IAEA-TECDOC-1110

Management of delayed nuclear power plant projects

INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA

September 1999

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The originating Section of this publication in the IAEA was:

Nuclear Power Engineering Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

MANAGEMENT OF DELAYED NUCLEAR POWER PLANT PROJECTS
IAEA, VIENNA, 1999
IAEA-TECDOC-1110
ISSN 1011–4289

Printed by the IAEA in Austria
September 1999

FOREWORD

According to the available information at the IAEA PRIS (Power Reactor Information System) at the end of 1998 there were more than 40 nuclear power plant projects with delays of five or more years with respect to the originally scheduled commercial operation. The degree of conformance with original construction schedules showed large variations due to several issues, including financial, economic and public opinion factors.

Taking into account the number of projects with several years delay in their original schedules, it was considered useful to identify the subject areas where exchange of experience among Member States would be mutually beneficial in identification of problems and development of guidance for successful management of the completion of these delayed projects.

A joint programme of the IAEA Departments of Nuclear Energy (Nuclear Power Engineering Section) and Technical Co-operation (Europe Section, with additional support from the Latin America and West Asia Sections) was set up during the period 1997–1998. The specific aim of the programme was to provide assistance in the management of delayed nuclear power plants regarding measures to maintain readiness for resuming the project implementation schedule when the conditions permit. The integration of IAEA interdepartmental resources enabled the participation of 53 experts from 14 Member States resulting in a wider exchange of experience and dissemination of guidance.

Under the framework of the joint programme, senior managers directly responsible for delayed nuclear power plant projects identified several issues or problem areas that needed to be addressed and guidance on management be provided. A work plan for the development of several working documents, addressing the different issues, was established. Subsequently these documents were merged into a single one to produce the present publication.

This publication provides information and practical examples on necessary management actions to preserve and further develop the capability to restart and complete delayed nuclear power plant projects. Its content reflects the experience and good practices concerning the following management issues:

- project control measures
- retention of human resources
- preservation and maintenance of site installations, structures and equipment
- updating to meet licensing requirements and technology upgrades
- preservation of project data.

It is expected that the material in this publication can serve as a useful contribution to assisting nuclear utilities with solutions to problems encountered by the management of delayed nuclear power plant projects. It can also be useful for managers of new projects who need to know about problems that might arise if work is suspended. Feedback on the use of the material will be useful to plan future IAEA actions directed to assist Member States in the area of delayed projects.

In thanking the many contributors to this publication, the Secretariat wishes to acknowledge the efforts and assistance provided by the participants at the preparatory and review meetings, who are listed at the end of the report. In particular, appreciation is due to the experts identified in the annexes for making available valuable examples reflecting practices in their countries. On the basis of the discussions and material provided by the contributors, preliminary working documents were produced by: Y.S.R. Prasad and A. Sanatkumar (India) addressing the subject of retention of human resources, S. Krishnan (India) on preservation and maintenance of site installations, structures and equipment, and Ch. Surendar (India) on updating to meet licensing requirements and technology upgrades. The work of integrating this material and incorporating the remaining contents to produce this publication was done by G. Wieckowski (Canada). The IAEA officer responsible for this work was N. Pieroni of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. Background

The concept for this publication arose from recognition that delayed nuclear power plants (DNPPs) pose a specific set of problems for which there has only been limited support and advice available.

Management of DNPPs and their particular problems is sometimes not clearly understood or adequately addressed and, as a consequence, is not applied in a manner which would produce maximum benefits to the project. As a result, some plants may have deteriorated and may experience significant performance problems when the time comes to resume their construction.

Guidance contained in this publication can be applied in part or in whole to management of DNPPs. They apply equally well to a country's first nuclear power plant or a plant which is a part of a larger national nuclear power programme.

Additional information on key management activities is provided in the annexes. This information has been acquired from nuclear utilities around the world and represents *effective practices* successfully applied by these utilities as solution to identified problems at DNPPs.

Experience has demonstrated that these effective practices achieve the desired results. They are offered as guidance for adaptation and application by the users of this publication.

However, it must be clearly understood that they are only suggestions and are *not to be interpreted as regulatory requirements*. The implementation of these effective practices must be consistent with the organization, culture and the operating environment of the project.

1.2. Objectives

The objectives of this publication are to:

- Alert the target audience, i.e. the utility and plant management, to the importance of addressing the issues present at and specific to a DNPP.
- Assist the plant management in implementing effective policies to preserve the plant and the personnel during suspension phase, through:
  - emphasizing the key role of management commitment
  - clarification of the role and importance of the **core group**[1]
  - listing of and commenting on the essential activities of the **core group**
- Assist in the solution of performance[2] problems through provision of effective practices.
- Provide a tool for assessing the quality of performance through the use of symptoms, attributes and quality indicators[3].

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[1] *Core group* Expert technical and administrative staff dedicated to the DNPP

[2] The word *performance* as used in the publication addresses and is concerned with the method of execution and the results achieved

[3] *Quality indicator* A parameter of performance, which is significant for quality, easily measured and numerically quantified

1.3. Scope

The publication addresses the following five management issues of DNPPs:

- Project control, including considerations for project re-start
- Retention of human resources
- Preservation and maintenance of equipment and facilities
- Updating for new technology and regulatory requirements
- Preservation of project data.

1.4. Structure

The publication offers an outline of managerial and performance functions for each of the issues, with limited commentary. No details of implementation are offered — other than in the annexes.

The publication deals with the essential management activities, stated in point form in simple and direct language. These activities have the potential to affect the outcomes of management policies and the capability to resume activities to complete the plant.

Each of the sections offers comments and advice on:

- Management, which discusses policy, planning, organization and responsibilities as well as types and stages of delays and other considerations which are relevant.
- Performance, which deals with activities while implementing policies for preserving the plant.
- Assessment, which offers a brief summary of assessment issues pertaining to DNPPs. Included in this section are symptoms of problems and attributes of good performance and quality indicators.

The appendices offer pertinent information of detailed nature which was not deemed appropriate for inclusion in the main body of the publication, but is nevertheless considered to be of interest.

The publication contains "Effective Practices" (annexes) which deal with some of the performance problems. These are the practices and strengths which have proven successful in nuclear utilities. They were selected from among the large number of practices which were reviewed and are based on activities performed by managers and staff as an integral part of their work.

2. PROJECT CONTROL ISSUES

Summary

The "Management" section deals with criteria for reaching a decision about the plant's future. Issues of project management and organization are discussed, with special attention to the

core group, quality assurance (QA) and preservation of key resources are briefly presented. Considerations for a strategic plan are reviewed, including preparations for project re-start.

The "Performance" section deals with issues affecting planning and implementation of activities at a DNPP. Activities of the **core group** are discussed. Considerations for having an effective communications programme are highlighted. Management of procurement as applicable to a DNPP is reviewed. Issues which impact on construction are presented.

The "assessment" section discusses assessment policy and offers a selection of quality indicators.

All sections present symptoms and attributes for their respective topics.

Conclusions

The following conclusions arise from "Management" section:

- Utility and plant management must support the decision makers by providing reliable and realistic information and predictions.
- The **core group** is a key project resource and a key part of project management team.
- Effective interface control is a necessity for smooth functioning of project organization.
- Preservation of resources must be addressed by all levels of management.
- A realistic strategic plan must be developed for rational decision making.

The following conclusions arise from "Performance" section:

- Ongoing technical support from the **core group** forms the base for trouble-free resumption of work.
- Configuration management should be maintained through the delay period.
- For effectiveness, public communications should be planned and implemented with assistance from communication professionals.
- Co-operative relationships should be established with vendors.
- Planning should continue throughout the delay period.

The following conclusions arise from "Assessment" section:

- There are no common specific standards against which performance of a delayed, dormant plant can be assessed.
- Assessments should evaluate performance in specific project functions against accepted standards.
- Symptoms and attributes, as well as quality indicators should be routinely scrutinized and trended.

2.1. Introduction

A nuclear power project represents a big investment, with a large productive potential. This investment must be protected and its productive capability maintained.

In a DNPP, resources should be provided to maintain project assets and to enable project resumption. This must be the primary preoccupation of the management of the utility and project management team.

Resources to be preserved are:

- Personnel
- Equipment and facilities
- Documentation
- Contracts and warranties.

The secondary preoccupation is planning for resumption of work, which is achieved through:

- Updating to meet licensing requirements and technology upgrades
- Preparing for eventual resumption of project work.

The project management team and its supporting organization are the key resource. This resource is typically split between the utility headquarters and the site, the relative strength of the two organizations depending on the degree to which the project has advanced.

This section deals with management actions to address problems associated with protecting the investment at a DNPP, and maintaining its ability to resume construction and eventually to produce power. Practical guidelines with regard to project control are given. They have to be adapted to the particular circumstances and culture of the plant.

2.2. Management

2.2.1. Criteria for decision

Many issues bear on the decision as to what to do with a NPP which has been delayed for a long time. Their relative importance will vary from plant to plant and from country to country, but there are several key criteria which must be considered.

Three alternatives present themselves:

- resume work and advance towards operations and production of electricity
- continue with the delay until conditions arise which permit resumption of work and eventual operations. It is essential to maintain the capability to resume work
- abandon the plant. This option is not considered here.

For the purposes of rational planning it is essential that a decision be made, even a interim one. Lack of the decision and resulting uncertainty are the most demoralizing factor which will result in loss of personnel and deterioration of equipment and site facilities.

The decision will typically be made by the government, with inputs from many concerned groups, including the management of the utility and the plant.

If the DNPP has been well managed and adequately supported, much of the required information should be readily available, but even so, the preparation of a suitable submission will require considerable effort and time. This will be extended if, for whatever reason, the plant has been neglected during the suspension period.

Several relevant criteria affecting the decision about plant future are discussed below:

- *Public acceptance* of the nuclear power option. This is perhaps the most difficult issue of all to assess, but the one which can override all the other issues. The aspect of influencing public opinion is very important, as there will be no NPP if the public does not accept it, or at least does not actively oppose it. Therefore, this is a key issue to be addressed in terms of planning and effort required to secure public acceptance.
- *Economic viability* and availability of long-term financing must be weighed against alternatives, both with regards to cost of plant, cost of power and relative cost stability of the nuclear option arising from its lack of sensitivity to fluctuations in fuel prices.
- Other influences on costs are:
  - Extent to which the needs of the plant (equipment, materials, expertise) can be supplied nationally, thus providing an estimate of imports.
  - Prospects of obtaining satisfactory terms from vendors and suppliers.
- *Technical feasibility* of restoring the delayed NPP to operating condition. The plant may be decayed, obsolescent and technically unable to meet acceptable safety standards.
- *Extent of plant completion* the further the plant is advanced the easier it is to bring it to completion and production. At the same time, the amount of money already invested may be very large and, in the event of further delay, there are costs associated interest to be paid and with protection of the plant from deterioration and obsolescence. Length of time required to bring the plant into production has a large influence on costs — the longer the time the more expensive the plant becomes.
- *Projected power demand*_on the power system and the urgency to obtain additional sources of power. A new nuclear power plant is a long lead-time project when compared to some alternatives, e.g. natural gas. However, nuclear power projects in advanced stage of construction compare favorably with alternatives in terms of time required to reach commercial operation.
- National *strategic considerations* associated with:
  - desirability of diversification of sources of power away from excessive reliance on fossil fuels.
  - introduction of a new and advanced technology which requires development of technological skills and infrastructure and thus provides an impetus to industrialization.
- *Availability of personnel* and the length of time before they become qualified, and the amount of training required.
- Prospects of obtaining the necessary *regulatory approvals*.

2.2.2. *Project management*

Projects involve many participants, each of whom makes a specialized contribution. The direction and coordination of these contributions is a complex undertaking where many managerial, technical and human issues have to be dealt with and resolved. Hence, the importance of:

- statement of project objectives
- project management team
- defined interface procedures.

Project objectives

- In the event of continued delay, the objective is to preserve the plant and its personnel in a condition which will enable a successful restart sometime in the future.
- When the plant is eventually completed and operational, it must be capable of meeting acceptable safety standards.

In order to achieve these objectives within project constraints, the management of a DNPP must determine current status of existing resources. In particular, it must be determined what key resources are available or missing to enable the management to "advance or hold" the project.

These key resources are:

- *Trained, qualified and competent* personnel in all disciplines and skills which are required at a NPP. The need for this resource varies over time.
  - With the project "on hold", only a core group of staff is required to monitor technical developments, maintain existing equipment and documentation and assure their protection.
  - On resumption of project work, the greatest need is for project and construction managers, engineers and skilled construction supervisors and tradesmen.
- *Technical assistance* with respect to major equipment as supplied by vendors. This is particularly important with respect to the reactor, turbine and auxiliaries, electronic and electrical equipment within the plant or at vendor's warehouses.
- *Contracts and warranties* as applied to previously acquired equipment.
- *Adequate documentation* pertaining to equipment already at the plant, with respect to all the details and records dealing with manufacture, operating characteristics and maintenance requirements.
- *Equipment and facilities* at site and in vendor's warehouses.

Project management team

There must be one person in charge of the suspended project, typically the project manager. The project manager must be supported by an expert "project management team".

The "project management team" is responsible for:

- licensing, nuclear safety and quality assurance
- approval of project strategic plan and subsequent changes.
- provision of adequate resources as required by project plans, budget, and schedule.
- monitoring of status
- resolution of arising conflicts.

Project management team member selection criteria should ensure that the team contains required competence in project management, technical, interpersonal, communications, time management, and leadership skills.

The core group

These are the staff who have the detailed technical knowledge and administrative skills. They support the management and are in turn supported by tradesmen and administrative staff.

The leader of the **core group** is a member of project management team. Possible composition and organization of the **core group** are shown in the table on the next page.

The table shows the important functions that should be implemented at a DNPP The functions are divided between headquarters and site, and some are present at both locations

The specific organizational arrangements or their location are not important, as long as assigned responsibilities are satisfactorily carried out.

Quality assurance and interface control

The project must have a QA programme which meets the applicable standards.

All activities should be integrated into the project QA programme. They should be consistent with project management's requirements and programmes and must fit into the normal way of doing work.

Since project execution requires extensive co-operation amongst members of the project management team and other involved organizations, the matter of *interface controls*[4] *is a key consideration.*

The most important interfaces are with·

- Regulatory authority
- Designers, vendors and consultants
- Reference plant (see 5.2.2.)
- Internally within the project organization.

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[4] *Interface* A common boundary between two or more departments at which co-operative interactions are required between two or more organizations in order to execute an activity

CORE GROUP	
SITE	**HEADQUARTERS**
SITE MANAGER	**PROJECT MANAGER**
Technical and Administrative Support : • Preservation and maintenance. – Mechanical – Electrical – Instrumentation and control – Facilities – Surveillance and inspections • Operations • Emergency preparedness • Records and documentation • Performance assessment (QA) • Licensing • Training • Radiation protection • Industrial safety • Site security • Purchasing : – Site supplies – Warehousing • Personnel • Public relations • Administration	**Technical and Administrative Support** : • Nuclear engineering – Risk assessment – Reactor engineering – Fuel Handling • Mechanical • Electrical • Civil • Instrumentation and controls • Computers/information • Chemistry and metallurgy • Records and documentation • Operating Experience • Performance assessment (QA) • Training • Radiation protection • Materials management : – Contracts – Warranties – Supplies • Personnel • Public relations • Administration

2.2.3. Personnel and training

Nuclear power plant economics and safety considerations require the utility *to attract, develop and retain quality manpower.* Wide range of technical disciplines are required.

It is the project's management responsibility to ensure that personnel *are trained, competent and qualified for their assignments.*

There should be redundancy in staffing levels, so that technical capability would not be compromised by a loss of a single individual.

In developing the personnel strategy for the project, management must assure that staff:

- are available in sufficient numbers to deal with the work load
- have been at the plant for sufficient time, to assure continuity of experience and background
- continue to receive appropriate training, to maintain and improve their expertise.

Management should ensure that the level of collective technical experience and expertise at the plant does not decline below optimum level.

2.2.4. Strategic plan

The strategic plan lays out the actions necessary to achieve stated objectives (continued delay or plant restart and commissioning) within the specified time frame.

The strategic plan should define the following:

- *Project objectives* (results to be achieved) which govern numerous decisions to be made. These decisions involve tradeoffs between time, cost, quality and various technical and administrative performance characteristics.
- Project objectives must be:
  - realistic and achievable
  - coordinated with the regulatory authority.
- *Project scope* (work to be done) definition is essential to proper planning and management of projects. The scope of a project is a qualitative and quantitative description of work to be performed.
- Loss of scope control is a leading cause of project cost over-runs and schedule delays. Poor project definition precludes development of a clear baseline upon which project decisions can be made.
- *Project estimates* evolve throughout the project life cycle based on quality of information and project progress. Estimates will normally carry a "modifier," such as *study, release, definitive, etc.*, intended to describe a confidence level of estimate accuracy.
- *Economic risk/contingency*. Delayed projects are particularly prone to uncertainty, and therefore risk. In estimating the total cost of a project, a large number of potential outcomes exist, ranging from the best potential under-run (opportunity) to the worst potential overrun (risk). The attention of the project management team should be focused on key risk items, with lesser surveillance of the remainder. Appendix 2 offers more information on "risk management".

The strategic plan should be periodically reviewed and updated to reflect current status.

2.2.5. Preparing for project re-start

If it is decided to proceed with completion of the plant, the management is faced with a difficult task of restoring plant's viability and advancing to active construction and operations within the minimum time.

Degree of difficulty of this task depends on the amount of effective planning and work which has been done during the "delay" phase. If planning had been done, the plant has been preserved, maintained, records kept and personnel developed, the task will be a lot easier than if that had not happened.

The government (or another decision making body) needs solid information as the basis for authorization of resumption of work at a DNPP, and additional large expenditures associated with it.

When the decision to re-start the project has been made, additional following considerations should be addressed.

Current condition of resources already at site should be determined:

- What is the level of competence of staff at the plant? How much additional training and updating will be required?
- What is the condition of equipment and facilities at the plant, some of which has been in storage possibly for several years? Has the equipment been adequately preserved?
- What is the condition of documentation and records? Are there any shortcomings which must be rectified?
- Have major suppliers maintained their capabilities?

Financing and project schedule

- A plan of financing for restart of construction has to be developed and implemented. The necessary arrangements are to be finalized to ensure adequate cash flow.
- Prerequisites for resumption of work and eventual commissioning need to be drawn up.
- Project schedule must be finalized. This will depend on the financing scheme schedules committed by the decision making body (government) vendors and contractors, taking into considerations all the expected costs and the necessary contingency fund.

Procurement and commercial considerations

- Resumption of negotiations with vendors, contractors and suppliers with objective of reviving the contracts that were suspended and negotiating new contracts.
- Awarding pending contracts, which have not been awarded, either for construction or supplies should be initiated and contracts finalized.

Organization

- The existing organization has to be accommodated to the new task at hand. The organization chart should be developed and people hired to fill the various positions created.
- Responsibilities of subordinate project organizations (engineering, procurement, construction, operations) and their reporting relationships must be defined. Everyone must understand what they have to produce and by what time, and there must be no overlap.

- Both organizations — at the site and at headquarters — have to be modified and augmented.

Conditions at utility headquarters should be accurately assessed to establish amount of work remaining to be done and any organizational and other changes necessary.

The following has to be assessed:

- Engineering and design already completed and required to complete the project
- Amount of additional equipment and services to be ordered
- Safety studies, reviews and submissions
- Status of licensing process, including additional requirements from Licensing Authority, and impacts on design or construction work already performed
- Amount of engineering upgrades, as consequence of operational assessment, technological development and regulatory requirements.

Construction

- A new construction group has to be established at the site, its functions and responsibilities defined.
- This group should prepare an estimate of equipment, manpower, training and schedule for advancing and completing the project.

Human resources

- It is essential that recruitment plans be finalized and put into action at the proper times, so that staff be in position in required numbers and quality.

Training

- A major training programme has to be launched to prepare for the operational phase. The programme must be synchronized with hiring and expected commissioning.
- Managerial, supervisory, operating and maintenance personnel must be trained in sufficient numbers in all the knowledge and skills required. This is a major effort, whose success is essential for satisfactory operations.

Records and documentation

- Condition of records should be assessed and appropriate corrective actions taken.
- All records on performance and assessments of P&M (preservation and maintenance) should be compiled and reviewed.

2.2.6. Symptoms and attributes

Symptoms of developing problems

- No one person can be held accountable for the results

- Important decisions are not made because ambiguity exists as to who should make them
- Documentation which defines the organizational structure and responsibilities is ambiguous and out of date
- Services/products are not delivered on time and/or are of inappropriate quality and type owing to poor interfacing
- If a strategic plan exists, it is largely ignored
- Strategic plan does not include assessment of existing condition
- Plan fails to recognize need for knowledge and skill development
- Stated strategic plan objectives are not achievable with project resources
- There are too many pre-requisites to performing specific work
- Planned activities are global in nature, not specific, hard to measure
- Strategic plan being "activity oriented" (concentrates on the process to the exclusion of results), rather than "results and process" oriented.
- Training materials out-of-date, do not reflect the current "state of art"
- Qualifications of personnel lapsing (e.g. welders), skills declining.

Attributes of effective management

- Organizational charts and documentation are clear and up-to-date
- Planning is based on realistic estimates of work to be done and resources are available
- Interfaces are well defined and controlled
- Training of personnel is planned and implemented with satisfactory results
- The core group is well staffed, motivated and competent, understands its mission.

2.3. Performance

2.3.1. Introduction

Projects have historically separated the various functions participating in the project, such as for example: design, construction, procurement, public relations, etc. Each function has individually tended to optimize effectiveness and to minimize cost and schedule. Optimizing the individual parts, however, does not result in the most successful project.

The most effective approach is when all units are committed to the *effectiveness of the whole* project and optimize the whole rather than the parts. This approach must be kept in mind when reviewing the various functions described in this section.

This section provides practical guidelines with respect to implementation of project control and the main issues affecting it. Theses guidelines have to be adapted to the particular circumstances and culture of the plant.

2.3.2. Technical support

The **core group** are the key resource for provision of technical support. They can, and should, be assisted by specialized consultants, architects-engineers and by vendors as the need arises.

The following areas need to be addressed:

- *Assessments*, which should be ongoing throughout delay phase.
- *Relationships*, which refer to the need to closely co-operate with vendors of major equipment and with the regulatory authority:
  - Long-term and co-operative relationship with vendors and architects-engineers can be very beneficial to the project.
  - Relationships with the *regulatory authority* should be sincere and open, but formal. Clear and unobstructed lines of communication should exist between the project and the regulator. While regulatory staff should have open and unrestricted access to the project personnel, the official contacts must take place through specifically designated personnel. Regulators should have easy access to the designated personnel and pertinent information.
- A co-operative *"experience programme"* should be established with other DNPPs for the purpose of exchanging information and learning from experience of others.

In order to carry out the above functions, the **core group** staff must be supported by a modern and complete record and information system which includes the design bases, equipment and construction information.

Configuration management

The **core group** must define requirements of plant configuration management and ensure establishment of business processes, procedures and information system necessary for its implementation.

In all cases it is very important to know the status of existing equipment, buildings and structures when making the decision to restart. At all times there must be an up-to-date record of status of the project.

Consequences of loss of control of plant configuration can be severe. The plant management needs to know exactly what is in the field and therefore what remains to be done. Lack of this information would mean that scope of project could not be reliably established with undesirable results for project planning.

Restoring configuration management to a satisfactory condition might be a very expensive and time consuming effort.

Integration of activities

Integration of construction, operations, and maintenance knowledge and experience from other plants into project planning and design should be a specific ongoing activity during suspension phase.

The intention is to promote gradual improvement, a forward looking, integrated planning approach rather than a backward looking review of completed design.

Updates and improvements

It must be recognized that codes, standards and industry practices change over time. Therefore, for projects which experience considerable delay it will be necessary to review and very likely update many of the designs, documentation and equipment to meet the current standards.

Additionally, as technology advances, it may be possible to significantly improve design and equipment selection by incorporating the advances. The project staff must keep up-to-date and be aware of these possibilities.

The improvement process should be managed through a programme of:
- design studies
- cost–benefit analysis
- re-assessment of safety analysis

Plans for re-start should include an allowance for the above considerations. Their satisfactory resolution will require commitment of significant resources — staff and money — and also time.

2.3.3. Communications with the public

Communications policy

Project management — in co-operation with corporate management and communications advisers — should develop a communication policy which would spell out principles on which the communication plan should be based. This policy should be approved by senior corporate management and supported by all staff.

Influencing public opinion through communications should be a long-term, continuous programme. Targets, contents and performance measures of the communication programme should be defined.

Main features of communications programme

- Communication shall be directed at the opinion formers and other target groups in the government, project stakeholders and society in general
- Target groups should be defined and identified
- Their opinion should be influenced towards active support of the nuclear power project
- Within the limits of communication policy, opinions promoted by opponents of nuclear power shall be countered and discredited, if incorrect or untrue.
- A senior management committee shall be formed to periodically review, direct and assess the extent to which objectives of communication/information programme are being achieved.

Target groups

A "target group" is an identifiable group of people who hold similar opinions and attitudes towards nuclear power in general, and the project in particular. "Target groups " for or against nuclear power project should be identified through opinion surveys and other techniques.

Target groups are important because they have influence and power in their respective domains to affect outcomes of various nuclear and other electrical power initiatives

Communication techniques

Standard communication techniques should be used, but expert advice from specialists in the field of communications, information, advertising and promotion, public and governmental relations should be obtained and heeded.

The issue of public and special-interest opinion is of extreme importance to the project and the nuclear power programme and as such should be dealt with professionally. Amateurs in the field – however well intentioned – should only be used when appropriate and only after they have received training in public speaking or presentation techniques.

Appendix 3 discusses additional details and considerations in regards to "communications with the public".

2.3.4. Management of procurement

Commercial considerations

Difficult and sometimes protracted negotiations are necessary to satisfactorily deal with the problems caused by extended delay of the project. The problems arising from the delay fall in the following categories:

- deliveries, and consequently payments to suppliers may have to be deferred. This creates a problem for the supplier who has invested money in materials and manufacture of equipment, even though it may not be completely finished.
- storage of completed or partially completed equipment at manufacturer's facility, sometimes for extended period of time. Matters of physical protection, storage fees and insurance are of concern.
- extension of warranty on the equipment so that it starts at the time of delivery, and not at completion of manufacturing.
- a related problem arises with equipment which has been delivered, but has been stored at site and not used.
- the matter of technical improvement to be incorporated and its cost. Related to this is the matter of upkeep of documentation, to ensure that the latest configuration of equipment is accurately recorded.

Supplier (vendor) relations

Relationships between buyer and supplier vary from adversarial to co-operative, with several variations in between.

In dealing with suppliers, there is a continuing need to establish a relationship that is built on mutual trust and respect and ethical conduct.

The delayed power project should strive to involve the supplier in the longer term and to get into the co-operative relationship mode, as several distinct advantages arise:

- The project gains access to information arising out of operating experience.
- Information about new technology and possible improvements to equipment become known to project staff, and thus represents an option. This is a form of a "transfer of technology" programme.
- Project personnel have an opportunity to form professional and personal relationships with their counterparts in the supplier organization, thus becoming better informed.
- Arrangements can be made for project personnel to visit, or work, at supplier's plant, for the purpose of becoming familiar with equipment.

In summary, good relations with the supplier (vendor) present several advantages and opportunities to the project, and conversely to the supplier.

Development of alternatives

During the delay period, project staff can be usefully occupied by addressing the technical and commercial considerations which might arise once the work on the project is resumed.

These are:

- preparation of tender documents for the future, allowing for inclusion of the latest standard's requirements and technical improvements
- reviewing and revising suppliers' list, based on research into and investigation of alternative suppliers
- exploring and developing local options for supply of some of the equipment.

2.3.5. Management of construction

General considerations

Construction management is a key component of project management team and must be fully integrated into it. Good communications between project managers, design, licensing, procurement, operations and construction organizations are a necessary pre-requisite to success.

When construction resumes the matter of its quality assumes primary importance. General planning for resumption of work should have continued throughout the "waiting period", but now details have to be worked out.

Assessment of condition

Detailed assessments of all equipment and facilities should be carried out, including:

- inspection of external and internal parts of components (prioritized).

- establishment of the exact point where each building, component or system has stopped when the construction was suspended and establishment of precise plan to re-start and complete all of them.

Information feedback

Construction experience should be feedback to the design organization to promote design and construction improvements. This information should be transmitted formally. Matters relating to difficulties encountered during construction are of special interest to the design organization.

Financial and schedule considerations play a key role in determining the economic viability of the project. Long delays cause interest payments on capital to accumulate. Cost overruns arising from poor project scope control, lack of control of labor, materials and construction processes add to overall cost of the project, as well as frequently requiring re-work, and thus adding to project delays.

Environmental considerations include minimizing the impact of the project on the environment and ensuring satisfactory cleanup once the work has been completed.

Documents and records

All work done must be documented and recorded. Records of work done must be maintained and transferred to the Commissioning and design organizations as appropriate.

Organization

The organization of a construction project usually has two main groups:

- *performance group*, who are responsible for directing and controlling the work being done at the site
- *oversight group*, who ensure that the work is being done in accordance with the design requirements. The "oversight group", sometimes called the "resident engineering" or “site engineering” carries out verification and ensures, on a daily basis, that work is done in accordance with design requirements.

Planning

Upon resumption of work, detailed planning for construction must start, taking into account the extent and condition of the existing structures and equipment.

As the first step, a "pending task list", which should have been kept up throughout the delay period, should be reviewed, updated and prioritized.

Planning includes:

- review of current code requirements, design specifications, design documentation, materials and equipment, manufacturer's specification and drawings.

- preparation of schedules, fabrication plans, inspection and test plans, checklists and control procedures.
- assuring adequate numbers of trained and qualified personnel
- confirming that work schedules coincide and dovetail with availability of material and equipment
- establishing requirements for records required by the quality assurance programme.

Management of materials

In order to deal effectively with materials, the following issues must be addressed:
- receiving
- storage (warehousing)
- issue of material
- quarantine of non-conforming material
- repair and refurbishment.

Consideration of spare parts policy at the plant — the responsibility of procurement -involves a large technical component. For that reason decisions with respect to availability of spare parts over the plant's life must include a very significant input from technical staff.

Of special concern is the issue of material traceability. Traceability is maintained by physical identification or, where this is impractical, by segregation or by records traceable to the item. A material identification system ensures that only the correct material is used.

Industrial safety, security and fire protection

Project management bears responsibility for welfare and well-being of workers at the project site. This implies dealing with psychological and physiological requirements of the work.

The project should have a documented Safety programme which meets the requirements of local regulations with respect to establishing, maintaining and reporting on safety of working practices.

Security of the project site must also be assured. It is usually assured through a security organization

Fire is an ever-present danger at construction site. Fire prevention and fire-fighting procedures should be developed and rigorously enforced.

Contracting

During planning of construction work, decisions are made as to what will be contracted out and under what arrangements. Contractors employed to construct the plant should be selected from those who can demonstrate that they are suitably qualified and experienced to carry out the work.

The following issues should be considered in development, establishment and management of contracts:

- the total agreement between the parties is of paramount importance, but the language of the individual contract clauses merits careful consideration.
- consideration should be given to applying the concept of partnering with external suppliers and contractors in situations where it is most cost effective to have an external organization provide long-term support.

It should be noted that inconsistencies and ambiguities in a contract breed misunderstandings, delays and increased costs. Clauses related to work scope definitions, changes and project control are the most frequent sources of disputes and poor project performance.

2.3.6. Symptoms and attributes

Symptoms of developing problems

Technical support

- there is large backlog of technical work
- many technical solutions are found ineffective, requiring repeat work
- there is lack of accurate record of plant equipment and arrangement (configuration control)
- individuals maintain their own private documentation systems instead of using the appropriate centralized documentation system.

Communications

- Utility employees not familiar or supportive of the nuclear programme
- Hostile articles in the press showing lack of information or understanding of issues
- Prominence given to opponents of nuclear power by the mass media
- Local opposition to nuclear power, arising of lack of familiarity with advantages of it
- Ambivalence on the part of government driven by lack of clear information from the nuclear proponents
- Communications with the regulator are inadequate and excessively formal.

Procurement

- Supplier refuses to negotiate any contract revisions arising out of project delay
- Equipment not being upgraded to keep up to revised standards and improvements in technology
- Adversarial relationship is developing between supplier and the project, with mutual suspicion, hostility and lack of co-operation

- Project staff are not actively searching for and evaluating alternative suppliers
- Quality of equipment is indeterminate due to lack of co-operation between supplier and project.

Construction

- Poor working relationships with contractors due to contract ambiguities
- Security infractions resulting in damage to buildings or equipment
- Minor fires frequently occur
- Safety programme ineffective in preventing injuries.

Attributes of effective management

- the core group provides effective technical support in an organized manner by answering questions and queries in a timely manner
- good working relationship with the regulator exists
- audits of configuration management confirm satisfactory performance
- there is a communications policy and communications plan and its being implemented
- relationships with vendors are managed in a professional manner in accordance with agreed procedures
- construction organization has been constituted and is performing its duties.

2.4. Assessment

2.4.1. Introduction

The importance of assessments arises from the need of management to have an impartial, objective and structured evaluation of quality of performance.

In the absence of such evaluation, the management might persuade itself that everything is going very well, especially as subordinates might be tempted to provide desired information only. Performance could then deteriorate rapidly, without management being aware of it.

In order to become pro-active and address problems promptly, the management must be aware what the emerging problems are. The best way to obtain this information is through effective assessment.

2.4.2. Assessment policy

There are no specific stndards against which performance of a delayed, dormant plant can be assessed. However, specific functions within the project, such as management, engineering, procurement and construction can be successfully assessed against accepted national and international standards, and also by "benchmarking"[5] against the best performers.

Additionally, performance can be assessed against:

- Project specification documents
- Manufacturer's documents
- Established good engineering practices.

The assessments policy should therefore·

- compare against the best and thus strive for excellence
- use applicable standards to the extent possible to assess functional performance within the project organization
- examine results achieved, rather than activities or compliance
- when assessing, apply "performance based"[6] methodology.

2 4 3 Symptoms and attributes

Symptoms of developing problems

- Assessments are routinely delayed or canceled
- Assessment results are not reviewed at the appropriate level in the organization and are not acted upon. Root causes of identified problems are not established
- All problems are treated equally, there is no evidence of prioritization of corrective actions
- Many ostensibly completed corrective actions are judged to be inadequate during independent assessment of their effectiveness
- There is evidence of lack of critical evaluation of plant performance and pro-active identification and correction of problems
- Lack of performance standards and performance measures which can be directly compared to other projects
- Problems reach a crisis level and are evident to all, including the regulators, before they are identified and corrected.

Attributes of effective management

- Personnel are involved in the identification and timely correction of identified deficiencies

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[5] *Bench marking* recognizes excellence in a particular function, (e g control of spare parts) by going to the best performer – who very often is not in the same industry - and establishing the techniques and root causes of the excellent performance

[6] *Performance based* approach pursues the achievement of quality of performance in all areas of the project This approach emphasizes the key management responsibility and accountability Attention is directed at performance and results, rather than compliance

- A formal process is employed for determining root causes of significant problems.
- Attention is directed to problems that matter most through a prioritization process
- Audits and assessments are scheduled and regularly conducted
- Management adopts constructive attitude to assessment results, such as:
  - Co-operates with auditors
  - Is willing to listen and learn from audit findings
  - Evaluates findings for root causes
  - Implements corrective actions
  - Confirms their long-term effectiveness.

2.4.4. Quality indicators

- Number of technical proposals which are behind schedule
- Number of regulatory inquires which have not been answered within specified time
- timeliness of answering technical questions from site
- Number of events where the documentation does not correspond to the equipment arrangement
- Number of popular publications and press articles published
- Number of visits to the public information center
- Number of meetings/presentations delivered to "opinion makers" and "decision takers"
- Number of international papers presented or published
- Number of contracts and warranties re-negotiated
- Number of visits to vendor facilities
- Number of items which cannot be traced
- amount of money lost due to deterioration of materials
- Number of lost-time accidents per 200 000 hours worked
- Number of "near misses[7]"
- Number of fires.

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[7] *Near miss*: An event in which a serious accident has been avoided through luck.

3. RETENTION OF HUMAN RESOURCES

Summary

This section deals with management considerations and activities aimed at preserving the manpower resources necessary for re-starting the plant. Factors affecting personnel attitudes, effectiveness and retention are discussed. Planning for retention of optimum numbers of personnel and activities to accomplish that are discussed. Symptoms of possible developing problems are presented.

Conclusions

The following conclusions arise from this section:

- Adequate human resources are the key to successful re-start,
- Effective measures to preserve human resources can be taken by the project and utility management
- As the minimum, a core group must be established and maintained to manage the most important activities and to provide continuity
- Theses measures must be adequately planned and supported.

3.1. Introduction

Adequate human resources, both in terms of quality and numbers, are the key ingredient for successful resumption of the NPP project, the eventual start-up and operation of the plant. Hence, project management must implement a set of effective steps to preserve, control and manage its personnel.

This section provides practical guidelines with regard to this issue. They have to be adapted to the particular circumstances and culture of the plant.

3.2. Management

3.2.1. Planning for preservation of human resources (HR)

The main objective is to retain essential personnel in order to be in position to re-start the project and complete it within the required time period.

Soon after plant suspension, management must develop a long-term plan with respect to its human resources, which should address the following issues:

- project organization and the role and responsibilities of the **core group**, both at site and at utility headquarters
- the numbers and skills which the "core group" must posses
- methods of ensuring preservation of the project "core group" and of other personnel
- activities and programmes which will enable the project to maintain and develop younger personnel.

The functions of this essential technical support core group, dedicated to the plant are:

- keep abreast of technical developments - new and developing technologies
- keep up-to-date with technical and quality standards
- maintain accurate status of plant (configuration management)
- be in touch with regulatory developments
- be in touch with operational experience
- periodically assess the plant condition, vis-à-vis developing requirements and identify the modifications necessary, together with time and resources required for their implementation.

When preparing the Human Resources (HR) plan, the following factors must be taken into consideration:

Finances

- *Cost and availability* of money is a key criterion in deciding on the measures to be undertaken in order to retain qualified personnel. Saving money — and having fewer personnel - during the delay period will result in a longer time being required to assemble appropriate personnel when re-start is attempted. Additional delay costs money.

Skills

- Keep abreast with the *latest state of art in safety and engineering* technology, to avoid obsolescence at the time of re-start of a delayed project.
- Availability of *technical skills external to the delayed project* (such as consultants, vendors, etc.) and opportunities for their effective utilization for developing their own personnel.
- Need for qualified persons to implement and ensure various *QA programme aspects* associated with the delayed project. In particular, at the time of project re-start, it would be necessary to carry out additional inspection at the vendors, and testing of components, structures and equipment in order to demonstrate their adequacy.
- Additional manpower *and skills required for re-negotiations* of technical, schedule and contractual arrangements between the NPP and its vendors
- Persons engaged in nuclear electricity generation must have multi-disciplinary technical and managerial skills in different fields acquired through training and experience. Once lost or dissipated, *these skills cannot be re-acquired at short notice.* Hence the incentive to preserve them.

Project phase

- *Phase of the project* at the time of onset of delay determines not only the number of persons engaged in the project, but also the nature and extent of work remaining to be done. Thus plans of action drawn up for HR management will be considerably different if the project were to be delayed when construction is at its peak, compared to either very initial stages or approaching completion and commissioning.

- *If the delay is long*, of the order of several years, the date of project resumption is difficult to predict. Thus the HR action plans drawn up must be flexible and periodically revised.

- Delay in completion of a project *by means of slow down*, rather than complete stoppage, will result in more effective utilization, and hence retention of personnel.

Contract specifics

- *Type of contract* under which the project is being executed (turn-key project or project with technology transfer included, etc.) has a big influence on HR planning. If external experts are present to guide the work, plant personnel have a good opportunity to learn and acquire experience "on the job".

Country specifics

- A broad based, multi plant nuclear power programme would inherently have provision for continued in-take and training of engineers, scientists and technicians at entry level, thus providing a *cushion for HR planning* for the delayed plant. This "cushion" does not exist for a single, first project in the country. In such a case, difficulties with retention and subsequent build-up of personnel are to be expected, and the HR plan will have to be more comprehensive, detailed and vigorously executed.

- In countries with advanced *industrial infrastructure* it may be possible to re-establish the project team and manufacturing capability on relatively short notice. Conversely, in countries with relatively weak industrial infrastructure, special measures must be proposed in the HR plan to retain personnel at the project and the vendors.

- Other factors which affect HR planning are :
  - social and cultural environment in the country
  - prevailing political and economic conditions
  - availability of acceptable alternative jobs for the skilled personnel of the delayed NPP.

3.3. Performance

Long project suspension and lack of clear picture about plans for the future may lead to demoralization of the staff, which can manifest itself by:

- Loss of work ethics and changes in working attitudes

- Loss of interest in project "well being" and its future development

- Frequent discussions and active search for better opportunities elsewhere.

Managers should be aware of these effects of long project delays and the problems which may arise in following areas:

3.3.1. Potential problems relating to personnel

Delays cause disruption of established working programme often resulting in:

- Loss of senior staff and reduction in:
  - Technical supervision
  - Knowledge and skills
  - Experience
- Loss of morale and motivation due to :
  - Uncertainty about future of the project and individuals associated with it
  - Lack of tangible results when not much is being done at the project
- Loss of urgency and need to meet schedules
- Possible changes and losses of personnel at the project and vendors
  - loss of continuity
  - organizational changes and upheaval.

These potential problems can be accentuated by:

- Negative changes in public perception about nuclear power
- Political/economic conditions reflecting on the future of DNPP.

As a result of the above, bright young engineers and technicians may not see a satisfying career in nuclear engineering (or subjects allied to nuclear power plants) and thus opt for other, more economically lucrative or intellectually satisfying jobs elsewhere.

This could result in the gradual increase of the average age of personnel in the organization and lack of trained, experienced,younger personnel to take over and to replace those retiring.

Severe shortages of experienced staff could develop and impact negatively on performance during re-start, commissioning and operation.

3.3.2. Measures to retain personnel

In order to retain and develop human resources, within their monetary and other constraints, managers of DNPPs must plan for and implement activities which will counteract the problems enumerated above. These activities must contribute to retention and development of personnel, while at the same time accomplishing useful work.

Some of these activities are enumerated below under various headings:

Keeping personnel actively involved in project work:

- Managers should set an example and counter tendencies to disregard schedule and lack of commitment to targets during the delay period.
- Project planning should be aimed at avoiding total stoppage of work. Activities such as design, analysis, keeping up with technology and regulatory requirements, construction, project monitoring, financial planning, procurement (re-negotiations with suppliers), or

quality assurance should be pursued, at least at a minimal pace so that project continuity is maintained.

- Tasks which can be performed (within the financial and other constraints) should be taken up and completed using a "sub-project" approach. For example, it may be possible to complete the erection and commissioning of a system or sub-system, or complete any design or analysis activities already on hand, thereby keeping the personnel actively engaged.

Keeping personnel informed:

- An important element in maintaining morale of project personnel is their need to know "what is happening?". Therefore, it is essential to systematically provide accurate information to the staff on the project status.
- Regular information meetings with staff are held by management to keep them informed and to answer questions in an open and truthful manner

Providing alternative opportunities:

- Project personnel may be encouraged to undertake engineering and consultancy services outside of the delayed project, while maintaining their commitment to the project. Thus project manpower may be temporarily re-deployed with a view to retain and enhance their skills. Contractual arrangements between individuals and the project have to be carefully thought out, as longer term outside assignments carry with them the risk of personnel refusing to return when needed
- Greater responsibilities should be given to younger staff, while utilising the more senior staff as "mentors". This will result in providing the manpower source for replacement of those retiring
- Employees should be trained and utilized for effective communication with the public for the purpose of positively influencing public opinion and awareness of the NPP

Maintaining satisfactory conditions of employment:

- Pay should be maintained at the level equal to or exceeding alternative opportunities
- Satisfactory social and cultural conditions should be maintained for employees and their families, thus minimizing incentive to move to other locations.

Providing developmental training:

- Management development programmes should be introduced for engineering staff, who would thus become familiar with various aspects of power plant management.
- Technical development programmes should also be introduced, to give engineers an opportunity to familiarize themselves with technical topics outside of their specialties.

Rotations and assignments within the project and the utility:

- Re-organization and re-assignment of work should be implemented to assist in keeping personnel engaged and motivated by providing opportunities to learn about many aspects of the project. While experience is broadened, care must be taken to maintain continuity.
- Management should support temporary assignments to other power plants, nuclear or otherwise, or to other industries for the purpose of exposure to other management and technologies, and for general industrial experience.
- Participation of project staff in peer-reviews by external specialists should be encouraged, possibly with IAEA assistance. This will help in widening the knowledge base of the participants in the peer-review programme.
- Self-assessments within the project should be regularly conducted. This provides training in auditing techniques and tends to promote small-scale improvements. Technical and managerial topics should be assessed.
- Co-operation between delayed projects in various utilities and countries should be encouraged. As many DNPPs experience similar problems, there is lots to be learned by personnel exchanges and visits. IAEA might facilitate these contacts.

Actively recruiting younger staff

- Plans to attract younger, new staff during delay phase and especially once the project resumes, should be developed. They must take into consideration the conditions and opportunities existing at the time and the current and expected career opportunities at the NPP. Part of the attraction might be the training and professional development opportunities offered.

3.4. Assessment

3.4.1. Symptoms and attributes

Symptoms of developing problems

- Assigned work is not completed on time, delayed for no obvious reason and put off till later. Schedules and target dates are routinely missed.
- Mistakes made due to reduction in experience and supervision and loss of continuity of personnel.
- Quality of work is indifferent. There is a clear lack of effort and desire to do excellent work
- Absenteeism is high because staff take time to look for other jobs being available. Search for other opportunities is discussed openly and information is exchanged.
- There is not enough work to keep everybody occupied. Staff don't conform to designated working hours.
- Staff openly complain about poor working and living conditions. They and their families, express unhappiness with accommodations and facilities at the project site.
- Employee surveys confirm the general feeling of dissatisfaction.

- Management is ineffective in combating lack of discipline. There is no long-range plan for personnel and no significant actions are taken to turn things around.
- Frequent personnel changes at the managerial level, lack of continuity in policy.

Attributes of effective management

- Management has a plan to pro-actively maintain staff morale and acts upon it.
- Alternative opportunities for staff are pursued and staff are encouraged to avail themselves of them.
- Management has a meaningful work and training programme and insists on timely completion of assigned projects.
- Satisfactory conditions of employment are maintained and management demonstrates their concern about employee well being.
- Management is open to staff, willing to listen, talk and accept reasonable suggestions.
- Participation in national and international activities is encouraged and supported.
- Staff is available to fill all positions without overload.

3.4.2. Quality indicators

- Annual staff turn-over, as compared to specified target
- Number of essential positions on the staffing plan not filled
- Number of essential positions filled by 1 person only i.e. without a back-up
- Number of staff participating in alternative employment/development opportunities per year
- Number of staff participating in international nuclear activities, per year
- Number of information meetings held in a year
- Per cent of staff whose personal performance assessment is better than specified target
- Per cent of work completed as per original schedule
- trend of average age of personnel (up or down).

4. PRESERVATION AND MAINTENANCE (P&M) OF EQUIPMENT AND FACILITIES

Summary

The "management" section deals with mission, objectives and organization of P&M team, including their necessary technical support group.

Training requirements are briefly discussed. Planning for P&M is reviewed, together with policies and issues which must be considered. These are both generic planning issues and issues specific to DNPPs, such as financing.

The "performance" section deals with planning and prioritization of preservation and maintenance activities. Considerations specific to DNPP are discussed. Also discussed are specifics of what is to preserved, degradation mechanisms and activities to implement preservation. Maintenance activities and methods are reviewed for selected equipment. Symptoms of developing problems and performance measures are presented.

Conclusions

The following conclusions arise from "Management" section:

- The project organization must include a dedicated P&M team and its technical support group
- Continuous training of personnel in matters pertinent to P&M is essential
- Both short-term and long-term planning must be performed and policy issues decided.
- P&M Manual should be prepared and kept up-to-date
- Contract and warranty issues are potentially very costly and must be carefully negotiated
- QA programme associated with P&M should be part of over-all project QA programme.

The following conclusions arise from "Performance" section:

- Successful P&M is achievable, methods and experience are available
- For success, close managerial control and assessment is necessary, including implementation of a surveillance, inspection and condition-sampling programme
- Prioritization of items and planning at plant level for their preservation and maintenance is essential.
- Preservation and maintenance methods of individual pieces of equipment need to be established. Good records and history dockets are necessary
- A co-operative relationship with vendors must be established
- Major degradation mechanisms are the chemical-metallurgical interactions.

4.1. Introduction

P&M of facilities and equipment serve to protect the investment already made at a DNPP and also make it easier, cheaper and possible to re-start the plant. Hence the importance which must be accorded to proper management and performance of theses activities.

In the context of this publication, preservation refers to activities associated with protection of facilities and equipment against deterioration due to elements and environment. Maintenance refers to activities necessary to maintain operational capability of the equipment.

These activities — P&M — must be done both at site and at the vendors, if that's where the equipment is. A well planned and rigorous programme is necessary to satisfactorily execute and record P&M activities.

This section provides practical guidelines with regard to this issue. They have to be adapted to the particular circumstances and culture of the plant.

4.2. Management

4.2.1. Objectives and organization

The main objective is to preserve and maintain facilities and equipment in order to protect the investment and also to be in position to re-start and complete the project within the specified time period.

The activities should focus on the preservation of physical condition of facilities and equipment, as well as on performance of maintenance necessary to retain operational capability of the equipment.

This can be best achieved through an *organized structure (P&M team)* responsible for the P&M aspects of the project. Responsibilities and accountability of P&M team should be clearly defined. Specific organizational arrangements for fulfilling P&M functions are not important as long as all the necessary activities are assigned and carried out.

The P&M team should be a part of the **core group** and be provided with appropriate authority and resources, which must include:

- People
- Materials
- Information
- Tooling
- Supplies and spare parts.

The mission of P&M team is to:

- Preserve and maintain project facilities and equipment
- Maintain project site
- Implement corrective actions to correct undesirable condition
- Keep accurate records of work done
- Implement modifications as required by project management
- Set up a programme for industrial safety and housekeeping;
- Set up an Operational Experience programme to exchange with other DNPPs.

The key responsibilities of the P&M team are:

- Planning for resource management in terms of manpower, materials, finances, procedural control and interface, providing sustained technical support, and implementing industrial safety and housekeeping programmes
- Preservation and protection of equipment in stores at site and at vendors
- Preservation, protection and maintenance of installed equipment and systems
- Preservation, protection and maintenance of facilities - civil structures and works, buildings, water and power supplies and similar
- Safety surveillance of the site, with respect to industrial safety
- Provision of infrastructure and support services including security, ware-housing, fire protection, etc.
- Preparation and upkeep of P&M Manual, which should be approved by project management. Manual contents should include:
    - Scope of the P&M programme,
    - Specifications for preservation of equipment
    - Performance acceptance criteria i. e. desired values of chemical parameters with tolerances
    - Details of control procedures and sampling frequencies
    - Thresholds and recommendations for corrective action.

The Manual should be periodically reviewed and updated.

To help the team in the accomplishment of its goals, the P&M team must have *long-term technical support*, dedicated to P&M team assistance and problem solving.

This technical support group should be a part of the **core group** and should consist of personnel who have knowledge and experience in P&M, with special strength in material sciences and chemistry and are capable of taking the long-term view.

The mission of the technical support group is to assist the plant management in the achievement of satisfactory long-term P&M performance. The key elements of this function are:

- Day-to-day advice and problem solving
- Taking the long-term view
- Establishing P&M performance standards
- Keeping in touch with new trends
- Ongoing assessment of P&M status and results at the plant
- Preparation and approval of P&M procedures.

4.2.2. *Training*

Personnel involved in planning and execution of P&M should be competent and receive specialized training in relevant areas, such as, for example:

- Protection requirements for specific materials, such as stainless steel or elastomers
- Corrosion protection and detection
- Principles and details of equipment lay-up schemes (mothballing) such as dry and wet preservation programmes and their relative advantages
- Preservation of civil structures, installations and buildings
- Warehousing procedures
- Inventory control
- Operational training at a power plant.

This training should be delivered by experts and include hands-on, practical experience in application and assessment of the lay-up programme.

Training should be carried out on a continuous basis and kept up to date with respect to operational experience elsewhere and new technological developments.

4.2.3. *Planning for preservation and maintenance*

Soon after plant suspension, management must develop a long-term policy and plan for P&M, which should address the method of approach to this problem.

The policy issues which must be decided are:

- Setting up an organizational framework for P&M work
- Selecting the overall method for implementing P&M
- Resolving the issue of provision of resources to adequately achieve P&M objectives
- Establishing the combined technical and economic (techno-economic) criteria for prioritization of P&M work
- Preparing cost estimates, control and budgeting of expenditure
- Dealing with contracts and warranties
- Addressing issues such as "replace or repair ", and "make or buy"
- Spare parts management.

Additionally, the plan must address the following issues:

- Composition and responsibilities of P&M team
- Criteria for deciding which systems should be completed and operated

- Establishing priorities for equipment preservation, based on techno-economic criteria
- Establishing priorities for facility preservation, based on techno-economic criteria
- Specifying requirements for records of work done, in accordance with the QA programme.

A **computerized database** designed to provide information about plant hardware and structures should be created. The data base should be integrated and compatible with other project data bases, e.g. documentation database.

When preparing the P&M plan, the following factors specific to the DNPP must also be considered:

- Finances
- Project phase
- Country specifics
- Contract specifics.

Finances

It is necessary to evaluate costs which will be incurred as the result of suspension and of subsequent P&M activities, with an assessment of various alternatives. Some of these costs are:

- Pending payments on activities performed before the suspension of the project, which will fall due during the suspension phase. All such due payments must be identified and introduced in the payment schedule.
- Cost of P&M and some essential project construction activities performed during the suspension period.

Project phase

- Phase of the project at the time of onset of suspension determines the amount of equipment and facilities to be preserved, with the amount rising as the project progresses.
- The resources required for effective P&M depend on:
  - Status of the project
  - Amount of equipment at site
  - Amount of equipment purchased and stored at vendors.

Fig. 1 illustrates the relationship between nature and duration of delay and P&M. Fig. 2 illustrates the relationship stage of completion and P&M efforts, which is also discussed in section 5.2.3.

Country specifics

- If the DNPP is part of a country-wide nuclear power programme consisting of other similar reactors, then very likely there is experience, procedures and practices directly applicable to equipment and facilities preservation. The DNPP should make maximum possible use of this experience and the personnel associated with it.

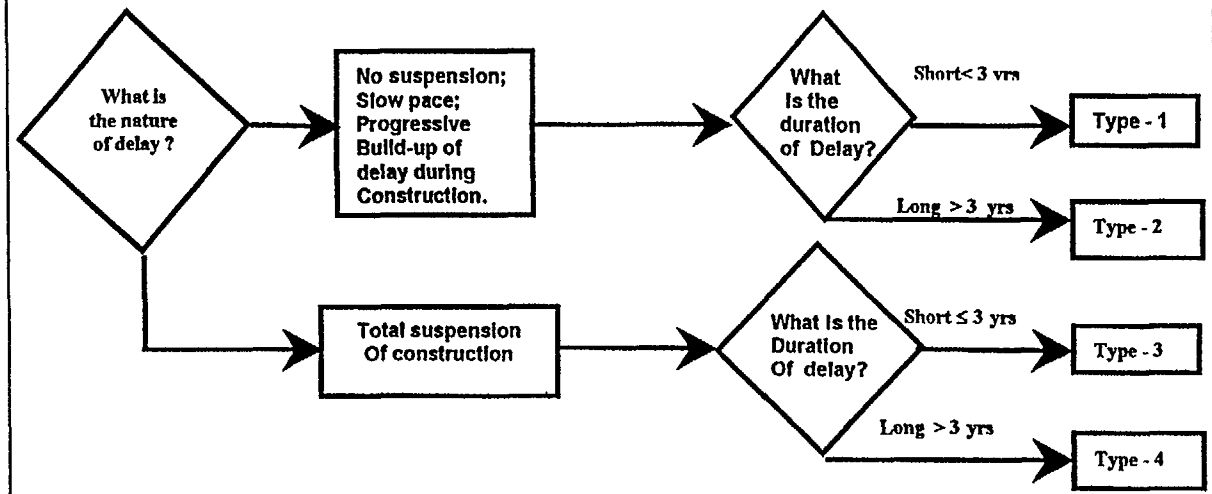
- This "cushion" does not exist for a single, first project in the country. In such a case appropriate procedures and methods must be developed. This is a difficult task and expert assistance is required from vendors and consultants.

Contract specifics

- Resolution of problems in this potentially costly area is to be negotiated and decided by project management with input from management of P&M function.
- In the case of long suspension, the financial and contractual implications are significant.
- Contracts and warranties are one of the major difficulties arising out of project suspension. The way these difficulties are resolved influences performance of P&M functions and responsibilities for it.
- In all contracts, warranty is invariably for a specific agreed period. In cases of delay, it becomes necessary to extend the warranty.

The table below provides a summary of costs which might be incurred.

CLASSIFICATION OF PRESERVATION AND MAINTENANCE COST	
Cost Concept	Description
Preservation and Maintenance of materials/equipment, structures and installations	Materials, facilities and equipment for preservation and maintenance of site installations, structures and equipment. Repair or replacement of items. Expenses towards repair, consumable materials, etc.
Wages and salaries	Wages and salaries of all technical, administrative, finance, legal, etc., staff
Insurance	Cost related to insurance charges for the property and other assets including work in progress and civil liability insurance
Supplier's advice and inspections	Charges towards advice and inspection from manufacturers or suppliers
Engineering	Expenses towards engineering support and preservation of engineering knowledge
Study, consultancy and other advisory contracts	Expenses towards contracts with specialist organizations for studies or provision of consulting services related to degradation effects and ways to reduce their impact
Contract cancellation, indemnity or warranty extensions	Expenses relating to cancellation of contracts, or adapting them to the new situation, and charges towards the extension of warranties or indemnities
Travel	Expenses towards travel expenses and allowances of the staff
Hired services	Expenses towards maintenance services carried out by off-site staff
National/local taxes and fees	Expenses towards various taxes; Charges payable to regulatory authority, and administrative fees if applicable
Other costs	All other preservation and maintenance costs not included in the above



<u>Type - 1 & 2</u> Construction work forces and facilities at site; frequent attendance to problems possible; preservation & maintenance could be done as part of construction.

<u>Type - 3 & 4</u> Construction suspended; special efforts required for mobilisation and management.

<u>Type - 1 & 3</u> Short delay and hence preservation and maintenance part of normal construction practice.

<u>TYPE - 2 & 4</u> Long delay and hence special preservation and maintenance measures needed.

FIG. 1. Types of delays in a delayed NPP.

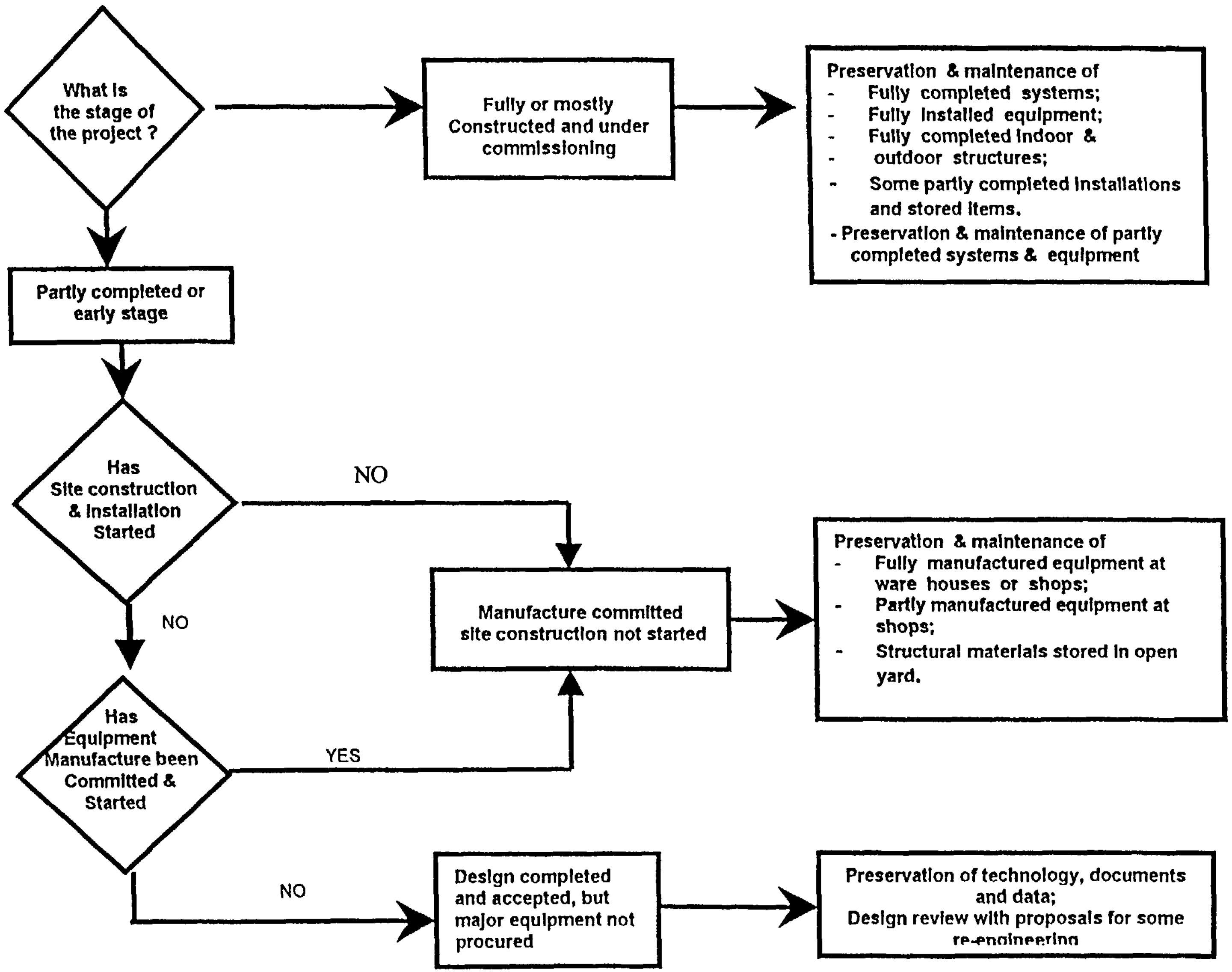


FIG. 2. Stages of construction in a delayed NPP.

4.3. Performance

4.3.1. Introduction

Items of the DNPP which are to be preserved and maintained are the following:

- Items stored at site warehouses
- Items located at the manufacturer's (vendor's) shops
- Items installed in systems which are either completed or not completed;
- Buildings and structures.

The key aspects of a preservation and maintenance programme are:

- Physical protection and preservation of components against damage for the suspension period
- Preservation and maintenance of completed system
- Performance of maintenance activities such as preventive maintenance, major overhauls, modifications, replacements and repairs where necessary.

4.3.2. Prioritization

The thousands of components in a DNPP need to be prioritized for P&M. It is neither feasible nor desirable to assign the same level of priority to all components. Prioritization should be based on:

- Importance to nuclear safety
- Value of the item and ease of replacement
- Condition of the item
- Future availability
- Sensitivity of item to lack of preservation
- Cost of preservation versus replacement

This prioritization for P&M is based on techno economic considerations and is not a substitute to any regulatory or safety classification.

Appendix 4 offers additional information on this topic.

4.3.3. Planning

Implementation of preservation and maintenance activities at DNPPs requires detailed planning, scheduling and control. A plan should be drawn up, aimed at directing and coordinating the efforts of all the organizations and people involved in the project in order to achieve an effective and smooth transition to the new situation.

Planning should include studies of the environmental conditions and other possible causes of degradation at site. The study should focus on the evolution of the plant materials over time, locations, intrinsic characteristics of the site, materials and applied protections.

The result of this analysis should feed back into the preservation programme thus improving its effectiveness. The following activities are to be planned:

- Protection and preservation of stored and installed items, and periodic inspection to confirm maintenance of the preserved status
- Routine and short-term preservation and maintenance
- Medium and long term preservation and maintenance
- Maintenance activities to repair, replace equipment or improve its condition through corrective maintenance
- Provision of handling equipment, tools and other means to carry out activities
- Maintenance and cleaning of the site, facilities and installations
- P&M of facilities - buildings and infrastructure.

The plan should also specify resources in terms of manpower, materials, tools, facilities and finances.

All routine and special work should be scheduled. Efforts should be made to consolidate work on equipment for maximum efficiency and also to equalize the work load on staff over time.

Expenses associated with P&M work should be tracked, based on cost control based on job estimates and annual budgeting and reporting of expenditures.

Performance of P&M activities should be documented and records maintained. History dockets on work performed must be maintained. For this reason, all items must be uniquely identified, in a durable way, both in the plant and in stores.

Appendix 5 offers additional information on this topic.

4.3.4. Preservation work

Potential for degradation arises out of the following factors:

- corrosion, erosion
- contamination by foreign agents
- biodegradation (for elastomers, lubricants) and shelf life limitation
- adverse environmental conditions
- loss of identification
- improper packing or protective measures
- obsolescence
- loss or physical damage
- prolonged non-operative mode of a rotating equipment or component with moving parts.

For some of these factors, degradation is a time dependent phenomenon and depends among other things on service conditions referred to as "stressors [8]". With proper P&M measures implemented, degradation due to "stressors" can be arrested.

Effects of chemicals and other preservation processes on materials inside equipment or its surfaces need to be carefully evaluated before application. Possibility of adverse chemical reactions must be considered as there is a risk of damaging equipment with inappropriate preservation and cleaning techniques.

Hazards associated with application of chemicals should be clearly spelled out in the P&M Manual. They are avoided by rigorous adherence to approved procedures.

Appendix 6 discusses the various categories of storage arrangements and the types of materials for which they should be used, as well as physical protection of storage areas and control of environmental conditions within them.

Preservation work includes:

- removal of delicate components for safe storage
- preserving identification
- physical protection
- control of environmental conditions
- surface protection
- surface cleaning
- preservation of structures.

Delicate components

Some components by their delicate nature are especially prone to damage based on environmental conditions at their location. They should be removed (even if they are already installed) and stored separately in accordance with manufacturer's instructions. Examples are: instrumentation, mechanical seals, electronic items, some electrical items like relays, switch gear, etc.

Identification

It is essential that identifications of all items be maintained whether in stores or installed. Shipping marks should be preserved for stored materials. For installed items, identification marks/tags such as equipment code, system code, etc. should be maintained. These markings should be clear and legible over long time.

Physical protection

The term physical protection used in this publication means reducing the risk of physical damage to stored or installed items by provision of cover, barriers and protection to separate items from the environment at their location. Physical protection measures should be durable to last for a long time (years).

[8] *Stressors*: Adverse conditions like temperature, saline environment, electrical and mechanical loading, radiation, chemicals, contaminants, atmospheric humidity, and system chemistry that may lead to degradation through various physical and chemical processes.

Control of environmental conditions

Considering that corrosion due to moisture and oxygen is the main cause of equipment damage, the basic protection consists of keeping the relative humidity below a fixed limit.

Surface cleaning

Effectiveness of any surface protection strongly depends on surface preparation. All surface contaminants must be removed before application of preservatives.

The following are some of the surface cleaning methods

- Abrasive cleaning
- Degreasing
- Pickling or acid cleaning. Use of this method has to be carefully evaluated against the type of materials in the component to avoid an undesirable chemical reaction.
- Passivation cleaning in oxidizing and acid solution may be necessary as a final cleaning operation.
- On completion of surface cleaning, surface must be washed or flushed with de-mineralized water and dried in clean, oil-free air, drying oven, or, for internal surfaces, by evacuation (vacuum).

Appendix 7 discusses the various methods by which equipment surfaces — internal and external — can be cleaned and protected.

Surface protection

Surfaces can be protected by:

- Elimination of aggressive agents (moisture, oxygen, acids, etc.)
- Surface passivation
- Surface coating.

Preservation of structures

- Internal surfaces of buildings should be painted to minimize dust. For building which have not been completed, measures such as protective covering, roofing, fencing and closure of openings are required.
- Steel structure surfaces should be cleaned and painted with primer and paint.
- Concrete encased elements such as anchor plates, anchor-bolts, sleeves, casings or couplings should be cleaned and surface and physical protection applied to preserve the metal and also prevent rainwater collection.
- Exposed reinforcement bars should be protected by a layer of mortar on the surface of the outdoor horizontal joint to divert rainwater. Exposed steel bars (reinforcing rods) should also be protected.

- Special structures like intake and discharge, temporary dam, shore protection line, dewatering pump house, etc should have a specific preservation programme depending upon the stage of construction of these structures and materials used.

4.3.5. Maintenance work

The task of maintenance work as referred to in this publication has two primary functions:

- maintaining the status of preserved items;
- performing maintenance activities on equipment and components in operating condition.

EXAMPLES OF PRESERVATION PROGRAMMES		
ITEM	PROTECTION	FOLLOW-UP
Piping in out-door storage	Sealing, surface protection of weld edges, Desiccants	Desiccant replacement and regeneration
Piping installed in plant	Cleaning and sealing by system	Corrosion sample
Heat Exchanger installed in plant	Isolation by system, & inhibitors or desiccants	Sample, replace desiccants & inhibitors
Storage tanks	Isolation plus Inhibitors	Sample, replace inhibitors
Ventilation equipment in plant	Isolation and internal heating, circulation	Temperature control
Pumps in plant	Isolation, inhibitors & desiccants	Sample, replace desiccant
Compressors in plant	Isolation, inhibitors & desiccants	Sample, replace desiccants & inhibitors
Turbine internals (plant)	Dehumidifying	Temperature and humidity control
Turbine internals (warehouse)	Surface protection	Sample, periodically replace
Reactor vessel internals in-plant	Humidity control	Sample, replace desiccant
Reactor vessel Internals In warehouse	Humidity control	Sample, replace desiccant
Machined surfaces	Surface protection	Periodically replace
Electrical contact surfaces	Surface protection	Periodically replace
In plant bearings	Lube oil or inhibitor	Level control
Embedments	Physical and surface protection	Check and replace

Maintenance work includes:

- routine equipment maintenance
- special maintenance
- maintenance of completed systems.

A predictive maintenance programme should be set up to detect developing problems. Routine testing and preventive maintenance should be controlled via a call-up system. All other maintenance and work should be scheduled.

Routine equipment maintenance

- Equipment stored at site requires maintenance, whose scope will be defined based on the following:
  - Applicable standards;
  - Manufacturer's instructions;
  - On-site observations and feed back surveillance and inspections
  - Environmental characteristics of the site.
- Routine maintenance is required for equipment with rotating or moving parts e.g. pumps, valves, etc., and also for equipment whose operation requires fluids such as transformers, batteries, etc.

Appendix 8 provides additional information on routine and special maintenance activities. Suggestions for inspection of stored parts are also included.

Maintenance of completed systems

The preferred status of completed and commissioned systems is to operate them, with a standard maintenance regime applied. If this is impossible, the system should be subjected to a preservation programme as described under "Preservation Work".

4.3.6. Inspection and surveillance

Routine surveillance and inspection of equipment and facilities should be conducted to assess effectiveness of maintenance and preservation activities, as well as the quality and completeness of their records.

Surveillance and inspection plan

- An overall surveillance/inspection plan should be prepared for preservation and maintenance activities identifying areas needing surveillance/inspection, complete with procedures and acceptance criteria.
- The plan should specify surveillance/inspection activities to be carried out, assign responsibility, specify scope, frequency, schedules, special inspection equipment, need for the presence of manufacturer's representatives, etc.
- Based on the level of importance, record, verification, witness and hold points requirements for surveillance/inspections should be established.
- The results serve as a feed back for corrective action.

4.3.7. Modification, replacement and repair

Modifications, replacements and repairs during the P&M phase are similar to the maintenance programmes of an operating station except for the specifics of the operating conditions of the suspended plant.

- In Sections 4.3.4 and 4.3.5, methods of performing preservation and maintenance work have been described. It is important to maintain the preserved status without degradation and also to carry out maintenance activities. Surveillance and inspection activities confirm condition of components.
- Arising from surveillance and inspections, the following actions emerge:
  - Items that are in acceptable condition should be left as is
  - Items that have degraded beyond repair should be replaced
  - Some items need to be modified/replaced due to various reasons;
  - Some items need to be repaired because of their degraded condition.
- If surveillance/inspection reveals the need for repair, the same should be carried out, the key point being timely corrective action. Necessary stock of spare parts should be maintained.
- Activities on modification, replacement and repair should be documented and history dockets kept. For special equipment, servicing activities will need advice and attendance by the manufacturers' representative.

4.3.8. Infrastructure, services and housekeeping

Essential infrastructure, facilities and services would have already been established for the project. For a suspended project, it will be necessary to scale down the level of facilities, so as to minimize the cost of preservation and maintenance.

Appendix 9 lists the essential facilities which must be kept in service at a DNPP.

Housekeeping should be given its due attention for improving personnel and facility safety (from fire hazards) and effectiveness of preservation and maintenance.

A culture of good housekeeping and consistent good practices will result in sustained good results.

4.4. Assessment

4.4.1. Symptoms and attributes

Symptoms of developing problems

- Lack of managerial oversight evidenced by neglected condition of equipment, site and buildings
- Cost exceeded due to poor budgeting and expenditure control
- Work done with no evidence of prioritization or planning

- Equipment being worked on several times due to lack of preparation and planning
- P&M work not being done properly because of inadequate assignment of responsibilities and accountabilities within the P&M team, e.g. routine maintenance or preservation not done on some equipment
- Routine testing for condition of equipment not done, or if done, not reviewed properly and no corrective action taken, if required.
- Incorrect chemicals applied because of poor control procedures and lack of technical oversight
- Equipment found without identification or history dockets
- Failure to carry out scheduled inspections and surveillance
- Lack of spare parts or incorrect spare parts installed due to absence of good records and clear spare parts policy

Attributes of effective management

- P&M manual kept up to date
- There is a clear policy on P&M and responsibilities are clearly assigned
- Management is frequently seen in the field inspecting conditions and offering support
- Co-operative relationships have been established with equipment suppliers
- Work is planned well in advance and expenditures are controlled within budget
- QA programme is well accepted and its requirements are adhered to
- There is close co-operation between staff in the field and the Technical Support Group
- Surveillance and inspections are regularly performed and confirm satisfactory condition of P&M
- Identified deficiencies are resolved in line with established priorities
- Training conducted as planned with satisfactory attendance

4.4.2. Quality indicators

- Per cent of planned P&M activities completed on time
- Per cent of scheduled training carried out
- Per cent of planned inspections of equipment at vendors facilities carried out
- Number of items found without identification or history dockets
- Number of items whose condition has deteriorated beyond repair
- Number of stored items found without appropriated protection or packaging
- Per cent reduction of costs of insurance, as the result of independent inspections

5. UPDATING TO TECHNOLOGICAL AND REGULATORY REQUIREMENTS

Summary

This section deals with activities necessary to establish a set of modifications required to bring the plant into conformance with the current regulatory and technology requirements. Factors influencing the achievement of this objective are presented. The key processes of planning, studying, evaluation and arriving at a decision are discussed. Interfacing with the regulatory authority and other organizations is reviewed.

Conclusions

The following conclusion arise from this section:

- Maintaining technical readiness for resumption of work is a continuous and demanding task
- A dedicated group of technical specialists is required on a continuous basis
- It is essential to maintain record of plant status
- Effective interfaces are a prerequisite for success
- Co-operation with a reference plant can be extremely helpful.

5.1. Introduction

Updating of an NPP — after delay — to meet current technological standards and licensing requirements is a complex process which must be carefully planned and managed. Effectiveness of updating process will have marked effect on licenseability of the plant and its subsequent operational performance.

This section provides guidelines to identify, evaluate and assess the necessary modifications so as to minimize additional delay after resumption of work. It provides a practical approach to selecting a strategy, which can be adopted by utility managers, decision and policy makers.

The primary objectives of this section are:

- To develop a common basis for assessment of DNNPs in accordance with current regulatory and technical requirements
- To develop an overall approach which should be used in this assessment
- To define the criteria that should be used to decide what actions are required before operations to meet current regulatory and technical requirements for a plant.

The guidelines offered in this publication are of the general nature and are applicable to DNPPs in a wide variety of conditions and scenarios. They have to be adapted to the particular circumstances and culture of the project.

5.2. Management

5.2.1. Objectives and organization

The main *objective of management* of the updating function is to identify the necessary modifications to ensure that the plant will eventually be restarted, licensed and will operate successfully. This implies that once the decision to restart has been made, there will be a known body of improvements which will have to be implemented for the plant to become viable.

To optimize this process, it is necessary that a methodology for assessing and evaluating the modifications be developed. The utility should develop a suitable *organizational structure* for managing these activities. A relevant part of such an organization is the **core group** — a "project dedicated" team — consisting of staff with appropriate skills to carry out and manage the most important activities and maintaining continuity (see 2.2.2).

The "updates section" within the **core group** should typically consist of technical specialists, whose responsibilities should include:

- Identification of modifications to plant design necessary to satisfy the current *licensing requirements*
- Identification of modifications which may be implemented as the result of *technological developments*
- Preparation of *recommendations for modifications*, based on cost-benefit analysis and other studies.

5.2.2. Reference plant

It is advantageous for the plant to develop a co-operative relationship with another NPP of similar design and vintage, and the one which has been operational for some time. Such a plant, sometimes called a *"reference plant"* will provide invaluable information about the modifications required to maintain the operating license and also about operational difficulties.

Information and experience from the reference plant will make it easier for utility and regulatory personnel to carry out assessments of proposed modifications.

It is desirable to establish this relationship in the early phase of restart process, if possible with the assistance of plant vendor.

The concept of a reference plant for the delayed project has inherent advantages:

- Provides a focus of the target to be achieved regarding safety, equipment and procedures
- Provides operational experience which can be used to evaluate proposed modifications
- Provides a focused and detailed reference for licensing requirements and ways of meeting them.

Personnel should be assigned to maintain contact with the reference plant and to properly distribute information gained within the DNPP.

5.2.3. Planning

When preparing the *"update plan"* there are a number of factors which determine the strategy to be adopted:

- Evolution of technology and licensing requirements during delay period
- Status of the NPP at the time of resumption of work
- Availability of funds
- Tentative schedule for the plant to become operational.

The needs and requirements of a DNPP to meet current licensing requirements and technological upgrades depend to a large extent on the status of the plant at the time of suspension of construction and design activities.

The possible scenarios are:

- Constructed and ready for commissioning
  - All design has been completed and accepted by regulator prior to suspension
  - Updating to current requirements may be difficult
  - Specialized support from vendors will be necessary.
- Site erection not started, but most equipment procured
  - Equipment will have to be stored and preserved
  - Additional information will have to provided to the regulatory body before resumption.
- Design completed and accepted, but major equipment not procured
  - Only basic design has been completed, and assessment of its statues consists of design review with proposal for some re-engineering.

The factors which influence the extent of necessary updating, and thus the preparation of plans for it are:

- Revisions to licensing requirements, as compared to the ones in force at the time of original design
- The degree to which the NPP is being built based on established and licensed design
- The ongoing evolution of design
- Impact arising from transition in the regulatory and utility regimes and concomitant uncertainties
- The need to meet current *licensing requirements*, in view of developments in :
  - Safety concepts
  - Safety systems
  - Engineered safety features
  - Radiological protection requirements
  - Emergency preparedness and accident management systems
- The need to meet current standards and *technological practices* in the following key areas
  - Process system design
  - Nuclear and process instrumentation

- Fuel and fuel handling
- Provisions for remote tooling
- Wiring, relays, switchgear
- In-service inspection
- Maintainability
- Seismic and environmental qualifications
- Fire protection.

To facilitate mutual understanding, with the regulatory body, of the issues affecting the updating plans, the utility should prepare a report on the present state of the NPP, which should include the following:

- Description of the NPP
- Description of the design basis of previous safety analysis and regulatory approvals
- List of designers, vendors and builders
- Description of current status of equipment and buildings
- Results of any special investigations of buildings, structures, designs
- Outputs of its integrated and prioritized **update plan** which are recommendations on proposed updates, listing all proposed modifications and their justification and impacts, such as:
  - safety and operational enhancement of the plant
  - project cost
  - project schedule
  - availability of material.

The plan must be integrated to ensure that all changes being made are appropriate, that they do not conflict or adversely interact, and that they are properly sequenced.

The update plan should consolidate contributions from project management, design, vendors, operations and procurement and should be submitted to the regulatory body for review, negotiation and eventual acceptance before the final decision to restart is taken.

5.3. Performance

5.3.1. Technological environment

The **core group** and in particular its update section should use the delay period to:

- Comprehensively and continuously assess the design, including basic safety principles, engineering design solutions and design approaches and requirements, in the light of changes in codes, guides and standards to the extent applicable
- Appraise themselves of the current licensing requirements and draw up a strategy for implementing necessary modifications to meet these
- Re-evaluate all accidents, taking into account the design of the plant
- Review safety concepts and its effect on safety systems and engineered safety features
- Identify possible modifications and carry out their preliminary assessment.

Particular attention should be paid to the more recent concepts which may not have been addressed in the original plant safety and design requirements.

The project should utilize the delay period to periodically review and prioritize the required modifications, so that a well considered preliminary assessment of the required changes is available on project restart.

A list of possible modifications should be maintained and periodically reviewed and revised, so that when the decision is made to restart the project, the **core group** is well on the way to preparing a report recommending the proposed plant modifications.

5.3.2. Identification and review of proposed modifications

As the project is restarted, its technical status has to be accurately assessed and confronted with the list of proposed modifications.

Agreement should be reached with the regulatory body about the scope of the review, research findings, technological innovations and requirements, standards and feedback from similar NPPs in operation as far as they relate to safety aspects.

The process of identifying and recommending modifications should include:

- Assessment of modifications against the plant status, to determine what can be implemented
- Demonstration of the safety enhancement achieved, resulting in their acceptance by the regulatory body
- Assessment of the modifications to be implemented with respect to the criteria listed in Section 5.3.3.
- Addressing unresolved licensing issues.

The following should be reviewed:

- Existing design and construction documents and data for completeness and acceptability.
- Present condition of the plant structures, systems and equipment and their capability of performing the desired functions.
- Present market status of installed systems and equipment, and whether these will continue to be supported with spare parts, for duration of operations.
- Site characteristics, whether any pre-existing or new features, including external hazards were not adequately taken into account in the design.

For the above assessment, the utility may employ special equipment and analysis tools, and specialist manpower.

In particular, the following systems require review, with ongoing inputs of stakeholders such as designers, vendors, project management, operations, procurement and regulatory body.

Safety systems and engineered safety features

The review should identify the deviations from the current requirements in basic design principles and engineered design solutions. The following should be examined:

- The design, as compared to the current analytical methods and practices.
- Impact of all identified discrepancies between design and requirements, and their combined effects.
- Completeness of the earlier safety reports and documents compared to current analytical methods and licensing requirements, in particular:
  - Environmental impact report and emergency planning, to understand how the existing design solutions meet the current safety criteria;
  - Protective parameter analysis, emergency core cooling, etc.
- Analytical methods, computer codes, studies for completeness and relevance.
- Postulated initiating events (PIEs) and the basis on which they have been postulated, e.g. deterministically or by probabilistic safety assessment (PSA) and/or experience form the reference plant and other similar NPPs.
- The ultimate heat sink. Careful study should also be made of the site specific changes that may have occurred to affect the ultimate heat sink, example being building of dams upstream, diversion of rivers. Another example is that revised seismic data about the site may show some essential structures like cooling towers need to be reinforced.
- Design bases for the containment and containment systems should be reassessed taking into account identified PIEs and provision of features for mitigation of the consequences of severe accidents.

Technology upgrades

The utility should conduct a comprehensive and detailed review to facilitate its own work as well as that of review by the regulatory body. The scope of the review should include, but not be limited to the following:

- Review research findings, engineering and technology innovations and upgrades, in the intervening period since halting of the project.
- Review of current standards (i.e. upgrades/modifications in standards since project suspension).

Environmental qualifications

A detailed review of the environmental qualification of the specified and procured equipment need to be undertaken, in view of:

- Technological advances in packaging, materials and systems may permit equipment to be installed safely in hostile environments.
- Safety analysis may indicate that the environment which the equipment is likely to face may be more hostile, during an accident, than originally conceived.

Radiological protection requirements for operating personnel and public

- International practices and the current national regulations concerning exposure to radiation workers and public should be examined concerning exposure limits.
- Modern techniques, materials and equipment may be instrumental in reducing exposures (examples are use of modular design, improved handling facilities and remote handling tools for maintenance, better shielding).

Emergency preparedness and accident management

Changes in the site and its environment should be studied and their impact on emergency preparedness and accident management should be assessed. Typically these are:

- Revised site specific data with respect to the frequency of internal and external man induced events and phenomena.
- New hydrological data e.g. change in river base and water table.
- Changes in traffic, particularly traffic patterns including air traffic.
- Significant changes in population distribution, land use, expansion of existing facilities and human activities and construction of high risk installations in the region.
- New seismo-tectonic data, if applicable.

Maintainability

The results of maintainability review may be of benefit in reducing construction, commissioning and down-times and could lead to improved availability, reduced radiation exposure and reduction in staff requirements. Examples are:

- Appropriate handling facilities for maintenance may be added at resumption of project,
- Improved diagnostic sensors for monitoring equipment condition.

Process system technology upgrades

Process systems technology is likely to undergo technological improvements. These have to be assessed, because:

- Changes in major equipment and systems are likely to have major cost and time penalties.
- Lead time for changes are large.
- Depending on the status of the plant equipment, backfitting problems will need careful planning. Examples are:
  - improvement in the materials of tubes in Steam generator, other heat exchangers and condensers
  - changes in some technical codes, which may require changes in process equipment (valves, wiring).

Nuclear and process instrumentation and control systems technology upgrades

This is the area, where the most rapid advances are taking place, and where the rate of obsolescence is the highest. Rapid obsolescence increases the pressure for change and updating.

Because of rapid obsolescence, the timing of implementing changes is particularly crucial. Fortunately, the lead time for procurement for such systems is not as high as that for many other systems of the project.

Some cost/benefits that may accrue are:

- Better control of plant parameters may be achieved leading to better plant performance.
- Upgraded operator support systems, leading to better appreciation of the plant conditions, better operations and more effective incident handling.
- Upgraded in-core instruments may lead to better assessment of core physics for initial start up and a more efficient re-fueling scheme.
- Advanced nuclear and process instrumentation are likely to be computer based and therefore rules for new software validation must be clearly established.

Assistance from designers would be helpful for review of the original design documents for completeness and the ability of the design to meet current licensing requirement. The original codes and analytical techniques would also need to be reviewed for adequacy.

In relation to the vendors, the review of modifications will offer an opportunity for them to comment on choices such as updating or replacement, status, obsolescence and availability of spares and alternate sourcing of equipment and systems.

5.3.3. Evaluation and acceptance of proposed modifications

An organization and system should be put in place which will review the proposed modifications, evaluate them and make recommendations whether to:

- Accept and implement before operations
- Accept and implement after commissioning completed and operations commenced
- Reject.

Appendix 10 presents a flowchart of activities for evaluation and acceptance of modifications.

Criteria for acceptance and implementation of proposed modifications have to be developed, and typically are based on:

- Degree of enhancement of safety
- Economics as determined by cost-benefit analysis
- Effect on cash flow and total expenditure
- Effects on plant schedule
- The extent to which the quality requirements have been met
- Timely availability of materials

- Ease and urgency of installation — off-power or on-power
- Commissioning results at the DNPP and operational feedback from the reference plant.

For the above review, the utility may have to employ specialized analytical tools and manpower. The decision making process could be aided by probabilistic assessment with respect to the adequacy of the change and its overall impact.

A prioritized list of changes should prepared by the utility and accepted by designers, vendors, project management, procurement, construction, operations and regulatory body for feasibility, costs and resources validation.

The issue of cost benefit and resource analysis will have a bearing on the start and scale of the updating programme. High cost of updating may have serious impact on resumption of the delayed project. Phasing of expenditures may diminish this impact, but the regulatory body has to agree to delays in implementing some of the desirable upgrades.

5.3.4. Prioritization

The result of evaluation studies of the plant may indicate the need for many modifications. These have to be categorized and prioritized and an integrated, detailed action plan prepared.

The following should be evaluated to arrive at a decision on what can be implemented before operations:

- Proposed modifications should be screened to determine which are important enough to be implemented before operations begin.
- Feed-back from the *reference plant* should be used effectively to arrive at decisions that can be implemented.
- It is possible that implementing some highest priority actions could result in the plant being judged acceptably safe for operation. Further modifications could be phased in as part of long term plan for updating after start-up.
- Based on this substantive review the utility should come to an agreement on the milestones for modifications which cannot be implemented before operations begin.

At the conclusion of this process, a final and agreed list of modification and their disposition should be prepared and be formally submitted to the regulatory body for acceptance.

It is not appropriate to wait for formal approval before commencing engineering work on the "install now" modifications. The utility should know which modifications are very likely to be approved. Waiting for formalities — which may take a long time — would only introduce additional delay.

5.3.5. Co-operation with the regulatory body and other organizations

Resolution with regulators

Before implementing the updating programme the utility should assist the regulatory body - by provision of information - in determining that:

- The utility has the capability to meet current licensing requirements and implement the updating programme. This includes in-house capability, employment of designers, consultant, information from vendors, etc.
- Site-conditions, including actual status of the plant and revised site data remain acceptable.
- The updating programme can meet the licensing requirements.
- The quality assurance programme of the utility, its designers and vendors meets the requirements stipulated.
- The design features, safety principles, general criteria, engineering design solutions, and reliability provide confidence of plant safety in accordance with the national requirements and international practices.
- The effect of delay and storage on plant equipment, structures and systems has been or will be satisfactorily counteracted.

After the utility and the regulatory body have satisfied itself that the main safety issues have been satisfactorily resolved and the remainder are amenable to solution before operations are scheduled to begin, the following consideration apply:

- Options for modifying plant safety features become restricted the more advanced the fabrication and construction had proceeded. Safety evaluation should be consistent with the manufacturing and construction status to ensure that important safety options are not foreclosed.
- At an appropriate stage, a comprehensive safety analysis has to be performed taking the design, actual plant condition and current licensing requirements into account.
- The overall results of this analysis may then be reviewed with the regulatory body to ensure that current licensing requirements are met or will be met during resumed construction and before operation starts.
- The utility is required to submit and make available all information that the regulatory body specifies. The utility should co-ordinate with the consultants, designers, vendors and Contractors to ensure that the required information is available.
- Information should be submitted according to an agreed programme and time schedule.

Assistance from consultants, vendors and international organizations

To facilitate the licensing process the utility may employ the services of external organizations as necessary, typically:

- Services of specialist analysts to review the safety codes, including computer codes, and also the services of designers to review the design bases, calculations and documents to meet current licensing requirements and technology upgrades.
- Services of vendors and suppliers may become essential, where the delay has been long and probability of obsolescence high.
- Whenever possible contact should be maintained with the suppliers, vendors, designers and Analysts during the suspension and updating periods. Inputs from these sources can be of great help in assessing the feasibility and cost/benefit analysis of the proposed modifications.

- Areas of rapid technological change and obsolescence should be addressed with the pro-active support of the vendors and suppliers, taking into account the developmental trends in the industry.
- Depending upon internal capabilities, the additional assistance may be provided by national or international organizations, such as for example the IAEA.

5.4. Assessment

5.4.1. Symptoms and attributes

Symptoms of developing problems

- There is not a clear assignment of responsibility within the core group for updating
- core group is unable to clearly summarize the extent of regulatory and technological changes which have taken place since project suspension
- There is no relationship with a reference plant
- There is inadequate communication with the regulatory body and other involved organizations
- The basis for preparation of an updating plan have not been determined
- There is no adequate updating plan in existence
- No self assessments have taken place.

Attributes of effective management

- Planning for modifications is evident with a comprehensive and prioritized list in place
- The **core group** is well informed of regulatory and technological changes which have taken place
- There is good contact and a co-operative relationship with the regulatory body and other involved organizations. Appropriate interface procedures are in place
- Plant configuration is being maintained with clear documentation
- Periodic self assessments are being done and corrective actions implemented.

5.4.2. Quality indicators

- Per cent of proposed modifications approved by project management and regulatory body
- Number of proposed modifications which are not approved based on their adequacy, prioritization or others
- Number of proposed modifications ready for implementation

6. PRESERVATION OF PROJECT DATA

Summary

This section deals with management considerations and activities aimed at preserving the engineering data and other documentation necessary for re-starting the plant. Factors which influence planning for data preservation are discussed, as are suggestions for accomplishing it. Symptoms of possible developing problems are presented.

Conclusions

The following conclusions arise from this section:

- Possession of complete and updated documentation is essential for plant re-start
- Pro-active, planned and organized action is required to adequately preserve data and documentation
- Existing document control procedures should be used as much as possible
- Document management must satisfy QA requirements
- Attempts must be made to recover/re-create missing or lost documents.

6.1. Introduction

Possession of valid and complete project data[9] is a pre-requisite for eventual re-start of construction, commissioning and operation of the plant. Therefore preservation of all relevant data from design, construction and vendors, during the delayed phase of an NPP is an important activity.

The data is likely to be in possession of many individuals and agencies such as architect-engineers, designers, consultants, vendors and suppliers. Some of them may go out of business without transferring the data to the project organization, thus impairing project viability. Steps must be taken to prevent such an event and to secure long-term availability of data.

This section provides practical guidelines that have to be adapted to the particular circumstances and culture of the project.

6.2. Management

6.2.1. Objectives and organization

The objective of data preservation is to have all necessary documentation and related engineering data in a condition that would permit restart of the project and its subsequent safe operation.

The activities should focus on the preservation of physical condition of documentation as well as up-keeping their technical consistency/accuracy with respect to the project.

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[9] *Project data includes*, but is not limited to, documents, records and software.

This should be achieved by a *team* responsible for preservation and maintenance of the data and documentation, with appropriate authority and responsibilities. Management must define the organizational structure, the role and responsibilities of the team and individuals for data preservation, both at site and at utility headquarters.

The project **core group** must be the main contributor to accomplishment of this objective.

6.2.2. Planning for preservation of project data

Soon after plant suspension, management must develop a long-term plan with respect to data preservation, which should address the following issues:

- deciding which documents/data must be preserved
- ways to secure a complete set of data which may originally have been dispersed amongst the various contributors to the project
- cataloging of documentation
- verification of data
- updating to ensure that current plant status is accurately documented
- data consolidation, secure storage and easy retrieval.

A systematic records management system with clearly assigned responsibilities is essential for the implementation of the objectives enumerated above. QA programme requires that such a system be established.

Documentation will be required to resume construction, to commission the plant and to subsequently operate it in a safe and reliable manner.

Factors *specific to DNPPs* that should also be taken into consideration:

Finances

- Availability of money and the costs involved are the main criterions in deciding on the measures to be undertaken in order to preserve data. If data and documentation are not adequately preserved, a great deal of effort will be required to re-create it on resumption of work, leading to errors and delays. Additional delay costs money.
- Adequate re-creation of data may not be possible to achieve, thus inviting regulatory intervention.

Types of documents

Types of documents to be preserved are:

- Technical documentation required for the QA programme for an operating NPP.
- Records of partially completed - and suspended - work
- Commercial documentation:
  - Contracts and purchase orders, including warranties
  - Technology transfer agreements

- Legal contracts and documents
- Government policies, directives and instructions.

Project phase

- Phase of the project at the time of onset of delay determines the amount of data and documentation to be preserved, as well as its quality, with more data having been generated as the project progresses. Thus plans for data preservation will be considerably different if the project were to be delayed when construction is at its peak, compared to either very initial stages or approaching completion and commissioning.
- While short-term delays in project execution may not need special additional efforts for preservation of documentation, longer delays would require special actions to be taken.
- At the time of project suspension some design data in particular may only be in a "semi-finished" state, that is, not completed or approved and being continually worked on. Arrangements must be made to capture and preserve this data at the appropriate moment in its development.

Country specifics

- If the DNPP is a part of a country-wide nuclear power programme consisting of other similar reactors, then procedures and practices for systematic collection and preservation of data are already in place. The DNPP should make use of methods and facilities already in place.
- This "cushion" does not exist for a single, first project in the country. In such a case difficulties with securing and verification of data are to be expected and the programme for achieving it will have to be more comprehensive, detailed and vigorously executed. Implementation must include both the project and vendor organizations.

Regulatory requirements

Regulatory requirements with respect to documentation, as applicable in individual Member States, have a significant bearing on requirements for extent of data to be preserved, manner in which it should be preserved, and frequency and extent to which data/information must be reviewed and kept updated.

6.3. Performance

Long project suspension and lack of clear picture about the future may lead to gradual deterioration and loss of documentation and data.

Managers must assign adequate resources for preservation of data consistent with the needs. Consequences of loss of documentation can be very expensive in additional delays or severe in casting doubt on project viability.

Managers must be aware of these considerations and undertake planned corrective actions to counter them. Some of these corrective actions are enumerated below.

Systems/Methodology

- To the extent possible, procedures for preservation of data which were used at the project during its active phase should be continued and enforced.
- Only where there is a clear and demonstrated need should new procedures, special for the DNPP be introduced. An example might be a procedure to preserve partially completed documentation, the work on which has stopped.
- The usual controls for accepting new documentation into the files and access to the files must be in place.
- Management should have a complete index of documentation in its possession, together with its classification and location of documents, for easy retrieval.
- The index of documents should be computerized to the extent possible, with the computer programme providing essential information on documents, such as history, classification, etc.

Configuration control

- In a dormant (delayed) power plant, special procedures are required to implement document verification, meaning that all documents have to be examined and confirmed as being complete and correct.
- Also, procedures are required to ensure that changes made to equipment and structures at the site or at the vendors' storage are reflected in the documentation and the revision are recorded.

Contract specifics

- Documents may be dispersed amongst many participants in the project, some within the country, some outside. Their availability, i.e. turn-over to the project team, is normally governed by contractual arrangements.
- Definite arrangements should be made with contractors and vendors about safekeeping of documentation and performance of audits by the project organization.

Storage requirements

- Decisions on storage requirements should take into account capital and recurring cost of preservation consistent with the importance and raggedness of documents.
- Different types of documentation require different storage facilities. For example, radiographs and magnetic tapes require different storage conditions from papers.
- Security of records must be assured.

Actions in case of missing documents

- When documents are determined to be missing, action is necessary to replace them and thus minimize future problems.

- Following actions might result in data/document recovery or re-creation:
  - Intensive search within existing files
  - Attempt to obtain copies from the vendor or design organization
  - Re-creating the documentation from measurements in the field or by repeating tests
  - Obtaining information from similar equipment/design existing elsewhere.
- Efforts exerted to recover/re-create documentation should be commensurate to its importance.
- In all cases the loss of documentation and the way it has been re-created must be recorded.
- If attempts at recovery or re-creation have not been successful, this fact must also be recorded along with a record that documentation has been lost.

6.4. Assessment

6.4.1. Symptoms and attributes

Symptoms of developing problems

- Documentation takes a unduly long time to locate due to deficiencies in indexing and storage
- Number of discrepancies uncovered between documentation and conditions in the field
- Number of documents found deteriorated due to poor or inappropriate storage conditions
- Document handling and storage procedures out of date and not followed
- Difficulties emerge when trying to locate documentation at vendors, due to lack of agreement and clear understanding of responsibilities
- There are many documents which cannot be found

Attributes of effective management

- Responsibilities for document preservation are clearly assigned and understood
- Clear understanding of management expectations with respect to documentation is evident throughout the project
- Adequate storage facilities exist, documents are in good condition
- Sufficient resources have been assigned to accomplish management's objectives
- Regulators express their satisfaction with documentation availability
- Documentation accurately reflects conditions existing in the field
- There is an effective procedure to re-create documents
- vendors understand the need and co-operate in preservation of project documentation

6.4.2. Quality indicators

- Per cent of requested documents which are found within the specified time target
- Per cent of lost documents which are found or re-created

- Number of filling or indexing errors made due to inadequate procedures
- Number of discrepancies between documentation and conditions in the field
- Number of expected documents not available at vendors
- Number of documents turned over to the QA vault.

Appendices 1–10

DETAILED INFORMATION

The appendices present information which elaborates in some detail on the concepts presented in this report. This information is often quite detailed, but not necessarily specific to DNPPs. This is why it has not been included in the body of the publication. Nevertheless, the information is pertinent to the subject at hand and attention of the delayed project/plant managers should be drawn to it.

Appendices should be read when more detailed suggestions are desired.

Appendix 1

SUMMARY OF PARTICIPANTS' PRESENTATIONS

Appendix 1 presents a summary of the presentations given by the participants at the first advisory group meeting, held in February 1997, on the subject of management of DNPPs.

This summary deals with:

- General status of the DNPP
- Main problems encountered
- Corrective measures implemented.

Appendix 1 has been revised to reflect the current situation as of November 1998.

1. GENERAL STATUS

Country	Unit	Physical progress [%]	Expended [equiv. mill. USD]	Reasons delay	Cost completion [equiv. mill. USD]	Schedule completion [months]
Argentina	Central Nuclear Atucha II	80	2700	1. Shortage of Argentina currency funds 2. Political decision of privatization 3. Institutional alteration on plant construction responsibility	692	60
Brazil	Angra-2	78	3200	1. Institutional alteration on plant construction responsibility 2. Shortage of Brazilian currency funds 3. Energy demand 4. Political decision associated to financial conditions	1200	30 from decision to acceler-ate comple-tion in 1996
Bulgaria	Belene	52	1200	- Lack of money - Political changes	1020	50-60 from start of the financing
Canada	Darlington (4 units)	100	10 000	- Demand declining - Manpower shortages - Financing difficulties	0	0

Cuba	Juragua # 1	Civil 75 Erection 20 Electric 16	1200	- Economical	600	54
Czech Republic	Temelin # 1 & 2	85	2000	1. The principle reconstruction-modernization 2. Political and economical changes in the Czech Republic	1300	(#1) 27 (# 2) 43
India	Kaiga # 1 & 2	92	526	1. Civil engineering problems - resolved 2. Seismic analysis and qualification of safety related structures, equipment and components — addressed 3. Inadequate performance by package contractors 4. Project processing well. Expected operational	681	(#1) 24 (#2) 7
	Rajastan # 3 & 4	88	427	- all problems similar to Kaiga 122 project processing well - expected operational 1999 — 2000 AD	591	(#3) 10 (#4) 19
Islamic Republic of Iran	Bushehr # 1	Civil 85 Electrmch 65	4000	1. Suspension & termination by the main contractor 2. Disinclination of the main contractor to finish the projects 1#2	1500	55
	Bushehr # 2	Civil 70 Electrmch 50	2500		---	--- at preservation

Romania	Cernavoda # 1	100	2000	1. Political involvement in the project management (before 1990) 2. Management planning & schedule 3. Lack of supervision in some areas 4. Lack of funds 5. Working in parallel for 5 Units	---	Dec. 1996 start of commer-cial operation
	Cernavoda # 2	40	650	1. Before 1990, the same reasons as for above Cernavoda# 1 2. Lack of funds and reliable financing 3. Preservation	750	
	Cernavoda # 3	25		1. Before 1990, the same reasons as for above Cernavoda# 1		(2002)
	Cernavoda # 4	15		2. Cernavoda # 3, # 4 and # 5 suspended in 1991 and go into the preservation		
	Cernavoda # 5	10				
Russian Federation	Rostov N1 WWER-100	90	1100	1. Rapid decline of investment volumes 2. Higher safety requirements, projects are to meet the new standards and requirements 3. Ecological and public expertise	110	18
	Kalinin N5 WWER-1000	70	700		350	32
	Kursk N5 RBMK-1000	70	900		420	40
	Voronezh	50	200		200	24

Slovakia	Mochovce # 1	in operation	(1 + 2) 700	- Lack of the financing sources	860 (# 1 & 2)	(#1) 30 (# 2) 44
	Mochovce # 2	in progress start up 12.1999			---	---
	Mochovce # 3	40	(3 + 4) 360	- Lack of the financing sources	930	(#3) 48
	Mochovce # 4	30		- New evaluation of the project	(#3 & 4)	(#4) 57
Spain	Valdecaballeros # 1 & 2	55	3100	- Regional political opposition - Load consumption decrease - High debt of the utilities due to previous investments in NPPs	2000 (forecast)	(#1) 48 (#2) 72
Ukraine	Rovno-4	93	1000	- Moratorium on the construction of energy units in Ukraine	>1000 (first 2 units)	not defined yet
	Khmelnitski #2	92	1000	- Political and economical changes		
	Khmelnitski-#3	30-40	600-800	- Decline in electricity demand	1000	
	Khmelnitski-#4	30-40	600-800	- Absence of investment	1000	

2. MAIN PROBLEMS

Country	Rank the main problem areas
Argentina	1. Preservation of long-term storage equipment and materials 2. Maintenance of site installations and local infrastructures 3. Maintenance of human recourses 4. Maintenance of main contractor's guarantees and warranties 5. Supply, construction and erection contracts continuation/discontinuation 6. Preservation of design and quality documentation 7. Maintenance of contractor's guarantees and warranties.
Brazil	1. Preservation of long-term storage equipment and materials 2. Maintenance of site installations and local infrastructures. 3. Maintenance of human resources from engineering firms involved in the project. 4. Maintenance of main contractor's guarantees and warranties. 5. Acceptance of Government authorities to give high priority for conclusion of the plant. 6. Project management due to budget restrictions. 7. Upgrading of project.
Bulgaria	1. Personnel 2. Preserving of the delivered equipment and already built units 3. Quality programme 4. Improvements within the project 5. Strategic plan 6. Work with the public 7. International co-operation between the IAEA staff and specialists in this field
Canada	1. Increasing project costs 2. Project plan rising difficulties 3. *Personnel leaving for other projects* 5. Negotiations with suppliers and contractors
Cuba	1. Economical and financial 2. Preservation of equipment, structures and installations 3. Retention of personnel 4. Preservation of quality documentation

Czech Republic	1. Timing and quality of the project preparation (limited capacity of general designer, limited engineering capacities) 2. The transition from the "eastern" philosophy to the "western" one (the way of designing, different codes and standards, ...) 3. Political and economic changes in the Czech republic (influenced contractors and their behaviour)
India	1. Financial constraints 2. Changes and up gradation in design after commencement of project construction. 3. Evolving regulatory guides and codes 4. Multiplicity of suppliers and contract agencies 5. Inadequate infrastructure facilities 6. Environmental considerations
Islamic Republic of Iran	1. Objection of western countries for co-operation with AEOI for the completion of the plant 2. Disinclination of KWU/Siemens in co-operation with AEOI for the completion of the plant 3. Lack of manufacturing documents 4. Preservation and maintenance of site installations, structures, buildings and equipment 5. Retention of human resources 6. Preservation of engineering and construction data 7. Upgrading the regulatory requirements, higher safety requirements, project are to meet the new standards and requirements
Romania	1. Provide adequate financial support for the project 2. Conclude a contract for Unit # 2 finalisation 3. Lack of qualified contractor personnel/human resources retention 4. Updating to meet licensing requirements 5. The quality of some equipment must be improved/technological upgrades.
Russian Federation	1. Lack of reliable financing 2. Non-payment and late payment of energy consumers, restrictions on construction of NPPs based on the decisions of regional governments and referendums 4. Loss of a considerable number of productive power units in Russia, CIS and Comecon countries.

Slovakia	Units 1 & 2 1. Holding the milestones from the contractual time schedule in frame of the original project according new contract from 04/96 for unit 2 2. holding the milestones from the contractual time schedule in safety measures part according contract from 04/96 for unit 2 Units 3 & 4 3. To achieve the Slovak Government decision for Units # 3 & 4 completion 4. To recognize, to identify possible loaners, investors and supporters.
Spain	1. Motivation of the people 2. Retention of skilled people 3. Preservation of specialized design teams 4. Public relations (with local authorities) 5. Documentation and information record & file
Ukraine	1. Lack of demand in electricity 2. Lack of strict government support 3. Requirements to safety upgrading 4. Deterioration of construction and supplier infrastructure 5. Lack of investment

3. MEASURES

Country	Proven measures	Desirable measures	IAEA assistance
Argentina	- Maintenance of storage equipment and materials, site installation and local infrastructures, in accordance with main contractor's procedures and supervision - Retention of the minimum human recourses to permit the restarting of the project - Negotiation with suppliers and contractors - Definition and preservation of the critical technical documentation		IAEA co-ordination for rational complementation of experiences among countries affected with the same problems.
Brazil	- Maintenance of storage of equipment and materials - Project up-dating - Retention of human resources - Assurance of main contractors' guarantees and warranties.		- Possibility to consult and obtain technical exchange from other countries with similar problems.

Bulgaria	1. The construction site is in good state 2. The equipment is being re-conserved 3. A development programme with minimum costs is in planning, including the Belene NPP 4. Studies were carried out by two projecting institutes in order to find out the expenditure and how much more financing is needed for the completion the project (in US $)	1. Licensing of the sites 2. Guarantees for the delivered equipment 3. Determining what exactly is to be modernised in the project 4. Ensuring financial support 5. Public relations	Assistance in working out the main principles of the following: 1. Modernisation of the WWER-1000 2. Quality programme 3. Strategic planning for the recovery of NPP construction 4. Unification of norms and standards including legislative norms 5. International co-operation and public relations in order to recover NPP construction 6. Possibility to consult different countries on specific problems.
Canada	-	- Better strategic planning - Minimise changes - Keep public informed	- Clarify/explain consequences of delay — Provide advice on effective corrective measures - Advise on actions, priorities and prerequisites for re-start - Advise on how to benefit/utilise outside assistance

Cuba	- Preparation of a feasibility study - Temporary paralization plan - Preservation of quality documentation in temporary quality vault - Optimisation of storage areas and moving all possible equipment to its location places	- Creation of enterprise for the construction work restart - Works for practical implementation of the recommendations mentioned in the feasibility study. Information about its cost.	- Support for training personnel - Technical support for construction restart - Technical support for the implementation of modifications in the basic design
Czech Republic	1. Stabilisation of project preparation 2. Stabilisation of contractors conditions 3. Staff and organisational stabilisation of the owner and operator of NPP	- Effective management of project implementation	1. Technical review 2. Personnel training 3. Standards comparison (East-West)
India	- Financial sanction in two phases one up to ground break and another beyond - Advance action for procurement of long delivery items - Parallel mechanical equipment erection with civil works construction taking adequate protective measures - Large scale mechanisation of construction activities - Large scale prefabrication modular construction - Special groups for over dimensioned components, public awareness, interaction with regulatory agencies	- Standardised design for unit size, type and location coastal or inland - 80% drawing release for construction prior to ground break	-

Islamic Republic of Iran	1. Finding other alternatives to complete the plant 2. Preservation of plant equipment, structure and buildings 3. Recruiting and training of young engineers 4. Upgrading the regulatory documents by the assistance taken from foreign consultant 5. Using the more advanced Russian reactor of WWER-1000 Model V-392 6. Making a comparative analysis report between the Russian codes and standards with the ones acceptable to Iranian regulatory authority	1. making changes in the existing design to upgrade the safety of the plant 2. Training of more personnel in the field of design, engineering, construction and project management.	1. Assistance in manpower development 2. Project management 3. Design and safety review of documents received from new contractor 4. Participation of Iranian experts in meetings & conferences related to WWER-1000 5. Increased scope of IAEA expert missions and advice through the mechanism of funds in trust from the recipient country 6. Assistance in upgrading the regulatory requirement and new standards
Romania	1. To motivate good people to keep them on site 2. To provide a good preservation for equipment 3. To select equipment supplier taking into account Unit 1 experience 4. To implement the good changes done in Unit 1 5. To update site facilities	1. Financial resources 2. Long term finalization	1. Training 2. Exchanging experience

Russian Federation	1. creation of a fund for the development of atomic energy by including the investments in the tariff 2. Analysis and changes to the projects in order to meet the new safety requirements 3. Licensing of the modified projects, of project and constructing organisations. Getting authorisation for the construction from supervising authorities 4. Ecological and public opinion expertise of the projects	1. Attraction of reliable financing: - foreign credit - financing from the state budget 2. Financing the research work in order to produce equipment which meets the quality requirements and standards 3. Public relations	- Assistance in getting foreign credit and in the field of public relations - Exchange of experience in the field of delayed projects
Slovakia	**Units 3 & 4** - To prepare 2 stages of least cost analysis - On the base least cost analysis to identify the potential loaners, investors and supporters	To accelerate the governmental decision to complete Units 3 & 4	- To observe the scope of work of the safety improvements and safety concept and approach for implementation of the nuclear safety level
Spain	- Suspension plan (three phases) - Conditioning of the plant (2nd. phase) - Protection and maintenance procedures - Specific quality assurance plan	- Clarify official positions from the beginning - Resumption construction decision	-

Ukraine	1. Creation fund to collect money for completion of Rovno-4 and Khmelnitski-2 2. Development of proposal to upgrade NPP to meet safety requirements	1. Restoration of supplier and construction infrastructure 2. To be sure that society demands new units for electricity generation 3. Attract reliable investment	1. Independent assessment of delayed NPP condition and recommendation to update situation 2. Assistance in exchange of experience with delayed NPP project management

Appendix 2

RISK MANAGEMENT/CONTINGENCY

This appendix discusses the general considerations of economic risk as it affects achieving desired project outcome.

Risk is defined in terms of its parent — uncertainty. Uncertainty is the set of all potential outcomes, both favorable and unfavorable. Those outcomes which are unfavorable represent risk; where those which are favorable represent opportunity. Risk is also defined as the probability that an unfavorable outcome will occur.

Uncertainties, and therefore risks and opportunities can be catalogued by source as follows:

- Technical
- Contractual
- Financial.

In estimating the total cost of a project, a large number of potential outcomes exist, ranging from the best potential under-run (opportunity) to the worst potential overrun (risk).

A total risk management programme has three stages as follows:

Identification: this is simply the categorizing of risks that may befall a project.
Measurement: this is measurement or evaluation of identified risks, in terms of potential impacts if the risk became an event.
Control: this includes risk avoidance, reduction, sharing, transfer, insurance, acceptance (with or without contingency), and containment.

Research on the subject of uncertainty shows an almost universal tendency for people to underestimate uncertainty and overestimate the precision of their own knowledge and judgment. Research also has shown that one can improve the confidence level by using evaluations and simulations that eliminate the biases of single-figure subjective judgments.

The attention of the project team should be focused on key risk items, with lesser surveillance of the remainder. A "**critical items report**" should be produced reporting any situation that has affected or has the potential for significantly affecting cost or schedule. This will allow these items to receive particular attention.

Appendix 3

COMMUNICATIONS WITH THE PUBLIC

This appendix discusses some key features of a project's public communication programme, which should be considered when preparing it.

Communications policy

A typical communications policy might state that:

- Influencing public opinion through communications shall be a long-term, continuous programme.
- Communications shall be pro-active, in that potential problems arising from inadequate communications or misconceptions shall be anticipated and addressed.
- Communications shall be honest, forthright and transparent, meaning that sources of information shall be identified.
- Communications shall be open, meaning that pertinent information about the project — good or bad — shall not be concealed.
- Clarity and ease of understanding of information shall be emphasized.
- Where possible alliances shall be formed and co-operation extended to organizations and groups who support nuclear power, such as, for example, nuclear association, engineering society or local political representatives, to lobby central government on behalf of the project.
- All staff shall be utilized — to the extent appropriate — in providing information to recipients, meaning that provision of information and influencing opinion will not be limited to staff expressly devoted to this role. Staff so utilized shall receive appropriate training in public speaking and presentation techniques.
- Support shall be available to all staff to ensure that they have the correct information to present.
- This policy shall apply to all corporate staff, in their official and unofficial communications.

Key features of communications programme

- Communication shall be directed at the opinion formers and other target groups in the government, project stakeholders and society in general.
- Target groups should be defined and identified.
- Their opinion should be influenced towards active support of the nuclear power project.
- Within the limits of communication policy, opinions promoted by opponents of nuclear power shall be countered and discredited, if incorrect or untrue.
- A senior management committee shall be formed to periodically review, direct and assess the extent to which objectives of communication/information plan are being achieved.
- There should be periodic sampling of opinion within the target groups and appropriate communication/education campaigns shall be conducted to influence these opinions in the desired direction.
- Communication/education activities shall be directed primarily at the target groups which have the power to influence the project, but secondarily at the country and society in general.

- To the extent possible, the important concerns within each target group shall be identified and appropriate information prepared and disseminated to address these.
- All employees shall be familiar with the objectives and techniques specified in the communication plan.
- Appropriate performance measures shall be developed and trended to assess effectiveness of communication plan.

Target groups

A "target group" is an identifiable group of people who hold similar opinions and attitudes towards nuclear power in general, and the project in particular. "Target groups" or against nuclear power project should be identified through opinion surveys and other techniques.

Target groups are important because they have influence and power in their respective domains to affect outcomes of various nuclear and other electrical power initiatives.

The following is a partial list of target groups in the various domains:

Public

- Mass media, such as television, newspapers
- Universities and schools with their faculty or teacher associations
- Neighborhood associations
- Professional associations, e.g. engineering, Medical, Legal
- Clergy
- Non-governmental organizations, such as environmental groups or special-interest groups
- Political parties
- Trade unions.

Government and elected representatives (parliament)

- Municipal (local)
- Regional
- Provincial
- National
- Various specialized government agencies.

Regulatory bodies

- Nuclear regulatory agency
- Other regulatory agencies, e.g. Pressure vessels and boilers

  Within each regulatory agency:
  - The president and members of the governing body
  - Managers
  - Staff experts, who advise the governing body and also conduct audits and assessments.

Utility employees:

- Managers and supervisors
- Professional staff (engineers, lawyers, accountants) and leaders of their staff associations
- Leaders of the trade unions representing employees
- Administrative staff (secretaries, security guards)
- All other employees.

Communication techniques

The standard communication techniques shall be used, but expert advice from specialists in the field of communications, information, advertising and promotion, public and governmental relations shall be obtained and heeded.

The issue of public and special-interest opinion is of extreme importance to the project and the nuclear power programme and as such should be dealt with professionally. Amateurs in the field – however well intentioned – should only be used when appropriate and only after they have received training in public speaking or presentation techniques.

Typical communication techniques include:

- Specialized publications.
- Articles in the press.
- Films and videos to be made available to universities and schools.
- Appearances of senior managers and public relations staff in public debates on TV, radio or at meetings.
- Presentations to employees.
- Participation at public exhibitions and seminars.
- Formation of speakers' groups, form amongst employees, to go and speak to organizations and clubs, such as church clubs and similar. The selected employees have to receive training and be coached and supported with information about current and general issues.
- Formation of public information centers equipped with appropriate materials and trained staff and regular "reports" to the public through publications or public meetings.
- Encouraging visits to the project — or other nuclear installations —– by the public ("open house days") and by elected representatives.
- Periodic personal or video presentations to parliament, politicians and government agencies.
- Sending "targeted information" to selected groups, such as parliament.
- Establishment of personal, long-term contacts between project staff and members of various "target groups" to promote good relationships, trust and personal transfer of information.
- Establishment of a formal and regular review process to assess project progress and problems, with governmental agencies and regulators.

Appendix 4

PRIORITIZATION OF ITEMS

This appendix outlines the criteria by which the thousands of items at a delayed NPP can be prioritized for application of P&M.

Prioritization should be based on:

- Importance to nuclear safety
- Value of the item and ease of replacement
- Condition of the item
- Future availability
- Sensitivity of item to lack of preservation
- Cost of preservation versus replacement.

Prioritization criteria

All items should be listed and categorized as follows:

- items important to safety
- high value items beyond specified threshold values in terms of cost
- rest of the items.

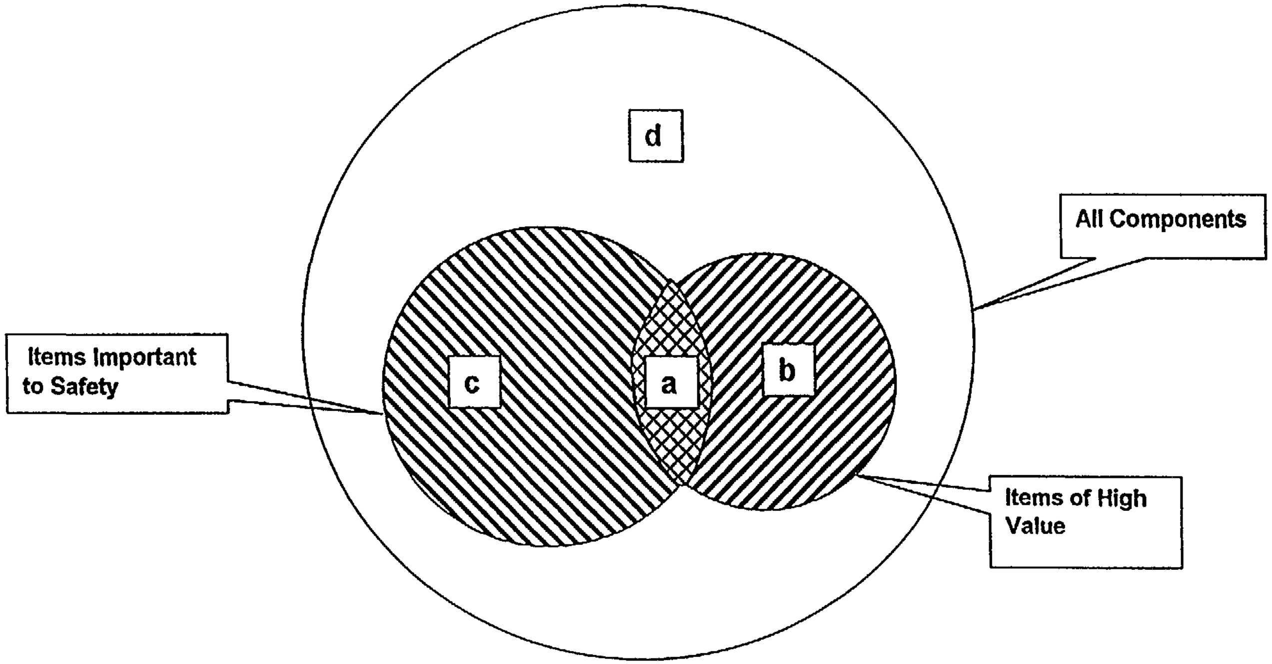
Arising from the above lists, all items should be classified as follows:

- *High value items important to safety*, typically: reactor pressure vessel, nuclear steam generators and primary coolant pump-motor assemblies degradation or damage that will render these items unfit, is a serious techno economic penalty.
- *High value items not important to safety*, typically :the turbine-generator.
- *Items important to safety but not of high value*, typically not very expensive items like small-medium size pumps and valves, in nuclear systems.
- *Rest of the items*, typically the items not important to safety and also below the threshold cost values.

Basic approach in preservation and maintenance should be to give a high priority to one or more of the characteristics, i.e. high value and safety significance. In decreasing order of importance priority should be assigned to:

- high value items important to safety;
- high value items not important to safety;
- items important to safety but not of high value;
- rest of the items.

Figure 3 illustrates the application of this principle.



Note:
(a) High Value Items Important to Safety.
(b) High Value Items not included in (a).
(c) Items important to Safety not included in (a).
(d) Rest of Items.

FIG. 3. Levels of importance for preservation and maintenance.

Appendix 5

PLANNING FOR EFFECTIVE IMPLEMENTATION OF P&M

This appendix provides more details for planning of P&M.

The following are additional considerations to be taken into account when preparing detailed plans for ensuring effective implementation of P&M:

Technical

- Analyzing suspension cost vis-à-vis completion cost in order to minimize investment in temporary installations.
- Systematically identifying and analyzing pending items and continuing with partially finished tasks.
- Avoiding any unstable states in structures, systems, equipment and components.

Supplies

- Maintaining supplies to support P&M programme
- Maintaining adequate stock of spares, taking into account critical long delivery supplies
- Considering obsolescence and possibility of manufacturers leaving the nuclear business
- Examining use of buildings for storage of equipment.

Site and facilities

- Preventing natural damage, flooding and water accumulation;
- Slope protection, completion of building closures and of roads;
- Implementing protection and maintenance of embedded parts and liners
- Implementing measures to assure personnel safety.

Appendix 6

STORAGE CATEGORIES

This appendix reviews the classification of storage facilities as developed by a member country, and its application to storage of specific materials. Physical protection of storage areas and control of environmental conditions within are also reviewed.

There are 5 typical *storage categories*, as follows:

- 1 — open yard storage with good drainage, fenced, free of plants, protected against flooding and fire hazards. Used for storage of outdoor components such as transformer, switchyard, intake equipment and bulk steel/structural materials. Tarpaulin cover may be provided to provide cover against rain.
- 2 — storage under roof with open sides. May be used for storage of piping and spool materials, structural parts, cable drums, cable tray structures, etc.
- 3 — storage areas within buildings, maximum temperature being limited to 40°C. Used for storage of instruments, valves, pumps, compressors, electric motors, etc.
- 4 — air-conditioned storage areas with temperature and humidity control used for storage of precision components and parts, electronic items, computers and its parts.
- 5 — storage areas created to suit special requirements, e.g. for elastomers for exclusion from sunlight and ozone.

Some of physical protection measures are:

- *Closure of buildings, zones and rooms*
- All external and internal openings leading into complete or partially completed buildings should be closed and secured to prevent water, dust, debris and animals from entering..
- *Packing*
- Equipment still in its packing crates and delicate items removed from the plant should be stored in packed condition.
- Damaged packing should be replaced and equipment inspected
- *Individual protection*
- Openings, machined surfaces and welds of some equipment and components require protection in installed condition, e.g. pipes, embedments, ventilation openings, valves.
- Protection materials such as plugs, caps, adhesives, rubber wraps, must be compatible with the item to be preserved, for example, plugs used in reactor vessel or steam generators.
- Measures must be undertaken to exclude all foreign material from insides of equipment.

Control of Environmental conditions

- Considering that corrosion due to moisture and oxygen is the main cause of equipment damage, the basic protection consists of keeping the relative humidity below a fixed limit.
- Conditioning the atmosphere of entire rooms or parts of buildings can be more cost effective than providing protection on individual basis.
- In order to avoid condensation, relative humidity should be controlled so that no condensation occurs at room or component temperature. A value of relative humidity below 60% is commonly used.

- Humidity in stored/installed equipment can be controlled by putting desiccants into evacuated and sealed internals *(dry storage)*. Internal humidity has to be periodically checked and desiccants refreshed.
- Oxygen can be replaced by an inert gas (usually nitrogen) through purging. Inert gas cover is then maintained, and regularly sampled.
- Alternatively, internal parts of systems or large components can be protected by purging and filling with water with chemicals added (wet storage). Circulation must be established and the contents regularly sampled.

Appendix 7
PROTECTION OF SURFACES

This appendix discusses the various methods by which surfaces - internal and external - can be cleaned and protected.

Surface cleaning
Effectiveness of any surface protection strongly depends on surface preparation. All surface contaminants must be removed before application of preservatives.
The following are some of the surface cleaning methods:

- Abrasive cleaning
- Degreasing
- Pickling or acid cleaning. Use of this method has to be carefully evaluated against the type of materials in the component to avoid an undesirable chemical reaction.
- Passivation cleaning in oxidizing and acid solution may be necessary as a final cleaning operation.
- On completion of surface cleaning, surface must be washed or flushed with de-mineralized water and dried in clean, oil-free air, drying oven, or, for internal surfaces, by evacuation (vacuum).

Surface protection. Surfaces can be protected by:

- Elimination of aggressive agents (moisture, oxygen, acids etc);
- Surface passivation
- Surface coating.

Aggressive agents can be removed *from internal surfaces* by:

- Drying, using desiccants. Periodic inspection and regeneration of desiccants is required.
- Maintaining a cover of inert gas
- Heating or circulating hot air through the component so that the surface temperature rises to 4 to 6°C above the room temperature thus preventing condensation and corrosion
- For *outside surfaces*, periodic cleaning of painted surfaces is effective.

Surface passivation (internal) is achieved by:

- Chemical anodic and cathodic inhibitors. Use of volatile corrosion or vapor phase inhibitors (VCI) for stored equipment and components offers simplicity in application in contrast to other corrosion protection methods.

Surface coating

- Preservatives, such as paints (strippable and primer coatings), oils, greases, and a number of proprietary compounds are used for surface coating. If preservative is to be used on inside surfaces that will become wet during plant operation, it must:
- Be removable completely by cold water flushing
- Have a low sulfur and halogen content.

Appendix 8

ROUTINE AND SPECIAL MAINTENANCE ACTIVITIES

This appendix discusses routine and special maintenance activities to be applied to equipment in storage at a delayed NPP or at manufacturer's warehouse. Suggestions for inspection of stored parts are also included.

Typical routine maintenance activities are:

Mechanical rotating equipment/components with moving parts

- In addition to applicable preservation measures such as surface protections of nozzles, sealing of openings, etc., the following maintenance activities would also apply:
- Control and replenishment of oil levels in the bearing oil housings and gear boxes and lubrication of points marked by the manufacturer.
- Periodic partial rotation of shafts.
- In some cases it may be necessary to dismantle and/or replace some elements, metal closures, gaskets, etc.
- The best way to preserve equipment already installed and commissioned is through periodic start-up and operation, and also through applying a routine maintenance programme.

Valves

- Control valves with positioners, electro-pneumatic converters, limit switches, etc. should be removed and stored. Packing materials around valve stems should be removed from the valves above specified sizes to avoid galvanic corrosion. If the packing has not removed for valves below specified sizes, stems should be periodically inspected for corrosion and appropriate corrective action taken.

Electrical/instrumentation & control equipment and components

- Storage of instruments and electronic components include dehumidifying, maintaining dryness, cleanliness and good ventilation.
- Where equipment is equipped with internal heaters, they should be energized.
- Equipment with windings (motors and alternators) should be periodically inspected and insulation resistance measured.
- Components with contacts (circuit breakers, contacts, relays, etc.) should be subjected to surface inspections and surface protection. For coil springs, pistons, etc., fitted into large circuit breakers, the appropriate preservation method specified by the manufacturer should be followed. Grease should be replaced periodically from circuit breakers as it has the tendency to harden. For some electronic equipment, it may be necessary to maintain a steady voltage across the terminals during storage.
- Equipment with fluids (e.g. transformers, switch gear) require specific preservation measures, such as:
    - Draining the liquid, purging and filling with an inert gas or
    - Providing circulation and temporary filters
    - Monitoring condition of the liquid
    - Keeping equipment energized at low voltage.

- If batteries have been filled with electrolyte, they should be subjected to a normal maintenance programme.

Static mechanical equipment

- Equipment should be pressurized with inert gas, and internals periodically especially welds, and for steam generators, contacts between tubes and support plates. Alternatively, wet storage methods may be selected.

General overhaul

- General overhauls of major rotating equipment should be considered following sampling of condition and advice of manufacturer. An overhaul calls for complete dismantling of equipment such as pumps, important valves, etc. These overhauls ensure assessment of internal conditions followed by applicable corrective actions. Often, warranties are also maintained.

Elastomers

- These have shelf and service life constraints and are to be protected from environmental condition such as exposure to sunlight and ozone. Flexibility of the elastomers should be tested and those outside specification should be discarded. Changing of elastomers like seals, valve diaphragm etc. after the expiry of shelf/service life is advisable as part of routine maintenance for operating equipment.

Special maintenance

For important plant equipment/components such as reactor, turbine generator, emergency diesel generator, it is necessary to carry out special maintenance programmes.

Reactor components

- Clean loose parts or sub-assemblies should be kept in evacuated and sealed airtight aluminum foils with humidity indicators or protected by removable surface coating and enclosed in protective covers. For equipment like steam generators, pressurizer, etc. preservation is achieved by maintaining nitrogen atmosphere. Conditions should be periodically sampled.
- The best place for adequate preservation of the reactor vessel and its contents may be at its final location. Once the vessels and internals are installed, preservation can be achieved by sealing and controlling the internal environment (temperature, humidity, oxygen) through closed circuit circulation loop. Preservation measures must meet manufacturer's instructions.

Turbine generator

- Loose parts, sub-assemblies are to be preserved and packed individually. Outer surfaces of the parts are coated with synthetic enamel paint. Internal surfaces coming into contact with steam are coated with paint capable of emitting corrosion inhibitors. Mating surfaces are coated with removable rust preventive.
- Attempt should be made to complete the installation of the turbine generator to the point where it can be sealed and protected by controlling the internal environment (temperature, humidity, oxygen) through a closed circuit circulation loop. Preservation measures must meet manufacturer's instructions. Conditions should be periodically sampled.

Suggested areas of surveillance/inspection

- Manufacturing Shops: identification, preservation and compliance
- Packages in stores: identification, storage and environment conditions
- Mechanical Items (static): component and surface condition, contamination
- Electrical, instrumentation and control components: preservation, condition and control of storage, electrical parameters
- Site: drainage, lighting, paint, condition and cleanliness, closure of temporary openings;
- Installed systems: preservation of components, surface cleaning and internal inspection of piping, painting, contamination, draining, drying, wet or dry preservation, desiccants or corrosion inhibitors, functional checks
- Maintenance of equipment: visual, cleaning, checks on oil level, electrical, pressure, leak tightness, and movements;
- Special P&M on parts like reactor and turbine generator as per manufacturer's instructions.

Appendix 9

ESSENTIAL FACILITIES

This appendix lists the essential facilities which must be kept in service at a DNPP during the delay period.

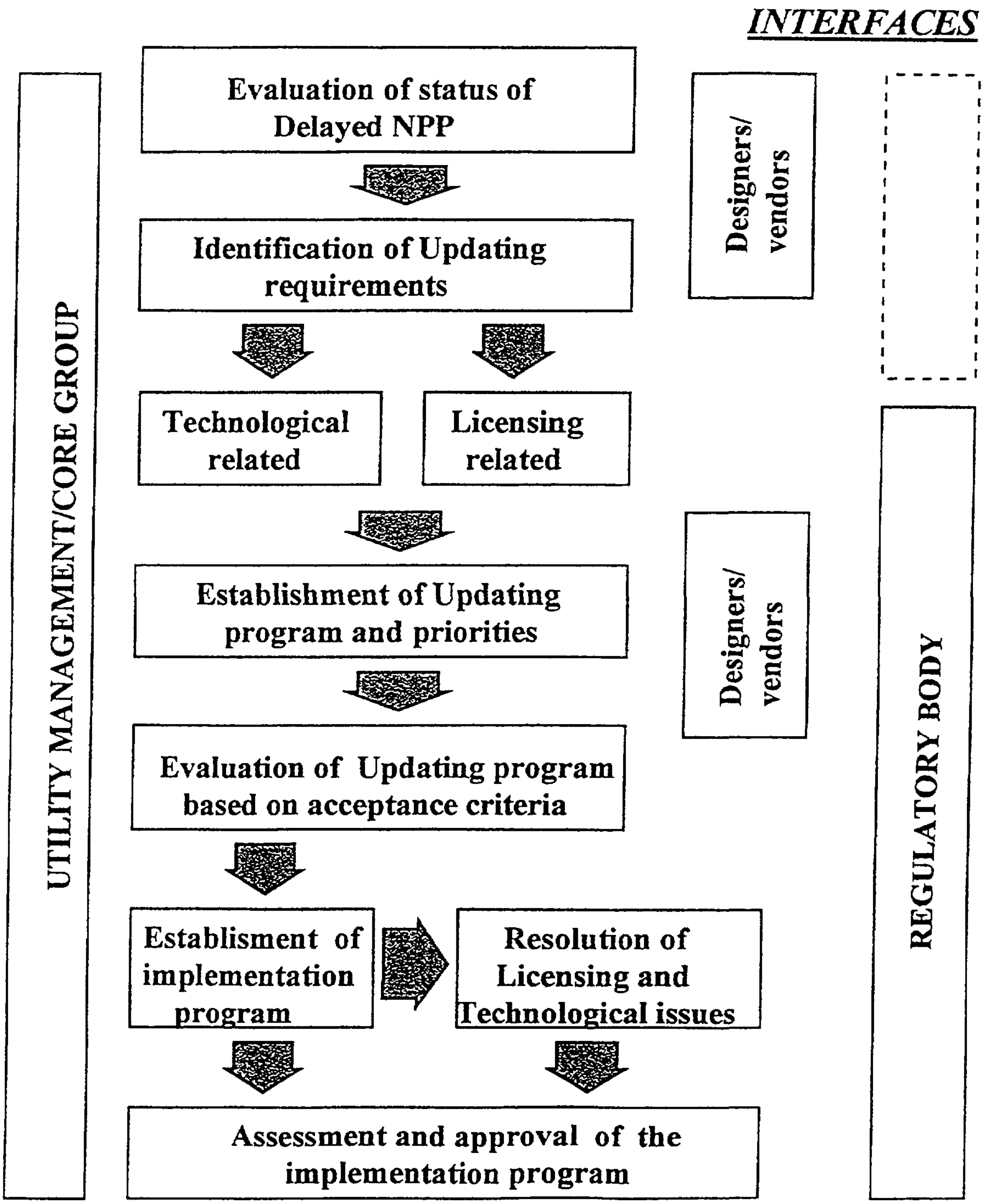
The following are the *essential facilities* to be kept in service:

- Storage areas and warehouses
- Construction/project office
- Security
- Fire fighting
- Water supply
- Power supply
- Compressed air, ventilation and other services
- Drainage, road, lighting, protective fence/compound wall
- Material handling equipment like cranes, forklifts, etc.
- Transportation facilities and road
- Repair and maintenance workshop
- Instruments/equipment and facilities for testing
- Calibration laboratory for the purpose of maintaining calibration of measuring instruments and accuracy of chemical standard samples
- Chemical control laboratory for evaluating samples from the field.

Supply of consumables like packing material, cleaning abrasives/agents, strippable coatings, corrosion inhibitors, preservatives, inert gas, diesel, petrol, and such other requirements should be maintained.

Appendix 10

FLOWCHART OF ACTIVITIES TO BE PERFORMED FOR DNPP WHEN UPDATING TO MEET LICENSING REQUIREMENTS AND TECHNOLOGICAL UPGRADES



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EFFECTIVE PRACTICES

Introduction

Effective practices represent the successful experience of nuclear power companies which have prevented or corrected problems in DNPPs. These practices solved the problem at a particular plant in a particular situation.

Practices obtained from nuclear utilities have been edited, and in some cases supplemented with extra elements, shortened and presented in the annexes in a standard form to permit the reader to grasp the essentials, without being cluttered with details. They need not be read sequentially.

For implementation, the process and the practice must be adapted to suit the culture, organization and the operating environment of the project.

To facilitate future reference for additional information, names of individuals who provided the practice and their power plant have been given at the end of each annex.

List of effective practices

Islamic Republic of Iran — Bushehr NPP

Annex 8:	Project control
Annex 8A:	Preservation and maintenance
Annex 8B:	Preservation and maintenance
Annex 8C:	Preservation and maintenance

Romania — Cernavoda NPP

Annex 9:	Licensing requirements
Annex 9A:	Project control
Annex 9B:	Assessments and evaluations

Slovakia — Mohovce NPP

Annex 10:	Project control

Spain — Nuclear power programme

Annex 11:	Project control
Annex 11A:	Project control
Annex 11B:	Project control

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Annex 1

ARGENTINA: ATUCHA 2 NPP — PRESERVATION AND MAINTENANCE

Summary

This annex deals with *preservation and maintenance*. It describes managerial actions and physical measures taken to preserve the equipment and facilities at site. Also described are the problems encountered, most of which appear to originate form management.

Overview

The construction of Atucha 2 (CNA-II) 700 MW(e) NPP) experienced several delays. Construction has been suspended since 1995 except for some contracts of components, supplies and items related to emergency power supply systems in operation.

About 100 000 items have been delivered to the site including turbine-generator, reactor pressure vessel, pipes, fittings, valves, pumps, motors, transformers, electrical cables, etc.

About 95% of the items are already either stored or erected at site. The civil works of buildings are 99% complete. About 35% of electromechanical components have been erected. Spools of piping have been pre-assembled to the extent of 58% and stored. Piping systems to the extent of 19% have been erected.

Key elements

- The main activity at Atucha 2 is the preservation of site installations, structures and equipment. The preservation programme was planned starting at project suspension. The programme is oriented towards the achievement of preserving the good condition of the installations, structures and equipment.
- Organization responsible for the engineering, construction and commissioning is also responsible for the preservation of NPP.
- The programme defines the minimum scope of preservation which achieve the planned goals with available resources.
- The organizational structure has been modified to incorporate a sub -organization whose specific responsibility is preservation.
- In order to augment the scarce manpower, the participation of the engineering personnel who have been involved in the design has been increased.
- To achieve the target of maintaining readiness for resumption of the project when the conditions permit, a *preservation programme*, having the following attributes was developed:
  - provide protection against corrosion damage, contamination, mix-ups or loss
  - be described in a procedure
  - be set up so that effectiveness of preservation measures can be easily checked
  - ensure that parts and components are be clearly identified
  - preserve civil works, structures and installations
  - generate evidence which will enable verification of the achievement of the programme objectives.
- Additional procedures to train and qualify personnel have been established.

- Manufacturers have qualified personnel to work on their components.
- Additional project specifications and work instructions have been established in order to define the manner of preservation, approval of process and equipment, monitoring, control and recording.
- According to the recommendations of the manufacturers and the requirements of the project specifications, a methodology for preservation in "as delivered" condition has been developed which includes measures for:
  - Packing for physical protection
  - Temporary protection against contamination
  - Marking
  - Storage conditions at site for each package
  - Inspection and recording of the packages and parts and preservation conditions.
- The programme applied at Atucha 2 for the preservation of mechanical, electrical and I/C parts and components has been subdivided in three principal groups:
  - Preservation of mechanical, electrical and I/C parts and components packed in original condition as delivered (wooden boxes in most cases) and preserved suitably against corrosion by means of intermediate storage preservation
  - Preservation of mechanical, electrical and I/C parts and components between the time of removal of the intermediate storage preservation and start of commissioning
  - Preservation of civil works, structures and installations.
- A system for surveillance, inspection and recording has been implemented.
- Self assessment and independent assessment (Main Contractor, Insurance Company, Owner, etc.) are carried out to determine the programme effectiveness and the adherence to the specific engineering standards and project specifications.

Problems encountered

The following main problems have been experienced:

- Preservation of installations, structures and equipment was not included in the original QA programme
- Preservation activities were not sufficiently described in a procedure
- No original provision of enough place to storage
- The packaging of national suppliers was not suitable for long time preservation
- No sufficient initial experience to manage preservation of actual volume of items
- The responsibilities for preservation and the organization were dispersed into the organizational structure and were not defined
- General economic restrictions affected the necessary human and material resources
- Difficulties to maintain qualified personnel.

Additional information

None.

Material provided by R. Ruben
C.N.Atucha 2, Argentina

Annex 1A

ARGENTINA: ATUCHA 2 NPP — MANPOWER AND DOCUMENTATION

Summary

This annex deals with *manpower and documentation*. The Atucha 2 project has been suspended and its future is uncertain. Additional uncertainty arises from de-regulation of the electrical market and possibility of privatization. This annex discusses some of the measures taken to retain personnel and to protect documentation.

Overview

In 1979 Argentina had set up a nuclear power plant programme that foresaw the construction of four plants. At the same time, construction of the 700 MW Atucha 2 plant was initiated. Later on the total plan was reduced to only Atucha 2 project.

The Atucha 2 project has experienced several delays and today, after 17 years, it is completely interrupted. A contract was signed with the foreign supplier as contractor and as the responsible agency for transfer of technology.

Key elements

Retention of human resources

Until 1995, due to lack of funds, the project progress was slow (average 5% per year).

In order to retain capability and to generate additional funds, contracts were signed by the plant management, to develop engineering and consultancy activities for conventional power plants.

A "sub-project", which would be subsequently required for completing Atucha 2, but was necessary to be taken up immediately for Atucha 1 was identified and implemented. This project pertains to the erection, commissioning and start-up of the emergency electrical system. This sub-project was completed in 18 months with very little incremental cost.

As a State owned company, salary policies were established with reference to salaries in Public Sector; these were inadequate to retain professionals with specialized skills.

In order to achieve significant salary compensation, in 1993, the engineering offices, hither located in Buenos Aires, were moved completely to site. As an added advantage, this measure made it possible for some of the personnel to participate in all phases of the project, namely erection, commissioning and operation.

In 1995, the Atucha 2 project was completely stopped, waiting for a privatization process. It was decided that only 50 persons will remain in the project, in order to be able to restart when the bidding process (related to privatization), is over.

Complementary activities planned for these personnel includes tasks not directly related to construction/erection, such as preparation of Operating Manuals, Safety Analyses Reports, risk Analysis Studies, Start-up Procedures etc.

Preservation of engineering and construction data

It is considered that if specific engineering and construction standards have been satisfactorily complied with during project execution, no other special measures are required, over and above an adequate physical preservation system.

A document titled "Engineering Progress Status Protocol" which includes complete snap-shot of the status of each of the engineering disciplines, at the time of project interruption, was issued.

Additional information

None

Material provided by R. Ruben
C.N.Atucha 2, Argentina

Annex 2

BRAZIL: ANGRA 2 NPP — PROJECT CONTROL

Summary

This annex deals with *project control.* Construction of Angra 2 has had strong decrease of investment from 1984 to 1994. Storage programme has been implemented and inspections are being planned. Personnel has been maintained to advance engineering work and to maintain site structures. Construction has been resumed with full co-operation of the foreign supplier. plant is 94% complete (October 1998).

General information

Construction of Angra 2 started in 1976 and was proceeding according to the project time schedule. In 1978 discussion with the licensing authority (CNEN) led to recalculation of containment foundations. Delay in project schedule resulted and the foundations were not finished till 1982.

From 1984 onward, the economic situation in Brazil had a serious effect on the implementation of the nuclear power program as well as on the construction of Angra 2.

Progress of the project, especially for the supplies and services to be provided in Brazil was limited and had to be geared to the annual budget provided by the Brazilian government.

This led to several postponements of the project. Notwithstanding these adverse circumstances, all parties in the project have permanently and jointly done their utmost to continue the construction of Angra 2, which is now 94% complete. Of the imported components, the foreign supplier delivered about 95%.

Total costs so far add up to US $4 000 000 000.

The current schedule calls for achievement of the following milestones:

- First hot operation — April 99
- Core loading — June 99
- First criticality — August 99
- End of trial operation — December 99

Measures implemented

Human resources:

The major partners in the project have maintained dedicated staff in their organizations:

- *The civil contractor* has maintained several hundred personnel at site. They are engaged in completion of structural, concrete work and also in finishing of structures. They also maintain and preserve the site installations.
- The *Brazilian engineering firm* (NUCLEN) has also kept several hundred engineers and technicians, and also some sub-contractor personnel. These people are kept busy with minimum activities.

- The foreign supplier has also maintained the Coordination Group and also carried out some engineering activities necessary to support NUCLEN. They have also supported inspections of equipment stored at the harbor up to 1993 and at Angra site from then on.

The total cost associated with these activities is estimated approx. US $450 000 000 in ten years, with no corresponding physical progress at site.

Preservation of stored equipment

Procedures have been implemented to assure save storage of equipment, as follows:

- Requirements for long-term preservation for national and imported components
- Instruction of storage and inspection
- Specific instructions and procedures for materials requiring special storage.

Currently there are 20 000 t of imported equipment and 13 000 t of national supplies stored at site. Storage area is 41 000 square metres, of which 27 500 square metres are enclosed.

Updating of project

In order to optimize, technically and economically, the construction and operation of Angra 2, and in accordance with a contractual commitment, the Brazilian Partners to the project have been continuously informed by the foreign supplier about updating measures in the design of the German 1300 MW PWR standard NPP.

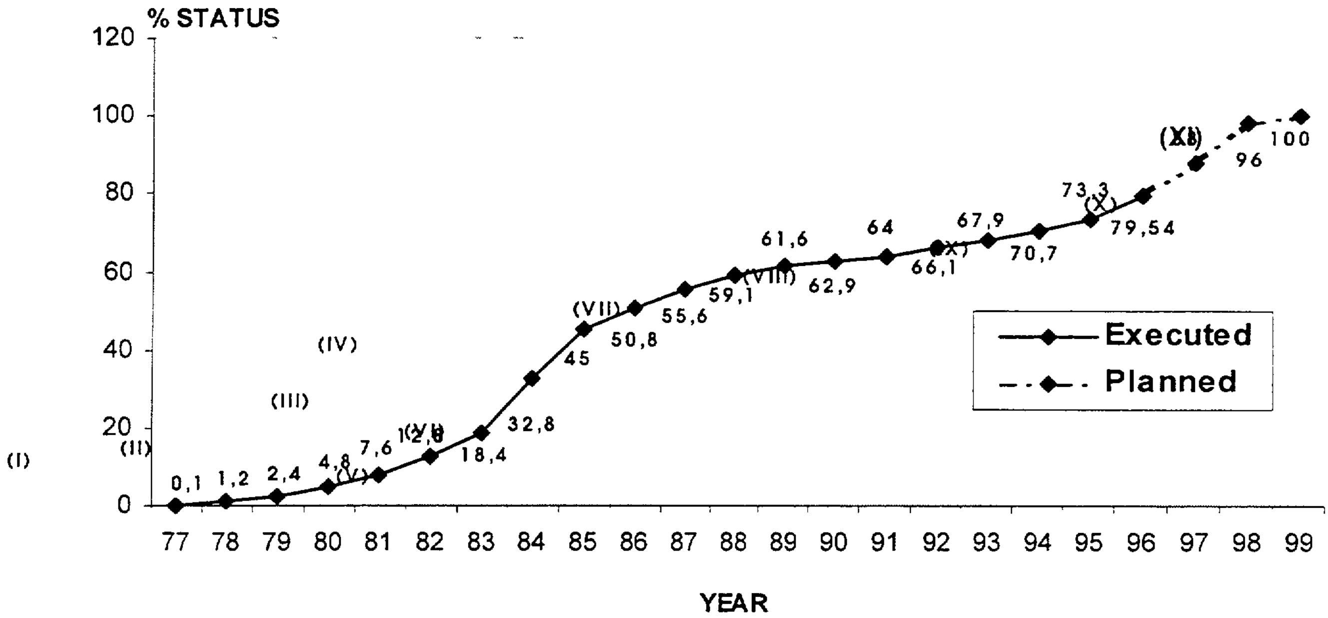
They have received recommendations on applicable and adequate technical updating measures concerning safety and availability of the plant.

Measures scheduled prior to plant completion

In order to assure functionality of components during commissioning and also to minimize commissioning time, a general inspection of equipment is being carried out during construction period. This will also assist in maintenance of insurance protection.

The general inspections are based on specific instructions prepared by the foreign supplier for imported components, and by NUCLEN for the domestic components.

Additional information



I -BEGINNING OF FOUNDATION WORKS.

II -FIRST DELIVERIES OF IMPORTED EQUIPMENT.

III -BEGINNING OF EXECUTION OF ROOF REACTOR BUILDING PILES AND MAIN BUILDINGS STRUCTURAL WORKS INCLUDING CONTAINMENT VESSEL ERECTION

IV -FIRST DELIVERIES OF NATIONAL SUPPLIES.

V -SITTING OF LOWER CAP OF CONTAINMENT VESSEL; FIRST UNLOADING OF IMPORTED HEAVY LOAD EQUIPMENT

VI -ESTABLISHMENT OF PRESERVATION PROGRAM FOR STORED EQUIPMENT.

VII -ACCOMPLISHED THE MARK OF 22.000 TON OF IMPORTED EQUIPMENT STORED IN BRAZIL.

VIII -ACCOMPLISHED 90% OF TOTAL CONCRETE WORKS.

IX -PERFORMED SEA TRANSPORTATION OF MAJOR HEAVY EQUIPMENT STORED AT NUCLEP'S FACILITIES TO ANGRA SITE (REACTOR VESSEL; STEAM GENERATORS; MAIN CONDENSER SECTIONS; TURBINE GENERATOR.

X -MAIN CONTRACTS FOR ELECTRICAL - MECHANICAL ERECTION (MECHANICAL-NUCLEAR, MECHENICAL - CONVENTIONAL AND ELECTRICAL AND INSTRUMENTATION AND CONTROL PACKAGES) SIGNED IN MARCH/96. MOBILIZATION STARTED ON MAY,06.

XI - EXTERNAL POWER SUPPLY (JUNE/97).

XII - CONTAINMENT PRESSURE TEST (DECEMBER/97).

XIII -WATER INTAKE FLOODING (SEPTEMBER/98).

Material provided by
J.E.B. Costa Mattos, Angra 2, Brazil

Annex 2A

BRAZIL: ANGRA 2 NPP — UPGRADES — MODIFICATIONS AND IMPROVEMENTS

Summary

This annex deals with *upgrades — modifications and improvements*. With decision to resume construction of Angra 2, a study was conducted to select modifications and improvements required to bring Angra 2 to the standard of the reference plant. This annex summarizes decisions reached.

General information

The original contract with the foreign supplier considered 1983 as the hand over date of the plant. Today, this is expected to occur in the second half of 1999. The reference plant was Grafenrheinfeld (KKG/BAG).

The licensing authority of Brazil approved the construction license based on the reference plant design. The contract with the foreign supplier foresaw the obligation of the vendor to update the plant design to the improvements introduced in its newer plants.

Key elements

During suspension phase there were changes of design and technology due to:

- Feedback from accident analysis (Three-Mile Island and Chernobyl)
- Additional licensing requirements in Germany, to the extent applicable to the reference plant,
- Newer plants operation experience feedback.

The Brazilian utility responsible for the project Angra 2, following the German Utilities' practice, voluntarily evaluated the applicability of accident management (AM) measures recommended by the German authorities.

Preventive AM measures that were contemplated are:

- Secondary bleed and feed,
- Primary bleed and feed,
- Third grid power supply, and

The mitigating AM measure:

- Filtered containment venting.

The following additional modifications to improve plant safety were implemented:

- Preventive measures related to leakage in the primary circuit,
- Re-qualification of I&C to guard against effects of rupture of high-energy piping,
- Re-design of steel platforms to guard against effects of rupture of high-energy piping,
- Upgrading of reactor protection, control & limitation systems,
- Automatic shut-off of accumulators N2 injection,
- H2 monitoring and reduction systems,

- Upgrading the residual heat removal system
- Re-qualification of post accident instrumentation,
- Upgrading pressuriser valve station.

Summary of modifications for improvement of plant safety

Description	Reference plant Grafenrheinfeld (backfitting)	Angra 2
Precautions related to leakages in primary Circuit: Seamless forged steel piping: pressurizer with only two forged steel rings: concept of exclusion of pipe-rupture for Primary Circuit and Main-Steam lines inside containment.	N	Y
Other preventive measures related to leakages in primary circuit: authorization of in-service inspection: leakage monitoring systems.	Y	Y
Consideration of effects of rupture of high energy outside containment for qualification of I & C and electrical equipment installed in the Annulus	N	Y
Consideration of thermal loads and jet forces in the design of steel platforms jeopardizing safety systems	N	Y
Upgrade reactor protections system using EDM equipment	Y	N
Upgrade reactor control and Limitation systems	Y	N
Start of emergency diesel with highest priority via reactor protection system in case of under-voltage	N	Y
Automatic shut-off of accumulators Infection to avoid insertion of N2 in the primary circuit	Y	Y
Improvements in the residual heat removal system (operation of low pressure pump as booster for high pressure pump: third train for refrigeration of fuel pool)	Partial	Y
Reactor pressure vessel level and temperature measurement and controlled pressure relief	Y	Y
Post-accident instrumentation with qualification for long-term operation	Partial	Y
Direct position indication for pressuriser safety and relief valves	Y	Y
H2 monitoring and reduction systems inside containment	Y	Y
Fire fighting protection system according to Brazilian rules (multiple protection levels, subdivision of buildings in fire-areas: risk analysis with improvements in the fire barriers etc.)	N	Y
Upgraded pressuriser valve station (state-of-art KONVOI)	Planned	Y
Provisions for feed-and-bleed	Y (Primary in 98)	Y (1)
Containment venting	Y	N (2)

Additional external power supply	Y	Under evalua-tion
Modification in the RCP for operation under LOCA conditions	Y	Under evaluati on
Additional measures to avoid leakages outside containment through auxiliary systems connected to primary circuit	P	Y

(1) Primary only through relief valves
(2) Plant prepared for future installation

Additional information

None

Material provided by
J. Spitalnik, Eletronuclear, Brazil

Annex 2B

BRAZIL: ANGRA 2 NPP — MANPOWER AND DOCUMENTATION

Summary

This annex deals with *manpower and documentation*. Several initiatives were implemented during the suspension period to preserve manpower and documentation at Angra 2 NPP. They have paid off and construction of the NPP was resumed wit relatively little unexpected difficulties. This annex outlines the essentials of these initiatives.

Overview

The Angra 2 project, a 1300 MW(e) PWR nuclear power plant, has been under construction since 1977. Due to lack of financial resources, its completion was delayed for several years. The project was never stopped. Supply contracts were stopped, activities at site were kept to a minimum, plant and equipment were stored and a preservation programme for equipment was implemented.

With electricity demand growing at about 5.5% a year the Brazilian Government decided, in 1996, that completion of Angra 2 should be expedited to start commercial operation in 1999. Retention of a "core manpower" in charge of project engineering was instrumental for successfully restarting the project and for attaining such a schedule.

Key elements

Retention of human resources

The slow down of construction of Angra 2 led to a reduction of manpower. Total engineering staff was halved to a manpower core of about 400 people who held the technology for project design and management of such type of plants, transferred by the foreign supplier to the Brazilian engineering firm NUCLEN.

For those engineering tasks that only required engineering expertise, with no specific knowledge of the basic design technology, subcontracts with local engineering firms were applied. Outside manpower was thus utilized as a cushion to minimize variations in the project requirements, in order to keep intact the core of staff for project design and management.

Angra 2 design was continuously updated especially in its safety aspects, following the technical level evolution of German plants after Grafenrheinfeld, the *Angra 2 reference plant*, thus keeping the design engineering updated and motivated.

Due to the ongoing programme of technology transfer, there was a formal transfer of scope from the foreign supplier to NUCLEN for Angra 2 systems design. For Angra 2, Nuclen's scope of systems design engineering increased from 67.2% to 95.6%.

To maintain its staff technologically updated, engineering services were provided by NUCLEN to the foreign supplier, under special contracts, for projects of the foreign suppliers responsibility in other countries (on average, some 155 man months/a.).

By expanding its area of business to cover not only the design and construction of NPPs, NUCLEN was able to provide engineering services that could be completed quickly. This helped to motivate its design engineering staff who could thus experience the results of their efforts.

Engineering contracts were made for maintenance and updating activities of another NPP (Angra 1) and some thermal power plants in the country, as well as for designing radioactive facilities and for performing feasibility studies related to energy supply.

The Angra 2 full-scope simulator was installed in accordance to earlier schedules of the plant. In order to keep the very specialised simulator manpower in readiness, several training contracts were signed with utilities having NPPs of same design. Many German and Spanish operators, an average of 110 operators/a during more than 11 years, were trained in the Angra 2 simulator by Brazilian instructors.

Training programmes for managerial development and technical training were in place during the Angra 2 project slowdown period, for updating knowledge and skill, and to generate personnel motivation. Management development courses in areas of human relations were of extreme importance as the slowdown situation created specific stressful conditions. Conflict Negotiation and management, Communication and Personal Interrelation, and team Build-up were subjects with great appeal.

Preservation of engineering and construction data

To assure availability of Angra 2 project documentation, a Documentation Manual for codification and retrieval of all plant documents was set up since the early stages of the project. The Documentation Manual instructions assure compliance with quality assurance and licensing requirements related with design, procurement, manufacturing, construction, installation, erection and commissioning.

Documentation management is the responsibility of the quality assurance group in the design engineering firm, NUCLEN. This group reports directly to the President of NUCLEN.

Two complete sets of the documentation are being kept at the project central office in Rio de Janeiro and at site in the documentation centre which has all facilities ensuring physical protection of the documentation.

A data processing system allows direct access to plant documentation during design, erection, commissioning and operation stages of the project.

Special attention to the influence of project delay in contractual documentation was required, in particular with respect to contract re-negotiations involving conditions for maintaining compliance with nuclear quality assurance concepts and contractual arrangements for guaranties (substitution of suppliers no longer in existence by others who had to undergo nuclear qualification processes; extension of guaranties for the performance of equipment or systems well after foreseen commissioning dates).

Additional information

None.

Material provided by
J. Spitalnik, Eletronuclear, Brazil

Annex 3

BULGARIA: BELENE NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. The Belene project has been suspended for 7 years after approx. 50% of money had been spent. Equipment, structures and documentation have been well protected, but majority of qualified personnel have been lost. Resumption of work awaits government decision and provision of funds.

General information

Construction started in 1982 with site preparation, infrastructure engineering, setting up of a construction and erection center and other temporary and ancillary structures.

The project was suspended in 1990. The main reason for suspension of the project is lack of funds. Suspension coincided with the disintegration of centrally planned economy as well as with the introduction of democratic process in Bulgaria.

All major equipment for Unit 1 had been received from various supplier countries and stored at the Belene NPP.

Costs incurred so far have been estimated at 1 billion US$ and of the site completion cost estimates, which represents approximately 50% of the over-all cost of unit 1.

Several possible time schedules for completion of unit 1have been developed. These vary from 5.5 to 6.5 years from management decision to resume work and from availability of financing. With a smooth financing process, it is believed the work could be completed in less than 6 years.

Problems encountered

Human resources

Staff cannot be retained for a long time after project suspension. The Belene NPP has been suspended for 7 years. Economic conditions in Bulgaria resulted in drastic reduction of construction and it was impossible to retain the human resources at the plant. Out of the initial 7500 employees, only about 200 are working at the site now.

Additionally, we were not able to retain skilful and experienced specialists and workers such as builders, erectors, designers, investors, etc. We need them to restart the project.

Engineering and construction data

No problems. Documentation well maintained and protected.

Site installation, structures and equipment

Warranties on the delivered equipment need to be reconfirmed. Missing items as well as construction, erection, start-up and setting-up and test activities have to be negotiated.

Measures implemented

Human resources

No action has been taken so far. With respect to personnel management, we will have to start almost from the very beginning. When the project is restarted we will have to hire staff and to re-establish personnel record system.

Engineering and construction data

The technical records, documentation and other engineering and construction data are comparatively well preserved. The main documents are kept in two separate storage areas.

Site installation, structures and equipment

The structures, equipment, and buildings are kept in good repair and condition.

À patented coating is used to protect the metal structures of the confinement enclosure.

Foreign equipment received repeated protection coating in 1996 with participation of engineers from the foreign supplier, and its operability has been verified through inspection.

Steps are being taken to apply similar protection to equipment supplied from Russia. This protection will be applied with assistance of Russian specialists for equipment supplied from their factories.

Additional information

The study report of foreign supplier describes the proposed improvements and upgrades which will bring the plant up-to-date with respect to technological and regulatory requirements and which will be compatible with a Russian new-generation nuclear power plant.

Material provided by
N. Nabatov, NECAD, Sofia, Bulgaria

Annex 4

CANADA: DARLINGTON NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. The just slowed down and delayed. Senior engineering, construction and procurement staff stayed with the project. Documentation was preserved though normal functioning of the records department project was completed and put into service with a few years' delay.

General information

Darlington NGS is part of Ontario Hydro, a public utility supplying electrical power to the Province of Ontario. The station comprises of 4 generating units, each having the capacity of 880 MW(e) net.

Construction of the project was approved in 1977 with completion (in-service) of the first unit scheduled for 1985 and subsequent units beginning production at 12 months intervals. This was an unrealistic schedule. Construction peaked in 1985 with 7000 workers on site.

At that time Ontario Hydro was engaged in large expansion of generating capacity with 3 other large generating projects under way (2 nuclear, 1 fossil). It was believed that power was urgently required.

Due to various delays, the first unit (# 2) started up in Jan. 90 and the last in April 93

There were two major delays:

- one ordered by Ontario Hydro top management in 1983
- one by the Government of Ontario in 1985

Problems encountered

Human resources

Due to several large generating projects being under way at the same time, severe engineering manpower shortages developed within the company. When Darlington NPP was suspended, engineering staff were transferred to other projects.

In that way Darlington project lost approximately 50% of its engineers, only some of whom were re-assigned back to Darlington when the project was resumed. Fortunately, most of the senior engineering staff remained with Darlington project organization, as it was clear that the project will resume after a relatively short delay.

The main problems associated with retention of personnel were

- Not sufficient trained personnel within the company to simultaneously handle all the work in the areas of engineering, construction and operations
- When project eventually resumed — after approximately 2 years — the following difficulties were encountered:

- New staff had to be re-trained and re-oriented
- Administrative and organizational confusion and slow-down with resultant loss of efficiency and morale
- Mistakes were made in design/construction as the result of inexperience.

All of the above created a heavy work load for the senior personnel.

There were also **some benefits** arising out of the delay and more time being available:
- Engineering and construction senior staff were freed from day-to-day pressures and had time to consolidate their concepts
- Operations organization had more time to train their personnel.

Engineering and construction data

No unusual problems were experienced:
- Data preserved through normal functioning of Records Department.
- Continuity of design studies and analysis was preserved through the senior personnel staying on the job.
- Extra time available permitted improvements in cataloging and storage of data.

Measures implemented

Successful:
- Communications with senior staff assuring them of project resumption
- Hiring and assigning staff back to the project.

Shortcomings – improvements for the future:
- Time schedule for project resumption not defined in advance
- Advanced hiring/training scheme not implemented.

Additional information

None

Material provided by
G. Wieckowski, Operations Quality Corporation
Pickering, Ontario, Canada

Annex 5

CUBA: JURAGUA NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. The long suspension of Juragua NPP has affected personnel, equipment and site structures. Efforts are being made to revive the plant and to protect existing resources (assets). An action plan has been prepared.

General information

The Juragua Nuclear power plant, located near Cienfuegos City, was planned for two power units provided with WWER-440/V/318 reactors of Russian design, an upgraded variant of the V-213 model.

On account of economical and financial reasons it was necessary to stop all construction activities at Juragua NPP. This was caused by the extinction of the former Soviet Union and the suppression of the economical and financial relationships.

The works on site started on August 1982 and stopped on September 1992.

Work completion status:

- Civil work of Unit N° 1: 75%.
- Mechanical installation: 20%
- Electrical installation: 16%
- Instrumentation and control system design must still be completed.

Most of the major components such as the pressure vessel, the pressurizer, the primary coolant pumps, the steam generators and the turbine are already on site, but more than 35% of mechanical equipment and 40% of electrical equipment must still be purchased.

The completion work cost of Juragua NPP Unit Number 1 has been estimated to be about 600 million US dollars.

A plan was produced for the temporary suspension period, which includes all activities to be carried out while this condition persists. Essentials of this plan are the subject of Annex 5A.

Main problems during temporary suspension period

Economic, financial and human resources

FACTORS	PROBLEMS	ACTIONS TAKEN	ACHIEVED OR EXPECTED RESULTS
Economic and financial	• No funds	• Feasibility Study completed • Creation of Cuban–Russian enterprise.	• Project viability with positive results. • Restart of construction work.
Retention of personnel	• Loss of qualified personnel.	• Strengthening of engineering and quality assurance activities. • Enhancement of life and working conditions. • Operation and maintenance of thermo-electric stations and other industries. • National qualification. • Personnel qualification system resume for the Juragua NPP operation.	• Retention of qualified personnel. • Operating and maintenance personnel completion.

Engineering and construction data

FACTORS	PROBLEMS	ACTIONS TAKEN	ACHIEVED OR EXPECTED RESULTS
Preservation of engineering and construction data.	• Risks of quality document lost because of project leaving of contractor organizations. • Indetermination about the access and preservation of quality documents produced by Russian organizations.	• Accelerated completion of the transient quality vault. • Transfer of quality documents produced by contractor organizations to the transient quality vault. Discussion and accord about the access and preservation of quality documents produced by Russian organizations.	• Transient quality vault. • Preservation of quality documents of contractor organizations. • To ensure the access and preservation of quality documents produced by Russian organizations.

Preservation of site installations

FACTORS	PROBLEMS	ACTIONS TAKEN	ACHIEVED OR EXPECTED RESULTS
Preservation of site installations, structures and equipment.	• High volume of preservation work • Lack of technologies and materials for long-term preservation. • Insufficient storage areas. • Equipment and materials possibly affected.	• Reorganize and optimize storage areas. • Move all equipment to its location places. • Technical assessment of equipment and materials affected.	• Closed storage areas optimized. • Equipment moved to its location places. • Acquisition of technologies and materials for long-term preservation. • To guarantee in 1997 the required preservation cycle for all stored and erected equipment. • Determination of equipment to be contracted again.

Additional information

Loss of personnel occurred due to:

- Staff moving to other enterprises motivated by professional, economic and personal reasons.

Main goals of "delayed (paralyzed) NPP plan":

- To establish main working directions with the objective that integrity of equipment, buildings and structures are preserved for the resumption of construction
- To implement reorganization and improvements needed to achieve excellence and enhanced effectiveness during construction and in later stages of the project.

Material provided by
M.A. Serradet
Ave. Salvador Allende 666
Havana, Cuba

Annex 5A

CUBA: JURAGUA NPP — UPGRADES — MODIFICATIONS AND IMPROVEMENTS

Summary

This annex deals with *upgrades — modifications and improvements*. Planning for resumption of work at Juragua NPP is under way, and a strategic plan of upgrades and modifications has been prepared. The proposed improvements were categorized, reviewed by the regulatory body and generally approved. This annex outlines the format of the plan.

General information

The "Juragua" NPP has 2 reactors of type WWER-440/V-318. During delay, recommendations for modifications were assessed from recent studies carried out by experts from international entities, as WANO and IAEA for this type of reactors, particularly to increase safety and reliability of reactors operation.

The list of proposed modifications was summarized in the feasibility study prepared to reinitiate work.

Categories of modification

The modifications were analyzed and grouped in the following main topics:

- Measures concerning to the primary circuit integrity.
- Measures for transients control.
- Measures related to containment integrity.
- Measures related to fire protection.
- Measures related to accident management.
- Measures related with radioactive waste management.
- Other measures.

Elements considered in respective modifications had been previously categorized as follows:

S1. Elements very relevant for safety.
S2. Other important elements for strengthening of safety.
O1. Elements considered essential for operational reliability.
O2. Other less important elements for operational reliability.

Actions

The improvement proposals were stated in detail based on analysis of characteristics of the Juragua NPP design. For each case, evaluation of the proposed modification was performed and a design proposal formulated. The main elements taken into account during the analyses were the following:

- Incorporated into the plant original and validated (no change).
- Not incorporated into the plant design.
- Contained in the requirements of the technical task of the I&C system with validation.
- Aspects to be taken into account for first fuel loading.

- Items that are new requirements from the regulatory body for the plant licensing.
- Aspects that improve the economical output of the plant and its competitiveness.

A work programme was carried out and sent to the regulatory body and to the designer. Suggestions and participation of some of their experts in the helped in its improvement.

Results

The results were organized in the following format:

- Title of the improvement.
- Reasons for the improvement.
- Status Juragua NPP for implementation.
- Evaluation of introduction and solution to the modification.
- Conclusion.
- References.

Modifications were grouped as follows:

- Included in the base design.
- Partially included.
- Expect introduction when the final safety report of Juragua NPP is elaborated.
- Expect introduction for fuel loading.
- Not introduced.
- It is necessary but more information required.
- Rejected.

The generated records are preserved as design records of the QA record systems.

The results were discussed and agreed with the regulatory body, the main designer and the main supplier.

All of them enclosed a cost/benefit analysis to be included in the feasibility study for the conclusion and plant operation.

Conclusions

The first unit of Juragua NPP belongs to a new generation of the WWER-440. Its design meets the main positive aspects of the previous versions and provides solutions to the majority of design problems of earlier ones.

Material rpovided by
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Havana, Cuba

Annex 6

CZECH REPUBLIC: TEMELIN NPP — PROJECT CONTROL

Summary

This annex deals with *project control.* project schedule and costs were heavily influenced by late design changes brought about by the desire to apply western technology. Problems developed in the integration of these changes into the project. These arose due to difficulty of the task, lack of clear responsibilities amongst project participants, and also due to lack of familiarity of personnel with the new concepts and managerial techniques. The project is now progressing well with fuel loading scheduled for late 1998.

General information

The initial date, set in 1985, for the completion of Unit 1 was 1992. The completion date has been revised several times and currently fuel loading for Unit 1 is scheduled for November 1998. Commissioning of Unit 2 is expected approximately 18 months later.

The main reason for the delay were :

- The extensive technical modifications deemed necessary as the result of transition of design concept from the "eastern" philosophy to the "western".
- Construction taking place in the period of a decline in the nuclear power engineering in Europe.
- Construction taking place in the period of overall change in the Czech Republic:
  - the end of central planning
  - privatization of the economic sector
  - transition to the market economy
  - development of new legislation
  - inertia in the attitude of people, etc.

Problems encountered

Human resources

The following problems arose as the result of inadequate human resources:

- The engineer/architect for the project — was incapable of independently creating the conceptual outline of the power plant.
- Similarly, limited project capabilities of individual final suppliers and general contractors also created problems of integration of designs.

The selection of western contractor for significant part of modernization work has caused further problems for the project staff. This arose due to change of the standards and project planning and implementation techniques (change of cabling is a typical example).

Engineering and construction data

No information has been provided with respect to any problems arising in this area other than reference to inadequate quality of supplier's documentation

Technical modifications

The timing and quality of project preparation is one of the main problem areas during the construction of the Temelín NPP:

- one reason is inadequate quality and completeness of supplier's documentation,
- secondary reason is the inability of the local organizations to develop, independently and on time, their respective parts of the documentation.

Complicating the issue were :

- significant technical changes in the project, leading to tens of amendments to the basic design
- arising from the above, the necessity of schedule modifications during construction

Schedule delays and increased costs

The Temelín project is complicated because of a large number of technical changes having been introduced during construction in order to enhance the plant's safety and reliability.

The question of project integration remains the most significant element of the project preparation and a significant contributor to the delay. None of the contractors, including the engineer/architect for the project — has a clear responsibility to assure integration of all parts of the project.

In spite of numerous modifications, the decision was made not to freeze project design, but to continue with construction while accommodating and absorbing all the changes.

As a predictable consequence, the project became exposed to an unusual number of interfaces, changes and adjustments with substantial impacts on all project functions.

It is only normal that the common denominators of all these complexities — the project schedule and budget — suffered substantially.

The main reasons of delay in construction can be summarized as follows:

- major redesign and consequent modifications of the project in the course of construction
- limited support offered by the foreign designers during changes to the original design
- decrease in the capability of engineer/architect for the integration of all project changes into the original design and weaknesses of engineering sections of major contractors in the areas of design completion and delivery
- transformations of the original contracts from conditions of central management into market conditions.

Measures implemented

Project management — schedule and cost

Based on the experience from other projects, organizational control systems were established at the Temelín project.

The management of the project is presently executed at four levels, according to responsibility:

- meeting of the general managers
- construction management - meeting of construction managers
- managing group (deputies of managers)
- working groups (heads of centres or departments).

In 1995, the project management decided on following priorities:

- stabilization of contractors' conditions (new contracts)
- stabilization of project preparation
- staff and organizational stabilization in the NPP Temelín
- effective management of the project implementation.

Additional information

Construction of Unit 1, including the auxiliary works is basically completed. Equipment in separate buildings, e.g. the pumping station, water treatment plant, auxiliary gas plant, etc. have been put into operation and have been used to carry out tests of other systems.

Material provided by
V Duda, CEZ, a s , Czech Republic

Annex 7

INDIA: PROJECT CONTROL

Summary

This annex deals with *project control*. India is a country with a long history of nuclear power development, mostly based on indigenous technology and resources. The nuclear power programme has suffered considerable delays due to technical and financial.

General information

Over the past 32 years, 10 nuclear power reactors have been constructed, commissioned and put into operation at five locations in India. 4 more nuclear power reactors are under construction.

All these projects have encountered difficulties and varied periods of delay. The delays were due to many reasons:

- Restrictions on technology transfer and consequent indigenous development effort
- Design improvement and technology upgradation based on operational feedback
- Regulatory requirements, necessitating design changes subsequent to project commencement
- Financial difficulties limiting advance procurement of long delivery items
- Land acquisition and environmental issues.

Problems encountered

Human resources

India has a long-term nuclear programme with a significant number of operating reactors and a large pool of highly trained nuclear professionals. These people have long-term career commitment to the programme. Consequently, there has been no immediate problem with availability of qualified manpower.

However, in the longer term due to reduced pace of nuclear power development, best of talent is not getting attracted to nuclear power development.

As a result of restriction on technology transfer and consequent indigenous development efforts, the programme went through a learning cycle to master PHWR technology.

Local and social considerations

Because nuclear power plants are located in remote places they require establishment of a self contained township near to project sites. Also, there is a need to deal with local social problems like land acquisition, compensation, re-settlement, etc.

Site installation, structures and equipment

Site specific problems such as heavy rainfall have slowed down construction and caused project delays.

Engineering and construction data

No problems with preservation and protection of engineering and construction data have been reported.

Measures implemented

Human resources

The vital resource for management of delay is human resource. Training programmes have been organized to update managerial skill of engineers. Training needs of construction and operations staff have been identified and training is being conducted.

Project management

The following steps are being taken to improve and streamline project management:

- identification, selection and short-listing of a few manufacturers, suppliers and contractors for nuclear power projects who are capable of meeting their commitments and who will undertake a major role in the execution of nuclear contracts
- establishment of co-operative development and improvement strategies for these and other national suppliers in order to generally raise the suppliers' performance standards and capability
- placing of orders well in advance for engineering and procurement of components having long delivery time
- completion of all site infrastructure and local social issues well ahead of ground-breaking.

Site installation, structures and equipment

Steps have been taken to protect equipment installed and stored at site from effects of corrosion or deterioration due to non-usage or exposure.

Procedures are being drawn up for short term and long term preservation of nuclear and conventional equipment and components.

Upgrading of projects

The following activities are under way in the effort to improve project performance:

- improving construction planning and execution techniques, planning for maximum number of possible parallel construction/design paths and for employment modern machinery to ensure timely completion of work.
- development of pre-fabrication and modular construction techniques to reduce on-site fabrication activities
- standardization and freezing of design and completion of site-specific design ahead of ground breaking at site. The target is to have at least 80% of drawings and tender packages ready.
- setting up of a public-relations programme to deal with:
  - environmental safety and public awareness issues
  - local concerns, such as land acquisition and compensation payments

- establishing better working relationships with the government and the regulatory agencies.

Additional information

Initially, the programme for nuclear power development had full financial support from the Government of India. In 1987, Nuclear Power Corporation of India Ltd (NPCIL) was formed with the objective of speeding up nuclear power development.

Material provided by V Raghavan
NPCIL, India

Annex 7A

INDIA: KUDANKULAM NPP — MANPOWER AND DOCUMENTATION

Summary

This annex deals with *manpower and documentation*. It illustrates flexibility in personnel retention arising from having a multi-unit, national nuclear power programme, supported by in-house technology. Steps taken to retrain and continually develop personnel are described. Also highlighted is the relative ease with which documentation is obtained and preserved.

Overview

India has a broad-based, long range nuclear power programme, based on construction of indigenously developed PHWRs of (220 and 500 MW(e) capacity). India's programme covers the entire fuel cycle from mining to power production and spent fuel reprocessing.

Work on Tarapur project (TAPP 3&4) with 2 × 500 MW(e) PHWRs is likely to commence soon. In this case, delay has been mainly due to lack of requisite funding.

In order to meet the immediate electric power demands, a decision was taken in November 1988 to set up two units of 1000 MW(e) WWER type of reactors at Kudankulam on a turn key basis. While project work was commenced in India in 1988, due developments in the suppliers country, in 1991, work had to be discontinued except for certain site infrastructure related jobs which were in advanced stages of completion.

Nuclear Power Corporation of India Ltd (NPCIL), a public sector undertaking under the charge of the Government of India Department of Atomic Energy (DAE), is responsible for design (of PHWRs), construction and operation of NPPs in India.

This case study highlights the flexibility available when the delayed project is a part of an overall programme.

Key elements

Retention of human resources

The Kudankulam NPP is a turnkey project with limited Indian responsibility. Philosophy adopted for manpower development was to set up a core group of around 15 to 20 senior engineers drawn from various groups of PHWR directorates having varied experience in different fields namely design, regulatory reviews, construction, procurement, operation. This group was to be supplement by around 25 to 30 freshly recruited engineers.

In parallel, a small group comprising of about 15 to 20 personnel with construction expertise was set up at Nagercoil (a town near the plant site) for the infrastructure work. Responsibility for tendering, technical evaluation of vendors, and supervision of site construction works was entrusted to a consultant.

During the years 1988 to 1991 work under NPCIL's responsibility was vigorously pursued. Also work on site infrastructure was started in full swing.

Just at the time when the contract for elaboration of DPR was about to be signed, negotiations were discontinued due to developments in the supplier's country. All the works related to infrastructure were also stopped except few which were in advance stages of completion.

In view of uncertainty about the situation in the supplier's country, a decision was taken to re-deploy the manpower.

Younger engineers were re-deployed to the various engineering and project directorates at NPCIL.

Senior engineers, of the core group, while continuing to be responsible for their areas of work of KK project, were re-deployed to undertake specialised assignments such as rehabilitation work of Narora Atomic Power Station which had earlier suffered extensive damages due to a fire incident, life extension and upgrading work being taken up for the older generation of PHWR. Some were also assigned to work in other directorates of NPCIL to provide manpower support for the PHWR projects on hand.

A small group of only 2 to 3 engineers was retained which is responsible for:

- retaining and maintaining various technical information and documentation,
- generated during the past negotiations and site works,
- monitoring and reviewing the various developments taking place in the Russian Federation,
- following reviews of WWER reactor designs carried out by IAEA and other international agencies and generating technical documentation pertaining to the outcome of these reviews.

Infrastructure work, wherever possible was discontinued. A small group is being maintained at site to look after the property, supervise the micro seismic study work, complete formalities with regard to land acquisition and interaction with local authority and State Government.

Revival of the project: In late 1993, the re-negotiation of the project was initiated. A team of engineers of earlier core group, who had been re-deployed during the interim period, was *reassembled* to participate in re-negotiations. The negotiations are in final stages and team required to handle DPR works has been formed.

Preservation of engineering and construction data (PHWR projects)

Since, so far, project delays have been mainly due to technical aspects associated with design, manufacture, construction and commissioning of nuclear power projects the delays have only been for a relatively short period of time (of the order of about 5 years). Hence, these delays have not resulted in any major difficulties in preserving engineering and construction data.

Preservation and retrieval of essential data is done through establishment of 'Reference data Centers' at project sites as well as at the design office at headquarters.

Data is systematically collected right from the inception of the project to ensure traceability. Thus, even at the tendering stage, it is ensured (by inclusion of appropriate conditions in the tender documents/specifications) that the suppliers and manufacturers must maintain and furnish to the Purchaser all test certificates, inspection reports, shop-test data, etc.

NPCIL participates as a 'partner-in-technology' with the manufacturers. Tender specifications stipulate submission of 'manufacturing drawings' by the supplier (except in a few cases of commercially sensitive information pertaining to components/equipment/processes developed by the supplier on his own) for the approval by NPCIL.

For all important items, 'history dockets' are prepared and issued to authorized persons in the plant.

Additional information

Large effort would be required to scan/vectorize or redraw using CAD, and convert all these drawings to the more modern and convenient computer based magnetic/optical storage. After such scan/vectorize or redraw, the drawings must once again be checked to ensure fidelity of conversion. This is a huge task in view of the large number of drawings (about 20 000).

Efforts are needed to systematically capture the data on magnetic media, as they are being created and then record and preserve the same.

Due to the high rate of obsolescence in computer technology, *continuous* efforts must be made to preserve the data.

Some of the important aspects on which work has been initiated are:

- creation and storage of permanent and temporary records
- improved methods for better storage and easy retrieval
- comprehensive documentation manual to ensure systematic generation and preservation of documents.

Material provided by Mr. S Krishnan
NPCIL, India

Annex 7B

INDIA: TARAPUR UNITS 3 & 4 (500 MW PHWR) — UPDATING: DESIGN AND ENGINEERING

Summary

This annex deals with *design and engineering* efforts to meet current licensing requirements and incorporate technology upgrades in Tarapur Atomic Power project Units 3&4, in India.

General information

Tarapur Atomic Power Project Units 3 & 4 (TAPP 3&4) are the first 500 MW(e) pressured heavy water reactor (PHWRs) plans to be constructed in India. Design work for these was started in 1984. project commencement was expected and engineering of various systems for TAPP-3&4 which were at different stages of completion has since been gone through to meet current regulatory requirements and technology upgrades. Excavation work commenced in October 1998.

Updating to meet current regulatory requirements

Problem statement

Evolving regulatory requirements, in the design and engineering of DNPP major portion of which has been finalized, result in a great deal of rework. In addition to re-engineering of the specific system involved, modification in the design of other systems may also be necessary.

Illustrative examples of improvement made to meet current regulatory requirement

Design of building and structures

In 1984, the criteria for civil engineering design was based on Indian Standards and Codes of NPP Design Practices. Later the Atomic Energy Regulatory Board (AERB) issued a directive that a consistent codal system for buildings or structures should be adopted. American Institute Code ACI-349 was adopted for all safety related structures, other than containment. For basic material properties Indian codes were used. ASC-4-86 document was mainly used for seismic analysis. In addition 3D analysis had to be performed in place of earlier practice of 2D analysis.

As a result, the column and foundation structures needed redesign and reanalysis. Also changes in mechanical and electrical system layouts, floor response spectra and consequent changes in design and location of embedded part for supports became necessary. Quantity estimates for cement, concrete and steel also increased.

Design of reactor building containment

The reactor building consists of unlined double containment with segmental domes. The inner containment is a pre-stressed concrete structure. The past practice of containment design had evolved over 15 years. However, in order to meet directives of AERB, French code RCC-G was adopted for the design of the containment and re-engineering was carried out.

Shielding design

AERB stipulated a limit of 5 mSv of effective dose for a member of public till 1985. Based on ICRP recommendations, a principal limit of 1 mSv per year, averaged over a period of 5 years, has been accepted subsequently. Similarly, for occupational exposure, the limit was brought down to 20 mSv in a year, from the earlier 50 mSv, in 1991. These changes led to redesign of shielding and ventilation system so that the dose level and derived air concentration (DAC) values are kept low to meet the above limits. The effluent discharge facilities were reassessed and upgraded to meet the new criteria.

Incorporation of technology upgrades

Problem statement

Decision on how to use the operating experience form similar plants and what technology upgrades to incorporate involves engineering judgment and review of in-depth cost/benefit analysis.

Illustrative examples of technology upgrades incorporated

Design for fire safety

There was a fire incident in the Narora Atomic Power Station (NAPS) in March 1993. A committee investigated the incident and made several recommendations for enhanced fire safety.

The design of TAPP-3&4, was reviewed in the light of the above and following additional provisions were incorporated.

- Enhanced fire barriers, fire stops/breaks
- Area-wise fire load analysis
- Cables and junction boxes for safety and safety related systems were physically separated
- Cable routing and equipment layout were revised to avoid proximity of safety related and non-safety related panels in control Equipment Room
- Enhanced fire ratings (2 hours) for reactor building structural steel.

Design of buildings and structures

There was a flooding of basement of turbine building of Kakrapar Atomic Power Station (KAPS) in June 1994. As a result of investigation of Causes of flooding, following changes were incorporated in the design:

- All the entrances of pipe trenches/tunnels leading to basements to be sealed effectively against water ingress with steel plates/RC walls.
- Minimize removable covers for all pipe and cable trenches and joints of such covers to be sealed effectively.
- The manholes for the trenches to be raised sufficiently above expected flood level in the area.

Design of turbine building

Turbine building is a non-safety related building and hence is of codal design. However, subsequently, it was decided to carry out check analysis and some modifications were made to ensure that the turbine building does not collapse and all on any safety related building in the event of an OBE level earthquake.

Coolant channel components

When the prototype coolant tubes and spools for TAPP-3&4 were produced, hydrogen content of the tubes was specified around 10 PPM. Current specifications for production have been modified to include limits on chlorine and phosphorus, while lowering the initial hydrogen level to 5 PPM.

Conclusion

The delay period during the design of Tampur Atomic Power Project 3&4 has been utilized for several technical upgrades, arising out of changing regulatory requirements and enhance nuclear safety. Many changes and re-engineering, as necessary were carried out. These were based on conscious technology management decisions. The changes implemented would contribute towards enhanced safety and availability of the plant, though at additional cost and effort.

Material provided by C Surendar
NPCIL, India

Annex 8

ISLAMIC REPUBLIC OF IRAN: BUSHEHR NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. After almost 17 years of delay due to revolution and war, the work on BNPP-1 resumed. The new plant will be a combination of German and Russian designs and as such will present many unique technical and managerial problems. These will be accentuated by the fact that Iranian nuclear personnel are relatively young and inexperienced. In spite of hostile environmental conditions at the site, the equipment, structures and documentation have been relatively well presented.

General information

The contract for construction of the two units of Bushehr Nuclear Power plant (BNPP) was signed in 1976 between Atomic Energy Organization of the Islamic Republic of Iran (AEOI) and a German concern. The construction work started soon after, but after the Islamic Revolution in Islamic Republic of Iran construction and manufacturing work were interrupted and the contract was eventually terminated in 1979.

At the time of suspension of construction in Feb.1979, status of the unit 1 was as follows:

- civil work completed about 85%
- electrical work completed about 65%.
- mechanical work completed about 65%
- common buildings, camp and social infrastructures 100%.

AEOI had paid the contractor about 5.6 billion Deutsche Marks in addition to local expenditures in Iranian Rials.

Following the government decision to resume work on BNPP-1, a contract was concluded between AEOI and a Russian concern. After thorough investigation of the status of equipment, systems, structures and components and also of the documentation, the Russian contractor declared its technical capability and readiness for reconstruction and completion of BNPP-1 project.

The contract specified using the main equipment of Russian design of WWER-1000 model V-392 and integrating it into existing systems, structures and buildings already erected/constructed. The new contract went into effect in January 1996.

Problems encountered

Human resources

- A considerable number of Iranian specialist experienced in nuclear power technology have left.

Site installation, structures and equipment

- The hostile environmental conditions at Bushehr region made the preservation of existing installed/erected equipment and buildings difficult.

Upgrading of project

- one of the main difficulties is getting access to international expertise and required supplies in the nuclear field due imposed embargo.

Measures implemented

Human resources

- AEOI has recruited young engineers to be trained by the Agency or other local institutions. A number of these engineers are working at the project but their numbers are not sufficient. They require more training and experience.

Site installations, structures and equipment:

- Despite hostile environment at the site, AEOI had been able to preserve most of equipment, structures and buildings using the most effective techniques
- Also, documentation had been preserved including drawings and engineering and construction data.

Upgrading of the project

- Another foreign contractor had been found to reconstruct and complete the plant, following a thorough evaluation of plant condition
- Regulatory documents had been updated in order to be in compliance with the requirements of the revised IAEA codes
- The Russian contractor had been asked to:
  - make a comparative analysis between the German and Russian technical standards
  - implement the necessary technical upgrades to meet the requirements of the Iranian Regulatory Authority (IRA)
  - initial steps have been taken to encourage exchange of information and experience between countries who have Russian WWER reactor and also the countries which have German designed plants.
- IAEA and other International organizations will be asked to provide technical and managerial assistance, especially in the areas of:
  - training and development of manpower
  - facilitating participation of Iranian experts in meetings aimed at improving safety of WWER-1000 plants
  - assisting AEOI in design and safety reviews.

This is of special importance since the integration of the German and Russian designs will present many unique technical and managerial problems.

Additional information

Early in the 80s, a contract was concluded between AEOI and a German concern for inspection of the equipment, structures and buildings and analysis of documentation of BNPP-1. A series of reports were submitted to AEOI giving the status of the plant.

During stagnation of the BNPP-1 project (for almost 17 years):

- the plant suffered damage due to passage of time and also during the war
- changes have occurred in the requirements of Iranian Regulatory Authority
- new requirements arose due to need to integrate Russian-made equipment with the existing systems and structures already in place
- as the result, additional changes are necessary in the design of existing systems and structures.

Material provided by Saboury
Atomic Energy Organization, Islamic Republic of Iran

Annex 8A

ISLAMIC REPUBLIC OF IRAN: BUSHEHR NPP — PRESERVATION AND MAINTENANCE

Summary

This annex deals with *preservation and maintenance*. It spells out the way in which condition of equipment and quality of storage are categorized and reported.

General information

The following two tables give the categorizations of packages of equipment and storage conditions.

The categorizations are based on the conditions of packages of equipment or materials received at site with particular attention to the type of protection (foiled or not foiled), contents and state of the damages.

Categorization numbers are in the increasing order of the severity of the condition of the damage, ranging from undamaged package with contents intact to unpacked and protection severely damaged (5).

Likewise, for storage conditions, categorization numbers are in the increasing order of severity of storage condition, with the highest number (4) representing un-protected storage.

Categorizations of packages

Serial number	Description
1	Undamaged crate or box Content is sealed with water-proof and vapor-proof foil (Undamaged)
2	Undamaged crate or box Content is not sealed with foil or foil seems to be damaged
3	Severely damaged crate or box Content may also be affected
4	Pellet, bundle or unpacked Component or material is protected by coating Finish machined areas are protected against mechanical damage
5	Pellet, bundle or unpacked Component or material is unprotected or protection is severely damaged

The categorizations based on the types and conditions of storage are given in the following table.

Categorizations of storage

Serial number	Description
1	Solid building, inflatable or canvas covered store which is dust proof and water tight and supplied with dry air
2+	Solid building, temporary store house or container, tight against rain water, flood but not dust proof, provided with dried air
	Solid building, temporary store house or container, tight against rain water, flood but not dust proof without air conditioning
3	Open air storage with provisional protection against rain water, sand storm, e.g. accessible canvas, covered scaffolding
4	Open air storage without protective measures or canvas-covered but not accessible

Material provided by A Moshfeghian
Atomic Energy Organization, Islamic Republic of Iran

Annex 8B

ISLAMIC REPUBLIC OF IRAN: BUSHEHR NPP — PRESERVATION AND MAINTENANCE

Summary

This annex deals with *preservation and maintenance*. The table below provides information about categorization of materials and components based on their sensitivity to humidity, dust, temperature, etc. in the surrounding environment which may lead to degradations such as corrosion, aging, and mechanical damage.

General information

Category number given in the table is increasing in the decreasing order of sensitivity.

Categorization of materials/components based on sensitivity

Sensitivity category number	Description of materials/components
1	**Sensitive components** Tanks, vessels, heat exchangers, pumps, valves, turbines, semi-finished components with partly finished machining (e.g. joint flanges, bore-holes, threads), switch gear cubicles (with contents), electrical and instrumentation & control equipment.
2	**Less sensitive components** Tools, empty cubicles, thin-walled ferritic materials and structures, austenitic materials, semi-finished components without finished machining
3	**Insensitive components** Thick walled ferritic materials, supports and steel structures

Material provided by A. Moshfeghian
Atomic Energy Organization, Islamic Republic of Iran

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Annex 8C

ISLAMIC REPUBLIC OF IRAN: BUSHEHR NPP — PRESERVATION AND MAINTENANCE

Summary

This annex deals with *preservation and maintenance*. The following table gives examples of general recommendations for urgent preservation measures and storage of equipment. Sensitivity, package and storage category numbers correspond to those given in previous Annexes 8A and 8B.

General information

In most cases, equipment which has been stored for a long time should be taken out of storage and re-qualified.

Re-qualification involves taking appropriate preservation measures preceded by inspection. Equipment should then be stored in accordance with its sensitivity category.

Sensitivity category	Package category	Storage category before inspection	General recommendations for urgent preservation measures	Recommendation: storage category after inspection
1	1	2	1. Open boxes, inspect content with respect to conditions of desiccant and corrosion; Percentage spot check: 5%, Percentage to be increased depending on the results of inspection. 2. Exchange desiccant; Preservation measures will depend on the result of inspections, seal foil and repack.	2
1	2	2	1. Open boxes, Inspect content, Percentage of spot check (a) 100% for water damage by flood (b) 10% for no water damage and percentage to be increased based on the inspection results. 2. Preservation measures will depend on the results of inspections, repack and store or store unpacked	2 (repacked) or 1 (unpacked)

1	4	2	1. Remove packing if any, inspect component (100%) 2. Repair painting or coating and protect against mechanical damage (outside). 3. Preserve interior 4. Establish maintenance programme	2
1	5	2	1. Clean component 2. Preserve outside painting or coating and protect against mechanical damage 3. Preserve interior 4. Establish maintenance programme	2
1	1	4	1. Open boxes, Inspect content with respect to conditions of desiccant and corrosion, percentage spot-check of 5%, percentage to be increased depending on results of inspections. 2. Exchange desiccant. reservation measures will depend on results of inspections, repack or store unpacked	2
1	2	4	1. Open boxes, inspect content, percentage of spot check: 25%, percentage to be increased up to 100% depending on the results of inspection 2. Preservation measures will depend on results of inspections, repack or store unpacked	2 (repacked) or 1 (unpacked)
1	3	4	1. Remove boxes, inspect content (100%) 2. Preservation measures will depend on results of inspections, repair boxes, repack and store or store unpacked	1 (repacked) or 2 (unpacked)

1	4	4	1. Remove packing if any, inspect component (100%) 2. Repair painting or coating and protect against mechanical damage (outside) 3. Preserve interior 4. Establish maintenance programme	2 or 3 (heavy components only)
1	5	4	1. Clean component 2. Preserve outside by painting or coating 3. Preserve interior 4. Establish maintenance programme	2 or 3 (heavy components)
2 2	1 2	2 2	No urgent measures required 1. Open boxes, inspect content, percentage of spot check (a) 100% for water damage (b) 10% for no water damage and percentage to be increased depending on the results of inspections 2. Preservation measures will depend on results of inspections	2 2
2	3	2	1. Remove box, inspect content (100%) 2. Preservation measures will depend on results of inspection, repair box and store	2
2	4	2	1. Remove packing if any, inspect component (100%) 2. Repair painting or coating and protect against mechanical damage 3. Preserve interior 4. Establish maintenance programme	2
2	5	2	1. Clean component 2. Preserve outside by painting or coating and protect against mechanical damage 3. Preserve interior 4. Establish maintenance programme	2

2	1	4	No urgent measure, but store (safety related equipment)	2
3	2	2	No urgent measures	2
3	3	2	No urgent measures	2
3	4	2	No urgent measures	2
3	5	2	No urgent measures	2
3	2	4	1. Open box, inspect content 10% 2. Preservation measures will depend on the results of inspections 3. 3)Repack and store or store unpacked	2
3	3	4	1. Remove box, inspect content 100% 2. Preservation measures will depend on results of inspections 3. Repair box and store or store unpacked	2
3 3	4 5	4 4	1. Repair painting 2. Clean and paint or stay as it is	3 or 4 3 or 4

Material provided by: A. Moshfeghian
Atomic Energy Organization, Islamic Republic of Iran

XA9953080

Annex 9

ROMANIA: CERNAVODA 2 NPP — LICENSING REQUIREMENTS

Summary

The annex deals with the Romanian Nuclear Safety Authority (National Commission for Nuclear Activities Control - CNCAN) *licensing requirements* for Cernavoda 2 NPP. These licensing requirements are in accordance with the Regulation Policy Statement applicable for Cernavoda NPP and contain the general aspects deriving from laws, regulations and regulation practices included in norms and in specific documentation. The licensing requirements issued by CNCAN in May 1997 takes into consideration the fact that Cernavoda 2 is a delayed NPP. This annex provides only those key elements, which are relevant to illustrate the regulatory requirements for Cernavoda 2 as a delayed NPP. More details are presented in the original document issued by CNCAN.

Key elements

General requirements

The licensing process for Cernavoda 2 NPP will be proceeded according to the following:

The juridical background

- The Romanian legislation and regulations framework constitutes the juridical background for the licensing process of Cernavoda 2 NPP.
- Regulation instructions are defined by the requirements of CNCAN authorizations and approvals. If necessary the regulation instructions will be included in the level 1 licensing schedule.
- Applicable codes and standards for quality assurance and design; safety design guides:
  - The most recent revision of standards issued by CSA (Canadian Standards Association) should be applied to Unit #2. Earlier revisions may be used provided that the owner receives a written approval from CNCAN based on a request containing the necessary justification;
  - The most recent revisions of AECL and Romanian Safety Design Guides and Safety Principles.

Principles used in the authorization process

- Cernavoda 2 has secured permission to use equipment built to codes in force at the time of manufacture.
- CNCAN shall identify, as applicable, for each authorization phase, any additional specific regulations that must be observed.
- In the event that conflicting provisions should exist, these provisions will prevail in the following sequence (unless otherwise specified in a document issued by CNCAN):
  - national laws and regulations
  - instructions/regulation policies statements, other provisions stated by CNCAN
  - international conventions, international and regional bilateral agreements signed by Romania, recommendations by certain international expert missions, etc.

- The events postulated for nuclear safety analyses as part of the safety analysis report and/or of the support documentation are presented in the regulatory document "Combinations of events to be analyzed by the FSAR (Final Safety Analysis Report) for Cernavoda 2 NPP" issued by CNCAN. The type of analysis and the acceptance criteria have been established in principle for all these events, any deviations therefrom having to be accepted by CNCAN prior to the request for obtaining of the commissioning license being submitted to CNCAN.
- The following nuclear safety related aspects shall be sustained by nuclear safety documentation appended to the safety report before the start of the commissioning phase:
  - Common use of the dousing system water and the ECCS medium pressure system;
  - Common use of buildings for Units 1 and 2;
  - Acceptability for coverage of the triggering off parameters by the RRS regulating system, without impacts on the nuclear safety, such as power oscillations or other phenomena, due to the fact that the prompt reverse reaction is not always positive.
  - Failure to observe the singular defect criterion defined for equipment rather than systems;
  - Acceptability of the plant behaviour from the point of view of serious accident related requirements postulated as being beyond those in the design.
- Finalize the Level 1 PSA (probabilistic safety assessment) for all the plant systems in full power operating condition and shut down and partial operating conditions, including external events.
- Finalize a document related to probabilistic assessment of the plant nuclear safety margin during an earthquake, considering the design requirements in effect.
- Prepare level 2 and 3 PSA programme acknowledged by the owner to be finalized no later than at the date when the test operation authorization request is presented to CNCAN. This programme shall be prepared along with other documents defining the strategy adopted for management of serious accidents ("accident management").
  - Program of equipment calibration to verify the surveys taken in the plant starting with Phase A commissioning;
  - Demonstrate that it is acceptable to use certain equipment that were manufactured to ISO 9000 standards. This demonstration can be done by presenting the results of the audit conducted in accordance with the international practices in effect to adjust the ASME programmes to the ISO 9000 ones.
- The details presented in the preliminary SAR and FSAR shall be the same as those contained in similar documents used for Wolsung 3&4 NPP.

Project management related requirements

- The owner's organization shall be authorized by CNCAN for performing nuclear activities, as per the legal requirements;
- The legal status of the Romanian contractors, including those that provide technical assistance shall be established in keeping with legal requirements;
- The Unit 2 management staff is separate from the Unit 1;
- The construction organization shall be separate from the Commissioning organization;
- The Romanian part shall coordinate preparation of the PSAR and the FSAR. The coordinator appointed by the owner shall be authorized by CNCAN;
- The construction, engineering, commissioning, nuclear safety and operation management staff shall be authorized by CNCAN as proposed by the owner.

Specific requirements

The specific licensing activities should restart after the owner will define and CNCAN will accept the followings:

The applicable design

The applicant for the license has to define the applicable design. The applicant will issue to CNCAN a document containing the following:

- the frozen date of the design;
- the way in which the outstanding problems determined by the interruption of the construction activities and the authorization process are resolved.

- the list containing the modifications implemented in Unit #1 design and the definition of the modification intended to be done to Unit #2 as they are known at the start of the licensing process.
- the spare parts acquisition programme and the list with the problems that can have an important impact on the nuclear safety with the definition of the proposed solutions.
- the evaluation programme for determining the ageing effects on the civil structures and the components that are already existing.

The licensing schedule

The applicant shall transmit to CNCAN a detailed schedule concerning construction and commissioning activities. The schedule should contain the dates and the duration of the project and should take into consideration the requirements asked for the authorization process. Considering this schedule, CNCAN will issue a Level 2 licensing schedule (more detailed than level 1) and the detailed requirements for the authorization for each step concerning this process. The licensing schedule will contain the following:

- the licenses, the notifications, and the approvals, that has to be obtained during the authorization process.
- The content of the formal requests concerning the licenses, the notifications and the approvals.
- the content of the support documents which are annexed to the requests mentioned above.
- The necessary duration for analyzing the requests and the support documentation, and for the verification on site.

Preliminary requirements for the restart of the authorization process

The owner will present prior to start the licensing process, as a preliminary condition, a document containing the solution for the problems that can have an important impact over the nuclear safety on long and medium term. This publication should have the CNCAN approval for both units 1 and 2.

The aspects regarding nuclear safety are the following:

- the management and the storage of the low and medium active wastes from U #1 and U #2;
- the fresh fuel supply and the storage of the spent fuel for U #1 and U #2;
- the heavy water supply for U #1 and U #2;
- the functioning of U #1 and U #2 in national grid;
- to provide the trained staff for the units;

- to provide the basis for the research programme regarding nuclear power plants and for the evolution of safety problems;
- to provide a department for the emergency and also an emergency control centre
- to provide the basis of a programme concerning the systematic control and the implementation of the operating experience accumulated from Unit #1 over the nuclear safety characteristics.

Material provided by L. Biro
National Commission for Nuclear Activities Control, Romania

Annex 9A

ROMANIA: CERNAVODA NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. Cernavoda NPP suffered considerable delay due to political and economic instability in Romania. The plant has recovered from these delays and unit 1 has been put into commercial operation. Contract negotiations for completion of unit 2 are under way. Construction and commissioning of Unit 2 stands to benefit from recent experience at unit 1. Should work on unit 2 resume in 1997, commercial operation is possible in 2001.

General information

The Cernavoda NPP was originally conceived as a 5 unit plant using 700MW(e) Candu PHW reactors. Currently unit 1 is in commercial operation and completion of unit 2 is under consideration. Other units have been indefinitely suspended.

The initial contract for Cernavoda NPP was signed in 1979, but the project suffered considerable delay form 1980 to 1991 due to:

- political and economic instability in Romania
- lack of competent project management, supervision and planning
- desire to perform all the work using Romanians resources.

By the end of 1990, *46% of work on unit 1* had been completed.
Work on unit 1 only resumed in 1991 and the unit went into commercial operation in 1996.

There has been considerable delay, between 1991 and 96, in completion of unit 1 due to:

- delay in obtaining the necessary financing
- technical upgrades to bring unit 1 to the standard of the latest Candu 6 plants
- refusal to deliver some equipment on the part of some local suppliers
- failures of equipment during testing.

Work on unit 2 started in 1982 but, as unit 1, unit 2 also suffered considerable delay.

The current status of unit 2 is:

- equipment and material procured and delivered 70%
- civil construction completed 65%
- mechanical installation completed 15%
- electrical and I&C installation completed 3%.

Preliminary, short term planning work by a small project management team for unit 2 has started in 1996. Contract negotiations for full resumption of work 2 are currently under way.

Upgrading of project management

The project management team has considerably improved management techniques through introduction of concepts of:

- definition of objectives, targets and responsibilities for all departments
- comprehensive planning
- quality and efficiency
- team approach.

Strategic strengths and challenges

Construction and commissioning of unit 2 will benefit from unit 1 experience through availability of:

- Project management team having recent experience in management of a CANDU project
- design and research organizations with experienced and trained personnel having detailed knowledge of CANDU technology
- local contractors, qualified and experienced to work at site
- domestic manufacturers, who are qualified with respect to QA programmes, technical capabilities and manufacturing procedures.

Following are the major challenges facing unit 2 construction and commissioning:

- signing of contract and securing the necessary financing
- keeping the experienced people from Canada, Italy and Romania working on the project
- upgrading of unit 2 to unit 1 standard
- performing detailed assessment of the unit 2 inventory of equipment and its condition
- informing and influencing the government and the public of the benefits arising from nuclear power development in Romania and it being the most acceptable solution to electrical power shortages.

Additional information

Cernavoda NPP has a training center with a full-scope simulator, which together with unit1 in operation will provide the conditions for selection and training of unit 2 personnel.

Material provided by I. Rotaru, M. Condu
Romanian Electricity Authority, Romania

Annex 9B

ROMANIA: CERNAVODA UNIT 2 — ASSESSMENTS AND EVALUATIONS

Summary

This annex describes the various *assessments and evaluations* undertaken to confirm economic and technical viability of unit 2. The extent of modifications and improvements arising out of the suspension period are also identified.

General information

In 1991, to conserve available financial resources and focus efforts, it was decided to continue works only on Unit 1, temporarily ceasing the works on the other units. Until 1998, only preservation and some remedial and progress works will be performed at Unit 2.

Unit 1 has been successfully put into commercial operation on December 2nd, 1996.

Unit 2 status

In 1991unit 2 status was as follows:

- The design was complete and all required approval from the regulatory authority obtained.
- About 70% of the equipment and materials, worth about 545 millions US $ have been procured
- Construction erection progress, over-all: 25%
- 65% civil: main buildings and structures erected; only some internal structures, repairs and finishing to be completed;
- 15% mechanical: few equipment (calandria, steam generators, pressuriser) and piping installed, mainly in turbine building;
- 3% electrical and I&C.

Key elements

Technical assessment

In order to support the decision to complete Unit 2 — Cernavoda, a re-evaluation of the project was initiated as follows:

- a detailed assessment of the Unit 2 safety design guides, design requirements and engineering design solution in the light of changes in codes, guides, standards and regulatory requirements, together with identification of the set of changes — possible to implement — necessary to meet the current technological and regulatory requirements.
- Unit 2 cost/benefit analysis to demonstrate the economic efficiency of the project.
- Evaluation of costs of alternatives versus forecast electricity demand to select the best development plan for the Romanian utility.
- review of *safety design guides*, design requirements and engineering design solutions in the light of changes in to codes, guides, standards and current regulatory requirements.

A joint expert team performed this evaluation, based on the following:

- Cernavoda Unit 1 as the reference project for licensing, design, construction, organization of the project
- Experience gained during construction and feedback from commissioning and operation of Unit 1and from other Candu 6 NPPs
- Existence on the market of the original equipment suppliers; their ability to provide support
- Equipment obsolescence (especially on electrical and I&C)
- Current Romanian regulatory requirements.

To define the design for Unit 2, "as built" documentation from Unit 1was used, amended with a number of changes necessary.

Of specific issues addressed by this activity, the following are of particular importance:

- Assessment of the ageing effect on the existing equipment and structures;
- Compliance with the latest Canadian regulatory guides/standards/codes
- Design changes that were implemented by the foreign designer to upgrade Candu 6 design
- Since it was not possible to review the design for code revision later than 1989, the following approach was adopted :
- design will comply with 1989 revision of Canadian Codes and Standards;
- equipment already procured to meet the requirements of the standards in force at the time of procurement;
- All new equipment will be procured in compliance to 1989 Codes and Standards or more recent revisions.

Considering the tight completion schedule an the cost restraints, the regulatory authority has agreed to delay of completion of following assessments, providing they will be based on safety philosophy used and accepted for Unit 1:

- common utilization of the water from dousing bay and medium pressure stage of ECCS, common civil structures for Units 1 and 2 and compliance with single fault criteria defined for equipment;
- Evaluation of plant behaviour during severe accidents (over the design base accident);
- Completion of level 1 PSA for all plant systems for nominal power, partial load and shut down status including external events before commissioning;
- Preparation of PSA level 2 and 3 in time for submission of the application for operation of Cernavoda Unit 2;
- Compliance with ISO 9000 for some manufactured equipment;
- Total replacement of BOP analog/digital control system with a distributed control system and replacement of the station computers;
- Improvements to the display/annunciation system in the plant control room, as well as greater attention to the ergonomics and human factors;
- Improved construction sequencing to shorten the construction schedule.

Economic assessment

To evaluate the capital cost required to complete Unit 2, all activities necessary to put it in commercial operation were. Physical quantities as applicable for the reference project and cost were assigned to each of them.

- *Engineering activities*:
  - Incorporation in the Unit 2 design the Unit 1 modifications, if applicable;
  - Engineering work due to equipment obsolescence;
  - Producing the construction and safety design packages.
- *Procurement evaluation*: the assessment represents the balance of material and equipment deemed necessary and what is already available from the original procurement for Cernavoda Unit 2, with the addition of equipment identified by preservation group as not suitable for use.
- *Construction assessment*: man-hours required to erect the necessary physical facilities, based on Romanian Labour Standards adjusted for the local labor condition and the experience gained during the construction of the Unit 1. *Project management*: mainly the manpower required on site to manage the project (site engineering, construction, procurement, material management, planning and scheduling, financial and administration), both Romanian and foreign specialists.
- *Training*: Cernavoda NPP has a training center equipped with a full-scope simulator. The scope of work will represents the foreign instructor man-hours.
- *Insurance*: includes the construction all risk (CAR) and the nuclear all risk (NAR) insurance.
- *Administrative and social costs to cover*:
  - An office building to be used for project operation;
  - Refurbishing of the existing offices
  - Refurbishing of the existing town site
  - Transportation facilities.
- *Cash flow analysis*:
  - A cash flow model has been developed. The financing scenario provides that all resources will be from loans, RENEL covering only interests during construction.
  - Analysis results indicate that Cernavoda Unit 2 is an economically feasible project.
- *Least cost power and heat*:
  - The selection of the "best generation plan" for the Romanian utility has been contracted to consultants, with the objective of recommending the "least cost alternative" for power and heat generation. The results indicate that Cernavoda Unit 2 is the first ranked option.
- *Management of activities*:
  - The management of the above activities and the interfacing with the regulatory authority is performed by the Nuclear Group at Head Office.
  - The entire exercise is an iterative process to design, erect and commission Unit 2, with nuclear safety parameters accepted by regulatory body, self sustained from the financial point of view and with attractive economic viability parameters.

Material provided by I Rotaru, M Condu
Romanian Electricity Authority, Romania

Annex 10

SLOVAKIA: MOHOVCE NPP — PROJECT CONTROL

Summary

This annex deals with *project control*. Mohovce NPP suffered considerable delay primarily due to lack of money. This situation was corrected and construction resumed in 1996. Throughout the "dormant" period the plant received considerable support from the major contractors, who maintained skeleton staff at site. Significant safety and managerial improvements are being introduced and a strategic plan for the plant has been developed.

General information

Construction work at Mohovce NPP, consisting of four 440MW(e) WWER reactors, started in 1983 and was suspended in 1993 due to:

- *lack of money and* inability to pay installments on supplier loans
- disintegration of national suppliers
- step by step withdrawal of personnel from the site.

Construction resumed in 1996 after financing problem was solved. the main financing sources are the following:

- Slovakia 36%
- Czech Republic 32%
- Others(Russia, France, Germany) 32%.

After work was restarted, 30 months were required for completion of original design and implementation of a large number of safety measures.

Unit 1 started operation in October 1998. Unit 2 is progressing on schedule, with start of operation planned for October 1999.

Current status(Nov. 98) of the completion of units 3 and 4:

Unit 3	40%
Unit 4	30%.

Planned commissioning dates for these units have not been decided.
Planned time to completion:

Unit 3	48 months
Unit 4	57 months.

Problems encountered

Human resources

Sufficient Slovak Power Utility staff remained at the site to provide protection and maintenance for equipment and structures.

There were no other requirements at site because work had come to a stand-still.

Staff at corporate head office remained in place and were occupied with analyses, studies and assessments of design and with work on other projects.

Major contractors maintained small core of managerial staff, but subcontractors left the site because of non-payment.

Technical modifications

Necessity to improve the older design and bring the units up to internationally acceptable nuclear safety level.

Measures implemented

Human resources

Human resource problems were addressed by Slovak Power Utility maintaining staff at corporate headquarters and at site and contractors keeping a small core of managerial staff at site, in anticipation of resuming work.

The following situation prevailed at site during the "dormant" period:

- Slovak Power Utility kept its staff at the plant and provided protection and maintenance for equipment and structures.
- general contractor maintained small core of managerial staff.
- general technological contractor maintained small core of managerial staff.
- main civil contractor kept an organizational unit at site.

Site installation, structures and equipment

Inventory and inspection of equipment at site was carried out.
Site installations, equipment and structures are being maintained in good condition.

Upgrading of project

Considerable upgrading of the project took place to bring it in line with the latest western standards, as follows:

- replacement of DERIS control system
- delivery of security system
- installation of simulator and its commissioning
- safety upgrading programme for units 1 and 2 was implemented in accordance with Technical Specification of Safety Measures, elaborated on the basis of following documents:
- Safety issues and their ranking for NPP WWER 440/213 (IAEA document)
- Evaluation of the Mochovce NPP safety Improvements (risk audit)
- Safety Improvement of Mochovce NPP project (IAEA Safety Review Mission report)
- nuclear safety improvements as per "Safety strategy" arising from recommendations from a German/French study
- safety analysis of radioactive waste disposal.

In addition, management of the project has been improved by:

- introduction of quality assurance programme
- utilization of construction management system based on French utility practice.

Establishment of strategic plan

The following strategic objectives have been identified:

For units 1 and 2:

- accomplish the current milestones for construction and commissioning
- accomplish the current milestones for studies and analyses
- develop good and clear working relationship with Slovak Nuclear Authority.

For units 3 and 4:

- continue to protect equipment and buildings against damage
- achieve government's decision and guarantee with respect of the future for these units
- identify potential sources of financing.

Performance measures have been developed for each of these objectives

Additional information

It was possible to maintain substantial portion of staff through the dormant period by having them do work for Bohunice NPP and for external customers.

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Annex 11

SPAIN: PROJECT CONTROL

Summary

This annex deals with *project control*. In 1984, construction of 5 nuclear units were suspended by the government under pressure from local authorities, for a period of approximately 6 years. Protective measures were implemented to maintain capability for resumption of work. The hardest hit were the project personnel, many of whom left. In 1996 all 5 units were permanently suspended ("long suspension phase")

General information

In 1984 the Spanish government, through the Spanish Energy Plan (PEN) for that year, suspended the construction permit for five nuclear units shared on three sites, as follows:

	Power (MW)	Start of constr.	Investment Incurred	Years to completion
Lemoniz 1	930	1974	90%	1<
Lemoniz 2	930	1974	30%	3 to 4
Valdecaballeros 1	975	1980	55%	3 to 4
Valdecaballeros 2	975	1980	35%	5 to 6
Trillo 2	1040	------	5% <	-------

Construction of the Lemoniz 1 and 2 commenced in 1974. In 1982 the Spanish government took control of Unit 1, due to the untenable pressure being exerted on the plant and its managers by a terrorist group. At that time, Unit 1 was practically completed, the testing programme was well advanced Unit 2 was approximately two years behind Unit I.

Another unit whose construction was suspended was Trillo 2, the second unit of Trillo Nuclear Power Plant. The construction permit was granted in 1979, at the same time as that for Unit 1, which is now in commercial operation.

Suspension of works at Valdecaballeros was unexpected. The root cause of the suspension was political opposition from regional authorities. The plan for re-starting work on this unit specified resumption of work in 1990 when time and the need for new power production facilities would have cooled opposition down.

At Valdecaballeros 1, not only was construction advanced, but most of the equipment and components were already at the site. Almost all the equipment had been purchased and the last components were being received There seemed to be no technical obstacle to prevent compliance with the construction and start-up programme for both units.

Problems encountered

Human resources

Personnel involved in the Valdecaballeros project suffered the most serious problems. It was impossible to avoid the dispersion of the highly qualified management, supervisory and operation personnel, who had been already contracted and available.

To counter the effect of suspension, personnel were assigned to completion of started activities or to activities in other areas of the company. In addition, operating personnel were seconded to other power plants (nuclear and fossil-fired) and there was continuity in the training programmes on site for the rest of the personnel.

Measures implemented

Human resources

Efforts to re-assign personnel within the projects were partially successful. As a result it has been possible to retain a continuity in the capability of the organization to re-start construction and to preserve structures and equipment throughout the suspension period.

Site installation, structures and equipment

While under suspension, the necessary criteria were established to achieve an optimum preservation and re-launch of problem-free construction. As the result, a number of building and areas were completed.

For the preservation of components and mechanical equipment, a decision was made to proceed with their dry preservation once they had been cleaned using air or a hydrolaser, depending on the process fluids, and subsequently dried.

Throughout the suspension period, on account of the requirements of the Spanish electricity system, the decision was made to finish and start up the substation, segregating it from the plant and integrating it into the national electricity network.

The water treatment plant was also put in operation, and temporarily, some ventilation and auxiliary electrical power supply systems.

Efforts were made to maintain warranties and otherwise deal with suppliers of major equipment.

Additional information

In 1994 Valdecaballeros "suspension plan" was prepared and approved. The assumption was that construction will resume in 1991 with 6 months notice to allow for orderly re-start.

The plan established 3 phases:

- Orderly suspension of construction activities
- Preservation with the development of construction activities
- Preservation only.

In 1989, instead of expected re-launching of construction, the government extended the suspension indefinitely.

Accordingly. the plan was revised to include a new phase:

- Preservation during extended suspension.

The suspension continued until the latter part of 1996 when the final cancellation of all units under suspension was decreed.

This decree was accompanied by the government's acknowledgment of a global compensation of approximately US $6,300 million to utility owners, which does not cover the total amount claimed by these utility owners. This compensation is reflected in the electricity rates as a surcharge.

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Annex 11A
SPAIN: PROJECT CONTROL

Summary

This annex deals with *project control*. This annex presents some details of the suspension program manual as prepared at a Spanish NPP. The manual is a pre-requisite for orderly transformation from construction to extended suspension phase. Table of content of the manual is given.

General information

the suspension program manual establishes the necessary activities to suspend construction in an orderly manner at a Spanish NPP and also those to be carried-out during the suspended situation.

Its aim is to define the objectives to be achieved and activities, with sufficient detail to be useful to upper, intermediate and area management.

The document establishes precisely the applicable organization and analyses the workforce evolution through different phases. It also gives the forecast of the costs for the period and specifies the budgetary control to be followed.

The regulatory body required this publication for examination and approval. It had undergone six revisions until the NPP entered into the long-term (period) suspension phase.

Key elements

The index of the documents broken down by subjects of preservation and maintenance is given below.

1. Scope and aim of the programme
2. Introduction
3. Status of the construction at the beginning of suspension
4. Objectives of the suspension programme
5. Structure of the suspension programme
- 5.1 Phases
- 5.2 Areas

6. Detailed suspension programmes for different phases
- 6.1 Project
- 6.2 Licensing
- 6.3 Quality assurance
- 6.4 Main equipment
- 6.5 BOP equipment
- 6.6 Civil work
- 6.7 Erection
- 6.8 Preservation and maintenance
- 6.8.1 Objectives
  - 6.8.1.1 Preservation
  - 6.8.1.2 Maintenance

6.8.2 Activities of the suspension programme

6.8.2.1 Preservation activities

- Procedures
- Equipment conditioning
- Physical protections
- Warehouses
- Auxiliary facilities and services

6.8.2.2 Maintenance

- General aspects
  - Procedures
  - Maintenance programmes
  - Optimising resources
  - Method and time control
  - Documentation control
  - Supply lists
- Applied maintenance
  - Piping in warehouses
  - Piping in-plant
  - Valves
  - Heat exchanges and tanks
  - Control room
  - Vessel and coolant pipe
  - Turbine
  - Generator
  - Pools
  - Water treatment plant
  - Substation
  - Structures
  - Embedments
  - Exposed reinforcement steel
  - Facilities and auxiliary services

6.8.3 Scheduling

6.8.4 Human resources and organization

6.9 Services

6.10 Start-up and operation

7. Budgetary and financial plans

8. Assessment of the work forces at site

ANNEXES:

- Objective basic plan
- Detailed activity scheduling
- Diagrams

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Annex 11B

SPAIN: PROJECT CONTROL

Summary

This annex deals with *project control*. This annex outlines the method of accounting and coding of expenses during the various phases of transition from construction to long-term suspension. In this way costs can be accurately traced and assigned appropriately. This is an essential part of managing during the suspension phase.

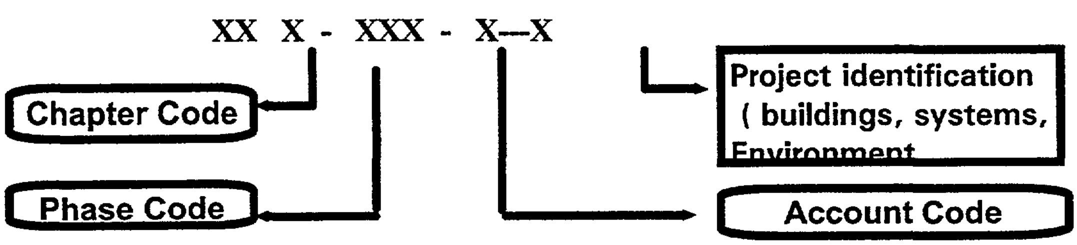
General information

The following is the breakdown of the cash flow plan for a DNPP in Spain. The cash flow plan has the typical breakdown structure consisting of different cost level codes (up to four) for allocating the costs and to permit cost control of different areas, specialties, etc. The structure has four levels: chapter code, phase (subchapter) code, account code and project identification (sub-account) code.

The break-up of the costs at different levels reflects the objectives and priorities in cost control for each particular project. For example, in this case, the splitting of the chapter code into three parts — nearly independent budgets — (plus another two chapters at the end for cancellation costs) takes into account the expenses solely caused by delay if it is to be separately compensated.

The "phase code" takes into account the very different impact of the cost accounts in each phase. Four different phases have been considered as shown below. For example, during the long-term suspension phase (the last one), the accounts 400 (BOP equipment), 500 (civil work-by contracts), 600 (erection by contracts), practically disappear, while the others, except code 700 Maintenance and Preservation, were maintained very low.

The " account code" gives the break up of the different cost booking headings.
The project identification (sub-account code) was applied only in some special cases to further break up a few account codes at the beginning of the delayed project.



Chapter Code

A0 Costs of activities performed before the suspension date
B1 Investment in activities belonging to the project
B2 Expenses caused by the delay
C1 æ Cancellation costs
C2 ä

Phase Code

1 Work force decrease phase
2 Construction and preservation phase
3 Engineering and preservation phase
4 Long delay phase

Account Code

100 Engineering and Licensing (Headquarters)

110 Headquarters management
120 Main architect and engineer
130 Auxiliary engineering
140 Site engineering
150 Safety and licensing
160 Studies, advisories and consultancies
170 Miscellaneous headquarters expenses

200 Quality assurance

210 Agencies for QA on manufacturers (by agency)
240 Agencies for QA on site (by agency)
290 Miscellaneous QA expenses

300 Main Equipment

310 Supplies of main equipment
320 Engineering from main supplier
330 Warranties extension
390 Miscellaneous main equipment expenses

400 BOP Equipment

410 Supplies category A (to be finished)
420 Supplies category B (to be frozen)
430 Supplies category C (to be purchased)
440 Complementary expenses for the above supplies (customs, transports, insurance, etc.)
490 Miscellaneous. BOP equipment expenses

500 Civil Work-by contracts, e.g.

510 Main civil work for the plant
520 Concrete
530 Reinforcement steel
540 Liners
550 Structural steel

590 Miscellaneous civil work expenses

600 Erection by contracts, e.g.

610 Mechanical equipment erection
620 Electrical equipment erection
630 I&C erection
640 Turbine-generator erection
650 Substation erection
660 Turbine-generator erection supervision

700 Maintenance and Preservation

705 Maintenance and preservation of equipment and components on factories
705 Maintenance and preservation of equipment and components on factories
710 Maintenance and preservation of equipment and components on site warehouses
715 Maintenance and preservation of equipment and components In-plant
720 Provisional closing of building openings
730 Specific supplies and works for maintenance and preservation
740 Preservation of structural steel and concrete
750 Piping preservation
760 Maintenance of equipment and systems for services
770 Insurance
790 Miscellaneous maintenance and preservation expenses

800 Start-up and Operation

810 Courses and other expenses for the operation staff
820 Salaries and wages

900 Site Management and Services

910 Management on site
920 Services (cleaning, security, healthy, etc.)
930 Maintenance of provisional facilities on site
940 Communications
950 Maintenance and expenses of the computers and office material
960 Taxes and juridical expenses
970 Information center and image expenses
990 Miscellaneous site management expenses

The accounts can also be divided into sub accounts using third level figures, e.g.:

541 Containment liner
542 Refueling pool liner
543 Spent fuel pool liner

751 High pressure piping preservation
752 Low pressure piping preservation
753 Tubing preservation

921 Cleaning service
922 Security service

923 Healthy service
924 Fire-fighting service

The project identification can be applied according to the concept of the accounts, e.g. buildings for civil work, systems for engineering and erection, etc.

Material provided by J L Montes Rodriguez
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Advisory Group Meetings & Management Workshops

Vienna, Austria: 3–7 February 1997, 1–5 September 1997, 26–28 May 1998, 6–10 July 1998

Consultants Meetings

Vienna, Austria: 14–16 October 1997, 24–26 November 1997,
20–22 January 1998, 10–12 November 1998

99-02373