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Effective corrective actions to enhance operational safety of nuclear installations

IAEA
International Atomic Energy Agency

July 2005

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FOREWORD

The safe operation of nuclear power plants around the world and the prevention of incidents in these installations remain key concerns for the nuclear community. In this connection the feedback of operating experience plays a major role: every nuclear plant operator needs to have a system in place to identify and feed back the lessons learned from operating experience and to implement effective corrective actions to prevent safety events from reoccurring. An effective operating experience programme also includes a proactive approach that is aimed at preventing the first-time occurrence of safety events.

In April 2003, the IAEA issued the PROSPER guidelines for nuclear installations to strengthen and enhance their own operating experience process and for self-assessment on the effectiveness of the feedback process. Subsequently, in the course of the Operational Safety Review Teams missions conducted by the IAEA that focused on the operational safety practices of nuclear power plants, the IAEA enhanced the review of the operating experience in nuclear power plants by implementing a new module that is derived from these guidelines.

In order to highlight the effective implementation of the operating experience programme and to provide practical assistance in this area, the IAEA organized workshops and conferences to discuss recent trends in operating experience. The IAEA also performed assistance and review missions at plants and corporate organizations. The IAEA is further developing advice and assistance on operating experience feedback programmes and is reporting on good practices.

The present publication is the outcome of two years of coordinated effort involving the participation of experts of nuclear organizations in several Member States. It provides information and good practices for successfully establishing an effective corrective actions programme. This publication forms part of a series that develops the principles set forth in these guidelines. The IAEA wishes to thank all participants and their Member States for their valuable contribution. The IAEA officer responsible for this report was F. Perramon of the Division of Nuclear Installation Safety.

EDITORIAL NOTE

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CONTENTS

SUMMARY

The purpose of this publication is to provide information and good practices to nuclear installations for improving the processes of developing, implementing and assessing the effectiveness of corrective actions for issues that have been identified in the Operating Experience (OE) programme. It is recognized that alternative means may exist and that a nuclear plant operator might effectively achieve the overall performance objective without meeting some or part of the specific criteria, attributes or practices described in the present publication.

The objective of an Operating Experience programme is to improve a plant's level of safety and reliability by ensuring the feedback of lessons learned. Improvements are identified through the review of internal plant events, self-assessment activities and the review of industry operating experience. This publication provides information and good practices for the key step of implementing the corrective actions that are derived from these processes. Each nuclear utility is expected to implement a corrective action programme. The programme will be created according to the utility's culture, know-how and OE feedback. The suggestions and good practices for successfully establishing a corrective action programme include the following aspects:

— developing effective corrective actions
— prioritizing corrective actions
— implementing corrective actions successfully
— assessing the effectiveness of the corrective actions.

Important elements to consider when developing effective corrective actions are:

— addressing the root causes
— selecting corrective actions
— conservative decision making
— corrective action implementation
— tracking of corrective action effectiveness
— prevent repetition
— rally commitments
— indicators
— self-assessment
— peer review
— benchmarking.

It is essential that the human performance aspects of the safety issue that has been identified are understood and that the corrective action considered addresses the underlying cultural issues that lead to the error, not just the specific error. A detailed methodology to effectively correct and prevent recurrence of human errors whilst working in different areas of performance is suggested.

Use of the information provided will contribute to ensuring that the corrective actions are prioritized and implemented in a timely manner that is compatible with the frequency and significance of the issue. Provisions are described for tracking the effectiveness of corrective actions following implementation and for periodically assessing the overall performance of the corrective action programme.

The international nuclear organizations have established initiatives in the area of operating experience feedback, implementation of corrective actions and identification of

good practices (e.g. IAEA, WANO, INPO, etc.). These identified good practices may be useful in assisting with the determination of corrective actions.

These initiatives have been mainly focussed on the operational nuclear power plant activities. However expanding these initiatives to all process activities in design, construction, operation and decommission, including all facilities and nuclear installations, power plants, research reactors, fuel cycle facilities, waste treatment process, etc. will be beneficial. These will be of interest to owners, operators, vendors, manufacturers, contractors, and the regulatory authorities in enhancing nuclear safety performance.

Finally, this report stresses that true success in the area of corrective action can only be achieved with strong management support. Management plays a vital role in (a) fostering an environment where workers feel free to identify issues, (b) ensuring that the resources are made available to implement effective corrective actions and (c) overseeing the programme to ensure that continuous improvement in plant operation is achieved.

1. INTRODUCTION

Every nuclear utility/NPP has its own operational experience (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 safety and reliability of the plant.

Figure 1 is an example of a flow chart of a typical OE process. Annex III develops the box "Corrective actions" of Figure 1 and interface process to show schematically an example of the typical process for a corrective action programme.

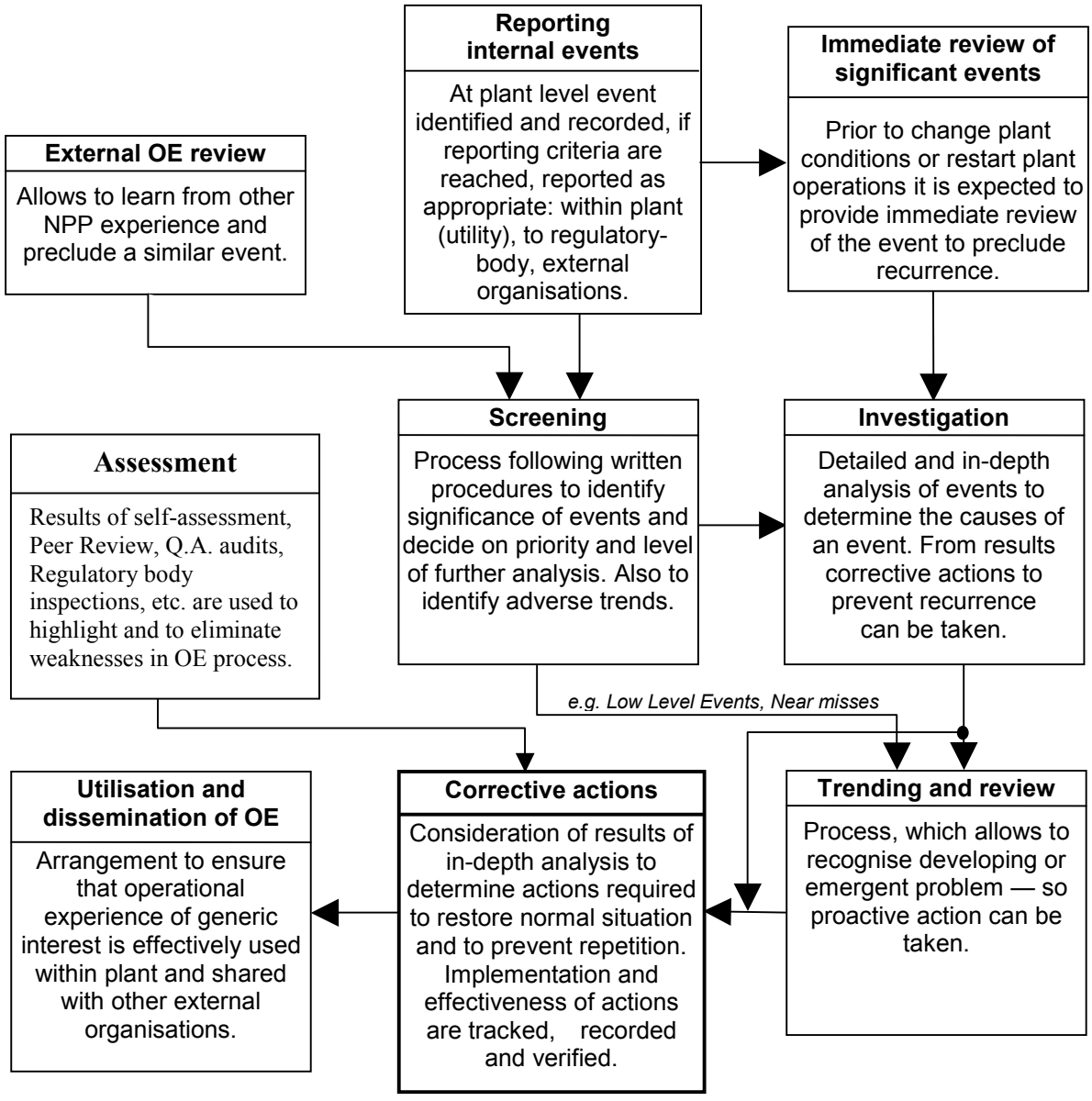

FIG. 1. Flow chart of a typical OE process.

While all the areas of the OE process are significant for attaining an effective implementation of the programme, the area of corrective actions is one of the most significant because it represents the final step where all the efforts converge to ensure that the situation is restored and subsequent satisfactory performance is obtained.

Results of different types of assessments (self-assessment, peer review, quality assurance (QA) audits, Regulatory Body inspection, etc.) are usually used to improve effectiveness of overall OE process.

Although corrective action when implemented after the event is a reactive approach, in this publication alternatives are also presented for a more proactive approach dealing with the appropriate resolution of problems before they become significant.

This publication is intended to illustrate the advantages of using an effective corrective actions program based on operating experience for the prevention and correction of degraded performance and the enhancement of the operational safety of nuclear installations.

2. OBJECTIVE

This publication has been developed to provide information and good practices to nuclear plant operators to strengthen and enhance their own OE process through the implementation of an effective corrective action programme in order to improve overall nuclear safety, radiological safety, industrial safety and operational reliability.

The purpose of this publication is to provide detailed information, suggestions and good practices in developing and implementing effective corrective actions to ensure subsequent satisfactory performance, event prevention and to assess their effectiveness during the plant life operation.

3. ESSENTIAL CHARACTERISTICS FOR EFFECTIVE CORRECTIVE ACTIONS

An effective corrective action programme relies on certain essential characteristics that provide support and enhance programme effectiveness. These characteristics are highlighted in the following paragraphs.

3.1. Overall characteristics

Corrective actions will not be effective unless the following overall characteristics have been adequately addressed:

- Policies are established by management to align the organization to effectively implement corrective actions and to set criteria for expectations and priorities.
- Personnel, including contractors, are actively encouraged by plant management to identify and report events. Reporting criteria and reporting systems are clearly defined and familiar.
- Reported events and minor problems are screened and evaluated in a timely manner based on their actual or potential consequences.

- Significant events and repeated problems are investigated to their root causes to identify effective corrective actions.
- Investigation of events of lower significance may focus on correcting immediate cause and trending and may not address the root cause.
- Personnel with sufficient knowledge and skills carry out investigations of significant events and recurring problems using well-defined root cause analysis techniques.
- Root causes, contributing causes and direct causes are identified by the investigation.
- The OE indicators (data gathered from significant events, low-level events, near misses, error-likely situations reporting, screening and investigation) are trended to identify system vulnerabilities, generic issues or weaknesses in the organization.
- Plant management encourages and reinforces the use of OE information (use of lessons learned) by personnel.
- Employees who identify problems receive feedback on decisions made and on corrective actions taken.
- Appropriate resources (personnel, equipment, funds) are allocated by the management to the corrective action programme.

The management of the plant ensures that these activities are addressed and that a satisfactory OE process is established. To evaluate how the above-mentioned activities are applied, a self-assessment to review the effectiveness of the operational experience process is periodically carried out at the plant.

3.2. Types of corrective actions

3.2.1. Types of corrective actions after an event

Operating experience and root cause analysis can result in three types of corrective actions:

- immediate corrective actions
- interim corrective actions
- corrective actions to prevent recurrence.

Immediate corrective actions are actions taken to promptly restore normal conditions or eliminate problems. For example, valves and pumps are repaired, procedures are written and a communication link is established between two affected groups, etc.

Interim corrective actions are short-term actions to reduce the risk of recurrence while awaiting long-term corrective actions. Interim corrective actions could be accompanied by compensatory actions. For example, an operating procedure to prevent a motor operator valve torque to be deficient while awaiting a design change to increase the size of the motor operator.

Corrective actions to prevent recurrence are the most significant of the three types. These corrective actions prevent the problem from ever happening again. Identification and selection of corrective actions that directly address the root cause(s) of the event is of utmost importance for the safety, reliability and performance, and for helping to prevent further events. They have a proven track record and do not cause unwanted problems in other areas.

3.2.2. Corrective actions to prevent safety significant events

Together with the review of internal events, the review of external operational experience is an opportunity to prevent the occurrence of significant events.

Plants have implemented operating experience programmes to review external events, and also have reporting systems to let the national and international nuclear community to know about internal significant events, and sometimes about minor-to-important events that could be of interest to other plants.

In this sense each plant systematically reviews the external operating experience in order to assess the necessity to implement corrective actions to prevent occurrence at the specific plant.

In addition the plants are encouraged to implement trending analysis of internal events, low level events, near misses and error likely situations, to identify and correct precursors to prevent more significant problems. Experience shows that precursors, if remain uncorrected, may lead to significant events or contribute to the development of significant events.

The prevention of significant events is the most important objective of an operating experience programme. Thus, as an overall essential characteristic, the corrective actions to prevent safety significant events receive the highest attention, resources and priority.

3.3. Elements of an effective corrective action programme

As a minimum, an effective corrective action programme contains the following elements:

- addressing the root causes
- selecting corrective actions
- conservative decision making
- prioritization
- corrective action implementation
- tracking of corrective action effectiveness
- prevent repetition
- rally commitments
- indicators
- self-assessment
- peer review
- benchmarking.

For the purpose of this publication each one of these elements is specifically addressed in Section 5 and further on in this publication.

3.4. Role of management

Management at all levels demonstrates ownership for the corrective actions programme by directing, promoting, prioritizing, and sufficiently staffing programme activities. The success of the corrective action programme depends, in large part, on the leadership shown by plant management. However executive management goes beyond this principle by closely following the thoroughness with which events are reported, the depth of event analysis, the

scope of the corrective actions and the timeliness and quality of corrective action implementation. In general, frequent management involvement is required for the corrective action programme to remain forceful, productive and efficient.

The international nuclear organizations have established initiatives of operating experience feedback, implementation of corrective actions and identification of good practices (e.g. IAEA, WANO, INPO, etc.). An important role of the management is to ensure that these initiatives are considered by the personnel. International data bases have been developed by IAEA, WANO and other organisations that can be accessed electronically by its members. Exchanging information and encouraging communication, comparison and emulation amongst the nuclear installations are essential components of these initiatives.

In the reference section of the present publication a selected list of IAEA publications is included that address safety fundamentals, safety requirements, recommendations and good practices for nuclear installations. In addition to fulfilling the safety fundamentals and requirements, the consideration of good practices may be useful to management in assisting with the determination of corrective actions to improve safety and performance.

Similarly, nuclear power plant organizations, institutes and owners group such as WANO, INPO, EPRI, Reactors Owners Groups etc. have issued a series of publications that are available to their members.

Management decision regarding the reporting level criteria, and the extent of evaluation or investigation that problems receive is a balance between evaluation thoroughness, corrective actions timeliness, and resource allocation considerations. The most effective balance depends largely on the continuous improvement programme strategy to focus on the progress of corrective actions implementation process. Management periodically review this balance and adjust the programme as needed.

Management and plant personnel recognize that minor problems are often precursors or contributors to more significant events. A corrective action programme related to the lower level events and near misses is implemented. The resultant programme will help to identify and resolve problems across a broad range of station activities. However, particular focus is needed on problems or trends that detract from safe and reliable plant operation.

Managers avoid a punitive approach to errors made in good faith as well as reacting defensively to suggestions for improvement. A non-blame reporting policy whilst maintaining an accountability environment, a self-criticism attitude, a continuous improvement effort, a rigorous approach and a good communication, are important factors of an effective corrective actions programme.

When discovering a problem, utilities and contractors plant personnel at all levels take immediate actions to address it. These actions include reporting the problem to the direct supervisor and to other affected areas of the plant, and initiating or ensuring the initiation of a deficiency report. The deficiency report contains adequate details to assist the investigation and the development of further effective corrective actions.

Management establishes a non-restrictive approach when considering the definition of recurring events. This expanded approach is directed towards considering internal recurring events and deficiencies, not only those that are the same as previous in-house events with the same root causes, but also those that are very similar and have similar causes as previous

events or deficiencies. This expanded approach also includes the concept that for an event or deficiency to be considered recurring, it does not need to have occurred at the same plant, but may have occurred at another plant of similar characteristics.

For a proactive approach this definition is further expanded to implement in-house effective preventive corrective actions for those events with actual or potential safety significance that have already taken place at several sites internationally, although they have not yet recurred within a given country or a given utility.

4. INPUTS OF A CORRECTIVE ACTION PROGRAMME

The main inputs to the corrective action programme can be identified in Figure 1 of the Introduction to this publication. These inputs are:

- reported internal events
- assessment results
- external OE review.

Inputs from assessment results to an effective corrective actions programme include not only those mentioned in Figure 1 but also quality non-conformances, test failure causes, deficiencies and deviations from specified requirements or recommended conditions. These assessment results are either trended or accepted as individual input depending on their significance to safety and reliability.

Some stations use a single formal corrective actions system to track all issues. Others use two separate programmes to distinguish significant and minor issues. Whatever the case, results of the trending analysis are integrated and periodic reviews are performed to preclude important issues in the higher level of operating experience and corrective actions, are not being reported instead in the lower level and near misses programme.

Due to the time and effort involved in evaluation of events, station procedures must ensure that the deepest analysis is reserved for issues of highest significance.

5. ELEMENTS OF AN EFFECTIVE CORRECTIVE ACTION PROGRAMME

5.1. Addressing the root causes

Transparency and open-mindedness of personnel and managers are necessary to effectively identify the root causes, and thus to define the appropriate corrective actions. Fundamental root causes can be due to equipment, man/machine interface design, procedure, documentation, management or human performance failures. Experience shows that equipment, procedure, and documentation failures are normally identified. This is not always the case for management, design and human performance failures, which require additional in-depth analysis and commitment.

When assessing the applicability of external OE, experience has shown the risk of adopting a defensive approach, with a tendency to focus the review on justifying why it is not applicable or why it cannot happen in-house. An effective corrective action programme

refrains from adopting such defensive approaches and focuses on how the lessons learned from the external event could be beneficial in house.

Problems are evaluated commensurate with their significance. The programme applies structured root cause evaluation techniques to important issues where recurrence is unacceptable. Management appoints an individual or team with the appropriate knowledge and skills to conduct problem analysis and corrective actions determination. Particular focus is needed on problems that deviate from safe and reliable operations or that cause events.

Analysing trends on low-level events and near misses can help to identify precursors and prevent more significant problems. Such trends are screened and reported as problems in the operating experience feedback programme, the root cause for the trend is identified and the corrective actions are determined.

Involving field personnel (operating personnel, maintenance personnel, radiation protection technicians, etc.) into event and root cause investigation is a helpful way to identify and eliminate circumstances which can lead to an event. It contributes to:

- Providing a cost effective and practical corrective action to resolve the identified problem areas;
- Providing an excellent opportunity for identification of needed training on the potentially problematic issues;
- Developing a sense of ownership among workers;
- Providing motivation and a sense of usefulness to the individual who identified the issue.

Root causes of common cause failures represent the highest risk since it could make several redundant trains of safety inoperable at the same time. Adequately addressing root causes for common cause failures is essential for an effective corrective actions programme to improve safety.

5.2. Selecting the corrective actions

When selecting the corrective actions, priority is given to safety issues and to the adequacy for each specific case of the different types of corrective actions: immediate, interim and corrective actions to prevent occurrence or recurrence of safety significant events.

In addition to the consideration of immediate and interim corrective actions, because of the time and effort involved, attention is devoted to address the significant root causes and select the corresponding corrective actions. Once the direct causes, contributors and root causes, inappropriate actions and failure status have been identified, listing the corresponding corrective actions is very useful for selecting the most effective and prioritize the most adequate.

In this endeavour, it is taken into account that not always the most expensive or complex corrective actions are the most effective. While ensuring the root cause is effectively addressed, the advantage of easy-to-correct corrective actions is that they can be readily implemented so as to immediately contribute to the effort towards effective plan safety performance. Nevertheless, attention is needed because minor and easy-to-correct problems may be advance warnings of precursors of more significant issues. Trending past history could provide an early indication of such issues.

The corrective actions are specific, practical, prioritized and the contents and schedule agreed. A practical acronym frequently used in the industry is that the corrective actions are SMARTER:

- **S**pecific
- **M**easurable
- **A**chievable
- **R**ealistic
- **T**imely
- **E**ffective
- **R**eviewed.

When selecting the corrective actions, strengthening existing programmes and defence in-depth barriers is preferable to developing new ones. Often the most effective approach is to implement a simple, passive or natural barrier. Complex barriers have the potential to introduce a new unforeseen error mechanism. It is not very effective to develop new barriers when the existing ones remain weak. As an example, retraining or counselling an individual, although it is an action in the right direction, it may not be a permanent remedy except in rare cases, but a better solution could be an improvement of an existing procedure.

Every corrective action has its own set of failure modes. All corrective actions can fail in some way. All proposed corrective actions are thoroughly analysed to provide reasonable assurance that they will not introduce a new failure mechanism.

Some factors to consider in making recommendations for corrective actions are:

- consequences of not implementing
- consequences of implementing
- possibilities of mitigation or prevention
- possible hazards
- cultural changes
- capability to address the change (knowledge, expertise)
- communication actions to promote the change
- training requirements involved, including mock-ups and job specific qualification
- As Low As Reasonably Achievable (ALARA) commitment
- cost of implementation.

It is important to use industry OE information when selecting corrective actions. The review of industry operating experience information is a helpful way to use industry lessons learned when in-house corrective actions are being defined. Industry OE information can be used:

- To resolve known deficiencies/error likely situations by reviewing how industry has dealt with the problem;
- To compare proposed solutions to the event resolving with previous solutions on this or similar events and the degree of effectiveness attained;
- To determine whether all aspects of the event have been considered;

- To verify if lessons learned from the industry have been taken into account for the selection as well as implementation of the corrective actions.

When implementing corrective actions that have been effective at other sites, care is taken to ensure that the corrective actions would be compatible with the station's design, local environment, resources and culture. The corrective actions are modified as necessary to the above-mentioned conditions to ensure that their effectiveness is maintained.

Selected corrective actions result from a rationale approach. The reason behind this approach (why it has been selected) is communicated and understood by the participants. The selected corrective actions could be in the form of change in operational practices, incorporation of some repair or replacement, design modification, organization or human performance improvement. These aspects are addressed specifically in Sections 6 and 7 of this publication.

5.3. Conservative decision making

Experience shows that criteria for decision making on corrective actions and their time schedule has been a weakness in the process of plant's operating experience feedback. As a result it is recommended that plant management establishes criteria for conservative decision making related to selecting effective corrective actions and setting a proactive time schedule for their implementation. The directive includes measures for avoiding unnecessary delays and expediting the necessary resources.

The decision making process includes a contingency plan and mitigating measures for any unexpected problem that may arise during the implementation of selected corrective actions. In this decision process however, the safety versus performance priorities is respected.

Levels of review and decision making process are commensurate with the importance for safety. The use of safety class, components quality lists, and unreviewed safety questions concept are important tools to determine the levels of review and to establish conservative safety margins. Adequate time, attention and resources are devoted to the task of review. Driving forces surrounding the sense of urgency on the internal review process or in the licensing regulatory review and approval process refrain from inappropriate pressure. Corrective actions that unnecessarily reduce safety margins are recognized and avoided. Review by experienced personnel is an important barrier in the defence in depth. Experience shows that important events have developed when this barrier has not been effective.

During the conservative decision process the assumptions on which the decision is based are carefully listed and challenged. Questions to consider includes:

- What is the worst thing that could happen if we proceed in this manner?
- Is this acceptable?
- Are the results safe enough?
- Is there any safer alternative?

If there is any doubt that the decision may have a negative impact on safety margins, an alternate action is developed obtaining additional information to solve the uncertainty. In particular, safety margins are substantially increased for first of a kind corrective action.

As a conservative approach, if event conditions have caused the plant to closely approach or even exceed a boundary or safety envelope, strengthening operating margins set before the boundary is an action considered in the decision making process. Effective corrective action re-establishes the desired level of safe and reliable operation. When it cannot be determined if a safety boundary has been approached or exceeded, the conservative decision making process presumes that the safety boundary may have already been exceeded.

Preconceptions, presumptions and narrow thinking are common weaknesses of the conservative decision making process. Lack of external information and questioning attitude can contribute to ineffective corrective actions. Management is in charge of directing the appropriate documentation searches, to seek external advice and to enlarge the views and scope of application in accordance to the significance of corrective actions.

Effective corrective actions based on a conservative decision approach is ensured for all levels of events. In most cases effective corrective actions are implemented for low-level events, deficiencies, equipment failures, human performance failures, procedure deficiencies, suggestions for improvement and documentation inconsistencies. But for all levels it is taken into account that, at the top of the process, as an utmost essential priority, the basic safety functions are ensured, protected and maintained. In nuclear power plants, the main basic safety functions are:

- reactivity control
- cooling of irradiated fuel (in or out the core)
- integrity of the physical barriers (fuel cladding, reactor cooling system pressure boundary, containment)
- availability of safety support systems.

5.4. Prioritization and implementation for corrective actions

The first step for corrective actions implementation is the implementation of immediate and/or interim actions to recover from the event, restore the situation and repair the deficiencies. Although permanent corrective actions address the root causes, implementation of short-term actions may be needed to correct immediate problems, repair the deficiency, recover functionality or reach a stable state. The capacity of this action to allow for continuing operations is evaluated and reviewed based on safety and regulatory principles and a reasonable decision made by the appropriate levels of management with the conservative approach in mind.

The overriding considerations for assigning priorities for implementation of various corrective actions is based on safety significance and extent of impairment of system or component functional capabilities and safety margins. Prioritization of corrective actions is further addressed in Section 8 of this publication.

Prior to the implementation of corrective actions, management has to reach the reasonable assurance that the selected corrective action or actions and their combined effort, will restore the situation, ensure satisfactory performance and prevent recurrence. To this end the factors to be considered include whether:

- The corrective action addresses the fundamental problem;
- The corrective action is compatible with other corrective actions previously implemented;

- The proposed corrective action has been tried before, and with what results;
- The corrective action is an immediate, an interim or a final solution;
- A risk factor is considered;
- The corrective action schedule for restoring the situation and the incremental improvement attributed to the progress of the implementation is compatible with reaching the satisfactory levels of safety and reliability on time;
- An action plan to periodically verify the effectiveness of the action is included.

Prior to implementation, the recommended corrective actions are reviewed and approved at an appropriate level. The objective of the approval is to ensure consideration of the above factors. The approval process depends on the significance of the corrective actions. Documents, when applicable, that are typically submitted for approval, may consist of:

- A detailed description of proposed alternative corrective actions (including drawings, schemes, etc.) stating the reason for rejection, if any;
- A safety review which assures that the proposed corrective actions improve safety and have no adverse effects;
- An identification of other areas influenced by the corrective actions and adjustments if necessary;
- Quality plans assuring compliance with design standards, policies and procedures;
- Plans and schedules for implementing the corrective actions and assigning responsibilities;
- Procedures for undertaking a safe working method;
- Organizational and human performance considerations.

Prior to implementation, the appropriate levels of management ensure that all personnel involved in the corrective action, including contractor staff if deployed, have a good and consistent understanding of the corrective action, its objective, scope, interfaces and precautions, so as to ensure that no errors occur due to misunderstanding.

The following steps are considered when corrective actions are implemented:

- Check that implementation is in agreement with the specified action.
- When non-conformance or discrepancies are identified they are resolved and the changes are submitted to the same process of approval as the initial specified action. An immediate review for safety and reliability is performed when new problems or unexpected conditions not considered during development of the corrective action are identified.
- Check if the performance is satisfactory and fulfils the specified expectations. If the corrective action involves hardware, test the equipment performance. If the corrective action involves training, ensure the understanding, qualification and agreement of the trainee. If the corrective action is procedure or documentation, verify that modifications are clearly stated, approved and recorded.

The implementation of the corrective actions is controlled in accordance with quality plans. These quality plans address specified expectations. The appropriate level of management review the process, the implementation and the results.

5.5. Tracking effectiveness of corrective actions

The first step for tracking corrective action effectiveness is to track implementation with regard to criteria provided in the previous chapter, with special attention to the following points:

- Has the corrective action been implemented in due time according to the planed schedule?
- Has the satisfactory implementation been controlled according to quality plans?
- When implementation has been planned in several phases, is the need for these phases reasonably justified?
- Is the scope of each phase compatible with a safe/stable status of the plant? Has each phase been implemented in due time as scheduled?

When tracking implementation, items affected by the corrective action are also identified and tracked. This refers to items such as: affected documents (to review the proper revision are in place), interviews with affected personnel (to verify improvement of their knowledge related to the change), affected training programme (to review whether new requirements have been included into the training), etc.

Field observations help to track implementation of the corrective action. Through observation of personnel activity, an assessment can be made whether applied personnel work practices reflect the corrective action. Whilst interviewing affected personnel, a question is asked on the personnel perspective of the corrective action effectiveness.

The next step is tracking performance. Personnel familiar with the subject review periodically the performance of the corrective actions to assess their effectiveness.

The responsible department with sufficient oversight is the preferred choice to conduct the effectiveness review to ensure that the review will be self-critical. When necessary, independent personnel familiar with the subject may conduct this effectiveness review. The purpose of the effectiveness review is a comprehensive and objective review to determine whether the corrective action is effective and to provide feedback to management. Special focus is directed on preventing the event from recurring and on reviewing actions taken to prevent significant events. The reviews are planned and the schedule followed. The results of the review may include recommendations for remedial actions as necessary.

The review frequency is established based on the importance, complexity, frequency of use, cross interactions and interfaces of the corrective action. This frequency is also consistent with the priorities of the continuous improvement programme strategy to focus effective progress. Management periodically reviews the priorities and adjusts the programme if needed.

The interval between effectiveness reviews is based on the nature of the event or deficiency being prevented. For example, an event that has the probability of occurring each day has a short review frequency, perhaps 2 to 3 months. An event that can only occur in a certain mode of plant operation may have a longer review frequency.

In addition to the planned review, performance of an effectiveness review is considered if at any time an in-house event occurs that should have been prevented by previously taken corrective actions. It is fundamental to determine why the corrective action has not been effective, and to propose necessary adjustments and remedial actions.

Preparation of a procedure for the effectiveness review of corrective actions is recommended. The purpose of this procedure is to provide a systematic approach to determine when an effectiveness review of the performance of the corrective action will be done and how to perform it.

When several consecutive periodic effectiveness reviews (two or three depending on the importance and complexity) have established effectiveness of the corrective action, then the review interval may be extended. The new extended period is based on performance history and relevant risk analysis.

Some typical questions to be answered during the effectiveness review are the following:

- Has the basis changed such that the corrective action is no longer valid?
- Has additional information come out that may impact the validity or scope of previous corrective action?
- Have the plant conditions, physical parameters, operating margins, or scheduled time frame existed since the implementation of the corrective action that the event could have occurred?
- Has the corrective action been altered so that it is no longer serving the original intent?
- Does evidence exist that the corrective action has effectively minimized occurrence of the event?
- Is there any reason that the corrective action should be re-opened to question its effectiveness? (Reasons such as: too narrow in scope, insufficient, overly restrictive, better and more efficient alternatives, etc.).

During the effectiveness review the involved personnel is interviewed. During the interview, a question is asked on their personal perspective of the corrective action effectiveness.

The evaluation determines the effectiveness of all the people involved at the different levels down to the lowest practical level (i.e. end user, end result, or field application).

For example, if the corrective action was to provide training, the evaluation does not stop at reviewing the lesson plan, attendance records, or class test results, the evaluation also includes determining the practical knowledge of the trained people. The evaluator interviews a sample of people that were trained. As an alternative the evaluator can observe jobs or tasks where the training is applied.

If the action was to implement a policy or procedure change, the evaluator determines whether the affected people understand and implement the change as intended. The evaluation does not stop at verifying that the policy or procedure change was issued.

When a corrective action is determined to be not effective all interested parties are promptly informed. Action is taken to investigate the causes of being ineffective. An evaluation to identify the aspects of the OE programme that failed to contribute to a successful corrective action is performed.

It is a good practice to establish a corrective actions database to help and support the tracking of effectiveness. Section 9 of this publication describes an example of the format and

content of a typical database that may be established for this purpose. It is recognized that other formats and contents may exist to help track the effectiveness of the corrective actions and to adequately support the corrective actions programmes. The final selected approach is adjusted to the plant organization needs and integrated in the overall plant management data system.

It is known that the power plants have programmes to trend performance of maintenance. These programmes come from the advantage and benefit of the follow up of the plant performance; and in other cases the regulatory bodies have required specific regulations like the Maintenance Rule programme. These programmes give results about performance upon particular parameters, for example, reliability and availability of safety significant structures, systems and components.

It is suggested to incorporate these programmes into the process of the corrective actions programmes, so as to enhance the synergies with the plant operating experience feedback programme. For example, in the case of the maintenance rule programme, when a system is below its expected performance, it is put on more strict practices of maintenance and surveillances until it is demonstrated by actual performance that the appropriate corrective actions were effectively applied.

Establishment of a Corrective Action Review Board or similar body to oversee, review and monitor the corrective actions programme, is considered to be good practice. This board may comprise of senior managers from Operation, Engineering, Quality Assurance, Maintenance, Licensing, Safety and other involved organizations. Strong communication is required between all participating and affected functional groups for this Board to be effective.

5.6. Preventing repetition

In the previous chapters, when analysing, selecting and restoring the situation, some of the criteria to prevent recurrence have been already discussed, namely:

- Ensuring the root cause is addressed;
- Ensuring compatibility with all modes of the plant status and procedures;
- Strengthening existing operating margins, plant programmes and defence in-depth barriers;
- Ensuring timely implementation;
- Controlling the quality of implementation;
- Analysing the consequences of not implementing;
- Implementing necessary culture changes to make the corrective actions permanently effective.

In addition to the above criteria the following management actions are considered beneficial as a proactive approach to prevent recurrence:

- Maintain awareness of the personnel on the operating experience history, particularly on the causes that contributed to the events, failures and deficiencies.
- Encourage the application of self checking, independent verification, pre job briefings, when encountering the same situations.
- Train the personnel to recognize when a situation is present that may be conducive to a failure in a way similar to those previously experienced.

- Review in advance the planned operating modes of the plant and the maintenance activities by performing proactive functional risk estimation and job risk estimation techniques, considering among others the mechanism for these failures to reoccur.
- Ensure that a review process is in place to assess if the fundamental causes of the events are effectively identified and resolved.
- Ensure that the effectiveness review of the corrective actions are performed.
- Maintain operating experience exchange with plants, utilities and organizations that have experienced similar situations or trending.
- Recognize the weaknesses of the organization and make efforts for continuous improvements necessary.

In any case, as soon as a reasonable doubt exists that the corrective action might be insufficient or ineffective, the corrective action is opened again for re-consideration, analysis and determination of the supplementary adjustments or a new corrective action. Effectiveness checks conducted at appropriate intervals are very useful in proactively verifying the effectiveness of a corrective action.

When necessary, the new corrective action or adjustment is subject to the same level of approval as the initial corrective action. All interested parties are promptly informed that the initial corrective action has not been effective and the causes of being ineffective are discussed and addressed.

5.7. Rally commitments

Experience shows that a successful corrective action programme requires the commitment of the organizations or individuals at all levels who are responsible for its implementation. This commitment is important in the following areas:

- Promoting: management promote the corrective action process, support and encourage effective problem identification and correction at all levels in the organization.
- Accountability: managers ensure that problems are addressed in a timely manner and are held accountable for meeting corrective action due dates. Extensions or exceptions are normally made only in response to issues of higher priority.
- Motivation: employees who identify problems receive prompt feedback about corrective actions. Informing employees of corrective actions taken or planned helps motivate workers to continue using the corrective actions process. Feedback is particularly important if a submitted problem is determined to be invalid or not worthy of additional corrective action.
- Ownership: corrective actions are discussed, understood and assumed for a successful implementation. A responsible group or person is nominated to own and co-ordinate the corrective actions.
- Training: the information on corrective actions is incorporated into the personnel training programme as soon as possible.
- Communicating: during the entire process, the results and the benefits expected/obtained from the corrective actions are communicated to all involved personnel.

5.8. Indicators

Use of indicators for monitoring the effectiveness of the corrective actions process is an important tool for management of the improvement efforts and for identifying areas needing focussed attention.

The actual numerical value of any individual indicator may not be significant by itself, but may be enhanced when considered in the context of other indicator performances. Trends of the indicators over a period of time can provide valuable information on the level of effectiveness achieved by the corrective actions process.

In this objective a set of indicators has been selected and grouped into three different aspects of corrective action activities so that when adequately combined they can provide a useful situational picture:

- programme indicators
- performance indicators
- distribution graphs.

The following selection is included as an example and is not intended to be exhaustive. Each plant and utility organization has to determine which indicators may best serve its particular needs. Also some indicators may be specifically appropriate to allow management to identify targets and set measurable goals as performance objectives for continuous improvement.

5.8.1. Programme indicators

- No. of pending corrective actions;
- Ratio of pending vs. approved corrective actions;
- No. of corrective actions re-scheduled;
- Most frequent postponed time when re-scheduling;
- No. of pending findings from corrective action programme with overdue date;
- No. of recurring findings from self-assessments of corrective actions programmes;
- No. of peer review findings not previously identified by internal reviews.

5.8.2. Performance indicators

- No. of corrective actions ineffective;
- Ratio of ineffective vs. requested corrective actions;
- No. of re-opened corrective actions for re-analysis;
- Ratio of recurring events per event;
- No. of times an activity was conducted successfully;
- No. of in-service hours since last corrective action;
- No. of recurrent causes of events;
- No. of corrective actions rejected by management review;
- No. of corrective actions based on industry lesson learned.

Other operating performance indicators may be helpful in providing additional insight into the effectiveness of corrective actions programme. Some examples are:

- No. of demands of safety systems (idem for non-safety systems);
- No. of failures of safety systems (idem for non-safety systems);
- No. of times a safety system is unavailable (idem for non-safety systems);
- No. of licensing requirement violations;
- No. of technical specification violations;
- No. of exemptions for limited conditions for operation (LCO);
- No. justifications for continuous operation (JCO);
- No. of failures to follow procedures;
- No. of workers receiving radiation dose above prescribed limits;
- No. of industrial safety events;
- No. of configuration control issues;
- No. of human performance errors: Skill based, Rule based, and Knowledge based.

5.8.3. Distribution graphs

- Distribution of corrective actions (pie graph):

  – equipment
  – design
  – procedures
  – documentation
  – human performance
  – management, organization.

- Distribution of recurrent events (pie graph):

  – recurring events
  – recurring near misses.

The selected performance indicators are trended to identify and investigate deficiencies in the corrective action programme. The use of a coding system to perform this trending is also considered.

5.9. Self-assessment

The overall corrective action programme is periodically assessed for effectiveness. An effective corrective actions process can significantly contribute to minimizing the recurrence of events. The periodic assessment includes all stages of the corrective actions process to ensure that all of its elements are performed effectively. Assessment activities determine the ongoing process performance compared to management expectations. Continuous improvement of the corrective actions process is an objective of the review. In general, there are two approaches in undertaking such a review:

- Self-assessment by the operating organization/licensee;
- Peer review to determine whether the process meets established international standard (see Section 5.10 Peer Reviews).

A self-assessment performed by the operating organization periodically reviews the effectiveness of the corrective actions programme. The purpose of this review is to evaluate the overall process effectiveness and to recommend remedial measures to resolve any

weaknesses identified. Indicators of process effectiveness are developed. These may include the number, severity, recurrence rate of events and causes of different events.

This self-assessment review:

- Verify that corrective actions are being implemented in a timely manner;
- Evaluate the effectiveness of solving the original problems and preventing recurrence;
- Review recurring events and deficiencies to identify whether improvements in the corrective action process can be made.

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

A typical self-assessment of corrective action programme effectiveness takes 2 weeks and involves a mixture of people directly and not directly involved with the programme.

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

The self-assessment includes a detailed assessment of the awareness and involvement of the personnel with the programme and their level of satisfaction with the process. The assessment also reviews the effectiveness of the corrective action programme in providing feedback of lessons learned to the internal operating experience programme.

The effectiveness review encompass a representative sample of corrective actions from both internal and external sources. Selected samples are representative of the different types of corrective actions:

- human performance
- equipment
- design
- documentation
- procedures
- management, organization.

Sometimes human errors are the result of error likely situations that come about due to the way that procedures are written, training is conducted, work practices are applied, or systems are designed. Management establishes a self-assessment programme on the effectiveness of above-mentioned elements. Results of this self-assessment are then included into the existing corrective actions programme to improve overall human performance.

The results of self-assessment are prioritized. Plant management approves identified weaknesses and suggested areas for improvement. If necessary, management sets up corrective actions for further improvement. These corrective actions are included in the corrective actions programme. They are monitored and tracked to ensure proper and timely completion.

If significant programme weaknesses are identified, consideration is given to benchmarking the corrective action programme against good practices in the industry.

Management reports are prepared and issued periodically in the framework of the corrective action programme. The periodicity and the content of these reports are addressed in Section 10 of this publication.

5.10. Peer reviews

The purpose of a peer review is to determine whether the corrective action programme process meets internationally accepted standards and to identify areas for improvement. The peer review:

- Review the comprehensiveness of the plant self-assessment and offer comment and recommendations to further enhance the conclusions of the self-assessment;
- Compare, as far as possible, the corrective action with guidance and equivalent good practices elsewhere;
- Is process performance related so that it is possible to accept different approaches to the implementation of the corrective action programme.

Some of the criteria typically used during a peer review for assessing the effectiveness of corrective actions process are:

- Inputs to the corrective action programme are comprehensive;
- Corrective actions are effective and fully implemented in a timely manner;
- Recurrences of internal events are minimized;
- The performance of the plant, with respect to industry accepted operating experience indicators;
- The plant continuous improvement policy and strategies and the corrective action programme are mutually consistent and in agreement with international best practices, in particular regarding the balance of priorities and allocation of resources.

Peer reviews include a follow up on the results of previous reviews to determine if the intended corrective actions and recommendations were implemented and effective. The plant organization provides to the peer review team adequate insight and requests special focus and attention to recurring issues of previous self-assessments and peer reviews.

5.11. Benchmarking

The purpose of benchmarking is to determine the level of effectiveness of the corrective action programme process and the effectiveness in practice of the implemented corrective actions compared with the level of effectiveness obtained elsewhere.

Benchmarking compares:

- The attributes and scope of the programme with those in place at each of the benchmarking participants;
- How the selection of corrective actions is made for similar events and the effectiveness in practice obtained by each benchmarking participant;
- The strengths and weaknesses of each benchmarking participant and assesses the cause for the differences taking into account the cultural differences.

The benchmarking brings out how the weaknesses can be resolved at each plant and how the strengths can be attained at the other plants.

The benchmarking includes a follow up meeting at an appropriate time to discuss the results obtained and the difficulties encountered when implementing the lessons learned from the benchmarking.

6. EFFECTIVE CORRECTIVE ACTIONS TO IMPROVE HUMAN PERFORMANCE

The selection and implementation of effective corrective actions to improve human performance is very important because typically 60-65% of event root causes are related to human factors involving individuals, team leaders, supervisors, and managers. Due to its complexity, this has been one of the most difficult areas to analyse. Some effective ways of addressing and selecting corrective actions related to human performance are described below.

6.1. Human performance errors

People are fallible and even the best may make mistakes. Industry experiences shows that almost every significant event is influenced by human errors of different types (slips, lapses, mistakes, violations) made by different people (designers, constructors, managers, operators, maintenance personnel, etc.). Using lessons learned from human errors is a way to reduce the number of events and to mitigate their consequences. Hence, analysing human error and taking effective corrective actions is a very powerful tool for preventing significant events.

6.1.1. Types of human errors

Human errors can be divided into two types:

- Unintentional errors:

  (1) Errors due to a slip, a momentary lapse of attention or memory, or worker complacency.

  The intention is correct, however incorrect actions are committed or expected actions are omitted with no prior thought due to a lack of attention.

  (2) Mistakes due to a lack of knowledge:

  The worker committed the wrong action because he did not understand the process, procedure, prescribed task, etc. There was no intentional act.

- Intentional errors:

Violations
Actions deliberately committed or omitted with the intention to successfully complete the task. The worker has a good understanding of the system, process, procedure, etc., but he believes his actions are correct or better than the actions prescribed by the procedures. This type of error is typical for experienced personnel.

6.1.2. Modes of human errors

These human error types can occur while the individual is working in the following modes:

- skill based
- rule based
- knowledge based.

Errors whilst working in the skill based mode occur due to slips or lapses whilst performing a routine task in a familiar environment. About 25% of all human errors are attributable to skill based mode and 90% of a person's daily activity is skill based. The typical error rate is 1:10000.

Errors whilst working in the rule based mode occur due to an incorrect conscious decision whilst applying accepted rules, due to misinterpretation of procedures, or due to errors in the procedure or instructions being used. About 60% of all human errors are rule based. The typical error rate is 1:1000.

Errors whilst working in the knowledge based mode occur due to an incorrect conscious decision in an unfamiliar territory. The individual use his knowledge and overall understanding of the situation and tries to respond with his conscious personal diagnose and problem solving capacities. About 15% of all human errors are attributable to the knowledge based mode. The typical error rate is 1:2.

6.1.3. Relation between human error types and modes

Table I provides the relation between human error types and modes of human performance:

TABLE I RELATION BETWEEN HUMAN ERROR TYPES AND MODES OF HUMAN PERFORMANCE

Type / Mode	Unintentional		Intentional
	Slip/Lapse	Mistake	Violation
Skill based	Section 6.1.4.1	Not Applicable	Not Applicable
Rule based	Not Applicable	Section 6.1.4.2	Section 6.1.4.3
Knowledge based	Section 6.1.4.4		

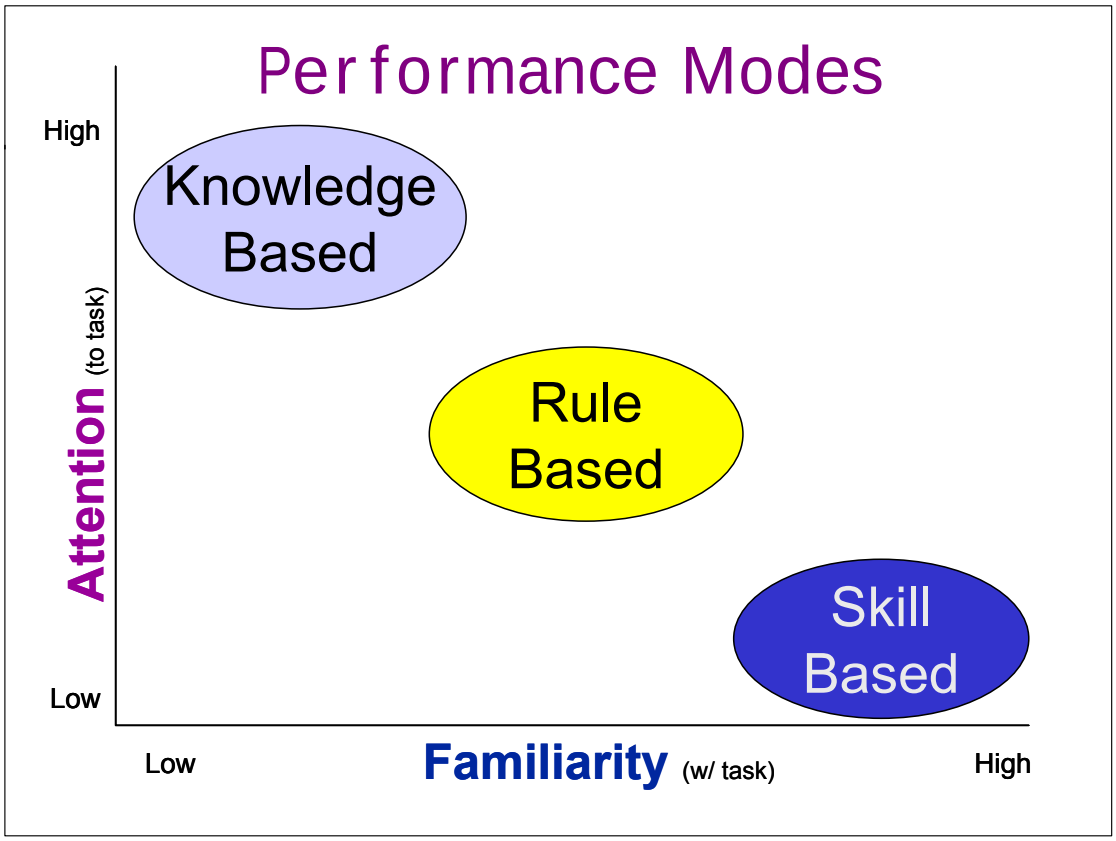

FIG. 2. Human performance modes.

6.1.4. Suggested corrective actions

6.1.4.1. Suggested corrective actions for skill based mode — unintentional errors

The worker is performing a routine task that has performed many times before in a familiar environment. Due to a slip, a momentary lapse of attention or lapse of memory, the error occurs. These types of errors can be prevented by a change in the work situation: by changing the man/machine interface, using warning aids, or by changing the work practices (for example verbalizing actions, applying the Stop, Think, Act, Review (STAR) method. Experience shows that using STAR the error rate is reduced by a factor of 4.

6.1.4.2. Suggested corrective actions for rule based mode — unintentional mistakes

When following procedures or complying with rules, the worker may misinterpret the procedures or instructions being used. These types of errors can be prevented by improving training, improving procedures and instructions or by management intervention (for example, increasing supervision, pre job briefings, clarifying misinterpretations, rewriting unclear paragraphs in procedures and encouraging workers to maintain a questioning attitude whilst performing tasks).

6.1.4.3. Suggested corrective actions for rule based mode — intentional violations

The worker has a good understanding of the system, process, procedure, etc., but does not follow the rules because he believes his actions are correct or better than the actions

prescribed by procedures. Taking short cuts is an example. These types of errors can be prevented by reinforcement of the desired behaviour and fostering a strong safety culture (for example, enforcing the expectation of procedural adherence and incorporating user's operating experience recommendations into procedural development).

6.1.4.4. Suggested corrective actions for knowledge base mode

The worker is performing a task beyond the scope of his knowledge and in an activity which is neither described in detail nor covered by the procedures. The error occurs due to an incorrect conscious or unconscious decision in this unfamiliar territory. These types of errors can be prevented by reinforcement of the need to stop work, involve others and ask for help/guidance when the worker is unsure of how to proceed when he finds himself in an unfamiliar territory. To improve the knowledge base of the work force is an additional action contributing to the effectiveness (for example, requiring an additional level of review for infrequently performed tasks, providing initial training and requiring the worker to be qualified to perform a specialized task, providing more detailed procedural guidance for the task, including related operating experience and adopting a conservative decision making approach).

6.1.5. Verification and response

In most of the previous cases, independent verification is a useful defence in-depth action. Independent verification is an act of checking activities by an alternate person of the same or higher qualification for this activity. This technique is very beneficial, for example in checking a component position and provides a high degree of reliability in correctly positioning plant components. It does not lessen the importance of self checking. It is mostly used when removing equipment from service, returning equipment to service after maintenance or testing, in system line ups, and to perform periodic checking during operation. The independence of verification involves techniques such as:

- different individuals operating and verifying
- performing separate readings of equipment labels
- double checking of main control room and remote indicators
- physical checking of component combined with observation of parameters, etc.

It is most effective when according to operating experience the need and the technique to implement of independent verification is already build in the procedures.

Organization responses to the human error are linked with organizational culture — there are different types of actions:

- Punitive actions — actors are punished, the organization changes people rather than the organization system;
- Local actions — organization admits the problem, however no systematic actions are applied. For example a re-training is provided only to the actors, a procedure structure (clearness, accuracy, warnings, step by step style etc.) is changed only in the procedure that contributed to the human error, etc;
- Generic actions — actions that address the problem in the whole organization.

The order of preference when selecting effective corrective actions is focussed more towards generic actions and by extending the scope of the corrective actions to similar areas

where the root cause or precursors may exist. Punitive actions alone are seldom effective. They are combined with other more systematic actions directed towards solving the root cause. Blame tolerance may be considered. They may be used only when strictly necessary to set the example in the face of wilful neglect, malevolent or falsification acts.

In-depth analysis of events, using established systematic approaches and human factors expertise, is necessary to correctly differentiate between situational contingencies and the culture of the organization.

Performing trending analysis and profile distribution analysis of human performance errors (Skill based, Rule based and Knowledge based) by plant, department, group, etc., and comparing them with industry data, is a good practice to go deeper into the lessons learned from human performance and improve the preparation of effective corrective actions.

6.2. Human environment conditions

Successful performance is highly influenced by the human environment conditions in which the activity takes place. Conditions such as high work load, time pressure, distractions and interruptions, resources management and excessive overtime, are some of the influencing precursors to human error. Circadian rhythms (regular changes in mental and and physical characteristics that occur in the course of a day) are also known to influence human error and to lead to impaired performance in several ways.

Operating experience shows that the risk of maintenance workers experiencing human performance problems is higher during midnight shift, after meal breaks and in the hour following the shift turnover. The risk for operators is higher during the day shifts when more activities are present and during the night shift when the alertness is degraded and the circadian rhythms are affecting. For all plant personnel the risk in experiencing human performance problems is higher the first day back after a medium or long absence. As a good practice, most plants have made the choice not to schedule important or critical activities for the personnel returning to the job site after a long absence. Instead, a defined recovery/rehabilitation programme is scheduled.

Observations of control room operations crews have consistently shown that crew performance is affected by the leadership of the shift supervisor and/or the control room supervisor. These supervisors must function as team leaders and maintain close oversight of control room activities environmental conditions in order to detect error or lapses in judgment, or breakdown in role responsibilities by other crew members. The supervisors must remain fully involved in all control room evolutions and be prepared to demonstrate their authority for command and control whenever high standards are not being maintained. Effective corrective actions address these attributes.

In addition, systematically allowing for poor shift schedules, much overtime, high work load, time pressures, scheduling of critical tasks at low circadian rhythms time (for example at 4 a.m.), increases the probability of triggering these precursors of human performance, and thus may be signs of a poor safety culture. Effective corrective actions also address this safety management aspect.

Doing more than one task simultaneously, doing things in a hurry, workers complaining about not having enough time to complete tasks, neglecting or ignoring rules, being rude to co-workers, omitting procedure steps, not maintaining a questioning attitude, may be signs of

time pressure and improper planning. As a corrective action, improved planning and resource allocation, as well as learning how to recognize the early signs of time pressure, are important management roles and oversight awareness attributes. Avoiding hasty decisions and hurried actions are important principles in nuclear power plant operations.

6.3. Person-system interface and person-machine interface

Person-system and person-machine interface design take into account human capabilities and limitations regarding the design of jobs, machines, operations and work environments. Considering the following design principles whilst analysing a human error can help to identify effective corrective actions:

- *Accurate mental model*
  There is always discrepancy between the state of a system and the user's interpretation of it, i.e. the user's model of the system and the system itself will differ to some extent as the user is rarely the designer of the system. A possible solution is to improve the user's familiarity with the system or to modify the system design to accommodate the user's model. By involving the user in the design criteria as early as possible, the design review or the commissioning of the systems is a good practice to prevent potential human errors.

- *Work environment*
  An adverse work environment can be a precursor to human error. Plant design accounts for all human capabilities and limitations. A possible solution is to improve the environmental conditions such as lighting, radiological conditions, humidity, temperature, noise, etc. If it is not possible to improve the environmental conditions further measures could be taken, such as improvement of equipment ergonomics, equipment labelling, signalling/displays, alarms/warnings, control schemes, accessibility, etc. Whenever possible, substituting mirror images by simple translation is a significant solution to reduce human errors, particularly in systems layout and cabinets installation.

- *Status of equipment*
  A system without indication of status and feedback for performed action may cause human error. Operating experiences show that numerous events occur due to inadequate system status indication for the operators. A possible solution is to add indicators or alarm functions to reduce the frequency of related events.

  Another type of error may occur when the user shows an over reliance on a "favourite" source of information and does not believe in other indications. In this case, the reason for the operator's behaviour is clearly identified and the user is trained to observe and consider all available indications.

- *Operability, maintainability and testability*
  Human errors may occur because the systems and equipments are not equipped with the necessary devices and subcircuits to facilitate operability, maintainability and testability. In this case, a possible solution is to equip the systems with these features so as to reduce human error when performing those tasks. Early involvement of experienced personnel in the design of systems is a good practice to reduce potential human errors.

- *Task complexity*
  The complexity of a task increases the likelihood for human error. Hence, reducing task complexity reduces the likelihood of events. A possible solution is to develop a work

schedule to minimize the number of simultaneous tasks for one operator and the number of critical tasks that are performed concurrently by different persons. Reorganizing the task to minimize the number of interfaces is a significant solution to reduce human errors.

- *Interlocks*
  Operating experiences show some events occurred because the operator did not consider the appropriate alignments and precautions of the actions in a timely manner. System design can prevent these errors by application of interlocks (or forcing functions). An simple example is to add an interlock to prevent operation of a pump if the suction valve is closed.

- *Defence in depth*
  Human errors may lead to safety significant consequences if adequate barriers are missing. An adequate number of physical and/or administrative barriers are incorporated into a system design or work plan to minimize the consequences of human errors. One approach is to implement "defence in depth" in system design and work plans. One example of a possible solution is to require double checking for significant tasks.

6.4. Organizational factors

Organizational factors may contribute to the root causes of events. A significant quantity of human errors are related to weaknesses in corporate or plant organization.

- *Safety Culture*
  Safety culture has two general components. The first is the necessary framework within an organization and is the responsibility of the management hierarchy. The second is the attitude of staff at all levels in responding to and benefiting from the framework. In any important activity the manner in which people act is conditioned by requirements set at a high level. Establishing effective corrective actions is one of these activities. In this process, management may have to emphasize that safety takes priority over production objectives. Experience shows that effectiveness of this message depends not only on how it is set and disseminated but also on how it is perceived by the staff.

  Failures and near misses are considered as opportunities that can be used to avoid more serious events. There is a strong drive to ensure that all events which have the potential to be instructive are reported and that timely feedback is given on the findings, trends and remedial actions. The staff is positively motivated to report all the necessary details in order to extract the lessons and to determine effective corrective actions.

  One of the most obvious signs that safety culture is starting to weaken is when there is a significant accumulation of corrective actions that are overdue or have not been effectively addressed. Managing priorities to ensure plant safety issues receive the attention warranted by their significance is the line of action in this area. Appropriate efforts are devoted to effectively implement the pending corrective actions and to reduce the backlog.

  In the references to the present publication some publications are included on how to assess and assist progress in the area of safety culture. Variations in national cultures mean that what constitutes a good approach to enhancing safety culture in one country may not be the best approach in another. This is considered when determining, selecting and implementing effective corrective actions in this area.

- *Process oriented management*
  The organizational structure, functional responsibility and lines of communication related to the corrective actions process are clearly defined. Adequate financial and staffing resources are allocated. Organizations conducting corrective actions establish processes such as:

  – Identifying the plant problems including event precursors;
  – Initiating and processing the activities regarding effective corrective actions;
  – Checking the adequateness of determination and implementation of effective corrective actions;
  – Tracking the effectiveness of conducted corrective actions.

  Experience shows that failures in the final success of the corrective actions is influenced by the degree in which the organization is managing the process and understands all the interactions. Where more than one organization is involved in the execution of a corrective action, some utilities have established an internal practice of appointing process owners as the primary customers to coordinate the various functions and work activities at all levels of the process, regardless of the functional organizations involved. They coordinate the process for the specific corrective action end-to-end so as to ensure optimal (effective and efficient) overall performance. They have direct channel to the appropriate level of management to report the important information regarding the effectiveness of the corrective action.

  The individual processes and the adequacy of the organization to conduct effective corrective actions are internally self-assessed by the major actors of the process. They are also periodically checked by persons of other organizations (or parts of the same organization) not directly responsible for performing corrective actions.

- *Team work*
  Team work is an important organizational factor contributing to the success of the corrective actions. Adequate regular communication between different levels of plant hierarchy is established in order to exchange significant information. Some organizations have found it beneficial to centre the team work activities around an integrated database. Whatever the interactive capabilities of the database in place are, a good practice is to enhance direct team communications by conducting regular meetings of all relevant departments and process owners with the plant management.

- *Task requirements and workers capabilities*
  A central part of managerial work is the allocation of tasks to personnel. Task requirements assigned beyond the worker's ability is an important contributor to human error. An effective corrective action ensures that the person is adequately qualified to perform the task and that this qualification is within the abilities and capabilities of the person to satisfactorily perform the job. Whenever this is not possible, reassigning the person to other jobs where his qualifications, abilities and capabilities could be positively used is often an effective management corrective action to enhance the satisfaction of personnel and to benefit the organization.

6.5. Procedures

Many human errors can be prevented by ensuring clear, accurate procedures exist and by management reinforcing that the procedures be used and followed. This will help reduce

worker's reliance on skill and memory to perform a task, assist workers in decision making and to help ensure a given task is performed consistently.

Written procedures provide step by step directions describing how and when to perform portions of the task. Job aids such as flow charts, decision tables and checklists can be used to concisely organize information needed to perform problem diagnosis and aid workers who are performing tasks involving numerous steps. The work is not directed to be different to what the work procedure states unless a review process is previously performed by the competent organization.

Procedures generally have the following key elements to enhance human performance:

- Procedure style and language is usable, familiar and comprehensible to personnel.
- Procedures are accurate, adequately detailed and complete, in order to ensure its credibility and guarantee continual use.
- Key decisions and safety critical steps are clearly delineated in the procedure.
- Steps of the procedure are described in proper sequence so that warnings and precautions are described before and not after the step is performed.
- Warnings and precautions do not contain decision steps or directive orders; they only have informative character.
- Acceptance criteria is included to ensure satisfactory accomplishment of the process.

In addition, the following administrative measures are taken into account:

- Experienced workers are involved in procedure development with proper frequency for procedure updating that ensures procedures are accurate and describe the ways in which tasks are to be performed in reality.
- A process is established for procedure users to initiate procedure improvements.
- Procedures are explained and available to workers who are expected to use them.
- The plant's quality management system ensures that the latest procedure version is available at the working place.

Corrective actions involving procedures address the above elements. Whenever possible and practical, corrective actions include the verification and validation of the procedures by experienced personnel, on the simulator and/or in the field.

When using instructions aids the effective corrective actions include provisions to ensure that the configuration control will be maintained.

6.6. Training

Training ensures personnel receive knowledge and practices necessary to effectively perform their functions. Operating experience is included in the training.

For events caused by inadequate training, corrective actions are performed to correct the training methods, programmes and documentation to be sure that the message is well understood by the trainees. For events that occur during activities where training is non-existent or insufficient, the following types of training have proven most effective in reducing human errors. It is a good practice to perform as far as practical an examination after training to ensure the training effectiveness.

- *Initial training*
  Initial training is generally conducted in the classroom or in the work place under supervision of instructors and supplemented with on-the-job experience. It prepares personnel for experiences they will routinely encounter and those they will infrequently encounter. If training does not include the infrequent events or situations, the likelihood of successfully handling such situations will depend solely on the problem solving and decision making skills of the individual. An effective corrective action considers developing training modules for these infrequent tasks.

- *Refresher training*
  In addition to initial training, refresher training on routine, non-routine or modified tasks will minimize human errors and reduce the potential for a worker's skills to deteriorate. A refresher training programme is needed to assist personnel in developing and maintaining a high performance level. Such a programme maintains the level of knowledge and even enhances skills beyond the initial training level. For example, the shift crew can practice an infrequently performed operational task at the simulator.

  When possible, performing training on equipment mock-ups to increase worker familiarity with the equipment prior to beginning work is considered.

- *Just-in-time Operating Experience feedback training*
  Collecting, informing and recalling operating experience just before and after a task is of utmost importance for keeping awareness about the potential pitfalls that may be encounter during the performance of a job.

  For example, training is provided on the use of operating experience information during pre job briefings, or on the problem reporting system by post job reports, particularly regarding human performance difficulties expected or encountered during the task or on the job site. In the pre job briefing, such questions as the following are considered:

  - What are the critical steps of this job?
  - How can I make a mistake at these critical steps?
  - What could happen if I make a mistake at a critical step?
  - What defences do I need to put in place in order to prevent failures at a critical step?
  - What to do when something goes differently to what is expected?

- *Communications training*
  Experience shows that many events originate from deficiencies in communications. Training personnel on the importance of clear communications, use of appropriate language, identifying on-the-spot potential misunderstandings and asking clarifying questions to ensure clear understanding, may avoid an important number of events. For example, training and reinforcing the use of three way communications has been very effective and is considered a good practice in control room and field communications, in distance communications, and in areas with noise levels. In some type of communications, for example, when naming a valve, the use of the phonetic alphabet could prevent mistakes.

- *Management systems training*
  Management system training ensures workers are familiar with current plant requirements, policies and standards. It helps to reinforce management expectations and

adherence to plant policies and standards. It contributes to conveying and enforcing safety culture at the plant.

6.7. Work practices

The methods of performing a task and ensuring a satisfactory realization comprises of numerous issues commonly summarized as work practices. These include quality standards, practices to detect failures, state of the art craftsmanship, use of materials, tools and equipment, use of the documentation and work preparation. Some elements of sound work practices are:

- Sound and timely planning and preparation of works;
- Quality of workmanship, activities conducted in a professional manner;
- Proper tools and equipment used and maintained in good condition;
- Spare parts handled appropriately;
- Procedures and protection rules followed;
- ALARA and potential exposure risks minimized;
- Fire protection work practices and industrial safety practices adhered;
- Adequate handling of chemicals and other hazardous substances;
- Tagging systems used correctly;
- Work sites maintained in clean and orderly conditions;
- Foreign Material Exclusion protective measures adopted;
- Temporary repairs and partial implementations minimized;
- Wastes minimized, segregated and adequately disposed.

Tasks performed are often complex which could create mismatches among tasks demands, work environment, human nature or/and individual capabilities. If discrepancy among mentioned elements are identified, corrective actions take into account difficulties, behaviour traps and potential pitfalls, raising the situational awareness and minimizing potential risks during the tasks.

Suggested effective tools at the individual performance level to reduce potential errors in work practices include: anticipating possible risks and precautions, “if-then” attitude, procedure adherence, verbalizing actions, self checking, stopping to request external support and peer checking, etc. In addition three other individual practices are most important to reduce human error at the work place: attention to details, avoiding short cuts and avoiding hasty decisions and hurried actions.

Supervisors and team leaders have additional effective tools to implement corrective actions for conditions that can lead to human error in work practices. These include: matching task demands with worker capabilities, supporting the task by additional experienced persons, conducting pre job briefings, reinforcing expected behaviour, encouraging personal accountability and responsibility, taking precautions on potential problems, fostering open communication in the team, performing job observations and post job briefings and handling the work environment to minimize manageable distractions.

Several other elements can contribute towards effectively reducing human errors in work practices. Examples of these elements are:

- Labelling with sufficient information for easy identification;
- Work conditions such as lighting to support the work practices;

- Limitations of main control room access, access to on-site work areas, avoiding interruptions and unnecessary distractions;
- Accessibility hoist and work platforms as needed to facilitate the task;
- Good housekeeping conditions.

These elements can create a better work environment that is less prone to human errors.

6.8. Fitness for duty

Adequate fitness for duty for staff and contractors is an important factor for satisfactory human performance. This includes consideration of factors such as the consumption of medications and others substances having temporary influence on the individual's physical and mental condition in performing work activities. This also includes tiredness, stress and illness. Setting requirements and ensuring compliance before performing critical works is an effective corrective action to reduce the possibility of human error. Learning how to recognize the early signs of tiredness and stress is an important oversight awareness attribute.

The first step for effective fitness for duty corrective actions is the development of a self reporting culture. The management encourages and organizes conditions for the personnel to be able to develop self control in a blame-free environment. First line management has sufficient openness for these issues. Station health care organization encourages personnel to self report any concerned fitness for duty problem.

6.9. Emotional factors

Emotional factors include the assembly of psychological qualities and attitudes rooted in environment relational and social conditions capable of providing adequate emotional stability during the performance of a job and contributing to the enhancement of cognitive motivation, team spirit and readiness to act.

Amongst the most important factors are: self esteem, pride of belonging to a team, sharing the values of the company, willingness to improve, enhancing prestige, improving moral, sense of achievement, adherence to clear goals, job satisfaction and self control.

Emotional factors are proactively managed in order to reduce human error so that adequate corrective actions can be implemented in advance. Setting adequate environment relational and social conditions and implementing actions that contribute to improving the emotional atmosphere before performing critical work, are effective corrective actions towards reducing the possibility of human errors.

6.10. Error likely situations and potential traps

Identification and reduction of error likely situations and potential traps existing in the plant (including tools, documents, etc.) that have caused or could cause an error, and suggestions for improvement are an important part of an effective corrective action programme. These error likely situations are provoked by unfavourable job site situations that either can result in an event or reduce the chances for success. Very often they become visible through near miss events. Establishing a good reporting environment and experience feedback programme for error likely situations and near miss events are the key to success for this effective corrective action.

7. EFFECTIVE CORRECTIVE ACTIONS TO IMPROVE SYSTEM AND EQUIPMENT PERFORMANCE

The following paragraphs include some of the most significant areas to be considered when defining effective corrective actions to improve system and equipment performance.

7.1. Margins

New analytical tools such as computer codes might be developed in order to provide better knowledge of the safety margins. The way in which this knowledge is used could affect the plant performance and the occurrence or recurrence of certain events. Precautions are taken when implementing modifications based on the reduction of the originally built up margins because a particular part of the installation may develop a new failure mode not previously experienced. Effective corrective actions include provisions for the verification and follow up of the effects of the reduction in the original margins. Similarly, for new or first of a kind corrective actions where new uncertainties may exist, safety margins are substantially increased to compensate for the uncertainties.

7.2. Maintenance modes and frequency

The performance of certain surveillance tests may cause stresses in the equipment tested. These stresses may affect the life time of the component. Reconsidering the modes and frequency of tests could be beneficial to effectively specify corrective actions without affecting the reliability of the equipment. For example, for emergency diesels the stresses during starts and test runs have, in many instances, considerably shortened the lifetime of this equipment. The conducting of the test determines to a great extent the failure rate of the engine. As a corrective action, new technical specifications have been issued to allow for a more gentle way of starting and loading diesel engines for most tests, thus reducing the stresses.

7.3. Compatibility of materials

Recurrent defects are sometimes identified due to insufficient compatibility of materials. These occurrences are particularly due to factors such as welding compatibility, galvanic corrosion, inadequate chemistry environment, effects of build up crud from corrosion products, etc. Possible solutions to these occurrences may be based respectively in using transition materials, cathodic protection, improved chemistry treatments, sludge lancing, etc. Whatever technique is used, the effective corrective action includes identification of the areas where similar phenomena may be developed, performing enhanced inspections and implementing predictive maintenance techniques. The objective of all of this is to foresee when the defects may reappear, to estimate their rate of growth and to determine the precautions and compensatory measures to be implemented.

7.4. Environmental conditions

Environmental conditions during storage and operation of materials and equipment are important to ensure their proper performance. Corrective actions involving relocation of materials or equipment ensure that the environmental conditions at the new location are covered by the environmental qualifications of these materials or equipment. The corrective actions to be effective include provisions to ensure that the equipment is qualified for the new

location. Environmental history and quality documentation demonstrate adequate conditions of materials and equipment.

7.5. Quality of repairs

Due to the nature of the work involved, the quality of certain repairs could be better when performed at plant workshops or at manufacturer's facilities rather than in situ. Effective corrective actions address these considerations to ensure the quality of the repairs. Furthermore, repairs and overhauls performed on components belonging to environmental qualified safety systems and equipment are also environmentally qualified as appropriate. This applies to activities such as: rewinding of motors, repairs of electronic cards, etc. To be effective, corrective actions address these provisions.

7.6. Qualification of manufacturers and contractors

Effective corrective actions address the qualification requirements of the manufacturers and contractors involved in the work. Quality assurance programmes of manufacturers and contractors involved in work important to safety are effectively in place and timely verified. The quality assurance programme of these manufacturers and contractors is periodically audited to meet the qualification requirements.

7.7. In-service inspection programmes

Effective corrective actions address the requirements for the periodic inspection of equipment, systems or materials once returned to service. Deficiency acceptability levels are specified. Provisions for ease of inspection for the equipment are provided, for example, removable insulation, use of accessible galleries, avoiding buried installations, etc. All results of the in-service inspections are documented, analysed and fed back as far as practicable before the equipment is put into service.

7.8. Redundancy and diversity

Redundancy and diversity are two important attributes when implementing corrective actions. Effective corrective actions include provisions to ensure that sufficient redundancy is maintained. In addition, effective corrective actions take into account potential common cause failures. Using diverse components whenever practical may help to prevent potential common cause failures.

7.9. Use of proven systems and equipment

Effective corrective actions ensure that effective performance of new systems and equipment have been previously proven in practice at another reference plant or installation. When this cannot be assured, the use of a pilot unit concept for testing the respective system and equipment prior to the implementation of the modification in the plant, is considered good practice. If the equipment tests cannot be performed in the correct environmental conditions, the related potential problems are thoroughly analysed. When a factor of scale is present, precautions are taken to analyse all modes of failures and ensure that adequate margins for satisfactory performance are in place for the upgraded installation. In some cases the use of simulators can be an effective tool to test modifications and to train personnel on the new conditions.

7.10. Validation of software

When the corrective actions include installation or modification of software, effective corrective actions include provisions to ensure the validation of software for the specified purpose.

8. PRIORITIZATION AND PLANNING OF CORRECTIVE ACTIONS

8.1. Prioritization

Management ensures that corrective actions are approved, prioritized, promoted and completed in a timely and comprehensive manner based on their significance. Prioritization will enable utilities to allocate resources and implement corrective actions effectively.

Management allocates responsibility and authority to set and approve priorities for implementation of corrective actions. Initial priorities may be proposed by the incumbent group, by the system engineers or by the owners of the process, and assigned by the regular operating meeting (Screening Committee).

Managing priorities is one of the activities where the level of safety culture of an organization is best shown. Experience shows that safety and quality go hand in hand with plant performance and availability, thus with production. Plants are maintained throughout their life at least in as good a condition as they were when commissioned and licensed. For plants at the end of life or near decommissioning, safety culture is an important factor when setting priorities. Prioritization policy of corrective actions throughout their life accounts for fulfilling these goals.

Use of a Corrective Action Review Board or similar body (see Section 5.5.11) to oversee, review and monitor the significant priorities, is considered to be good practice. In the case of less significant priorities, line management or appointed process owners may take the decision. In all cases strong communication is required between participating and affected functional groups and other persons involved.

The prevention of significant events is the most important objective of an operating experience programme. Corrective actions to prevent significant safety events receive the highest attention, resources and priority. Safety is the most important aspect for assignment of priorities for the implementation of corrective actions. Safety in this context includes, for example:

- nuclear safety
- radiation safety
- industrial safety
- environmental impact
- security.

The use of PSA and experts' judgement when available and practical, to help determine safety significance, is considered as good practice because it provides quantitative assessment of the importance to safety.

In setting priorities, consideration is be given to:

- The potential for common cause failures;
- Unnecessary challenges to safety features;
- Plant reliability;
- External operating experience related to that particular event;
- Recurrence of the event;
- Ineffectiveness of a previous corrective action linked to the event.

Setting priorities for corrective actions may be approached in a number of ways**.** Annex II provides an example based on levels of non compliance with operating limits, regulatory requirements and lower level deficiencies.

8.2. Planning

Implementation of corrective actions is planned. When planning and scheduling corrective action implementation, precedence is given according to the priority of the corrective action. Planning for implementation of significant corrective actions is integrated into the organization's business plan. The implementation deadline is set in the work management system according to the priorities assigned to the corrective actions. Priorities for the review of effectiveness are planned and scheduled.

The following factors will influence the implementation planning of the corrective actions:

- human resource
- difficulty and complexity of implementation
- implementation time
- plant status mode required
- lack of experience with the particular planned corrective action
- material procurement
- economic considerations.

Management ensures all resources actively support the implementation of the corrective action process according to the priorities.

9. CORRECTIVE ACTION DATABASE

Monitoring the effectiveness of the corrective action process is an important activity for an effective corrective action programme. The establishment of a corrective action database to help and support the tracking of corrective action implementation and process effectiveness is considered as good practice.

The current chapter presents an example of the format and content of a typical database that may be established for this purpose. It is recognized that other formats and contents may exist to adequately support the corrective action process and to help track the effectiveness of the corrective actions. Whatever the choice, the final selected methodology ia adapted to the plant organization needs and integrated into the overall plant management database system.

Management assigns responsibility for development, maintenance and administration of this corrective action database.

For the purpose of the present publication the content of the database example focusses on the corrective action process characteristics. For a full Operating Experience feedback programme database the present content is expanded to include other characteristics, such as: when and where the event or deficiency occurred (location, system, discipline, functional and cross functional areas, plant status when the event occurred, etc), timing inputs, identification of the recurrence of the event, direct causes, contributing factors, root causes, precursors, etc.

When creating the format and the content of the Corrective Action database the following information fields may be considered:

- Identification of the event;
- Identification of the causes;
- Identification of corrective actions;
- Description of the corrective actions;
- Status (for example completion and follow up of the status) and priorities;
- Responsibility and deadline for implementation of corrective actions;
- Effectiveness of corrective actions;
- Related work orders.

Annex I includes examples of corrective actions database fields and an example of a database screen layout for the follow up of the effectiveness of the corrective actions, showing a typical format and content. Where necessary the list boxes deploy the list of alternatives to choose from. As an optional feature, when applicable, windows and buttons include hyperlinks to the referenced documents.

The database may be designed with additional features to allow exchange of information within the organization and to follow up the progress of the implementation through the steps of the process.

10. MANAGEMENT REPORT

It is recommended that the operating organization prepares and issues a periodic report, at least annually, which summarizes the activities performed in the interval considered in the framework of the corrective action programme. The Corrective Actions Review Board or similar body, if used, is also involved in the preparation and review of the report.

Such a report lists:

- significant corrective actions approved
- status of their implementation
- effectiveness of the corrective actions
- performance indicators related to the corrective action activities.

The report also includes:

- Summary of the results of self-assessment activities performed periodically to review the effectiveness of the corrective action process;
- Summary of the effectiveness of the corrective actions from self-assessments;
- Root cause determination and main contributors;
- Graphical representation, and trend analysis of the programme.

The periodic management report is made available to all persons of the organization.

Management analyses the information on the corrective action process and defines further actions to eliminate deficiencies in the process. Management may also utilize the data contained in the report to promote utility ownership of the effective corrective action programme.

The management report addresses the planning programme for the upcoming year. This planned programme highlights the corrective actions already scheduled. The consecutive periodic reports compare the actual implementation with the planned programme and analyse the gaps.

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ANNEX I

Examples of Database Fields and Screens for an Experience Feedback Programme in the Database

TABLE I.1. EXAMPLES OF CORRECTIVE ACTION IN THE DATABASE

ID Event	Identification number of the event or deficiency related to the corrective action.
Title of event	With the link to the event database.
Level of event	Either significant event (SE), low level event (LLE), significant near miss (NMS), less significant near miss (NML).
Origin	Source of the event reporting: **i**nternal OE, external OE, self-assessment, peer reviews, QA audits, QA non conformances, deficiencies/deviations, test failures, documentation.
Type of event analysis	Extent of the event analysis performed according to the significance of the event: Full Root Cause; Simplified Root Cause; Direct Cause; Trending.
JIT OE	Link to the just-in-time operating experience.
ID CA	Identification number of the corrective action.
Date CA	Date when the corrective action has been decided.
Associated cause	Root, contributing or direct cause into which the corrective action is related.
Description of CA	Description of the corrective action.
Type of CA	Broke/fix, immediate CA, permanent CA, interim CA, temporary measures, compensatory measure, CA to prevent recurrence.
Applied to	Management/Organization, Human Performance, Equipment, Design, Procedures, Documentation.
Priority	Assigned overall level of priority (1, 2, 3, 4).
Safety level factor	High safety level (HS), low safety level (LS); non safety related (NS).
Cost factor	High cost (HC), low cost (LC).
Time factor	Long term (LT), short term (ST), e.g. linked to an outage.
Priority time set	Either urgent, to be implemented in the first working day, in 72 hours, in one week, during the first system window, during the next outage, other.
Difficulty level	High difficulty **(**HD); low difficulty (LD).

Severity level	Some plants assign an overall severity level to the event.
Implementation Q-Plan	Identification reference of the quality plant to control the implementation.
Changes	Modifications introduced to the original corrective action to be adapted.
Implementation completed	Date when the implementation of the corrective action was completed.
Follow up effectiveness programme	Programme established to follow up the effectiveness of the corrective action.
CA Effective?	YES, NO with justification.
Effectiveness verified by	Name of the person responsible for verifying the effectiveness.
Causes for being non effective	In case of insufficiently effective, list of the causes or feedback comments.
CA reopened/reanalysed	Date when the corrective action was reopened/reanalysed due to ineffective results and the corrective action redefined.
CA substituted by	Identification number of the new corrective action substituting the ineffective corrective action.
CA cancelled	Date when the corrective action was cancelled, the reason(s), justification and authority for cancellation.
Previous related CA	Link to similar corrective actions previously implemented in other areas.
Effectiveness of previous related CA	Link to the effectiveness result of previous corrective actions.
Related work orders	Work orders related to the corrective action
Attachments	Link to other attachments or graphical information relevant to the corrective actions.
Responsible persons	Names and functional groups in the organization responsible for implementation of CAs.
Deadline	Deadline for the implementation of the corrective action.

Note: A full operating experience feedback programme uses many other database fields to record and control the different steps of the process.

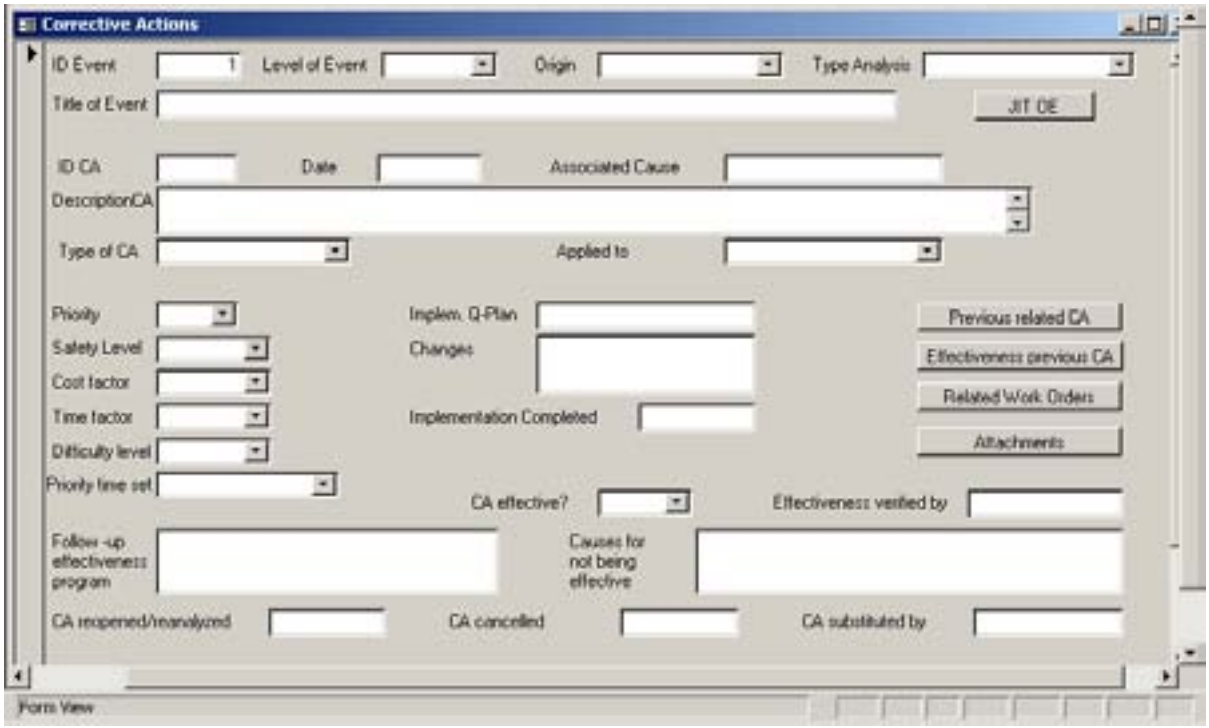


FIG. I.1. A typical database screen for the follow up of the effectiveness of the corrective actions.

Note: This example shows only one of the screens showing the effectiveness of corrective actions. A full operating experience feedback programme uses many other screens aimed at controlling the different steps of the process.

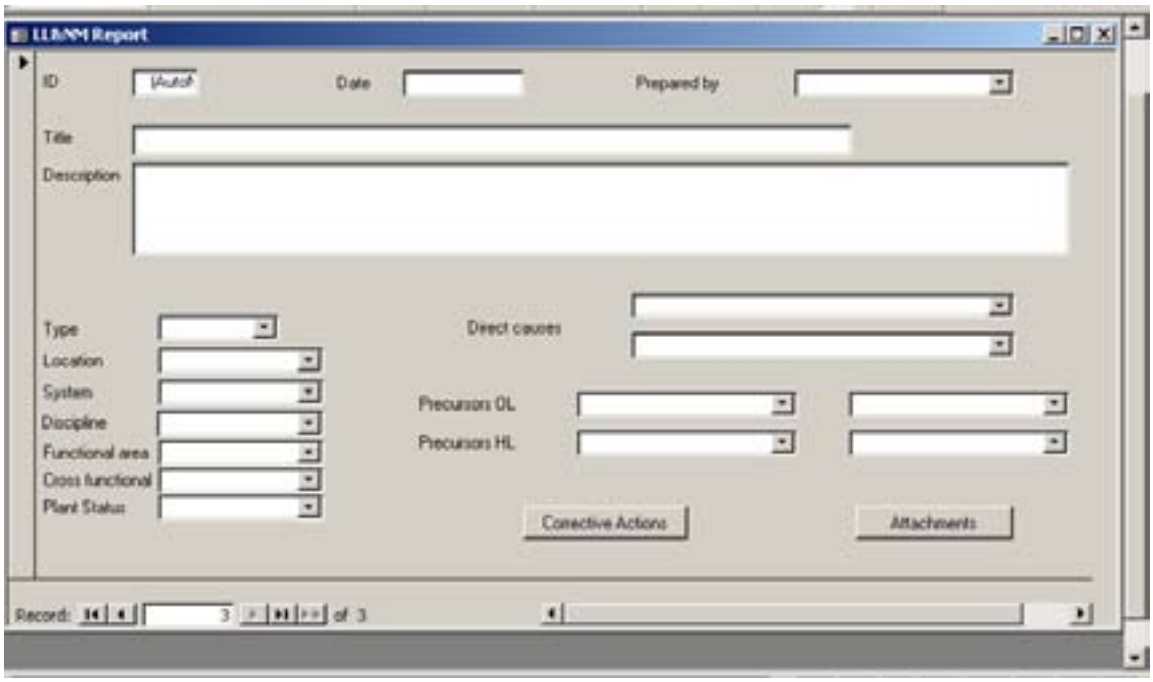


FIG. I.2. A typical database screen for the operating experience process interrelated to the corrective actions programme.

Note: This example shows only one of the several screens related to trending low level events. It is included solely for the purpose of illustrating the connection of other areas of the operating experience process to the corrective actions programme A full operating experience feedback programme uses many other screens directed to control the different steps of the process.

ANNEX II

Examples of Prioritization Criteria for Corrective Actions

Procedure: First, classify the non compliance associated to the event according to level A, B, C definitions. Then assign the priority for the corrective action according to priority 1, 2, 3 definitions.

TABLE II.1. EXAMPLE OF CRITERIA FOR PRIORITIZATION

Level	Criteria
A	Non compliances with operational limits and regulatory requirements; situations that can produce reactor trip, ESF actuations; effluents emissions over legal limits, etc.
B	Non compliance of commitments with regulatory requirements, minor incidents that could lead to level A incidents if not detected, etc.
C	Non compliance of procedures that do not affect the above levels criteria. Others

Priority 1: Corrective actions that if not implemented could lead to a level A non conformance. It is considered unavoidable and it must be performed as soon as possible.

Priority 2: Corrective action that if not implemented could lead to a level B non conformance. It is considered necessary.

Priority 3: Corrective action that if not implemented could lead to a level C non conformance, or part of corrective actions derived from level A or B that are considered not essential to solve the non conformance. It is considered convenient.

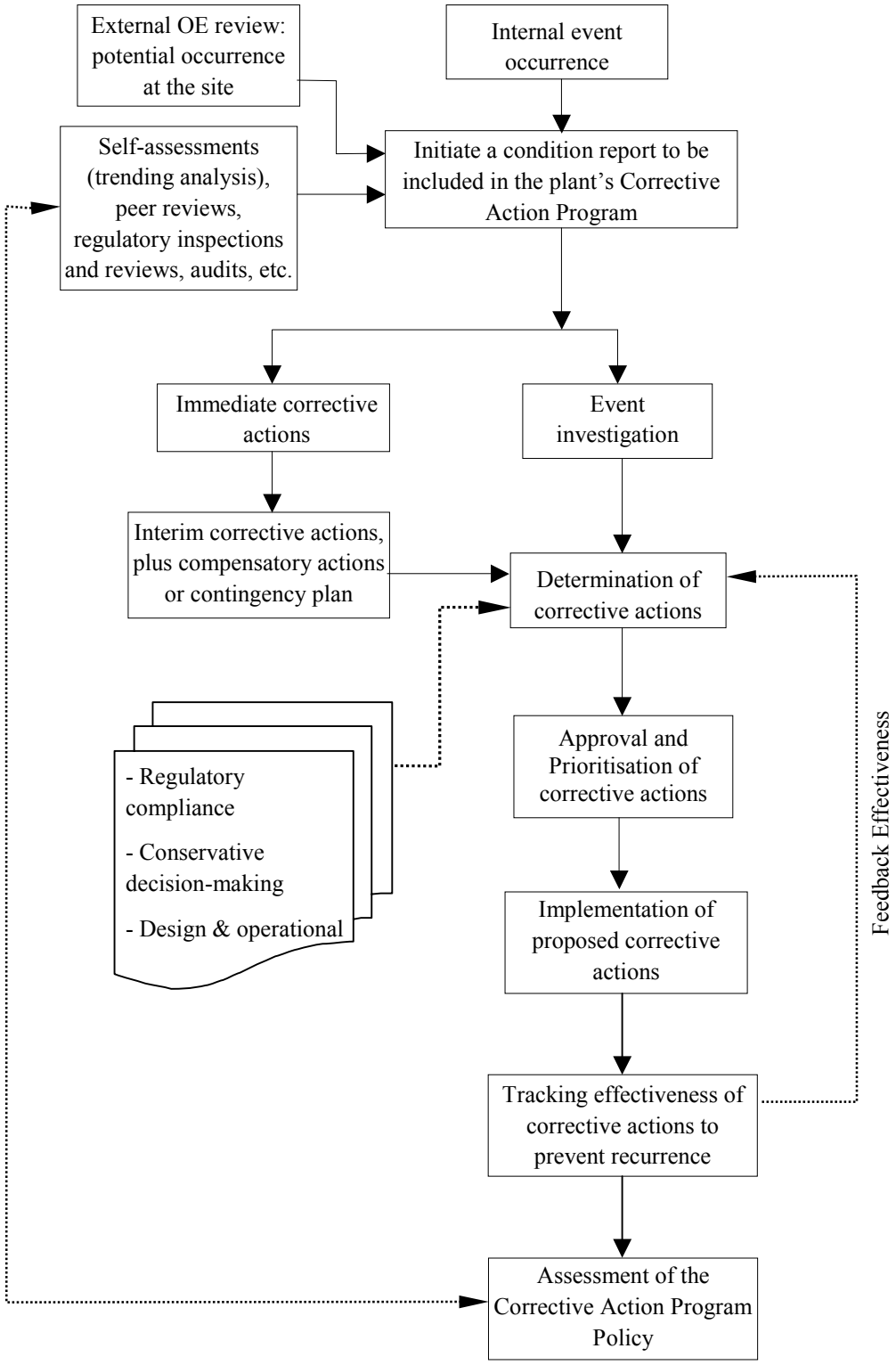
Notes:

Process improvement actions are considered, in principle, Priority 3. They can be upgraded if deemed necessary.

Assignment of priorities and classification levels are not intended to substitute the criteria for safety classification of structures, systems and components and have not to be used for this purpose.

Annex III

Example Flow Chart of a Typical Corrective Actions Programme



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Consultants Meeting

Vienna, Austria: 1–5 September 2003

Technical Meeting

Vienna, Austria: 14–18 June 2004