IAEA Safety Standards
for protecting people and the environment

A System for the Feedback of Experience from Events in Nuclear Installations

Safety Guide
No. NS-G-2.11

IAEA
International Atomic Energy Agency

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (i.e. all these areas of safety). The publication categories in the series are **Safety Fundamentals, Safety Requirements** and **Safety Guides**.

Safety standards are coded according to their coverage: nuclear safety (NS), radiation safety (RS), transport safety (TS), waste safety (WS) and general safety (GS).

Information on the IAEA's safety standards programme is available at the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at P.O. Box 100, A-1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by e-mail to Official.Mail@iaea.org.

OTHER SAFETY RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety and protection in nuclear activities are issued in other publications series, in particular the **Safety Reports Series**. Safety Reports provide practical examples and detailed methods that can be used in support of the safety standards. Other IAEA series of safety related publications are the **Provision for the Application of Safety Standards Series**, the **Radiological Assessment Reports Series** and the International Nuclear Safety Group's **INSAG Series**. The IAEA also issues reports on radiological accidents and other special publications.

Safety related publications are also issued in the **Technical Reports Series**, the **IAEA-TECDOC Series**, the **Training Course Series** and the **IAEA Services Series**, and as **Practical Radiation Safety Manuals** and **Practical Radiation Technical Manuals**. Security related publications are issued in the **IAEA Nuclear Security Series**.

A SYSTEM FOR THE FEEDBACK OF EXPERIENCE FROM EVENTS IN NUCLEAR INSTALLATIONS

Safety standards survey
The IAEA welcomes your response. Please see:
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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

IAEA SAFETY STANDARDS SERIES No. NS-G-2.11

A SYSTEM FOR THE FEEDBACK OF EXPERIENCE FROM EVENTS IN NUCLEAR INSTALLATIONS

SAFETY GUIDE

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

IAEA SAFETY STANDARDS

SAFETY THROUGH INTERNATIONAL STANDARDS

While safety is a national responsibility, international standards and approaches to safety promote consistency, help to provide assurance that nuclear and radiation related technologies are used safely, and facilitate international technical cooperation, commerce and trade.

The standards also provide support for States in meeting their international obligations. One general international obligation is that a State must not pursue activities that cause damage in another State. More specific obligations on Contracting States are set out in international safety related conventions. The internationally agreed IAEA safety standards provide the basis for States to demonstrate that they are meeting these obligations.

THE IAEA STANDARDS

The IAEA safety standards have a status derived from the IAEA's Statute, which authorizes the Agency to establish standards of safety for nuclear and radiation related facilities and activities and to provide for their application.

The safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment.

They are issued in the IAEA Safety Standards Series, which has three categories:

Safety Fundamentals

— Presenting the objectives, concepts and principles of protection and safety and providing the basis for the safety requirements.

Safety Requirements

— Establishing the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements, which are expressed as 'shall' statements, are governed by the objectives, concepts and principles of the Safety Fundamentals. If they are not met, measures must be taken to reach or restore the required level of safety. The Safety Requirements use regulatory language to enable them to be incorporated into national laws and regulations.

Safety Guides

— Providing recommendations and guidance on how to comply with the Safety Requirements. Recommendations in the Safety Guides are expressed as 'should' statements. It is recommended to take the measures stated or equivalent alternative measures. The Safety Guides present international good practices and increasingly they reflect best practices to help users striving to achieve high levels of safety. Each Safety Requirements publication is supplemented by a number of Safety Guides, which can be used in developing national regulatory guides.

The IAEA safety standards need to be complemented by industry standards and must be implemented within appropriate national regulatory infrastructures to be fully effective. The IAEA produces a wide range of technical publications to help States in developing these national standards and infrastructures.

MAIN USERS OF THE STANDARDS

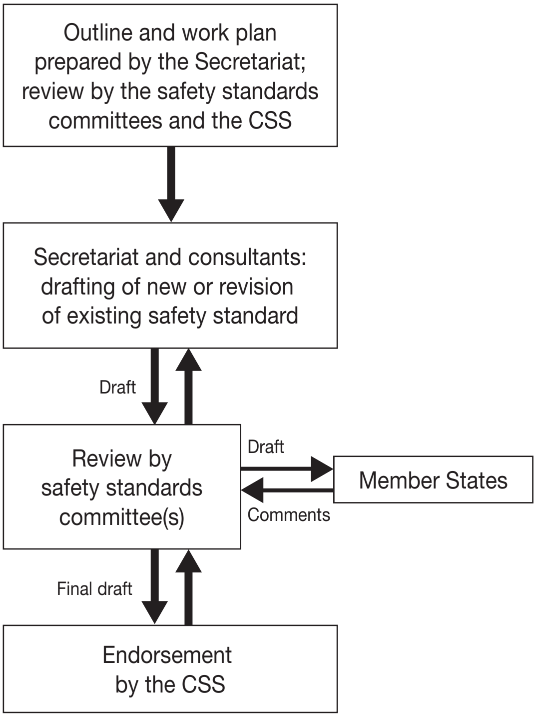
As well as by regulatory bodies and governmental departments, authorities and agencies, the standards are used by authorities and operating organizations in the nuclear industry; by organizations that design, manufacture for and apply nuclear and radiation related technologies, including operating organizations of facilities of various types; by users and others involved with radiation and radioactive material in medicine, industry, agriculture, research and education; and by engineers, scientists, technicians and other specialists. The standards are used by the IAEA itself in its safety reviews and for developing education and training courses.

DEVELOPMENT PROCESS FOR THE STANDARDS

The preparation and review of safety standards involves the IAEA Secretariat and four safety standards committees for safety in the areas of nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS), which oversees the entire safety standards programme. All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the CSS is appointed by the Director General and includes senior government officials having responsibility for establishing national standards.

For Safety Fundamentals and Safety Requirements, the drafts endorsed by the Commission are submitted to the IAEA Board of Governors for approval for publication. Safety Guides are published on the approval of the Director General.

Through this process the standards come to represent a consensus view of the IAEA's Member States. The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the standards. Some standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the International



The process for developing a new safety standard or revising an existing one.

Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

The safety standards are kept up to date: five years after publication they are reviewed to determine whether revision is necessary.

APPLICATION AND SCOPE OF THE STANDARDS

The IAEA Statute makes the safety standards binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA concerning any form of Agency assistance is required to comply with the requirements of the safety standards that pertain to the activities covered by the agreement.

International conventions also contain similar requirements to those in the safety standards, and make them binding on contracting parties. The Safety Fundamentals were used as the basis for the development of the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The Safety

Requirements on Preparedness and Response for a Nuclear or Radiological Emergency reflect the obligations on States under the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

The safety standards, incorporated into national legislation and regulations and supplemented by international conventions and detailed national requirements, establish a basis for protecting people and the environment. However, there will also be special aspects of safety that need to be assessed case by case at the national level. For example, many of the safety standards, particularly those addressing planning or design aspects of safety, are intended to apply primarily to new facilities and activities. The requirements and recommendations specified in the IAEA safety standards might not be fully met at some facilities built to earlier standards. The way in which the safety standards are to be applied to such facilities is a decision for individual States.

INTERPRETATION OF THE TEXT

The safety standards use the form 'shall' in establishing international consensus requirements, responsibilities and obligations. Many requirements are not addressed to a specific party, the implication being that the appropriate party or parties should be responsible for fulfilling them. Recommendations are expressed as 'should' statements in the main text (body text and appendices), indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures) for complying with the requirements.

Safety related terms are to be interpreted as stated in the IAEA Safety Glossary (http://www-ns.iaea.org/standards/safety-glossary.htm). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard within the Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the main text, is included in support of statements in the main text, or describes methods of calculation, experimental procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the standard. Material in an appendix has the same status as the main text and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material published in standards that is under other authorship may be presented in annexes. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Operating experience is a valuable source of information for learning about and improving the safety and reliability of nuclear installations.[1] It is essential to collect such information in a systematic way that conforms with agreed reporting thresholds for events occurring at nuclear installations during commissioning, operation, surveillance and maintenance activities and decommissioning, and on deviations from normal performance by systems and by personnel, which could be precursors of events.

1.2. In 1989 the IAEA issued a Safety Guide on A System for Reporting Unusual Events in Nuclear Power Plants (Safety Series No. 93). The Safety Guide presented a recommended scheme that was based on available national practice and was applicable to the management of safety related operational experience in nuclear power plants. The Safety Guide consisted of two parts: Part I, A National System, and Part II, the IAEA Incident Reporting System. The Incident Reporting System was developed in the early 1980s by the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) and has been a single system jointly operated by the IAEA and OECD/NEA since 1998. The joint IAEA/NEA Incident Reporting System Guidelines have been published by the IAEA [1]; they supersede Part II of Safety Series No. 93.

1.3. The IAEA Safety Standards Series publications Safety of Nuclear Power Plants: Operation [2] and Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] set out safety requirements for the feedback of operating experience. In the Nuclear Safety Convention, which entered into force in July 1996, the importance of the feedback of operational experience is fully recognized in Article 19 as a tool of great importance for the safety of the operation of a nuclear power plant and its further enhancement.

[1] A nuclear installation is a nuclear fuel fabrication plant, nuclear reactor (including subcritical and critical assemblies), research reactor, nuclear power plant, spent fuel storage facility, enrichment plant or reprocessing facility.

1.4. This Safety Guide provides recommendations and guidance on meeting these requirements as established in Refs [2, 3] and constitutes an update and an extension of Part I, A National System, of the Safety Guide on A System for Reporting Unusual Events in Nuclear Power Plants (IAEA Safety Series No. 93).

OBJECTIVE

1.5. The objective of this Safety Guide is to provide guidance for the establishment of an operational experience feedback system for managing operational experience on a national basis. It brings together common elements that typically constitute an effective system at the national level. It should be noted that the process of feedback of operational experience is undertaken by many different organizations throughout the world (licensees, regulators, designers, international organizations) which, by cooperating, can help to ensure that the overall process of gathering operational experience for feedback is efficient and effective. This Safety Guide identifies the various organizations within a State and their roles and responsibilities, and gives guidance on the timing of their involvement in the overall process.

SCOPE

1.6. This Safety Guide provides recommendations on all the main components of systems for the feedback of operational experience for gathering relevant information on events and abnormal conditions that have occurred at nuclear installations throughout the world. It focuses on the interaction between the different systems for using feedback on operational experience. The publication provides guidance for all the organizations that are professionally involved in the nuclear industry, such as regulatory bodies, technical support organizations, operating organizations with ongoing or planned nuclear programmes, vendor companies (designers, engineering contractors, manufacturers, etc.), research establishments and technical universities with studies in the nuclear field.

1.7. Operational experience feedback systems are based on systems of plant operators. Relevant guidance is provided, for example, in Safety Guide No. NS-G-2.4 on The Operating Organization for Nuclear Power Plants [4]. Such systems make use of experience from the recurrent testing and maintenance of safety related equipment and the collection of plant specific reliability information and data on performance indicators of system or human performance.

1.8. This Safety Guide does not deal with the special reporting procedures covered by the Convention on Early Notification of a Nuclear Accident or those that may be necessary under emergency conditions or that are covered by the International Nuclear Event Scale [5].

1.9. This Safety Guide is not intended to cover communications subsequent to an event at a nuclear installation that relate to decisions concerning the operation of the installation during an accident.

STRUCTURE

1.10. Section 2 covers the need for a national system for the feedback of operational experience. Sections 3–10 address the process that should be established for the feedback of operational experience, covering: screening of events (Section 3), investigation and analysis (Section 4), corrective actions (Section 5), trending and review (Section 6), utilization and dissemination of information (Section 7), reviewing of effectiveness (Section 8), quality assurance (Section 9) and reporting of safety related events (Section 10). Additional detailed guidance is provided in Appendices I–IV. Additional information is given in the annexes.

2. MAIN ELEMENTS OF A NATIONAL SYSTEM FOR THE FEEDBACK OF OPERATIONAL EXPERIENCE

GENERAL

2.1. IAEA Safety Requirements publication No. NS-R-2 on Safety of Nuclear Power Plants: Operation [2] establishes in Section 2 the requirements for setting out a system for the feedback of operational experience to report, investigate, evaluate, trend, correct and utilize information in relation to abnormal events occurring at nuclear power plants and to disseminate this information to the relevant governmental bodies, national and international organizations and the public. In addition, IAEA Safety Requirements publication No. GS-R-1 on Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] sets out the authority of the regulatory body to make available to other governmental bodies, national and international organizations and the public, information on incidents and abnormal occurrences. It also states the regulatory body's responsibility to establish national regulations in the field of operating experience feedback and to ensure that operating experience is appropriately analysed, that lessons to be learned are disseminated, and that appropriate records relating to the safety of facilities and activities are retained and are retrievable.

2.2. The importance of the feedback of operational experience as a tool of great importance for the safety of the operation of nuclear power plants and the need for its further enhancement are fully recognized in the Convention on Nuclear Safety, which entered into force in July 1996. Article 19 of the Convention, concerning Operation, requires that "…each Contracting Party shall take the appropriate steps to ensure that (vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body; (vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies."

IMPORTANCE FOR SAFETY OF LEARNING FROM THE FEEDBACK OF OPERATIONAL EXPERIENCE

2.3. One general technical criterion of safety for nuclear installations is that the organizations concerned ensure that operational experience and the results of research relevant to safety are exchanged, reviewed and analysed, and that lessons are learned and acted on. The primary objectives of a system for the feedback of operational experience are that no safety related event remains undetected and that corrections are made to prevent the recurrence of safety related events by improving the design and/or the operation of the installation. This criterion reflects the notion that an accident of any severity would most probably have been marked by precursor events, and to this extent would have been predictable and, therefore, avoidable. Feedback of experience also increases knowledge of the operating characteristics of equipment and performance trends, and provides data for quantitative and qualitative safety analysis.

2.4. The investigation and reporting of events contribute to improvements in nuclear safety and have the following objectives:

- To identify and quantify events and conditions that are precursors to significant degradation and that have the potential to cause accidents that can lead to plant damage or releases of radioactive material;
- To identify events that are important to safety and their associated safety concerns and root causes, and to determine the adequacy of corrective actions taken to address the safety concerns;
- To discover emerging trends or patterns of potential safety significance;
- To assess how situations could have developed;
- To assess the generic applicability of events;
- To prevent the recurrence of similar events.

2.5. The organization that operates a nuclear installation should maintain an effective system for the collection and analysis of operational experience and should promptly disseminate safety significant information among its own staff and to other relevant organizations. The causes of all safety significant events should be determined and analysed. Events that may be regarded as precursors of accidents should also be identified and actions should be taken to prevent their recurrence. Each organization should learn from the experience of other organizations. The sharing of operating data should be coordinated nationally and internationally. In identifying important precursors, accident sequence precursor (ASP) studies (also termed probabilistic safety assessment (PSA) event analysis) are useful. Further information on ASP studies is provided in Annex I, paras I–12 to I–15.

2.6. Plants are designed to be safe. A systematic analysis of many potential failure sequences under the assumption of certain criteria (e.g. the single failure criterion) has helped in achieving the present generally high level of safety. To address the possibility of a potential failure of any of the plant's safety features, the concept of defence in depth [6] has been applied to the plant design. Owing to their well engineered design and the application of the defence in depth concept, most of the unplanned events that occur in nuclear installations do not have major consequences.

2.7. Events in nuclear installations are indicators of a weakness in, or the failure of, one or more of the barriers providing defence in depth. The complete and systematic detection of all failures of barriers is impossible. In many cases events may also indicate a lack of adequate supervision or deficiencies in the management of safety at the nuclear installation. From this point of view an event[2] should be taken as an opportunity for learning. The comprehensiveness and trustworthiness of the information on events that is provided to the regulatory body is an indicator of the installation's safety culture.

MAIN ELEMENTS OF A NATIONAL SYSTEM FOR THE FEEDBACK OF OPERATIONAL EXPERIENCE

2.8. Although national systems vary from State to State, an effective system for the feedback of operational experience relating to safety should cover the following:

— Reporting of events at plants;
— Screening of events — primarily on the basis of safety significance;
— Investigation of events;
— In-depth analysis, including causal analysis, of safety significant events;
— Recommended actions resulting from the assessment, including approval, implementation, tracking and evaluation;
— Wider consideration of trends;
— Dissemination and exchange of information, including by the use of international systems;
— Continuous monitoring and improvement of programmes for the feedback of safety related operational experience;
— A storage, retrieval and documentation system for information on events.

2.9. The above elements describe generally the important components that should be considered in the development and implementation of a national programme for the feedback of operational experience. Annex II presents an example of the main elements of a system for the feedback of operating experience. There should be a commitment from the management in the various participating organizations involved in the national operational experience feedback programme to ensure that it is efficient and effective.

[2] An event may be either a plant transient with accompanying failures or the anomalous performance of a function, or it may refer to a particular condition or the discovery of shortfalls in the plant safety systems, without an actual initiating transient. However, the distinction should be maintained between a low level event (with no consequences) as contrasted with a reportable condition, which may have a high significance for risk even though it has no immediate consequences.

2.10. A system utilizing the feedback of operating experience is a two way process, i.e. for both providing and receiving experience. Internal operating experience refers to the process whereby a nuclear installation learns from its own experience — including sharing that experience with others — while external operating experience refers to the receiving of information that relates to another nuclear installation, which may lead to the development of corrective or preventive actions to avoid the recurrence of an event.

INVOLVEMENT OF THE REGULATORY BODY, OPERATING ORGANIZATION AND OTHER ORGANIZATIONS

2.11. Information on events, anomalies, situations and conditions starts at the plant level and should be communicated within the operating organization and then, in accordance with the relevant requirements, to the regulatory body, to other operating organizations and to research organizations, designers, contractors and other relevant parties. As a minimum, if event information yields lessons to be learned for other States it should be sent to the relevant international bodies (the IAEA/NEA or the World Association of Nuclear Operators/Institute of Nuclear Power Operations (WANO/INPO) reporting systems or both) for distribution. The flow of information on operational experience can thus run its full course from one State to another via the international coordinating agencies. At each step in the process of the dissemination of information, a number of the aforementioned elements (see para. 2.8) should be involved. Screening and analysis are two important elements in the flow of information.

2.12. A detailed procedure should be developed by the operating organization on the basis of the requirements for a national system established by the regulatory body. This procedure should define the process for dealing with all internal and external information on events at nuclear installations. The procedure should precisely define the structure of the system for the feedback of operational experience, the types of information, the channels of communication, the responsibilities of the groups and organizations involved, and the purpose of the documentation produced. Organizations that have various roles within the national process for the feedback of operational experience usually include operating organizations, the regulatory body, plant designers and research organizations. The procedure should be made available for review or approval by the regulatory body, if so required.

LINKS BETWEEN NATIONAL AND INTERNATIONAL REPORTING SYSTEMS

2.13. The effectiveness of national systems for the feedback of operational experience can be significantly strengthened by linking them with international systems. Links between national and international systems for operational experience feedback broaden the sources of information on safety significant events, on the related lessons learned, and on the corrective actions taken at the plant or national level. Participants in such international systems can mutually benefit by sharing experience, reducing the risk of duplication and optimizing the use of resources to run the programmes in the domain of operational experience feedback.

2.14. Participation in international systems for operational experience feedback necessitates the establishment and harmonization of relevant parts of national systems for the feedback of operational experience. National systems for operational experience feedback should have procedures in place to deal with international information from the moment that it is received until the time that it is disseminated. The standard format and contents of Incident Reporting System reports [1] may be considered for adoption into national systems for operational experience feedback in order to link national and international systems more efficiently.

2.15. Some form of ranking of events should be considered in view of the number of events likely to be of interest and the resources needed to evaluate them.

2.16. Reports initially screened at a nuclear installation for applicability should also be screened by the regulatory body. This screening should consist of evaluating the specific area of applicability and the possible effects on the nuclear installation, and of estimating the potential for the event to occur at that nuclear installation.

2.17. The IAEA and the OECD/NEA jointly operate an international reporting system for exchanging information on safety related events that have occurred in nuclear installations, for States to benefit from the experience in operational safety gained in other States with nuclear power programmes. The international Incident Reporting System is established as an efficient system for exchanging important lessons learned from operational experience gained in nuclear installations in IAEA Member States and NEA States. The Incident Reporting System functions on the basis of the voluntary commitment of the participating States and is dependent on national reporting systems that together allow an international perspective. The Incident Reporting System provides information for regulatory bodies and technical support organizations since it provides insights on important international operational experience for oversight and licensing purposes.

2.18. Operating organizations have their own event reporting system, the WANO reporting system. The WANO operational experience programme provides a forum for utilities that operate commercial nuclear installations to exchange event information for the purposes of enhancing both nuclear safety and plant reliability. The criteria for reporting events to WANO, while similar to those of the Incident Reporting System, are directed towards the needs of operating organizations. The WANO event database therefore may contain a different selection of events than that of the Incident Reporting System.

2.19. IAEA/NEA and WANO have undertaken to cooperate in certain areas to minimize duplication for operating organizations and to ensure a common understanding of particular themes in terms of cooperation in data analysis. These areas include the coding structure for the Incident Reporting System database and the WANO events database, as well as the common areas of guidelines for operational experience and tools for the investigation of events.

3. SCREENING OF EVENTS

PURPOSE OF SCREENING

3.1. Screening of event information is undertaken to ensure that all significant matters relevant to safety are considered and that all applicable lessons learned are taken into account. The screening process should be used to select events for detailed investigation and analysis. This should include prioritization according to safety significance and the identification of adverse trends.

3.2. The quality of screening depends, in part, on engineering judgement. Highly experienced and knowledgeable personnel should be assigned to this task. Many of the basic causes of events contain an element of human factors. It follows, therefore, that selected feedback of operational experience derived from events occurring at the plant or at other plants should be scrutinized not only by personnel with engineering and scientific perspectives, but also by personnel with knowledge of matters concerning human performance and behaviour.

3.3. All organizations involved in the process of operational experience feedback should screen information on events, taking into account their own needs. Operating organizations should have the objective of enhancing safety, plant availability and commercial performance by identifying the causes of events so as to be able to avoid their recurrence, and by evaluating the applicability of good practices used by others. Regulatory bodies should review the screening of events to gain insights that can be used to inform their inspection programmes, licensing activities, and the elaboration of regulations and requirements for safety backfits. Regulators should screen national reports for their international use. Vendor companies should use the data from the feedback of operational experience to improve their design and manufacture of structures, systems and components. Similarly, research establishments may use the data from operational experience feedback in support of their research goals and programmes.

3.4. As one element of the screening process that is carried out centrally or at plant level, consideration should be given to the applicability of corrective actions taken at other plants following the investigation of an event.

SCREENING AT THE PLANT LEVEL

3.5. At a nuclear installation, two sources of information are available: internal operational experience and external operational experience. Internal operational experience is experience from events that occur at the plant itself. External operational experience is experience from outside the plant, either from within the same State or from another State, from nuclear installations that utilize similar technologies or from those that utilize different technologies.

3.6. The screening of internal events should be carried out promptly to assign priorities in the process for the feedback of experience from events and in the follow-up actions. The screening of internal events should be performed first by appropriate personnel to determine whether there is any immediate implication for the plant. Events should then be screened by a suitable multidisciplinary group of plant personnel on the basis of specified criteria to determine whether the regulatory body or representatives of the utility need to be notified. This group should meet regularly to review every event that occurs at the plant and to discuss whether the causes have been clearly identified, whether corrective actions have been taken or planned, and whether the corrective actions are commensurate with the causes of the event. The events that were screened and initially found to be of less safety significance should be considered for trend analysis. The results of screening may be reviewed in subsequent periodic plant self-assessments or in peer reviews. The history of the screening process should be made available to the regulatory body.

3.7. The use of external operating experience can have the benefit of discovering latent potential failures that could pose concerns for safety. Such information should first be reviewed to determine whether it is applicable to the plant; this review should include consideration of aspects such as:

— Generic implications that apply to the plant;
— Whether there is similar equipment at the plant;
— Whether there are similar practices at the plant that predispose it to similar events;
— The possible prior occurrence of a similar event;
— Reported actions taken that are applicable to the plant.

3.8. The screening of external events should be undertaken periodically at the plant level. The screening criteria for external events should follow the criteria that govern the reporting of internal events to determine whether detailed investigation is necessary. Those inputs considered applicable should be distributed to the relevant branches (e.g. radiological protection, operations, maintenance) for analysis, assessment and consideration of applicability or for information. The results of screening of external events at the plant level should be recorded for evaluation in subsequent periodic self-assessments or peer reviews. The history of the screening process for external events should be made available to the regulatory body if so required.

3.9. Information on operational experience that is found to warrant further investigation should be considered in sufficient detail to gain a thorough understanding of the event. This often implies obtaining additional information primarily from the plant at which the event occurred, but also from other organizations (e.g. other plants of the same type, the utility's headquarters, international organizations) if necessary. After completion of this step, a decision should be made on whether the information needs to be analysed in depth.

SCREENING AT THE NATIONAL LEVEL

3.10. In States with a nuclear industry based in several locations additional screening should be conducted by the following organizations:

(a) A centralized group to provide leadership for the process of feedback of operational experience, including issues of safety assessment and cause analysis (this may be a joint undertaking involving several utilities);
(b) Vendors, suppliers and designers who use operational experience to improve their designs;
(c) Research institutions.

3.11. The regulatory body not only should conduct screening of incoming information on events but also should investigate the nuclear installation's screening process to ensure that the screening is effective in identifying events for analysis. The regulatory body should also have a strategic responsibility and should monitor the process of feedback of operational experience to ensure that it is conducted effectively by the operating organizations.

4. INVESTIGATION AND ANALYSIS OF EVENTS

INVESTIGATION OF EVENTS

4.1. The IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Operation [2] states in para. 2.21 that "Operating experience at the plant shall be evaluated in a systematic way. Abnormal events with significant safety implications shall be investigated to establish their direct and root causes. The investigation shall, where appropriate, result in clear recommendations to the plant management, which shall take appropriate corrective action without undue delay. Information resulting from such evaluations and investigations shall be fed back to the plant personnel."

PURPOSE AND GENERAL CONCEPTS

4.2. Accordingly, the operating organization or licensee, as appropriate, should have procedures in place specifying the type of investigation that is appropriate for an event of any particular type. Such procedures typically outline the conduct of an investigation in terms of means of initiation, duration, composition of the investigation team, terms of reference for the investigation team and format of the final report. A typical outline of an investigation process is given in Appendix III.

4.3. The level of the investigation carried out should be commensurate with the consequences of an event and the frequency of recurring events. Significant factors that would influence the magnitude of an investigation may include the following:

— The consequences of the event and the extent of damage to systems, structures and components;
— Any injury to on-site personnel;
— Whether a similar occurrence has taken place earlier at the same installation or at an installation of a similar type;
— Whether a significant radiological release or an overexposure of personnel has occurred;
— Whether plant operation exceeded the operational limits and conditions or was beyond the design basis of the plant;
— Whether there is a pattern that is complex, unique or not well enough understood.

4.4. The scope of investigations of events should vary appropriately:

— In the case of a single serious event there should be a Panel or a Board of Inquiry chaired by a senior officer, involving many people and making extensive use of root cause analysis techniques;
— For an event with no consequences or a minor event, or for adverse trends, a relatively quick and simple investigation should be conducted by an individual trained in event investigation techniques; this latter type of investigation may result in the identification of an apparent cause only (rather than a true root cause).

4.5. Paragraph 5.16 of Safety Standards Series No. GS-R-1 [3] establishes a requirement that “the regulatory body shall carry out inspections at short notice if an abnormal occurrence warrants immediate investigation”.

ANALYSIS OF EVENTS

4.6. Reference [3] establishes a requirement in para. 3.3 (7) that “the regulatory body shall ensure that operating experience is appropriately analysed and that lessons to be learned are disseminated”.

4.7. Event analysis should be conducted on a timescale consistent with the safety significance of the event. The main phases of event analysis can be summarized as follows:

— Establishment of the complete event sequence (what happened);
— Determination of the deviations (how it happened);
— Cause analysis:
  • Direct cause (why it happened);
  • Root cause (why it was possible);
— Assessment of the safety significance (what could have happened);
— Identification of corrective actions.

4.8. At the plant level, as well as at the level of the regulatory body, several follow-up activities should be undertaken after the analysis of an event. These activities comprise documentation of the analysis of the event and storage of the documentation, dissemination of significant results, and monitoring of the implementation of corrective actions and assessment of their effectiveness.

4.9. It should be noted that the designation of the safety significance may be changed in the analysis of the event. The regulatory body should be kept informed of any such changes so that it can perform its duties and discharge its responsibilities (e.g. for making available information on incidents; para. 2.6 (12) of Ref. [3] establishes a requirement “to make available, to other governmental bodies, national and international organizations, and to the public, information on incidents and abnormal occurrences, and other information, as appropriate”).

4.10. The analysis of any event should be performed by an appropriate method. It is common practice that organizations regularly involved in the evaluation process use standard methods to achieve a consistent approach for the assessment of all events. These standard methods usually involve different techniques. Each technique may have its particular advantages for cause analysis, depending on the type of failure or error. It is not possible to recommend any one single technique. Either one technique or a combination of techniques should be used in event analysis to ensure that the relevant causes and contributing factors are identified, which aids in developing effective corrective actions (further details on methods of event analysis are provided in Appendix III and Ref. [7]).

5. CORRECTIVE ACTIONS

GENERAL

5.1. Actions taken in response to events constitute the main basis of the process of feedback of operational experience to enhance safety at nuclear installations. Such actions are aimed generally at correcting a situation, preventing a recurrence or enhancing safety. The safety significance of the event, which includes its potential consequences, determines the depth of the cause analysis necessary and subsequently determines the type of corrective actions and the time limit for their implementation.

5.2. The development of recommended corrective actions following an event investigation should be directed towards the root causes and the contributory causes, and should be aimed at strengthening the weakened or breached barriers that failed to prevent the event. Personnel at nuclear installations are responsible for implementing corrective actions promptly and effectively. A sense of personal interest or 'ownership' should be promoted by involving the members of the organization's event investigation team in formulating the corrective actions to be recommended.

TYPES AND AREAS OF CORRECTIVE ACTIONS

5.3. Recommendations on corrective actions should be proposed on the basis of the feedback of either internal or external information and should be identified prior to or as a result of a thorough analysis of an event. Corrective actions should be developed by the operating organization of the plant affected. However, in some cases, such as for generic safety issues, the development of the corrective actions should involve other relevant organizations and, depending on the national regulatory infrastructure, may involve the regulatory body. Recommended actions should be aimed at improving human performance, equipment or managed processes, such as by means of:

— Modifications to equipment and the installation of additional devices and means to prevent the recurrence of the same or similar events;
— Improvements of procedures and administrative measures, and additional checks and control;
— Rectifying deficiencies revealed in the documentation for operation (operation manuals);
— Rectifying deficiencies in normative documents;
— Training personnel to perform jobs properly;
— Making changes to the working environment;
— Making changes to the planning and scheduling of work and/or to the individuals assigned to particular duties.

5.4. Corrective actions may also be applicable for other operating plants, plants under construction or future plant designs, for operational limits and conditions, and for the improvement of procedures and the training of personnel, in addition to their suitability for the nuclear installation affected. The corrective actions may also have implications for other operating organizations and regulatory bodies. Where a corrective action is screened and found to be relevant it should be included in the corrective action plan for the plant itself.

5.5. A number of important factors should be taken into account when determining corrective actions. These should include the need for:

— Restoring or maintaining the desired level of nuclear safety;
— Addressing human and organizational factors;
— Considering the implications of the action for existing documentation and for operational aspects.

5.6. Generating too many actions may overwhelm the intended beneficiary and may result in some important actions being left pending for too long. Corrective actions should therefore be prioritized. Those actions affecting safety should be given the highest priority, while the actions that are desirable rather than essential should be shown as such. Corrective actions may be either immediate, interim or long term with a need for detailed evaluation. Examples of immediate actions are measures to recover from a plant transient or to isolate contaminated areas. A specific procedure should exist to ensure that appropriate control measures are carried out (see Appendix IV).

TRACKING OF ACTIONS

5.7. A tracking process should be implemented to ensure that all approved corrective actions are completed in a timely manner and that those actions with long lead times to completion remain valid at the time of their implementation in the light of later experience or more recent developments. A periodic evaluation should be carried out to constantly review the need for items in the pending corrective actions list and separately to check the effectiveness of actions implemented. Primarily, the implementation and tracking of corrective actions should be performed by the plant management. The regulatory body may monitor the progress of certain recommended actions. This may be done by requiring nuclear facilities and/or operating organizations to provide periodic progress reports.

5.8. In addition to the documentation and tracking of actions associated with each single event, a systematic compilation of actions should be made to provide a historical information base of lessons learned. When these actions are compiled and sorted on the basis of the systems affected or the safety issues raised, they can serve as solutions for similar problems that could arise in the future at the plant or at other plants.

6. TRENDING AND REVIEW TO RECOGNIZE EMERGENT PROBLEMS

6.1. The IAEA Safety Requirements for Operation [2] states in para. 2.23 that "…operating experience shall be carefully examined by designated competent persons for any precursors of conditions adverse to safety, so that any necessary corrective action can be taken before serious conditions arise".

6.2. Trending is a process used to identify conditions of degradation on the basis of the analysis of past events (precursors) at the plant. Plant operating organizations trend causal factors in events derived from analysis of apparent causes and/or root causes. The goal of any trending programme should be to identify an abnormal trend early enough that the operating organization can initiate an investigation and take corrective actions to prevent a significant event. Corrective actions that are directed at weaknesses that have been identified should be specified and implemented through the corrective action programme. Industry experience indicates that trending of event information in this manner makes full use of information from investigations and can provide useful indications of the safety culture at the plant for line managers.

PURPOSE OF TRENDING OF INFORMATION FROM THE FEEDBACK OF OPERATIONAL EXPERIENCE

6.3. The purpose of an event trending process should be to determine the frequency of occurrence of certain conditions that have been gathered from reports on minor and major problems and event investigations. These data include information about equipment failures and shortfalls in human performance, and situational data that describe conditions at the times of the events.

6.4. Data from programmes other than problem and deficiency reports should also be trended to obtain a broader perspective of strengths and weaknesses at the plant. For example, trending of information from industrial safety reports, radiological contamination reports and records of maintenance work can provide useful insights.

6.5. Trending should be used to analyse the performance of various work groups, to identify those factors that result in either less than desired or better than expected performance. Follow-up investigations should be performed to gain a better understanding of why an abnormal trend is occurring so as to determine the causal and contributing factors.

6.6. A coding system should be applied that enables events to be characterized. Selected parameters or groups of parameters can then be trended to identify recurring themes (e.g. plant system, work group or cause of the activity). Examination of these parameters can permit the identification of adverse trends and the potential for events to recur.

6.7. Types of trending that provide useful information are those that identify:

- Recurring data derived from the events coded, preferably after detailed investigation;
- Abnormal trends relating to plant work groups;
- Abnormal trends in certain operating modes and during certain activities;
- Recurring failures of systems and components;
- The differences between trends during an outage in comparison with trends during non-outage periods;

— Those work groups that are performing well;
— Doses arising from different activities, as an input to ensuring that exposures to radiation are maintained as low as reasonably achievable.

METHODS FOR DETERMINING ADVERSE TRENDS

6.8. Since trending is performed to identify a deviation from an expected value or level, a method of recognizing deviations is necessary. Generally, a comparison should be made between the frequency with which a parameter occurs over time and a threshold value that should encompass the expected values. Any deviation beyond the threshold value should be considered for further analysis.

INVESTIGATION OF IDENTIFIED ABNORMAL TRENDS

6.9. Arrangements should be in place for personnel at nuclear installations routinely to identify adverse trends on the basis of data from event analysis so that follow-up investigations may be undertaken. Coding of data makes this task easier.

6.10. Once an abnormal trend has been identified it should be treated as an event, and the established deficiency reporting programme should be used to initiate an appropriate analysis and to determine whether the trend is identifying adverse performance. The level of the analysis should be based on the significance of the trend and its potential consequences. A thorough root cause investigation can be made so as to identify causal and contributing factors to explain why a trend is occurring. Corrective actions should be focused on addressing the causes and should be incorporated into the organization's process or programme for corrective actions. Subsequent follow-up actions should be taken to verify that the adverse trend has been corrected or to modify the original corrective actions.

6.11. The investigation should then be focused on these more frequent factors, thereby increasing the probability that the actual (root) cause(s) of the adverse trend will be identified.[3]

[3] This point is important because most of the data on causal factors are obtained from apparent cause analyses. Since apparent cause analysis is not rigorous, it follows that investigation in greater depth is necessary to obtain additional details regarding causal factors for events.

REPORTING THE RESULTS OF TREND ANALYSIS

6.12. Trend analysis reports should do the following:

— Provide useful information to line managers at a regular frequency that depends on the amount of coded event data generated;
— Focus attention on those items in the trend report for which further action may be necessary;
— Provide sufficient detail in the report so that adverse trends can be understood;
— Provide clearly labelled graphs where appropriate;
— Present data in a format (e.g. in tables) that is easy to reference.

6.13. When reporting trend data, only information that is both useful and necessary should be provided. The primary goal of trending is to provide an ‘early warning’ to the management of the operating organization of abnormal trends and to help in gaining an understanding of the factors that may be responsible. A group of people within the operating organization or licensee should be brought together to review and examine trends and patterns on a routine basis (e.g. every three months). Line managers are ultimately responsible for deploying the resources necessary to identify the causes of adverse trends and to implement the necessary corrective actions.

7. UTILIZATION, DISSEMINATION AND EXCHANGE OF INFORMATION ON OPERATING EXPERIENCE

7.1. The IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Operation [2] establishes in para. 2.22 that the operating organization “shall obtain and evaluate information on operating experience at other plants to derive lessons for its own operations” and in para. 2.25 that the plant management “shall maintain liaison as appropriate with the organizations (manufacturer, research organization, designer) involved in the design, with the aims of feeding back information on operating experience and obtaining advice, if necessary, in the event of equipment failures or abnormal events”.

UTILIZATION OF OPERATING EXPERIENCE

7.2. Managers of nuclear installations should clearly define their expectations regarding the systematic reporting, screening and use of internal and external operating experience. Information on operating experience should be made readily accessible to plant personnel. For example, licensees should issue information relating to operating experience (e.g. in the form of a synopsis of past events, team briefings, work briefings, so-called just in time (JIT) information about events that have occurred elsewhere under similar plant conditions, and lessons learned) when assigning plant work. In this way personnel are reminded of previous problems that have occurred locally and at other locations and that are relevant to the plant on which they are about to work. Effective use of the feedback of operational experience should be actively encouraged and reinforced by plant managers and supervisors, including the use of operating experience in refresher training for plant personnel.

DISSEMINATION AND EXCHANGE OF INFORMATION

7.3. The objective of disseminating information on events should be to facilitate the following:

— For operating organizations or licensees to be able to enhance the safety of the plant by implementing the applicable corrective actions as derived from operational experience;
— To improve the understanding by the operating personnel of the operating conditions and response characteristics of the plant;
— To enable the vendors to be able to improve their design and manufactured products by taking into account lessons learned;
— To enable contractors providing maintenance services to be better prepared so as to anticipate potential problems;
— To enable research establishments to prioritize research and to provide an additional means of improving their knowledge, which may be of help to the operating organization of the nuclear installation.

7.4. For maximum impact and benefit, appropriate information relating to the feedback of operational experience should be disseminated to relevant bodies. This should occur at appropriate levels (e.g. the plant level, the operating organization level, and the national and international level). A list of possible recipients for different types of information should include: regulatory bodies, organizations with planned or ongoing nuclear programmes, technical support organizations in the nuclear field, vendor companies (including design firms, engineering contractors and manufacturers), research establishments and universities working in the nuclear field.

7.5. The dissemination of information involves a number of organizations, such as the regulatory body and the operating organization, and use should be made of the centralized international reporting system set up by the IAEA and OECD/NEA and by WANO, although other arrangements that fulfil the same objectives may be adopted.

7.6. By actively participating in the programmes for the dissemination and exchange of information, the originator should also benefit from the increased opportunity for receiving feedback from other organizations and service providers. In this way dissemination leads to a more broadly based effort to enhance safety by using operational experience from nuclear installations and other related industries. It may contribute to the effectiveness of decision making at the affected organization and it may enhance the confidence of the regulator in the safety of the operation of the plant.

7.7. Information to be disseminated should be derived from a number of sources, typically including early notifications with corrective actions taken or planned, main reports of events and follow-up reports. In addition, other periodic reports issued within the framework of the system for feedback of operational experience (for example, monthly reports, annual reports, topical study reports and summary reports to highlight valuable operational experience) should also be included.

7.8. Legal requirements and commercial interests in a State could restrict the dissemination procedure (e.g. in relation to matters such as the dissemination of proprietary or confidential information). The regulatory body and the operating organization should make the necessary arrangements with the organizations concerned to ensure that any restrictions on the information to be disseminated are minimized.

7.9. To facilitate the dissemination of information, a procedure should be developed at the national level. This procedure should define the following:

— The roles and responsibilities of the organizations involved (e.g. the operating organization or licensee, the regulatory body, the IAEA-OECD/NEA Incident Reporting System, WANO);

— The interfaces between these different organizations and the means of reporting (compatibility with international systems and other reporting systems should be achieved during the establishment of this process);
— The requirements for early notification so that information can be transmitted by the operating organization or licensee to the designated organization for onward transmittal (e.g. the regulatory body, the utility headquarters);
— The mutually agreed time for distribution among the recipients of main reports, follow-up reports and other types of reports;
— The means of responding to urgent requests for additional information made by any of the interested groups and identifying the extent of the information to be provided, to discourage excessive requests for additional information.

7.10. Modern means of disseminating and sharing operational experience, such as CD-ROMs and other electronic media (local networks, email and the Internet), have been found to be particularly convenient. Technical meetings or seminars held on a periodic basis help to consolidate the information exchange.

7.11. A specific means exists for reporting information on events that may be of interest to the international nuclear community through the Incident Reporting System [1]. A regular joint review of information from the feedback of operational experience that has been issued to the Incident Reporting System should be held on a routine basis (e.g. at least every six months). Typically, representatives of the regulatory body (in cases where it is undertaking the role of national coordinator for the Incident Reporting System) and the operating organizations should carry out the review. This promotes confidence and understanding between these parties while ensuring consistency of reporting nationally, between plants and also internationally. In this respect it is interesting to compare the actions taken in the various participating States in response to a given safety significant event. Harmonization between States should be an objective.

8. REVIEWING THE EFFECTIVENESS OF THE PROCESS FOR THE FEEDBACK OF OPERATIONAL EXPERIENCE

8.1. A periodic review should be undertaken of all stages of the process for the feedback of operational experience to ensure that all of its elements are performed effectively. Continuous improvement of the process for the feedback of experience should be an objective of the review. Guidance for such reviews can be found in the IAEA's PROSPER Guidelines [8]. An effective process for the feedback of operational experience can contribute significantly to minimizing the recurrence of events. In general, there are three approaches to undertaking such a review:

— 'Self-assessment' by the operating organization of the nuclear installation;
— Peer review to determine whether the process meets established international standards;
— Regulatory review and/or inspection.

SELF-ASSESSMENT

8.2. The operating organization or licensee should periodically review the effectiveness of the process for the feedback of experience. The purpose of such a review is to evaluate the effectiveness of the overall process and to recommend remedial measures to resolve any weaknesses identified. Indicators of the effectiveness of the process should be developed. These may include the number, the severity and the recurrence rate of events and the causes of different events.

8.3. The following should also be done as part of the self-assessment review:

(a) It should be verified that corrective actions arising from the process for the feedback of operational experience are being implemented in a timely manner;
(b) The continuing need for each of the outstanding corrective actions should be considered;
(c) The effectiveness of the solution of the original problems and the prevention of their recurrence should be evaluated;

(d) Recurring events should be reviewed to identify whether improvements can be made in the process for the feedback of operational experience.

8.4. The operating organization should issue a periodic report, at least annually, that summarizes the activities performed in the interval that was considered in the framework of the process for the feedback of operational experience. Such a report should list the internal and external experience that was analysed, and the corrective actions that were approved and the status of their implementation. A target completion date should be assigned for those corrective actions that are still under way.

PEER REVIEW

8.5. The purpose of a peer review is to determine whether the process for the feedback of operational experience meets internationally accepted standards and to identify areas for improvement.

8.6. The peer review should do the following:

- Review the comprehensiveness of the plant self-assessment and offer comments and recommendations to further enhance the conclusions of the self-assessment;
- Compare, as far as possible, the process for the feedback of operational experience for an operating organization or licensee with guidance and equivalent good practices used elsewhere;
- Be related to the performance of the feedback of operational experience so that it is possible to accept different approaches to the implementation of the process.

8.7. Some of the criteria typically used for assessing the effectiveness of operational experience feedback are whether:

(a) All applicable external experience is analysed;
(b) All internal events are included in the process for the feedback of operational experience;
(c) Corrective actions are fully implemented in a timely manner;
(d) Recurrences of internal events are minimized and no single root cause dominates the statistics;

(e) The performance at the plant with regard to events, the response to challenges to safety systems and the unavailability of safety functions show no adverse trends over the period assessed.

9. QUALITY ASSURANCE

9.1. The operating organization or licensee should be responsible for integrating operational experience feedback into its quality assurance/ management system[4] in accordance with national and international standards. The operating organization or licensee should establish procedures for the control of activities at the site for the feedback of operational experience to ensure that they are consistent with the objectives of the management system. Arrangements should be made to ensure that these procedures are reviewed and approved before issue, and that their subsequent amendment is controlled. Requirements and guidance on a systematic and structured quality assurance programme can be found in Ref. [9].[4]

9.2. The system at the plant for the feedback of operational experience should be audited by the operating organization or licensee at regular intervals, usually annually, by an experienced group not directly involved in the programme of that plant for the feedback of operational experience. This audit team should usually be made up of quality assurance staff belonging to the same operating organization. As a good practice, at least one member from a different plant should be involved. The independent audit team should act on behalf of the senior management of the operating organization, to whom the audit's conclusions should be reported.

[4] The IAEA is revising the requirements and guidance in the subject area of quality assurance as established in Safety Series No. 50-C/SG-Q (1996) in new safety standards on management systems for the safety of nuclear facilities and activities involving the use of ionizing radiation. The term 'management system' has been adopted in the revised standards instead of the terms 'quality assurance' and 'quality assurance programme'. The new standards will integrate all the aspects of managing a nuclear facility, including the safety, health, environmental and quality requirements, into one coherent system.

9.3. For such an audit of the feedback system to take place, the operating organization should establish a process that is open to scrutiny and that defines how every element of the programme for the feedback of operational experience is carried out, from reporting up to the implementation of corrective actions. A complete documentary history of each element of the programme should be maintained in documents that specify its purpose and scope, procedures, roles and responsibilities, the records that should be kept, the definitions of terms and references. This suite of documents should be periodically reviewed internally and should also be made available for any external audit or inspection (e.g. by the regulatory body or by WANO).

9.4. Problems or deficiencies noted in the audit report covering the overall administration or function of the programme for the feedback of operational experience should be identified and discussed with the senior management of the plant or the operating organization. A system or process should be put in place to address and resolve these audit findings within the remit of the management system. Any weaknesses identified should be assessed to determine their actual or potential impact on the overall effectiveness of the programme, and corrective actions should be identified for implementation. Such actions should be taken in such a way that the feedback process itself continues to function without interruption.

9.5. The regulatory body should include the process for the feedback of operational experience as an item for regulatory inspection. The intervals for such inspections should be decided in the context of the overall regulatory inspection programme. In addition to inspecting these elements, the regulatory body should also examine the roles of all the organizations involved to ensure that information on incidents and abnormal occurrences is communicated effectively to governmental bodies, national and international organizations and others, as appropriate (see para. 2.6 (12) of Ref. [3]).

10. REPORTING OF SAFETY RELATED EVENTS

10.1. The IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Operation [2] states in para. 2.24 that "All plant personnel shall be required to report all events and shall be encouraged to report on any 'near misses' relevant to the safety of the plant."[5] The Safety Requirements publication on Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] states in para. 2.6 (12) that "The regulatory body shall have the authority to make available, to other governmental bodies, national and international organizations, and to the public, information on incidents and abnormal occurrences, and other information, as appropriate."

EXPECTATIONS FOR THE REPORTING PROCESS

10.2. Operating organizations should develop documents specifying appropriate reporting criteria specific to the type of plant being operated and consistent with national regulatory requirements. These criteria should specify the types of events and incidents, including problems, potential problems, non-consequential events, near misses and suggestions for improvement. These reports about events and incidents should be collected and reported internally, and some of them should be reported externally to the plant or utility. To promote understanding and cooperation between the plant(s) and the regulatory body, documents setting out these criteria should be provided to the regulatory body. These documents should be suitably controlled within the scope of the management system.

10.3. Operating organizations should use a system of coding for reported events. This system should facilitate the evaluation and trending of information derived from the feedback of operational experience.

REPORTING OF OPERATING EXPERIENCE

10.4. Operating experience should be reported in a timely manner to facilitate learning from events. To this end operating organizations should put in place the necessary arrangements to ensure that all events that occur during operation of the plant are systematically reported and analysed.

10.5. As part of an effective national system for the feedback of operational experience, the regulatory body should make clear its criteria for the events to

[5] A near miss is a potentially significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the plant conditions prevailing at the time.

be reported to it by the operating organization or licensee. Furthermore, the regulatory body should encourage and support the collection and analysis by the operating organization of data relating to low level events,[6] including near misses, even if such events do not reach the threshold for reporting to the regulatory body.

10.6. For events to be reported to the regulatory body the following should be specified (see also Refs [2, 3]):

— Criteria and categories for identifying the information to be reported;
— Procedures to ensure that the operating organization reports in a uniform and timely manner, since it is vital that all safety significant events be reported;
— Channels of communication and assignments of responsibility for reporting.

10.7. The reporting arrangements that enable compliance with national requirements should be clearly specified. These arrangements should define the roles and responsibilities of personnel from both the nuclear installation and the responsible regulatory body.

REPORTING CRITERIA

10.8. While the aim is to encourage the reporting of all events, including near misses, higher levels of the reporting process should only be initiated when one or more of the specified criteria are met. The key criteria for events that should be reported to the regulatory body should include the following (Appendix I describes these in further detail with supporting information):

(1) A plant shutdown as required by the operational limits and conditions [10];
(2) An operation or condition prohibited by the operational limits and conditions;

[6] A low level event is the discovery of a weakness or a deficiency that could cause an undesirable effect but has not, owing to the existence of one (or more) barriers of defence in depth. It includes near miss events (see footnote 5, p. 28).

(3) Any event or abnormal condition that resulted in the condition of the nuclear installation, including its principal safety barriers, being seriously degraded;
(4) Any natural phenomenon or other external condition that posed an actual threat to the safety of the nuclear installation or that significantly hampered site personnel in the performance of duties necessary for safe operation;
(5) Any event or abnormal condition that resulted in the manual or automatic operation of the reactor protection system or of engineered safety features;
(6) Any event in which a single cause or condition caused a significant loss of operability in a safety system;
(7) Any liquid or airborne releases of radioactive material to unrestricted areas in excess of authorized limits, or exposure of site personnel in excess of authorized limits;
(8) Any event that posed an actual threat to the safety of the nuclear installation, or that significantly hampered site personnel in the performance of duties necessary for safe operation, including fires, releases of toxic gases and radioactive releases;
(9) Declaration of an emergency condition as specified in the emergency plan;
(10) Any problem or defect in the safety analysis, design, fabrication or operation that has resulted in, or that could result in, an operating condition that had not previously been analysed or that could exceed design basis conditions;
(11) Any safety significant event during shutdown or refuelling (e.g. the dropping of a fuel assembly);
(12) Any nuclear event that results in the death of or serious injury to personnel on the site.

REPORTING PROCEDURES

10.9. The operating organization should develop detailed procedures for the reporting of events. Such procedures should ensure that events of major safety significance are communicated promptly to the appropriate organizations, both internally (on the site) and externally to the utility’s headquarters, the regulatory body and any other relevant organization.

10.10.The procedures should be such that plant specific and generic implications of the events reported can be evaluated and appropriate actions can be determined. The procedures should stipulate a time limit for reporting events, the format for the type of reports and the administrative arrangements for their distribution. The types of report that should typically be included in a national system for the feedback of operational experience are given in Appendix II.

STORAGE AND RETRIEVABILITY OF INFORMATION FROM THE FEEDBACK OF OPERATIONAL EXPERIENCE

10.11.The IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Operation [2] states in para. 2.26 that "Data on operating experience shall be collected and retained for use as input for the management of plant ageing, for the evaluation of residual plant life, and for probabilistic safety assessment and periodic safety review."

10.12.Reports in the system for the feedback of operational experience should be stored in such a manner that the information they contain can be easily sorted and retrieved by both the operating organization of the nuclear installation and the regulatory body, as appropriate. The information should be organized to facilitate frequently needed searches for, for example:

— Events at similar units;
— Systems or components that failed or that were affected;
— Identification of the causes of events;
— Identification of lessons learned;
— Identification of trends or patterns;
— Events with similar consequences for personnel or for the environment;
— Identification of failure types or human factor issues;
— Identification of recovery actions and corrective actions.

10.13.At the level of the plant or the operating organization a special division or team may be responsible for the collection of data on events, their analysis, the preparation of reports, and the storage and dissemination of information relating to the events. The source documentation should include extracts from different logs, records of parameters, results of in-service inspections and further testing, and notes made by personnel. According to established practice the reports are usually stored starting from the construction of the plant. The entire history of all components and systems can thus be followed, which allows the analysis of their performance over the lifetime of the plant. If the information is also stored in a computerized database, the data can readily provide the basis for assessing the reliability of systems and components. For low level events, data collection, analysis and storage should be performed by the relevant technical departments.

10.14. Operating organizations should store coded information from the feedback of operational experience in company-wide or (in some cases) national databases to facilitate easy access to and handling of the data (see also Annex I). The information should be organized with a clear and logical structure and should be readily available to any user without the need for extensive searching. Internet based systems with hyperlinks for various aspects have been found to be particularly convenient for accessing information from the feedback of operational experience.

Appendix I

REPORTING CRITERIA AND CATEGORIES

I.1. While the aim is to encourage the reporting of even near miss events, the process of reporting to the regulatory body is initiated only when one or more criteria are met. The reporting criteria for events that should be required to be reported to the regulatory body include the following:

(1) *A plant shutdown as required by the operational limits and conditions* [10]. For example, if a limiting condition for operation required that the plant change mode from full power operation to another mode, such as hot shutdown or cold shutdown, because of the unavailability of an essential electrical transformer, then this should be reported pursuant to this criterion.
(2) *An operation or condition prohibited by the operational limits and conditions*. The operational limits and conditions include values for safety limits, limiting safety system settings, limiting conditions for operation, levels for surveillance, design features, and various administrative and organizational requirements if directly connected with plant operations. For example, if a component in a safety system (for example, a pump) was found to be inoperable for more than 7 days, but was only allowed by the operational limits and conditions to be out of service for a maximum of 7 days during an outage, then this would be reportable as a breach of the operational limits and conditions.
(3) *Any event or abnormal condition that resulted in the condition of the nuclear installation, including its principal safety barriers, being seriously degraded.* This criterion could include conditions for which the plant was in an unanalysed condition; a condition outside the design basis; or a condition not covered by the normal or emergency procedures for the plant. For example, if a pressurized water reactor were in a transition state in terms of temperature and pressure, in which the pressure–temperature relationship was outside the range covered in the operating guidance, then this would be reportable. Degradation of the fuel, the primary coolant system or the containment as the principal barriers would be included in this criterion.
(4) *Any natural phenomenon or other external condition that posed an actual threat to the safety of the nuclear installation or that significantly hampered site personnel in the performance of duties necessary for safe operation.* Examples include earthquakes, fires of an external nature, high winds,

tornadoes, lightning, floods and external threats that might arise from any industrial facilities nearby.

(5) *Any event or abnormal condition that resulted in the manual or automatic operation of the reactor protection system or of engineered safety features (with some exceptions, dependent on the actual circumstances, such as actuation from any part of a preplanned testing sequence, or when the system was removed properly from service, or if the actuation occurred after the safety function had already been performed).* Use of this criterion by the regulatory body may require the specification of which systems are included as part of the engineered safety systems. Typical systems would include the emergency power system, the emergency core cooling system, the auxiliary feedwater system, the service water system, the containment cooling system and other systems relating to accident prevention and the mitigation of consequences. For example, if there were a failure in an instrument line connected to a reactor coolant system and a resultant leak at a rate of 300 L/min, then there should be an actuation of a high pressure pump to compensate for this small loss of coolant event. The event would be reportable under this criterion.

(6) *Any event in which a single cause or condition caused at least one independent train or channel to become inoperable in multiple systems, or two independent trains or channels in a single system to become inoperable, for systems designed to shut down the reactor, to remove decay heat, to control the release of radioactive material or to mitigate the consequences of an accident. This criterion addresses two common cause concerns that are not necessarily comparable in terms of risk significance or severity.* Events reported under this criterion can include previously unrecognized common cause (or dependent) failures and system interactions. For example, if a number of pipe snubbers were found to be inoperable such that they would not have worked properly, then this could be an instance of generic common mode problems in several independent trains in multiple systems designed to remove decay heat.

(7) *Any liquid or airborne releases of radioactive material to unrestricted areas in excess of authorized limits (generally as specified in the operational limits and conditions), or exposure of site personnel in excess of authorized limits.* For example, if a valve in the gaseous waste system was inadvertently opened in such a way that there was a release that was in excess of authorized limits off the site, then this would be reportable under this criterion.

(8) *Any event that posed an actual threat to the safety of the nuclear installation or that significantly hampered site personnel in the performance of duties necessary for safe operation, including fires, releases of toxic gases and*

radioactive releases. The actual threat referred to is from an internal event, since external threats are covered by criterion (4) above. The intent of this criterion is to ensure the reporting of events that compromise the safety of the plant or disrupt personnel in the performance of their duties necessary for safe operation. For example, if a fire (or radioactive release) necessitated the evacuation of a room for which access was needed to deal with conditions at the plant, then it would be reportable under this criterion.

(9) *Declaration of an emergency condition as specified in the emergency plan.* In general, the declaration of an emergency condition is communicated to the regulatory body in a different manner from that described in this Safety Guide. For example, the regulatory body may receive notification of the declaration of an emergency by telephone, by facsimile or by direct communication to a resident inspector. Generally, the condition that prompted the emergency declaration would be an event specified in other numbered items in this appendix and would result in the generation of an event report.

(10) *Any problem or defect in the safety analysis, design, fabrication or operation that results in, or could result in, an operating condition that had not previously been analysed or that could exceed design basis conditions.* An example would be a report by a vendor that a particular circuit breaker has a non-revealing fault that could cause binding (for example due to the use of a lubricant that breaks down with age) with consequent common mode failure to actuate on demand. If the plant had a number of these breakers in service in various safety systems there would be a cause for concern and this criterion would suggest making an event report.

(11) Any safety significant event during shutdown or refuelling, such as the dropping of a fuel assembly, the dropping of an object into an open reactor vessel in a fuelled state, the loss of boron control during refuelling, the loss of shutdown heat removal systems or the loss of water inventory in the reactor vessel.

(12) Any event that results in the death of or serious injury to personnel on the site.

Appendix II

TYPES OF EVENT REPORT, TIMING, FORMAT AND CONTENT

II.1. The *preliminary report* (sometimes termed the early notification report) should be submitted by the operating organization to the regulatory body electronically or by telephone or facsimile. These preliminary reports should be followed by a brief written confirmation, as appropriate, to ensure that adequate information is transferred. Before a detailed written report (herein-after termed the main report) is submitted, additional information may be needed for reasons such as the following:

— Further degradation in the level of safety of the plant;
— Major changes in the perception of the significance of the event as a result of a subsequent evaluation;
— New information;
— The need to correct factual errors.

II.2. A *main report* should then be prepared by the operating organization. This report should be submitted to the regulatory body (and possibly other organizations) as soon as practicable. The main report should be marked as provisional if additional information is to be gathered later for evaluation and, if necessary, submitted in a *follow-up report* to finalize the main report.

II.3. The operating organization should submit *follow-up reports* if the initial report is known to be incomplete or if significant additional information becomes available. The operating organization should also submit specific additional information and assessments as it considers necessary, or at the request of the regulatory body if the regulatory body finds it necessary for a complete understanding of an event. When such a request is made, the information and assessments should be provided within an agreed time period. If, after the main report is submitted, significant further corrective actions are taken or more information gained from further investigations becomes available, this should be reported to the regulatory body as follow-up information. Reports should, wherever possible, be communicated and disseminated widely to relevant bodies (see Section 7.3) and should be considered for serving as the basis for information to be exchanged internationally.

II.4. The operating organization should prepare the main reports in sufficient technical detail for persons conversant with the design of the nuclear installation. In addition to technical details, whenever appropriate the reports should contain data on human factors necessary for an understanding of the event without the need for additional information. The standard format and contents of reports to the IAEA/NEA Incident Reporting System [1] may be considered for adoption in national systems for the feedback of operational experience, to link national and international systems more effectively.

II.5. The main report should be as comprehensive as possible and should be set out in an orderly and consistent manner. The main report should include the following:

— Basic information;
— Narrative description;
— Safety assessment (consequences and implications);
— Causes and corrective actions (taken and/or planned);
— Lessons learned;
— Graphic information for a better understanding of the event (if necessary);
— Guide keywords with their respective codes.

II.6. *Basic information*. This should include such items as the type of event, the date of occurrence, identification of the plant (name, site), the plant type and the rated power output, the date of commencement of operation and an abstract. The abstract should be a brief statement of the major occurrences in the event, including all actual faults and failures of systems and components that contributed to the event, all relevant actions by personnel or violations of procedures, and any significant corrective action taken or planned as a result of the event. It should also include an explanation of the way in which the event was detected and an account of any individual harm or injuries, radiation doses received and radioactive material released, together with information on the classification of the event, which should be compatible and consistent with the International Nuclear Event Scale.

II.7. *Narrative description.* The narrative description should explain exactly what happened and what was discovered in the event. Emphasis should be put on how the plant responded and how structures, systems and components and operating personnel performed. Descriptions of what the operator(s) saw, did, understood or misunderstood, and how the event was discovered, are important and should be included. Any unique characteristics of the plant that influenced the event (favourably or unfavourably) should be described. The following specific information should be included: the plant's status prior to the event, the event sequence in chronological order, faults of systems and components, operator actions and/or procedural controls, and recurrent events. This should include beneficial or adverse actions, the use of procedures and any procedural deficiencies, and any aspect of the human–machine interface that contributed to the event. This information should help in detecting and diagnosing safety related problems to which the event gave rise.

II.8. The *safety assessment* should be focused on the safety consequences and implications of the event. The primary aim of this review is to ascertain why the event occurred and whether it would have been more severe under reasonable and credible alternative conditions, such as at different power levels or in different operating modes. The safety significance of the event should be indicated.

II.9. *Causes*. The direct causes, root causes and causal factors of the event should be clearly described. (Annex I provides more details on direct and root causes in paras I–10, I–11.) The reasons for equipment malfunctions, problems of human performance, organizational weaknesses, design and manufacturing deficiencies and other relevant facts should be included under causes. Whenever appropriate the method used for cause analysis should be referenced in the report.

II.10. Where an event investigation reveals shortcomings in human performance it is important to specify the inappropriate human actions taken (i.e. the response as well as the causes). The aim should be to provide both the technical details of the event and the lessons concerning human performance in ways that can be understood and applied easily to other situations. Human performance is greatly affected by the management systems that are put in place to help workers perform well (e.g. in the planning and scheduling of work, training, supervision, work practices, written instructions and the work environment). When there are latent weaknesses in any of these systems, conditions may exist that are likely to lead to errors. Information about previous malfunctions should also be provided. To enable others to learn effectively from experience, event reports should provide clear explanations of what the weaknesses are, how they were detected and the measures taken to eliminate similar weaknesses.

II.11. All information concerning persons involved should be depersonalized to maintain the privacy of the individuals concerned. If the persons interviewed are made aware that the information they provide will be kept private, the fullness and quality of the report is likely to be improved.

II.12. *Corrective actions*. Corrective actions taken or planned owing to equipment failures or human errors should be reported. Some corrective actions are more important than others, and those that are desirable but not essential should be listed as such or even omitted to avoid making excessive demands on an organization's resources. All corrective actions should be listed and described in sufficient detail, primarily to allow their applicability to other plants to be determined. Inclusion of details of the following aspects is good practice and should be considered:

— The nature of the corrective action (recovery, short term or long term) and any target dates set for its implementation;
— The authority taking the action (the operating organization);
— The personnel group responsible for implementing the action (e.g. operations group, maintenance group or analysis group);
— For each corrective action, cross-references to the identified causes that gave rise to it, to allow an assessment of the adequacy of the corrective action.

II.13. *Lessons learned*. The report should clearly identify learning points. The communication of lessons learned can lead to enhanced safety, positive changes in working practices, increased reliability of equipment and improvements in procedures. The sharing of lessons learned from operational experience is one of the most valuable parts of the process of feedback of operational experience.

II.14. *Graphic information for a better understanding of the event.* The report should provide supporting information if necessary, such as: diagrams; data printouts; plots of the changes in the main equipment parameters; protocols and checklists of equipment tests performed after the event; and operational data on damaged or failed equipment.

Appendix III

INVESTIGATION AND ANALYIS OF EVENTS

INVESTIGATION OF EVENTS

III.1. The level of management to which investigators report should depend on the severity (or the potential severity) and the frequency of occurrence of the event concerned. Minor events that occur frequently should be investigated just as one-off events with serious consequences should be, given that all events have the potential to be more serious.

III.2. The number of investigators and their areas of expertise should be based on the type of plant and the characteristics of the event. Suitable experts in reactor systems, human factors and operations, and specialists in mechanical, electrical or instrumentation and control systems may be needed. Additional members could include specialists in physics, plant behaviour, radiological assessment, health physics, chemistry, materials science, emergency preparedness or other specialized areas.

III.3. Training (both initial and refresher) should be provided for the staff who might take part in an investigation. This should include training in investigation techniques, documentation needs, witness interviews, conflict resolution and dealing with confidentiality issues. Event investigation training for personnel from operating organizations is frequently available at the corporate department, the supporting organizations, the WANO and the Institute of Nuclear Power Operations, as well as through the IAEA. Whereas all investigators should receive some basic training in event investigation, including root cause analysis, for more difficult and complex investigations there may need to be at least one expert facilitator who is familiar with such methods of investigation.

III.4. A mandate should be established for the investigation activities. This should set out the format and terms of reference and should typically cover the following areas:

— Conditions preceding the event;
— The sequence of events;
— Equipment performance and system response;
— Considerations of human performance;

— Equipment failures;
— Precursors to the event;
— Response and follow-up at the plant;
— Radiological considerations;
— Considerations relating to the regulatory process;
— Safety significance.

III.5. The mandate should include a review of the design and licensing basis for the nuclear installation as necessary, as part of the assessment of causes of the event under investigation or to identify a plant response that is beyond the licensing basis.

III.6. The event investigator (or the lead investigator if there is more than one) should be competent in investigation skills as well as having technical, administrative and managerial competence.

III.7. The on-site investigation should be commenced as soon as practicable to ensure that information is not lost or diminished and evidence is not removed. It is vital that the on-site investigation should not inhibit operational staff from bringing the plant to a stable state.

III.8. Interviews should be conducted with all the staff who were involved in the event or who were witnesses to the event. Interviews should be transcribed. A sequence of events listing (e.g. an event and causal factors chart) should be started immediately and should be continuously updated as new data are obtained.

III.9. Investigators should prepare a written report and should present it to the management group that commissioned the investigation. In some cases there will be a request for corrective actions to be taken that are commensurate with the identified root causes.

III.10.The investigation should include:

— Preparing progress reports and other interim reports documenting significant activities, findings and concerns;
— Ensuring safety, as appropriate, at the scene of the incident;
— Ensuring that the investigative activities do not result in adverse impacts on the rest of the plant;
— Ensuring that the plant management is advised of the status of the investigation and of progress and future plans in relation to it;

— Initiating requests for information, interviews with witnesses, laboratory tests and technical or administrative support;
— Maintaining control over information and material collected as part of the investigation of an event.

III.11.It is not the objective of an event investigation to apportion blame or to determine fault, or to recommend or dispense disciplinary actions. Conducting investigations in such an environment is not conducive to establishing the facts that will assist in the identification of root causes, and hence lead to the corrective actions necessary to enhance safety and to improve the performance of equipment and human performance.

ANALYSIS OF EVENTS

III.12.In most instances the first step in the analysis of an event and the basis for further evaluation is the establishment of the event sequence. This means the listing in chronological order of all relevant occurrences or activities leading to the event and subsequent to it.

III.13.On the basis of the event sequence all deviations of conditions from the expected state should be determined as far as possible. The occurrences and activities that should be analysed in depth can thus be identified. Different areas should be considered in the analysis, such as design, organization, procedures, human actions, component faults and behaviour of materials. In some cases the involvement of additional expertise in the cause analysis should be considered. Very often the notions of immediate (direct, observed) causes, root causes and contributing factors are used in the cause analysis. Cause identification should be carried out for the formulation of corrective actions. The depth of the causal analysis should be adequate for ensuring the determination of appropriate corrective actions.

III.14.Numerous methods of root cause analysis, many having a similar basis, have been developed or are under development for addressing the connection between root causes and corrective actions (see the annexes). Since there is no single best technique for use for all events in all States, the evaluator should select the most appropriate tool for use for the event in question, in the context of national capabilities.

III.15.The analysis of events relating to human characteristics should include the causes and circumstances of any problems with human performance that contributed to the event. Human errors that affected the course of the event may include either errors of commission or errors of omission. There may also have been procedural deficiencies, and there may have been a combination of human errors and procedural deficiencies. There may have been errors and human performance related issues in the areas of procedures, training, communication, engineering for human factors[7] and the human–machine interface, management and supervision The analysis should be sufficient to categorize the human performance issues (the annexes cover the treatment of human errors in event analysis in more detail).

III.16.The analysis should consider and resolve the following issues:

— Whether human errors were cognitive (such as failure to recognize the actual plant conditions, failure to realize which systems should be functioning, or failure to recognize the true nature of the event), or whether there was an error in the following of procedures;
— Whether human deficiencies in the use of procedures were characterized by difficulty either in terms of failure to follow an approved procedure, or in the use of a procedure that contained erroneous instructions, or were associated with an activity or task that was not adequately covered by a procedure;
— Whether any unusual characteristic of the working location, such as heat, humidity, noise, radioactivity levels, accessibility or signage contributed to the problem with human performance;
— Whether there were any ergonomic issues, or issues relating to engineering for human factors;
— The type of personnel involved (such as a licensed operator, an unlicensed operator, supervision and management staff or contractor personnel).

[7] Engineering for human factors is engineering in which factors that could influence human performance are taken into account.

Appendix IV

APPROVAL AND IMPLEMENTATION OF CORRECTIVE ACTIONS

IV.1. The recommended corrective actions should be reviewed and approved at the appropriate level prior to their implementation. The approval process will depend on the significance of the corrective actions and on the national practice. An administrative verification should ensure that the requirements for the approval process itself have been met and that the proper documentation and forms have been completed. Documents that are submitted for approval may typically include:

— A detailed description of proposed corrective actions (including drawings, schematics, and process charts or flow charts);
— A safety review for the purpose of ensuring that the proposed corrective actions will enhance safety and have no adverse effects;
— High quality plans for the purpose of ensuring compliance with design standards;
— Plans and schedules for implementing the corrective actions, designations of the persons responsible and terms of implementation;
— Procedures for ensuring a safe working method;
— Discussions of organizational considerations and considerations of human performance.

IV.2. The corrective actions proposed should then be discussed with and accepted by the organizations or individuals who are to be made responsible for their implementation. There are at least three levels of approval — the plant management (on the site), the operating organization and the regulatory body. The information on the corrective actions to be taken should be incorporated into the training programme for personnel as soon as possible.

IV.3. Factors that should be considered in the formulation of corrective actions include the following:

— Whether the proposed corrective action addresses the fundamental problem;
— What adverse consequences may result from the implementation of the corrective action;
— Whether the corrective action is compatible with other corrective actions that have been implemented previously;

— Whether the corrective action has been taken before and with what results;
— Whether the corrective action is an interim solution or a conclusive solution;
— For plants at which risk assessment techniques are used in formulating corrective actions, the risk improvement factor;
— An assessment of the corrective action schedule, which should be made with account taken of the base level of risk and the incremental improvement that may be attributed to the corrective action.

IV.4. The plan for corrective action should include a provision for verification of the effectiveness of the actions.

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Annex I

DATA MANAGEMENT FOR THE FEEDBACK OF OPERATING EXPERIENCE

LOW LEVEL EVENTS

I–1. For the purposes of this Safety Guide, a low level event (which includes near misses) is the discovery of a weakness or a deficiency that could have caused an undesirable effect but did not, owing to the existence of one (or more) barriers of defence in depth [I–1]. (Instead, there would have been minimal or no consequences of the low level event.) Low level operational events are those reported within the plant or operating organization as anomalies, conditions or situations that are usually screened out in the process of dealing with safety significant events (such as findings during testing, in-service inspection or surveillance). They would form the majority among the reported events at the plant. Individually they may appear to be unimportant. However, when aggregated with other low level events they can reveal features of common patterns, trends and recurring information that may be significant and useful for enhancing plant safety.

I–2. Owing to the large number of low level events that may occur and the difficulties in determining the useful elements of such information, it is generally accepted that low level events are dealt with by the operating organization, perhaps with the aid of computerized systems (databases) that can effectively sort and manage the large quantities of data accumulated.

I–3. Evaluation and analysis in depth of operating experience is not restricted to lessons learned from safety significant events. It is also extended to lessons learned from situations and events of lesser importance that would have had the potential to develop into safety significant events but were prevented from doing so by features of the plant design and/or by corrective actions by the operator.

MANAGEMENT OF INFORMATION FROM THE FEEDBACK OF OPERATIONAL EXPERIENCE

I–4. The retrieval and evaluation of information can be facilitated by using a coding scheme (e.g. the IAEA/NEA Incident Reporting System or WANO coding systems) and arranging for the storage system to contain records of each component fault, system fault or personnel action involved in a reported event. Different techniques are used for the storage, tracking and documentation of national event reports, from the simple storage of hard copies to storage in computerized full text databases using guide words and codes for quick searching for and retrieval of information.

I–5. It is useful to develop a standard data input sheet for gathering information from the narrative report to facilitate computerized storage and retrieval. One of the essential features of the computerized system is the ability for key word searches (single key words, a combination of key words and limited field searches) and full text searches. The use of computerized information management is advisable when the amount of information involved justifies it. Such a system could also ideally be adapted to enable finely structured searches to be made for the information that is needed to support in-depth safety investigations or to detect trends and generic aspects.

I–6. A computerized system for preparing, storing, disseminating, searching for and retrieving information from systems for the feedback of operational experience can do the following:

— Increase the effectiveness of experts in nuclear safety in analysing and communicating operational safety experience;
— Facilitate the process of preparing, storing and disseminating information from the feedback of operational experience;
— Promote the most advanced methods for dealing with the information.

I–7. Linkage of the database on feedback from operational experience with programmes for other applications, such as programmes for technical information on plant design and construction, plant reliability databases, performance indicators and other analytical programmes, can enhance overall nuclear safety assessment

I–8. The aim of a programme for the feedback of operational experience is to ensure that the following objectives are achieved:

(1) The collection of information is sufficiently comprehensive that no relevant data are lost (this necessitates broad reporting criteria and low detection thresholds);

(2) The information collected is screened efficiently to ensure that all important safety related issues that ought to be analysed with priority will actually be selected (this necessitates clear ranking criteria);
(3) The issues selected are analysed in sufficient depth to permit the identification of the underlying root causes in the design, in the surveillance activities carried out on equipment, in personnel qualification and in aids for personnel;
(4) The relevant corrective actions are implemented promptly enough to prevent the recurrence of similar events that could be caused by underlying root causes of the same category;
(5) The lessons learned are disseminated promptly enough to enable other plant operating organizations to take corrective actions before other similar events occur.

TOOLS FOR CAUSAL ANALYSIS

I–9. The following explanations are useful for the purposes of causal analysis.

I–10. The immediate cause, sometimes termed the direct or observed cause, is the occurrence (or occurrences) which breaches or violates certain authorized or prescribed processes and conditions at the plant. The repair or correction of the identified direct cause is of primary importance for plant safety, and possibly for the restarting[8] of the plant.

I–11. The root cause (or causes) may provide an explanation of why the immediate cause occurred. The root cause indicates the appropriate corrective actions, since remediation of the root cause is aimed at preventing its recurrence. The root cause is the most basic cause or causes of an event that can reasonably be identified, and it is directly correctable. To be considered a root cause, the cause needs to meet one only of the following criteria:

— The problem can be duplicated;
— The problem would not have occurred if the causes had not been present;
— The problem will not recur as a result of the same cause if the cause is corrected.

[8] In some instances, authorization for restarting of the plant is granted by the regulatory body before the full range of root causes is determined.

I–12. Depending on the nature of the event, there may be an additional tool available for the safety assessment of the event. This tool, known as precursor analysis, uses a probabilistic approach. Usually the probabilistic approach is applied for precursor studies in the domain of event analysis, but events can also be analysed with the same objectives as for the probabilistic approach itself.

I–13. By use of the precursor analysis method, known in several States as either the accident sequence precursor method or probabilistic safety assessment event analysis, what is known as a conditional core damage probability can be obtained. This sort of analysis produces a quantitative assessment of the likelihood of reactor core damage occurring if additional failures or errors have also occurred. A precursor to potential severe core damage is an event or condition that could have been serious if plant conditions, action by personnel or the extent of equipment failure or faulting had been slightly different from the actual circumstances. Because of the relatively small number of events that might warrant investigation by means of the precursor method it might prove an impractical method for States with few plants. A recently developed method based on probabilistic safety assessment, termed probabilistic precursor event analysis, has been used more often as it also allows for the quantitative estimation of the safety significance of events. This method can be applied to improve the reliability of the selection of events for analysis in depth as well as in the process of selecting and prioritizing corrective and preventive actions [I–2].

I–14. On the basis of practical investigations, several analytical techniques have been developed, tested and implemented for directing the investigation process. All of the available techniques serve three purposes:

— To organize the information on events once the evidence has been collected;
— To help in describing the causation of events and developing hypotheses for future examination by experts;
— To help with the assessment of proposed corrective actions.

I–15. Such techniques can support an investigation and can help to focus it on the important features of the event causation. Several, if not all, of the available techniques can provide useful frameworks for demonstrating and documenting the cause–consequence relationships. They can also be used to develop visual aids for better communicating the lessons learned.

TREATMENT OF HUMAN ERRORS IN EVENT ANALYSIS

I–16. To understand operational events with human factor characteristics it is necessary to understand the causes of human errors. This necessitates knowledge of the mechanisms of human activity; that is, a knowledge of basic human behaviour under particular circumstances and in a particular context. Human errors can seldom be attributed to one cause. Many influences in the environment have a direct or indirect influence on an individual.

I–17. Specialists in human factors may participate in the event investigation and in the evaluation of the contributory personal, group and organizational deficiencies. Their specialist knowledge of human behaviour may provide a valuable contribution to the analysis.

I–18. Since the treatment of the human dimension in event analysis issues necessitates knowledge of the context that individuals perceive during their activities, the collection of information on human characteristics and the corresponding analysis needs to be started at the plant level. As stated in para. I–1, low level events, which include near misses, with aspects relating to human factors need to be reported to the operating organization. The operating organization needs to retain information on such low level events, even if they do not reach the threshold for reporting to the regulatory body.

I–19. The purpose of an analysis of the human factor aspects of an event is not to delve into the psychologies of individuals, but rather to take into account and to use established knowledge about basic human behaviour so as to understand the contributory and influencing factors that have led to an error, or may have predisposed someone to make an error, either of omission or of commission.

I–20. Different models of human performance exist that can readily be understood by interested persons without special training in social sciences. Use of these models can contribute much to the diagnosis of human performance during a reportable event at a plant.

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Annex II

EXAMPLE OF ELEMENTS OF A NATIONAL FEEDBACK SYSTEM FOR OPERATING EXPERIENCE

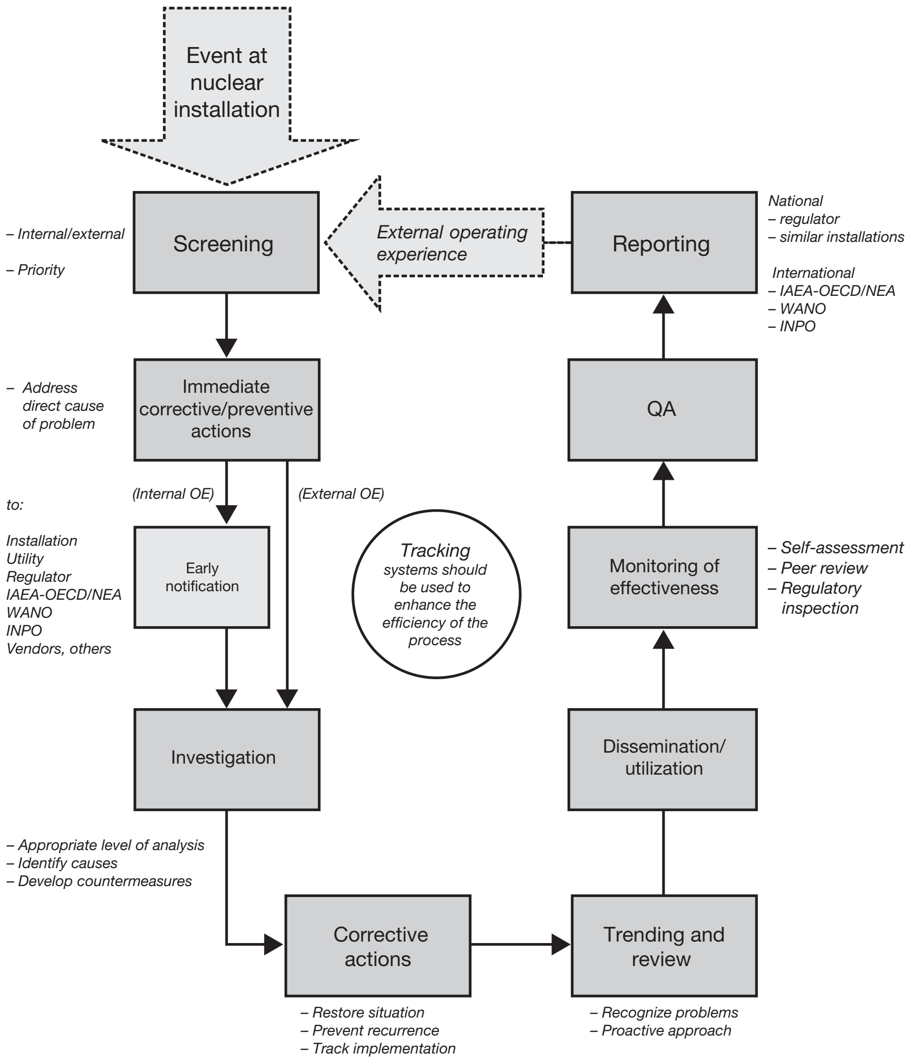

FIG. II–1. An example of elements of a national system for the feedback of operating experience.

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