IAEA-TECDOC-1078

Technical support for nuclear power operations

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

April 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

TECHNICAL SUPPORT FOR NUCLEAR POWER OPERATIONS
IAEA, VIENNA, 1999
IAEA-TECDOC-1078
ISSN 1011–4289

Printed by the IAEA in Austria
April 1999

FOREWORD

This report is the latest in a series of IAEA publications that address the problem of improving the operating performance of nuclear power plants. Safe and reliable operation is essential to strengthening the viability of nuclear power in the increasingly competitive market of electric power. Thus power station managers are committed to performance improvement programmes consistent with a high level of operational safety. In this respect lessons learned and success stories of the world's leading nuclear power plant performers represent valuable guidance for the nuclear industry worldwide and the need sharing this experience is apparent. Noting the importance of strong and competent technical support to safe and reliable operation, this report has been prepared with the objective of providing operators of nuclear power plants in Member States with information and guidance concerning the establishment and role of such support.

This report discusses the basic principles and requirements around which plant technical procedures and practices are developed, reflects the best current international practices and presents those management initiatives that go beyond the mandated regulatory compliance and can lead to enhancement of operational safety and improved plant performance.

The report is the result of work of a group of senior experts from nuclear operating organizations. By correlating their experience and additionally by representing collective effective practices, it should assist nuclear station managers in achieving improvement in operations through the contribution of effective technical support.

Contributions from senior personnel from nuclear utilities in Member States who assisted the Secretariat by providing relevant information and source materials are acknowledged. Special appreciation is due to J.T. Wieckowski of Operations Quality Corporation in Canada.

The IAEA officers responsible for this publication were F. Calori and K.V.M. Rao of the Division of Nuclear Power.

CONTENTS

SUMMARY

This publication is intended for plant and technical support (TS) managers of operating and newly built nuclear power plants. It offers valuable guidelines with respect to the role, importance and specific activities that are incorporated within the framework of TS functions at a nuclear plant. As part of a series of IAEA publications on improving the operational performance of nuclear plants, this publication refers to terms and concepts well understood in the nuclear industry and used in those publications; for purposes of clarity and consistency of usage, key terms and phrases are defined in the glossary.

In general, TS functions at nuclear power plants encompass a range of managerial support activities related to the technical oversight of plant operations and performance, both on a day-to-day and longer term basis. At some plants, TS staff are a separate organizational unit, while at others, they are incorporated within a broader managerial structure, serving as task forces for achieving specific objectives. No mandatory organizational structure is proposed here for TS functions, as the desired approach should be determined by plant management. Rather, managers of operating plants can refer to this report to assess the scope and performance of their TS functions against recommendations made here. Managers of new plants can use this report as a guideline for the development of TS functions in their emerging organization.

The following key conclusions arise from this report:

- TS is an essential primary technical resource at a plant
- TS activities must be integrated into and be consistent with major activities and programmes at the plant and must conform to the plant management's requirements for those programmes
- TS has an identifiable set of cross-functional core activities which must be carried out
- The specific organizational arrangement for fulfilling the TS functions is unimportant as long as the core activities are satisfactorily carried out
- TS provides an important link to ensuring short and long-term compliance with the plant design safety requirements
- Multi-layered assessment of the TS function is necessary
- Attributes for assessing TS quantitatively have been established.

The report discusses managerial considerations which — when executed — would ensure that requirements arising from "conclusions" are adequately dealt with at the plant. It also provides guidance with respect to performance of "core activities" as well as other important TS activities.

The "core activities" of TS are those which must be carried out in order to maintain and enhance nuclear safety and operational reliability. These have been emphasized and discussed in the report.

They are:

Daily oversight of operations

- "Operability determination and operability evaluation" (OD&OE) being the day-to-day support and assessment of operations
- Surveillance/monitoring (day-to-day testing and evaluations).

Nuclear engineering

- Risk assessment
- Reactor engineering support
- Fuel handling support.

Optimization of plant performance

- Optimization of components of plant performance
- Computer applications and software management
- Experience feedback

Long-term issues

- Control of permanent modifications
- Long-term technical issues, both plant-specific and generic.

The "conclusions" and "core activities" are addressed in four major chapters as follows:

Management

- Managerial programmes necessary to ensure satisfactory, long term performance and support of the plant. Because TS is positioned within the overall management framework of the plant, aspects of management applicable to established management principles are not repeated and restated within the report.

Performance

- Core activities of TS are emphasized, their scope and key performance issues discussed
- Review and discussions of non-core, but important, supporting TS activities at the plant are also offered.

Assessment

- Assessment of TS by plant management is discussed, stressing the periodic, in-depth reviews
- Typical attributes and symptoms of good or poor TS performance respectively and typical performance measures are offered
- Self-assessment by the TS management is emphasized.

Effective practices

- Offers a number of effective practices that describe how some plants and utilities have successfully achieved technical performance objectives in the various activities.

These effective practices have been validated by experience. They are recommendations only and are *not to be interpreted as regulatory requirements.*

Chapter 1

INTRODUCTION

1.1. BACKGROUND

The concept for this TECDOC arose from recognition that the technical support (TS) function at some nuclear power plants is sometimes not clearly understood or adequately addressed and, as a consequence, is not applied in a manner which would produce the most benefits to the plant. As the result, some plants have experienced significant performance problems.

It is also recognized that the provision of effective technical support is essential if the plant is to operate safely and to maximize its power producing potential.

Recommendations contained in this report represent many years of nuclear power plant experience.

These recommendations apply equally well to a utility's first nuclear power plant in its design stage, or to an operational plant deciding to review and improve its technical support.

Additional information on key TS activities is provided in the annexes. The annexes are contributions from nuclear utilities across the world and represent *effective practices* successfully applied by these utilities in solution of identified problems.

It must be clearly understood that the effective practices are only recommendations and are *not to be interpreted as regulatory requirements.* Their implementation must be consistent with the organization, culture and the operating environment of the plant.

1.2. OBJECTIVES

The objectives of this report are to:

- Alert the target audience, i.e. the utility and plant management, to the importance of having a competent and well focused technical support at the power plant.
- Assist the plant and TS management in achieving an effective technical support organization through:
  - — emphasizing the key role of management commitment
  - — clarifying the role, importance and core activities of TS at the plant
  - — listing and commenting upon the core, or essential, TS activities
  - — offering recommendations with respect to management, performance and assessment of TS.
- Affect improvement of performance of TS. The word "performance" as used here addresses and is concerned with the *method of execution* and the *results achieved,* rather than the adequacy of various supporting pre-requisites, such as for example procedures.
- Offer references (bibliography) and alternative sources of information (sources of effective practices) for plants and utilities.

1.3. SCOPE

This report offers an outline of managerial performance and assessment functions of TS, with limited commentary. No details of implementation are offered — other than in the annexes — as these can be obtained elsewhere. The bibliography offers a selection of publications which provide details of functions described in the report.

The report deals with the essential aspects (core activities) of TS stated in point form in simple and direct language. These activities have the potential to affect the safety and reliability of a nuclear power plant and include the conventional part of the plant. The report can be used as a convenient checklist or guideline.

Where appropriate, the importance of performing a particular activity is emphasized, as are the consequences of doing it poorly, or not at all.

The report contains "effective practices" to deal with some of the performance problems. These effective practices were selected from a large number of practices that were reviewed and are based on activities performed by managers and supervisors as an integral part of their work.

It is recognized that there are many supporting functions performed by corporate organizations, architects/engineers, plant vendors and consultants.

1.4. STRUCTURE

This report is intended to be used by plant and TS management. An attempt has been made to give clear guidelines on actions to be implemented to improve the effectiveness of TS in facilitating the long term achievement of quality in operations. Details of implementation have been omitted so the reader can concentrate on the essentials.

The report is organized by functional areas within the scope of TS. Major elements which should be addressed to achieve quality of performance in each functional area are referred to.

The annexes describe selected effective practices. They are preceded by a short statement explaining their relevance and the reason for being included in the report.

These effective practices do not offer any theoretical considerations or justification. They are practical recommendations and summaries of methods that have worked well in a power plant.

All of the practices are written in condensed, standard format and in simple language to facilitate the reader's grasp of the concept and of the process presented. A matrix relating practices to topics in the report is provided ahead of the practices as is a list of sources for the annexes.

The meaning of less common or specialized terms is explained in the glossary.

The report is primarily directed at the management of an operating nuclear power plant. However, the concepts and effective practices presented can usefully be applied to other stages of "life" of a nuclear power plant or other nuclear facility.

1.5. HOW TO USE THIS REPORT

The managers of TS function at the power plant should read the summaries at the beginning of each major chapter and assess their situation with respect to the topics discussed. They should also read Section 4.1., "Assessment of TS effectiveness by plant management", and review the attributes, symptoms and performance measures.

If sufficient concerns are raised regarding a particular TS activity or function, further review of the pertinent chapter of the report is warranted, together with applicable "Effective practices", if available. Further study of implementation details from the bibliography might also be undertaken.

Chapter 2

MANAGEMENT

Summary:

This chapter deals with management controls and activities as they apply to TS, starting with "Mission" which stresses the long-term aspects of TS involvement in the plant. Various types of "Organization" are identified as are the services which must be provided. Importance of planning, prioritization and controlling of engineering work is stressed. "Training and development of TS staff" is reviewed at some length and key knowledge and skills of TS personnel are specified. Lastly, planning for "Quality improvement" is presented, as are some of the tools to be used. Integration of plant records and administrative support is encouraged.

Conclusions:

The following conclusions arise from this chapter:

- TS is an essential primary technical resource at the plant and should be implemented early in the plant's life cycle
- TS activities must be integrated into and be consistent with management requirements and programmes at the plant
- Specific organizational arrangements for fulfilling the TS function are unimportant as long as the core activities are satisfactorily carried out
- Continuous training and development of TS staff is essential. It is to be regarded not as a cost but as necessary investment in people.

2.1. MISSION

The mission of technical support (TS) is to assist the plant management in the achievement of operational performance objectives of the nuclear power plant. The plant must have at its disposal a group of highly qualified technical staff capable of, and dedicated to, providing technical analysis and advice to support operations over the long term.

TS management and the staff must be clear about the desired standard of performance of their activities. The standards of expected performance in each of the many TS activities must be routinely reinforced by managers and defined in the documentation by which these activities are conducted.

Technical staff must have expertise in all technical areas relevant to the plant, be supported by a modern and complete record and information system which includes the design bases, construction information, commissioning information and operational history.

Additionally, TS should also be supported by organizations at corporate headquarters, specialized consultants, architects-engineers and vendors of plant's equipment. Together, they constitute the technical support for the plant.

The mission is fulfilled by provision of expert services, as follows:

- Daily oversight of operations (operability determination and operability evaluation - OD&OE)
- Operational documentation and recommendations
- Multi-disciplinary and specific technical know-how
- Effective control of plant configuration
- Expert support of non-routine activities
- Maintaining mid to long-term focus on technical aspects of operations.

Technical support function is of supportive and advisory nature. Technical staff have direct responsibilities with respect to the technical status of the plant, but are not responsible for actual performance of operational activities in the plant, the responsibility for which rests entirely with the operating organization.

TS exerts its most significant influence and advice throughout the operational phase of plant life. However, the need for its expertise arises earlier, during design and commissioning phases. For that reason, organizational foundations for TS function should be established early in the development of the plant and key personnel selected.

During design phase, senior TS staff should be in very close contact with plant vendors and designers in order to ensure that the particular and specific opinions and requirements of operating organization are represented and given due consideration.

Commissioning is often conducted by the operating organization. In this situation TS staff will posses the best knowledge of the plant design and its operating characteristics and will therefore be in a position to offer system training to operating and maintenance staff. TS will also be in position to implement the commissioning process and oversee its execution.

Decommissioning of a nuclear power plant is usually started by the operating organization who possess the necessary detailed knowledge of the plant and its operating history. As the result, there needs to be considerable involvement on the part of TS in planning and implementing the initial phases of de-commissioning process. This involvement should gradually diminish and cease once defuelling has been completed.

2.2. ORGANIZATION

Different organizational structures can be equally effective in achieving the objectives of TS. Selection of a particular organizational pattern depends on the management style and tradition of the utility.

Three basic organizational patterns are in use:

- TS is centralized in a single department, with designated sections providing long-term services to the various areas of the plant, e.g. chemistry control, mechanical maintenance, reactor safety, etc. The department manager is responsible for performance and accomplishment of objectives of TS and reports to the plant manager.
- In a matrix organization TS is headed by a manager and his team members are drawn from different vertically oriented, specialized units. Personnel are selected from the specialized units and formed into teams as needed to address plant problems. The teams are dissolved once the problem is solved. The manager is responsible for achieving the TS performance and accomplishment objectives and reports to the plant manager.
- TS staff are assigned directly to the departments they are supporting, e.g. maintenance, operations, procurement, etc. TS is therefore decentralized.

Some power plants use a combination of the three organizational patterns.

The main advantages of the centralized approach are:

- There is a consistent standard applied to all staff with correspondingly consistent set of expectations and training
- In case of need, overall plant priorities can be addressed by concentrating personnel on the big problem at hand
- Staff are focused on and dedicated to technical issues.

The main advantages of the decentralized approach are:

- TS staff are closer to the "customer" and can therefore provide more focused support
- there is better communication and therefore better implementation of technical recommendations
- Support is more specialized and can therefore be more effective.

There are some common considerations which must be satisfied by any type of organization:

- The organization must be structured to provide effective service to the plant with minimum organizational overlap or hindrance
- There must be a uniform standard of performance to ensure that the "product" is of consistently satisfactory quality. This implies consistent application of quality management;
- A senior TS manager should normally be designated the "design authority" for the plant to render engineering decisions and judgements at the plant
- Responsibilities of TS in general and of individuals in particular must be clearly spelled out
- There must be performance measures — and a performance-measuring information system — which enable the plant management to assess the effectiveness of TS as constituted
- All the technical requirements of the plant must be addressed.

TS must not be locked into a particular organizational mode. Its organization should be flexible and adaptable and respond to changing conditions at the plant during its life cycle.

Every organizational group at the plant has its "customers" — the people who use the group's output and who define the items or service to be provided. For TS, the "customers" are the plant management and primarily the operations departments, who use the outputs of TS to guide their actions.

It is important for TS staff to realize that their primary function is the support of the plant through supporting their "customers".

It is also important for the "customers" to recognize that because of the expert nature of the engineering support function, failing to follow the advice of the engineering function is perilous. Because of this, many organizations have the engineering manager in a position of authority when it comes to engineering decisions.

TS should establish formal interfaces with regulators and other organizations outside the plant which provide support functions, including:

- Corporate support groups such as engineering, procurement
- Contractors, vendors, architects-engineers and consultants.

Relationships with the Regulatory Authority should be sincere and open, but formal and at arm's length. Clear and unobstructed lines of communication should exist between the plant and the regulator. While regulatory staff should have open and unrestricted access to the plant, pertinent information and personnel, the official contacts must take place through specifically designated personnel

Regular contacts with regulators are especially important because they provide an insight to the way regulators view the plant's performance. Since TS is usually asked to provide information for regulatory safety reviews and periodic plant licensing application, such an insight into regulatory thinking is particularly valuable.

2.3. QUALITY MANAGEMENT

The following quality management (QM) requirements are particularly applicable and important to TS:

TS, just like all other functions at the plant, must operate in accordance with procedures. TS procedures serve to define processes to be used while at the same time allowing for exercise of judgement in their detailed application.

A "procedure maintenance process" shall be in existence to ensure that all procedures are periodically reviewed at a frequency related to their importance and use. This review should be jointly undertaken by TS and other affected departments.

The extent to which QA requirements are to be applied should be consistent with the operational significance of the item, service or a process. A graded approach to quality requirements is desirable which can satisfy the necessary and appropriate requirements for each item and at the same time ensure the required quality.

An effective programme for dealing with deficiencies and corrective actions is a pre-requisite to satisfactory and long-term operation, and TS are the "owners" of it.

In the absence of an effective and structured programme to identify, record and resolve deficiencies, they could accumulate to the point where safe and reliable operation of the plant would be jeopardized. At that point management would have lost control of plant by not knowing what is in satisfactory working order and what is not.

Identified problems often require detailed review and analysis to determine the "root cause" of the deficiency. This analysis is sometimes complicated and lengthy, but nevertheless is absolutely necessary if the deficiency is to be resolved permanently.

Verification shall be applied to items, activities, services and processes such as, for example, in the case of TS:

- Preparation of documentation, procedures and plans
- Revisions to procurement specifications (substitutions)
- Engineering calculations and analysis
- Computer software.

Many activities at a nuclear power plant require co-operation of a number of organizations inside and outside the plant. Interaction between them takes place at the so-called interfaces which must be controlled and optimized. Interfaces can be formal or informal.

For TS, informal interfaces include:

- TS personnel being often in the field and observing work
- Discussing operations with shift supervision
- Talking to workmen with respect to ease of performance of carrying out the work:
  - — possible improvements to work methods
  - — problems with particular systems or equipment
  - — TS personnel participating in delivery of specialized training.

Some formal TS interfaces, which need to be controlled by "interface procedures", include, within the plant:

- Need to include operations staff in preparation and review of operating and maintenance procedures
- Having the responsible shift crews verify procedures and plans prepared by TS
- Shift crews having to provide formal feedback on the appropriateness and ease with which plans/procedures have been executed.

Clear understanding must be in place with respect to the involvement of TS staff in field operations, so that TS staff do not assume responsibility for conduct of work. Similarly, the operations staff should not undertake engineering activities, but should seek advice where appropriate.

TS must take steps to ensure compatibility, consistency, verification and prompt up-dating for changes and modifications of plant technical and operational documentation, such as, for example:

- TS procedures
- Commissioning procedures
- Operating procedures
- Maintenance procedures
- Training manuals
- Computer software
- Original design documentation and documentation of subsequent modifications, in accordance with configuration control requirements
- Siting, safety and other studies associated with licensing.

2.4. TRAINING AND DEVELOPMENT OF TS STAFF

It is the plant's management responsibility to ensure that personnel are trained, competent and qualified for their assignments. TS staff must acquire knowledge of plant systems and understanding of operational methods and environment, so that they can effectively guide and interact with operating and maintenance personnel.

Training should promote comprehension of technical and organizational issues and also encompass:

- Plant orientation, with special emphasis on understanding of major systems
- "Common plant" procedures, e.g., emergency procedures
- "Assignment specific" training, including shift and simulator assignments and focusing on detailed knowledge and understanding of assigned systems and processes
- Specialized technical skills particular to TS (e.g. technical codes)
- Human relations and "soft skills"
- Training in quality fundamentals, practices and the basic "tools of quality" (e.g. root cause analysis, histograms, cause and effect diagrams).

Collectively, TS must be competent in all branches of technology which have frequent application at the NPP. Typical examples are:

- Nuclear engineering
- Computer hardware and software
- Mechanical engineering
- Electrical engineering
- Chemistry
- Instrumentation and control
- Health physics (radiation protection)
- Human factors considerations.

TS management should take steps not to allow the level of collective technical experience and expertise at the plant to decline below optimum level.

Solutions to plant's problems often involve creation of teams. To be effective as members of problem solving teams and promoters of innovation, TS staff must have the soft skills which facilitate human interaction. TS management should insist on the soft skills being included in the training and development plans for members of TS and recognize and support their proficiency in this field.

In developing their personnel strategy for TS, management must assure that TS staff:

- Are available in sufficient numbers to deal with the work load
- Have continuity of experience and background
- Continue to receive appropriate training to maintain and improve their expertise.

Typically, training of TS personnel might require 10% of their working time. Additionally, pertinent training outside the utility (e.g. at university) should be supported. Training should not be regarded as a cost, but considered a necessary investment in people.

TS personnel should be encouraged to participate in nuclear industry activities, for the purpose of developing contacts and being aware of developments. Such activities might include:

- Development of standards
- Attendance at seminars, conferences and trade shows
- Presentation of technical papers.

TS should also participate in peer evaluations or international assessments such as OSART. Participation can be a staff development tool and means sending people out as evaluators and inviting evaluations into the plant.

Staff development should be a co-operative effort between the individual and the management. Management should be open to capitalize on and accommodate the individual's strengths and expressed career objectives.

2.5. PRIORITIZATION OF PROJECTS

Since TS and plant resources are inevitably limited, there is a compelling need to a have a rational, valid, effective and transparent process to evaluate and prioritize all non-routine TS work. It is essential to move from "fire fighting" to orderly management.

Prioritization process must be based on the following principles:

- All non-routine projects must be screened and prioritized
- There must be a set of criteria against which all projects shall be evaluated
- There must be a weighting scheme for each criteria, which may change from time to time to reflect the plant's/utility's priorities
- There must be a way to convert the evaluation results to a common parameter, usually money, for direct comparisons.

A typical set of criteria — subject to periodic review — for project prioritization are:

- Nuclear safety — public and plant personnel
- Environmental considerations
- Plant availability/reliability, including human factor considerations
- Development of plant personnel capability
- Cost effectiveness — economics of operation
- Public opinion and relations
- TS effectiveness/efficiency (e.g. acquisition of additional computers and software).

An effective prioritization system will result in TS management being able to:

- Easily review and prioritize each project
- Concentrate on some tasks/projects while declining to work on others
- Develop valid work plans and credible budget estimates
- Reduce back-log of outstanding projects to a manageable and predictable amount, by rejecting some.

TS should routinely interface with planning groups in other departments within the plant to provide technical advice in :

- Preparation of daily/weekly/monthly work plans
- Assessment of importance and priority of the work being called up
- Assessment of need to conduct non-routine tests.

2.6. CONFIGURATION MANAGEMENT

TS must define requirements of plant configuration management and ensure establishment of business processes, procedures and information systems to prevent divergence, over plant's life cycle, between:

- Important design and safety information (design basis)
- Physical (layout) and functional characteristics of the plant
- Relevant data and information (documentation).

TS should be the "owner" of configuration management and is responsible for its continued implementation through oversight and control of following activities:

- Plant modifications
- Operation, maintenance and testing to prevent unauthorized modifications and to ensure continued compliance with design requirements
- Management of materials to ensure conformance of materials to design requirements
- Management of documentation to ensure that relevant records and documents are updated and controlled.

TS should utilize and combine data and information available from its many activities (programmes) and use it to create and augment an effective configuration management system.

Since modifications to the plant occur on a frequent basis and over many years, an effective configuration management programme should be an ongoing effort to control and record changes.

Consequences of loss of control of plant configuration can be severe including a forced shut-down. The plant would not know exactly what is in the field and therefore could not assure the regulatory authority of controlled and safe operation. Restoring configuration management to a satisfactory condition might be a very expensive and time consuming effort.

Effective implementation of configuration management is also important because it will assist TS in execution of following activities:

- Procedure revisions: background information necessary to evaluate and change plant procedures is readily available
- Material control and procurement: documentation is available to ensure that correct materials are consistently available
- Licensing: documentation is maintained, including revisions arising out of modifications
- Equipment qualification, in-service inspection and plant life extension: information to support these programmes is available.

2.7. QUALITY IMPROVEMENT

Quality improvement (QI) is a process whose objective is to achieve and sustain excellence through involvement, commitment and contribution of all personnel. TS management should vigorously support QI within TS. QI processes within TS should be very much in evidence and serve as an example to the rest of the plant.

Tools for improvement are:

- Continuous measurement and trending of performance, using pertinent measures
- Periodically reviewing and assessing, in a structured manner, status of major programmes
- Setting targets and carrying out bench marking activities
- Analysing results of assessments and implementing effective corrective actions
- Effective prioritization of work
- Formation of multi-disciplinary improvement teams
- Anticipation and prevention of developing problems.

All of these "tools" are discussed elsewhere in this report except the last two, which are discussed here.

TS management should foster formation and support operation of multi-disciplinary improvement teams and provide suitably trained people to work on them. Teams are effective in problem resolution because they utilize synergy which arises from co-operative activities of staff with different backgrounds, all concentrating on the problem at hand.

Unanticipated problems develop as the result shortcomings of management and also as the result of developing technical problems not being effectively dealt with (see Section 2.9).

Shortcomings in management have been investigated by INPO through evaluation of events which have led to incidents at NPPs. INPO has found that major problems are usually preceded by conditions which they called "precursors". These are problems or errors of recurring nature which have generally occurred routinely and were well known to the management, and tolerated.

TS can make a significant contribution towards early correction of precursors as identified by INPO, some of which are:

- Acceptance of low standards of performance — by redefining and emphasizing the expected standard
- Ineffective management monitoring of performance — by being present in the field and observing the work being done, examining performance indicators and following up on corrective actions
- Inadequate procedures — by improving the standard of operational procedures
- Ineffective training — by improving the quality of training materials
- Insufficient use of operating experience — by improving quality and effectiveness of operating experience programme (OPEX)
- Root causes not determined — by improving quality and effectiveness of root cause analysis and following up on corrective actions which have not been effective
- Design configuration not controlled — by improving the thoroughness and accuracy of configuration control, documenting and limiting use of temporary modifications.

TS must be pro-actively involved in correction of precursors and also utilize technical information provided by its programmes to address the longer-term technical problems. Through participation in the plant management team TS should contribute to development of operational strategy for the plant, focused on the priority issues.

2.8. TECHNICAL ASSISTANCE

Provision of short-term technical assistance to other departments is a TS responsibility. An engineering assistance request procedure should be used to obtain technical assistance, information and evaluations in the following typical areas:

- Engineering, and documenting, of minor plant modifications as suggested by the production departments
- Evaluation of substitutions of similar but not identical components
- Root cause analysis of repeated operational difficulties
- Special measurements, technical assessments or calculations.

An important part of TS mandate is provision of interpretation and advice on technical codes and standards. TS collectively should have good knowledge of all relevant codes and standards or know where to obtain it.

A priority system should be established to ensure appropriate attention and timely resolution for each request for technical assistance.

2.9. LONG-TERM TECHNICAL PROGRAMMES

There are many technical problems at the plant which require perseverance and long-term commitment. TS takes the leading role in defining the programme requirements and provision of resources to address these problems.

Developing technical problems can be identified by study of system/equipment performance and by periodical in-depth reviews of major plant systems by senior technical (TS) staff, together with plant and utility managers.

Examples of long-term technical problem, some of which are discussed in this report, are:

- Erosion of piping
- Inter-granular corrosion cracking of primary circuit components
- Motorized valve maintenance
- Steam generator tube leaks
- Cracks developing in reactor vessel or pressure tubes
- Equipment qualification (EqQ)
- In-service inspection (ISI)
- Plant life extension (PLEX)
- Procurement, to assure long-term availability of spare parts.

There are several techniques and tools used by industry for managing aspects of the technical support function. These include various programmes, such as:

- Quality assurance
- Quality management
- Configuration management
- Equipment/environmental qualification
- Information management
- Quality improvement.

Many of these programmes are discussed in this report. It is important for the plant management to recognize that these programmes, while very useful, have overlaps and must be integrated and aligned to ensure their effectiveness.

It is important to emphasize that these programmes should be executed within the normal functions of TS and using generic management techniques and existing plant administrative supporting systems. Setting up of separate organizational units for each of these programmes would result in excessive costs and loss of effectiveness due to organizational overlaps.

The long-term programmes require a number of common, complementary and overlapping supporting elements. TS has the primary responsibility for these programmes at the plant and therefore must take an active part in planning for their implementation, which is usually done at by a multi-disciplinary team. TS should also arrange for integration of the common elements at the plant.

The common programme elements are:

Meticulous records and documentation. Initial specification of performance requirements must be recorded. Subsequently, records of equipment condition as established through testing and evaluations carried out over the years must also be kept. These records and a data base form the basis for tracking changes of condition of critical plant components and of actions to establish and maintain long-term functional capability and qualification of equipment.

Inspection and records programmes should be established early in the life cycle of the plant, most desirably during the design and construction stage, as arrangements can easily be made to:

- Facilitate future repeated inspections
- Obtain base line information about initial condition of critical components
- Set out operational policies to maximize component life
- Collect and catalogue information which will be useful later.

Multi-disciplinary teams for solution of complex technical problems. Contributors to these teams usually include:

- Utility's specialists or consulting engineers
- Plant designers (architect/engineers)
- Members of TS staff from the power plant(s)
- Equipment manufacturers and suppliers
- Inspection and testing laboratories.

TS participation on these teams is required in order to:

- Achieve clear understanding of objectives, provisions and methods of execution of these programmes which are usually common to all power plants in the utility
- Present, to the team, information about the plant and its equipment
- Represent special concerns of the plant management.

Long-term technical focus, involving R&D activities and contacts with departmental co-operation is required over a number of years. Effective interface control is a necessity.

Also, there is a need for TS to keep up to date with developments which programme implementation, particularly with respect to:

- Programme requirements
- Inspection techniques and tooling
- New technology.

Maintenance of contacts with other organizations engaged in these programmes is important, particularly with those having reactors of similar type.

Chapter 3

PERFORMANCE

Summary:

This chapter stresses the core activities which TS must perform. These have been divided into four sections:

— Daily oversight of operations
— Nuclear engineering
— Optimization of performance
— Long-term issues.

The fifth section, Supporting Activities, deals with other important, but not essential activities of TS.

Conclusions:

Key conclusions arising from this chapter:

- TS must have multi-disciplinary technical capability to provide analysis and support in all technical specialities relevant to the plant.
- Many of TS activities require team effort and interaction with other organizations, inside or outside the plant. TS staff should therefore be trained and competent in team skills.
- TS must be supported by administrative systems providing timely communications and complete, current plant information.

All these activities contribute directly to achievement of nuclear safety through ensuring that operations are consistently conducted within boundaries of "operational limits and conditions", as defined in the design basis documents.

3.0. NUCLEAR SAFETY

Nuclear safety is of paramount concern for the plant management. TS function, through performance of its core activities, is the key contributor and watchdog towards achieving it.

TS must ensure that an effective nuclear safety policy, having the following key elements is in place:

- Promotion of operating standards based on best nuclear safety practices and consistent application of concepts of safety culture
- Development and implementation of nuclear safety policies
- Management of routine nuclear safety activities, surveillance
- Ensuring that the plant is operated in a manner consistent with the safety report, licensing documentation and the utility's nuclear safety policies
- Ongoing review of design and operation from the nuclear safety perspective
- Review of events and trends at the plant and elsewhere with objective of identifying incipient problems.

TS must assist the plant management in demonstrating — to the regulator — satisfactory performance in the area of nuclear safety during routine regulatory safety reviews and applications for licensing. TS must also ensure availability of adequate documentation to satisfy regulatory requirements

Effectiveness of the nuclear safety policy must be assessed by routine review of plant performance and comparison with current best practices and performance indicators developed by organizations such as IAEA, WANO, INPO.

3.1. DAILY OVERSIGHT OF OPERATIONS

Summary:

This section deals with activities which have an immediate effect on daily operations. The objective is to ensure that departures from approved procedures are promptly detected and corrected. TS achieves these objectives through on-going review of operating results, frequent interaction with the operating staff and provision of technical guidance and assistance in problem resolution.

Conclusions:

- Daily oversight of operations and immediate support in problem resolution is essential for continued safe operation

  Effective "daily oversight" requires:

- Personnel experienced in operations and having detailed knowledge of plant
- A clear definition, understanding and acceptance of activities and functions of the engineers responsible for the various plant systems.

3.1.1. Operability determination and operability evaluation

The daily oversight by TS personnel is often referred to as "operability determination and operability evaluation" (OD&OE) and consist of a number of distinct activities:

- Provision of daily technical advice and guidance, in response to current problems
- Frequent, formal and informal contacts with operations personnel
- Frequent, visible presence in the plant, with observation of work being done and the condition of plant equipment
- Control of temporary modifications, both to equipment and to operating procedures.

OD&OE activities are supported by system/equipment surveillance, specified by TS, the results of which are continuously reviewed and evaluated.

These activities are, in general, carried out on a system basis by the engineer with system responsibility. They result in TS having accurate and up-to-date knowledge of the condition of the plant, the work under way, the problems being encountered, and thus being able to immediately offer technical advice and support in problem resolution.

Monitoring of system operation and maintenance involves periodic presence and observation — by the responsible engineer — of activities in the control room and in the field, such as walk downs of the system to assess condition of equipment. Field tours form an essential part of this activity and must be done at a frequency sufficient for the engineer to stay in touch with system condition and performance.

Temporary modifications to equipment and procedures should be controlled by TS, the exception being those of very short duration and approved by the shift supervisor. It is intended that temporary modifications be minor in scope, of short duration and few in number. They must be evaluated by TS before installation and removal and appropriately approved. Temporary equipment modifications may require temporary procedure change, drawing revisions or annotations and temporary training. TS must ensure periodic review of all temporary changes for continued applicability.

3.1.2. System/equipment surveillance

The objective of system/equipment (S/E) surveillance is to detect, and prevent, equipment and procedural degradation, so that satisfactory and reliable operation of equipment and systems is assured over the short and the long term.

The S/E surveillance programme is designed to confirm that:

- The plant is operated and maintained in accordance with the operating license
- Systems are being operated and maintained in a manner which optimizes reliability while being cost effective in terms of manpower and material usage
- System performance is routinely monitored and tested in a systematic manner such that trends towards degradation of performance and documentation are identified early
- Management systems are in place to confirm effectiveness of surveillance.

The following departments have an important role to play:

- TS has the overall responsibility for the S/E surveillance programme, including the development of technical requirements and review of results
- Operations — including maintenance — have the responsibility for observation, monitoring and testing of plant systems and equipment and for prompt, complete reporting of the results
- Quality department is responsible for verification of proper execution of S/E surveillance.

TS must ensure that:

- S/E surveillance programme is specified, documented and cross-referenced to licensing requirements and safety analysis basis and addresses possible failure and deficiencies in equipment, materials, software, configuration and human performance.
- Surveillance tests incorporate all regulatory and standard requirements and that:
  - — all essential operating and annunciation components are tested
  - — validity of tests is assured by making sure that no special actions are taken in advance to assure a successful test
  - — human factors are taken into consideration to minimize mistakes and errors during testing
  - — hazards and risks of performing tests, as well as precautions are identified
  - — acceptability criteria for each test are identified
  - — frequency of testing is commensurate with the availability to be confirmed
  - — reporting of test results is prompt and accurate.

The S/E surveillance programme has three major components:

- Technical surveillance
- Operational surveillance
- Maintenance surveillance.

Technical surveillance is an activity performed by TS, who must ensure that:

- Current state of the plant is routinely assessed through evaluation of results of surveillance testing and also through observation of operations in the control room and the field
- Operating parameters are reviewed with regard to trends
- Current deficiencies, operating logs and maintenance activities are reviewed and assessed
- Results of routine system tests are promptly reviewed, evaluated, trended and reported
- Technical, operating and maintenance documentation is periodically reviewed by operations and TS for agreement with current practice at the plant

- Information obtained through the S/E surveillance programme is evaluated and consolidated in order to yield useful conclusions.

Operational surveillance consists of monitoring and testing systems, equipment, components and structures to ensure they are performing or are ready to perform their function in accordance with design intent and are operated within operational limits.

Maintenance surveillance encompasses a system of testing and observation of equipment and of reporting of results. Activities should be integrated with operational and technical surveillance (integrated maintenance planning). The framework of the maintenance surveillance is a "call-up system".

TS must ensure that a clear process is in place to promptly evaluate surveillance data for special safety systems for implication for performance and availability and for feeding back the results of these evaluations to the responsible parties.

Most of provisions of S/E surveillance should also be applied to protection devices installed on conventional systems — such as steam safety and relief valves, turbine and generator protection.

3.2. NUCLEAR ENGINEERING

Summary:

This section deals with issues which are specific and unique to nuclear power reactors. They arise from both the static and dynamic characteristics of reactors, and the general problem of reactivity control and the need for continuous heat removal from fuel. Assessment of effects of neutrons on materials, instrumentation and coolant chemistry are part of nuclear engineering.

Conclusions:

- Satisfactory execution of nuclear engineering activities requires specialized, multi-disciplinary knowledge and skills.
- Due to complexity of the technical issues, outside specialized support is often necessary.
- Care is required to ensure integrity of specialized computer codes used.
- Consequences of failing to execute this function adequately can be severe.

3.2.1. Risk assessment

TS uses results of surveillance testing to update the plant's risk model throughout its life. Outputs of risk assessment are:

- Safety analysis to continually asses the "safe operating envelope"
- Assessment of severity of adverse events
- Analysis of abnormal events and operating conditions, i.e. departures from standard operating mode
- An aid to judgements and decision making with respect to operations.

Operations occasionally depart from "standard operating mode" — such as, for example, during unit or system outages, non-routine maintenance or special testing or inspections. TS evaluates and assesses the significance of reduced safety margins arising out of reduction of redundancy of equipment and of changed reactor nuclear characteristics.

3.2.2. Reactor engineering

Reactor engineering deals with the analysis of reactor operation and the capability of reactor systems to satisfy the safety, design and regulatory requirements of routine and non-routine operations.

In order to satisfy these objectives, TS must arrange for satisfactory performance of the following activities:

- Development of standards and targets in the areas of reactor physics, reactivity control, chemistry of coolant and cover gas, fuel management, fuel performance and fuel inventory management
- Approval and upkeep of operating documentation regarding reactor physics
- Provision of reactor physics expertise to technical, operations and training groups, including the operation of the plant simulator.

Achievement of the above is backed up by:

- Thermal-hydraulic safety analysis
- Conduct and assessment of thermal power measurements
- Assessment of proposed safety system modifications
- Technical surveillance of chemical parameters
- Technical surveillance of fuel performance and fuel inventory control
- Trending and assessments of safety system performance.

Computational methods and tools for reactor engineering — including computer software — must be verified, regularly updated, maintained and safeguarded. Independent verification of computational results should be mandatory for all calculations. Verification of results by comparison with measurement should be routinely carried out.

3.2.3. Fuel handling

Fuel handling activities deal with management and handling of fuel in and out of core, while maintaining control of the reactor and preventing damage to fuel while it is being transported, stored or manipulated.

TS must ensure that the following activities are satisfactorily performed:

- Development of standards, precautions and procedures for:
  — receipt of new fuel
  — loading fuel into the core — off power or on power depending on reactor type
  — discharging irradiated fuel form the core
  — subsequent handling and storage of irradiated fuel
- Approval of operating and maintenance documentation regarding fuel handling
- Assessment of proposed modifications to fuel handling procedures or equipment.

In view of significance of fuel movement, the refuelling activity is the most important element of fuel handling. TS must ensure that methods used to control fuel movements — whether on power or off power — are specified, authorized and performed in accordance with the calculated core configurations.

3.3. OPTIMIZATION OF PLANT PERFORMANCE

Summary:

This section deals with longer-term trends and "optimization of components of plant performance". TS activities in this area are a key contributor to managerial and technical optimization of the plant. Factors affecting performance of "operating" and "maintenance" activities and their optimization are discussed. The central importance of "Learning from experience" (OPEX), its key aspects and managerial considerations are presented, as is "Optimization of procedures". TS

contribution to planning, optimization and safety of outages is emphasized. "Optimization of computers" and the use of computerized plant information system to optimize operations is discussed.

Conclusions:

The following conclusions arise from this section:

- Optimization of plant performance is one of TS functions which has the most potential for positively affecting the long-term performance and viability of NPP.
- Optimizing of plant performance must be recognized as being one of the key outputs of TS and be included in annual work plans and reviews.
- Optimization is a team effort requiring inputs and co-operation from operations, maintenance and other departments. It is led and co-ordinated by TS.
- Surveillance programme and the OPEX programme provide important inputs into optimization activities.

TS contributes to excellent operation by providing technical inputs and support for optimizing components of plant performance, such as:

- Plant procedures
- Operations, including maintenance
- Computer usage
- Technical advice and assistance.

Architect-engineers and major vendors can also contribute to optimization of performance. TS should therefore strive to develop and maintain long-term co-operative working relationship with them through:

- Provision of performance feedback
- Establishment and maintenance of personal contacts at various management levels
- Establishment of long term contracts for inspection/maintenance/engineering services.

Benefits arising form these relationships include:

- Access to expert technical support services, methods and techniques
- Access to high-quality, cost effective contracted services.

3.3.1. Optimization and upkeep of procedures

Procedures are the key ingredient of consistently satisfactory performance. TS is heavily involved in preparation, revision and review of maintenance and operating procedures and also must approve them. TS can therefore specify high standards of preparation and upkeep of permanent, temporary and emergency procedures.

TS must enforce a standard for procedures which ensures that they are:

- Optimized to support excellence in operations
- Prepared in accordance with the plant standard
- Verified as being complete and correct
- Kept up to date with feedback from users and in step with modifications
- Periodically reviewed for compliance with plant practice.

Operating and maintenance aids form an important part of procedures. They also must be correct and meticulously kept up to date.

- Typical operating aids are:
  - — process flow sheets
  - — power supply lists
- Typical maintenance aids are:
  - — system wiring diagrams and lists
  - — lists of lubricants and filters.

3.3.2. Optimization of operating activities

Operating activities are carried out in accordance with procedures over which TS exerts a controlling influence. Through procedures and frequent interaction with operating department, operations can be optimized by:

- Minimizing the potential for inadvertent transients
- Careful determination of set points
- Recommending duty cycles of equipment (service rotations)
- Optimizing of testing
- Making annunciation user-friendly
- Introducing temporary modifications to facilitate operations.

Maximum stability and predictability of operations is a requirement for good operations. TS should ensure that routine and non-routine operating procedures are carefully prepared in the manner which will minimize the possibility of inadvertently introducing plant transients.

As the plant matures and systems and operating procedures are modified, TS should optimize process and trip set points to provide better operating margins and to make operations easier, while at the same time preserving the design intent.

It is a normal operating practice to rotate the duty amongst redundant components. There is some operational risk associated with transfer of equipment duty. TS should optimize frequency and specify plant/equipment conditions under which equipment service should be rotated.

TS should also optimize routine testing. Frequency and method of testing influences equipment wear and therefore must be balanced against benefits, such as assurance of availability. Also, method of testing and the timing of tests might in fact temporarily diminish plant reliability by reduction of redundancy.

Annunciation schemes should also be optimized to facilitate interpretation of information.

The plant has at times to operate in an unusual configuration either due to conditions existing at the plant (equipment out of service) or due to conditions outside of the plant, for example on the power grid. Such situations may require temporary modifications, to be implemented — such as a temporary operating procedure or equipment configuration. TS must evaluate these conditions and provide clear instructions outlining operations under these unusual conditions.

3.3.3. Optimization of maintenance activities

Maintenance activities are carried out in accordance with the maintenance programme over which TS exerts a controlling influence.

TS can therefore optimize maintenance by contributing to its improvement in a number of ways:

- Optimization of the maintenance programme and the continuous improvement of maintenance procedures by, for example introducing integrated maintenance planning

- Frequent contact and interaction with the maintenance department
- Analysis of unexpected and repeated failures
- Equipment layout and specialized tooling
- Control of material.

Maintenance programme encompasses activities, some of which can be optimized by TS. For example:

- Deciding which equipment should be the subject of on-condition maintenance and which parameters should be monitored
- Supporting the establishment of equipment database and providing the necessary technical information
- Deciding on the frequency and extent of preventative maintenance
- Specification of testing and acceptance criteria following maintenance
- Promotion of integrated maintenance planning techniques.

Unexpected and repeated failures represent a shortcoming of maintenance and must be analysed to determine the root cause. This analysis is best performed by TS staff with the necessary expertise, detailed knowledge of the system and equipment and access to supporting services (laboratories) and experts outside the plant.

By being aware of difficulties and conditions at the work site, TS can optimize working conditions through:

- Improving layout of equipment,
- Improving access to equipment, provision of lifting facilities, easing removal, calibration and adjustment of equipment,
- Provision of specialized tooling and testing equipment
- Provision of permanent or temporary radiation or thermal shielding.

This will influence the quality of work being done.

TS inputs have a significant role in the control of spare parts and especially of material substitutions. Many parts must meet requirements of traceability and "equipment qualification" to identify them as nuclear parts. In many cases shelf life must be controlled (e.g. elastomers) under specified storage conditions. Substitution of parts must be evaluated and approved by TS personnel.

3.3.4. Optimization of outages

TS can make a very significant contribution to orderly and timely execution of outages by contributing to outage preparation and planning in the following areas:

- Reactor safety considerations, such as reactivity control and provision of heat sinks. These considerations include:
  — activities to enhance and continually monitor safety margins
  — verification of status of safety systems and operating plans prior to return to power.
- Worker safety as impacted by hazards which might arise from unusual configurations or operations. Both conventional and radiation hazards are to be dealt with.
- Discovery work, defined as unexpected work discovered during an outage as a result of inspections or opening equipment, must be minimized through carefully analysing results of surveillance and operational records of equipment.
- Modifications to be installed during an outage must be ready to go well in advance, with design documentation, approvals, materials and installation plans all available.

- Detailed work plans must be available for major outage tasks well in advance of their execution, and be updated during the outage as necessitated by field changes and conditions.
- Any special and non-routine inspections must be carefully planned and prepared and their consequences reviewed with special emphasis on plant safety, personnel safety and licensing requirements.
- Review of preventive maintenance programme to minimize shut-down work by
  — modifying work procedure and tooling
  — assessing equipment condition and deciding to defer the work
- Planning and spacing of in-service inspections among several outages, so as to minimize the over-all outage time.

3.3.5. Optimization of computer usage

Effective management of information is an essential requirement for enabling staff to do excellent work. TS should therefore ensure that the plant has an excellent database.

Use of the database for purposes of analysis, prediction and trending should be encouraged, as should the use of specialized engineering software for calculations, code interpretations and similar activities.

Computers are a tool which can contribute to dramatic improvement in efficiency of work and reduction of errors. TS should promote the use of computers throughout the plant as follows:

- Computerizing, to the extent possible, of plant operating, maintenance and technical data
- Ensuring that software which is used for system control, monitoring and annunciation is optimized for:
  — timeliness and clarity of presentation
  — ease of use
- Introducing of new computer functions which will facilitate operations.

TS must ensure that computer software meets technical, security and regulatory requirements with respect to function and control of software and documentation.

3.3.6. Operating experience programme (OPEX)

TS must develop disciplined and consistent approach to review and analysis of adverse events and trends. Such analysis contributes significantly to achieving improved performance through identification and understanding of past and present problems and correction of conditions which led to them.

Major components — inputs — of this approach are:

- OPEX programme — learning from events that happened at the plant and elsewhere
- Root Cause Analysis (RCA) — focusing investigation, correction and prevention activities towards resolution of root causes

Major outputs are:

- Corrective actions — implementing solutions and improvements to identified precursors of problems in an effort to prevent them from happening.

The necessary supporting component is the plant data base — an information resource to facilitate recording, analysis, evaluation and trending of events and their causes.

TS are the “owners” of OPEX, the objective of which is to learn from experience, so that:

— adverse effects do not re-occur at the plant. This is achieved by identifying root causes of events and correcting them.
— events that occurred elsewhere are prevented from occurring. This is achieved by alerting the management to eliminate conditions which have led to adverse events at other locations.

The two components of OPEX programme are:

- Investigation of in-house adverse events
- Evaluation of external experience.

TS must examine all adverse events, including “close calls”, at the power plant for their significance to safety and reliability and evaluate them for consequences and lessons to be learned.

More serious “consequential” events are additionally reviewed by the plant Nuclear Integrity Review Committee (NIRC) on which TS is represented. Conclusions of reviews must recommend specific corrective actions.

TS administers the OPEX programme at the plant with the support of operations to carry out investigations in the field and effectively implement corrective actions. TS co-operates with the central (corporate) OPEX co-ordinator for disseminating plant information and receiving applicable OPEX information from other plants and utilities.

The nuclear industry (INPO, IAEA, WANO) operates several data bases to record and disseminate operating experience. Both good practices and adverse events are recorded. This information is generally available throughout the industry and is routinely routed to interested parties. Additional information is also available from vendor organizations.

Most utilities have a central co-ordinating OPEX group who are responsible for:

- Maintenance of utility data base of consequential events
- Transmitting and receiving information about consequential events
- Review and screening of consequential events for applicability to utility’s plants
- Promptly advising the utility’s power plants about the applicable internal and external consequential events.
- The questions to be asked are :
  — do conditions exist at our power plants for a similar even to occur?
  — if so, what can be done to prevent this from happening?
- Review and assessment of utility’s own consequential events for the purpose of detecting patterns and trends.

3.4. LONG-TERM ISSUES

Summary:

This section deals with TS issues which have a long-term horizon and influence on plant performance. Importance of ensuring long-term availability of spare parts is stressed. Significance of effective control of “permanent modifications” is emphasized. The three TS programmes which aim at establishing the condition of plant components and extending their “life” are discussed with emphasis on TS activities and involvement. The three programmes are: “equipment qualification”, “in-service inspection” and “plant life extension” (PLEX).

Conclusions:

- Successful execution of these long-term technical programmes requires team effort and multi-disciplinary technical expertise
- Long-term focus and planning must be maintained with dedicated, adequate, and skilled resources
- Considerable benefits can accrue to the plant when these programmes are successfully executed. Conversely, consequences of poor execution can be severe:
  — the benefits arise from improvements in, and assurance of, satisfactory plant condition and extended operational life
  — inadequate performance in these programmes can result in loss of configuration control and intervention from the regulator
- All of long-term technical programmes use the same basic, generic management techniques. The three discussed in this chapter are an example and a selection of many such programmes at a power plant.

3.4.1. Management of materials

The overall objective of materials management is to ensure that correct materials are consistently obtained and used throughout the plant over the long term.

TS is responsible for provision of technical advice in matters of:

- Extent of inspection on receiving at the plant
- Storage requirements in cases where part/materials need special, controlled environment, and definition of their "shelf life"
- Ensuring that correct materials are installed through provision of appropriate information and controls on issue of materials
- Defining traceability requirements for nuclear class materials
- Evaluation and approval of new parts and substitutions.

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 TS.

The technical issues to be considered are:

- Technical inputs necessary to develop alternative suppliers,
- Addressing problems of rapid obsolescence of some specialized equipment (e.g. plant computers) and associated dwindling or non-availability of spares
- Identifying and dealing with anticipated upgrading of regulatory requirements for replacement parts
- Policy for in-plant manufacturing.

3.4.2. Permanent modifications (change control)

TS controls and approves all permanent modifications to systems, components, software, set points, layout, structures and operational procedures.

Plant modifications can be initiated by operations or design organizations and will frequently be desirable in order to:

- Take advantage of operating experience
- Satisfy new regulatory requirement
- Benefit from new technological developments.

TS must ensure that:

- Coherent and rational modification policy and process is in effect
- Modifications are prioritized according to criteria which reflect plant's operating objectives.

The process should encompass the following elements:

- Encouragement of ideas for improvements in plant design
- Careful review, approval and establishment of priorities for modifications to ensure best use of limited resources
- Tracking and timely feedback on the status of modifications
- Thorough and documented technical reviews, with participation from plant's TS, including review with respect to effects on safety design assumptions
- Commissioning and testing to ensure design conformance and system compatibility
- updating of documents used in plant operations prior to returning affected systems to service (configuration control)
- Training of personnel to ensure their understanding of the modification.

TS should act as the "project manager" on behalf of the plant and confirm, through periodical reviews, appropriate co-ordination and timely progress of work. Since many groups are involved in the modification process, it is necessary to clearly identify respective interfaces and responsibilities.

TS should limit the number of modifications under way at any one time to what can be comfortably managed and absorbed.

3.4.3. Equipment qualification

The objective of the equipment qualification programme (EqQ) is to provide assurance that the basic safety functions will always be capable of execution. This is achieved through assessing, monitoring and maintaining the required capabilities of all safety related equipment over operational life of the plant.

There are two concerns which EqQ is intended to address:

- The principal concern of EqQ is with ageing effects that occur during the equipment's long term exposure. Capability of equipment to perform as designed under "design basis accident" becomes gradually impaired
- A secondary concern is the reduction of capability of equipment to operate, sometimes for a long time, in a hostile environment following an incident.

TS is the "owner" of EqQ programme at the plant and is responsible for its continued implementation, through following activities:

- Upkeep of the list of equipment requiring qualification
- Drawing up the plan for EqQ and oversight of its implementation at the plant, including requirements for:
  - — special documentation
  - — maintenance, calibration and replacement of some qualified equipment or parts
  - — a "condition surveillance programme", by which condition of qualified equipment can be assessed
- Evaluation of equipment following failures, which must consider the effect of failure on maintenance of the qualification of this and similar equipment

- Oversight, evaluation and assessment of the results of these activities and specification of appropriate corrective measures.

3.4.4. In-service inspection

The objective of the in-service inspection programme (ISI) is to ensure continuing integrity and operability of pressure-retaining components.

TS is the "owner" of ISI programme at the plant and is responsible for its continued implementation, through following activities:

- Drawing up the plan for ISI for the plant which specifies:
  — list of the components to be examined
  — the type of non-destructive examination to be performed
  — frequency of examination
  — specialized tooling and facilities to be provided.
  These might consist of:
  — non-destructive testing equipment
  — access platforms and scaffolding
  — easily removable insulation panels
  — radiation shielding
- Establishment of appropriate documentation and records
- Establishment of base-line information record before operations begin
- Evaluation and assessment of the results of these activities and findings and specification of appropriate corrective measures.

3.4.5. Plant life extension

The objective of a plant life extension programme (PLEX) is to set in place mechanisms which would enable the management to:

- Assess the condition of the plant's components (degree of age-based degradation)
- Identify operational strategies to minimize deterioration
  so that extension of the original plant design life can be technically justified.

TS is the "owner" of PLEX programme at the plant and is responsible for its continued implementation, through the following activities:

- Definition of an action plan to preserve the option (i.e. to enable PLEX to be implemented at some time in the future) to extend plant life for critical components:
  — establishment of an appropriate database, listing details of critical components
  — initial inspections, preferably at the time of construction to establish "base line" conditions
  — establishment of a long-term inspection plan
  — monitoring and surveillance
  — specification and optimization of O&M practices
- Establishment of requirements for documentation and records
- Evaluation and assessment of results and specification of appropriate corrective measures.

TS must ensure that as much information as possible is obtained from routine operating records, maintenance inspections and other records kept by the plant and vendors. All of this information must be compiled and preserved in a data base to be used by the PLEX programme expert team.

3 5 SUPPORTING ACTIVITIES

Summary

This section deals with important activities which are outside the "core" of TS responsibilities This means that while they must be satisfactorily performed, they do not necessarily constitute a key TS responsibility Others might have the expertise and the organization to carry these functions out This chapter addresses "root cause analysis" and its importance to effective corrective action Key TS inputs to "emergency preparedness" are discussed Considerations of "radiation protection" at the plant and "minimization of solid radioactive waste" are reviewed

Conclusions

- Proper execution of the so-called "supportive activities" is very important for satisfactory performance of the plant
- Even though TS may not be the primary organization to carry out these activities, it still must maintain significant input and oversight in order to ensure their satisfactory execution
- Notwithstanding the above, these activities are, in the majority of cases, carried out by the TS at the plant

3.5.1. Root cause analysis

TS has a significant involvement in trend analysis, root cause analysis and the corrective action processes These processes are interactive, interdependent and collectively constitute the plant's problem solving system Consistency amongst these processes must be maintained for effective long-term problem resolution

When confronted with a significant problem, or a consequential event, it is essential to avoid the natural inclination to look for a "quick fix" and instead to undertake a disciplined analysis into the root cause

Root cause analysis is usually conducted by TS, who should also promote training of managerial and supervisory staff in the basics of problem investigation and correction This will enhance effectiveness of problem solving efforts at the plant

There are many techniques that can be used to perform root cause analysis The best technique is the one that can accurately identify the root cause of a problem and its permanent solution, and can be understood by the user Regardless of the method used, factual evidence must serve as the basis for any conclusions

Analysis should be focused on identifying the "systemic factors" which permitted the event to occur

These are

- **Personnel** — training, communications, human factors
- **Procedural** — quality and availability of procedures
- **Equipment** — design, selection, maintenance, installation
- **Materials** — specification, quality, storage, environment, identification
- **Environment** — working conditions, access, ergonomics, hazards

Difficulties with plant's problem solving system result in long-standing problems where corrective actions have not been effective in such cases Corrective actions address symptoms, but fail to correct the root cause and similar problems can arise in another area When that happens, TS management should re-assess and improve the problem solving system and skills at the plant

3.5.2. Emergency preparedness

Emergency preparedness deals with the capability of coping with nuclear incident situations at the plant, mitigating their consequences and protecting the health and safety of site personnel and the public.

The importance of competent "emergency preparedness" capability arises from potential consequences of inadequate response. These consequences include:

- A relatively small accident at the plant may escalate into a major one with serious consequences for plant personnel and the public
- Poor communications may result in misunderstanding of the actual hazards arising out of the accident and may cause panic amongst the public
- Either of those two would result in higher than necessary costs and bad publicity.

TS must ensure that emergency preparedness programme incorporates the following elements:

- Emergency plan and implementing procedures, which are kept up to date, including communications and notifications
- Co-ordination of emergency response training of on-site personnel and off-site supporting agencies
- Adequate working relationships with interfacing off-site organizations
- Provision of support to interfacing public authorities in the development and maintenance of their emergency response plans and ensuring that these plans are co-ordinated with and compatible to the plants
- Regular conduct of drills and exercises in accordance with prepared scenarios, involving both on-site and off-site personnel
- Evaluation of effectiveness of procedures and training, and of performance of personnel and equipment in the drills and exercises
- Correction of deficiencies discovered through drills, audits or other means
- Assessment and action on improvements suggested by staff, comparisons with other plants, new technical developments and information
- Maintenance in the state of readiness of emergency response facilities, equipment and resources.

3.5.3. Radiation protection

Radiation protection (RP) deals with minimizing radioactive exposure in accordance with the ALARA Principle and recommendations contained in IAEA Safety Standard No. 9 "Basic Safety Standards for Radiation Protection". TS has the primary responsibility for assuring effectiveness of radiological protection at the plant.

Radiation protection measures are implemented by operations personnel in accordance with standards laid down by plant management. All levels of line management and all site personnel have individual responsibility for safe work practices and for keeping the exposures "as low as reasonably achievable".

TS must ensure that:

- Adequate RP assistance and advice is available to Operations
- Appropriate RP advice is received and incorporated into work plans and procedures prepared by TS and others

- Plant RP regulations and procedures are prepared in accordance with the pertinent international and national practices, recommendations and codes
- An adequate degree of competence and familiarity with RP exists in the plant
- and is maintained by regular training
- Targets for individual and collective exposures are set.

TS must maintain routine oversight of RP practices at the plant and periodically conduct assessments of effectiveness of radiological protection. The results of these and other independent assessments shall constitute an input into annual reviews of RP by plant management.

3.5.4. Minimization of solid radioactive waste

In the context of this chapter, the radioactive waste referred to is restricted to low level solid material not suitable for release to the environment. It is desirable to minimize the amount of radioactive solid waste generated in the power plant because radioactive waste represents a potential hazard to workers and ultimately to the public and because handling and disposal of radioactive waste is costly.

TS must ensure that the following activities are carried out:

- Operational limits are set for radioactive waste, based on IAEA Safety Series No. 69 "Management of Radioactive Wastes from Nuclear Power Plants" or national guidelines
- Procedures are prepared detailing the activities necessary to implement waste management programme
- Challenging but achievable targets for waste management programme are set and performance with respect to these targets is tracked
- Appropriate training materials are available and training is conducted
- Improvements suggested by staff, by comparisons with industry practices or by new technical developments, are assessed and incorporated as appropriate.

Chapter 4

ASSESSMENT

4.1. ASSESSMENT OF TS EFFECTIVENESS BY PLANT MANAGEMENT

Summary:

This section deals with the conduct of and inputs to "management assessments" of TS performance. Requirements for in-depth annual reviews of TS by plant management are defined. Also offered are "Symptoms and attributes" of potential problems and good performance of TS, respectively. These will enable managers to decide quickly if potential problems exist, and if further, more detailed consideration is warranted. Also included are typical common "performance measures" and a discussion of their usefulness.

Conclusions:

- It is important for the plant management to assess performance of TS on an on-going basis and also to conduct periodic in-depth reviews
- To facilitate these assessments it is necessary that valid performance measures be established and trended
- The key criteria of performance are:
  — extent to which TS contributes to plant performance objectives within its designated role
  — feedback from "customers", such as operating and maintenance departments
- Symptoms and attributes of TS performance can be very useful in alerting plant and TS management to possible problems
- Assessments by plant management and self-assessments at all levels by TS management and staff should be routinely conducted. These multi-layered assessments contribute to adequate identification and subsequent correction of existing and developing problems.

4.1.1. Management assessments

Assessment of effectiveness of TS should be an ongoing, routine function of plant management. It is important for management to know the extent to which TS is meeting its commitments and obligations. Management has to have the ability to identify situations not sufficiently dealt with by the normal functioning of the organization.

Assessment of the effectiveness of TS should based on:

- Existence of clear standards of performance
- Collection and evaluation of pertinent data
- Feedback from "customers" within the plant and outside.

Management must obtain data on which to base the assessment. Forms of data collection are:

- Performance measures and trends
- Corrective action status and assessments
- Self-assessments by TS
- Audit and peer evaluation findings
- Meetings with staff.

Informally, data can be obtained through:

- Questions directed to staff at all levels regarding the functioning of TS
- Informal feedback from plant managers and employees
- Formal or informal feedback and surveys of "customers" and staff.

In addition to ongoing reviews of TS effectiveness, an annual in-depth review by the plant management should be held. This review shall be formalized and performed in accordance with a procedure. There should be participation from people outside the plant, such as by plant vendors, consultants and regulators. TS should be the key contributor to these reviews and also encourage and arrange for outside participation. Actions arising from the review shall be recorded.

The review should consider:

- Past performance, with emphasis on nuclear safety
- Organizational and managerial problems, with emphasis on the effectiveness of management processes and human performance
- Key technical issues confronting the plant, especially with respect to nuclear safety
- Future priorities, plans and resources required.

4.1.2. Symptoms and attributes

The following paragraphs are devoted to a review of:

- Symptoms which signal the existence of shortcomings in TS

Existence of these symptoms at a nuclear power plant should alert the plant management to the possibility of problems in the performance of TS.

- Attributes of a well-managed TS

While it is encouraging to have these characteristics present, they should not be a cause for complacency. A number of problems inhibiting optimum performance could still exist.

Routine review of the systems and attributes should assist plant managers in assessing the performance of the TS at the plant and in undertaking appropriate actions.

If new, unknown problems are identified through any of independent assessment processes (peer evaluations, audits), two concerns arise:

- The identified problem
- Why has the organization not found it themselves through its normal functioning and monitoring?

Typical symptoms of problems related to the performance of TS may be categorized into the following five groups.

Group 1:

- There is a large backlog of technical work and plant defects which have not been addressed.
- Problems which are reported from the field do not appear to be acted upon, leading to low morale, passive attitude to problem solving, lack of ownership and empowerment, and mistakes.
- There is a large number of temporary modifications, both equipment and procedures, which persist for an excessive amount of time.
- Many technical solutions are found ineffective, requiring repeat work. As a result, there are many repeat audit findings and repeat problems, even though they have ostensibly been corrected.
- Technical problems reach crisis level and are evident to all, including regulators, before they are addressed.
- Events occur which have previously occurred at the plant and elsewhere.

Group 2:

- Excessive demands are made, without effective prioritization on TS, diverting them from supporting the plant and "pro-active" surveillance.
- There is continuous overload, as evidenced by excessively long hours worked by the staff.
- Senior TS staff are routinely involved in detailed problems, which should be handled and resolved by subordinates.
- TS personnel are not visible in the plant and have limited contacts with plant personnel.
- There is a tendency to blame outsiders (e.g. designers, manufacturers, regulators) for the inability of the plant to deal with its operational and technical problems.
- Management are repeatedly surprised by emergence of significant problems.
- Various reasons (mostly imagined) are given why identified problems cannot be corrected.

Group 3:

- Staff do not understand how excellent performance in their individual job impacts on meeting the plant's performance objectives.
- TS is in a chronic, "reactive mode" i.e. in a continuous state of crisis and moving from one urgent matter to the next, without taking the time to resolve any of them.

Group 4:

- Major projects are embarked upon without a thorough and formal assessment of the priority, costs and benefits.
- Projects are frequently cancelled after a significant development effort and an expenditure of large amounts of money.
- Important projects are deferred owing to budgetary constraints, with money being spent on less important projects.

Group 5:

- Individuals maintain their own private documentation systems instead of using the appropriate centralized documentation system.
- There is lack of accurate record of plant equipment and arrangement (control of configuration) and routine excessive delays are experienced in obtaining plant related information.
- Surveys and feedback from other departments point to poor communications and contacts with TS.

Attributes of well managed TS may be categorized into the following five groups:

Group 1:

- Nuclear safety, reliability, efficiency and other short and long term goals are used as the primary criteria for prioritizing and scheduling of TS activities.
- Emergent problems are anticipated by systematically examining trends and symptoms, as available, from the various assessment and surveillance activities.
- Attention is directed to problems which matter most.
- Events which have occurred elsewhere in the industry are systematically reviewed and assessed for plant applicability and potential corrective action.
- New projects are evaluated with regard to long term plant and corporate objectives before being undertaken.
- Projects are not undertaken if their execution would result in prolonged staff overload, and until staff availability and relative priorities have been considered.

- "Corporate groups" and outside groups support plant objectives.
- Resources external to the plant are utilized through integration into the plant's plans.

Group 2:

- An appropriate level of verification to ensure the required level of quality is routinely applied. This includes a clear understanding of the responsibility attached to signatures.
- A formal process is employed for determining the root causes of significant problems. This process is carried out by individuals who have received formal training in root cause analysis. Both equipment and human performance factors are analysed.

Group 3:

- TS staff routinely carries out oversight and performance assessments through a number of activities, such as:
  — walking around the plant and observing the condition of systems and the work being done and the standards maintained;
  — being visible in the plant and listening to suggestions from operations staff;
  — examining system and equipment trends and performance measures.
- TS managers are personally involved in assessing quality of performance.

Group 4:

- TS management as well as the staff are clear about the desired level of performance, as established by plant management, participation in industry groups and through bench marking.
- Self-assessment processes are implemented at all levels, from management to supervisory.
- Personnel are committed to their responsibilities and authorities, accept them and are held accountable for specific results. There is one individual in charge of every system, process or job. Expectations with respect to outcome are clearly spelled out.
- A systematic approach is taken to ensure that all positions are filled with trained, qualified, competent and experienced personnel.
- TS staff routinely participate in industry activities, and are well informed of developments and advances in industry practices.

Group 5:

- Information is a key resource. Technical information is user friendly, up to date, accurate and correct, is in the right place at the right time and readily available to users.
- Good working relationships exist with architects/designers and vendors of equipment, with pertinent information and experience being freely exchanged.

4.1.3. Performance measures

Performance measures (PMs) are a necessary pre-requisite for continuous evaluation of performance and for identifying weaknesses. Many performance measures are generated and trended in a power plant. TS should use those which are pertinent to its work.

TS management must carefully select the correct measures, the criteria for selection being that each measure must be:

- Quantitative
- Significant, with respect to what is being measured
- Simple, so that its message cannot be misinterpreted

- Direct, i.e. measure the effect itself to the extent possible
- Readily available.

Additionally all important areas of performance should be measured.

For each performance measure, there should be a "standard" and a "target". "Standards" are set by comparison with the best plants in the nuclear industry and they are the indication of where this TS organization intends to be in a few years time. "Targets" are set for the organization as a challenging but achievable objective to be reached by the TS within a specified time period.

Judgement must be applied when interpreting and acting on trends of performance measures, with the following being considered:

- Measures indicate results. Results are the outcome and cannot be retroactively managed to improve quality. To achieve improvement, usually the process has to be modified.
- Performance measures must not be used to penalize people. If that is done feedback will be incomplete and many problems will be hidden from management's view.
- Consistent definitions must be used and they should remain unchanged for sufficiently long time for meaningful trends to develop.
- Results and trends obtained should be shared with the staff, so that all know how their group and the plant are performing.
- Prompt and visible action should be taken to correct identified deficiencies so that the staff can recognize and support improvement efforts.

What follows is a partial listing of typical, frequently used performance measures together with an indication of their area of applicability. Many more performance measures can be developed and used. Additional guidance in this area is available from international Organizations such as IAEA, WANO, INPO.

Overall performance of TS, measured in number of events in a specified time period:

- Backlog of technical work, measured in man-days
- Deadlines for delivery of technical work not met, measured in days of delay
- Technical surveillance activities omitted or deferred
- Recurring technical problems not identified or corrected
- Operational performance out of specification due to inadequate direction from TS
- Operating or maintenance errors made due to inadequate procedures
- Review of adverse events behind schedule.

Additional performance measures of special interest:

- Repeated undesirable events
- Significant surprise findings discovered by outsiders
- Ineffective TS corrective actions, as identified by quality dept. assessments.

Performance measures indicative of success of TS:

- Performance trends for TS programmes show steady improvement
- Problems are solved permanently, on schedule and with willing co-operation
- People are proud of their solutions and accomplishments
- Activities are planned, there is little "fire fighting".

Performance measures applicable to nuclear safety and nuclear engineering:

- Results of surveillance tests not reviewed within specified time
- Advice from TS with respect to nuclear safety frequently ignored or improperly interpreted

- Operating decisions not made conservatively
- Complaints from regulatory staff about minor infractions of license
- "Close call" involving nuclear safety.

Performance measures applicable to System/Equipment surveillance:

- Errors committed during testing (measure of adequacy of test procedures, of training and of "safety culture")

Performance measures applicable to optimizing of plant performance — operations and maintenance:

- Temporary modifications (jumpers) remaining in place after expiry date
- Temporary operating instructions remaining in place after expiry date
- Errors found in operating and maintenance aids, such as:
  — flow sheets
  — power supply lists
  — instrument air supply lists.
- Number and frequency of alarms in the control room
- Annunciation remaining in alarm state for extended periods of time
- Number and frequency of set point adjustments required, (effectiveness of "set point control" procedure),
- Repeated failures of identical equipment (small valves, switches)
- Incorrect spare parts used (e.g. bursting discs, piping components)
- % of routine maintenance deferred.

Performance measures applicable to optimization of outages:

- amount of "discovery work", percent
- operating license violations during outages.

Performance measures applicable to root cause analysis:

- Repeat threshold events/year
- Percent of threshold events for which corrective actions remain effective after 1 year implying that:
  — corrective actions have been verified for effectiveness, and
  — corrective actions stay implemented and effective, for a year
- Outstanding TS corrective actions past due date.

Permanence measures applicable to permanent modifications:

- availability of design information and materials at the specified time, well ahead of installation, %.

Performance measures applicable to materials management:

- Incidents of incorrect parts installed
- Incidents of loss of traceability of materials
- Reported difficulties of finding what the correct part is
- Parts manufactured/year due to unavailability of approved parts.

4.2. SELF-ASSESSMENTS AND AUDITS

Summary:

This section deals with the need for TS management to have in place processes which will identify existing and developing problems. The preferred, pro-active process is "TS self-assessment",

the key elements and importance of which are discussed. Two other processes are discussed briefly: "Peer evaluations" and "Audits". Significance of these processes and TS's involvement with them are highlighted.

Conclusions:

- TS management must be aware of problems within its organization. It is not appropriate for people outside of the TS organization to identify performance problems of which management is not aware.
- TS management must adopt a pro-active stance towards identifying and correcting problems within TS.
- To this end, TS management must actively support self-assessments at all levels of the organization, assess the findings and implement corrective actions.

4.2.1. TS self-assessment

Self-assessment requires examining ones own work in a disciplined manner. TS management implements and supports self-assessment through following activities:

- Planning for self-assessments and establishing a schedule
- Setting performance standard for self-assessment activities
- Getting personnel responsible for performance in an area involved from the start
- Providing training in the process and the necessary skills
- Encouraging ownership and thus commitment to corrective actions, and empowering personnel to implement them
- Occasionally seeing these actions fail, without recriminations
- Focusing almost exclusively on performance problems.

Self-assessments examine five issues:

- Is there a performance standard?
- Does the performance meet the standard?
- Are personnel qualified?
- Does existing documentation (procedures) adequately define the standard, qualifications and performance?
- What steps should be taken to improve performance?

Self-assessment achieves results through:

- Getting supervisors, managers and staff involved in identifying problems in their own departments
- Providing training in auditing and observation skills
- Providing experience and assistance in analysing problems
- Building commitment to corrective action through "empowerment"
- Focusing on performance problems.

Self-assessment should not result in a conclusion that others should initiate corrective actions. Self-correction of identified problems is the rule. The key is to focus energy toward what has been learned, how to resolve the issue, and how to keep it from recurring. Focus should be on deficiencies of the system being examined rather than individual performance.

4.2.2. Peer evaluations

Peer evaluations are a form of corporate self-assessment. They are carried out by peers of the people in the area being evaluated. This means that people evaluating performance of TS at the plant perform TS activities at their own plants.

TS should actively participate in the peer programme by welcoming evaluators, as peer findings often identify significant quality problems, of which management may not be aware This presents opportunity for improvement

Also, TS staff should be assigned to become evaluators at other plants Experience gained as an evaluator can be profitably applied to improving management processes at "home"

Peer evaluation examines the application of management processes to identify their weaknesses resulting in inadequate performance An additional objective is to identify existing excellent practices, so they can be duplicated at other plants

The peer evaluation process identifies and documents problem areas very effectively However, only the TS line management can resolve theses issues Therefore for this process to ultimately result in improved performance, there must be strong management commitment for determined application of appropriate corrective action

4.2.3. Audits

The importance of audits arises from the need of management to have an impartial objective evaluation of quality of performance In the absence of such evaluation, the management might persuade itself that everything is going very well while in fact performance has deteriorated badly Audits are a mandatory requirement of QA programme

TS management should adopt a constructive attitude to audits Such attitude manifests itself when the management

- Co-operates with auditors
- Is willing to listen to and learn from audit findings
- Evaluates findings for root causes
- Implements corrective actions
- Confirms long-term effectiveness of corrective actions

Audit personnel must have sufficient authority and organizational freedom to make the audit process effective and must have direct access to the appropriate level of management to ensure that appropriate corrective actions are implemented

Chapter 5

EFFECTIVE PRACTICES

5.1. INTRODUCTION

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

At the time of preparation of this report (1996) the practices were validated as useful and effective at their respective power plants.

The practices are referenced with TS activities through matrices. Each practice is deemed to have primary applicability to a particular activity and a secondary applicability to several others. Owing to the complexity of TS activities, some overlap in their applicability exists.

A paragraph indicating the relevance of each practice to a TS activity has been written to highlight why this particular practice is of sufficient interest to have been included in the report.

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 flooded 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 plant.

5.2. MATRIX OF EFFECTIVE PRACTICES AND TS ACTIVITIES

Management

2.3 Quality management —— O
2.4 Training and development of staff —— O
2.5 Prioritization of projects —— O
2.7 Quality improvement —— O
2.9 Long-term technical programmes —— O

Annex number and effective practice title					
3. Probabilistic safety assessment techniques			**X**	*	
7. Team work and problem solving skills		*		**X**	
9. Forward engineering plans	**X**				*
10. Training profiles for Engineering Dept. staff		*		**X**	
12. Engineering Dept. Manual		*			**X**
16. Training for managers Safety Culture and QA				**X**	*
19. Orientation programme for new engineers				**X**	*

Assessment

2.3 Quality management —— O
4.2 Self-assessments and audits —— O

Annex number and Effective Practice Title		
18. Assessment of effectiveness of Technical Support function	**X**	*

X : this practice applies *primarily* to the TS activity
* : this practice has *some relevance* to the TS activity

Performance

3.0 Nuclear safety
3.1 Daily oversight of operations
3.2 Nuclear engineering
3.3 Optimization of plant performance
3.4 Long-term issues
3.5 Supporting activities

Annex number and effective practice title						
1. Plant equipment failure trending programme			X		*	
2. Reliability-based method to improve system performance		*	X			
4. Minimizing occurrence of similar events	*		X			
5. Joint reviews of plant systems			*		X	
6. Surveillance test procedure document			*		X	
8. Root cause evaluation of human performance events	X					*
11. Enhancement of nuclear safety during outages			*			X

X : this practice applies *primarily* to the TS activity
* : this practice has *some relevance* to the TS activity

Performance (cont.)

3.0 Nuclear safety
3.1 Daily oversight of operations
3.2 Nuclear engineering
3.3 Optimization of plant performance
3.4 Long-term issues
3.5 Supporting activities

Annex number and effective practice title	3.5	3.4	3.3	3.2	3.1	3.0
13. Lessons learned programme			**X**	*		
14. Operating experience feedback (OPEX)	*		**X**			
15. Control of surveillance testing			*		**X**	
17. Computerized plant documentation system		*	**X**			
20. Reducing the number of plant events	*		**X**			
21. Plant Nuclear Integrity Review Committee			*		**X**	
22. Process for procurement of materials		**X**	*			

X : this practice applies *primarily* to the TS activity
* : this practice has *some relevance* to the TS activity

5.3. EFFECTIVE PRACTICES

Annexes 1–22 contain examples of effective practice.

ANNEXES 1–22

Annex 1

PLANT EQUIPMENT FAILURE TRENDING PROGRAMME

Applies primarily to activity 3.3
Performance - "Optimization of maintenance activities"

This is an example of how to structure and use a plant equipment database. Trending of equipment failures can help to discover precursors and generic failure modes.

A.1. OVERVIEW

The plant equipment failure trending programme has been effective in identifying and resolving repeat failures of important plant equipment. Failures are identified and analysed, and changes are made to preventive maintenance programmes and plant equipment to avoid repeat failures.

A.2. KEY ELEMENTS

(1) Approximately 5000 components have been identified as critical components.
(2) The scope of the critical components list includes some key equipment not included in the Nuclear Plant Reliability Data System, allowing inclusion of other important equipment in the failure trending programme.
(3) Quarterly trend reports identify repeat failures and unfavourable failure trends in critical components.
(4) Actions are then assigned to identify root causes of failures and for implementation of corrective actions.
(5) The system includes the ability to search the equipment lists by manufacturer model number, allowing review of failures of similar components in different applications.

A.3. ADDITIONAL INFORMATION

This programme has identified generic failure modes in cases where no individual component failed twice. The programme has been particularly useful to system responsible engineers in assessing performance of system components. It is being continually streamlined and developed.

This material was supplied by: Oyster Creek NPP, P.O. Box 388, Forked River, NJ 08731, USA, Tel. (601) 971 4770.

Annex 2

RELIABILITY-BASED METHOD TO IMPROVE SYSTEM PERFORMANCE

Applies primarily to activity 3 3
Performance – "Optimization of maintenance activities"

This practice illustrates application of reliability-based methods to optimize maintenance Since considerable amount of work is involved in setting this up, only selected systems are thus analysed

A 1 OVERVIEW

This approach to maintaining selected plant systems provides a method to improve system performance This approach is unique in that it concentrates on system performance, rather than component performance

A 2 KEY ELEMENTS

(1) A detailed plan for conducting an in-depth analysis of system performance is drafted by an interdisciplinary group that includes engineers, instrumentation and control technicians, electricians, mechanical maintenance and management
(2) All components are included in the analysis, including power supplies, instrumentation and instrument loops, auxiliary support systems, interlocks etc
(3) The plan specifies responsibilities, due dates, analysis methods to be used and an outline of how analyses should be performed The plan is formally approved
(4) System weaknesses are identified Most are described in terms of how the system operable lifetime is shortened by the weakness with no mitigating maintenance
(5) For example, if the system is designed with a filter that is not self-cleaning, the system operable lifetime could be reduced to about one week if no maintenance was performed to change the filter
(6) The results are documented in a report specific to the system A matrix is produced summarizing common failure modes and recurring weaknesses
(7) Maintenance activities are proposed and analysed according to their effectiveness in eliminating the weakness and their impact on system performance
(8) Using the example above, a possible maintenance activity would be to change the filter once per week However this would require shutting off the pumps once each week, causing an additional 50 cycles/yr on the power supply breaker each year This could lower system operable life time due to additional wear on the breaker

A 3 ADDITIONAL INFORMATION

Maintenance activities that result from reliability based analyses are put into the preventive maintenance programme for implementation These items, as well as other preventive maintenance tasks, are re-evaluated each year when the annual preventive maintenance plan is developed

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This material was supplied by Paks NPP, Paks, P O Box 71, H-7031, Hungary, Tel 9131 18 2422, Fax 9131 18 4033

Annex 3

PLANT USE OF PROBABILISTIC SAFETY ASSESSMENT TECHNIQUES

Applies primarily to activity 2.5
Management – "Prioritization of projects"

This practice illustrates the applicability of PSA to analysis of issues to which it is not normally applied. Considerable benefits can accrue to the plant when PSA is applied to prioritization of projects.

A.1. OVERVIEW

Probabilistic safety assessment (PSA) techniques are used to prioritize projects. PSA is normally used in assessment of risk, but the station has applied this technique for prioritization

A.2. KEY ELEMENTS

Using station specific data and PSA techniques, the station applies the results in the following areas:

(1) Relative ranking of modification activities and alternatives based on risk.
(2) Relative ranking of equipment and components based on importance to safety.
(3) Development of reliability centred maintenance and resultant changes to the preventive maintenance programme for selected systems.
(4) Guidance on risks associated with shutdown-related conditions and activities.
(5) Guidance to management on the importance of day-to-day issues.
(6) Allocating resources in specific areas, such as security or fire protection.
(7) PSA results have led management to take several specific actions. As an example, PSA demonstrated that the safety margin is significantly reduced during drain down of the reactor coolant system at the start of a refuelling outage. Management implemented corrective action to compensate for the reduction and also restricted operational and maintenance activities at reduced coolant inventory while fuel is in the reactor vessel.
(8) PSA results have also been used to successfully demonstrate that the safety margin increase associated with some specific modifications would not justify the cost involved, while alternatives may provide a greater improvement in safety margin.

A.3. ADDITIONAL INFORMATION

These decisions help to effectively channel available resources into areas providing a greater benefit.

This material was supplied by: Koeberg NPP, Private Bag X10, Kernkag - 7440, Republic of South Africa, Tel.: 0027 21 553 211, Fax.: 0027 21 550 5300.

Annex 4

MINIMIZING OCCURRENCE OF SIMILAR EVENTS

Applies primarily to activity 3.3
Performance – "Operating experience programme"

This practice indicates the amount of effort and persistence necessary to learn from experience and achieve prevention of potential problems. The need for considerable co-ordination and follow-up is also identified.

A.1. OVERVIEW

The potential for occurrence of events similar to those described in both in-house and industry event reports is minimized by effective multi-disciplinary review and clearly defined authority and accountability for determining necessary courses of action.

A.2. KEY ELEMENTS

(1) Representatives of at least two organizations from within the plant review each industry operating experience report to determine applicability to the station. The OPEX group assigns an individual experienced in the relevant technical area.

(2) An experienced plant employee is assigned as an "issue manager" for each operating experience report. This accountable individual is given authority for the following:
- Interfacing with supporting group managers for services of personnel having the appropriate technical expertise to complete rigorous investigations.
- Co-ordination with implementing group managers to determine the most appropriate corrective actions and to secure proper priority for these actions.
- Scheduling and tracking action items to completion, and assisting in resolving difficulties.
- Provision of continuity from the time of identification to final resolution.

A.3. ADDITIONAL INFORMATION

In response to an industry notification of problems with a certain manufacturer's circuit breaker, a review of the plant equipment list indicated that the breaker was not installed in the plant. An additional review, performed by design engineering, determined that a similar circuit breaker had been purchased for a modification.

This material was supplied by: Summer NPP, South Carolina Electric and Gas Company, Mail Code 193, Columbia, SC 29218, USA, Tel.: (803) 345 4722 / 803 748 3429.

Annex 5

JOINT REVIEWS OF PLANT SYSTEMS

Applies primarily to activity 3.1
Performance – "S/E surveillance"

This practice illustrates the benefits of teamwork between plant and design engineers. During joint system reviews, a wide spectrum of problems are looked at with corresponding corrective action from both departments.

A.1. OVERVIEW

Comprehensive reviews of selected plant systems are conducted quarterly with joint participation of the plant system engineer and the design system engineer. These reviews complement on-going monitoring and monthly reviews conducted by plant system engineers.

A.2. KEY ELEMENTS

(1) During these reviews, the design and plant system engineers walk down the system to observe the material condition of equipment in the system; review the backlog of open action requests, non-conformance reports, quality evaluations, and work orders; and status of pending design change requests.
(2) The engineers prepare a report that summarizes the state of health of the system, and highlights priority issues that need action or monitoring.
(3) The report receives wide distribution, including the station manager and the off-site engineering manager.

This material was supplied by: Diablo Canyon NPP, P.O. Box 56, Avila Beach, CA, 93424, USA, Tel.: (805) Fax.: (805) 545- 4985.

Annex 6

SURVEILLANCE TEST PROCEDURE DOCUMENT

Applies primarily to activity 3 1
Performance - "S/E surveillance"

This practice illustrates the importance of making the relevant information readily available The information enables engineering staff to make prompt assessments of out-of-normal test results without having to search for pertinent information

A 1 OVERVIEW

The plant is developing surveillance test procedure bases documents that are an effective means of documenting backup information related to surveillance tests A series of over 400 surveillance test procedure bases documents are being produced, one for each of the major surveillance tests

A 2 KEY ELEMENTS

(1) Each surveillance test procedure basis document covers the basis for the test frequency, limitations, conditions, and precautions relative to conducting the test, discussion of the bases for acceptance criteria, and the history of procedure development, including commitments
(2) By incorporating this information in a separate document, the surveillance test procedures can be significantly simplified for use in the field
(3) With the bases documents, system engineers and plant engineers can achieve more timely and consistent decisions to evaluate test results or make operability determinations

A 3 ADDITIONAL INFORMATION

The bases documents are produced using a writer's guide and receive a review by the surveillance test group, the applicable system engineer, and the nuclear steam supply vendor

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This material was supplied by Diablo Canyon NPP, P O Box 56 Avila Beach, CA, 93424, USA, Tel (805), Fax (805) 545 4985

Annex 7

TEAMWORK AND PROBLEM SOLVING SKILLS

Applies primarily to activity 2.4
Management - "Training and development of TS staff"

This is an example of how a utility trains its TS and other supervisory staff in "soft skills". The extent and scope of training is detailed. Importance of practical exercises is highlighted.

A.1. OVERVIEW

Teamwork and problem-solving skills for engineering support personnel and maintenance supervisors have been improved through a training programme that integrates classroom training, full-scope simulator exercises, and in-plant activities.

A.2. KEY ELEMENTS

(1) The 2-day classroom training on teamwork skills includes such topics as conflict resolution, accountability, and communications. These skills are then reinforced through the application of practical exercises.

(2) The 2 1/2-day training on problem-solving techniques is taught in the classroom and reinforced during exercises on the full scope simulator. Simulator exercises include students role-playing as control room operating crews are challenged with identifying a simulated problem with a plant component, such as a heater drain pump trip caused by a faulty electrical bus, and determining a course of corrective action.

(3) The focus of the session is on problem-solving skills, rather than plant operational skills.

(4) In-plant activities are conducted in which students role-play as maintenance personnel asked to solve a problem similar to the type encountered during the simulator exercises. These "maintenance personnel" inspect the plant equipment, review station documents, and then formulate a solution to the problem.

This material was supplied by: Diablo Canyon NPP, P.O. Box 56, Avila Beach, CA, 93424, USA, Tel.: (805), Fax.: (805) 545 4985.

Annex 8

ROOT CAUSE EVALUATION OF HUMAN PERFORMANCE EVENTS

Applies primarily to activity 3 5
Performance - "Root cause analysis"

This practice identifies elements of a programme to identify and analyse human performance problems with the objective of reducing human error rates

A 1 OVERVIEW

This programme provides the means to identify and analyse human performance problems The programme incorporates voluntary reporting of human performance problems and near misses, so that causal factors can be identified and preventive measures taken to prevent recurrence To organize this effort, a systematic method is provided to analyse and evaluate human performance problems This programme can be structured in a number of ways as long as certain basic elements exist

A 2 KEY ELEMENTS

The following key elements are the necessary prerequisites for identification of root causes of human performance problems

(1) High level management support including assignment of key personnel to evaluate human performance problems
(2) Emphasis on the positive side of identifying and correcting problems that affect human performance
(3) In-plant training for station personnel and managers on how to recognize and report human performance events
(4) Visible support, such as plant newspapers, letters from plant managers to all plant personnel, and verbal support by managers at meetings
(5) Recognition that plant personnel involved in everyday operation of the plant want to do well but that mistakes reported by any person are reviewed as opportunities for improvement
(6) Voluntary and, if desired, confidential reporting of human performance problems (inappropriate actions, near misses)
(7) A plant-specific procedure, approved by management, that describes the programme

A 3 ADDITIONAL INFORMATION

This programme will yield positive results only if management is supportive and forgiving of honest mistakes

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This material was supplied by INPO Good Practice, E - 904, 600 Galleria Parkway, NW Atlanta, GA 30339-5957, Tel 404 644 8000, Fax 404 644 8549

Annex 9

FORWARD ENGINEERING PLANS

Applies primarily to activity 2.9
Management - "Long term technical programmes"

This is an example of how a utility plans for the long term through identifying emerging technical problems and then follows through with plans for resources — people and money — required to deal with the identified potential problems.

A.1. OVERVIEW

The Forward Engineering Plan (FEP) acts to provide assurance to the company that the generating asset is being properly managed and developed. For each significant part of the plant it details the status of any major deficiencies that exist, or can be expected to arise, and the actions to be taken at some time in the future.

A.2. KEY ELEMENTS

The FEP is arranged such that it:

(1) Identifies the principal threats and opportunities to the plant that may arise within its remaining life. These opportunities and threats may be far reaching, considering items such as plant lifetime limitations, plant obsolescence, output improvement opportunities, threats to generation, availability, efficiency and safety enhancement.

(2) Prepares estimates of significant revenue and capital expenditures on engineering activities for the plant. This forward view of the required resources is essential if the plant is to ensure the provision of appropriate resources when required. The plant's Business Plan will provide the shorter term, more accurate information.

(3) Assists in planning the financial and human resource requirements for the company. This forward view will be gained from combining the information from the individual plant FEP's.

(4) Provides an accurate status of the condition of the plant, identifying potential work that may be selected for inclusion into future five-year Business Plans.

A.3. ADDITIONAL INFORMATION

The FEP can be held on a computerized database such that the engineering status of any item of equipment can be easily assessed. TS staff are able to update the database continuously so it remains a "live" plan that always gives an accurate picture of the engineering "health" of the plant.

This material was supplied by: Oldbury-on-Severn Power Station, Nuclear Electric plc, Oldbury Naite, Thornbury, Avon BS12 1RQ, United Kingdom, Tel.: 0454 416631, Fax.: 0454 893724.

Annex 10

TRAINING PROFILES FOR ENGINEERING DEPARTMENT STAFF

Applies primarily to activity 2.4
Management - "Training and development of TS staff"

This practice illustrates the extent of planning and care which need to be applied to initial and continuous training and development of staff. Comprehensive, individual development planning is stressed.

A.1. OVERVIEW

Training modules are defined for the Engineering Department staff and are categorized as either statutory, essential or recommended. All types of training are included enabling a comprehensive programme to be built up for each member of staff.

A.2. KEY ELEMENTS

(1) A "Level 1" document exists in the form of a matrix of all the training modules and the staff positions in the department. Where modules apply to a position, there is an indication of whether it is a statutory requirement, essential or recommended.

(2) The modules cover:
   - (a) Technical courses delivered in classroom
   - (b) Plant induction requirements
   - (c) Safety courses
   - (d) On-the-job training
   - (e) Plant familiarization
   - (f) Special processes
   - (g) Management skills training.

(3) For each staff position a programme in the form of a flow chart is produced.
On-the-job training and plant familiarization requirements are detailed. This represents "Level 2" of the training profile.

(4) Each module and sub-module has documentation associated with it, which defines the training aims, objectives, method and means of assessment. This is the "Level 3" of the training profile.

A.3. ADDITIONAL INFORMATION

The training profile represents an initial assessment of the training necessary to enable a member of staff to undertake the duties and responsibilities of his post. The profile also includes requirements for periodic refresher training. In addition, an appraisal process ensures that additional training and development needs are regularly identified, even for experienced staff.

This material was supplied by: Oldbury-on-Severn Power Station, Nuclear Electric plc, Oldbury Naite, Thornbury, Avon BS12 1RQ, United Kingdom, Tel.: 0454 416631, Fax.: 0454 893724.

Annex 11

ENHANCEMENT OF NUCLEAR SAFETY DURING OUTAGES

Applies primarily to activity 3.0
Performance - "Nuclear safety"

This practice identifies steps undertaken to enhance nuclear safety margins during outages, improve outage performance and the work management process. The practice highlights the multi-disciplinary review of outage plans and pre-outage training for nuclear safety.

A.1. OVERVIEW

The station has adopted a systematic approach to the planning, multi-disciplinary review, and implementation of defence-in-depth measures. Specific responsibilities were assigned and structured reviews of effectiveness of nuclear and conventional safety measures were routinely scheduled before and during the fuelling outage.

A.2 KEY ELEMENTS

(1) The outage schedule was developed by outage management scheduling personnel based on maintaining defence-in-depth for key safety functions. This approach is part of a formal procedure that details the planning and conduct of outages to ensure defence-in-depth.

(2) A safety review was performed by a multi-discipline assessment team, in accordance with the procedure, and their recommendations were provided in a detailed safety assessment of the outage plan. Recommendations provided by the review were incorporated into the schedule to enhance defence-in-depth. For example, the reactor protection system relay replacements were rescheduled to be performed while two trains of fuel pool cooling and cleanup were available to provide improved decay heat removal availability.

(3) Effective pre-outage defence-in-depth training was performed for station and contract personnel assigned to support the outage. Workers were instructed and understood the need to contact their supervisor or the unit supervisor if given a work assignment in a posted protected equipment area. The training was evident in the random interviews conducted by the team.

(4) There is a shift safety advisor available at all times during the outage. This safety advisor is an engineer responsible for reviewing outage scope additions to determine the effect on defence-in-depth, and to maintain postings and barricades used to identify equipment required for defence-in-depth. The shift safety advisor also reviews system configuration and availability changes and answers any questions concerning defence-in-depth.

(5) Other measures that enhance awareness of defence-in-depth include reinforcing defence-in-depth in the first two pages of the outage handbook. Also, operations personnel maintain a status board in the control room that identifies available systems for key safety functions and time-to-boil upon loss of decay heat removal capability.

This material was supplied by: Perry NPP, 10 Center Road, Perry, OH 44081, USA, Tel.: (216) 259-3737.

Annex 12

ENGINEERING DEPARTMENT MANUAL

Applies primarily to activity 2 3
Management - "Quality management"

This practice gives an example of how the mission, organization and functions of TS are defined within the plant and the QA programme Core activities and objectives of TS are shown

A 1 OVERVIEW

The purpose of the Engineering Department Manual is to set out the arrangements, procedures and practices of the Engineering Department which are used to meet the requirements of the plant and its quality assurance programme

A 2 KEY ELEMENTS

(1) The Manual sets down the objectives of the Department as
- (a) approve and monitor the effectiveness of specifications for operation and maintenance, in line with the company policies and standards, legislative and other mandatory requirements
- (b) maintain and monitor adherence to the plant's design basis documentation[1] and safe operating envelope, including the control of modifications
- (c) provide performance monitoring, plant efficiency and chemistry service to optimize the use of the plant
- (d) specify work that meets the output requirements placed upon the plant at as low cost as possible for both operation and maintenance while still achieving the required standards
- (e) establish and maintain appropriate managerial, supervisory and technical skills to satisfy the above

(2) Detailed organization and section responsibilities are defined, together with the Department interfaces and the means by which they are controlled

(3) Activities undertaken by the Department are listed and their management arrangements described

(4) Requirements for document control, review and audit are defined

A 3 ADDITIONAL INFORMATION

The manual provides definition of the role, objectives and responsibilities of the Engineering Department This is essential to ensure that all plant staff clearly recognize their own roles and responsibilities This clarity also extends and is visible to the regulatory authority, giving them confidence that all aspects associated with safe operation are adequately covered

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[1] *Design basis documentation* a set of up-to-date documentation depicting the condition of the plant as designed and incorporating all subsequent modifications

This material was supplied by Oldbury-on-Severn Power Station, Nuclear Electric plc, Oldbury Naite, Thornbury, Avon BS12 1RQ, United Kingdom, Tel 0454 416631, Fax 0454 893724

Annex 13

"LESSONS LEARNED" PROGRAMME

Applies primarily to activity 3.3
Performance - "Optimization of outages"

This programme illustrates a technique by which lessons learned from outages are solicited, recorded, tracked and evaluated for implementation in subsequent outages. Of particular significance is the direct involvement of lower levels of staff.

A.1. OVERVIEW

The station has implemented a programme to actively solicit and follow-up suggestions for improving performance in outages. All employees are encouraged to participate through focus groups. Suggestions are evaluated, tracked and — if valid — implemented in subsequent outages.

A.2. KEY ELEMENTS

(1) Focus groups are identified for each major outage group, such as the turbine, motor-operated valves, and refuel floor work groups. Group participants are selected early in the outage to reinforce the need to capture lessons learned. After the outage, these focus groups review their performances for "lessons learned", and items for implementation are tracked by each group as appropriate.

(2) The tracking number assigned for each lesson learned is added to the station's plant tracking system. This tracking system identifies the responsible manager, the associated pre-outage milestones for the next refuelling outage, and the date required for the lesson learned to be implemented. Prior to officially meeting the pre-outage planning milestone, each activity assigned to the milestone must be closed.

(3) The motor-operated valve programmes a good example of improvements that have been made based on previous outage experience. The station had experienced difficulties in the previous outage with maintenance and testing of motor-operated valves. As a result, work was suspended until the deficiencies could be corrected. Improvements were made to the programme based on lessons learned from the outage. An electrician interviewed said that the training he received on the refurbishment and testing of motor- operated valves made a big improvement in his ability to perform his job.

A.3. ADDITIONAL INFORMATION

Participation in the "lessons learned" programme has grown from 10 suggestions submitted in the third refuelling outage to 300 in the fourth. Over 120 suggestions were submitted in the first 11 days of the fifth refuelling outage.

This material was supplied by: Perry NPP, 10 Center Road, Perry, OH 44081, USA, Tel.: (216) 259 3737.

Annex 14

OPERATING EXPERIENCE FEEDBACK

Applies primarily to activity 3.3
Performance - "Operating experience programme (OPEX)"

This practice illustrates the details of application of OPEX. The extent of analyses performed and the skills of people performing them are specified. Of primary interest are: level of corporate involvement in feedback analysis, accumulation of experience at corporate headquarters and prompt "vertical" communication. Due to standardization of reactor design in France, it is possible to look for similarities and "families of events".

A.1. OVERVIEW

The nuclear operators have all adopted a system of experience feedback at
— plant level
— at corporate level, for all plants within the utility
— world wide.

Analysis is conducted at the plant and at the corporate headquarters with corrective actions or stop-gap measures implemented with appropriate priority.

A.2. KEY ELEMENTS

(1) The main elements of OPEX are:
- — detection of events liable to affect safety
- — identification of significance of these events
- — tracing and identifying their causes (root cause analysis)
- — drawing useful lessons for plant design and operations
- — taking corrective action to avoid repetition of events

(2) Two types of events have been selected for experience feedback:
- — incidents significant to safety, which must be reported, analysed and input into experience feedback system
- — safety-related incidents, which must be recorded for statistical data

(3) Incident analysis is carried out at two levels:
- — at the plant
- — at the corporate headquarters

(4) Significant events are reviewed at the plant in a series of examinations, focusing on:
- — provision of interim or final measures to restore plant availability with sufficient safety level, once the cause of failure has been clearly identified
- — determining the causes of the incident by collecting all the relevant information
- — determination of corrective actions, or stop-gap measures to prevent re-occurrence

(5) Corporate analysis examines incidents which are:
- — significant in their impact on plant or personnel safety
- — repetitive in character
- — of generic and cross-disciplinary nature — with respect to equipment or operating procedures

(6) Corporate analysis examines events, or groups of events, to confirm and explore
- — causes of failure (root cause analysis)
- — the most appropriate measures to prevent a recurrence, such as :
  - — modification of equipment
  - — changes in operating procedures
  - — personnel training
  - — improvements in supervisory and managerial surveillance

(7) Corporate analyses are conducted by engineers who are specialists in:
- — safety
- — operation
- — equipment and maintenance
- — human factors
- — radiation protection, environment

(8) Completion of analyses and implementation of corrective actions may be time consuming. In consideration of potential impact on safety of certain events, provisions have been made for the fast communication of these events and their recommended corrective or stop-gap measures to the power plants. Conditions conducive to repetitive events are thus promptly eliminated. This is called "rapid experience feedback".

(9) All activities associated with reporting of incidents, analysis and the resulting actions are fully documented.

A.3. ADDITIONAL INFORMATION

Following need for improvements in the area of OPEX have been identified:

- — direct analyses and corrective measures towards improvement of work methods
- — orientate corporate analyses toward families of events
- — improve quality of analysis at the plants through provision of specialized training in root cause analysis to plant personnel.

This material was supplied by: Electricité de France, Centrale Nucléaire de Flamanville, P.O. Box 4, F-50340 Les Pieux, France, Tel.: 3308 9595, Fax.: 3304 1300.

Annex 15

CONTROL OF SURVEILLANCE TESTING

Applies primarily to activity 3 1
Performance - "S/E surveillance"

This practice describes a method of controlling surveillance testing, which permits quick changes to test schedule in response to changing plant conditions A computerized database is the tool used Its key features are briefly described

A 1 OVERVIEW

A group in TS, called "Nuclear technology and computers" (NTC) is responsible for scheduling and updating of surveillance test requirements They also review test results and control surveillance test computerized database As required by plant Operating License and specified by technical specifications, testing is executed by several departments Co-ordination and control are therefore important

A 2 KEY ELEMENTS

The computerized system contains records of each test, the test results and proof of their verification It also contains a record of test execution and its timeliness, or lack of thereof, for each organization charged with test execution

(1) A database has been created, which includes
- — surveillance test requirements — what is to be tested, how and why
- — technical procedure to be followed
- — group responsible for test execution
- — test frequency
- — plant condition necessary for the test
- — associated technical specification

(2) A schedule of all tests to be done is produced once a week Should plant conditions change, it is revised and re-issued (from on-power to shut-down or similar)
Schedule is sent to all groups who do the testing
Because of the large number of tests to be executed by Operations, they have a special schedule which they control This schedule includes only tests with frequency less than a week (e g daily, every shift)

(3) To each schedule sent to each testing group, there are attached control sheets — one for each test — which must be filled out, signed and returned to NTC after test completion, with test results entered
This is the basis on which test data base is updated and is also a record of test execution

(4) To simplify matters, Operations can enter their test data into the computer directly from the control room

A 3 ADDITIONAL INFORMATION

This system of test control and reporting has been very useful during normal, on-power operations and also during shutdowns It permits quick changes to test schedules, as required by the plant condition and verifies completion of specified testing

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This material was supplied by Endesa - Iberdrola, Central Nuclear Vandellos II, Apartado de Correos, 27 - 43890, L'ospitalet de L'infant, Tarragona, Spain

Annex 16

TRAINING FOR MANAGERS - QUALITY MANAGEMENT AND QUALITY ASSURANCE

Applies primarily to activity 2.4
Management - "Training and development of TS staff"

This practice details training in concepts and application of Quality Management and Quality Assurance. The extent, contents and methods of training are indicated.

A.1. OVERVIEW

This training will enable the participants to:

- Understand and adopt the important quality concepts and applications, such as requirements for and use of operations documentation
  — technical resources necessary for management of operations
  — management of operations under adverse or emergency conditions
- Understand the concepts and applications of the principles of Quality Assurance
- Integrate quality methods into the operations process
- Understand the way to improve efficiency of plant operations through the application of the above concepts.

A.2. KEY ELEMENTS

(1) Training methods
The training methods include:
— lectures and presentations in class
— panel discussions
— exercises followed by discussions
— case studies
— exchange of experiences

(2) Contents of training
Basic concepts of Quality Management:
— promotion of safety attitude
— rules, regulations and guidelines
— technical regulations with respect to safety
— necessary plant documentation
— guidelines for development of emergency procedures(event-oriented, safety-function oriented)
— routine in-service inspections(principles, details and implementation)
— concepts for development of preventive maintenance programmes
— methods for development of a comprehensive training programme (guidelines, contents, measurement)
Details of the Quality Assurance (QA) programme
— QA Manual — contents and preparation
— QA requirements for preparation of plant documentation
— application of QA to operations
— application of QA to training activities.

(3) Participants
8 to 10 persons, responsible power plant personnel, mainly from different levels of management.

(4) Duration
Recommended duration for this course is 4-5 days.

(5) Training materials

The training materials consist of:

Training manuals with:

— written text

— copies of all transparencies used during training descriptions of exercises used.

This material was supplied by: Siemens AG, Power Generation Group, Nuclear Power Plant Services, P O. Box 3220, D-91050, Erlangen, Germany, Tel.: 9131 18 2422, Fax.: 9131 18 4033

Annex 17

COMPUTERIZED PLANT DOCUMENTATION SYSTEM

Applies primarily to activity 3.3
Performance - "Optimization of computer usage"

This practice describes the extent and utilization of a comprehensive computerized plant data system. Services available from the system and the benefits arising from it are stated. Arrangement of the data base permits analysis at system or individual component level.

A.1. OVERVIEW

In order to provide comprehensive and effective support for an economical and appropriate planning, execution, documentation and evaluation of power plant maintenance and modification, a computerized plant documentation system has been implemented. The users benefit from the system by more efficient personnel employment, higher plant availability, optimized spare parts management, better work quality and higher safety. The relevant regulations and requirements are incorporated into the system routines and are therefore satisfied automatically.

A.2. KEY ELEMENTS

The system is designed to meet the requirements of nuclear power plants. It consists of several modules, which work together in a fully integrated manner.

(1) Plant database
A description of the plant configuration and equipment details provides up-to-date plant information during the entire plant life cycle. In a "process-specific" manner all plant items (systems, valves, drives, instrumentation & control, etc.) are identified on the basis of the particular plant identification system in use, classified and structured according to the relevant plant configuration. The specific requirements are described with technical design data. The "product-specific" view describes all equipment in use to meet these requirements. The inherent flexibility is particularly suited to utility installations which comprise a variety of plants.

(2) Maintenance management
Provides support to ensure that maintenance operations and routine in-service inspections are performed reliably, on schedule and at reasonable cost. The operational procedures embedded within these modules are based on the "know-how" of utility operational management practices and the requirements of the Regulatory Authorities. The data obtained can be used to improve maintenance strategies and thus over time enhance plant reliability and availability.

(3) Modification management
The support for the execution of plant modifications ranges from the recording of initiating events and project proposals up to the documentation of any actions taken. On completion of the planning, a modification application is printed which contains all the relevant information for internal and external licensing. The subsequent steps through the licensing instances is followed up by recording of approval data. References to the affected items of plant equipment, documentation, applicable licenses, regulations etc. facilitate the observance of all statutory regulations.

(4) Document management
Registration and administration of the entire plant documentation. By cross-referencing the documents to the relevant plant items, work orders, system isolations, etc. the fast access to the up-to-date issue by any member of the operating crew is ensured and the documentation is readily available for use in all operational situations.

(5) Materials management

This functional area facilitates the management of consumables, spares and substitutions of parts for the plant equipment Observance of technical and quality requirements is verified and documented In association with other computerized system modules, optimal spare parts management for all maintenance operations is ensured

(6) Computer interfaces

The computerized system can be linked, via data interfaces, to other existing systems which operate on either mainframe, workstation or personal computer platforms This results in consistent work processes The system thus evolves to its full efficiency as an "integrating system" for the entire organization

A 3 ADDITIONAL INFORMATION

The system has been designed for use by operating personnel at all levels Its practical application does not require computer knowledge Particular emphasis has been placed on user-friendliness It utilizes mid-range central and/or personal computers and the standard UNIX or VMS operating system Various hardware platforms can therefore be used

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This material was supplied by Siemens AG, Power Generation Group, Nuclear Power Plant Services, P O Box 3220, D-91050, Erlangen, Germany, Tel 9131 18 2422, Fax 9131 18 4033

Annex 18

ASSESSMENT OF EFFECTIVENESS OF TECHNICAL SUPPORT (TS)

Applies primarily to activity 4.2
Assessment - "TS self-assessment"

This practice is important because it illustrates the technique employed in assessment of effectiveness of TS. Frequency of assessments is stated and the questionnaire used is presented.

A.1. OVERVIEW

Effectiveness of technical support is assessed by an annual survey. The survey is performed by people on manager level from departments not involved in the particular part of the technical support to be assessed. The basis for the survey is a questionnaire which is used every time. The method used is to interview the main users of technical support. The questionnaire is used as the basis of the interview of the managers and staff of user groups. The interview takes normally about one hour.

A.2. KEY ELEMENTS

(1) Based on the response from all main users, a report is produced which gives the customers' view of the effectiveness of technical support, and also their opinion about the trend in TS performance.

(2) A summary is produced with classification and analysis of responses. This feedback is then contrasted with TS objectives. Areas needing improvement are identified and specific goals specified.

(3) Additional assessments are performed through quality audits carried out every third year by a "peer" group created especially for that purpose from within the whole organization. This group evaluates the procedures and management practices to assess the extent to which the requirements of the quality system are met.

(4) A report is produced with all observations, recommendations and good practices found during this evaluation. This report is distributed to all departments in the company. This ensures that problems and good practices will be known to TS departments at other plants, for them to learn.

(5) Example of the questionnaire is presented below. Identification codes are used for the different departments involved in providing technical support.

- What are your requirements which must be fulfilled by Dept. "X"?
  In your opinion, have these requirements been fulfilled in a satisfactory and timely manner?
- Which are the best characteristics of Dept. "X"? What do you find the most satisfactory?
- Which are the worst characteristics of Dept "X"? What annoys you the most?
- What would you wish to change in the way you interact with Dept. "X"?
- Do you always know whom to contact when you need support from Dept. "X"?
- In your opinion, are there significant technical shortcomings in quality of support provided by Dept. "X"?
- Is the timeliness of support provided acceptable and commensurate to the urgency of the issue?
- Is the level of documentation of the task, provided by Dept. "X", sufficient to meet your needs?

This material was supplied by: OKG Aktiebolag, Oskarshamn NPP, S-572 83, Figeholm, Sweden, Tel.: 46 491 863 38, Fax.: 46 491 869 57, Sweden.

Annex 19

ORIENTATION PROGRAMME FOR NEW ENGINEERS

Applies primarily to activity 2 4
Management - "Training and development of TS staff"

This practice is important because it outlines the extent and methods of training given to new engineers at a power plant Supervision of and support given to trainees is identified The role of "mentors" is stressed "In class" learning and practical experience in the plant are emphasized Length and extent of particular training assignments is given

A 1 OVERVIEW

This orientation programme is a continuation of the introduction given to all new staff It extends over the period of approx 8 months and covers most activities within the utility

The aim of the programme is to give a newly appointed engineers
- the insight, information and knowledge about the organization, activities and routines
- an opportunity to establish contacts and form networks valuable for future assignments

In parallel with the orientation programme, the new engineers work within their respective work units on their own assignments This is in order to acquire "hands on" familiarity with the work and to establish working contacts within their own organization The engineer's progress within the orientation programme is carefully monitored

A 2 KEY ELEMENTS

(1) Each new engineer will have a "mentor" appointed by the Department Head The mentor's responsibilities are
- to offer support and guidance, as required, and on daily basis, to the engineer
- to review the orientation programme with the engineer
- to monitor progress in the orientation programme and to apply corrections as appropriate

(2) The orientation programme is divided into 7 sections The assignments, length of time spent at the various departments and the type of work to be done are agreed upon between the engineer, the mentor and the contact person within the particular department
The 7 sections are
(a) **Practice** at the various departments in the power plant to gain first-hand knowledge of their organization and routines
Typical departments for "practice" assignments are
- chemistry/radiation protection
- mechanical/electrical/instrument maintenance
- reactor maintenance
- data processing
- nuclear waste handling

(b) **Shift work**, to gain first-hand knowledge of the organization, duties, routines and difficulties of the production unit The engineer should work in the production section associated with engineer's particular TS department He should participate in most activities of the work, including attendance at routine and non-routine meetings This assignment typically lasts 4 weeks
(c) **Information briefings,** to gain knowledge of various departments' organization and activities and to become aware of company policies and administrative routines The following are typical departments to offer information briefings
- Administration, Information and Public Service
- Personnel
- Nuclear Safety

(d) **Training**, in the following typical subjects and procedures:
- — nuclear power technology, reactor physics
- — radiation protection
- — safety regulations and technology
- — plant knowledge and systems, specific to each production unit
- — modification procedures and controls
- —quality assurance

Total duration of this training is approx. 22 days.

(e) **Meetings,** to acquire familiarity with company "meeting culture" and to observe the interaction between the company and the trade union.

Typical meetings to be attended:
- — engineer-on-duty meeting
- — personnel committee
- — local safety meeting
- — audit review meeting

(f) **Networking,** to establish possibilities for future exchange of experience. The existence of an effective network will be confirmed by the mentor.

(g) **Study visits**, to provide an opportunity for broadening of experience and contacts. Typical study visits might be arranged to other nuclear power plants or to a contractor's facilities.

(3) Progress through the orientation programme is routinely monitored by the mentor, and also formally tracked through a series of review meetings, with the objective of ascertaining the effectiveness of:
- — time planning, with respect to length of assignments
- — contents of the programme
- — quality of the programme with respect to the information provided.

The meetings are attended by the mentor, the engineer and a representative of the personnel department.

(4) During these meetings the new engineer is required to:
- — show the current status of his individual orientation programme comment on the validity and value of the various sections of the programme
- — offer his views on the quality of information presented.

This material was supplied by: OKG Aktiebolag, Oskarshamn NPP, S-572 83, Figeholm, Sweden, Tel.: 46 491 863 38, Fax.: 46 491 869 57, Sweden.

Annex 20

REDUCING THE NUMBER OF PLANT EVENTS

Applies primarily to activity 3.3
Performance - "Operating experience programme (OPEX)"

This practice is important because it describes the way in which analysis of in-plant adverse events and the associated Root Cause Analysis are used to identify and track corrective actions at the plant level. Frequent and direct involvement and oversight by senior plant management are illustrated.

A.1. OVERVIEW

Management oversight, use of in-house operating experience, and the development of a performance reporting programme have been helpful in reducing the number of adverse events at the plant.

A.2. KEY ELEMENTS

Contributing to this performance are the following aspects of the programme:

(1) Screening of plant and industry events by plant management during the daily meeting is routinely performed to ensure investigations are performed at the appropriate level. In addition, in-house event reports are reviewed by the operations review committee for completeness of immediate and interim corrective actions. A final review by management is performed to ensure completeness of investigations and implementation of all longer term corrective actions. These reviews help to ensure the root causes were determined and corrective actions implemented to prevent recurrence of similar events.

(2) A performance reporting programme has been developed to inform management of trends of:
- — significant and non-significant events,
- — root cause category for events, which aid in identifying the specific line organization where corrective actions should be developed.

The reports also assist management in determining the effectiveness of corrective actions previously implemented.
Items in the programme include the following:
(a) a comparison of the number of significant events to the total number of events to indicate the effectiveness of corrective actions in preventing future significant events.
(b) a graphical comparison of the number of event reports opened, closed, past due, and average age of open investigations.

(3) Reports containing performance information are periodically presented to management. The reports include:
- — a summary of each event,
- — discussion of the root cause investigations and associated corrective actions,
- — analysis of event cause categories for each line organization and the station as a whole.

This aids management in directing corrective actions to the appropriate in-plant organization.

(4) Examples of items that were developed from the in-house operating experience and performance reporting programme include the following:
- — improvements were made to the ergonomics of rod control push buttons. This enhancement included improved labelling, colour coding and a mechanical mouse trap type device that is aimed at preventing control rod mis-positioning events.
- — an enhancement to the plant-wide procedures programme included identification of the need for development of some specific procedures, and improvement in procedure usage and technical content.

A.3. ADDITIONAL INFORMATION

This process is noteworthy because it has direct involvement of senior plant management. Both the events and corrective actions are tracked and this results in the OPEX process being fully integrated with routine plant management. Additionally, these regular management reviews represent an "early warning feature" with respect to identifying precursors for potential problems.

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Annex 21

PLANT NUCLEAR INTEGRITY REVIEW COMMITTEE

Applies primarily to activity 3 1
Performance - "S/E surveillance"

This practice is important because it illustrates the seriousness with which nuclear safety is approached at a power plant This is a team effort to oversee and reflect on status of nuclear safety at the plant Participation by the Regulator and worker's representatives is an unusual feature TS is the primary contributor to NIRC's deliberations through provision of analysis and assessment of adverse events TS is also involved in many of the corrective actions

A 1 OVERVIEW

The plant Nuclear Safety Integrity Review Committee (NIRC) addresses all aspects of nuclear safety with reference to the protection of the public and the personnel from radiological risks associated with the operation of the plant All "consequential events" are reviewed Only acute radiological risks to the environment are addressed

A 2 KEY ELEMENTS

(1) The objective of NIRC is to review operational events to ensure achievement of nuclear safety over the long term Reviews identify action items which are tracked until their satisfactory resolution is achieved

(2) NIRC meets monthly The members of NIRC are
- Operations Manager
- Nuclear Safety Manager (Chair)
- Engineering Services Manager (TS)
- Production Manager
- Fuel Handling Manager
- Worker's Union representative

(3) The regulator and a representative from the corporate Nuclear Safety Directorate have a standing invitation to attend Input into discussions is expected and readily accepted It is recognized that the regulator must maintain the independence required by its role

(4) Rigorous investigation is performed for all consequential events The manager of the generating unit on which the event occurred is responsible for initiating the investigation This manager is also responsible for presentation of findings and corrective actions at the second NIRC meeting following the event The responsibility for investigation, specifying of corrective actions within a specific time

(5) NIRC assesses performance with respect to nuclear safety and identifies areas for action through reviews of
- significant nuclear safety events to ensure that nuclear safety issues are adequately addressed and that the resultant actions are dealt with in a timely manner
- root cause investigations of significant nuclear safety events
- external events, as reported through OPEX, for plant implications
- nuclear safety performance measures and trends
- completed post-trip investigations
- proposed significant revisions to operating standards and procedures
- plant activities from nuclear safety and management process point of view

(6) NIRC also
- provides a forum for discussion and consideration of key issues which impact on the plant's safety culture and initiates actions to address these issues
- monitors the status of identified problem areas and of corrective actions assigned by NIRC

— through its "open door" policy, provides an opportunity for plant personnel to submit and discuss nuclear safety concerns which, in their opinion, have not been adequately addressed through the normal management process
— provides feedback to plant personnel on committee concerns, decisions, corrective actions and other initiatives

A 3 ADDITIONAL INFORMATION

The major "stakeholders" for the subject of nuclear safety are·
— Plant Leadership Team (Chair — Plant Manager)
— corporate NIRC
— corporate Nuclear Leadership Team (Chair — Vice President, Nuclear)
Minutes of NIRC meetings are kept for review by the corporate NIRC, at their discretion

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Annex 22

PROCESS FOR PROCUREMENT OF MATERIALS

Applies primarily to activity 3 4
Performance - "Management of materials"

This practice describes the process used for materials management and controls imposed by it Involvement of various departments is discussed Responsibilities and actions to be taken by TS are identified Importance of QA programme for this application is stressed

A 1 OVERVIEW

Control of materials and spare parts is accomplished through the use of computerized database which contains details of all materials, including spares Responsibilities for activities within the Material Management Process are clearly assigned

A 2 KEY ELEMENTS

(1) The process of managing procurement of materials addresses the following issues
- — procedure for routine ordering
- — electronic procedure for material detail and spare part changes
- — resolution of procurement inquiries
- — technical review of safety related item procurement
- — substitute item approval and data administration

(2) The following departments interface to ensure effective procurement of materials
- —Materials Management
- — Engineering Services (TS)
- — Operations, including Maintenance
- — Finance and Business Services

(3) Detailed technical information must be available for each item in the data base, as follows
- — manufacturer and model number
- — technical specification
- — plant system and item identification
- — item description in standard format
- — nuclear, environmental, seismic and safety related qualifications
- — Quality Assurance Programme level

(4) Procurement inquiry is initiated if material detail is found to be inadequate or the vendor cannot supply the item as ordered Materials Management decides if the inquiry is "technical" or "non-technical"

(5) Technical inquiries deal with issues related to
- — safety related item purchase review
- — Quality Assurance Programme
- — technical specifications and material qualification (nuclear, seismic, etc)
- — substitutions or obsolescence
- — inquiries of complex nature or which may impact on material characteristics

Non-technical inquiries deal with issues such as cost, deliveries, packaging

(6) Following are the responsibilities for management of procurement
- — Materials Management
- — identify material detail deficiencies during procurement
- — initiate and close out procurement inquiries
- — update Materials Management System database
- — Operations obtain material information from the field, as requested
- — Engineering Services (TS)

— ensure accuracy, consistency and completeness of the technical data in the databases
— perform equipment substitution evaluation to ensure substituted equipment meets the design requirements
— co-ordinate resolution of procurement inquiries.

(7) All proposed parts substitutions must be approved. The approval process ensures that the licensing conditions and the requirements of the applicable technical and quality standards have been met.

A.3. ADDITIONAL INFORMATION

Quality principle: "Use the right material, equipment and processes, and control any change to them". In accordance with this principle, material specifications and details must be maintained to ensure that the material installed in the plant meets the design requirements and the applicable codes and standards. Quality assurance programme requirements are strictly applied to the management of materials process.

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GLOSSARY

Note: Some of these terms and definitions are specific to this publication only.

authorization. The granting of written permission to perform specified activities.

attribute. A positive performance characteristic.

availability. The fraction of specified time period that a passive safety system is fully capable and able to satisfy the design intent ("passive" — a system which plays no part in the normal operation, but remains poised, ready to operate when required).

bench marking. The activity of observing the practices, processes and results of companies recognized as industry leaders.

call-up system. A *listing of routine activities, together with their dates (frequency) of execution,* designed to remind the plant staff that they must be carried out

close call. A serious adverse event which almost happened, but was avoided through luck and fortunate circumstances.

configuration management. The act of reviewing, inspecting, testing, checking or otherwise determining and documenting whether items, processes, services or documents conform to specified requirements.

consequential (or significant) event. An event which has significant measurable adverse effect or result in a key performance measure and which requires root cause investigation.

corporate groups. Departments at corporate headquarters whose function is to support plant operations through the provision of services.

corrective action. Action taken to correct the root cause of an identified deficiency.

cost-benefit analysis. Evaluation of a proposed course of action to assess benefits versus costs.

critical component. Those components, any failure of which could limit the life of the entire plant. They cannot be easily or cheaply replaced, and sometimes cannot be replaced at all.

customer. The organizational unit which defines the item or service to be produced in terms of function, quality, timing and cost, and also has the resources to pay for it.

design authority. A senior person — usually the engineering manager — who has the authority to render engineering decisions and judgements at the plant.

design basis accident. An open-ended set of postulated events and combinations of events against which the design of a nuclear plant can be tested in order to demonstrate that it meets the public safety criteria.

design basis configuration. A set of up-to-date documentation depicting the condition of the plant as designed and incorporating all subsequent modifications.

discovery work. Unexpected work discovered during an outage as the result of inspections or opening up equipment.

empowerment. Having the power to make important decisions which affect the way in which the work of an individual or a team is being done

equipment qualification. A programme to ensure that equipment as installed in the plant satisfies the applicable mandatory quality requirements, e g "nuclear class equipment" See Section 3 4

field. Areas in the power plant where equipment is located, as distinct from operating, technical and administrative offices

"fire fighting". A colloquial expression indicating a continuous state of crisis and moving from one urgent matter to the next, without taking the time to permanently resolve any of them

graded quality requirements. Specific QA requirements reflecting planned and recognized differences in quality for each identified item, service and process

human performance factors. The physical characteristics of the work place and psychological influences on workers, which affect their performance

incident. A "level 2" event as measured by IAEA's INES event scale, defined as "event with significant failure in safety provisions but with sufficient defence in depth remaining to cope with additional failures"

INPO. Institute of Nuclear Power Operations, based in Atlanta, Ga , USA

integrated maintenance planning. A planning process where all maintenance and testing requirements of equipment are integrated and co-ordinated in a way to minimize duration of equipment outage

interface. A common boundary between two departments at which co-operative interactions are required between two or more organizations in order to execute an activity

mentor. A senior, experienced individual charged with overseeing, guiding and advising on progress of a junior individual

networking. Process of establishing contacts with individuals for the purpose of future co-operation, exchange of information and working partnerships

on-condition maintenance. Maintenance based on measurement and analysis of equipment condition so that corrective action can be taken in advance of breakdown

operability determination and operability evaluation (OD&OE). Term used to describe the daily interaction and oversight of operations by the TS

operational limit. Amount of radioactivity or contamination in or on an item established by the power plant for the purpose of controlling, with a margin of safety, the unconditional release of items "Operational limit" is always smaller than "exempt quantity"

operational limits and conditions. The set of rules which set forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the Regulatory Body for safe operation of the nuclear power plant

ownership. Of a process or equipment means assuming personal or team responsibility for the results of a process or an operation, and being proud of it

peer evaluation. Performance based evaluation of a plant conducted by a group of peers from another plant in the utility or from other utilities. A form of corporate self-assessment.

performance measure. Quantitative (numerical) measurement of output of a process which indicates the degree of success with respect to achieving its objective.

plant design life. The assumed number of years of plant operation, used as the basis for plant design.

preventive maintenance. Scheduled actions routinely taken to prevent equipment breakdown.

pro-active mode. A mode of management which defines its priorities (agenda) and actively pursues them.

procedure-maintenance process. Assures that procedures are kept in step with activities, as they change due to improvements to process and modifications to equipment. The process centres on scheduled reviews of procedures by TS and operations.

qualified person. A person who, having complied with specific requirements and met specified conditions, has been officially designated to discharge specified duties and responsibilities.

quality management. A process for determining and implementing the quality policy.

"quick fix". A colloquial expression referring to an attempt to solve a problem by addressing the symptoms without analysing the cause.

reactive mode. A mode of management which responds to pressures from others and does not impose its own agenda.

reliability-centred maintenance. Approach utilizing systematic evaluation for developing and optimizing the maintenance requirements of equipment according to the safety and operational consequences of failure and the degradation mechanism responsible for it.

risk. The product of the probability of the occurrence of an event and the magnitude of the consequences resulting from the event.

risk model. A probabilistic model of plant's responses to various operating configurations, used in assessing the risk involved in operating under stipulated conditions.

root cause. The fundamental cause that, if corrected, will prevent recurrence of similar event or adverse condition.

rotation of duty. Routine rotation of equipment status between stand-by and operation, to equalize wear among identical pieces of equipment.

safety culture. The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear safety issues receive the attention warranted by their significance.

Self-assessment. Output of an individual or organization by that individual or that organization itself.

soft skills. Interpersonal skills which relate to dealing with individuals and groups with respect to influencing their behaviour or attitudes.

systemic factors. The way the management organizes, plans, controls and provides for safety and quality.

threshold event. An event which triggers root cause analysis, as per previously determined criteria.

user friendly. Documentation (procedures) which is (are) designed and laid out to maximize error free ease of use.

verification. The act of reviewing, inspecting, testing, checking or otherwise determining and documenting whether items, processes, services or documents conform to specified requirements.

WANO. World Association of Nuclear Operators, based in London, UK.

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