL MAINTENANCE F CREW</td>
</tr>
<tr>
<td>CPS</td>
<td>CENTRAL PRODUCTION SERVICES</td>
</tr>
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<td>CT</td>
<td>CHEMICAL TECHNICIAN</td>
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<td>CONSTRUCTION</td>
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<tr>
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<td>EXTERNAL HYDRO</td>
</tr>
<tr>
<td>M1</td>
<td>OPERATORS</td>
</tr>
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<td>M2</td>
<td>MECHANICAL MAINTENANCE</td>
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<td>MPR</td>
<td>PROTECTION AND CONTROL</td>
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<td>QC</td>
<td>QUALITY CONTROL</td>
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<td>RC</td>
<td>RADIATION CONTROL</td>
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<td>SM1</td>
<td>SERVICE MAINTENANCE, BUILDING MECHANIC</td>
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<tr>
<td>SM2</td>
<td>SERVICE MAINTENANCE, INSULATORS</td>
</tr>
<tr>
<td>ST</td>
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### MANPOWER ALLOCATION

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<th>MANPOWER REG'D FOR POISON &amp; MTCE OUTAGE</th>
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<td>4</td>
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</tr>
<tr>
<td>C1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>K1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SM1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
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**Note:** OPS, WM & CM please review poison outage work program, submit PCl's prepare, check & review work permits for work identified.
### Pickering NGS

**Project:** Unit 5 S/D Work <32hrs.

**Issue Date:** 18Dec90

#### Operator Routines

<table>
<thead>
<tr>
<th>M</th>
<th>U</th>
<th>R</th>
<th>HOURS SINCE POISON OUT</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>SS 1  C</td>
<td>10000001 10000002</td>
<td>P=PASS</td>
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<td>THE WORK IDENTIFIED BY MAJOR I</td>
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<td>EE THE DEFICIENCY WHICH</td>
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<td>BROUGHT THE UNIT DOWN.</td>
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<tr>
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<td>0910</td>
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<td>&quot;ISSUE DR'S AS REQ'D FOR REPAIRS&quot;</td>
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**Legend:**

- X = SCHEDULED DURN
- C = CRITICAL DURN
- E = EARLIEST START
- = FLOAT
- = SCHEDULED DELAY
- L = LATE FINISH
Inspection Intervals and Tolerances

The inspection schedule states the intervals at which the individual inservice inspections are to be carried out. These intervals are given as multiples of the following units:

- Week \( w \)
- Month \( m \)
- Year \( a \)
- Refueling \( B \)

These intervals can also be dependent on a specific event (EA).

The schedule also shows the intervals for inspections in which the Authorized Inspector participates.

The allowable tolerances for inspection intervals are as follows:

- 1\( w \) : each week \( \pm 3 \) days
- 2\( w \) : every 2 weeks \( \pm 5 \) days
- 1\( m \) : each month \( \pm 8 \) days
- 2\( m \) : every 2 months \( \pm 12 \) days
- 3\( m \) : every 3 months \( \pm 16 \) days
- 4\( m \) : every 4 months \( \pm 22 \) days
- 6\( m \) : every 6 months \( \pm 1 \) month
- 1\( a \) : each year \( \pm 2 \) months
- 2\( a \) : every 2 years \( \pm 4 \) months
- 3\( a \) : every 3 years \( \pm 5 \) months
- 4\( a \) : every 4 years \( \pm 6 \) months
- 5\( a \) : every 5 years \( \pm 7 \) months
- 8\( a \) : every 8 years \( \pm 11 \) months
- 10\( a \) : every 10 years \( \pm 12 \) months

The performance of scheduled inspections at intervals exceeding the above tolerances requires the approval of the Authorized Inspection Agency.
The performances of scheduled inspections within the tolerances stated above does not change the due date for performance of the next inservice inspection.

In the event of plant outages exceeding 6 months, an extension of the inspection intervals can be applied for from the licensing authorities.

Unless an earlier date is specified by the pertinent nuclear codes and standards or legal regulations, inservice inspections shall commence upon initial criticality; i.e. the first due date shall be, at the latest, the date upon which the first inspection interval expires.

12-/18-Month Fuel Cycle

In the case of inspections that are to be performed every 2 years or at longer intervals (2a) and only when the plant is in the shutdown condition (e.g. NDE as per KTA 3201.4), the date of the last refueling preceding the next due inspection date shall be taken as the date for the inspection. The time period between any two successive inspections shall not exceed the specified interval plus the allowable tolerance, whereby in the long term the specified inspection frequency must be complied with.

Condition of Plant for Inspections

The plant conditions under which the inspections are performed are given in the inspection schedule as follows:

- BT Operation (power operation up to 100%)
- BT75 Part-load operation (e.g. power operation up to a max. of 75%)
- AN Start-up
- AB Shutdown
- AS Hot standby (subcritical, reactor coolant temp. and pressure between values for power operation and shutdown cooling mode)
- AF Cold shutdown (subcritical, shutdown cooling mode)
- BW Before/during/after refueling (integrated into refueling operations)
- X Any operating condition

Additional information (e.g. specified requirements and restrictions, etc.) is entered as remarks.
## Nuclear Steam Supply System J

<table>
<thead>
<tr>
<th>Inspection No.</th>
<th>Interval Op./AIA</th>
<th>Plant Cond.</th>
<th>Subject of Inspection, Designation, Type and Scope of Inspection, (Remarks)</th>
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<td>JAA 50.0</td>
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<td>X</td>
<td><strong>Sling Attachment Points on Shielding Cover JAA 01 JS 001:</strong> Visual inspection (prior to use, not more often than 1a/1a) Nondestructive examination (prior to use, not more often than 3a/3a)</td>
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<td>JAA 50.7</td>
<td>EA/EA</td>
<td>X</td>
<td>(JAB 30.1) 1B/1B AF By measuring range switchover, functional test using JEF 30.1 By manual reactor trip, functional test using JEF 31.1</td>
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<td>1B/1B</td>
<td>AF</td>
<td>(JAB 31.1) 1B/1B AN Reactor Pressure Vessel Internals JAC: Visual inspection Holddown springs in upper guide structure: check of spring rates</td>
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<td>4a/4a</td>
<td>BW</td>
<td>JAC 40.2 4a/4a BW</td>
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<td>BW</td>
<td>Reactor Pressure Vessel Internals JAC: Visual inspection Holddown springs in upper guide structure: check of spring rates</td>
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<tr>
<td>JDA 10.0</td>
<td>1B/1B</td>
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<td>(JDA 20.1)</td>
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<td>BT</td>
<td>Assembly drop time measurement (100 %, prior to and after removal of RPV closure head) Recordllg of travel time osclliogram</td>
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<td>JDA 22.1</td>
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## A. PWR Plant, Japan

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<td>Overhaul Inspection of High Pressure Core Spray System Main Valves</td>
</tr>
<tr>
<td>16</td>
<td>AUTOMATIC DEPRESSURIZATION SYSTEM - Functional Test</td>
</tr>
<tr>
<td>17</td>
<td>FEED WATER PUMP - Functional Test</td>
</tr>
<tr>
<td>18</td>
<td>CONTROL ROD DRIVING SYSTEM</td>
</tr>
<tr>
<td>18-1</td>
<td>Hydraulic System</td>
</tr>
<tr>
<td>18-2</td>
<td>Overhaul Inspection of CRD Mechanism</td>
</tr>
<tr>
<td>18-3</td>
<td>Overhaul Inspection of Scram Valves</td>
</tr>
<tr>
<td>19</td>
<td>REACTOR STANDBY LIQUID CONTROL SYSTEM - Functional Test</td>
</tr>
<tr>
<td>No</td>
<td>Inspection Item</td>
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<tr>
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<tr>
<td>20</td>
<td>INSTRUMENTATION AIR SYSTEM - Functional Test</td>
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<td>REACTOR PROTECTION SYSTEM</td>
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<td>21-1</td>
<td>Calibration of Protection Detection Elements</td>
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<tr>
<td>21-2</td>
<td>Confirmation of Set-point of Protection Detection Elements</td>
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<td>22</td>
<td>INTEGRATED INTERLOCK FOR COMBINATION OF REACTOR, TURBINE AND GENERATOR - Functional Test</td>
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<tr>
<td>23</td>
<td>FUEL HANDLING EQUIPMENT - Functional Test</td>
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<td>24</td>
<td>RADIATION CONTROL AND MONITORING SYSTEM</td>
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<td>Field Monitoring System Functional Test</td>
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<td>24-2</td>
<td>Area Process Monitoring System Functional Test</td>
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<td>STAND-BY GAS TREATMENT SYSTEM</td>
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<td>Filter Performance Test</td>
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<td>26</td>
<td>EMERGENCY HVAC SYSTEM FOR MAIN CONTROL ROOM</td>
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<td>Functional Test</td>
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<tr>
<td>26-2</td>
<td>Emergency HVAC Filter Performance Test</td>
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<td>27</td>
<td>RADIOACTIVE GASEOUS WASTE TREATMENT SYSTEM - Functional Test</td>
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<td>RADIOACTIVE LIQUID WASTE TREATMENT SYSTEM</td>
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<td>28-1</td>
<td>Functional Test</td>
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<tr>
<td>28-2</td>
<td>Liquid Waste Storage &amp; Treatment Facility - Interlock Functional Test</td>
</tr>
<tr>
<td>29</td>
<td>RADIOACTIVE SOLID WASTE TREATMENT SYSTEM</td>
</tr>
<tr>
<td>29-1</td>
<td>Incinerator - Functional Test</td>
</tr>
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<td>29-21</td>
<td>Storage Facility - Management Audit</td>
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<td>30</td>
<td>DETECTION AND ANNOUNCINATION SYSTEM FOR LEAKAGE OF LIQUID RADIOACTIVE WASTE - FUNCTIONAL TEST</td>
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<tr>
<td>No</td>
<td>Inspection Item</td>
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<td>----</td>
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<tr>
<td>31</td>
<td>PRIMARY CONTAINMENT VESSEL - Leak Rate Test</td>
</tr>
<tr>
<td>32</td>
<td>PCV ISOLATION VALVE</td>
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<td></td>
<td>32-1 Functional Test</td>
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<td>32-2 Overhaul Inspection</td>
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<td>33</td>
<td>PCV VACUUM BREAKER - Functional Test</td>
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<td>PCV SPRAY COOLING SYSTEM</td>
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<td>34-2 Overhaul Inspection of Pumps</td>
</tr>
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<td></td>
<td>34-3 Overhaul Inspection of Main Valves</td>
</tr>
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<td>35</td>
<td>FLAMMABILITY CONTROL SYSTEM</td>
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<td>35-2 Overhaul Inspection of Main Valves</td>
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<tr>
<td>36</td>
<td>REACTOR BUILDING - Air Tightness Performance Test</td>
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<tr>
<td>37</td>
<td>EMERGENCY DIESEL GENERATOR</td>
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<td>37-1 Functional Test</td>
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<tr>
<td></td>
<td>37-2 Overhaul Inspection of Diesel Generator</td>
</tr>
<tr>
<td></td>
<td>37-3 Overhaul Inspection of High Pressure Core Spray</td>
</tr>
<tr>
<td></td>
<td>System D/G</td>
</tr>
<tr>
<td>38</td>
<td>OVERALL PLANT PERFORMANCE TEST</td>
</tr>
</tbody>
</table>

Note on Periodic Inspection Items:

1. Annual inspection for Japanese nuclear power plants is performed voluntarily by the utility. Specific inspection items within the inspection are required either to witness the test or to review the record of the inspection/test by the regulatory body. Above lists show such items as to subject to the regulatory witness or review.

2. Sipping test could be omitted for the case of no leakage is confirmed by Iodine concentration in reactor water, exhausted gas monitor measurement during operation and no additional release of Iodine after shutdown, etc. where applicable.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>DETAIL</th>
<th>FREQ. (DAY)</th>
<th>DUR. (MIN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containment leak test rate.</td>
<td></td>
<td>1820</td>
<td>4320</td>
</tr>
<tr>
<td>Moderator temperature control test.</td>
<td>(MTC program and temperature control valve test)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Moderator pumps start logic test</td>
<td></td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>D20 moderator supply and extraction line test.</td>
<td>(Line pressure test)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Pressurizer relief valves test.</td>
<td>(verify opening for Air loss, energy loss or high pressure)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Desgaser condenser relief valves test.</td>
<td>(to verify opening loss of energy and hp)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Pressurizer heater trip test</td>
<td>(for low level)</td>
<td>0364</td>
<td>0120</td>
</tr>
<tr>
<td>Desgaser condenser heater trip test</td>
<td>(for low level)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Desgaser condenser pressure control valve test.</td>
<td>(opening for hp)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Desgaser condenser valve test</td>
<td>(close for hp, low level (normal, low pressure (sólido))</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Heat exchanger of desgaser temperature protection test.</td>
<td>(valves close for high temp. in outlet of exchanger)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Vent condenser pressure protection test.</td>
<td>(insulation valves for hp and lp in vent condenser)</td>
<td>0364</td>
<td>0060</td>
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<tr>
<td>Vent condenser temperature protection test.</td>
<td>(insulation valves close for hp)</td>
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<td>0060</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>DETAIL</td>
<td>FREQ. (DAY)</td>
<td>DUR. (MIN)</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>-------------</td>
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</tr>
<tr>
<td>AREA : NSP</td>
<td></td>
<td></td>
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<tr>
<td>Feed pump aspiration pressure test.</td>
<td>(with lp aspiration: 1) Feed valves in pressure control, 2) pumps trip)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>Purification temperature control and protection</td>
<td>(to verify close valve HCV5)</td>
<td>0364</td>
<td>0090</td>
</tr>
<tr>
<td>S.D.C. pumps operation, 3341 MV17/MV18 Logic test.</td>
<td>(logic verify)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>D20 recovery system functional verification test.</td>
<td>(logic verify)</td>
<td>0064</td>
<td>0120</td>
</tr>
<tr>
<td>Sprayer system valves air supply test.</td>
<td>(air loss verify)</td>
<td>0728</td>
<td>2880</td>
</tr>
<tr>
<td>AREA : NSP</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Loss of capacity of sprayer valves without air supply test.</td>
<td></td>
<td>1820</td>
<td>4320</td>
</tr>
<tr>
<td>E.W.S. retention valve test.</td>
<td>(leakage test)</td>
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<td>0180</td>
</tr>
<tr>
<td>Main steam system security valve test</td>
<td>(opening pressure test)</td>
<td>0364</td>
<td>0060</td>
</tr>
<tr>
<td>M.S.S.V. valves functional verification test.</td>
<td>(opening pressure test)</td>
<td>0364</td>
<td>0240</td>
</tr>
<tr>
<td>Primary system relief valves test. (chanel D)</td>
<td>(opening pressure test)</td>
<td>0182</td>
<td>0030</td>
</tr>
<tr>
<td>Primary system relief valves test (chanel E)</td>
<td>(opening pressure test)</td>
<td>0182</td>
<td>0030</td>
</tr>
<tr>
<td>Primary system relief valves test (chanel F)</td>
<td>(opening pressure test)</td>
<td>0182</td>
<td>0030</td>
</tr>
<tr>
<td>Free drop of cut rod for trip test.</td>
<td></td>
<td>0364</td>
<td>0240</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>DETAIL</td>
<td>FREQ. (DAY)</td>
<td>DUR. (MIN)</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>Steam system security main valves test.</td>
<td>(opening pressure test)</td>
<td>0364</td>
<td>0240</td>
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<tr>
<td>Air compressor 34320-CP1 and pneumatic valve test.</td>
<td>(with loca signal:)</td>
<td>0364</td>
<td>0120</td>
</tr>
<tr>
<td>Retention valve test.</td>
<td>(functional test)</td>
<td>0364</td>
<td>0030</td>
</tr>
<tr>
<td>M.S.S.V. reserve air tanil test.</td>
<td>(availability test)</td>
<td>0364</td>
<td>1440</td>
</tr>
<tr>
<td>Vent and h.p. insulation valves with ap 600 psi test in compress air system</td>
<td>(functional test)</td>
<td>0364</td>
<td>0120</td>
</tr>
<tr>
<td>AREA : BOP</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Turbine trip for over speed test (test B)</td>
<td></td>
<td>0364</td>
<td>0015</td>
</tr>
<tr>
<td>Turbine trip for over speed test (test C)</td>
<td></td>
<td>0364</td>
<td>0030</td>
</tr>
<tr>
<td>Turbine trip for over speed test (test E)</td>
<td></td>
<td>0728</td>
<td>0015</td>
</tr>
<tr>
<td>T/C acceleration control amplifier tests (every startup)</td>
<td>(functional test)</td>
<td>----</td>
<td>0015</td>
</tr>
<tr>
<td>Fast transfer panel test</td>
<td>(functional test)</td>
<td>0364</td>
<td>0010</td>
</tr>
<tr>
<td>Loss of class IV test.</td>
<td>(functional test)</td>
<td>0364</td>
<td>0045</td>
</tr>
<tr>
<td>Loss of class IV in class III bar test.</td>
<td>(functional test)</td>
<td>0182</td>
<td>0060</td>
</tr>
<tr>
<td>Fired detectors test.</td>
<td>(functional test)</td>
<td>0728</td>
<td>0120</td>
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</table>
The manpower forecasting system used at Pickering NGS forecasts the maintenance personnel required to both maintain operating units and execute unit outages over the next ten year period. To do this, data is collected from a number of sources and entered into a Maintenance Labour Forecasting Program.

One source is the manpower allocation from which data is collected weekly from each crew through submission of a Manpower Allocation Sheet. This form records administration and maintenance hours for the week with the maintenance hours broken down into the following groups: whether the work was preventive or corrective in nature, whether the corrective maintenance was scheduled or unscheduled, whether it was done on an operating or shutdown unit and, if it was work on a shutdown unit, whether it was a planned outage or a forced (poison) outage. The weekly data is entered into a Manpower Allocation Tracking Program which calculates the annual work hours for each of the above categories.

From here Maintenance Labour Forecast Program forecasts the number of personnel required in each of the five regular maintenance positions (Mechanical Maintenance Journey person, Shift Control Technician, Building Mechanic, Service Maintainer, and Handyperson). This forecasting program requires the historical manpower allocation data mentioned above, the historical number of planned outages, the forecast operating hours, forecast forced and planned outages, maintenance backlog, and standard workhours (as well as allowable overtime) for each of the five regular positions. The following is a simple schematic of the manpower forecasting process:
Manpower Allocation Sheets

Manpower Allocation Tracking Program

Additional Data

Labour Forecasting Program

Forecast of Required Personnel (over next 10 years)
### ENERGY SUMMARY

#### TW*h

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td><strong>Primary Demand</strong></td>
<td>136.9</td>
<td>140.2</td>
<td>143.6</td>
<td>148.3</td>
<td>152.3</td>
<td>156.3</td>
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<td><strong>Secondary Sales</strong></td>
<td>6.8</td>
<td>7.7</td>
<td>8.8</td>
<td>9.2</td>
<td>9.4</td>
<td>9.5</td>
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<td><strong>Hydraulic Production</strong></td>
<td>35.2</td>
<td>35.4</td>
<td>35.5</td>
<td>35.7</td>
<td>35.6</td>
<td>35.6</td>
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<td><strong>Nuclear In-Service</strong></td>
<td>70.6</td>
<td>76.9</td>
<td>87.3</td>
<td>91.5</td>
<td>96.4</td>
<td>99.9</td>
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<td><strong>Commissioning</strong></td>
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<td>0.7</td>
<td>1.1</td>
<td>0.5</td>
<td>0.0</td>
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<td>Interconnections</td>
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<td>1.1</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
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<td>Non Utility Generation</td>
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<td>3.1</td>
<td>4.1</td>
<td>5.1</td>
<td>5.2</td>
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<td>Other Interchanges</td>
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<td>-0.2</td>
<td>-0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
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<td><strong>Total External Resources</strong></td>
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<td>4.0</td>
<td>5.4</td>
<td>6.4</td>
<td>6.5</td>
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<td><strong>Fossil Production</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Coal</td>
<td>34.9</td>
<td>32.5</td>
<td>24.4</td>
<td>24.4</td>
<td>23.2</td>
<td>23.6</td>
</tr>
<tr>
<td>Oil</td>
<td>0.5</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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<td><strong>Total Fossil Production</strong></td>
<td>35.4</td>
<td>32.9</td>
<td>24.5</td>
<td>24.5</td>
<td>23.3</td>
<td>23.7</td>
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<tr>
<td>Locked-In-Energy</td>
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<td>1.3</td>
<td>0.2</td>
<td>0.0</td>
<td>0.1</td>
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<td>Unutilized Baseload Energy</td>
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<td>0.2</td>
<td>1.1</td>
<td>0.8</td>
<td>1.2</td>
<td>1.4</td>
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<td>Acid Gas (Gg)</td>
<td>365</td>
<td>269</td>
<td>171</td>
<td>171</td>
<td>161</td>
<td>153</td>
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</tbody>
</table>
The Barsebeck NPP has a staff of 350 employees. At the head office in Malmo there are only about 20 persons occupied with tasks concerning operational matters of the Barsebeck plant.

The organization consists of a plant coordination group and the following six different departments.

- Operations
- Electrical Maintenance
- Mechanical Maintenance
- Protection and Chemistry
- Nuclear Technology
- Administration

The plant coordination group coordinates outage planning, QA matters, plant modifications, emergency preparedness, and foreign business.

The same fundamental organization is used during the outages as during the normal operation. During an outage about 600 contractors are added to the organization without changing its original structure. The different groups are responsible for technical as well as financial matters.

Outage Coordinating Group

Immediately after the outage of one year is finished, the plans and preparations for the following year's outage start. To coordinate the different activities there is a special outage coordinating group with members representing the various departments of the organization. The coordinating group is supervised by the outage manager from the plant coordination group. Twice a month the group meets to discuss the work and coordination of the coming outage.
The representatives are assigned different tasks which are to be discussed with the staff of their departments. The necessary arrangements in the respective departments is then made and the coordinating group is informed at the next meeting.

The outage coordinating group coordinates all kinds of jobs, e.g:

- Preventive maintenance
- Corrective maintenance
- Safety related jobs
- In-service inspections
- Plant modifications

Various kinds of jobs are prepared by the work groups, but they are selected and sorted in different priorities. By decision some jobs might be deferred until the next outage, by way of example.
Barsebäck Nuclear Power Plant

PLANT SUPERINTENDENT

PLANT COORDINATION

OUTAGE COORDINATION GROUP

OPERATION

ELECTR. MAINT.

MECH. MAINT.

PROTECT. CHEMISTRY

NUCLEAR TECH.

NUCLEAR SERVICE

ADMINISTRATION

PLANT SERVICE CENTER

OP. TECHN.

STAFF

PLANNING

HEALTH PHYSICS

CORE MANAGE.

ENGINEERING

I & C

TURBINE MAINT.

TURBINE

ABB ATOM

ABB STAL

200 GROUP

300 GROUP

350 GROUP

TRANSPORTS

CRANES

CONSTRUCTION WORK

PAINTING

DEWATERING

DECONTAMINATION

HOUSKEEPING

SAFETY ENGINEERING

WORK SHOP

QUALITY CONTROL

WATER TREATMENT

WORK PERMIT

SHIFT GROUP

AUX. OP. GROUP

VALVE TEST

WATER WORKS

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER

PLANT SERVICE CENTER
Annex 3.2

OUTAGE PLANNING AND PREPARATION
(page 20)

A. Barsebeck, Sweden

Barsebäck NPP Outage Planning - Decision Phase

- KAS = Outage Plan
- Outage 6-Year Plan
- Work Schedule Outage YY
- Preliminary Main Schedule
- Preliminary Umbrella Schedule
- Decisions about the Scope and Extent of Outage YY
- Update of MMS-Lists
- Main Schedule Umbrella Schedule
- Outage Activities Presentation Meetings

- Testing Program
- Fault Reports
- Plant Modifications
- Experiences

- MMS = Maintenance Management System (Computer System)
- KAS = NPP Outage Coordination (Sweden and Finland)

Barsebäck NPP Outage Planning - Preparation Phase

- Detailed Schedules for Special Jobs
- Outage Start Schedule
- Operation Plan
- Revision of Schedules

- Detailed Work Planning
- Detailed Scheduling in Work Groups
- Resource Calculation
- Work Preparation in MMS Data Base
- MMS-Lists

- Resources, Own and Contractors
- Supervisors Resources

- Work Instructions
- Drawings
- Checking
- Testing
- Scaffolding
- Insulation
- Spare Parts
- Tools

---

90
Compilation and Coordination of Outage Activities
Attached is the schedule of pre-shutdown activities for the 1990 Planned Outage of Unit 8.

Unit 8 will shut down on March 30, 1990, and return to service June 8, 1990. During the vacuum building outage scheduled for May 6 to May 30, 1990, no work will be scheduled on Unit 8. Unit start-up activities will commence May 31 with synchronization date of June 8, 1990.

Please note the key dates identified for when information is required by Planning and the Production Section. Work identified by the Technical Unit for the outage will be planned on the basis of detailed work plans which have been approved by the responsible Technical Section MP6. (This is a minimum requirement, the work plan will be flagged by "Draft" if further approvals are specified.)

Permitry, OTOs and condition guarantees specifically required for detailed work plans will be prepared once the plan is fully approved.

The dates specified are the latest dates recognizing the lead time required by Planning and the Production Section in order to produce a meaningful outage schedule and prepare permitry in advance.

Therefore, all draft work plans (approved by Technical Supervisor) and DRs identifying major work activities must be received by Planning no later than FEBRUARY 2, 1990, for scheduling and allocation of manpower. All approved work plans received by Planning after FEBRUARY 23, 1990, must be covered by a memo to the Planning Supervisor justifying late identification and stating reasons why it should be considered for the Planned Outage.
<table>
<thead>
<tr>
<th>No.</th>
<th>Resp. Sect.</th>
<th>T - Technical Section</th>
<th>F - Planning Section</th>
</tr>
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<tbody>
<tr>
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**UNIT - SCHEDULE OF PRE-SHUTDOWN GENERAL ACTIVITIES**

**UNIT 8 1990 PLANNED OUTAGE**

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N.B. DATA IN BRACKETS AFTER EACH ACTIVITY BAR INDICATES THE LATEST COMPLETION TARGET.
A schedule showing the main activities of the preparation period is developed just after finishing the last outage of the year. The preparation activities are followed up by the coordinating group.
SIMPLIFIED EXAMPLE OF PLANNING AND PREPARATION WORK SCHEDULE USED AT BARSEBACK NUCLEAR POWER PLANT, SWEDEN

Barsebacksvetet Outages 1990
Planning and Preparation Work Schedule

900419

Dep Managers Approval

October November December January February March April May June July August September

40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140

Outage Unit 2

Identification and Decisions of Modifications

Modifications Design

Identification of Outage Activities

Outage Activities Presentation Meeting

Outage Planning

Detailed Work Planning

Preparation of Work Orders in WMS

Revision of Schedule

Calculations for Fuel Load Program

Preparation of Operation Orders for Fuel Handling

Preparation of Work Permits

Preparation of Work Orders for Modifications

Publication of Work Orders

Revision of Operation Procedures

Post-Outage Review

CONTRACTORS

EVALUATION OF CONTRACTORS Hired DURING LAST OUTAGE

REQUEST FOR OFFER

Preliminary Manpower Estimation

Final Manpower Estimation

Total Outage Cost Calculation

Orders to Contractors

PRELIMINARY MANPOWER ESTIMATION

TOTAL OUTAGE COST CALCULATION

FUEL LOAD PROGRAM

PREPARATION OF OPERATION ORDERS FOR ELECTRICAL WORK

PREPARATION OF WORK ORDERS FOR MODIFICATIONS

FINAL WORK ORDER

POST-OUTAGE REVIEW

OUTAGE Unit 1

Identification and Decisions of Modifications

Modifications Design

Identification of Outage Activities

Outage Activities Presentation Meeting

Outage Planning

Detailed Work Planning

Preparation of Work Orders in WMS

Revision of Schedule

Calculations for Fuel Load Program

Preparation of Operation Orders for Fuel Handling

Preparation of Work Permits

Preparation of Work Orders for Modifications

Publication of Work Orders

Revision of Operation Procedures

Outage Unit 1
Annex 3.5

DESCRIPTION OF COMPUTERIZED PLANNING SYSTEMS
(pages 21, 35)

A. LEIBSTADT: ARTEMIS

Summary

Leibstadt has been using network planning for all refuelling outages (first outage 1985, 6th outage in planning for 1990). The computer program ARTEMIS by Metier has been used from the beginning. The planning process concentrates on the critical path for overall duration. Planning is done to the degree of detailedness that allows scheduling and expediting of individual job orders. The resources/planning tool of ARTEMIS:

- is being used to minimize the number of external workers and helpers,
- will be used to resolve capacity problems with testing specialists and,
- to resolve capacity problems of our infrastructure.

Planning Process

The planning process at Leibstadt follows the steps and time schedule that is considered to be good practice; ie,

- Identify major outage work (refuelling, inspections, revisions, plant modifications) by October of the preceding year; ie, 9 months prior to start of the outage.
- Draft overall schedule, using standard schedule information for tasks that have been done in earlier years, and best estimates for new tasks. This step is done in November. In this phase of planning, the critical path is identified and next-to-critical paths are analyzed for the potential of becoming critical.
- Propose general content and schedule of the outage to utility management, for approval (Production planning for the year concerned). Decision by Management by year end.
- Issue planning level of outage plan, called level-2. This level lists some 180 to 200 items. It highlights the complete critical path. Non-critical chains of activities are scheduled to show at least 24 hours of free float. This plan to be available by end of January of the year of the outage.
- All activities on the critical path are scheduled in more detail (Level 3 Plans) using 24 hour a day and 7 days per week. All major tasks, by complexity and/or manpower involved, are scheduled to the same Level 3, but not necessarily to a strict and complete network of interdependencies. Detailed schedules must provide proper "boxes", into which later on job orders will be sorted. Level 3 planning is to be completed by early March of the year of the outage.

- Job orders are being written. They contain information on the time and manpower needed, mainly as a feedback from previous outages. Generation of the job orders is done on a computer system; the job orders contents are available to other services like radiation protection or manpower procurement. 80% of the expected total of job orders (planned maintenance activities) are to be completed by early May of the year of the outage. A typical figure for planned job orders is 2,000.

- Resources are summed up for certain trades and/or tasks and smoothing of the number of individuals is accomplished using some of the free float a network plan offers. This means, that for the purpose of a good and continuous loading of the manpower, activities may be scheduled to start not at the earliest possible moment, but rather when manpower becomes available, that was used for higher priority work in the early days of the outage.

This smoothing process finalizes the contracting of manpower needed by early May of the year of the outage.

**Further use of the ARTEMIS Schedule**

Each job order gets its planned starting and end date directly form the ARTEMIS Schedule. Any change in the ARTEMIS Schedule will automatically reschedule the affected job orders. Data transfer between ARTEMIS and the job order system is by computer routines.

Each job order is examined by licensed plant operators as to the safety tagging and securing needed. A separate computer program lists all safety tags identified and correlates them to the job orders. With the job orders having an assigned starting date and end date, it is possible to see immediately by when safety tags shall be set and released in the plant.
The overall schedule identifies which groups of safety tags need to be resolved before any of the usual System Functional Tests (SFT) can be started. In the context of this description the Instrumentation Functional Test (IFT) are considered to be all successfully completed. These SFTs are required as a prerequisite for the plant to be ready for startup. SFTs tend to accumulate in the very last days and hours towards the end of an outage. They require, on the other hand, highly qualified engineers and licensed operators, both of which are very rare. We will treat this problem in the future with special attention and load the SFT and IFT activities onto the ARTEMIS system.

Capacity Planning of SFT Crews

SFT's will be identified with the special types of licensed operators and engineers needed for its execution. The limited capacity of these specialists will signal upcoming bottlenecks. Smoothing of the SFT tasks will be needed to be done, making again use of the free float that is still available on maintenance activities. This will mean, that certain groups of activities, which are tied to the same safety tags and hence to the same SFTs, will be required to be finished earlier than calculated by the straight forward time schedule. These components and systems will be finished tested and ready for startup somewhat earlier than the latest allowable moment. The benefit of this situation will be a test crew that has the minimum time available to do a decent job. Upcoming deficiencies identified during testing have a better chance to be corrected before becoming critical on the overall plant startup schedule.

We are convinced that by the detailed scheduling of this testing activity, the test quality can be maintained with a smaller impact to the overall outage duration.

Optimization of Manpower Capacity

Optimization has been done in a systematic manner since 1988. The total number of external individuals present during an outage (not counting the station staff) lists as follows:

1987 - 860
1988 - 750
1989 - 630
The total work scope for 1989 was similar to the one for 1987, but was handled with only 75% of the manpower.

Benefits are multiple:

- Less external manpower to be instructed and supervised,
- Better working climate with well supervised crafts,
- Lower burden to the supporting services (Radiation Health Services, change facilities, cafeteria, administration, guard services, access control, etc).
- The fewer and more efficiently working men accumulate less total dose. This is very important for plants with relatively big controlled zones and for plants that are confronted with areas with high radiation background.
What is FREMIS?

FREMIS is a comprehensive Project Control System using the Precedence (PDM) or Arrow (ADM) network technique of representing the logical inter-relationships between the activities which comprise a complete project.

A project may be defined as a large complex task comprised of many smaller interconnected subtasks or activities. Project Management is the process of achieving the project objectives within the limits of certain constraints; such as, available resources (men, machines), project end date, a budget and technical specifications.

FREMIS can provide management with information in a clear and concise form on which to base decisions related to the first three of these constraints; that is:

- To make resources available which are required by the project.
- To ensure that the project is completed on schedule.
- To ensure that the project is completed within cost and man-hour budgets.

The sophisticated resource analysis and scheduling capabilities of FREMIS can provide management with answers or insights into the following practical alternatives:

- If only the available resources are used, by how much will the project end be extended? (manpower constraints, resource limited).
- If the project end date is to be met, how many extra resources (if any) will be required? (time constrained)
- If overtime is worked on the project, by how much will the end date be brought forward? (A combination of time and manpower constraining).
- What is the cash flow on the project and how does it vary as constraints change?
- Is each individual item and the project as a whole over or under on budget?
• How will a design change affect the project schedule, the resources required, and the budget?
• If project A is given top priority, how will this affect projects B, C and D?
• If activity schedule dates are changed, what will be the effect on the project schedule and resources?

Using the network diagram and other project data (resources, resource constraints, costs, etc). PREMIS can simulate these situations and provide management with more meaningful and realistic information on which to base decisions.

Extremely flexible report generation facilities are an integral part of the PREMIS system and can be used to select only that information which is relevant to the various levels within the management structure.

PREMIS can operate within a hierarchical responsibility or interest structure that is often found in large organizations with many areas of application. Smaller organizations may only require a few levels within their hierarchical structure.

There are six levels within this structure of which the last five are available to the user:

- System
- Subsystem
- Network
- Subnet
- Activity
- Detail (Equipment lists, drawing lists, etc)

The powerful sorting and report generation facilities of PREMIS can be used to provide virtually any format of detailed reports at the lowest hierarchical level (activity detail) sorted in any desired sequence for operations on site or summary reports at any higher or group of higher levels for management.

Reporting at any specific level may be referred to as "horizontal" reporting.
Higher levels in the structure can obtain specifically selected detailed reports for key or milestone activities from a lower level.

This may be referred to as "vertical" reporting. That is, people need only see that information which is relevant to them.

In addition to the sophisticated project scheduling and sorting and report generation techniques, FREMIS also has integrated input and update generation facilities which can accept many different formats of input and update data at the activity or detail levels, which can be converted to a standard format within FREMIS for processing. Details of these facilities are described in the FREMIS Technical Guide.

A significant advantage of this combination of capabilities occurs when an organization is responsible for a large project in which several subcontractors are involved, many of whom may have their own Project Control Systems with totally different input, update and report formats and capabilities.

PREMIS permits the different users to continue using the input, update and report formats to which they have become accustomed while all are actually using PREMIS since the processing is "transparent" to the user.

Multi-lingual or Multi-national companies may wish to take advantage of this facility to print out the error detection messages and any reports in foreign languages compatible with the character set of the printer.

Overall control of the various (generation and project scheduling) modules of PREMIS is directed by the System Control Language (SCL). Various sets of SCL control cards can be stored on disc and recalled by a single control statement. The project scheduling modules may be retrieved in the same way from the project library.

Standard versions of the SCL control statements exist to facilitate ease of operation of PREMIS for most users.

In summary PREMIS may be thought of as a Project Management and Information System Generator.
(1) SYSTEM

(2) SUB-SYSTEM

(3) NETWORK

(4) SUB-NET

(5) ACTIVITY

(6) DETAIL
Twelve years ago we initiated the design of a computerized Maintenance Management System (MMS). Our own computer service company, Ellips Data, was engaged to make a computerized MMS. At Barseback we made the premises, how the computer system should be structured to suit our plant the best, while ellips made the programming. The Barsebeck MMS is based upon an on line system which means that all terminals are directly connected to a data storage unit. Since all modifications in the records are made from terminals in the plant, the MMS is consequently continuously updated.

The system consists of five data bases comprising component data, preventive maintenance, spare parts, component history and finally work orders and work permits. Even though the different data bases were not developed at the same time, it is simple to "jump" from one system to another. For a smooth MMS this possibility is a must. When doing a work preparation or work order for instance, one has to get information from the Component Data Bases, The Spare Part System, the history file and of course the base storing work orders and work permits.

The computerized Barsebeck MMS was designed to fulfill those purposes required in a nuclear power plant, no more, no less. Since it is not overdone but made for a nuclear power plant exclusively, it is simple to use and understand. This is important considering that all plant staff will have the possibility to use it.

Major efforts have been made in creating an elaborated screen layout. Easily surveyed lists enable the user to obtain extensive and detailed information rapidly. Another advantage with the Barsebeck MMS is that the access to the various files is controlled centrally within the NPP. In this way the computer system is run independently by the plant, and all changes of the records are treated in a more secure manner. Our policy has been an openness concerning the presentation of data, while changes and supplements of records are limited to persons obligated to do such tasks.

The Barsebeck MMS is a flexible system with low running costs, and we have the experience to build-up and run such a system exclusively made for a nuclear plant.
Spare Part System

Among the first developed and utilized data bases was the computerized Spare Part System (SPS). Since our computer system is capable of development, the SPS has gradually been transformed into a fully utility adapted and valuable part of the MMS and has now no resemblance to its original structure.

The Barsebeck SPS is very comprehensive. Thorough information about each component is received. All kinds of spare parts are included in the SPS, process connected as well as non-process connected and daily goods. However, it is also a system for stock bookkeeping with accounts and suppliers, etc. For cost estimation and automatically evaluated medium price is set on spare parts. Today we have about 45,000 articles in stock of which 10,000 are daily goods and the total value of spare parts is approximately 350 million SEK.

The Barsebeck SPS supplies a complete survey of the spare part content which enables standardizing the different spare part types and thus minimize the number of components in stock. It also provides statistics for stock minimizing. On the data screen you can find out exactly where and in which stock room a certain spare part is stored. The continuous consumption of spare parts varies because of the more frequent use of spare parts during the outages. A development of the present system would enable you to estimate the minimum number of components needed in the plant at a certain time of the year.

Wherever you are in the power plant, spare parts can be ordered from a terminal. Automatically, the store personnel receives an order form containing information about what type and number of spare parts are requested and where they are located. This, of course, facilitates the work for the staff involved and reduces the paperwork. It also minimizes the time spent between ordering and receiving the spare part. When ordering, the records in a file, comprising spare part consumption for a certain object, are automatically supplemented. This is important when you want statistics for spare part consumption. In this file a sudden change in the normal amount of spare parts consumed is detected. Making reservations for spare parts in advance is possible.

On the data screen you can find out the number of a certain spare part available, the largest number possible to store and at which quantity the stock should be replenished. The need of replenishment is checked regularly.
To renew the stock is easily done with the SPS providing all the necessary information about the affected spare part type, including the number of articles that should be bought, the cost, the name and address of the contractor and the duration of delivery time. In order to check that you actually received what was ordered and in due time, the SPS is provided with a delivery control. The system informs which and at what time, within a period of six weeks, the spare parts are expected to be delivered.

Our SPS has been developed through years of experience and it is constructed exclusively for a nuclear power plant in operation. However, it can also be adopted in the process industry because of the similarity between such industries and nuclear power plants.

**Component Data System**

In about 1980 there was a strong need to computerize all data concerning the plant components at Barsebeck. All records, gathered in files, had been put together by the main contractors. This led to the record systems not being standardized. It was furthermore difficult to find and to supplement the data wanted. Our own computer service company, Ellips Data, was engaged to make a non-limited component data system (CDS).

In the CDS every component is a part of an object, which could be a pump with an electric motor and a shaft coupling. The object belongs to a larger system; eg, the cooling system for the generator, which finally is part of either our first or second unit. Every component has accordingly its own unique code depending on its component type, to which object it belongs and so on. At Barsebeck we have for the moment about 76,200 components and 45,000 objects.

There are different ways to obtain the information you want from this vast data storage. You can either use a preprogrammed presentation system or ask the computer to list data of your own premises. The preprogrammed presentation system is most frequently used. Here it is possible to get all necessary records on each object and its components directly. You can also obtain information by using an easily surveyed questioning list, where you can ask for the most modern supplements in the CDS, the number for a certain design or a manufacturer list sorted by code, by way of example.
To make a CDS where you can list data for your own desires, a firm discipline is important when supplementing the records. To facilitate this particular information it is possible to register through a code system only, where every component type has its own identification.

**Work Orders and Work Permits**

Nearly all maintenance measures taken require a work order produced by a system supervisor. When it is done, the operating staff designs a work permit based on the work order. There are a lot of things the system supervisor has to bear in mind while producing a work order. The time needed to accomplish the job, the need of scaffolding and decontamination, the extension of the job, etc. Here our data base for work orders and work permits is of great benefit. All previous work orders as well as failure reports and different kinds of work permits are and will be stored. This implies that since a lot of our maintenance is periodical, much routine work is saved. Once a measure is taken, the system supervisor will receive a feedback on his work and thus the work orders will gradually become more complete as time goes by.

The work permit routine is handled by the operation staff. They gather all the work prepared by the different offices and design work permits by making sure the environment of the jobs will be secured. The operating staff register the work permits in the computer helped by a certain work permit routine which has been developed through the years. During the outage a shift operator controls the work permit handling in a room connected to the controlled area. The shift operator always notes at what stage the different maintenance jobs are performed. This is what we call a "stop-list" which always has to be followed.

By computerizing the work order and the work permit handling we have above all improved the safety and efficiency. The shift operator has a good survey of the situation and since everybody has access to the information about work permits and stop-lists through terminals, the communication between offices has improved a lot. Work preparation has been facilitated and paper work has diminished in extent.

**History File and Preventive Maintenance Data Base**

In the history file we store the history of every component concerning all performed maintenance measurements, corrective as well as preventive.
This file is closely integrated with our Preventive Maintenance data base and together these two data bases are of great help when planning outages to come.

By using the data in the history file the preventive maintenance data base lists the following information about each component:

- object and component type
- last performed maintenance
- frequency of preventive maintenance
- the importance of preventive maintenance. This is a grading made according to safety regulations and human experience.
- during which outage the component is planned to be maintained the next time.
- maintenance time needed during an outage.

This list is of course not static but is changed from year to year. It becomes consequently more and more accurate, as the experience and the ability to estimate the lifetime of a plant component increases. With this system we obtain a total survey of the component history which enables us to adjust our outage schedule. Based on these adjustments the maintenance frequency can be changed by way of example.

Advantages of the Barseback Maintenance Management System

Our system has been developed during many years of experience and it is made for a plant in operation. This fact results in certain advantages which we now will describe with the help of some keywords.

Safety

The Barsebeck MMS facilitates and simplifies the record handling and gives a complete survey of the process systems. Every document and its content is typed in, which means that failure reports, work orders and work permits will not be lost and are furthermore double checked. The safety of the system is enhanced by an unambiguous nomenclature. Unforeseen occurrences during an outage may extort a change in the original outage plan. By this system such alterations are accomplished promptly and safely. The Barsebeck MMS is also a tool for an effective QA.
Economy

Less administrative personnel is needed. Through the possibility of thorough planning and giving exact orders manpower can be minimized. By the survey we can standardize and fix the lower limit for or spare parts. The potential of shortening the outage in a safe manner is excellent.

Coordination

Planning and cooperation between the different groups are facilitated. During an outage of two and a half weeks, in our case, 2,000 jobs are accomplished.

Communication

The access to the terminals is overall and the information is continuously updated. The service to the contractors increases and people's attitude to their work is improved.

History

All performed maintenance and modifications of the objects are described in the history data base. This is important information and statistics for the long range outage planning.

Modification Management System

The administration of large and complex systems is significantly improved with state-of-the-art technology. The reason for the wide appreciation of the Modification Management System in our plant is the highly adaptable software and tailor made screens allowing easy handling and smooth operation.

One way of defining a modification is to say that it is a change affecting the documentation of the plant. Giving it a thought, we realize that modification management is an extensive field demanding careful administration. If not, both control and clearness are easily lost. By being excellent in storing and sorting facts as well as presenting them clearly, computers can in this case be of real help.
The objective of the system is to:

- Create an efficient system for joint planning, follow ups and information that can all ideas, proposals, investigations and plant modifications.
- Ensure required review and approval of all plant modifications and to fulfil all QA requirements.
- Continuously keep the plant documentation up to date and easily being able to verify implemented modifications.

Our computerized Modification Management System covers the entire process from idea, or problem, to documentation. On different screens a certain modification can be followed all the way through the process and by everybody concerned. The screens show the contents of symbolic "boxes", each containing its specific information. The "boxes" are as follows:

- The Proposal Box, where a proposal is initiated and described.
- The Survey Box, containing a central screen showing all the key information, such as persons and departments involved, economical aspects of the modification, and future treatment before documentation.
- The Department Boxes, with tailor-made screens, showing every step a department has to take when treating a modification.
- The Question Box, available to everybody, where you can ask any question imaginable by stating conditions for inclusion on a list; eg, "list all installed modifications". You can decide according to which parameters how the list shall be sorted, which other parameters that are to be included and which numerical fields you wish to get summed up.
- The Peek Box, which offers the possibility to look at any screen without being able to change anything.
- The Reward Box, which keeps track of the rewards offered persons whose ideas or proposals deserve extra attention.

It is essential that the documentation is correct and properly updated. In the Modification Management System there are routines included how to update the documentation, data bases, drawings, operation procedures, etc. This is done in parallel with the construction of the modification, so when we take the unit into operation after the outage period, where the modification has been implemented, this will be done according to the correct documentation.
Annex 3.6

BARSEBECK - PRELIMINARY TIME SCHEDULE
(page 25)

Preliminary Main Time Schedule

A preliminary main time schedule is developed very early. Large works are examined thoroughly as they influence the length of the outage periods. We mean the time schedule must be optimistic but also realistic. Spare time is never considered in the time schedule. It is more simple to prolong an outage period than shortening it. The jobs within the critical path are always planned as shift works, 24 hours a day. Large maintenance works on the turbine are planned and executed at the same time as large works on the reactor.

Main Schedule

The main schedule shows all the main activities. Some activities on the critical path are divided into smaller parts. The critical path is carefully followed up and decisions about this path will, of course, affect other activities.
Umbrella System

One major concern during an outage is how to arrange the isolation of a component in order to be free to work on it. An annoying but by no means unusual situation is the sight of several clearance tag outs on one component at certain times. Besides being a source of confusion such a situation is an indication that much work has been spent administrating the tag out procedure.

Administratively, we have divided our mechanical components and fluid systems into predetermined groups. We call them umbrellas, and they are used as units of clearance tag outs. An individual system contains 3 to 8 umbrellas. Totally, we have about 300 such umbrellas for the entire plant. The umbrellas vary in scope. Some contain only a few components. Others include complete systems. Work can be performed on any component within the established umbrella clearance.

We have developed instructions on how to establish and remove umbrella tag outs. The instructions also identify the boundary devices and the sequence list of tagging. The umbrellas are clearly marked out on drawings to show the boundaries and components included.

Umbrella Schedule

The umbrellas are a very effective instrument for planning outages. At a very early stage of planning we make a schedule of umbrella clearances. This schedule is based on work planned in the different systems, and the work groups contribute with the time needed for different activities. (Information gathered in the Maintenance Management System.)

The Umbrella Schedule is developed in order to take care of all safety regulations related to operation of cooling and safety systems during the outage period. When the umbrella schedule is approved, the work groups are expected to plan and execute their work within the periods when the umbrellas are established.
The umbrella schedule makes the outage management clear thus increasing the reactor and labour safety. Replanning due to unforeseen disturbances is carried through more rapidly. In combination with our computerized Maintenance Management System the umbrella system is a valuable tool for outage management and its economical importance cannot be underestimated.
• THE UMBRELLA SCHEDULE

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<td>351</td>
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</tbody>
</table>
Operating Plan

To be sure that all systems are operating according to the safety regulations, a special schedule is made, which is called the operating plan.

In this plan, more important pumps, (which also means the part of the system needed), are marked out when they should be in operation according to the technical specifications. Periods for umbrella clearances and work on electrical supply busbars are also marked out.

To the right, references to the technical specifications are noted.

This plan is an effective instrument for:

- Checking the planning during the preparation period
- Checking where to plan an upcoming job during an outage
- Checking if it is possible to prolong a work permit during an outage without affecting the safe operation of the needed systems.

Reactor Flooding Schedules

Special schedules are developed for showing the planned operational status of systems for supplying the reactor with water during the outage period.

Reactor Cooling Schedules

Special schedules are developed to show the planned operational status of systems for cooling the reactor during the outage period.

Electrical Supply Schedules

Special schedules are developed to show the planned operational status of buses, diesels, gas turbines and other electrical equipment important for a safe supply of electricity during the outage period.
New schedules are made, when the operational status is planned to change, so there could be about ten different schedules for each of the above mentioned types.

These schedules are put up on a special board in the central control room, and it is the task of the operational staff to change the schedules when the operational status changes during the outage.

The schedules provide a good overview of the planned status and are very important for decisions about changes during the outage period.

### THE OPERATING PLAN

<table>
<thead>
<tr>
<th>SYSTEM OBJECT</th>
<th>POWER SUPPLY</th>
<th>W827</th>
<th>W828</th>
<th>W829</th>
<th>W830</th>
<th>W831</th>
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</table>
• REACTOR FLOODING SCHEMATICS

• REACTOR COOLING SCHEMATICS
Remote Controlled Stud Bolt Handling Device for Reactor Pressure Vessel

Remote controlled stud bolt handling device for RPV

The principal work of opening and closing RPV head includes stud bolt cleaning, stud bolt tensioning and removal and refitting of nuts. These tasks have been carried out manually by many operators. In order to permit efficient execution of these tasks, the equipment for stud bolt cleaning, nut handling and stud bolt tensioning has been combined in such a manner that makes it possible to automatically perform all stud bolt cleaning, nut removal and refitting, stud bolt tensioning and positioning. Shortening of working hours and labour saving can be accomplished to a major extent with this device and the overall time required for annual inspection of a nuclear power plant can be shortened.

Components

1. Stud bolt cleaners (4 units) ——— Clean stud bolts.
2. Stud bolt tensioners (4 units) ——— Apply suitable tension to stud bolts.
3. Nut handling equipment (4 units) ——— Turn, remove and refit nuts.
4. Stations (4 units) ———— Suspend stud bolt cleaners, stud bolt tensioners and nut handling equipment and carry them to the appointed positions.
5. Stud bolt tensioner support and circular rail ——— Support and guide stations.
6. Position detecting sensor ——— Sense mutual positions to stud bolts and automatically position the equipment.
7. Control equipment ———— Performs remote automatic control.

Fig 1 Flange section and stud bolt
Remote controlled stud bolt handling device for RPV

Operating Procedures

The remote controlled stud bolt handling device for RPV performs all movements of stud tensioners, stud tensioner setting, stud bolt cleaning, stud bolt tensioning, nut turning, removing and refitting under remote control.

Features

Automation & labor saving

1. The length of time required for the tasks is shortened to a major extent, as stud bolt cleaning, nut handling and stud bolt tensioning are performed in parallel.
2. This device will reduce the number of operators to a major extent.
3. Positioning and centering is performed automatically through scanning of stud bolt positions and feedback of deviation of stud bolts from the equipment.
4. The nuts removed by the nut handling equipment are lowered onto the appointed nut holders as they are. The reverse motions are performed at the time of refitting the nuts, and it is not necessary for operators to directly touch the nuts.
5. This device is able to set and remove the RPV head, therefore it is not necessary to use the RPV head sling.

Safety design

1. Each motion of the device is provided with various interlocks to provide safety to a high degree.
2. Rust and other foreign matter removed as a result of bolt cleaning is collected by suction of a dust collector, or without scattering of dust. This prevents contamination of the working area.
3. Each unit is of module formation to facilitate removal, installation, maintenance and inspection of units.
4. Steady rest mechanisms are provided at unit hanging portions to reduce vibration of units caused by movement of the system in the turning direction and radial direction in order not to allow occurrence of mutual interference of units.

Effects

When this new device is used, the length of time required for annual inspection will be shortened by 2 - 3 days. The opening and closing of RPV head are critical paths of each nuclear power plant during the period of annual inspection.

<table>
<thead>
<tr>
<th>Item</th>
<th>Before Device</th>
<th>After Device</th>
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<tr>
<td>No. of operators</td>
<td>14 persons</td>
<td>3 persons</td>
</tr>
<tr>
<td>No. of working days</td>
<td>5 - 6 days</td>
<td>3 - 4 days</td>
</tr>
<tr>
<td>Exposure dose</td>
<td>3 - 9 man-rem</td>
<td>0.3 - 1.0 man-rem</td>
</tr>
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</table>
During plant outage, approximately 20% of the control rod drives loaded in the nuclear reactor are removed for inspection, and reinstall after its inspection.

The Automatic CRD Handling machine permits the removal and installation of CRD, which previously required many workmen to work in a radioactive environment, to be performed automatically from a remote control room.

Features
1. Automatic operation performed from remote control room.
2. Automatic positioning, continuous operation and prevention of improper operation made by a computer.
3. Simultaneous removal and installation of 8 CRD mounting bolts and automatic torque control.
4. Monitoring of each step of works by TV cameras.
5. Automatic drainage made when CRD is withdrawn.
The Automatic CRD Handling machine combines the various components required for CRD replacement and accomplishes the work automatically, thereby achieving a great improvement in work safety and reliability.

---

**Procedures**

The CRD removal procedures are shown in the illustrations below. The installation procedures are performed in reverse order. The operation is very simple. CRD removal and installation are performed by operating sequential flicker buttons on the operator console.
The operation control is made by a computer, and the speeds of individual motors (travelling (R), rotating (Θ) and elevating/lowering (Z)) are controlled at 2 stages: "High Speed" and "Low Speed." Thus, the positioning is automatically made to the target position.

In addition to the continuous operation (of individual movements), works such as "monitoring of status of units", "digital indication of position" and "recording and control of replacement work" are performed.

Various operation modes are available to correspond to the operating requirements: "automatic operation", which is performed using the computer, "remote operation", which is based on operator judgement, and "manual operation", which is performed directly on the machine for major operations.
In BWR power plants, during plant outage in addition to replacing 25% of the fuel in the reactor, the other fuel is also shuffled. Refueling service which previously required manual operation on the machine is to be performed automatically using this machine operated from the remote control room.

Features

1. Fully automatic operation performed from remote control room
2. Speed control using Thyristor Leonard control.
3. Prevention of improper operation by computer control.
4. Improved positioning accuracy due to precise multi-stage cylindrical telescopic mast.
5. Safety design from both mechanical and electrical standpoints.
Due to such aspects as increased bridge rigidity, a precise multi-stage cylindrical telescopic mast and position detectors, the Automatic Refueling Machine has achieved increased operating speed and more accurate positioning. As a result, fuel which is approximately 15 meters below under water can be handled automatically. In addition, from safety features, dual wire suspensions and the grapple hook with mechanical interlock, as well as various electrical safety interlocks have been provided.

![Fuel being loaded into the reactor](image)

![Fuel grapple](image)

**[Procedures]**

- Number 1 grapple position and number 2 release position to be set at operator console (resting of 100 cycles is possible)
- Throwing of operation switches
- Refueling machine to run
- Fuel grappling at number 1 grapple position
- Fuel releasing at number 2 release position
- Completion of 1 cycle operation

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All operations are performed automatically from the remote control room by computer control. In addition, the operating conditions of the refueling machine as well as the fuel loading conditions can be verified by computer, thereby insuring operating safety.
It is possible to carry out delicate maintenance operations at the Cetic on equipment which is difficult to access in a power plant. As a result the staff and the levels of exposure to personnel are reduced. The quality of work has improved by the validation of new tools, new techniques, and the requalification of used equipment which is slightly radioactive. In addition maintenance crews are trained in a realistic environment. These activities, when performed prior to any operation, increase efficiency by reducing delays due to untried procedures, unexpected equipment failures and an insufficient training of personnel.

The Cetic is a Maintenance Activities Simulation Centre comparable to the operation training centres equipped with simulators which nuclear utilities already have. One of the most remarkable features of the Cetic is the training of specialist teams for the loading and unloading of fuel assembly in conditions as close to reality as possible using the Cetic's real refuelling machine.

The Cetic represents equipment and installation of an "open heart" nuclear unit.

The design of the mock-ups is as close as possible to that of the main components of the "nuclear boilers", in order to qualify the procedures in the actual working conditions:
- same dimensions,
- same materials,
- same environment,

with three main advantages:
- accessibility without constraint,
- adaptability of the mock-ups to the project,
- interchangeability of the parts worked on.
Potential Activities

Validation of maintenance techniques, qualification of tools, training of working crews, in the following fields:

- reactor cavity,
- 900 or 1300 MW pressure vessel,
- pressure vessel head,
- pressurizer,
- steam generator (SG)
- 900 or 1330 MW reactor coolant pump,
- upper and lower reactor internals,
- fuel assembly,
- fuel handling machine,
- torquing bench for stud tensioner qualification, etc.

Training and Qualifying for Unloading and Reloading Fuel Elements

Realistic simulations of the very delicate operations of fuel element loading and unloading have been made possible by the Cetic's real refuelling machine for a 1300 MW PWR. The gantry can also be adapted to simulate operations on 900 MW PWR.

Simulations are carried out with the lower internals placed inside a 900 MW vessel submerged under 2000 ppm borated water in the reactor cavity mock-up. The simulation fuel elements used have almost exactly the same weight and dimensions as standard fuel assembly. Some of them can also be used to recreate deformities caused by radiation (buckling, warping).

The Cetic has been cleared to receive tools with low levels of radioactivity due to use in a reactor.

This enables Cetic to:

- requality such tools,
- train the personnel who use it.
The hall is composed of two bays of 75 m x 50 m (230 x 150 feet) and 35 m (100 feet) high. It holds a 1300 MW unit type reactor cavity containing 2500 m$^3$ (670,000 US gallons) of 2000 ppm borated water, in three compartments of 28 m x 10 m (85 x 30 feet), the largest being 22 m (70 feet) high.

The 900 MW type reactor pressure vessel (35 metric tons) fits inside the 1300 MW reactor pressure vessel (46 metric tons).

They are designed to work on the seal faces, the radial support key, the nozzle ends, the studs, the threaded stud holes, the "M" shaped support and all related central activities, etc.

The upper and lower reactor internal structures.

They are designed to work on the control rod guide tubes, the handling holes, the mixers and conduits, the thermocouple columns, the radial support keys, etc.

The pressurizer (15 metric tons).

It is designed to work on the heater penetrations, strainer, surge line, spray pipe and safety valve nozzles, manways, etc.

Steam generator (SG).

It is designed for activities such as: repairs inside the channel head, decontamination, plasma cutting of primary pipes, straddle lancing, tube plugging and extraction, anti-vibration bars replacement, U-bend heat treatment, etc.
I  Information Part

A. Operational results and some information about news since last outage. A photo documentation from last outage.

B. Organization sheets for the outage organization showing how the contractors are involved and supervised.

C. Schedules for the outage at Barsebeck-1
   • main schedule
   • schedule for the first days of the outage
   • detailed schedules
   • start up schedules

D. Schedules for the outage at Barsebeck-2
   • main schedule
   • schedule for the first days of the outage
   • detailed schedules
   • start up schedules

II  Instructions and Handbook Part

What you need to know before you are coming to Barsebeck

1. Announcements of arriving contractors.
3. How to send tools and material to Barsebeck.
4. How to order electrical supply of welding machines and other tools.

What you need to know when you are working at Barsebeck

5. Security routines and entrance routines.
6. Responsibilities of the foreman.
7. Routines for handling of contractors tools.
8. Available services from the service centre.
10. Work permit.
11. Radiological permit.
12. Fire protection permit.
13. Spare parts, material and tools from stores.
14. Reporting of performed work.
15. Work time report, routines for follow up of work time.

Health Physics, Industrial Safety, Emergency Routines

17. Alarm signals.
18. Industrial safety, audits of industrial safety, health physics.
19. Fire protection activities.
20. Information about asbestos.

Quality Assurance and Quality Control

21. Quality assurance and quality control routines.
22. Colour markings on welding material, welding data sheets.
23. Instructions for pipe couplings.
24. Instructions for expander screws.
25. Information about electrical safety.
26. Routines for handling of electrical equipment.
27. Routines for handling of chemicals and information about how they are marked.

Practical Information

29. Routines for the hotel at plant. Routines for using caravan site.
30. Maps and information about how the gates and entrances are marked.
Annex 4.1

BARSEBECK - STARTUP SCHEDULE
(pages 25, 27, 40)

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<td>CONTAINMENT</td>
<td>CONNECTION TO POWER OPERAION</td>
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<td>CLOSING OF CONTAINMENT OPENINGS</td>
<td>WATER FILLING IN REACTOR POOL</td>
<td>CONTAINMENT CLOSED</td>
<td>CRITICALITY TESTING</td>
<td>RELIEF VALVE TESTING</td>
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<td>REACTOR VESSEL UO MOUNTING</td>
<td>CORE SPRAY</td>
<td>FINAL LINE-UP</td>
<td>TEST OF START SEQUENCES</td>
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Annex 4.2

OUTAGE EXECUTION ORGANIZATION
(page 40)

A. BARSEBECK

Barsebeck NPP uses basically the same organization (see Annex 3.1) during planning and execution. The outage coordinating group has the responsibility for coordination of the outage execution. The Outage Manager is the Chairman in outage coordinating group meetings and daily meetings during outage. He reports directly to the Plant Superintendent.

During outages contractors are added into the Barsebeck organization. The staff in the Maintenance Departments have the same responsibilities but get during outages more people to supervise. The picture shows an example of how contractor companies fit into the organization and work for the Reactor Maintenance Group and the Turbine Maintenance Group in the Mechanical Maintenance Department.

During outages, the service group within the mechanical maintenance Department, becomes "the Plant Service Centre", described in Annex 4.7.
B. JAPAN

General Manager of Power Station

Deputy General Manager in Charge of Administration

Deputy General Manager in Charge of Engineering

Deputy General Manager in Charge of Nuclear Safety

Management will direct all activities as routine work with assistance of the Engineering Section

These staffs will present at the withness of the regulatory body in the specific inspection items

Routine activities on general affairs

Interfacing to the regulatory body
Planning/control of detailed schedule
Preparation of formal documents
Organizing of daily/weekly meetings

Check that all outage activities are agreed with the technical specification

Routine radiation control during Periodical inspection outage

Necessary operating activities for individual inspections and tests

Inspection, test and maintenance of mechanical components and systems including routine QC procedures

Inspection, test and maintenance of electrical components and systems including routine QC procedures

C. EMBALSE

OUTAGE CO-ORDINATOR

ACTIVITIES COORDINATOR

AREA COORDINATOR

MAINTENANCE WORK GROUPS

GENERAL SERVICE

PLANNING

SUPPORT GROUP

For critical or relevant activities

- Reactor Building leak test
- Pressure Tube Inspection
- Steam Generator Inspection
- Cobalt 60 Withdrawal
- Moderator Heat Exchanger Inspection
- Garter Springs relocation
- Turbine Inspection
- Etc.

- Reactor Building - Service Building - Turbine Building

- Mechanical - Electrical - I&C

- Expediting - Cleaning - Purchasing & supplying - Transport - Food & drink

- Masonry - Scaffolding - Thermal insulation - Shielding - Welding - Non destructive test
The above document is provided to first line supervisors to assist them in discussing hazards with their workers prior to work commencing. It provides a structured approach to ensure that all relevant hazards as well as the appropriate barriers are reviewed.

Supervisory training focuses on the use of this form along with other tools to promote safety. Its use is confirmed by supervisory audits and safety performance results.
Annex 4.5

PICKERING - SHIFT SUPERVISOR TURNOVER PROCEDURE
(page 42)

1.0 GOVERNING POLICY

Shift relief and turnover is a key activity with respect to continued safe operation of a nuclear power plant. It is essential that a full interchange of information occurs between on-coming and off-going shift personnel.

2.0 SCOPE

This procedure defines the responsibilities, procedures, and documentation required to ensure that the on-coming operating personnel are sufficiently informed that they may adequately carry out their shift responsibilities. It also identifies the mandatory items to be included in the Official Station Log.

3.0 DEFINITIONS

Shift Turnover - The transfer of information and duties between on-coming and off-going shift personnel.

Station Log - The chronological record of events related to operation of the station.

Operating Records - All other documents related to operation of the station, eg, boiler water pH records, descriptive log, fuelling machine log and radioactive release permits.

4.0 PROCEDURE DESCRIPTION

4.1 General Responsibilities

All shift personnel have the responsibility to provide accurate information for their relief, either directly if on-the-job turnover is required; or indirectly through clear and concise work reports and/or fully marked-up Detailed commissioning Procedures, Work Plans, PFs or Maintenance Procedures.
Shift relief/turnover shall at all times be conducted in a professional manner.

Each individual shall be responsible for reviewing and understanding the logs and check sheets applicable to their shift position before assuming the shift.

For on-the-job relief, the outgoing individual will not permit him/her self to be relieved unless and until all three of the following conditions are met (and will notify their supervisor accordingly):

- Relief must be by a qualified person who is properly authorized and/or qualified to assume the shift position.
- The relief must be alert, coherent, and fully capable of performing the assigned duties.
- The relief must be fully aware of existing conditions.

Each individual shall review pertinent information with their relief to highlight any abnormal conditions and revised procedures which affect the position.

Shift personnel shall advise their supervisor if their relief is:

- Not authorized and/or qualified for the position.
- Not fully aware of existing conditions.
- Not in a fit condition to perform all necessary duties safely and efficiently.

All personnel have the responsibility to notify the Shift Supervisor of the following:

- Any problems or conditions which jeopardize the normal operation of the station.
- Any problems which jeopardize normal full power operation.
- Any injury to personnel.
- Pressure boundary defects (actual or potential).
- Any other condition which, in their opinion should be brought to the attention of the Shift Supervisor.
4.2 Shift Supervisor Turnover Procedure, Duties and Reports

4.2.1 Turnover Procedure

The relief/turnover for this position will be guided by and include all the information as can be found in the Shift Supervisors Reports. For a detailed description see section 4.2.2 of this procedure.

In addition, the on-coming Shift Supervisor:

- shall review each unit's status shortly after assuming the shift; which may include (as appropriate) control panel inspection, unit log review, discussion with the Shift Operating Supervisor
- will satisfy himself through his individual work group supervisors that the minimum shift complement requirements have been satisfied
- will verify completion of the Shutdown Heat Sink check sheet (when required) and the Unit Emergency Control Centre (UECC) Panel check sheet (PNGS-B only).

After assuming shift, the Shift Supervisor shall:

- resolve any deficiencies in the total shift operating and maintenance complement criteria as identified by the Shift Operating Supervisor or Shift Maintenance Supervisor
- conduct, with the Shift Operating Supervisor, control panel inspections, unit log reviews and discussions with Senior Control Room Operators as appropriate
- review with the Shift Operating Supervisor and the Shift Maintenance Supervisors all pertinent turnover information and all work scheduled for that shift to:
  - ensure consistency of turnover information
  - schedule changes to, or deviations from work plans and routines.

4.2.2 Shift Supervisors Reports

4.2.2.1 Introduction

In the course of a shift, the Shift Supervisor takes a number of decisions and actions to maintain the necessary safe configuration and direction and progress of operation and maintenance. There is a need to summarize the
status of systems, operational conditions and progress of work; so that subsequent shifts, and other staff understand what changes have occurred, what progress was achieved and what they must do to maintain a consistent direction to operation and maintenance.

These objectives will be met by maintaining:

- Shift turnover
- Update of daily work program/outage plant, etc.
- Shift Supervisor Report

4.2.2.2 Shift Turnover

This sheet (PF-1150) provides a summary of the status of important operations and maintenance work at shift end, which the Shift Supervisor wishes to communicate to the incoming crew.

It also provides a medium for the communication of specific questions, instructions, information and requests for assistance, to subsequent crews or other staff.

Most items which are passed on, have been well developed over the years. They must include the following.

Work Progress

- Ongoing work
- Mandatory work scheduled or required for the incoming crew.
- Problems requiring investigation or special attention.

Items To Be Passed On To Future Crews

There are items which have more lasting importance and must be communicated to all crews, or relief shift supervision. They are flagged to be carried on future turnovers until the situation or question is resolved, ie:

- Questions raised for an absent crew
- Instructions/follow-up/answers for an absent Shift Supervisor
- Changes in direction of work
• Significant event reports/reports to the Production Manager to be written
• New operating memos in effect
* Cancellation of operating memos.

Items To Be Passed On To Days

These items could include comments, questions or requests which the Shift Supervisor wants passed on to day staff, such as Planning Section, commissioning Section, Technical Section, Maintenance Supervisor, Radiation Control Supervisor, etc.

A new shift turnover will be prepared by the duty Shift supervisor at the end of each shift. One copy of the turnover will be maintained complete and in chronological order in a loose leaf binder in the Shift Supervisor's office for thirty-five days. No other copy will normally be made or retained. After thirty-five days the sheets will be removed and destroyed.

Signing of Shift Turnover Sheet

The off-going and on-coming Shift Supervisor will formally sign the Shift Turnover sheet when they are mutually satisfied that turnover is complete.

4.2.2.3 Update of Daily Work Program/Outage Plan/Etc.

As work progresses throughout the period of currency of a daily work program, time gained or lost, changed circumstances, or new priorities may require the Shift Supervisor to authorize departure from the program.

The Shift Supervisor's copy of the program must then be suitably amended, with reasons for the decision noted on the program or plan copy. Feedback to the Planning Section will be provided via the regular planning meeting, and via comments in the feedback sections of the Shift Supervisor's work program copy. This is to be returned to Planning Section after expiry.

4.2.2.4 Shift Supervisors Summary Report

A Shift Supervisors Summary report, summarizing the unit reports, will be completed for each shift. Copies of the reports for the previous 24-hour period are to be distributed before 08:00 h (Local Time) each day.
The Shift Supervisors Summary Report consists of the following statements:

**Personnel Safety**

This is a summary of reportable accidents, safety DRs raised, safety concerns, actions taken.

**Environmental Protection**

The station ΔT and effluent temperature are entered in this section. Detailed instructions for completing this section of the report are to be found in PF-729.

**Energy Production**

This is a summary of any energy losses, or reactive power limits for each unit with associated causes.

**Demineralized Water Production**

This section details the status of the water treatment plant.

**Recovery Production**

This section gives the capacity factors for Sulzer, UPP and Clean-up as calculated from PF-574 and PF-1144 respectively.

**Load Maneuvering Capability**

This section gives initial and available additional load maneuvering capability per unit.

**Heavy Water Management**

This section is a summary of the Unit Heavy Water Management report contained in PR-136.
Fuelling

The fuelling statement is a summary of information obtained from the Shift Fuel Handling Report PF-8.

Significant Events

This statement describes any significant occurrences or achievements which occurred on any unit. (SERs/RPMs and outage critical path status must be highlighted.)

4.3 Shift Operating Supervisor

The SOS will immediately after assuming the shift:

- review each unit's status. This review will include control panel inspection, unit log review and discussion with the Unit First Operator
- verify completion of, and approve, all Unit Panel check sheets
- review his Operator complement and ensure that all minimum shift complement criteria are satisfied. Any deficiencies noted will be reported to the Shift Supervisor and immediately acted upon to rectify the deficiency
- ensure that Operators are effectively deployed in response to identified priorities, and will confirm that in those circumstances where on-the-job turnover is required, the necessary instructions have been issued.

During the shift the SOS will:

- review with the Shift Supervisor all pertinent turnover information and scheduled Operations work for the shift
- inform the Unit First Operators of any scheduled work which deviates from approved work plans
- ensure that any changes in procedures or conditions affecting the scheduled Operations work have been issued to the appropriate Operator.

Prior to shift end the Operating Supervisor shall prepare a log, to be used for the shift turnover, containing pertinent turnover information for each unit under their supervision, including as a minimum:
• abnormal status or conditions of systems or equipment
• status of ongoing Operations work detailing any significant hazards (radiation/conventional) and approved changes in procedures
• any conditions or work requiring immediate attention by incoming crew
• addition or removal of operating memos and jumpers.

4.4 Unit Operators

4.4.1 Turnover

The off-going Unit First Operator will:

• take a unit alarm summary to identify to the on-coming UFO any significant outstanding alarms
• record in the unit log all new and cancelled operating memos and make particular reference to them during the turnover
• complete a shift end summary in the unit log (see section 4.7 Station Logs).

The off-going and on-coming UFOs will:

• discuss any unusual events, plant configurations, and current status of the unit to ensure that the relieving Operator has a clear understanding of these items.

Prior to assuming the shift the on-coming UFO shall:

• personally determine the status of the special safety systems
• read the unit log shift end summary for the precious shift.

The off-going and on-coming UFO will:

• formally sign the unit log when they are mutually satisfied that turnover is complete (see section 4.7 Station Logs)

After assuming shift the UFO shall:

• take a full alarm summary at the beginning of the shift and satisfy him/her self that he/she is conversant with the reason for every alarm,
and that the appropriate corrective action is being, or will be, taken

- perform a unit panel check. The panel check sheet results, control
  program summaries and observations of systems behavior must be reviewed
  by the Unit First Operator and corrective action taken when required.
  The completed check sheet shall be submitted to the shift
  Supervisor/Shift Operating Supervisor (as appropriate) for verification
- review, as soon as practicable, the log and new/cancelled operating memos
  since he/she was last on duty
- assign a UECC qualified Operator, to carry out and complete the UECC
  panel check sheet. This check sheet will be reviewed by the UFO on
  completion and send to the Shift Supervisor for verification
- when applicable, complete the "Head Sinks After Shutdown" check sheet and
  have this verified by the Shift Supervisor
- review the turnover with the Shift Operating Supervisor and the Second
  Operator in charge of field activities, highlighting:

  - status of major systems or equipment under their responsibility
  - maintenance, testing and commissioning carried over from the
    previous shift
  - operations work scheduled for the shift and its implications

The Unit Second Operator will:

- record in the area log all new and cancelled field action type of
  operating memos and make particular reference to them during the turnover
- complete a shift end summary in the area log
- discuss with the on-coming Second Operator any unusual events, plant
  configuration, current status of the unit to ensure that the on-coming
  Second Operator has a clear understanding of these items.

The off-going and on-coming Unit Second Operators will:

- formally sign the area log when they are mutually satisfied that turnover
  is complete.

4.4.2 PA Announcements

An UFO who initiates or authorizes changing conditions or who is made aware of
such changes, must ensure that a PA announcement is made to warn workers who
may be affected. Other persons such as Mechanical Maintenance Unit Foremen, Vault Supervisors, etc. who become aware of significant changes in conditions should inform the appropriate UFO immediately.

As a minimum, announcements should include the nature of the hazard and its location, and it should be repeated at least once. Circumstances which require a PA announcement include the following:

- Reactor criticality approached
- Access control power level reached
- Reactor power increased (above criticality) without all access keys in the control room
- Radiography beginning (ending)
- Noise hazard generated by testing
- Spill of heavy water
- Movement of radioactive equipment
- Significant increases in gamma fields in the reactor auxiliary bay (or elsewhere) due to the transfer of contaminated heavy water
- Adjuster rod movements with workers in the boiler room (BR)
- Refuelling operation with workers in the BR
- Significant increase in airborne activity in any location including the reactor buildings (RBs) and the irradiated fuel bay
- RB box up.

Follow-Up

It must always be recognized that PA announcements may not be clearly heard by all persons affected. It is necessary in all cases noted above, that the UFO review work authorizations to determine which individuals are involved. These individuals or their supervisors must be contacted directly and informed of the hazard to ensure appropriate response to the situation.

4.4.3 Shift Unit Report

The Shift Unit Report to be completed for each unit each shift, consists of four statements.
Energy

This statement consists of an energy balance (Net Unit Output = Gross Unit Generation - Unit Electrical Service and may be positive or negative) against the Perfect Net Output.

Fuelling

The number of channels fuelled and the fuelling machine availability at the end of shift are to be recorded.

Significant Events

A descriptive report of two most significant events that occurred during the shift and outstanding problems this shift.

D₂O Management

The D₂O Management Statement tabulates vapour recovery rates and isotopics together with liquid recovery rates and isotopics. This enables an upkeep cost of $/h to be calculated. Detailed instructions for completing this section of the unit report are to be found in Operating Manual 0-38000.

4.4.4 Unit Summary of Conditions

This will summarize unit system and equipment conditions. A detailed unit status is printed and maintained in a binder at each unit. The Unit First Operator will be required to review the previous days chronological events and update the status each #1 shift. The remaining shift, 08:00 - 20:00 h need only to note changes in the above conditions on their shift end summaries, including D₂O losses, MWe losses.

4.5 Fuel Handling First Operator

The off-going Fuel Handling First Operator will:

- ensure that a shift end summary is made up in each of the Unit Fuel Handling logs and the Irradiated Fuel Bay log.
The off-going and on-coming Fuel Handling First Operators will:

- discuss any unusual events, fuelling system configurations and current status to ensure that the relieving Operator has a clear understanding of these items.

Prior to assuming the shift the on-coming Fuel Handling First Operator shall:

- read the fuel handling logs shift end summaries for the previous shift.

The off-going and on-coming Fuel Handling First Operators will:

- formally sign the logs when they are mutually satisfied that turnover is complete (see section 4.7 Station Logs).

Fuel handling shall be done in accordance with the requirements of P-PSP-1.2 Fuel Handling Procedures.

After assuming shift the Fuel Handling First Operator shall ensure that the appropriate Unit First Operator is advised of any fuel handling abnormalities which could have an effect on unit operation. Further, if a fuel handling operation is in progress a shift change using the "Manual" mode and a standard check sheet, the check sheet shall be signed by both the off-going and on-coming Fuel Handling Operators at the step where turnover takes place.

4.6 Shift Maintenance Supervisor

After assuming shift, the Shift Maintenance Supervisor shall:

- check that the minimum maintenance complement criteria are satisfied, and report and deficiencies to the Shift Supervisor
- review with the Shift Supervisor pertinent turnover information and scheduled maintenance work for the shift
- ensure that any changes in procedures or unusual conditions affecting scheduled maintenance line supervisors.
Prior to shift end the Shift Maintenance Supervisor shall prepare a log containing pertinent turnover information including as a minimum:

- status of ongoing maintenance work detailing any hazards (radiation/conventional) and approved changes in procedures
- work requiring immediate attention by the incoming shift crew.

4.7 Station Logs

4.7.1 Log Structure

The Pickering NGS(PNGS) station log is a handwritten chronological document which forms an ongoing permanent record of changing unit conditions. Some of the more important functions of the station log are:

- It is an important method of communication between shifts.
- It indicates outstanding items which require additional follow-up on succeeding shifts and therefore contributes to the coordination of intershift effort.
- Important items demanding caution, reminders, etc, should be clearly stated.
- It provides a source of information for other work groups such as the Planning and Technical Sections which is of assistance in monitoring job progress, coordinating the effects of the different shift units, monitoring trends, fault analysis, etc.
- It provides a historical record which is useful for conducting reviews of incidents and post-upset analysis and troubleshooting.

Allowing all of the foregoing, it is evident that the station log is probably the most important station record.

Because of its importance, any effort expended in making the log entries neat and legible, and in organizing the wording to efficiently convey the message, is worth it.

Accountability for the station log rests with the Shift Supervisor. Responsibility for the quantity and quality of logged information is delegated to those members of the shift whose task it is to accumulate written data.
These delegates are also responsible to police entries made in the log by non-shift members. This is normally delegated to the Unit First Operator or Fuel Handling First Operator.

In order to achieve some uniformity of effort across the shifts, the following standard shall apply.

The station log will consist of the following:

- Combined chronological-descriptive logs, one for each unit, to be kept at the unit desk in the control room.
- One descriptive log for Unit 0 to be kept in the Unit 0 First Operator's office.
- Fuel handling logs.
- Water treatment plant log.
- All written work reports and orders to operate (OTOS).
- Radiological Log.

Additional logs may be kept, as required by the Production Manager, to provide records of special operations (for example, during an extended shutdown of a unit). These logs will become part of the station log.

Other logs may be kept as convenient to facilitate record keeping and transfer of responsibility between shifts. They shall not be part of the station log.

**EXAMPLE:**

- Unit area logs
- MM log and others

### 4.7.2 Chronological-Descriptive Unit Log

The unit log will contain two categories of entry

- A brief chronological record of events and facts entered by the Unit First Operator or his delegate.
- Descriptive entries which may summarize a sequence of events or happenings of significance or may convey some message to all shifts. Such entries may be made by anyone with the Unit Operator's permission.
Descriptive entries should be as brief as possible, consistent with conveying a clear and meaningful message. Entries by anyone other than the Unit Operator must be signed by the author.

4.7.3 Water Treatment Log

The water treatment plant log shall contain the same type of information as the descriptive-chronological unit log.

4.7.4 Unit 0 Log

A descriptive log will be maintained by the Unit 0 First Operator or his delegate. It will include for each shift a descriptive entry recording the status of each area under the Unit 0 jurisdiction including bulk gases, $D_2O$ cleanup, UPP, sulzer, screenhouse, water treatment and active waste disposal.

4.7.5 Fuel Handling Log

The fuel handling log will consist of the following:

- Operations log
- Maintenance log.

Operations log, one for each unit, to be kept at the fuel handling consoles.

This are both chronological and descriptive logs, providing a brief record of events, facts and happenings of significance. The principal information they must contain is as follows:

- Time at which fuelling machine operations commence, defined as the time the upstream fuelling machine unclamps from the transfer port.
- Channels fuelled.
- Time at which fuelling operations cease, defined as the time that the last spent fuel bundle from the last channel fuelled has been received in the spent fuel bay.
- Time at which fuelling operations are forced to stop, and a brief statement of the reason for stopping, eg, "W FM latch ram not moving...", or "fuelling suspended due to lack of manpower", and the time at which operations resume.
• Description of any out-of routine or abnormal operations or conditions with starting and completion times.
• Time of issue, and description of work authorizations, also time of surrender.
• Irradiated and auxiliary irradiated fuel bay operations.
• At end of each shift, a summary of the status of the system and whether or not the system is available for fuelling.
• Identity of operator(s) responsible for the unit.

Mechanical Maintenance and Control Maintenance logs are kept by the Shift Mechanical Maintenance Foreman and Senior Shift Control Technician respectively. Maintenance logs being composed purely of maintenance work reports.

* 4.7.6 Radiological Log

The radiological log consists of two categories of entry:

• The results of routine radiological surveys entered by the person who completed the survey including the time of the survey.
• Descriptions of non-routine surveys (including rationale for their performance) and incidents involving radiological protection (eg, alarming of portal monitor, incident of personal contamination, spills of D₂O, etc.).

Descriptive entries should be as brief as possible, consistent with conveying a clear and meaningful message. Entries shall be signed by the author.

The radiological log shall be reviewed and signed by the Shift Supervisor at the end of each shift.

4.7.7 Standards

The logs will be neat, concise and legible. They should be composed in a manner such that the reader will understand their content without the necessity of verbally interfacing with the author.

Untidiness in the log is unacceptable as it can be cured by the writers spending a little more time with their entries. The incurable illegible shall be required to print.
Brevity is desirable but brevity to the point where the entry has no meaningful substance is unacceptable.

Log entries are required to be made as soon as possible following the event or operation to be logged. The practice of keeping a scratch sheet and filling in the log at the end of the shift is unacceptable. If the level of activity is so high that the log cannot be kept current, then a suitable scribe should be appointed.

4.7.8 Instructions

Anyone can make an entry in the logs. The First Operators must themselves ensure that anyone other than themselves who makes an entry in the log signs his/her full name and indicates any other information required to locate him/her if required.

Specific instructions regarding log writing are spelled out in the following:

- Ontario Hydro Corporate Safety Rules 1979—Section VIII
- Administrative Policies and Procedures — HO 369
- Administrative Policies and Procedures — HO 368

All First Operators must familiarize themselves with these instructions.

With regard to HO 368, the off-going First Operators will time and sign their shift end summary. The on-coming First Operators will signify their acceptance of the unit conditions by signing their name below the off-going operator's name and noting the time. This automatically places them in charge.

Summary of Conditions

This will summarize unit system and equipment conditions. A detailed long-term unit status is printed and maintained in a binder at each unit. The Unit First Operator will be required to review the previous days' chronological events and update the status each #1 shift. The remaining shift, 08:00 to 20:00 h, need only note changes in the above conditions on their shift end summaries, including $D_2O$ losses, MWe losses.

Each Monday #1 shift a photocopy of the corrected long-term unit status will be forwarded to the Clerk Typist Production for updating. The corrected status will be returned to the control room on Monday #2 shift. The Unit
First Operator will compare the corrected status to the original to ensure it is correct. The Unit First Operator will then sign and date the last page of the status.

**Identification**

Station log books shall be clearly identified by unit and location. In addition, each white page shall be stamped to indicate the unit and location of the log. The date and the page number shall also be entered.

Log books will be numbered numerically for each unit in each calendar year, eg, descriptive 71-1, 71-2, etc. Completed log books will be filed in a filing cabinet located in the work control area and then forwarded to Central Records. Water treatment plant logs shall be stored in a filing cabinet in the treatment plant.

**4.7.9 Incidents and Events Which Shall be Logged**

A list of incidents and events which shall be logged is given in Appendix 1.

**4.7.10 Document Control**

Each weekday morning, the Control Room Clerk will process the logs as follows:

- File logs in a binder in the work control area (binder will be subdivided by unit)
- Review contents of binder and remove "old" logs, i.e., remove those which have been there for two or more weekdays
- Unit First Operator - Days reviews logs and forwards to Records Central.

**4.7.11 Verification**

The originals of all unit logs are forwarded to the Days Shift Operating Supervisor for review. It is the responsibility of the Days Shift Operating Supervisor to review the logs for completeness, legibility and conformance to the requirements as laid out in this procedure.

It is the responsibility of the incoming Shift Maintenance Supervisor to review the outgoing shifts work reports and ensure they are legible, correct and informative.
APPENDIX 1

Incidents and Events Which Shall be Logged

1. A shift change list of operating personnel on unit.

2. Disturbances, interruptions, voltage and load reductions with cause or reason, eg, reactor trip, load rejection, setback, stepback.

3. Unavailable apparatus and return to available state.

4. Station/unit inspections if completed. If it is not possible to make a field tour, an entry must be made in the unit log to explain the reason.

5. Weather reports.

6. Descriptive entries of work completed during shift.

7. Any fault, safe or unsafe, on any safety or safety support systems, all operations inspections, tests, maintenance.

8. All successful tests on safety and safety support systems, DRs and test numbers if test failed.

9. Any fault on a process system which has caused an upset or has the potential to cause an upset, eg, silt, fish run, algae run.

10. Completed activities on start-up and/or shutdown plan, eg, time reactor critical, time at full power.

11. Activities on start-up and/or shutdown plan that are not required to be performed and person authorizing such action.


13. Situations where prompt action is taken that is not covered by an authorized procedure.


15. Fires with details.

16. Reactor power changes and reason, eg, adjuster rod withdrawal due to lack of reactivity reactor power decreased.

17. Fuelling operations - closure plugs removed, insertion, channel fuelled.

18. Control room and unit emergency control centre panel inspections.

19. Completion of call-ups and field operator routine inspections.

20. Completion of on-load turbine trip tests. D$_2$O shipments or receiving.


22. Receiving of fuel oil for standby generators/emergency power generators.
23. Generator stator cooling high leak rate, i.e., SV500 operation greater than once every hour.

24. Unauthorized chemical releases to environment Lake Ontario including:
   • location of spilled material in the lake
   • direction of movement of polluted area in the lake
   • wind direction, weather, lake conditions.

Latter two should be recorded at sufficient time intervals to track the movement of material in the lake.

25. Chemical analysis results, e.g., moderator cover gas, heat transport iodine, status of moderator ion exchanger (IX) columns, status of heat transport IX columns, generator hydrogen purity.

26. Addition of oxygen to moderator cover gas.

27. Purging of systems, e.g., liquid zone cover gas, generator stator cooling, etc.


29. \( \text{D}_2 \text{O} \) additions to heat transport and moderator systems.

30. Excessive consumption of bulk gases, e.g., \( \text{H}_2, \text{H}_2, \text{CO}_2, \text{N}_2 \).

31. \( \text{D}_2 \text{O} \) losses.

32. Issuance and completion of "OTO".

33. Deviation from expectations stated on OTO, e.g., "check closed" and value found "open".

34. Caution tag, caution tag records and caution tag labels placed on unit.

35. Entry into confined spaces – acceptance, issuance and subsequent acceptances and reissues.

36. Issuing and returning of registered and nonregistered station keys.

37. Issuing of, and person issuing, hold-off tags and access control keys and returning to control rooms.

38. Work authorizations – issuing, suspending, surrendering with details of work completed, outstanding or function tests to be performed.

39. Receipt of a PCI.

40. Changing of a page of an "OTO".

41. Results of potential checks performed by an operator for work protection.

42. Verification of work protection isolation and operator who performed verification.

43. Approved work practice in effect.
44. Issuing, acceptance, subsequent issuance and accepting, tests and surrendering of a work permit.

45. Issuance and surrendering of red tag work protection.

46. Operation of terminal point between PNGS-A and -B.

47. Computer software changes, verification and on-line test.

* 48. Receipt and cancellation of operating memos.

* 49. Completion of placing and/or removal of flags/supplementary copies required by an operating memo (ref P-SRP-0.13).

50. New operating manuals received.

51. Main and alternate shutdown heat sinks.

52. Regional overpower calibrations on SDSI and/or SDS2.

53. Events as required by Shift Supervisor, Shift Operating Supervisor, Regional Operator or station instructions.


55. If emergency route used to exit an access controlled area.
Annex 4.6

EMBALSE – A DESCRIPTION OF THE INTERFACE
BETWEEN THE CONTROL ROOM STAFF AND MAINTENANCE
(page 43)

The criteria followed for the planning and fulfillment of tasks during the programmed outage are as follows:

- The usual crew should be on duty at the main control room and in the field to make a follow up of the systems still in operation. Under these circumstances, the staff should have a particular care as the tasks involve different parameters and different working conditions (open systems, out of service equipments, increased number of personnel working in areas which are normally restrinced areas, noise levels different from the standard ones, etc.)

- A support group of the Main Control Room should be formed during the preparation and fulfillment of the outage. The aims of this group are as follows:

a. During the programming stage

- To give a convenient sequence from the operation point of view to the tasks to be carried out.
- To give a convenient sequence regarding the preparation of securities programming in similar dates equipment having the same sources such as thermal, electrical, hydraulic power so as to avoid duplication of tasks.
- To give colaboration to programme the fulfillment of the preventive maintenance inspection sheets to the equipments given to the preventive maintenance sectors.
- To prepare the forms required as per procedure for the equipments deliverd (Order to Operate) and securities request. this will avoid wasting time during the fulfillment of the outage.
- To give colaboration to the crew on duty when performing the functional tests which are carried out as a pre-requisite of the outage.
- Under a request of delivery of a system or equipment, the criterium to be followed is that they shall be made personally at the maint control room by authorized persons who shall carry out the procedures already in force.
The persons involved in the above-mentioned requests or delivery shall foresee the time considered necessary to carry out this requisite in due time. The purpose is to avoid an impact in the fulfillment of the maintenance personnel schedule, i.e. to avoid dead times.

Every sector minimize the number of authorized persons to request and to deliver work permits. There shall be one person responsible for each discipline and one responsible for the Main Control Room. Ex= Mechanical Maintenance Supervisor, Electrical Maintenance Supervisor, I&C Supervisor and Supernumerary Shift Supervisor.

b. **During the fulfillment stage**

- To deliver to the Supervisors all the systems in which reparations are to be performed as per the outage programme. This is to be done with the acknowledgement and authorization of the Shift Supervisor on duty.
- To receive by hand of the the supervisor the systems in which reparations have been performed. To acknowledge the Shift Supervisor on duty and to remove the security cards.
- To make agile the collaboration made by unions in groups that need to participate in different disciplines.
- To give collaborations in the fulfillment of the Functional Tests and Inspection sheets in the systems affected directly or with respect to the outage. This is to be pointed out in the outage programme.
- To monitor the outage programme master which is useful in the identification of the following:
  - Activities considered to be within the established schedules.
  - Activities considered to be delayed and/or advanced with respect to the established schedules.
  - Activities that, in spite of being pointed out in the initial programme, on not to be fulfilled due to determined reasons.
  - Activities that are to be carried out in spite of not being pointed out in the initial programme.
c. Once the outage is over, the Supernumerary Shift Supervisor and his group will:

- Remove the security cards in the conditioning systems for the station re-start up.
- Collaborate in the fulfillment of the Functional Tests and Inspection Sheets in the systems affected to the station re-start up.
- Collaborate in the normalization of the systems for the station re-start up.
- Collaborate to solve eventual operation difficulties that may arise as a consequence of the re-start up.
Annex 4.7

BARSEBECK SERVICE CENTRE
(page 43)

During outages Barsebeck establishes the "Plant Service Centre". It is the service group in the mechanical maintenance department which plays a more important role during outages.

The service centre is responsible for services like:

- housekeeping
- decontamination
- insulation
- scaffolding
- transports
- cranes
- construction work
- painting
- dewatering

The service centre is supervised by the service coordinator and the office is strategically located in the plant to provide easy access for all personnel.

The service centre provides effective and timely service support for the maintenance and modification work. The coordinator receives requests for services for the various work groups in the plant via the computerized "Outage Management System" and coordinates assignment of his labour force (both contractors and own people) to supply those services when needed. This means that the work groups can concentrate more on the in-process work.
WORKORDER PROCEDURE DURING OUTAGE

DATABASE

EXECUTION

MAINTENANCE STAFF

OPERATIONAL STAFF

PRINT

START

OUTAGE CONDUCT CENTRE

PERMISSION

CONTROL ROOM

FINISH

HISTORY

OUTAGE CONDUCT CENTRE

Q.A.

TURNOVER ON THE WORKPLACE

TURNOVER ON THE WORKPLACE

OPERATIONAL STAFF

Q.A.
WEEKLY SUMMARIZED WORKORDERS
OUTAGE OF UNIT 3
08.09-09.14 1988

Number of workorders

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COLLECTIVE EXPOSURE OF PERSONNEL
OUTAGE OF UNIT 3 IN 1988

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<th>Dose (mSv)</th>
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<tr>
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<tr>
<td>Reactor</td>
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<td>Manufacturing</td>
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</tbody>
</table>
Annex 4.11

LEIBSTADT – DOSIS ALLOWANCE FOR WORK AND PERSON
(page 44)

Note: - For each important work in the radioactive protected area a ticket is prepared for each person involved in the work.
- When dosis allowance for the job is exceeded FEEDBACK is given to the person. Either EXCESS is justified or IMPROVEMENTS for the next time have to be put on PROTOCOL
Control and Collection of Dosis
Assigned to individual jobs

Protected Area

Check Point

Dosimeter

Check Point
1. Introduction

In 1988, Electricité de France has produced 341 TWh of electricity, 75% of this production being nuclear.

Up to 1989, the development of the French nuclear program has involved the construction of 18 nuclear sites, representing 56 nuclear units, 48 of which being in operation at the beginning of 1989.

The industrial policy applied to nuclear power facilities has allowed us to achieve good unit standardization, based on the same technology and a single design.

The adaptations and modifications proved necessary as experience has been acquired have been backfitted to all operating units.

In 1988, about 1988 million man-hours were devoted to nuclear power plant maintenance. Three-quarter of the total maintenance work was subcontracted to 1,500 contractors.

The different areas of maintenance activities are:

- Conventional mechanical and electro-mechanical
- Nuclear mechanical and electro-mechanical
- Instrumentation and control & data processing
- Non-destructive examinations
- Civil work
- Engineering Consultancy
- Cleaning and decontamination

Given the massive contribution of nuclear energy (primarily generated by PWRs) compared with the other electric energy sources, it is vital that France's nuclear units always operate at the highest quality level. This means that they must always operate with the highest possible availability - at the lowest cost - while meeting all requisite safety criteria, and this throughout their expected lifetime of 40 years.
This objective can only be reached by mastering the different units unavailability causes and essentially the duration of the scheduled outages.

EDF's experience in the field of refuelling outages of PWR units (200 refuelling shutdowns by the end of 1988) shows that their duration depends on the following constraining factors:

- Preventive maintenance activities, including the regulatory requirements, as described in the basic maintenance programs.
- Execution of all necessary modifications.
- Monitoring of so called "sensitive" components, ie, steam generator tubes, turbine rotors, etc.
- Major maintenance activities monitored at corporate level.
- Other site-specific maintenance activities or perhaps activities applicable to all the sites (qualification of a new maintenance technique; inspection of a specific component whose failure might be a generic nature).

To reach these safety and availability goals, EDF's Nuclear and Fossil Generation Division implements the program defined in the Quality Assurance Organization Manual (QAOM), a reference program for all nuclear units and all offsite contractors in particular in the maintenance field. The general rules in the manual are applicable to equipment categorized as "important to safety", as well as to equipment whose failure would have an adverse impact on plant availability.

2. **EDF's Policy for Service Contractors**

EDF awards contracts to offsite companies, requiring them to:

- implement a QA program approved by EDF.
- adhere to rules and regulations allowing EDF to exercise its responsibilities as Nuclear Plant Operator, in coherence with its own in-house rules (the QAOM), thus allowing EDF to supervise the contractors at all the different work stages.

Within this frame, the originality of EDF's approach is apparent at two levels:

- defining – in the form of precise requirements – the rules and obligations imposed on the contractors, according to the type of service required, based on general QA publications such as ISO standards.
• negotiating these requirements with the trade representatives of the
different professional categories of service contractors, resulting
in the signature of mutual agreements.

This approach has proven itself necessary, because of the specificity of
the activities to be performed on operating nuclear plants equipment, and for
the following reasons:

• it is difficult to schedule most of the activities a long time in
advance. Sometimes, after an inspection, they are decided at the
very last moment,
• the working period is short: from four to six weeks,
• work is not always repetitive from one unit to the other,
• the activities require a high degree of skill and outstanding
quality control,
• in case of on-site work, activities are performed away from the
contractor's facilities, and at all times of the day (nights, weekends, etc).

These contractual QA requirements are a reference for EDF. In
particular, they allow:

1) The rating of the contractors QA programs according to the services
offered.
2) The compilation of a list of contractors meeting the requirements.
3) A good evaluation of activities costs and a comparison of the
different service levels.

Currently, these requirements cover two types of relations between EDF and its
contractors:

• on-site work performed at PWR plants
• equipment repair at the contractor's workshop

3. EDF Contractors Relations For On-site Activities at PWR Plants

Three cases have to be considered for this type of services:

Case 1
The Contractor's QA program entirely applies.
Case 2
The Contractor's QA program applies, as well as part of EDF's Assurance program.

Case 3
The Contractor performs the activities, but EDF's QA program applies.

3.1 Case 1: Activities covered entirely by the Contractor's QA Program.

For these activities the contractor performs all technical controls and verifications according to its own quality control program.

The technical control, applied to all quality concerned activities, should verify that:

- each activity has been performed according to the defined specifications.
- the end product is of the expected quality level.
- appropriate corrective and preventive actions, intended to correct the discrepancies and non-conformances, have been taken.

The verifications should ensure that the measures intended to guarantee the quality of the work have been efficiently implemented. These verifications, performed on a random basis, address the organization put in place at the technical aspects of the activity. In the frame of the verifications, the contractor defines the corrective actions to treat the discrepancies.

Technical quality control and verifications are performed by qualified contractor's staff.

The contractor writes and verifies all the procedures necessary to perform and to control all the activities falling under his contractual responsibilities.

This applies essentially to major maintenance activities or modification work.
3.2 Case 2: Activities covered by the Contractor's QA program and partially by EDF's QA program

The quality control of these activities is performed by the contractor under the same conditions as described in Chapter 3.1, within its own QA organization.

Technical quality control of these activities is performed by qualified contractor's staff.

However, verification activities are performed by qualified EDF personnel within their own QA organization.

For these activities, EDF specifies in the contract signed with the contractor, the procedures necessary to perform and control the verification work falling under its responsibility.

This applies essentially to normal maintenance work performed on equipment of the nuclear or conventional island (reactor coolant pumps, valves, turbine, etc).

3.3 Case 3: Activities performed by the contractor, but entirely submitted to EDF's QA program.

The contractor's personnel carries the necessary qualification to be integrated to EDF's teams. The activities are then falling within EDF's QA organization.

Technical quality control and verifications are performed by qualified EDF personnel within their own quality organization.

For those activities specifically assigned to the contractor and described in the contract, the contractor will:

- adhere to the terms of the contract related to the qualification of his personnel.
- provide his staff with EDF QA training.

This applies to technical assistance and consulting activities.
4. **EDF Contractors Relations for Equipment Repair work at the Factory**

These activities are related to operating equipment owned by EDF and having undergone a technical inspection.

Three categories of repair activities have been defined:

**First Category**

The repair work necessitating re-design activities, as well as development, qualification and implementation of repair techniques.

**Second Category**

The repair work necessitating the development, the qualification and the implementation of repair techniques, based on technical specifications and procedures established by EDF and mentioned in the repair contracts.

This would apply to delicate decontamination work, complex machining, forming operations, mechanical tube expansion, welding, thermal treatment, etc.

**Third Category**

Repair work limited to the use of EDF qualified techniques and mentioned on the repair contracts.

This would apply to cleaning, decontamination, disassembling, reassembling, standard machining activities, etc.

Three types of contractors are associated with these three repair categories:

- **First Type:**

  The contractor has the technical expertise and skills to perform category 1, 2 and 3 repairs.
This is normally original manufacturer of the equipment.

Prior to the repair work itself, the contractor establishes all technical and control procedures required by the QA program.

- **Second Type**

  The contractor has the technical expertise and skills to perform category 2 and 3 repairs.

  Prior to the repair work itself, the contractor makes sure that he is in possession of all the documents as mentioned by EDF in the repair contract. He writes all the necessary control procedures and the related quality program.

- **Third Type**

  The contractor has the technical expertise and skills to perform the repair techniques specified by EDF.

  Prior to the repair itself, the contractor makes sure that he is in possession of all the documents mentioned by EDF in the repair contract. He writes the additional procedures and the related quality program.

5. **General QA Requirements for all Activities and Services**

In order to satisfy the specific QA requirements for nuclear plants activities, EDF requires its contractors to implement QA programs meeting the specifications of the documents related to "quality" systems, such as the European Standards ISO 9001, ISO 9002 and ISO 9003.

The upgrading of the French contractors QA organizations to the European Standards and the implementation of the resulting quality programs, are an important factor of success for our industry in the perspective of the future 1993 European Common Market.

6. **Contractors QA Program Qualification Process**

The content of the contractors QA programs and their implementation are evaluated every three years by specialized EDF teams.
Following these evaluations, a qualification related to well defined specific levels and areas of services are granted to the contractors.

Currently, 250 contractors are qualified by EDF/Nuclear & Fossil Generation to perform work on nuclear sites or repair safety-related equipment. This number will be increased to four to five hundred in the coming years.

7. Follow-Up of Qualified Contractors

Between two acceptance evaluations, EDF monitors in a systematic manner the implementation of the QA programs by the qualified contractors. This monitoring consists of a technical and administrative follow-up of the company by EDF during the performance of their services. The resulting appreciations address the technical performances and the adherence to the QA rules. It is formalized by a report referred to as a "synthesis report".

These synthesis reports are sent to the Corporate Maintenance Organization of EDF to be analyzed. This analysis triggers two types of actions:

- an immediate contact with the contractor to launch corrective actions in case of important violations of the QA rules during specific activities.
- a long-term action following a trend analysis of the non-adherence to the QA programs or the observation of discrepancies not highlighted during the preliminary enquiries, and forcing the contractor to take the necessary corrective measures.
ANNEX 4.14
EXAMPLES OF GOOD HOUSEKEEPING STANDARDS DURING OUTAGE
(page 46)

A. FRANCE

1. Identify and integrate necessary cleanliness steps in procedures (installation of screens, plugs or blanking flanges, cleaning, parts accountability).

2. Use cleanliness hold points at critical steps during the work.

3. Take cleanliness requirements into account during work planning.

4. Coordinate work area cleanliness when several groups are involved and at shift turnovers (cleanliness review).

5. Prevent non-cleanliness at its source (eg, clean work areas prior to start of work, spare parts and tools should be clean, tools and components in work area should be inventoried).

4. Minimize the time that equipment is opened to that which is strictly necessary.

7. Implement a surveillance programme to verify that cleanliness requirements are being met by procedures and at the worksite.

8. Clean electronic/electrical and mechanical areas after work completion.

9. Identify loss of cleanliness incidents and integrate them into the experience feedback programme.

10. Develop cleanliness habits as part of normal work practices.
B. JAPAN

During the periodic inspection outage, opening of boundaries, overhaul/inspection of various facilities/components are executed within the limited working area. From the standpoints of working safety, schedule keeping, radiation dose reduction, etc. securing of good working environment is the important factor for outage execution. Followings are the examples actually applied in BWR power plants.

(1) Management of temporary working area

Principally, overhaul/inspection, repair, modification activities of the facilities/components are executed in the working area adjacent to such facilities/components.

For the cases that the area is in high radiation dose zone or the work may associate with dust or fire, as well as safety securing or area size problems due to overlapping of several works, temporary working area is separately set up.

For the set up of such new working area, the section of the power station in charge of major work holds specific meeting with related sections and subcontractors and adjustment of use of the area to prevent interference with other work is made beforehand.

Also, for the work that may cause contamination or dust generation will be performed in the temporary housing with exhaust fan facility for dusty work and for the work associated with fire or spark (such as welding), installation of fire extinguishers, removal of burnable materials or provision of anti-fire sheets are required.

In the case of handling of activated component, special shielding materials are provided to reduce radiation dose of individual workers.

(2) Management generated waste

For the waste generated in the work is decontaminated, if necessary, by individual subcontractor then classified according to kind of waste, surface radiation level, burnable/not burnable and transported
to the specified place where waste is packaged into the utility-supplied drum (with radioactivity mark) and prepare specified report mentioning date of package, work location, content, packaging method etc. for efficient and quick disposal of the generated waste.

For the waste oil which is not disposable by the liquid, waste disposal system is stored in the utility-specified waste oil drum and is treated according to its kind.

Safety patrol is appropriately executed to watch and confirm correct disposal status of various wastes from the standpoints of good housekeeping and fire protection, etc.

(3) Management of temporary materials storage

Principally, temporary materials storage is not permitted in the radiation control area. In case of necessity of such temporary materials, storage within control area, utility-specified sign board for "Temporary Storage of Materials for Work" mentioning period to be stored, reason of temporary storage, location of storage, name of subcontractor, etc. is required to post upon approval of section of power station in charge and shift supervisor.

Safety provisions during temporary storage, such as securing personal path, prohibit of additional placement in front of panels or racks, floor preparations, if any are also mentioned in the sign board for confirmation by the safety patrol on the temporary storage conditions.

(4) Management of jigs and tools

For the jigs and tools to be used for overhauling/inspection of the component during the periodic inspection, basic request that unnecessary jigs and tools should not be brought into the working area and, upon completion of the work using such jigs and tools, they should be removed from the working area as soon as possible. Jigs and tools used by individual subcontractors are checked by list to prevent leaving them inside of component or piping.
(5) Temporary installation of local air conditioner

Temperature within the control area is basically controlled by building HVAC system. In case that high temperature is locally expected, local air conditioner will be installed. During periodic inspection outage, the same air conditioning as in operating period is kept. However, from the health control point of view for the worker, high temperature areas such as cloth changing room on the operating floor, drywell inlet, CRD repairing room are equipped with local air conditioners.

Recently, from the standpoint of improvement of environmental conditions for workers, plant HVAC system is being modified for this purpose.
C. ARGENTINA

Outage work planning establishes a coordinator for each important job, who is responsible not only for work performing but also for safety assurance and housekeeping in his work area. General housekeeping standards are established for the whole station and job coordinator as well as outage general coordinator must accomplish these standards. For this purpose, each work group for important jobs is composed of the necessary maintenance personnel and besides it includes a radioprotection and safety officer, who is responsible to assure acceptable safety conditions in his work area, and also responsible to maintain a good housekeeping. Safety officer counts with one, two or more assistants to help him in cleaning and arranging the area, waste handling, and other jobs.

It is possible to describe a general procedure which can be used to assure housekeeping and safety:

(a) First of all it is necessary the working area qualifications, where workplaces are previously classified depending on specific risks (fire load, contamination, heat load, etc.) defining protection devices, signaling and procedures before starting.

(b) If it is possible, floor must be covered with plastic film to avoid contamination and dirt (particularly oil and/or grease).

(c) If it is necessary, temporary plastic ducts must be installed for area ventilation.

(d) Appropriate bins and loks must be installed for clean clothes and safety personal equipment (plastic suits, maskss, etc.).

(e) A bench and/or posts must be installed to indicate the access to the work area and where personnel dose control would be installed if necessary.

(f) Radioprotection officer must have at the place the necessary equipment (exposimeter, contamination monitors, dosimeters, etc.) as well as cleaning equipment and material (Vacuum cleaner, mops, decontaminating solution, etc.).
CLEANLINESS

- Special attention is put in personnel indoctrination in order to keep the working areas free of scrap, garbage and flammable material. Regular garbage containers are installed. Those containers must be of easy transportation and unloading.

- Labeled drums are used to contain used oil, fuel, etc. in order to differentiate used and new material.

- Cleaning and absorbing paper and cloth must be kept always in baskets or plastic bags. Insulation material, specially glass wool must be collected avoiding its spreading.

- Cleaning patrols during maintenance are enlarge. Special indoctrination must be supplied in order to "clean with knowledge" and "ask your supervisor if you have questions".

RADIOACTIVE WASTE MANAGEMENT

- During a planned outage, a considerable amount of low level and intermediate radioactivity levels are generated (radiation fields and contamination levels).

Instructions are given in order to reduce waste production rates and to reduce volumes after segregation (pressing, drumming, etc.).

For liquid waste, special attention is given to avoid mixing of liquid waste of different levels. There is a big amount of liquid which can be released without any type of treatment, but you can "contaminate" it just adding inadvertently higher activity level. Such situation would require the processing of big amount of liquids.

Remember that liquid treatment during outages is normally one of the "bottle necks" with a relevant financial and schedule impacts.

NOISE POLLUTION AND COMMUNICATION CHANNELS SATURATION

- Special recommendations are given on communication inside – outside the plant during outage.
- Public address must be used just in the necessary level. Walkie-talkies are preferred inside authorized areas.

- Phone communications must be reduced to the necessary traffic avoiding as much as possible external private calls.

PLANT ACCESS

- Reduce as much as possible personal belongings in order to avoid X-ray and other screening devices at the Plant entrances.

- Private cars and official cars authorized to enter the plant are reduced during plant outages. Only utilitarian cars/trucks operate inside the plant.

REACTOR ACCESS

- Entrance is controlled in depth, only plant personnel and qualified senior personnel are authorized to access in the building.

MINIZONES AND MONITORING

- Total compliance with radiological minizones procedures is required. Personnel, tooling and material monitoring (controlled area) are strongly required.

TURBO SET ACCESS CONTROL

- Access to the turbo set is strictly controlled. Only personnel involved with that job is admitted in the area.
1.0 GOVERNING POLICY

To ensure the integrity of the generator, the electric, magnetic, cooling and oil circuits must operate free of foreign materials. The assembled generator is designed with various enclosures and seals to achieve this.

It is important to keep ALL foreign materials out of the generator during maintenance work.

Small metallic particles can easily damage the insulation systems. Other foreign particles can cause considerable damage to the generator by blocking cooling passages, damaging cooling system hoses, and usually cause considerable damage to the equipment and pose great risk to personal nearby.

2.0 SCOPE

This procedure defines the guidelines and responsibilities for the maintenance work on the generator and its associated systems.

3.0 DEFINITIONS

none.

4.0 PROCEDURE DESCRIPTION

4.1 Minor Generator Outages

4.1.1 General

Minor generator outages refer to:

- Generator inspections/maintenance work through the inspection hatches.
- $H_2$ seals replacement.
Main and/or pilot maintenance work and
Maintenance work in the bushings compartment.

The objective is to prevent the carry-over of foreign objects and/or dirt into the work area and to control the tools and materials used to prevent them from being accidentally left or lost in the work area.

4.1.2 Guidelines

The Generator Supervisor or delegate shall be responsible to:

- Ensure the area within 5 feet of the piece of equipment being maintained is fence roped with signs erected to provide one controlled entrance.
- Ensure the area within the fence is cleaned up regularly, ie, at least once per shift.
- Ensure tools and materials are accounted for and no foreign objects are left accidentally or lost within the work area.
- Ensure that a rubber mat is covering the scaffolding next to the inspection hatches. The rubber mat is to be cleaned twice per shift when maintenance work is ongoing or prior to entry into the generator for inspections.

4.1.3 Work Practices

Personnel working on minor generator outages shall be responsible to follow and practice the applicable work practices that apply for Zone (see section 4.4 and 4.5).

4.2 Major Generator Outages

Major Generator Outages refers to maintenance on the generator which requires the enclosures (end doors) to be opened. Consequently strict practices are necessary to ensure that on reassembly the system will be free of foreign materials or practices.
Examples of major generator outages are:

- Generator rotor replacement
- Generator Stator Inspection/Maintenance

Note: Erection of the Zone B barriers should only be completed after all the major components of the generator have been dismantled. (Example - Generator Rotor removed).

4.3 Zones

4.3.1 Definition of Zones

A three-zone system is chosen to satisfy the objective of the clean area requirements.

Zone A is to be used to enclose the general work area and the laydown areas for the disassembled components.

Zone B will establish a perimeter around the generator area inside which all work and entry into it must be authorized by the Generator Supervisor or his delegate.

Zone C consists of the parts of the generator and its associated electric, magnetic, cooling and oil systems.

Appendix 1 shows one possible configuration.

4.3.2 Zone A

4.3.2.1 Objective

To restrict the entry of personnel to those involved in maintenance work and safety control.

To provide a laydown area for components, tools, and materials.
4.3.2.2 Guidelines for Laydown Areas

Equipment disassembled from the generator, tools, and materials should be kept or laid down a reasonable distance away from the entrance to Zone B. This is to facilitate the cleaning of the area surrounding the entrance to Zone B.

Major equipment such as core, rotor, \( H_2 \) seals, main and pilot exciters must be protected from dirt and accidental contact when laid down. A tarpaulin should cover the rotor, main and pilot exciters. Plastic sheetings is to cover and protect the core and \( H_2 \) seals. \( H_2 \) seal cover must be protected by circular aluminum box and \( H_2 \) journal surface on the shaft protected by aluminum semi-circular plates similar to bearing protectors. In addition, placement of major pieces of equipment must be in such a manner to allow easy dismantling and reassembly of the generator.

The immediate area surrounding the laid down equipment is to be fence-roped and signs placed at convenient locations. See Appendix 2 for a typical sign (SCN 822B 1525).

4.3.2.3 Work Practices

The Zone A area is to be marked off with rope fence and signs (as in Appendix 2) are to be placed at convenient points.

The area would include the 294° elevation turbine floor of a shutdown generator unit, other laydown areas as required and the areas surrounding the bushing compartment at elevation 274'.

Persons entering this zone must obtain the approval of the person in charge of the job, ie, the Generator Supervisor, Mechanical Maintenance Foreman or Control Maintenance Technician III (Generator).

The Generator Supervisor or delegate shall ensure that the area surrounding the entrance to Zone B and all other clear areas within Zone A must be kept clean. A Service Maintainer will be assigned to sweep these areas (or any other clean-up duties) once per shift, or as required by the Generator Supervisor.
4.3.3 ZONE B

4.3.3.1 Objective

Clean area to be established when inner aluminum doors are removed and terminated when reinstalled.

To prevent the carry-over of foreign objects and/or dirt into the generator, ie, the clean area (Zone C).

To provide a checkpoint for tools and materials to prevent them from being accidentally lost or left Zone C, ie, the generator.

To provide an adequate and safe working area for the performance of tests, movement of tools, materials, and personnel.

4.3.3.2 Guidelines

The Generator Supervisor or delegate shall be responsible to:

- Ensure barriers and signs are erected providing one controlled entrance.
- Ensure the entry point is equipped with a sign (see Appendix 2), procedural sign (see Appendix 4), a table, dry boot boy, an accounting log (see Appendix 3), paper coveralls.

For a layout of the entrance point to Zone B, see Appendix 5:

- Ensure dry boot boy is operational at ALL times, and there is a supply of coveralls.
- Ensure fibreen paper is taped to the floor area inside the zone (after rotor has been removed). The fibre paper is to be replaced as required. If the generator rotor has not been removed, Fibreen paper must be laid down before the inner door is removed.
- Ensure that a Service Maintainer is available to clean and vacuum the inside of Zone B at least ONCE per shift, or as required.
- Ensure the exhaust of the vacuum cleaner when cleaning Zone B is directed AWAY from Zone C (if possible). Contents of cleaner must be checked for magnetic material for assessment.
• Ensure spilled liquids are removed with absorbent wipers. Any spill inside the generator must be identified to Generator Supervisor immediately.

Note: "Stay-Dry" oil absorbent is not to be used inside the zone.

• Authorize entry of personnel to the zone ensuring they are aware of their responsibilities and requirements.
• To suspend any work which may jeopardize the Zone B criteria until the necessary corrective actions can be taken.
• Ensure that tools and materials not in use are not left inside the zone unnecessarily.
• Check the accounting log prior to the end of each shift to ensure that ALL foreign materials are accounted for at shift turnovers. Consumable materials are to be accounted for in the comments column. Ensure log entries that are completed are checked off in the column provided.
• Place a guard at the entry point to control traffic of men, and tools during high activity periods or during periods when the normal barriers are dismantled. (Example: Removal of rotor or other major components.)

4.3.3.3 Work Practices

The following rules apply to personnel entering Zone 'B':

• Obtain entry authorization from the Generator Supervisor or delegate.
• Remove all jewellery, ie, chains, rings, watches, etc. and empty contents of all pockets before entry, ie, loose change, pens, badges, etc.
• Make an accounting log entry for each item to be taken into the zone, ie, tools, materials. Check off the out column of the log when the item is taken out of the zone. All items must be accounted for at the end of each shift.
• Items (tools, materials) no longer used inside the zone are removed immediately. This prevents items left behind from accidentally entering Zone C.
• Clean the bottom of footwear using the dry boot boy.
• No smoking within Zone 'B'.

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4.3.4.1 Objective

To maintain cleanliness and care to ensure the interior of an assembled generator is free of foreign objects and dirt.

4.3.4.2 Guidelines

The Generator Supervisor or delegate shall be responsible to:

- Authorize entry and work in the zone.
- Choose zone boundaries to meet the criteria (maintain the zone as small in size as practical).
- Ensure the entry point is equipped with a sign, paper coveralls and paper boot covers. Ensure the loose leg of the zipper is clipped off prior to entry.
- Ensure Zone C openings are covered with clean tarpaulins, plastic sheeting, temporary blanks or covers where possible to prevent the accidental entry of foreign materials.
- Ensure that personnel entering the zone understand the possible effects of failure to comply with the work practices.
- Suspend any work that may jeopardize the Zone C criteria until corrective measures are implemented.
- Ensure that the work practices described are adhered to and practiced.
- Ensure adequate protective coverings and/or cleaning equipment is used to prevent cuttings or dirt being entrapped in the zone.
- Ensure bolts and nuts have locking devices installed.
- Ensure a thorough inspection is carried out for foreign materials in Zone C prior to boxing up the system.
- Ensure that cleanliness in the zone is maintained at all times, by all personnel.

4.3.4.3 Work Practices

The following rules apply to personnel entering Zone 'C':

- Obtain authorization from the Generator Supervisor or delegate.
- Be familiar and practice the requirements for Zones B and C.
- Wear paper coveralls and paper boots over normal footwear.

Note: All coveralls and boots should be discarded upon exiting the zone.
• Secure tools, materials, or parts thereof with string or tape to prevent them from falling into the stator cavities.
• Items lost or misplaced in the generator (Zone C) must be reported immediately to the Generator Supervisor or delegate.

**LOST ITEMS MUST BE LOCATED AND RECOVERED.**

The time spent to locate and recover the lost article may well prevent a costly unit outage lasting several weeks and prevent considerable damage to the generator (if not catastrophic altogether).

• The following operations should be avoided *in and around Zone C*:
  - drilling
  - filing
  - scraping
  - grinding
  - brazing/soldering and
  - welding

The authorization of the Generator Supervisor or his delegate has to be obtained, if any of the above operations are necessary. Tarpaulins, plastic sheeting or other suitable protective covering is to be used to prevent loose particles from entering the generator. When these operations are interrupted or terminated, the work areas are to be cleaned up by vacuuming. For items (iv), (v), and (vi) a fire extinguisher is required. The CO₂ type extinguisher is the ONLY type recommended for use in Zone C.

• Temporary tapes, fastenings, etc., that are applied are easily identified by contrasting colour with the background to make it easy and obvious to identify for later removal.
• No smoking within Zone 'C'.
• Ensure that plastic sheeting is positioned in the end windings region to prevent water from entering the generator when draining water boxes, removing hoses, flushing stator conductor bars, and disconnecting water and oil piping.
• Ensure that equipment to be used on reassembly, ie, inner door, and doors, etc., are cleaned up prior to lifting them into Zones B and C.
APPENDIX 1

Typical Zoning For Major Generator Work

APPENDIX 2

Zone A Sign/Clear Zone Sign

ENTRY MUST BE AUTHORIZED BY M.M. FOREMAN OR CONTROL TECH. III
APPENDIX 3

CLEAN AREA LOG ACCOUNTING SHEET

<table>
<thead>
<tr>
<th>Item/Description</th>
<th>Initial Specific Use</th>
<th>Install</th>
<th>Service Control Technician Comments</th>
<th>Log Entry Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool No. (A23)</td>
<td>Items 83</td>
<td>In</td>
<td>Where What Job?</td>
<td>Hours Out</td>
</tr>
</tbody>
</table>

Note: If there are a great number of pages with one entry not completed, it may be desirable to carry them forward and make out a new summary sheet.

APPENDIX 4

Entrance to Zone B

ZONE "B"

LEGEND
1 Entry sign SCN 82281526
2 Paper booties / or rubber
3 Paper overall
4 Dry boot box
5 Table
6 Carpet/or paper
7 Accounting log

Note: Carpeted area (Item 6) to be vacuumed twice per shift as required.
Appendix 5

Responsibilities

1. Personnel entering Zone 'B' shall be responsible to:

- Obtain authorization from Generator Supervisor or delegate.
- Remove jewellery and contents of all pockets before entry.
- Make an accounting log entry for each item to be taken into the zone. Check off the "out" column of the log when the item is taken out of the zone.
- Clean bottom of footwear using dry boot boy.
- Ensure no smoking in the zone.

2. Personnel entering Zone "C" shall be responsible to:

- Wear paper coveralls and footwear paper covers.
- Clip off loose leg of coverall zipper.
- Secure with tape or string, tools or materials (or parts that may drop into small openings.
- Ensure that temporary tapes or fastenings applied be identified by a colour that contrasts with the background to make it easily identified for removal.
- Report immediately, the loss of any tool or material inside the zone so an immediate search may be carried out.

3. Entry guard responsibilities

- Ensure the clean area accounting log is kept updated.
- Ensure no unauthorized entry.
- Initiating immediate clean-up as required.
Example: The 10 jobs with highest dose in the DRYWELL AREA in the 1990 outage at the Leibstadt NPP.

<table>
<thead>
<tr>
<th>Job</th>
<th>Sievert</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISI at RPV - Cylindrical Portion</td>
<td>0.065</td>
</tr>
<tr>
<td>- Nozzles</td>
<td>0.076</td>
</tr>
<tr>
<td>- Bottom</td>
<td>0.025</td>
</tr>
<tr>
<td>Recirc. piping</td>
<td>0.038</td>
</tr>
<tr>
<td>CRD - work: Preparation Set Up</td>
<td>0.032</td>
</tr>
<tr>
<td>Rod Change</td>
<td>0.036</td>
</tr>
<tr>
<td>Radiation Protection</td>
<td>0.043</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>0.019</td>
</tr>
<tr>
<td>Thermal Insulation Work</td>
<td>0.035</td>
</tr>
<tr>
<td>Cleaning</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Note: The jobs are very carefully analysed for potential dose reduction. In 1989, the CRD - work was much higher when most of the work was performed without automated special tool. As a result of the high dose, an automated tool was used in 1990. Continued effort will lead to an optimised dose/work effort relation.

Similar lists are performed for other areas (buildings).
The efficiency of the planning phase is measured in the NPP-Leibstadt by the number of late preparation of work orders for an outage. In Annex 5.2 the work order accumulation is shown. The graph depicts the number of work orders cumulated up to April, and the added on numbers for the months May – August and during the outage itself.

Two positive observations are drawn:

1. The total number of additional work orders has decreased from 1988 to 1990 i.e. the degree of outage preparation improved.

2. The total number of work orders could be reduced. Reasons for this trend: changes in the plant technical specification which allow outage work on redundant equipment during power operation, reduced inspection work due to better surveillance of equipment during operation.

Note: The creation of trends to finally produce performance indicators related to maintenance and operation allow the optimization of the plant management based on safety availability and cost.
RNP - UNIT #2 1988 REFUELING OUTAGE PLANNING OBJECTIVES

1. The planned outage will be completed within 10% of the planned duration, i.e. critical path schedule. But in no case will exceed the nuclear operating plan length of 49 days.

2. Outage exposure/contaminations/radwaste will not exceed 354 man-rem 175 contaminations and 2000 cu. ft. of radwaste, respectively.

3. All exceptions to modifications completed prior to February 1988 not specifically requiring an outage. Will be closed out prior to the start of the 1988 outage. Specific exceptions can be exempted by joint concurrence of the manager of design engineering, Manager of construction and the outage manager.

4. There will be no more than 2 CP & L accidents and no more than 10 contractor accidents during the outage.

5. There will be no unplanned reactor trips. Runbacks or power reductions from power operation due to equipment modified. Installed or maintained during the 1988 outage for 30 days following the outage. This does not apply to normal restrictions on power escalation rates for new fuel or the new high pressure turbine rotor.

6. Total on-site personnel excluding those specifically assigned to unit #1. Shall not exceed 1500.
Annex 5.4

EDF - OUTAGE FEEDBACK FORM
(page 52)

<table>
<thead>
<tr>
<th>Job Completed on</th>
<th>By</th>
<th>Contractor or Section</th>
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<tr>
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<thead>
<tr>
<th>Procedure #</th>
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<tr>
<th>Equipment</th>
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**PROBLEMS ENCOUNTERED**

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<tr>
<th>Special tools</th>
<th>Standard tools</th>
<th>Consummable</th>
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<table>
<thead>
<tr>
<th>Safety requirements</th>
<th>Spare parts</th>
<th>Drawings</th>
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<tbody>
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**PROCEDURE INSTRUCTIONS**

- Not Applicable Drawing # | Missing Drawing
- Procedure Not Applicable: To Unit | To Equipment
- Inadequate Explanations On Instructions | On Report
- On Measured Criteria

**COMPLETE EXPLANATIONS**

<table>
<thead>
<tr>
<th>Engineer</th>
<th>Planner</th>
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The Planning Supervisor will prepare an outage report which will include the following information.

**Introduction**

The introduction to an outage report should give the overview of the outage with scheduled and actual completion targets, critical path, outage extensions and reasons.

**Major Jobs and Problem Areas**

Using feedback obtained from the Production Section and the Technical Section factual information should be provided describing work on the major jobs especially work on the critical path or any job which had a significant impact on the performance of an outage work in regards to safety, reliability and efficiency.

**Workload vs. Manpower Analysis**

Using the workload vs. manpower analysis reports produced before and during an outage, the statistics should be provided to show the estimated and actual workload, the estimated manpower requirement and the actual manpower used to complete an outage.

Information should be provided regarding any problems in meeting the manpower requirements and any significant delays which were caused due to lack of manpower resources.

**Safety**

The safety records during the performance of outage work showing statistics regarding lost time or near miss accidents and the number of reported accidents requiring medical attention.
Radiation Dose

Accounts of jobs performed in high radiation field, radiation dose statistics obtained from the Radiation Supervisor's report with reference to the report for detailed information.

Productivity Improvements

Changes in work methods which produced significant improvements in the performance of outage work.

Post-Outage Review

The account of the post-outage review meeting and the actions agreed on.

Summary

Highlighting problems which had the greatest impact on the outcome of the outage and performances which contributed to the successful execution of a particular job or a whole outage.

To give recognition to groups or individuals for the significant contribution towards the success of an outage.
RECENT MEETING ON OUTAGE MANAGEMENT IN NUCLEAR POWER PLANTS

In April 1991 the International Atomic Energy Agency held an International Seminar on Efficient Outage Planning and Management Practices in Nuclear Power Plants. The Seminar reviewed the following papers:

Session 1: **Long-term Outage Strategy**
- T. Futami (Japan): Basic Concepts of Maintenance Management
- J.C. Peltan (France): Programmaton des arrêts de Tranche REP. Contraintes de maintenance.
- Y. Hase (Japan): Kansai's Approach to Higher Reliability through Better Operation and Maintenance
- J.F. Nicaise (France): Standard Reference Outage Programmes
- L. Fabjan (Yugoslavia): Periodic Inspection during Outages in Krsko NPP
- V. Juan de Paz (Argentina): Scheduling Planned Outages in Atucha NPP
- J.P. Hutin (France): Maintenance of French Nuclear Steam Supply Systems
- V.D. Gourinovich (USSR): First Stage of Automated Maintenance Management System of the USSR Ministry of Nuclear Power and Industry
- A. Bystrikov (USSR): Backfitting Measures to up-grade Safety of Soviet NPP during Annual Repair and Maintenance Outages

Session 2: **Outage Planning**
- D.K. Doo (UK): Outage Planning
- P. Löfberg (Sweden): Organizational Structure for Outage Planning and Execution at Barsebäck NPP, Sweden
- J. Ritter (Germany): Outage Planning
- J. Eck (Hungary): System Oriented Outage Planning at Paks NPP
- P. Löfberg (Sweden): The Outage Planning and Preparation Process at Barsebäck NPP, Sweden

Session 3: **Outage Execution**
- R.C. Morrison (Canada): Optimizing for Effectiveness
- P. Löfberg (Sweden): Maintaining Safe Shut-down Conditions during Outage at Barsebäck NPP, Sweden
- M.J. Bultel (France): Réalisation de l'arrêt de Tranche
- K. Ikeda (Japan): Execution of Periodic Inspection Outage
- T. Andreeff (Canada): Outage Performance Measures
- A.N. Shkarovsky (USSR): Outage Execution in WWER NPP

Session 4: **Learning from Experience**
- F. Galán (Spain): Learning from the Experience
- P. Claisse (France): Dampierre 1 - 1990. Un arret de Tranche exceptionnel dans une centrale nucléaire EdF.
- R.J. Strickert (Canada): Pickering Unit 3. Retubing/Rehabilitation Outage
- R. Häusermann (Switzerland): Approach to Successful Outage Management at Leibstadt NPP

201
R. Mokka (Finland): Experience with Outage Management in Olkiluoto NPP
A. Becquaert (Belgium): Doel NPP: Outage Planning and Management Practices

Session 5: Promoting Effective Outage Management
- N. Pieroni, C. Chen (IAEA): Quality Assurance as a Tool for Outage Management

Copies of these papers may be obtained on request from

Director of Division of Nuclear Power
IAEA
P.O. Box 100
Wagramerstrasse 5
A-1400 Vienna
Austria
<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Miguel Joseph</td>
<td>Comisión Nacional de Energía Atómica, Argentina</td>
</tr>
<tr>
<td>Pierre Tremblay</td>
<td>Ontario Hydro, Canada</td>
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<tr>
<td>Remy Hochart</td>
<td>Electricité de France, France</td>
</tr>
<tr>
<td>Zoltan Kiss</td>
<td>Paks Nuclear Power Plant, Hungary</td>
</tr>
<tr>
<td>Isao Asai</td>
<td>Agency of Natural Resources and Energy, Japan</td>
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<tr>
<td>Yoshinori Tatsuta</td>
<td>Agency of Natural Resources and Energy, Japan</td>
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<tr>
<td>Mikio Hada</td>
<td>Nuclear Power Safety Research Centre, Japan</td>
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<tr>
<td>Peter Löfberg</td>
<td>Sydsvenska Värme kraft AB, Sweden</td>
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<td>Rudolf Häusermann</td>
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<td>John Lance</td>
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<td>F. Calori</td>
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<td>B.J. Csik</td>
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<td></td>
<td>Scientific Secretary</td>
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II. Consultants' Meeting on Good Performance for Outage Management, 30 October - 3 November 1989, Vienna