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Best Practices in the Utilization and Dissemination of Operating Experience at Nuclear Power Plants

IAEA
International Atomic Energy Agency

March 2008

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FOREWORD

IAEA Safety Standards Series No. SF-1 entitled Fundamental Safety Principles: Safety Fundamentals states the need for operating organizations to establish a programme for the collection and analysis of operating experience in nuclear power plants. Such a programme ensures that operating experience is analysed, events important to safety are reviewed in depth, lessons learned are disseminated to the staff of the organization and to relevant national and international organizations, operating experience is utilized and corrective actions are effectively implemented.

This publication has been developed to provide advice and assistance to nuclear installations and related institutions, including contractors and support organizations, to strengthen and enhance their own feedback process through the implementation of best practices in the utilization and dissemination of operating experience and to assess their effectiveness.

Dissemination and utilization of internal and external operating experience is essential in supporting a proactive safety management approach of preventing events from occurring. Few new events reveal a completely new cause or failure mechanism. Although not recognized prior to the event, most subsequent investigations identify internal or external industry operating experience that, if applied effectively, would have prevented the event. Therefore, the establishment of an effective utilization and dissemination process is very beneficial in raising awareness of the organization and individuals of available operating experience, and focussing effort in the implementation of the lessons learnt. This leads to improved safety and reliability.

The present publication is the outcome of a coordinated effort involving the participation of experts of nuclear organizations in several Member States. It was written to complement the publication IAEA Services Series No. 10 entitled PROSPER Guidelines — Guidelines for Peer Review and for Plant Self-assessment of Operational Experience Feedback Process and it is intended to form part of a suite of publications developing the principles set forth in these guidelines. There are also other publications in this, namely IAEA-TECDOC-1477 entitled Trending of Low Level Events and Near Misses to Enhance Safety Performance in Nuclear Power Plants and IAEA-TECDOC-1458 entitled Experience in the Development of Effective Corrective Actions to Enhance Operational Safety of Nuclear Installations.

The IAEA wishes to thank all participants and their Member States for their valuable contributions. The IAEA officer responsible for the preparation of this publication was F. Perramon of the Division of Nuclear Installation Safety.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. Background

Few events occur today that reveal a completely new cause or failure mechanism. Although not clear during an event, most investigations find that internal or external industry operating experience (OE) was available which, if used effectively, could have prevented the event. In fact, a station manager provided the following comments concerning a recent event at his station:

"This event was preventable, had we correctly applied previous operating experience. Perhaps, because of the design basis of our system, we were too narrowly focused in the past when reviewing our plant for vulnerabilities. This illustrates why the best use of operating experience is to look for similarities that could apply to your plant, rather than for differences that should lead you to screen the experience out."

Experience has shown that the use of operating experience does not always require a lot of resources. Continuous improvement requires more management and personnel commitment than resources.

IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles: Safety Fundamentals [1] states the need for operating organizations to establish a programme for the collection and analysis of operating experience. Such a programme ensures that operating experience is taking into account, events important to safety are reviewed in depth; and lessons learned are disseminated to the staff of the plant and to relevant national and international organizations.

IAEA Safety Standards Series No. NS-R-2, Safety of Nuclear Power Plants: Operation [2] establishes in paragraph 2.22 that the operating organization "shall obtain and evaluate information on operating experience at other plants to derive lessons for its own operations" and in paragraph 2.25 that the plant management "shall maintain liaison as appropriate with the organizations (manufacturer, research organization, designer) involved in the design, with the aims of feeding back information on operating experience and obtaining advice, if necessary, in the event of equipment failures or abnormal events".

IAEA Safety Standards Series No. NS-G-2.11, A System for the Feedback of Experience from Events in Nuclear Installations [3] states in paragraph 2.8 that "an effective system for the feedback of operational experience relating to safety should cover…dissemination and exchange of information, including by the use of international systems".

Effective use of operating experience, both internal and external, requires analysis to identify fundamental weaknesses in the plant organization, equipment (structures, systems and components), procedures and human performance, and then identification of appropriate station specific corrective actions that will minimize the likelihood of similar events occurring at the station. Once the fundamental weaknesses are identified the OE must be disseminated in a timely manner both internally and externally and utilized in order to prevent recurrence of the problem.

Every nuclear utility/NPP has its own OE process. This OE process encompasses internal and external experience and is able to incorporate the consequent lesson learned, in order to enhance the operational performance of the plant. Figure 1 shows a flow chart of a typical OE process.

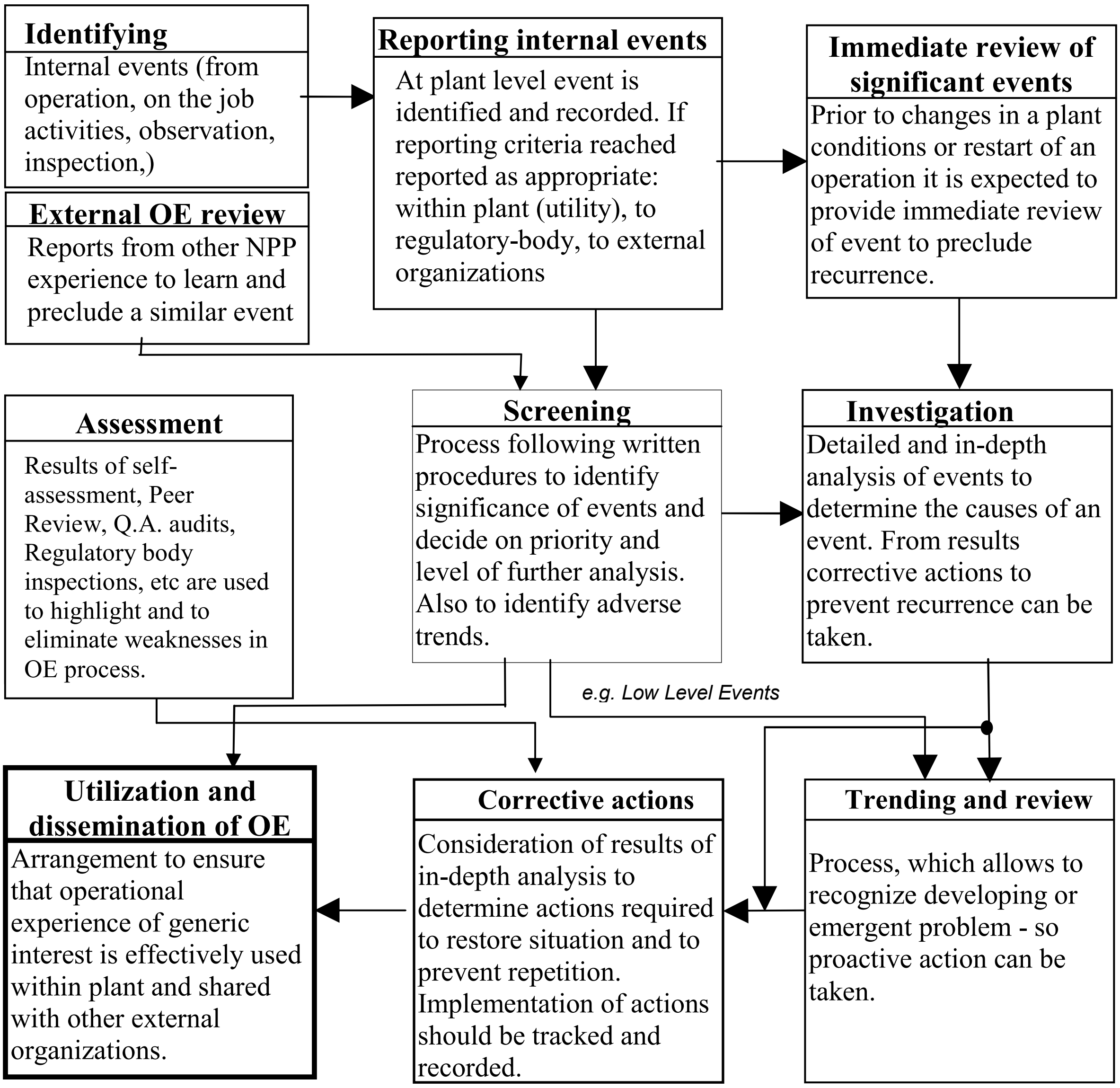


Fig.1. Flow chart of a typical OE process.

In order that the OE process of the NPP is effective, a set of key activities has to be carried out (Fig. 1). Each of these activities is regarded as essential and the OE process will not be effective if any one of them is omitted or inadequately performed.

The effective use of operating experience is substantiated through the two final steps of the process: the implementation of the corrective actions and the utilization and dissemination of the lessons learned. The implementation of the corrective actions is addressed in IAEA-TECDOC-1458 entitled Effective Corrective Actions to Enhance Operational Safety of Nuclear Installations [4]. The present publication addresses the area of utilization and dissemination of the lessons learned and focuses in the effectiveness of this particular area. This publication describes best practices regarding utilization and dissemination of operating experience of generic interest so that it is effectively used within the plant and shared with other external organizations.

For the purpose of this publication:

- Dissemination of OE includes not only the distribution of the information but also the measures to ensure the usefulness, understandability and retrievability of the information by the end user.
- Utilization of OE includes all the activities that ensure the awareness of the individuals and organization of the lessons learned and the application of these lessons into the activities of the facility/organization.

Inputs to the process of dissemination and utilization are the OE publications generated in the reporting, screening and investigation processes. Thus timely reporting, screening and analysis of OE will be key factors to improve the results of the dissemination and utilization processes. Also the quality and effectiveness of the dissemination and utilization process will strongly depend on the senior management support, the individuals who lead the process, the resources provided, ease of access to information and the acceptance of the process by managers and workers.

The present TECDOC forms part of the suite of publications developing the principles set forth in the PROSPER guidelines.

1.2. Objective

This publication has been developed to provide advice and assistance to nuclear utilities, individual nuclear plants and other relevant institutions, especially to support regulatory organizations, vendors, owners groups and contractors, fuel fabrication facilities and research reactors to strengthen and enhance their own OE feedback process through the implementation of best practices in the dissemination and utilization of operating experience in order to improve overall nuclear safety, radiological safety, industrial safety and operational reliability.

The purpose of this publication is to provide guidance, recommendations, suggestions and good practices in developing and implementing effective dissemination and utilization of operating experience to ensure continuous performance improvement, event prevention and to assess the effectiveness of the above areas during the lifetime of the plant. It is recognized that alternative means may exist and that an organization might effectively achieve this overall performance objective without meeting some or part of the specific criteria, attributes or practices described in the present publication.

1.3. Scope

This publication was written to complement IAEA Services Series No. 10, PROSPER Guidelines — Guidelines for Peer Review and for Plant Self-assessment of Operational Experience Feedback Process [5]. This publication explains the importance of the effective dissemination and utilization of lessons learned from operating experience and the ways to use and share event information and good practices.

This publication is not intended to cover other relevant stages of operating experience programme such as identification and reporting, screening, investigation and analysis, trending and review, and corrective actions, etc. (see Fig.1).

1.4. Essential management characteristics

A primary responsibility of management is to develop a culture and establish an organization to disseminate and utilize operating experience (OE). The operating organization has the responsibility to assure that operating experience is used effectively to promote safety within his organizations and installations. OE information is considered beneficial and is a vital component for top safety performance in all areas of station operations.

Managers are committed and remain aware of the station efforts to disseminate and use operating experience. Management consider the following:

- Type and scope of OE information provided to personnel. (For the purpose of this publication personnel includes all utility and contract personnel working for the utility.)
- Timeliness of operating experience dissemination/availability both internal and external.
- Frequency of occurrence, applicability and safety significance of OE.
- Results of operating experience reviews and its effectiveness.
- Benefits obtained from the use of OE.

While the overall responsibility for the OE remains at the top-level management, the accountability for the effective dissemination and utilization of operating experience information at the work place belongs to facility line managers. See Section 2.1.a for line managers' responsibilities.

An operating experience programme cannot be fully effective unless it includes worldwide operating experience. For that reason it is essential that both the regulator and operator have access to international information sources. The activities and reports that may be performed by these sources are a supplement but not a substitute for individual operating plant programmes. The regulator should be aware of these reports and those of other industry and government organizations, and of the lessons learned.

Regulatory bodies and owners groups can make a significant contribution to promoting safety by making the results of its collected operating experience widely available throughout the nuclear industry, both nationally and internationally. Of course, the procedure must provide for protection of proprietary, confidential and sensitive security information.

An effective operating experience programme relies on certain essential characteristics that provide support and enhance programme effectiveness. The main characteristics related to the dissemination and use of OE is highlighted in the following paragraphs.

1.4.1. Overall characteristics

The dissemination and use of OE process will not be effective unless the following overall characteristics are adequately addressed:

- Policies are established by management to align the organization to effectively implement the process and to establish expectations and priorities.
- Structure of organization ensures effectiveness of the OE process.
- Appropriate resources (personnel, equipment, funds) are allocated by the management to streamline the process.
- Management of the process is focused on improvement of plant safety, reliability and performance.

- Events and issues are reported in a timely manner and the OE is recorded properly so as to ensure that learning opportunities are clearly identified, can be extracted and followed through.
- Information dissemination is sufficiently comprehensive so that no relevant data is lost. The cumulative effect of the related/relevant OE is disseminated and utilized.
- OE information is widely distributed to personnel.
- OE information is shared with the industry in a proactive and timely manner.
- Applicable external OE is made available to the organization, including both deviations and good practices, in a manner that makes it easily retrievable and usable.

The benefits of a good OE dissemination and utilization process include:

- Personnel awareness of the OE information that could result in a reduction of events and their significance.
- Identification of areas for improvement.
- Willingness of the organization to report problems.
- Transparency and willingness of management and personnel to share the internal OE within the organization.
- Consideration of external experience for the performance improvement.
- Feedback to facility personnel on the value of their input. This helps to encourage the organization to report.

Some barriers have to be taken into account in order to adequately disseminate OE. These are:

- Lack of timeliness in dissemination of information, both internally and externally.
- Lack of resources to support information dissemination.
- Fear of misuse of the internal OE by external agents.
- Tailoring the OE reports to the audience that will receive the information, e.g, operators, maintenance technicians, chemistry technicians, etc..
- Confidentiality and proprietary information.
- Conflict of interest between different internal and external organizations.
- Plant isolationism.

Some barriers have to be taken into account in order to adequately utilize OE. These are:

- Overconfidence that some external events cannot happen to us, based on things such as plant age, design and past operating success.
- Need to translate information into a language that is understood by personnel.
- Information overloading on personnel.
- Insufficient quality or complexity of information.
- Potential misleading information.
- Lack of resources to support information utilization.
- Differences in plant design.
- Process too cumbersome or not effectively aligned and streamlined.
- Difficulty to retrieve OE information in a timely fashion.

The following factors can contribute to better disseminate and utilize the OE information:

- The use of information technologies: intranet, corporate and plant databases, electronic publication filing systems, electronic mail, etc.
- The use of OE information available on nuclear safety regulatory bodies websites.
- Cooperation with national and international organizations, such as national institutes, research organizations, WANO and IAEA.
- A culture of transparency and blame-free environment.
- The establishment of communities of practice to share experience. (community of practice is a group of individuals from different organizations that share an interest and knowledge in a specific area.)

The management of the facility ensures that these barriers and contributing factors are addressed and that a satisfactory OE utilization and dissemination process is established. To evaluate how mentioned barriers and contributing factors are addressed, an assessment to review their effectiveness is carried out periodically.

1.4.2. Role of management

Management at all levels demonstrat ownership for the dissemination and use of OE process by directing, promoting, prioritizing, and sufficiently staffing programme activities. Programme success depends, in large part, on the leadership shown by management.

Management decisions regarding the dissemination and use of OE are driven by safety as a first priority and are a balance between the search for improvement, the timeliness of the process, resource allocation considerations, and overload of information. The most effective balance depends largely on the continuous improvement programme strategy and focuses on the actual needs and the effectiveness of the progress. Management periodically review this balance and adjust the programme as needed. Care is always exercised to ensure that this balance does not prevent management from providing the necessary resources for the OE programme, so as to meet the management objectives of safety receiving the overriding priority.

Management and personnel recognize that minor OE issues/problems are often precursors or contributors to more significant events. Consequently, the dissemination and use of OE includes lower level events and near misses. However, at this level the particular management effort is mainly focused on trends that detract from safe and reliable plant operation.

Management encourages dissemination of OE related to human errors. Weaknesses in these areas are influenced by safety culture.

To best ensure that the plant arrangements meet international standards and good practices, management promotes benchmarking and peer reviews in order to compare actual performance with the best performance and practices in the industry.

2. DISSEMINATION OF OPERATING EXPERIENCE

The objective of disseminating OE information is to facilitate the following:

- For operating organizations or licensees to be able to enhance the safety of the plant by implementing the applicable corrective actions as derived from operating experience;

- To improve the understanding by the operating personnel of the operating conditions and response characteristics of the plant;
- To enable the regulatory body to be informed on safety conditions of the nuclear installation;
- To enable the vendors to be able to improve their design and manufactured products by taking into account lessons learned;
- To enable contractors providing services to be better prepared so as to anticipate potential problems;
- To enable research establishments to prioritize research and to provide an additional means of improving their knowledge, which may be of help to the operating organization of the nuclear installation.

Any plant that promotes a learning culture and develops an OE programme has to find ways to efficiently incorporate OE information into line activities. The methods outlined in the next paragraphs are derived from the best industry practices, but they are not necessarily the only methods available. Each organization can adopt any programme that has chances to be successful within the existent culture.

The most common methods used to disseminate information include:

- Training activities;
- Just-in-time information;
- Pre-job briefing;
- Shift briefings;
- Regular meetings;
- Station publications, highlighting industry and facility OE information;
- Posting of industry and station OE on electronic bulletin boards and e-mail;
- Operating experience notebooks;
- Utility periodic reports of OE addressed to other facility within the utility or to external organizations;
- Using WANO/IAEA/utility websites and data base;
- Networks established through communities of practice sharing information;
- Information from and to the designer/vendor, if applicable.

Dissemination of OE includes both the dissemination of internal and external OE and the external dissemination of the in-house OE. Nuclear installations such as NPPs are already obliged to report to the regulatory organizations certain levels of events. For this purpose, operating organizations fulfil the reporting activities in accordance to the nuclear regulatory requirements and with a consistent format and level of detail. The present publication is not intended to address the practices for the required reporting to the regulatory bodies. These practices can be found in the respective regulatory guidelines.

In the dissemination process two main aspects to be considered are the Characteristics of the information and the Individuals who will be using the information.

Characteristics include but are not limited to:

- Accuracy of the information;
- Completeness of the information;

- Understandability of the information;
- Friendliness of the presentational methods such as operator aides, tables, charts, drawings, etc.

Individuals include but are not limited to:

- Facility personnel;
- Regulatory body;
- Contractors;
- Vendors/ designers;

Since many organizations are outsourcing more activities, the dissemination of the OE information to the organizations providing resources or services is critical.

2.1. In-house dissemination of OE

OE information is used at any level in the organization and in all areas of activity of the plants.

Appendix X provides an example of an in-house OE information processing and dissemination flow. The purpose of this example is to illustrate a typical participation and interfaces between the nuclear power station and the corporate organization in the dissemination of OE. The participation and interfaces in place may vary depending on the organizational culture and management structure of the plant and the company.

Following are some of the most common applications for in-house dissemination of OE:

a) Line management

Each line manager has the following responsibilities related to dissemination of OE:
- Participate in the operating experience review process;
- Distribute appropriate OE information to department personnel for review and dissemination to the workers;
- Conduct and publication structured work group discussions;
- Determine frequency, training method, and setting for departmental OE information training;
- Provide feedback to the training department on training effectiveness and additional training needs;
- Assist the training department in developing case studies or identifying training material for training on selected events;
- Incorporate OE information into the daily activities.

b) Just-in-time OE information

Line management is responsible for ensuring that prior to performing a significant or high-risk activity, the operating crew and other plant personnel involved are given evolution specific OE information to ensure they fully understand and appreciate the procedures and risks associated with this activity (Appendix II contains an example of just-in-time OE information). For some highest risk activities, additional compensatory measures are taken in some plants.

c) Incorporating OE into regular training

The training department in cooperation with the operating experience group (OEG) and line organizations provides the following:

- Identify OE information for inclusion in the training programme;
- Analyse lessons learned and compare them to tasks, skills, and knowledge items included in existing training programmes;
- Develop training objectives using lessons learned from the applicable operating experience;
- Determine appropriate training methods and settings;
- Schedule and conduct training;
- Evaluate training effectiveness and revise as necessary;
- Review, modify, and develop initial and continuing training material to incorporate operating experience lessons learned;
- Develop case studies for structured discussions by work groups;
- Conduct training on selected operating experience information and help other groups conduct this training.

When selecting OE information to be discussed in training, a combination of internal experience and applicable industry OE is considered. Some external OE issues that generally apply to all plants are as follows:

- Reactivity control;
- Decay heat removal disturbances;
- Personal, industrial, and radiological safety events;
- Switchyard and electrical distribution events;
- Equipment failure events;
- Foreign material intrusion events;
- Conservative decision-making;
- Teamwork;
- Procedure error events;
- Fundamental knowledge weaknesses;
- Misalignment events;
- Tagging errors;
- Wrong-unit/wrong-train events.

Training includes dissemination of good practices. Training activities ensure that personnel learn how to implement specific good practices and are aware of the advantages and benefits of their implementation

The training department selects the appropriate training methods and settings:

- Classroom lectures;
- Simulator exercises;
- Mock-up/laboratory exercises;
- Industry events discussion;

- On-the-job training and evaluation;
- Required reading.

d) Shift briefings

The Shift Supervisor is responsible to ensure that shift briefings occur. These briefings provide a good opportunity to discuss relevant operating experience concerning an actual event or an upcoming evolution before personnel assume a shift, such as:

- How the same type of OE (internal or external) can influence operations;
- What the shift crew can do to prevent that type of OE;
- What kind of barriers that are intended to prevent this type of OE;
- What they can do if that type of OE occurs.

e) Planning and pre-job briefings

The assigned supervisor is responsible for ensuring that the work package contains operating experience information and that pre-job briefings occur. The OE staff might attend these briefings.

In some organizations the planning personnel incorporate existing OE information into the work package. For this purpose the relevancy of OE information and precautions is highlighted. This information is then taken into account when scheduling the upcoming work and identifying key activities for pre-job briefings. Examples of this kind of OE information are included in Appendix III to V.

Lessons learned from execution of these activities are identified during post-job briefings and incorporated into the OE process.

f) Other briefings to prevent events

Management ensures that station personnel are periodically informed on in-house and industry OE. Briefings to prevent events have proven to be an effective tool for the utilization of OE. Key aspects of OE are continuously communicated to personnel especially those who actually operate and maintain plant systems, through various means such as:

- Plant management briefings;
- Daily management meeting station minutes;
- On-the-job training sessions;
- Operations crew briefing for an upcoming evolution;
- Developing briefing material for outage evolutions;
- Craft information meetings pre-job briefings and post-job briefings.

Weaknesses and strengths in personnel knowledge, policies, procedures, specifications, or design that are identified during these briefings and reviews are given as a feedback to the appropriate department through the deficiency reporting process.

g) Key activities notebooks

Some stations have prepared notebooks (“notebook” does not necessarily refer to a physical notebook but refers to a collection of accessible information) containing applicable OE information that relates to specific key activities, such as mid-loop operations or low-power operations

These notebooks are developed to provide easy access to internal and external OE related to the specific subject or activity. The notebooks are readily available to managers and work group supervisors, and management strongly encourages the use of these notebooks prior to the performance of an activity. The notebook is also useful to enhance the utilization of the operating experience when planning for contingencies.

Experience has shown that the development of key activity notebooks to support the performance of some tasks and evolutions provides critical insight into the potential problems that may be encountered prior to and during the task performance. Entries in the key activities notebook may be applicable to the performance of several tasks, in which case the entries are cross-referenced to other related notebook activities.

Examples of activities that may be covered by key activity notebooks are:

- Conservative reactivity and power management;
- Avoiding losses of decay heat removal;
- Personal, industrial, and radiological safety;
- Low-power operations;
- Reactor water level control including mid-loop operation and operating at reduced inventory;
- Shutdown operation;
- Plant startup;
- Fuel movement;
- Nuclear instrumentation calibration;
- Supervisory oversight;
- Teamwork;
- Outage activities;
- Controlling contractors;
- Clearance and tagging;
- Control of special tests;
- Effective feedwater control;
- Restoring plant system to proper configuration;
- Temporary modifications;
- Work package planning;
- Event reconstruction.

h) Use of internal communication means

Many facilities use additional communication means to widely disseminate OE information, such as internet, intranet, visual supports, internal publications, and various types of bulletin boards.

These means are also used to disseminate OE information even before the corresponding analysis is fully completed, for immediateness.

Displays are also used to post the OE information together with the affected materials, parts and equipment to visually show the anomalies, recognize the deficiencies and be aware of the potential consequences.

2.2. External dissemination of OE

Operating organizations provide OE information to different external organizations or bodies. Some of these reports are stipulated by national legislation, such as reporting operating events to regulatory bodies. Other information comes out from an involvement of operating organization in different bilateral, national, regional or international programmes.

Appendix XI provides an example of an external OE information processing and dissemination flow. The purpose of this example is for information only to illustrate a typical participation and interfaces between the nuclear power station and the corporate organization in the dissemination of OE. The participation and interfaces in place may vary depending of the organizational culture and management structure of the plant and the company.

The thresholds for disseminating are mutually defined in the agreements. As a general rule, an overall criterion to determine if an in-house event should be shared externally is to consider if your own plant would have liked to be informed and learn from it in case the event would have happened at another plant.

In addition to regulatory bodies, some of the more significant recipients of OE information are given below:

a) IAEA and OECD/NEA Incident Reporting System (IRS). Reporting is performed through a national coordinator (typically an individual within the structure of the regulatory authority). The good practice is that before reporting an event to this system, the national coordinator sends the report to the operating organization for review and approval.

b) WANO OE database. Criteria for reporting operating events are set in the WANO guidelines. Typically the reporting is performed via a WANO interface point of contact.

c) INPO OE network SEE-IN (Significant Event Evaluation and Information Network).

d) Sharing OE information with other nuclear industry bodies. Operating organizations usually exchange OE information with other utilities or facilities, within the owners group, with vendors, technical support organizations and so forth. Extend and form of the OE exchange depends on the plant design, national or regional experience or needs. Based on the international practice, operating organizations are encouraged to be very open and communicative on sharing OE information, and so contributing to a learning environment.

e) Communities of Practice – individuals from different organizations that share an interest or knowledge of a specific area and set procedures for mutually sharing OE in this area (web sites, conferences, workshops, etc.).

Special care is taken to prepare the OE publications to be disseminated externally in a way that they are understandable by a variety of final users. This requires the avoidance of acronyms and the use of broadly accepted terms. Also the quality of the publications is controlled to ensure that the information provided is sufficiently comprehensive in a way commensurate with the timely of reporting. Typically a prompt initial report with the direct cause and the consequences is developed into a comprehensive report, within a specified timeliness, including the results of the analysis, safety assessment, root causes, lessons learned and corrective actions.

3. UTILIZATION OF OE

The purpose of the OE utilization process is to continuously apply the lessons learned from station/utility OE and industry to improve plant safety and reliability. The goal is that the OE is recognized by personnel at all levels as helpful and important, and lessons learned are used at every opportunity.

The primary objective of assessing OE is to identify and transfer lessons learned from one individual or station to another. Experienced utility/station personnel screen through multiple sources of experience for applicability, significance, and the potential that a similar OE could occur at the station.

The screening process selects the issues requiring more in-depth evaluation to identify and implement effective corrective actions (see IAEA-TECDOC-1458 [4]). As a result the nuclear industry continually generates information about station events and other information relevant to OE, including good practices that can be used in the improvement of activities and to avoid recurrence of events.

Experience has shown that the causes of minor events and near-misses that do not significantly impact operation (such as a promptly identified miss-positioned valve) are similar to the root causes of significant events that result in transients (such as scrams, feed water upsets, and safety system malfunctions). Therefore, it is also desirable to utilize the identified results from minor event trending analysis to correct weaknesses to prevent significant events. (see IAEA-TECDOC-1477 [6]).

Data on OE collected and used in facilities is retained as input for safe operation, the management of plant ageing, evaluation of residual plant life, probabilistic safety assessments and periodic safety reviews.

In the best performing utilities, managers have defined clear expectations regarding the use of OE. Individuals are aware of all the sources of OE information available in their plant/utility and have the skills and necessary training to obtain and utilize this information as needed.

Processes, programmes, procedures and instructions that define how the station uses the OE mainly include the following:

- Responsibilities and authority of involved organizations and personnel;
- Interfaces among station, corporate organizations, contractors, regulators and other related organizations;
- Methodology for effective and timely use of OE;
- Event information exchanges within the industry in a timely manner;
- Outside organizations, as soon as practical following a severe, unusual, complex, or recurring event;
- Understanding and incorporation of lessons learned into appropriate station programmes and processes;

- Expectation to review OE information prior to preparing work packages and during pre-job briefings;
- Assignment of station resources to readily obtain operating experience information;
- Methodology for monitoring the effective implementation of the lessons learned and to verify the short and long term effectiveness of the corrective actions;
- OE reviews, (performance indicators);
- Periodically assessing the OE programme;
- Utilization of OE methodology for management, human performance and operations performance.

As a result of an effective utilization of OE the station can expect continuous improvements in these main areas:

- Plant structures, systems and components;
- Procedures;
- Organization (e.g. structure, processes, activities);
- Human performance;
- Decision making process.

Experience shows that effective utilization of OE does not always require the involvement of significant financial resources, in the sense that many OE actions and lessons learned, particularly those related to human performance and attitudes in individuals and organizations, are mainly dependant of management commitment, clear communication of management expectations and continuous example by the management.

3.1. Utilization of OE to improve plant structures, systems and components

The design studies for new plants use lessons learned from other plants OE. The results of the OE review are provided to the designers and is later verified that the OE has been incorporated into the new design.

The design studies for modifications of operating units also use lessons learned from OE.

Examples of studies where OE is integrated include:

- Periodical plant structures, systems, components and their functions reviews;
- Equipment safety and reliability reviews;
- Systematic review of specific issues (valve mispositionning, labelling errors);
- Technical or engineering reviews;
- Periodic safety reviews;
- Deterministic risk analysis;
- Probabilistic risk analysis (adjusting modes of failure, failure rates, etc);
- Safety analysis review either by regulatory bodies, operators or technical support organizations.

Whenever practicable the modifications are systematically validated on one unit using the concept of pilot plant before generalization to others units.

OE is also used to improve operability, surveillance, maintainability and inspectability of the plant. By taking into account the significant events and the low level events that occurred, as well as good practices, the plants are designed or modified, and lessons learned are adapted, to avoid the events and facilitate the operation and maintenance tasks, including surveillances and inspections.

3.2. Utilization of OE to improve procedures

The procedure development instructions (procedure on how to prepare procedures) contains references to the review of OE prior to writing the procedure, including lessons learned and good practices.

Operating experience is introduced in the procedures at every time that a new procedure is prepared. The plant departments receive prompt information of the OE through the dissemination activities. The data base is screened to select the relevant OE to be included in the procedure. The applicable OE used to develop the procedure is highlighted in the references of the procedure, in a similar way as the codes, standards, and regulations.

Additionally, during periodic procedure review, the available OE internal and external on the subject of the specific procedure, as well as cross sectional generic lessons learned, is reviewed to select new OE available since the last revision and to identify potential areas of improvement. Lessons learned and good practices are thus systematically integrated when the procedures are periodically revised.

For large organizations a dedicated group of corporate personnel analyse all the OE and systematically integrates internal and external OE into corporate policies and procedures, ensuring standardization and harmonization of policies and procedures across the fleet.

3.3. Utilization of OE to improve organization

3.3.1. Organizational structure

Operating experience trending analysis and assessments are used to identify latent organizational weaknesses that might be further assessed through larger integrated periodic organization reviews. As a result weaknesses such as overlapping or unclear responsibilities, inconsistencies or gaps in interfaces, need for additional staffing or qualifications, or need for reallocation of resources may be identified

This applies to the organization structural departments organized by disciplines such as operation, maintenance, engineering, technical support, fuel management, chemistry, radioactive waste, radiation protection, quality assurance, training, emergency preparedness, plant security.

The use of OE is of particular importance in the cross sectional activities directly related to safety, such as:

- Fire protection;
- Industrial safety;
- Risk management;
- Configuration control;
- Work management;
- Safety culture;
- Human performance;
- Self evaluation;
- Ageing management/ life extension;
- Strategic planning.

The use of OE is of especial significance in the high level organizational structures and advisory bodies related to oversight and/or safety review, such as:

- Corporate nuclear safety committee;
- Plant nuclear safety committee;
- Regulatory body review safety committee(s);
- Other committees (technical, industrial safety, etc.).

The utilization of OE in some of the above structural activities is further discussed in the corresponding chapter of the present publication.

3.3.2. Processes

Lessons learned from OE are integrated into the utility processes.

Examples of main overall processes established and controlled at a higher level by utilities, were OE plays a major role in constantly improving, are the following:
- Nuclear safety performance;
- Industrial safety performance;
- Radiological protection performance;
- Environmental performance;
- Overall plant performance;
- Taking advantage of the nuclear fleet effect (for utilities with several NPP units).

These overall processes are supported by departmental processes related to OE such as:
- Monitoring OE feedback programme and lessons learned;
- Ensuring the effectiveness of corrective actions;
- Motivation and improvement in human performance and human factors;
- Monitoring recurrent events.

Other processes are established to support the above, such as:
- Event based process (significant events, low level events, near-misses, early signals);
- Safety analysis of events;
- Regulatory body reviews and inspections;
- Corporate OE analysis and trending process;
- Potential sensible issues identification and anticipative approach and technical; challenges (to identify medium terms hazard for plant performance);
- Fast track experience reporting (to make a fact known rapidly to management or to other sites);
- Modifications (to introduce OE in modifications packages);
- Reliability centered maintenance and maintenance rule;
- Good practices, harmonization of practices and methods to take advantage of best practices;
- ALARA in radiation protection;
- ALARA in waste management;
- Overall environmental protection;
- International experience;
- Reports and indicators.

The utilization of OE in some of the above process activities (such as human performance, decision making process) is further discussed in the corresponding chapter of the present publication.

A high level "process owner" is nominated for the overall OE process, which has the strategic responsibility for the general organization of OE activities and the overall management of the OE programme. It is an experienced person, with recognized prestige within the organization, good knowledge of the organization, multidisciplinary background, motivation to enhance safety, quality and reliability, and a vision of internal and external relations.

A point of contact is nominated at the corporate level to promote and facilitate the communications with national and international organizations that are used as a source of OE information.

In addition, identified process coordinators are nominated for each sub-process and each in-house structural group/section. The coordinators are responsible to promote and ensuring the effective utilization of the OE within their respective processes. In many cases the same person is also the one nominated as point of contact coordinator within their own structural group/section.

The proactive utilization of OE in the form of antecedents and precursors as early warnings of declining performance is substantial in improving the plant safety and preventing events. Appendix I provide examples of these potential early warning flags.

3.3.3. Activities

The routine and non routine activities performed at the plant are one of the best opportunities to use record and disseminate OE. Examples of these routine and non routine activities are the following:

- Management oversight;
- Material condition review;
- Surveillance;
- In-service inspection;
- Regulatory body review and licensing;
- Regulatory inspections;
- Implementation of modifications;
- Plant walkdowns;
- Shift turnover;
- Transient evolutions;
- Spare and replacement parts quality and adequacy;
- Tagging protections;
- Plant labelling;
- Circuits and valves alignments;
- Work package planning;
- Work authorizations;
- Calibrations and set point adjustments;
- Handling operations;
- Training and qualification of personnel;
- Trouble shooting;
- Outage (planned and unplanned);
- Periodic safety review;
- Commissioning;
- Decommissioning.

All activities important to safety, reliability and availability are performed according to procedures. This is particularly important for the new, complex or special activities. The procedures are prepared, reviewed and approved taking into account OE events and best practices. OE has identified numerous weaknesses that have occurred during preparation and implementation of activities. As a result of the review of these weaknesses many routine activities are improved and formalized.

One of the main attributes for a successful preparation and implementation of routine and non routine activities is the identification and selection of related OE (previous events either one time or recurrent), the anticipation of the contingency situations, the constant awareness of what can go wrong, the self checking and the readiness for implementing mitigation or compensatory measures.

Daily and weekly plant meetings, either at the department, section or group level are also opportunities to discuss OE related to the subjects of the agenda. During these meetings operating experience information is examined with managers and applicable events are discussed. The lessons learned from these events are then distributed for utilization by the staff.

Managers consider the probability that similar events could occur and, if necessary, barriers and processes are analysed to determine the potential or actual weaknesses that may not prevent similar events. As a result, corrective actions are defined and their implementation and effectiveness is followed up.

3.4. Utilization of OE to improve human performance

Operating experience information is broadly used to improve human performance by making a comparison of lessons learned from OE regarding the skills and knowledge and attitudes of personnel. The OE information include but are not limited to: staff selection and training, retraining, personnel related issues, style of procedures, human factors and human-machine interface, verbal and written communications, visual graphics, work duration, physical, psychological and attitudinal issues.

Some examples of techniques and good practices, based on OE, to improve human performance are:

- Pre-job briefing;
- STAR (Stop, Think, Act, Review);
- Three-way communication;
- Self checking;
- Peer checking;
- Independent verification;
- Supervisor observation;
- Post job reporting and debriefing;
- Build in regular time-outs to capture learning and refine work plan;
- Just-in-time operating experience;
- Recognizing when getting into uncharted territory;
- Identifying and awareness of error likely situations;
- Improving work practices;
- Setting error barriers in the job from OE;
- Self-assessment, task improvement studies, etc.;
- OE in succession planning.

Training is one of the activities where OE is introduced in order to improve human performance. In-house and external OE and good practices are included in the training modules for the different disciplines, such as simulator training for operators, mock-up training for maintenance, interactive graphic simulator for design engineers, etc. The management of training department receive prompt information of the OE through the dissemination activities. Together with the plant and corporate line managers they select the relevant operating experience to be included in training.

The following are examples of training activities where OE is included:

- Class room training;
- Simulator training;
- Training in mock-ups;
- Case study training;
- On the job training;
- Required reading;
- Self pace training;
- Just-in time training.

Appendix 1 provides examples of potential early warning signs from OE that are useful to consider when improving human performance. Appendix VI provides examples of good practices for utilization of OE in human performance.

3.5. Utilization of OE in the decision making process

The utilization of OE is a key factor in the operational decision-making process. It helps to select the appropriate alternatives based on experience and identify the benefits and potential risk involved. It helps also to identify how everyone's subsequent actions (control room operators, field technicians, maintenance personnel, etc.) can impact plant safety and performance.

The decision making process is reviewed periodically by reviewing the decisions taken on significant events. The analysis is performed in a collective way by assigned management teams from station and corporate organizations. These analyses are focused on how the different operating aspects (basis, criteria, alternatives, and hypotheses), safety, radiation protection, availability, environment, and their respective weight (importance) in the final decision have been considered. It helps to identify the fundamental reasons that have been the key factors for these final decisions.

The review of OE allows the organization to:

- Obtain lessons learned from previous events and to implement necessary corrective actions as well as to adjust and improve the decision making process and mechanisms;
- Develop the questioning attitude within the team and to train the team on the decision making process;
- Enhance awareness of the risk linked to the decision making process;
- Record the experience on handling the key issues as a reference for future decision making needs.

3.6. Utilization of OE in plant and corporate nuclear safety committees

The nuclear safety committees are organized in accordance with an administrative procedure that defines the responsibilities, scope of the review, the nominated member participants and the formal agenda.

One of the responsibilities of the nuclear safety committee is the review of the OE. For this purpose the nuclear safety committee reviews the actual plant(s) organizational and operating performance since the previous meeting. The committee also reviews and discusses the evolution of the overall plant safety performance over a larger period, identifying and analyzing the issues of relevant interest in order to enhance the focus of the meeting in a proactive safety approach.

To this objective the following subjects related to OE are included in the agenda and discussed during the meeting:

- Significant events occurred since the previous meeting: a summarized description of the events is provided in advance to the members of the committee. The description includes the direct causes, the consequences, the second causes and the root causes (or potential root causes in case the event has not yet been fully analysed). A practical rule to prepare this summary is to describe the event, the consequences, if it is recurrent or similar to a previous event and the result of asking three consecutive times why it has occurred.

- Review of the incident analysis reports that have been completed during the period: this review includes the results of the investigation, the comprehensiveness and completeness of the full root cause analysis, lessons learned and the adequacy of the corrective actions.

- Trending review: in addition to the detailed analysis of significant events, the committee reviews the collective results of the events trending analysis to identify or recognize generic problems, recurrent or emerging. These can be substantial as early signs of declining performance or potential precursors of more significant events. By identifying and recognizing these issues proactive actions are implemented to recover the positive trends.

- The trending analysis considers the significant events as well as low level events and near misses. Low level events include also items such as failures, deficiencies, deviations, degraded conditions, non conformances, and quality deficiencies. A summary report of the collective trending study classified by technical, human, organizational and procedure issues, allow the committee to discuss the issues, to deepen the analysis where necessary, and to focus on the subjects according to their relevance as early signs of potential safety concern.

- Effectiveness of corrective actions: the committee reviews how effective the corrective actions have been in preventing the recurrence of events and improving the anticipated trends. For this purpose the committee is provided with information about which safety corrective actions have not resolved the issue (the problem persists) or relevant data demonstrating the lack of recurrence. This allows assessing the need of defining new corrective actions, additional measures or compensatory actions.

3.7. Utilization of OE to improve outages

An outage experience feedback system includes the review of own outage performance and evaluation of outage experience feedback from other plants. The post outage review provides important feedback for the optimization of next outage planning, preparation and execution. Benchmarking is a helpful tool for optimising outage performance.

Overall, the utilization of OE is focussed to support safe operation of the unit during the outage, smooth operation of next cycle, execution of the outage according to schedule and budget, good industrial safety and low collective dose. The utilization of OE involves also the contractors. During the everyday works the utilization of OE contributes to a proactive approach in the prevention of events, personnel injuries and material damage, and to fulfil the ALARA principles of radiation and environmental protection.

Key activity notebooks (see Section 2.1g) are often published to support the outages. The outage team identifies the main and high risk activities where lessons learned from OE should be applied. This information is used to develop specific trainings before the outage and to prepare briefing publications to be used by managers and operating shifts.

Events and good practices during outages are put in the OE database. The data base incorporates the lessons learned from the post-outage critiques. The lessons learned from the experience accumulated in the database are integrated in the preparation of outages and their implementation is verified during the risk analysis of the outage project.

Examples of good practices used for the planning and preparation of outages include the following:

- Selection and dissemination of external and internal operating experience relevant to the outage and ensuring these are considered in the procedures;
- Use of a milestone planning for the preparation that supports timely definition of the outage scope and predictability of the work scope;
- Checking for and reserving material, spare parts and consumables available on site well before the outage starts;
- Anticipation of unexpected problems which could impact safety, schedule and costs;
- Involvement of contractors from the early steps of outage preparation;
- Walk-downs of preparation team to overview the working place and early inspections of systems and components taking into account their related activities during the outage;
- Installation of easily removable insulation and permanent or temporary working platforms.

During the execution of the outage:

- The daily coordination meetings at department, section and group level are good opportunities to recall, discuss and utilize just-in-time OE and lessons learned from previous OE related to the works to be performed. Good house keeping, clean environment of the working places, foreign material exclusion and low dose rates are important prerequisites to ensure successful application of the OE in the daily works;
- The organization process is in place and ready to take corrective actions quickly when problems arise in areas such as nuclear safety, industrial safety and radiation protection. For this reason, a rapid feedback system is established to monitor the personnel performance and quickly identifying potential problems and contingency situations;

After the end of the outage, a review of the entire process is performed to assess the work done and provide feedback to further optimize the next outages. The experience report is disseminated to other plants and interested organizations of the utility.

For forced outages or unplanned outages it is equally important to implement the same safety and quality standards as during planned outages. Management ensures enough time to analyse shutdown causes, perform the safety evaluation and to develop a strategy to work out the unplanned outage taking into account OE.

3.8. Utilization of OE in the ageing management / life extension

Utilities have in place specific ageing management / life extension programmes that start with the design and construction phase through proper material selection and consideration of design features. During the operation phase the process is continued via periodic safety reviews, in-service inspection, monitoring of relevant parameters, operational modes and residual lifetime evaluation.

Mechanism providing an effective feedback of OE is in place for ageing management / life extension programmes to benefit from the use of both internal and external operating experience. These mechanisms are set up by defining and tracking the specific information required in the aforementioned areas, and disseminating this information to the corresponding users.

Typical data that is disseminated through the OE programme for use in ageing management / life extension programmes is data related to:

- Plant ageing;
- Material obsolescence;
- Lessons learned from long term behaviour;
- Experience on degradation mechanism;
- Relation between the age of the installation and their effect on safety;
- Organizational issues, succession planning and transfer of knowledge ;
- Combined effect of management, human performance and technical issues in the safety of the long term operations;
- Influence of the approach to decommissioning on the motivation of personnel.

This data is disseminated and used by means of the trending data on:

- Equipment reliability;
- Predictive maintenance programme and ISI results;
- Corrective maintenance and failure statistics;
- Recurrence of events;
- Frequency of replacement and repair activities;
- Comparison with other plants.

Utilization of this data is mainly to support decisions on long time operations. While many of the decisions for life management/life extension are related to economic viability, all are grounded in the premise of maintaining plant safety.

3.9. Utilization of OE in strategic planning

During the operation phase strategic planning for the management of the assets utilizes OE considering inputs such as those resulting from periodic safety reviews, in-service inspection, and assessment of reliability of equipment and installations, and residual plant life.

Typical data that from OE that is used for strategically planning is related to issues such as:

- Experience on national policies and utilities strategies;
- National and international OE, especially on significant events;
- Experience on technological advancements modernizations;
- Safety issues to be tackled;
- Additional safety analysis;
- Material obsolescence;
- Experience on degradation mechanism;
- Experience on organizational issues, succession planning and transfer of knowledge;
- Combined effect of management, human performance and technical issues in the safety of the long term operation;
- Experience in emergency planning, preparedness and exercises.

The data is disseminated and used by means of the trending data on:

- Equipment reliability;
- Predictive maintenance programme and ISI results;
- Corrective maintenance and failure statistics;
- Recurrence of events;
- Frequency of replacement, repair and rework activities;
- Results of quality assurance audits;
- Comparison with other plants.

Utilization of this data is mainly to support decisions on asset management to build up the Strategic Planning considering plant safety and economic viability

3.10. Other good practices to enhance utilization of OE

Appendix VII to IX provides examples of good practices to enhance the utilization of OE. These are:

- Use of the PDCA cycle to promote continuous improvement;
- Other experience exchange practices such as benchmarking, community of practice and appreciative enquiry;
- Examples of OE good practices identified during OSART and PROSPER missions.

Also, management systems are evolving from the classical compliance and quality assurance model to more comprehensive integrated management systems. In the new management developments and organization models the results achieved by the organizations, the organizational culture and the management processes are considered interrelated and are aligned to achieve higher levels of safety and performance results well beyond compliance. These new developments consider the utilization of OE as an essential part of the integrated management system.

4. EFFECTIVENESS REVIEW OF OE DISSEMINATION AND UTILIZATION

4.1. Self assessment

A self-assessment performed by the operating organization periodically reviews the effectiveness of the dissemination and utilization process. The purpose of the self-assessment is to recommend remedial measures to resolve any weaknesses identified and improve the process. Indicators of dissemination and utilization effectiveness are developed.

The assessment frequency is established based on management's concerns of programme effectiveness. A typical periodicity is annually.

Personnel familiar with the assessment of operating experience information perform the review of effectiveness. Consideration is given to using personnel from other stations or utilities on a reciprocal basis to assist the review.

If significant weaknesses are identified by the assessment process, consideration is given to benchmarking the dissemination and utilization processes against good practices in the industry. The results of benchmarking are utilized for further improving the process, if applicable.

The process of conducting the self-assessment of dissemination and utilization of OE is clearly defined and documented. It is to be carried out by monitoring of activities and evaluation of performance indicators related to the dissemination and utilization of OE. The scope of the self-assessment includes recent OE information from all sources regularly analyzed or used by plant personnel. It includes also the review of plant procedures, OE indicators, training documentation, corrective actions tracking logs and databases. Interviews are also used to conduct the self assessment. Appendix XII provides a list of questions for the self-assessment of the dissemination and utilization processes.

4.2. Performance indicators

A set of relevant performance indicators is developed by the operating organization to monitor the effectiveness of the dissemination and utilization of OE programmes. These indicators will provide a structural approach for the evaluation of the dissemination and utilization of OE programmes and give the operating organization the opportunity to assess the actions taken by dedicated personnel within the process as well as to understand strengths and weaknesses of the programmes.

Based on the dissemination and utilization OE processes designed for an organization the following typical indicators related to the dissemination and utilization could be applied to monitor its effectiveness. Examples of indicators are:

- Number of internal OE reports disseminated internally and to outside organizations;
- Number of internal OE reports communicated to regulatory body;
- Number of external OE reports disseminated internally;
- Number of recurrent events;
- Timeliness of communicating events to the in-house organization;
- Timeliness of communicating events to the outside organization;
- Number of good practices introduced to the organization as the result of external OE;
- Number of good practices disseminated to the organization from internal OE;
- Ratio of good practices disseminated that are effectively used.

These indicators are trended in order to identify the evolution of the performances. Nevertheless, management does not only rely on these indicators to assess the full picture of the utilization and dissemination process.

Appendix I

EXAMPLES OF OE EARLY WARNING SIGNS OF DECLINING PERFORMANCE

ORGANIZATIONAL level

- Complacency and lack of self criticism;
- Acceptance of low standards;
- Ineffective management oversight and monitoring;
- Production priorities;
- Ineffective managing of change;
- Ineffective use of OE and corrective actions ;
- Isolationism and lack of benchmarking;
- Long-standing problems;
- Ineffective training;
- Procedures not sufficiently used, adhered to, lack of or incorrect;
- Deficiencies in configuration control;
- Insufficient accountability;
- Insufficient resources.

HUMAN PERFORMANCE level

- Time pressure;
- Distractive environment;
- High workload;
- First time evolutions;
- Not following procedures;
- Insufficient briefing, vague or incorrect guidance;
- Poor communications;
- Verification and self-checking;
- Lack of questioning attitude and attention to detail;
- Cumbersome processes;
- Overconfidence and short-cuts.

TASK level

- Time pressure build in the tasks;
- Simultaneous work / multitasks;
- Repetitive actions / monotony;
- Change from usual way;
- Communications difficulties;
- Vague or incorrect guidance;
- Independent review not included;
- Configuration control deficiencies;
- Planner walkdowns not performed;
- Culture about procedure use;
- Confined space / cumbersome gear.

Appendix II

EXAMPLES OF UTILIZATION OF JUST IN TIME OE INFORMATION

Experience has demonstrated that prior to conducting specific safety related activities such as reactivity manipulations it is beneficial to review the relevant external and internal OE with the personnel involved in the activity and to provide the operating crew and other personnel involved of a summary of useful OE information. This information is often referred to as 'just-in-time OE information'. These summaries help to raise the awareness of personnel on the important factors and considerations prior to the activity. The summarized information provides also a reference code on the OE data base where personnel can find more information if necessary. Below is an example of just-in-time OE information.

SUBJECT: PRESSURIZED WATER REACTOR CONTROL ROD MANIPULATIONS AT LOW POWER

Inappropriate control rod withdrawals at low power have resulted in excessive startup rates, reactor scrams, and concurrent addition of positive reactivity during reactor coolant temperature reductions.

Events:

EVENT TITLE: Withdrawal of control rods during transient condition –

With the unit at 6.5 percent power in preparation for main turbine startup, an inadvertent overfeeding of the steam generators resulted in a main turbine trip. The reactor operator began a rapid control rod insertion to reduce reactor power to less than 3 percent. In addition, the control room supervisor directed the steam dumps to be manually opened. Reactor coolant system temperature was reduced. Subsequently, in response to a greater than expected decrease in power, the control rods were withdrawn by the reactor operator to raise reactor power from 0.2 percent to 2 percent. Temperature was restored to the no-load condition.

Important Factors	• The reactor operator rapidly inserted control rods without knowing the resultant end state. • The subsequent withdrawal of control rods occurred while positive reactivity was also being added by reactor coolant temperature reductions. • Manual operation of the steam dumps exacerbated the transient.
Causal Factor	• Reactivity management requirements were unclear regarding withdrawal of control rods during transient conditions.

EVENT TITLE: Reactivity excursion and reactor scram from low

Inadvertent overfeeding of both steam generators at low power resulted in a cooldown transient. The reactor operator inappropriately withdrew control rods to restore reactor coolant temperature. The reactor automatically scrammed at 13 percent power.

Important Factors	• The reactor operator did not understand the dynamics of operation at low power and core characteristics versus core life.

	• The reactor operator did not monitor startup rate (reactor period) during reactivity changes. • The shift crewmembers did not effectively communicate among themselves expected reactor core and plant responses.
Causal Factor	• Equipment problems and other evolutions distracted shift crewmembers during reactivity changes. • Control room operators were unfamiliar with feedwater control system response characteristics.

EVENT TITLE: Inappropriate operator actions during low-power

During a cooldown transient partially caused by a rapid boration while shutting down the reactor, the reactor operator withdrew rods to maintain reactor coolant temperature while at low power. The combination of decreasing reactor coolant temperature and rod withdrawal resulted in a 0.95 decade per minute startup rate. The combination of average coolant temperature recovering and the large water mass swelling in the steam generator resulted in an automatic feedwater isolation and turbine trip on high steam generator level.

Important Factors:	• Evolutions (turbine and control rod drop testing) were planned such that multiple activities affecting core reactivity occurred simultaneously making it difficult to control reactor power and average coolant temperature.
Causal Factors:	• The reactor operator did not anticipate the effect of a rapid boration and did not understand effects of loss of feedwater heating. • In-house operating experience of previous tests was not incorporated into the training programme or plant procedures to train operators of expected responses. • Control room supervisors did not perform adequate oversight during reactivity changes.

Utilization of OE – Important considerations:

Important considerations prior to control rod manipulations at low power (lessons learned)

- ☐ Which instrumentation are we going to monitor during reactivity changes at low power? How has this information been communicated to the operators? Do any of the instruments have inherent time delays?
- ☐ What low power operation evolutions that affect core reactivity are we anticipating?
- ☐ What are the reactivity management requirements regarding withdrawal of control rods during transient conditions?
- ☐ If reactor coolant average temperature decreases, what are the proper methods, to stop the decrease?
- ☐ What possible scenarios and expected responses during control rod manipulations at low power have been briefed to crewmembers?
- ☐ How have we ensured that the responsibility for supervisory oversight during

reactivity changes will not be compromised?

- ☐ What compensatory actions will be taken if multiple evolutions involving reactivity changes occur? Who is responsible for initiating these actions?
- ☐ What actions should be taken during reactivity changes if equipment problems or unexpected responses occur? Who is responsible for initiating these actions?
- ☐ What are the reactor engineering responsibilities during critical low power operations? Should the reactor engineer be in the control room? Have teamwork expectations been communicated?
- ☐ When was the last time operating crews participated in low-power simulator training? How has this training verified crew competence in applying core low-power operating characteristics' knowledge?

Appendix III

EXAMPLES OF UTILIZATION OF OE IN MAINTENANCE ACTIVITIES

Experience has shown that due consideration of previous events in pre-job briefing is beneficial in increasing the technicians' awareness of potential problems that may be encountered during the conduct of activities. The examples below refer to maintenance activities. The summaries and the corresponding list of important considerations were developed to help focus and increase maintenance technician awareness of potential problems that could be encountered, while performing maintenance on an air operated valve. The summarized information includes a reference code on the OE data base where personnel can find more information if necessary.

Subject: Air operated valve maintenance

EVENT TITLE: Undetected emergency feedwater valve leakage

It was discovered that air-operated emergency feedwater isolation and regulating valve for steam generator number 1 had excessive valve seat leakage. This leakage resulted from improperly performed maintenance activities two years earlier. The amount of seat leakage could have complicated recovery efforts in response to certain accidents. The seat leakage was not detected for a long period of time because seat leakage was not checked in the post-maintenance testing, which was based on the applicable in-service test for the valves.

Cause(s):
The valve disc was coupled to the air-operated actuator 180 degrees out of alignment, resulting in excessive seat leakage when the valve indicated fully shut position. Post-maintenance testing performed was the applicable in service test that consisted of a valve stroke test and a check for external leakage only. There were no permanent external markings to indicate proper valve disc position, thereby contributing to the improper alignment.

EVENT TITLE: Generator output reduction due to main feedwater control valve drive air leakage

With the reactor operating at full power, operators in the control room noticed that there was a discrepancy between the opening of the D-main feedwater control valve and its controller output. Initial local inspection of the valve found air leakage from the drive air chamber (diaphragm chamber) flange. Subsequently, the leaking part was inspected and damage to the diaphragm seal was found. Power had to be reduced to 15 percent to allow use of the feedwater bypass system in order to make repairs.

Cause(s):
The diaphragm had tears at 4 locations and elliptical deformations which were caused by being pulled into the bolt penetrations near the part of the valve where the leakage occurred. Elliptical deformations occurred near the bolts having low fastening torque. It was found that a variation in the fastening torque of 1.3 to 4.0 kgf-m could occur during fastening the diaphragms of the feedwater valves if the fastening work was performed in a relatively short time, even if the bolts were fastened in a diagonal sequence with the standard torque (4.2 kgf-m). As the diaphragms were fastened in a relatively short time when they were replaced, there was substantial variation in the fastening torque. This variation was increased by the change

of diaphragm pressure during subsequent operation, which was accompanied by the compression of diaphragms under compressive stress. This reduced the torque of some bolts below the minimum fastening torque (0.4 kgf-m).

EVENT TITLE: Conducting preventive maintenance on air-operated valves

An air-operated feedwater regulating valve for the 2D steam generator failed shut, resulting in a reactor scram due to low steam generator water level. The station investigation identified that a feedwater regulating valve had failed shut and would not respond to manual controller demand. In addition, control air pressure to the valve positioner varied from 0.2 bars to 1.03 bars, but did not result in valve motion.

Cause(s):
The investigation identified several internal component problems with the feedwater regulating valve air-operated positioner. All O-rings in the positioner were hardened and brittle, resulting in significant air leakage which caused the valve positioner to oscillate.

The feedback nozzle chamber air filter was plugged and contributed to valve positioner oscillation. As a result of valve positioner oscillations, more air was processed through the feedback nozzle chamber air filter, which increased the amount of filter plugging. This filter had never been changed.

Also, an internal control valve in the valve positioner was noted to have burrs on the stem where it passed through the retaining washer. During this event, as the valve positioner oscillated, the control valve was pushed down and jammed, partially due to the burrs on the stem. As a result, the valve positioner became stuck, and the valve positioner air pressure bled off, causing the feedwater regulating valve to close.

EVENT TITLE: Failure to perform preventive maintenance results in AOV not opening on demand

While performing startup activities from an outage, a heater extraction steam bypass AOV failed to open as required. The electrical maintenance department was asked to investigate the failure and determined that the solenoid valve was working properly and that the problem was likely a mechanical issue with the AOV.

The mechanical maintenance department (MMD) initiated troubleshooting activities on the AOV. The 'as-found' stroking revealed jerking at a certain position. During the course of the disassembly additional troubleshooting was performed with the actuator, bonnet and stem assembly removed from the valve body. The mechanics noted that the assembly stroked slowly and with some hesitations even on the bench top. Following full disassembly, the packing was found to be hardened and that the stem was scored. No other problems were identified.

Cause(s):
The apparent cause is dry hardened packing.

Asbestos packing is no longer used, mainly because of its inherent health related hazards but also because of its negative effects on valve performance, both from a friction and an age hardening aspect. Graphite material has become the material of choice within the industry. Graphite provides lower packing friction, has no ageing concerns, and is self-lubricating.

Utilization of OE – Important considerations:

Important considerations prior to air-operated valve maintenance (lessons learned)

- What other maintenance tasks or plant evolutions are in progress that could affect our planned air-operated valve maintenance? How have we verified that our air-operated valve work will not cause an unexpected plant transient if performed under these conditions?
- How would the failure of air-operated valves we are about to work on affect plant safety and reliability?
- What air-operated valve preventive maintenance do we perform? How does our preventive maintenance programme account for any unique operational or environmental conditions for the specific air-operated valves we are about to work on?
- How has our training prepared us for the air-operated valve maintenance tasks we are about to perform? How have we verified that maintenance workers involved in this task have been adequately trained?
- What OE information exists from prior air-operated valve maintenance at our own plant?
- How have we verified that, where necessary, correct valve markings are in place?
- How do we verify that the feedback linkage on air-operated valves is properly tightened and torqued to manufacture's specifications? How do we verify the valve air actuators at our station go to the fail-safe position if the feedback linkage fails?
- How do we identify air-operated valves that are in "failure likely" environments at the station? What are these "failure likely" environments? How do we report these adverse conditions? What air-operated valves are located in areas with high ambient temperatures? How do our preventive maintenance tasks consider the accelerated ageing effects caused by increased temperature?
- How do we determine when elastomer parts are reaching the end of their service life? What are the indications of degraded elastomer parts? How do we identify and report degraded elastomer parts?
- How have we verified that our procedures provide the level of detail necessary for the specific maintenance tasks we are about to perform? How do we verify that our procedures include appropriate manufactures' recommended preventive maintenance tasks for air-operated valves?
- How do we ensure that staff carrying out maintenance are aware of the required procedures and comply with all aspects of the procedures?
- How have we verified that our post-maintenance testing provides adequate guidance for all anticipated system conditions that require reliable valve operation? Why is it important to verify fluid system valve leak-tightness after valve actuator only maintenance? How does our post-maintenance testing confirm leak-tightness for all anticipated system conditions?

Appendix IV

EXAMPLES OF UTILIZATION OF OE IN RADIATION PROTECTION

Experience in the performance of some tasks and evolutions provides critical insight into the potential problems that may be encountered prior to and during the task performance. The examples below refer to radiation protection. The summaries and the corresponding list of important considerations were developed to help focus and increase personnel awareness of potential problems that could be encountered. The summarized information includes a reference code on the OE data base where personnel can find more information if necessary.

Subject: Radiation protection

EVENT TITLE: Higher than normal dose rate during flood-up

After reactor head removal, in preparation for upper internal removal and fuel movement the post flood-up dose rates were several hundred times normal. All work was stopped.

Cause:
The dose rates were due to a crud burst which had not been cleaned up via the mixed bed demineralizer and the RCS filter.

EVENT TITLE: Radiation exposure of contractor, exceeding annual dose limit.

A contractor had declared his dose during the year nil and worked in one unit during annual shutdown and received dose of 10.57 mSv. In the meantime the dose data from the other units located at other sites were collected. This revealed that he had already received a dose of 4.93 mSv. Thus he received a cumulative dose of 15.5 mSv exceeding the annual administrative limit of 15 mSv.

Cause(s):
1) A national occupational dose registry system does not exist which can eliminate such incidents;
2) Integration of the data on individual occupational dose is not sufficiently coordinated or timely performed;
3) Contractor has supplied incorrect/false information.

EVENT TITLE: Unauthorized on-power entry in moderator room

Unit-1 was under shutdown for an all coolant channels replacement job. Unit-2 was operating at 175 MWe. Visual inspection of stainless steel (SS) pipelines was planned in both the units. After completing the visual inspection of SS pipelines in the shutdown Unit-1 QA section planned to carry out this job in the moderator system of the operating Unit-2. During unit operation, entry to the moderator room is allowed only after taking the radiological work permit (RWP) from the health physics group and also an on power entry (OPE) permit from control room. Two QA section personnel entered the moderator room of the operating Unit-2 after taking a RWP but they did not take an OPE permit. After sometime in the field one of the persons checked his dosimeter and found it to be off scale. He immediately alerted his colleague and both came out of the area. They received a radiation dose of 16.52 mSv and 19.12 mSv respectively.

Cause(s):

- Violation of access control procedure;
- Insufficient rigorous approach of individuals and supervisors;
- No provision of alarm in main control room on opening of moderator room door;
- No provision of clear posting on the moderator room door regarding the access permits needed when the plant is in operation.

EVENT TITLE: Heat stress of a radiation protection technician in the refuelling cavity resulting in transport of contaminated injured worker

A radiation protection (RP) technician experienced symptoms of heat stress while providing RP coverage. The RP technician became contaminated during the removal of his PC. Some decontamination of the RP technician was performed; however, the RP technician's core body temperature was not lowering so it was decided to transport the RP technician to an offsite medical facility. The RP technician donned white paper coveralls and was transported to the medical facility. The injured technician was treated for heat stress and released from the hospital and successfully decontaminated.

Cause(s):
Change management: The task was delayed approximately 7 hours to put water in the lower cavity which created a significant industrial safety risk and did not take into consideration the engineering controls needed to reduce the heat stress potential. The job scope changed several times and lengthened the time needed in the lower cavity. From 3-5 minutes it expanded to nearly 15 minutes and created the misjudgement opportunity for the RP technician due to perceived schedule pressure and created an error likely situation. The planning for how to rescue an individual from the lower cavity was not considered in the planning process. The radiological concerns were addressed with engineering controls by adding water to the lower cavity to reduce contamination and dose concerns.

Misjudgement: The RP technician did not stop the job when he began to feel hot and needed to climb out of the lower cavity to sit and attempt to cool off. He was very knowledgeable and experienced and had worked during refuelling outages at many nuclear facilities. His decision to continue could have been based on past experiences and habits. The person had not ever had heat stress before this incident.

EVENT TITLE: Unplanned internal contamination during reactor cavity decontamination

Thirteen unplanned intakes of radioactive material and twenty- one low level external personnel contaminations occurred as a result of decontamination activities in the reactor cavity. The maximum dose to any individual as a result of the intakes was 8 millirem, however many inappropriate actions and programmatic weaknesses were identified during the investigation.

Cause(s):
Radiation protection personnel failed to determine the radiological conditions prior to allowing work to begin. A lack of management reinforcement of standards, a mindset based on historical data, and improper focus on completing work resulted in the failure to perform adequate surveys to characterize the radiological conditions before allowing work to be

performed existed. The reactor vessel head was suspended over the flange for about three hours, including turnover time, allowing the upper internals to dry out. Also, no smear surveys, beta dose rate measurements, nor breathing zone air samples were taken during the initial entry to the reactor cavity area.

Utilization of OE – Important considerations

Important considerations from previous events prior to radiological work (lessons learned):

- Double check the individual data on the national occupational dose registry system if exist or verify that the data on individual occupational dose is up-to date and has been timely integrated;
- Ensure adherence to radiological procedures and rigorous approach of individuals and supervisors;
- Verify the ALARA prescriptions to optimize the cleaning of crud before working in a primary environment in the reactor cavity;
- Determine effectively the radiological conditions prior to allowing work to begin;
- Ensure awareness of the workers on the precautions for working in moderator room. Verify that provisions are in place such as remote alarm information and clear posting in moderator room access;
- Verify the status of potential human performance error traps contributing to the individual succumbing to heat stress such as: change conditions (job scope, time duration), physical environment (heat), and vague or interpretive guidance. Coach individuals as necessary.

Appendix V

EXAMPLES OF UTILIZATION OF OE IN FUEL HANDLING

Experience in the performance of some tasks and evolutions provides critical insight into the potential problems that may be encountered prior to and during the task performance. The examples below refer to the utilization of OE during fuel handling. The summaries and the corresponding list of important considerations were developed to help focus and increase personnel awareness of potential problems that could be encountered. The summarized information includes a reference code on the OE data base where personnel can find more information if necessary.

Subject: Fuel handling

EVENT TITLE: Contact made between bottom of fuel assembly and adjacent fuel assembly bail handle during transition in the core

While moving fuel in the core, the bottom of a fuel bundle came in contact with the bail handle of an adjacent fuel bundle. The operator moving the fuel bundle had not raised it sufficiently before beginning lateral motion

Cause(s):
Procedure guidance was deficient. The procedure directed that the fuel bundle be raised high enough to clear all obstructions, but did not provide a specific value. Additionally, management oversight of this activity was less than adequate, in that the lack of specificity in the procedure was not noted. Procedure guidance was revised to include a specific value for bundle elevation before beginning movement and personnel were briefed on the event.

EVENT TITLE: Refuelling bridge mast became bound

During refuelling the refuel bridge mast became bound in the up direction without a fuel bundle during the phase 2 shuffle. Refuelling operations were stopped to investigate binding with the tubular refuelling bridge mast. The telescoping mast was not holding a fuel bundle at the time the binding occurred. The mast was removed from the bridge and disassembled to evaluate for damage and repairs.

Cause(s):
It appears that the fuel pool FME is the cause for the rollers to have locked-up causing at least two rollers to have acquired the flat spots on a section of the rollers splines.

During disassembly the following anomalies were found:

- All rollers needed extensive cleaning.
- Two rollers had flat spots.
- Both mast cables had been overstrained a few inches from where the cable end barrel is captured by the common take-up reel.
- Scratches were noted on the outside surface of the grip that attaches and secures the electrical cable to the mast. It is believed that it has been previously caught between these sections.

EVENT TITLE: Control rod assembly lifted with upper guide structure during refuelling outage

During a refuelling outage, the upper guide structure (UGS) was raised about one foot above flange level when it was discovered that the control rod assembly (CRA) number 65 was attached to the UGS and partially withdrawn from its fuel assembly. Due to events at other utilities, a stop point had been implemented during the lift at approximately one foot above flange level where an underwater camera is used to verify the CRAs are not attached. It was during this stop that the CRA was discovered attached to the UGS.

Cause(s):
The root cause was determined to be that the CRA failed to be uncoupled due to confusion in the uncoupling sequence. Although other utilities have experienced similar events, this OE is being issued to share the human performance factors involved with this event.

The CRA uncoupling procedure has provisions for recording data related to as-found coupled and as-left uncoupled measurements. This information is focused on ensuring CRAs are uncoupled completely. However, the datasheet does not include any reference to "expected" values for which to compare the information. The procedure also did not include any requirement to use or analyse the information in a manner that could detect this condition.

Self-checking was not applied. When attempting to disengage the CRA, the individual uncoupling the CRAs failed to properly verify the correct core location, resulting in disengagement of the wrong CRA.

Written communications provided inadequate document provisions. The CRA uncoupling procedure has provisions for recording verifications and second person verifications of CRA rest heights and CRA weights. It does not include any provisions or sign off verification that the correct CRA location is obtained during each CRA uncoupling or ensuring that the tool is indexed on the desired CRA.

An equipment interface design display was needed but not available in this plant configuration. There are no accessible labels or CRA component serial numbers that can be viewed to ensure the correct CRA is being selected for uncoupling. The uncoupling procedure does reference the alpha-numeric core map location for each CRA however this information is not useful for determining if the right CRA is actually being attached to with the CRA change tool. The only method available to determine if the right CRA is selected for uncoupling, is a visual verification from the bridge and comparison to the core map in the procedure.

EVENT TITLE: Improper fuel reloading results in the incorrect locations for 113 fuel assemblies

During fuel reloading at an error occurred when fuel assembly 25 was about to be reloaded. Fuel assembly 26 was mistakenly placed in the location specified for assembly 25. The error was not immediately detected, and loading continued with each successive fuel assembly mispositioned by one place. The error was not identified until fuel assembly 139 was loaded, resulting in 113 fuel assemblies located incorrectly.

While fuel reload was in progress, with 23 fuel assemblies reloaded, the control room requested a pause in the reload to calibrate the source range detectors. The refuelling manager, located in the containment building, acknowledged the control room's request; however, the fuel building supervisor, who was controlling fuel movements in the fuel building, was not informed that fuel reload was being paused.

When the fuel building supervisor became aware of the interruption, fuel assembly 24 was in its rack in the fuel pool, awaiting transfer to the reactor building. The fuel movement team, anticipating the next transfer, recorded that fuel assembly 24 was transferred to the containment building. Fuel assembly 25 also was in its rack in the fuel building and its fuel movement checklist was also filled out in advance, indicating that it too was in the containment building.

Following a crew change and movement of sequence 24, the new crew, noting that the fuel reload checklist was completed up to step 24 and that the transfer steps were already filled in for step 25, concluded that assembly 25 was already loaded into the core.

Consequently, the fuel handling crew began moving fuel assembly 26, which was then incorrectly loaded into the core position specified for step 25. Reload continued with each subsequent fuel assembly mispositioned one place. The error was discovered by the fuel handling machine operator when assembly 139 was loaded. This fuel assembly contained a thimble plug instead of a control rod as expected. Refuelling operations were immediately suspended and all fuel assemblies were unloaded from the reactor vessel.

Significant aspects of this event:

- With 113 fuel assemblies mispositioned, the margin to criticality (effective multiplication factor, $_{Keff}$) was reduced to less than the required 0.95; however, $_{Keff}$ remained less than 1.0.

- Under worst-case conditions, criticality could have occurred and would not have been quickly detected because neutron emissions from the already loaded assemblies would have been masked by fresh fuel located closer to the detectors. Although any power increase would have been relatively slow, personnel on the lower floors of the containment building could have received higher doses of radiation than anticipated.

- The reloading error resulted in an asymmetric core configuration with assemblies that were more reactive located in one quarter of the core, as well as mispositioned control rods located inside the fuel assemblies during reloading.

Cause(s):
The event resulted from weaknesses in procedure use, communications, crew
turnover, and the poor visibility of fuel assembly identification markings during the re-loading process.

EVENT TITLE: Bent bail handle prevents fuel assembly from being released from fuel handling grapple

During fuel sipping in the Unit 1 spent fuel pool a fuel assembly could not be released from the main grapple of the refuelling platform after the assembly was seated in its storage location. When a fuel assembly is lowered into a target location, it is normal for the lower tie plate to come in contact with the sides of the sipping can, core, or storage location. As the assembly is further lowered into a spent fuel pool or core location, the built-in tolerances allow the assembly to centre itself into these locations.

Following several unsuccessful attempts to release the grapple, a visual inspection with binoculars revealed a bent bail handle. The grapple could not be opened with actuating poles and hooks. The fuel assembly was removed from the storage location and placed in the fuel sipping can. When the refuel platform was jogged in the direction of the bend, the grapple was successfully released. The grapple was able to be released from the bent bail handle while in the larger opening of the sipping can, but not while in the storage rack.

Further investigation revealed that while the fuel assembly was being lowered into a sipping can, the assembly had hit the top of the can and tilted, allowing the assembly's weight to rest on the can, at an angle to the main grapple. This caused the bail handle to bend in the direction of the main mast.

Cause(s):
The bent bail handle was caused by allowing the assembly to contact the sipping can. Also, the assembly was not lowered slowly enough to prevent bending. Discussions with the fuel handling director and the refuel platform operator revealed that lighting was poor in the area of the sipping can. Visual observation of the fuel pool confirmed these conditions. Since this event, additional lighting was placed over this fuel pool location. Additionally, the training for the fuel handling director and for the fuel handler does not address using the slow speed, nor does training emphasize the importance of adequate lighting during fuel handling operations.

Utilization of operating experience

Important considerations when performing fuel handling (lessons learned):

- Have we verified that proper fuel handling equipment inspections and preventive maintenance have been performed prior to fuel handling? What tests have we conducted to confirm proper operation of equipment?
- What previous problems have we had with refuelling equipment? How might we need to address any problems that have not been fully resolved?
- What barriers are in place to ensure the correct fuel assembly or core component is positioned properly in the core or fuel storage location?
- What contingency actions will we use to compensate for cooling water flow disturbances near vessel flow nozzles that may make it difficult to properly position assemblies?
- Have we verified that our fuel movement procedures do not allow a fuel assembly to be left unrestrained in the core by moving all adjacent assemblies next to it?
- When is two-plane (horizontal and vertical) fuel handling movement not allowed?
- What actions are we taking to maintain water clarity during fuel handling activities? What contingencies are established to halt fuel handling activities if visibility is impaired?
- What indications are we using to verify proper engagement or position of a fuel assembly? How will we verify that all indications agree?
- What indications will we use to determine when it is safe to release a fuel assembly or other core component from the fuel-handling machine or tool? How do we verify that all indications agree before the refuelling machine is moved from that location?
- What equipment associated with the refuelling bridge mast has the potential to come in contact with reactor internal components or other obstructions during fuel handling? What steps have we taken to prevent this equipment from being damaged?

- What actions have we taken to keep fuel handling areas free of equipment that might obstruct fuel handling equipment operations? What foreign material exclusion controls are in place? How will we reduce the number of personnel in the refuelling areas to minimize distractions to the refuelling operators?
- How have we verified that the roles and responsibilities of the fuel handling team members, including expectations for supervisor monitoring, communications, and verification of compliance with the fuel movement sequence are clearly understood? How are these aspects reinforced during fuel handling activities?
- What type of communication methods will we use during fuel handling?
- What actions will we take if we identify a fuel handling problem? What are our contingency plans if fuel is found damaged?
- What are the potential consequences of leaving a fuel assembly unattended in a location other than its designated storage location? How will we prevent this?

Appendix VI

EXAMPLES OF GOOD PRACTICES FOR UTILIZATION OF OPERATING EXPERIENCE IN HUMAN PERFORMANCE

Pre-job briefing

The objective of this good practice is to be prepared individually and collectively to perform an activity, and to anticipate the management of potential problems associated to this activity and their contingency measures.

It is performed immediately before starting a risk activity, even if it is a routine activity. Also after a significant interruption of the activity or a change in the personnel involved.

The pre-job briefing consist of an organized discussion among the involved personnel (worker, supervisor, planner, manager) on the overall development of the activity, the critical elements, the precautions, the particular surveillance points (either for self checking or requiring independent inspection), the potential risk and associated contingency measures (including the worst that can happen), the handling of communications, the coordination /synchronization among participants, and the previous operating experience (with their consequences and barriers to prevent recurrence).

Self –Checking - STAR (Stop, Think, Act, Review)

The objective of this good practice is to reduce the possibility of error and to ensure personnel and installation safety.

In the self- checking the performer of the action identifies, with its finger on the procedure, the action to be performed and reads (voice verbalized) the title of the action. With the other hand/index he points out the material involved and reads (voice verbalized) the name tag identification showed on the equipment.

In a comprehensive approach the self checking is performed within the STAR protocole. This good practice is performed immediately before (Stop, Think), during (Act), and after (Review) an action.

Stop
Pause and consider intended actions
Verify that you are in the right unit, the right train, the right equipment, the right procedure
Identify the correct component/item/plant
Check the safety documents/procedures are adequate
Check if assistance is needed
Review the environment around and identify the potential risks
Eliminate all sources of distraction
If the activity restarts after an interruption, verify that you restart from the precise point of interruption.

Think
Understand what has to be done before operating any equipment
Identify the correct component /item; use your visual, audible, signalling and touching senses

Anticipate expected responses and think about associated indications (alarms, vibrations, noise, and smell).
Consider expected responses to the action either normal or abnormal. Anticipate contingencies.

Act
Look at the component, without losing eye contact, touch, but do not activate it
Confirm correct component/system.
Compare component with procedural identification
In some situations, it is good to verbalize the name of the component that you are going to act
Perform the action still keeping eye contact on component

Review
Ensure that action resulted in expected response
Be ready to act at unexpected response
Adopt a conservative approach
Complete record documents checking and accuracy
Inform supervisor of any irregularity

3-WAY communication

The objective of this good practice is to ensure that information through oral communication is in a clear, comprehensive and knowledge manner, and to ensure that the message is received and well understood.

3-WAY communication consists in a following a protocol comprising the following steps:

Emission of the message: the emitter speaks the message in a clear, completed and concise manner (including name of the receiver, complete identification of the material, concise sentence for the action or information).

Message repetition: the receiver repeats back to the emitter the message received, in an identical and complete way using the same exact words.

Confirmation: the emitter confirms in a simple way that the message received has been well understood by the reviewer (using one standard pre-defined word such as OK, correct, right).

3-WAY communication protocol is used to prevent errors in understanding communication when an order for action is transmitted concerning safety or reliability of the installation (equipment, procedures and personnel). It is also used in all exchange of information involving important activities, parameters and setpoints for the installation (such as reactor criticality, chemistry data, fire protection, calibration adjustments).

Independent verification

The objective of this good practice is to ensure in a proactive way that actions involving risks are independently controlled before they are implemented. This independence is what makes the difference with the self-checking.

The independent verification, after the action, of the obtained results, is another kind of verification. However, this is a reactive way that do not prevent of doing it right at the first time and preventing human error.

The independent verification consists of controlling the work or the action by another person with equivalent or superior capacities to those of the performer, for the purpose of ensuring the correctness of the performer execution, prior to implementing the action.

The performer of the action announces (by voice) the action he is going to do and points out with the gesture of the hand/finger the components involved. The independent controlling person verifies the intended action (including correctness of the material and positions identified) and provides his agreement. Subsequently the performer of the actions performs it.

Post job debriefing

The objective of this good practice is to collect the experience (difficulties, events, ideas) obtained during the performance of the activity, including opportunities for improvement in environmental conditions, work layout, human factors, communications, use of the documentation/procedures, error likely situations/traps, contingencies and coordination/organization issues.

The post job debriefing is made by the performer to his supervisor or manager. To facilitate understanding, the best practice is to be present whenever possible at site at the end of the task in order to discuss the feedback with explanations in-situ.

The noteworthy remarks collected from the post job debrief must be documented in order to facilitate the inclusion in the operating experience feedback process. For this purpose it is a good practice to include a space in the work order form to be filled-up by the worker/supervisor with these noteworthy remarks. Also, the corresponding low level remarks are included in the data base for low level events and near misses for subsequent trending.

Adherence to procedures

Use and adherence to approved and controlled procedures takes precedence over other kind of documents including uncontrolled operating aids or on the spot improvisation. Deviations to the intent, direction and approved process increase the potential risks for an event to happen. Personnel practice is to adhere to procedures and to always fulfil the "Do not work around" principle. However personnel always maintain a questioning attitude to identify errors. If during the performance of a task the written procedure is found to be ambiguous, incorrect or inappropriate, the subsequent actions are:

- Stop the work
- Make the job safe
- Inform the supervisor
- Get the procedure officially amended

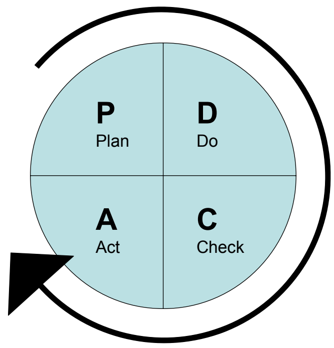
Also, if as a result of following a procedure a plant abnormality occurs, there might be a reason for suspecting the procedure to be defective. In this case the performer stops the work and seeks advice from the line supervisor.

Appendix VII

EXAMPLES OF GOOD PRACTICES OF UTILIZATION OF OPERATING EXPERIENCE FOR CONTINUOUS IMPROVEMENT

PDCA Cycle

The PDCA (Plan-Do-Check-Act) cycle is a process composed of four stages to get from “problem-faced” to “problem solved”. The operating experience obtained through the PDCA cycle is used to progress effectively towards continuous improvement.



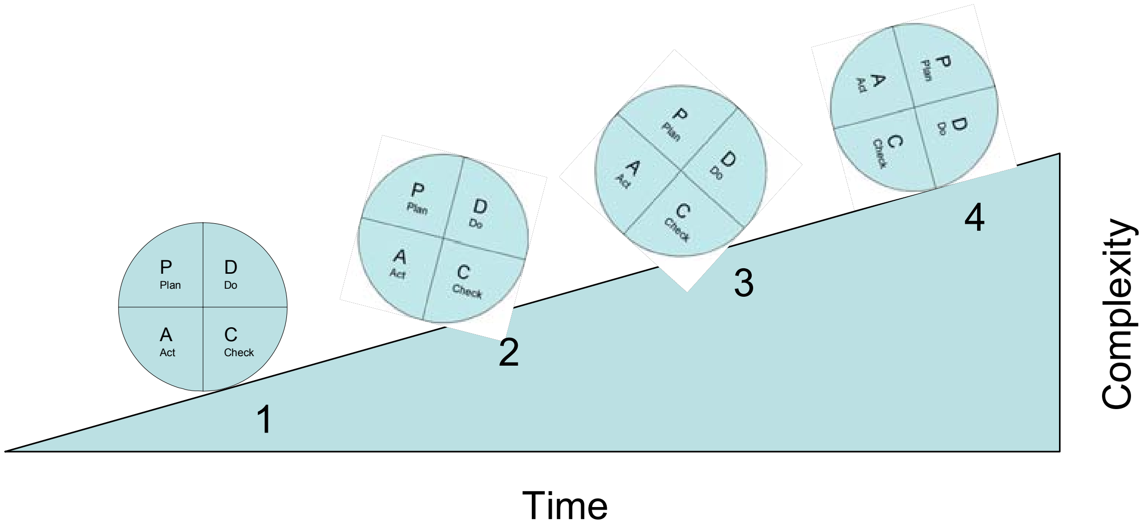
Use of the PDCA cycle to coordinate the continuous improvement through the following stages:

- **Plan** to improve your operations first by finding out what things are going wrong (operating experience). Identify the potential cause of the problems. Collect additional data if needed to identify and verify root cause. Come up with ideas to solve these problems.

- **Do** changes designed to solve the problems on a small or experimental scale first. Establish criteria for selecting a solution. Generate solutions that will address the root cause of the problem. Gain approval and support for the selected solution. Implement the chosen solution on a trial or pilot basis.

- **Check** whether the trial or pilot experimental changes are achieving the desired results or not. Gather data on the solution and analyse it. Check key activities to ensure that you know the quality of the output and identify new problems when they appear.

- **Act** to implement changes on a larger scale if the trial or pilot experimental change is successful. Involve other persons (departments, suppliers, contractors) affected by the changes and obtain their cooperation to implement them on a larger scale. Plan the ongoing monitoring of the solution. Feedback the operating experience. Continue to look for incremental improvements to refine the solution. If the change led to a desirable improvement or outcome, you may consider expanding the solution to a different area. Look for another improvement opportunity.



The ramp of improvement is a systematic representation of the use of the PDCA cycle in the improvement process. The PDCA cycle is a dynamic process. The completion of one turn of the cycle flows into the beginning of the next. A process can always be reanalysed and a new trial can begin. As each full PDCA comes to conception, a new and slightly more complex project can be undertaken taking into account the previous operating experience. This rolling over feature is integral to the continual improvement process and the use of the operating experience to establish a successful learning environment.

Appendix VIII

EXAMPLES OF OPERATING EXPERIENCE EXCHANGE PRACTICES

Community of practice (CoP)

CoPs are groups of people who come together to share and learn from one another, face-to-face and/or virtually. They are bound together by shared expertise in a body of knowledge and are driven by a desire and need to share problems, experience, insights, templates, tools and best practices. The objective of a CoP is to expand opportunities for knowledge sharing and learning. A CoP is an industry peer group of experts in a business process or sub process manageing the solution of issues in the area of this process and determining future directions. The CoP is one of the keys to transferring knowledge and experience within the industry.

Benchmarking

Benchmarking is the process of identifying, understanding and adapting outstanding practices from organizations anywhere in the world to help your organization to improve performance. Benchmarking is aimed to determine who is the very best, to figure out how he got to be the best and to determine what your organization has to do to reach this quality level. Any business process can be benchmarked. Benchmarking is not limited to a comparison within your own industry. The final purpose of benchmarking is to improve your own performance.

Benchmarking helps to identify the best process practices that are adaptable to your own organization, and to understand and identify the weaknesses of your own process. In this endeavour it helps to obtain critical management support for improvement so that what has been learned can be incorporated to change the performance for the better.

Appreciative inquiry

Appreciative inquiry (AI) is a methodology by which an organization’s strengths and potentials are identified through employee interviews focused on what is working well in a particular area of the organization. Considerations are then made concerning whether and how to transfer internal good practices and creative ideas to other areas of that organization.

Appendix IX

EXAMPLES OF OPERATING EXPERIENCE GOOD PRACTICES IDENTIFIED DURING OSART AND PROSPER MISSIONS

Good practice:
Weekly video conference to communicate and disseminate OE.
A weekly video conference takes place with the participation of technical director, chief inspector, head of licensing, chief engineers and managers of all NPPs. The agenda of the videoconference included general comments of technical director about the importance of departmental level events and the results of major inspections by chief inspector. A detailed presentation about recent events is included. The presentation explains background of the event, sequence of the event, event consequences, direct and root causes and corrective actions. Other video conferences also take place to discuss operating experience, this time with participation of other countries utilizing the same or similar type of NPPs.

In case of a safety relevant event at a nuclear power plant, there is an extra videoconference to provide technical assistance to the plant. In addition to nuclear plants, the conference is attended by design/engineering companies, scientific support organizations and manufacturers. There is an on-line detailed discussion of the event and of its consequences. Plant participants tell about similar events at their stations, if any, and on corrective measures. Other participants give design and engineering recommendations. On the whole, owing to the videoconference, the owner of the event receives assistance essential for implementing measures to resolve the event and prevent the event recurrence.

Good practice:
'Good example of STAR'
'Good example of STAR' supplements the negative term 'near miss' in order to encourage personnel to report near misses when application of STAR approach successfully prevented the event. 'STAR' approach is well communicated and understood by personnel. All workers who actively participated in the reporting of cases when applying the STAR approach helped to prevent an event are consequently awarded by symbolic STAR pen. In the case of the most honest and valuable reports even financial awards are used.

Good practice:
'Survey for technical challenges'
The results of a periodic survey of technical challenges (such as degradation of materials, erosion corrosion of some circuits, reliability of certain equipment, spurious signals or erratic response in some instrumentation and control measurements, etc.) are used to notify corporate engineering units of any technical problems that could be hazardous to the power plants in the medium or long term.

Once each hazard has been analysed it is returned to all power plants with the name of the corporate contact person assigned to the problem in question, the existing or future type of follow-up, as well as a summary of all hazards (type of equipment, challenges, etc.).
The purpose to this exercise is to:

- Encourage power plants to adopt a proactive approach towards potential problems by urging them to consider future difficulties and by notifying them of potential problems raised by other plants.
- Create a link between plant engineering structures and corporate engineering units,

- Ensure that corporate engineering units are adequately addressing issues raised by the power plants.

Good practice:
'Reporting good practices from assignments'
All staff returning from international missions (such as peer reviews, exchange visits, twinning missions, etc.) are required to report good practices examples.
The network of experts temporary assigned to other external organizations (seconded experts, internship participants, etc.) is also used as a source of external operating experience.

Good practice:
'Pilot-plant concept for testing modifications prior to implementation in the fleet.'
Before being implemented on all the fleet, selected modifications are pilot-tested on one unit. Gathering experience feedback about this modification is a great part of the corporate modification process.

The pilot unit collect all the pilot OE information and use it to provide an operating experience feedback report. The OE report includes: fulfillement of the objectives, degree of satisfaction, integration of new objectives and cost considerations. Final decision to implement on all the fleet is based, among others, on this report.

Implementation leader draws up an annual assessment report of implementation on pilot units.

Good practice:
'Use of event base experience feedback sheets and organizational experience feedback sheets to improve outages'
The use of event base experience feedback sheets and organizational experience feedback sheets as a tool to improve outages is considered a good practice. Outage-related operating experience includes experience feedback from refuelling outages and the sharing of this feedback with the various plants and corporate entities. Outage managers use it to compile their risk assessment for the outage schedule, particularly with regard to the critical path.

On the basis of "notable outage events" detected from week events, experience feedback sheets are compiled. These documents are used by outage teams to familiarize themselves with events having a significant impact on the critical path and having occurred during other outages (notion of exchange). Five months prior to disconnection from the grid, the sheets are submitted to the outage manager. The outage manager conveys them to plant departments involved in the process, for incorporation into outage risk assessments.

The plant's outage planning committees check that these sheets are taken into consideration and acted upon where necessary. During outage, implementation of any preventive measures adopted by the outage teams is checked against the schedule. At the end of outage, the usage of these sheets is discussed at a review meeting.

Event base experience feedback sheets and organizational experience feedback sheets are reviewed on a monthly basis. Sheets that have been incorporated into new procedure, as well as sheets that have become obsolete or not found useful by the plants are either revised to increase their effectiveness or withdrawn. This is an effective way of preventing an eventual build-up of too many sheets.

Good practice:

"Just-in-time" OE information for pre-job briefings during outages

At the beginning of every outage meeting, a safety update is provided by the outage safety engineer. On this occasion, a document is handed out and presented to all participants. This document lists the activities of the 3-day schedule (title and code) where nuclear safety risks have been identified. It also specifies which craft will be performing the activity. Each activity where risks have been identified is directly linked to OE feedback from events, safety expectations and traps which should be avoided. The document is also distributed to shift teams and discussed at the start-of-shift briefing. Useful OE information for future activities is presented. (In order to prevent errors from future events). Craft attention is focussed on risks associated with their activities. Risks are illustrated using concrete examples. Expectations for each activity are restated. Crafts are provided with a document that they can then discuss with their teams.

Good practice:

Use of noteworthy events to identify precursors to challenging the core integrity

The precursor concept is applied to significant events where the possibility of melting the core is challenged. The precursor programme detects notable events on the basis of deterministic criteria as well as from probabilistic analysis showing an increase in core meltdown risk.

By quantifying the gap separating an actual event from a potential accident with unacceptable consequences, the event's degree of severity can be assessed. This value, which represents conditional probability of core damage, bearing in mind that the event did occur, is referred to as the Potential Risk Index (PRI). Events with a PRI>10-6 are known as 'severe accident precursors', i.e. liable to result in high probability of core damage.

The results obtained by this practice have proven the benefits of this approach to ensure that these precursors are incorporated in the OE programme, to rate the events with a view to setting priorities, to raising the plant operator awareness to the most important lines of defence, and to enhance the attention of the whole nuclear power units fleet.

In addition, the identification of the high level precursors helps to questioning and assessing in depth the safety basis of the decisions to justify the continued operation of the plant after an event or in situations associated with technical specification waiver requests.

Good practice:

A risk quantification matrix is used to perform risk evaluation and to rank the low level and near-miss events that are reported.

The use of a risk evaluation matrix permits the calculation of risk of low level events and near misses in respect of the potential consequences. The areas that are considered in this evaluation are: nuclear safety, industrial safety, public acceptance, environment and financial consequences. This is done using a clear and visual aid (coloured matrix). As a result this events are distributed in several categories from the point of view of consequences (such as slight, limited, very serious consequences), from the point of view of probability (such as improbable, rare, infrequent, regular, frequent) and from the point of view of risk (low risk, medium risk, high risk, extreme risk).

The tool has proven to be useful to determine the degree of analysis that is required. It can also be useful to find precursors and to measure the performance of near miss reporting: more events of a lower risk level indicate improvement.

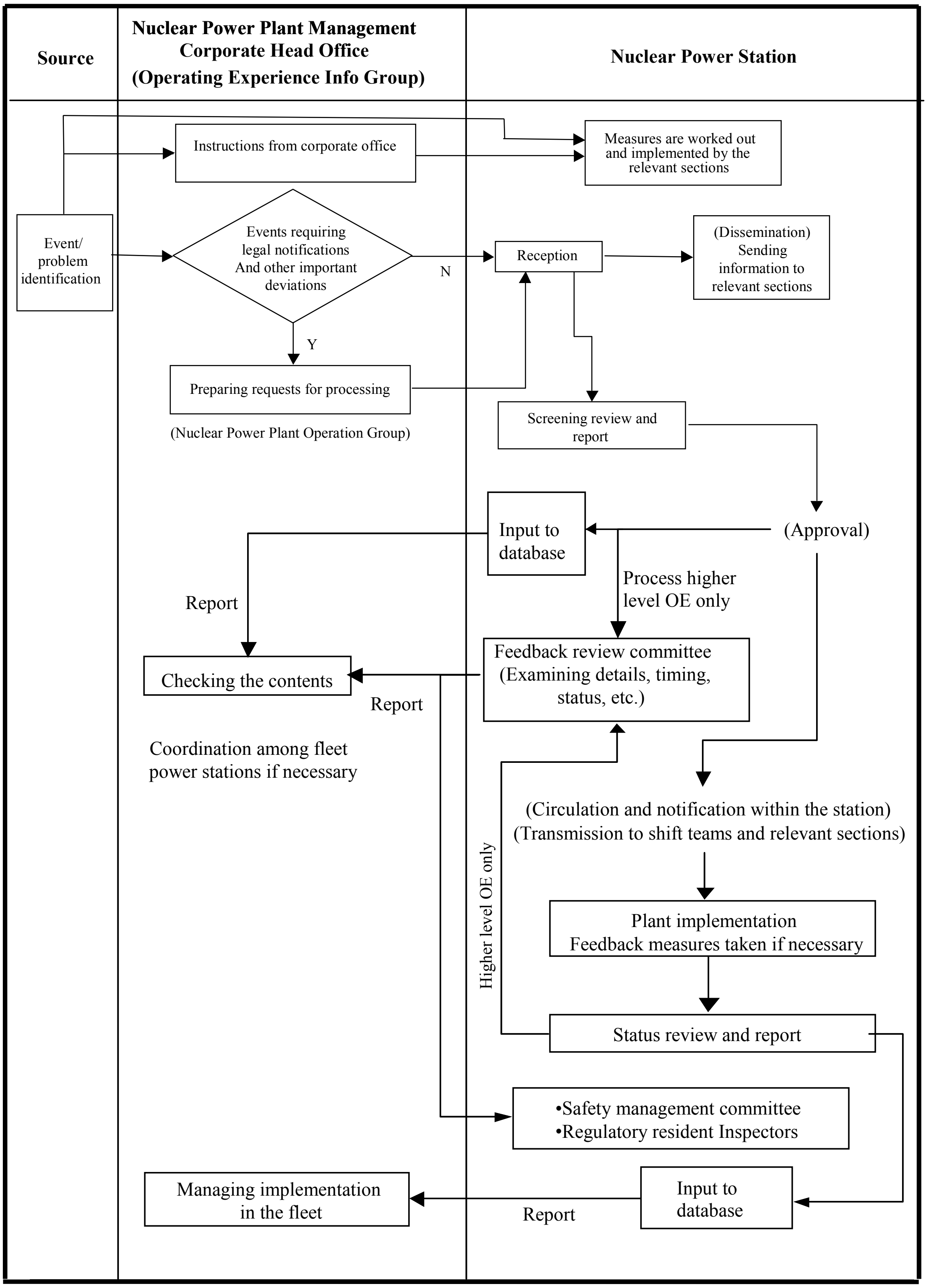
Good practice:
Dissemination of OE through publications
Corporate organize OE information dissemination through publication and intranet. Different products answering expectation of wide range readers are available. It provides general information on events occurred in-house as well as external events. Most of these publications are managed by an editorial committee. Examples are:

- Quarterly letters for a specific area (such as chemistry, radiation protection) highlighting technical events and nuclear operating issues.
- Quarterly comics strips dedicated to aware staff on industrial safety, mostly focused on near misses occurred on NPPs.
- Weekly technical newsletter widely disseminated to provide, a good understanding, also to non technical staff, of current domestic NPP's events and major external events occurred.

Good practice: Assessment and indicators of operating experience: OE self evaluation programme indicators
Self evaluation programme indicators are used to improve activities in the areas of corrective action programme, self assessment, benchmarking, and operating experience. These indicators are weighted with an emphasis on quality (60%). The other 40% measures timeliness standards. The results display green as on target, yellow as in jeopardy and red as off target with monthly performance trend (improving, stable, degrading).The indicators are updated and reviewed monthly at the department, site and corporate level. This indicator, along with the other self evaluation programme indicators is included in the indicators report reported to corporate. These measures have focused attention on the quality and timeliness of actions of operating experience leading to better performance in this area.

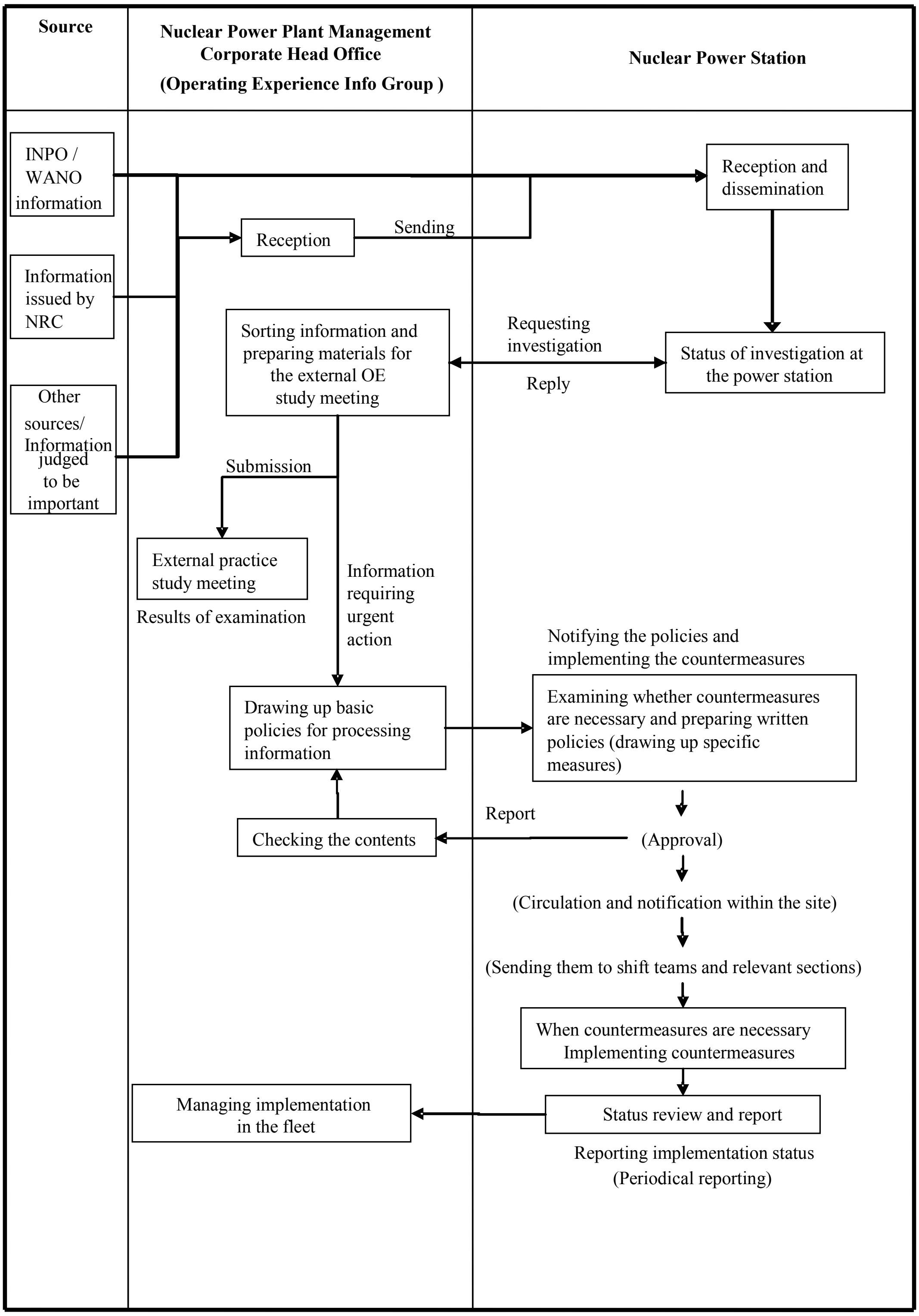
Appendix X

EXAMPLE OF FLOW OF IN-HOUSE OE INFORMATION PROCESSING AND DISSEMINATION



Appendix XI

EXAMPLE OF FLOW OF PROCESSING EXTERNAL OE INFORMATION



Appendix XII

EXAMPLES OF QUESTIONS FOR SELF-ASSESSMENT OF DISSEMINATION AND UTILIZATION

Questions to ask and follow-up:

(1) Are plant personnel knowledgeable of recent relevant significant events, both internal and external?
(2) Is relevant OE information readily available to all concerned plant personnel?
(3) Is the information apparent in the plant (OE bulletins, notices, posters, etc.)?
(4) Is there evidence of prompt decision and action regarding the use of OE following events with significant plant impact (e.g. reactor trips)?
(5) Are there regular meetings of plant personnel at different levels where relevant in-house and industry event information is presented and discussed?
(6) Are lessons learned from recent external and internal events included in refresher training (e.g. simulator training)? Are other disciplines included other than operations (e.g. maintenance)?
(7) Are lessons learned from previous events disseminated and used in pre-job briefings? Is the information provided in a timely manner and pre-job "just-in-time"?
(8) Have the lessons learned from immediate reviews of events with significant plant impact been timely disseminated to personnel?
(9) Are regular staff briefings on safety issues and lessons learned carried out by management/supervisory staff? Are these briefings effective in enhancing the performance of personnel?
(10) Are the engineering department and other corporate organizations involved in the OE programme and effective use of the information to support the plant activities?
(11) Are workers/engineers aware of significant OE information in the nuclear industry, specially those involving similar technologies affecting the plant
(12) Are the good practices considered when reviewing procedures or issuing new procedures?
(13) Is industry OE information used during in-house events analysis?
(14) Is the participation of employees in communities of practice and benchmarking activities encouraged and supported by management?
(15) Is OE systematically utilized in review of process, technical documents and system performance?
(16) Does the facility have criteria and objectives to ensure the OE information is delivered to the industry in a timely manner?
(17) Does the facility utilize OE in the life management programme? Have the result been documented and are they effective?
(18) How is OE disseminated to Contractors? Are contract personnel knowledgeable of recent relevant significant events, both internal and external?
(19) Do contractors incorporate OE information into their work practices?
(20) How is OE information incorporated into the Outage Programme?

Activities to be performed in support of self assessment:

(21) Attend OE meetings to observe and verify the involvement of participants and the effectiveness of the meetings.
(22) Attend plant daily meetings to observe and verify if OE issues are addressed and receive the appropriate attention.
(23) Attend training sessions to observe and verify if OE issues are addressed and included in the training programme.

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