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FOREWORD

The IAEA Assessment of Safety Significant Events Team (ASSET) Service provides advice and assistance to Member States to enhance the overall level of plant safety while dealing with the policy of prevention of incidents at nuclear power plants. The ASSET programme, initiated in 1986, is not restricted to any particular group of Member States, whether developing or industrialized, but is available to all countries with nuclear power plants in operation or approaching commercial operation.

Conservative design, careful manufacture and good construction are all prerequisites for safe nuclear power plants. However, their safety depends on the capability to prevent any incident during operation.

ASSET missions consider this aspect in assessing a facility's operational practices in comparison with those used successfully in other countries and when exchanging, at the working level, ideas for enhancing prevention of incidents.

The IAEA Safety Series publications form common basis for the ASSET reviews, including the Nuclear Safety Standards (NUSS) and the Basic Safety Principles (Recommendations of Safety Series No. 75-INSAG-3). The ASSET Guidelines provide overall guidance for the experts to ensure the consistency and comprehensiveness of their review of incident investigations. Additional guidance and reference material is provided by the IAEA to complement the expertise of the ASSET members.

ASSET reviews accept different approaches that contribute to ensuring an effective prevention of incidents at plants. Suggestions are offered to enhance plant safety performance. Commendable good practices are identified and generic lessons are communicated to other plants, where relevant, for long term improvement.
EDITORIAL NOTE

In preparing this material for the press, staff of the International Atomic Energy Agency have mounted and paginated the original manuscripts and given some attention to presentation.

The views expressed do not necessarily reflect those of the governments of the Member States or organizations under whose auspices the manuscripts were produced.

The use in this book of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

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1. INTRODUCTION

Stimulating and contributing to the ongoing process of striving for excellence in the area of operational safety of nuclear power plants worldwide is one of the essential duties of International Atomic Energy Agency.

Since 1986, in the frame of its operating experience feedback system, the IAEA has been offering the ASSET service (Assessment of Safety Significant Events Team) as an international mechanism to draw and to disseminate specific and generic lessons for enhancement of the level of operational safety. Several operating organizations have already benefitted from such an in-depth technical exchange of experience directed to the improvement of policies of prevention of incidents at NPPs.

1.1 Purpose of the ASSET guidelines

An ASSET working session concentrates on issues selected by the operating organization and reviews the various steps of the analysis performed by the operating organization. The final goal of an ASSET review is to provide conclusions on the appropriateness and completeness of the planned and implemented corrective actions. Generic lessons are drawn and suggestions are offered when necessary to improve plant management control on prevention of incidents thus enhancing the overall level of operational safety.

For this purpose, comprehensive expertise and a systematic analysis methodology are both indispensable for the conduct of conclusive investigations. The following guidelines are developed to ensure consistency in the application of the ASSET analysis methodology.

This guidance is not intended to infringe an expert's prerogative to investigate additional items. Its main purpose is to provide a basic structure and ensure consistency in the assessments. Use of the ASSET guidelines should also facilitate comparisons between the observations made in different nuclear power plants and harmonize the reporting of generic ASSET results. The guidelines should always be used with a critical attitude and a view to possible improvements.
1.2 **Application of the ASSET guidelines**

The ASSET guidelines are provided to guide the systematic review of each issue submitted by the operating organization. The provided instructions within the guidelines are not intended to be used as a check list with an obligation to check each item individually or with a prohibition from adding more items.

1.3 **Structure of the ASSET guidelines**

The ASSET guidelines are based on the application of the "in-depth defence concept" for prevention of incidents at nuclear power plants.

The level of quality required for safe operation is expected to be reached prior to operation through an effective quality assurance programme. However, the ultimate barrier consists of the plant surveillance programme which should be capable of timely detection of any latent weakness and of prompt restoration of the level of reliability, in such way diminishing the potential for incidents.
2. ASSET APPROACH TO PREVENTION OF INCIDENTS

The ASSET approach is based on the following:

- EVENTS (deviation, anomaly, issue, incident or accident) occurred always because of a

- FAILURE (occurrence) to perform as expected due to a

- LATENT WEAKNESS (direct cause) which was not timely eliminated due to

- DEFICIENCIES OF PLANT SURVEILLANCE PROGRAMME (Detection and Restoration) on equipment, personnel, procedures (root cause)

Striving for safe and reliable operation is the primary goal of any operating organization. Prevention of any negative impact on safety and reliability is the primary target of plant management: "NO INCIDENT".


Safe operation and good performance at nuclear power plants require at all time the full operability of the three basic operational functions "man", "machine" and "interface man-machine".

The objective of full operability of the basic operational functions is met through compliance with the following requirements:

- At the stage of design: The necessary provisional redundancies (hardware and software) are provided in accordance to the average level of quality expected from personnel, equipment and procedure to ensure safe operation.

- At the stage of preparation prior to operation: A quality assurance programme ensures that, during the off-line plant activities aiming at preparation for safe and reliable operation, the resulting quality of operating personnel, equipment and procedures has reached the expected level prior to putting these elements into operation.
Event

Reported causes or consequences

Occurrence

Failure of personnel, procedure, equipment to perform as expected

Root cause

Failure of the ultimate barrier to eliminate latent weaknesses

Due to

Deficiency of plant surveillance, poor detection capabilities, poor restoration process

Direct cause

Existence of a latent weakness among personnel, procedure, equipment

Due to

- Degradation during operation
- Poor preparation prior to operation
At the stage of operation: A prevention maintenance programme ensures that the necessary actions are properly taken to prevent any degradation of the level of quality of personnel, equipment and procedures. A surveillance programme (Detection and Restoration) ensures that, during plant operation, any latent weakness, which might affect the expected quality of operating personnel, equipment and procedures, is detected and corrected through permanent assessment and prompt restoration.

Current plant designs are generally considered acceptable even if hardware provisions have to be supplemented by operational provisions to reach an optional level of safety. Preparation for operation and plant operation are the areas where weaknesses may usually happen.

The occurrence of events (incidents or accidents) demonstrates only that existing latent weaknesses were not detected and corrected on time. Personnel, equipment or procedures should therefore not be held responsible for failing to perform as expected. Quality assurance during preparation prior to operation and surveillance during plant operation were simply not effective enough to detect or to correct latent weaknesses among personnel, equipment or procedures.

Timely detection of latent weaknesses and effective restoration provide therefore the ultimate barrier of the defence in-depth concept dedicated to prevention of incidents.

The detection programme should aim at thoroughly assessing proficiency of personnel, usability of procedures, operability of equipment to be capable of identifying latent weaknesses which might lead to personnel, equipment or procedures failure, under adverse circumstances.

The restoration process should aim at eliminating the latent weaknesses detected in order to fully recover operability of the functions "man", "machine", "interface man-machine" and at preventing any recurrence of such weaknesses:

- Either by eliminating the deficiencies of the programme of quality assurance of the various preparatory activities involved in quality of personnel (recruiting, training, motivating and licensing) of equipment (designing, manufacturing, storing, installing, maintaining and qualifying), of procedures (writing and validating)

- or by eliminating the deficiencies of the programme of surveillance of quality of these elements in the course of operation.
## Asset Approach to Prevention of Incidents

*(Reach and Maintain the Required Level of Quality)*

### Level of Quality Required

- **Preparation for Operation**
- **Surveillance in Operation**

#### Minimum Threshold of Quality

**Potential of (Latent Degradation Quality weakness)**

**Incident**

<table>
<thead>
<tr>
<th>Time</th>
<th>Reaching the Quality Level Prior to Operation</th>
<th>Surveillance of the Quality Level During Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personnel</strong></td>
<td>Preparing</td>
<td>Checking</td>
</tr>
<tr>
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<td>Proficient personnel</td>
<td>Proficiency of personnel</td>
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<td><strong>Procedure</strong></td>
<td>Preparing</td>
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<td></td>
<td>Usable procedure</td>
<td>Usability of procedure</td>
</tr>
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<td><strong>Equipment</strong></td>
<td>Preparing</td>
<td>Checking</td>
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<tr>
<td></td>
<td>Operable equipment</td>
<td>Operability of equipment</td>
</tr>
</tbody>
</table>
3. ASSET METHODOLOGY FOR ANALYSIS OF EVENTS

The analysis of an event is conducted step by step through the application of a systematic methodology that concentrates on the five following areas:

- **Selection of the occurrences to be analyzed:** What is the occurrence (element that failed to perform as expected) or the combination of occurrences most significant to safety in the sequence of the event?

- **Identification of the direct cause:** What was the latent weakness which was affecting the element (personnel, equipment or procedure) that failed to perform as expected?

- **Identification of the root causes:** Why was the latent weakness (of the element which failed to perform as expected) not eliminated earlier by the plant surveillance (detection or restoration) programme?

- **Determination of the corrective actions:** What are the areas of improvements and the corrective actions needed to enhance both, quality and surveillance of quality of the element which failed to perform as expected?

- **Generic lessons:** What are the generic lessons to be disseminated for further enhancement of prevention of incidents?

3.1 **Selection of the occurrences to be analyzed**

- An event (incident, accident) is a reportable situation defined by reporting criteria related to either causes or consequences.

- The title of an event may greatly vary according to the emphasis given to the various aspects of the event: actual consequences, failures to perform as expected, causes, contributors, significance to operational safety, etc.

- Events are very often a combination of several occurrences.
<table>
<thead>
<tr>
<th>IAEA</th>
<th>EVENT INVESTIGATION</th>
<th>ASSET</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>SELECTION OF THE OCCURRENCES MOST SIGNIFICANT TO SAFETY AMONG EVENT SEQUENCE</td>
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<tr>
<td></td>
<td>IDENTIFICATION OF THE DIRECT CAUSE OF EACH OCCURRENCE SELECTED</td>
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<td>IDENTIFICATION OF THE ROOT CAUSE OF EACH OCCURRENCE SELECTED</td>
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<td></td>
<td>DETERMINATION OF CORRECTIVE ACTIONS TO ELIMINATE DIRECT AND ROOT CAUSES</td>
<td></td>
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<tr>
<td></td>
<td>GENERIC LESSONS FOR PREVENTION OF INCIDENTS</td>
<td></td>
</tr>
</tbody>
</table>
SELECTION OF OCCURRENCES TO BE ANALYZED

1. Identification of the occurrences that happened in the course of the event

2. Establishment of chronologic sequences of occurrences

3. Establishment of the logic tree of occurrences

4. Assessment of significance to safety of each occurrence

5. Selection of the occurrences to be analyzed
An occurrence is a failure to perform as expected of one of the basic elements (personnel, equipment or procedure) involved in plant operation.

A chronological sequence of the various occurrences of the event may be established from the narrative description of the event.

Each occurrence in the chronological sequence of the event is either independent or connected to other occurrences.

The logic tree of occurrences shows the interconnections between occurrences and enables concentrating on the main branch of occurrences related to the reported event.

Each occurrence of the logic tree has a different weight to be assessed in connection with potential and actual significance to safety.

The assessment of the significance to safety of each occurrence is based on both aspects, potential and actual consequences to safety.

+ The potential significance to safety may be assessed through an:

- Quantitative evaluation of the increase of the probability of occurrence of unacceptable situations such as harm to public, harm to plant personnel, uncontrolled radioactive releases, core damages, inoperability of safety functions, etc.

- Evaluation qualitative of the potential consequences to safety of the occurrence under circumstances different from the event considered.

+ The actual significance to safety may be assessed through an:

- Evaluation of the actual consequences to safety of the occurrence under the present circumstances of the event (impact on environment, radioactive releases, core damages, inoperability of safety and support functions).
- Evaluation based on the regulatory reporting criteria.

- Evaluation based on the exceeding of the plant operational limits and conditions (technical specifications) for safe operation.

- Only a probabilistic approach enables a detailed quantitative assessment of the potential significance to safety of an occurrence provided that it takes into account the contribution of the three basic elements (personnel, procedure and equipment).

- On the other hand, operational limits and conditions (technical specifications) might also be used as a sound basis for evaluating potential significance to safety if their consistency with a plant probabilistic safety assessment has been checked.

- In case a probabilistic assessment is not available and cannot be performed to assess potential significance, occurrences to be analyzed may be selected on the basis of their actual significance versus the following ranking criteria.

- Criteria of high significance to safety:

1. Impact on the environment (public and plant personnel)
   - death
   - injury
   - irradiation superior to 50 mSv

2. Uncontrolled radioactive releases
   - Iodine 131 superior to 10E10 Bq
   - Gas and aerosols superior to 10E10 Bq
   - Liquids superior to 10E10 Bq

3. Core damages
   - melting superior to $10^{-3}$ of core

4. Inoperability of safety functions
   - Loss of the function "Reactor shutdown"
   - Loss of the function "Cooling of fuel"
   - Loss of the function "confinement"
5. Inoperability of the support functions
   - Loss of the function "off-site electrical power"
   - Loss of the function "on-site electrical power"
   - Loss of the function "Cooling water"
   - Loss of the function "instrument air"

6. Potential for one of the above events.

   - The occurrences selected are always a personnel deficiency, a procedure deficiency or an equipment deficiency which happened in the course of the event.

   - Caution should be taken at this stage to identify clearly the element requested for on-line operation which did not perform as expected.

3.2 Identification of the direct cause of an occurrence

   - The starting point of the investigation is the selected occurrence either a personnel deficiency, or a procedure deficiency or an equipment deficiency.

   - The direct cause of an occurrence is the pre-existing latent weakness of the basic element (personnel, procedure, equipment) that failed to perform as expected in the course of the event associated with the contributors to the existence of the latent weakness.

   - The latent weakness of the element which failed to perform as expected affected either proficiency of personnel, or usability of procedure or operability of equipment.

   - Identification of the latent weakness of the personnel involved is carried out by referring to the characteristics of personnel proficiency required for the task where the individual failed to perform, as expected:

   - Identification of the latent weakness of the equipment involved is carried out by referring to the characteristics of equipment operability required for the task where the equipment failed to perform as expected.
DETERMINATION OF THE NATURE OF OCCURRENCE TO BE ANALYZED

FAILURE OF

- PERSONNEL
- PROCEDURE
- EQUIPMENT

IDENTIFICATION OF THE PRE-EXISTING LATENT WEAKNESS OF THE ELEMENT THAT FAILED TO PERFORMED AS EXPECTED

- RELIABILITY IN OPERATION
- FITNESS TO WORKING CONDITIONS
- QUALIFICATION FOR TASK

IDENTIFICATION OF THE CONTRIBUTORS TO EXISTENCE OF THE LATENT WEAKNESS

DEGRADATION DURING OPERATION (MAINTENANCE)

POOR PREPARATION PRIOR TO OPERATION (QUALITY ASSURANCE)
Identification of the latent weakness of the procedure involved is carried out by referring to the characteristics of procedure usability required for the task where the procedure failed to provide proper guidance as expected:

The existence of a latent weakness is the result of a discrepancy which happened in the course of:

- either preparation prior to operation of personnel, procedure, equipment.
- or plant operation due to unforeseen reasons.

The existence of the latent weakness is due to various contributors which are identified among the following areas:

- Preparation prior to operation: The quality assurance programme was not effective enough to ensure that the expected level of quality was reached.
  - Uncomprehensive verification of personnel proficiency, equipment operability, procedure usability prior to operation
  - Inadequate acceptability criteria
  - Ineffective correction of detected discrepancies

- Degradation in operation: The level of quality required prior to operation was reached but due to unforeseen reasons a degradation occurs in the course of operation because of:
  - Inconducive environmental conditions beyond the specifications taken as reference for preparation prior to operation of personnel, procedure and equipment.
  - Premature degradation of personnel proficiency, of procedure usability or equipment operability (poor maintenance programme).

The contributors to the existence of the latent weakness of the element which failed to perform as expected are usually a combination
of several factors that have to be addressed to prevent any recurrence.

- Caution should be taken at this stage to identify clearly the factors that are under plant management control and those which are not.

- Limitations in the depth of the search for contributing factors have to be considered. Although the origin of any latent weakness is always due to human factors, only those which are related to plant personnel under plant management control are investigated. Human factors having contributed to any latent weakness in the course of the activities of preparation for operation that are outside plant management control are not addressed. Surveillance in operation is the plant management tool expected to detect and correct latent weaknesses which were not identified by commissioning tests. They generally resulted from activities such as designing, manufacturing, installing equipment.

3.3 Identification of the root causes of an occurrence

- The starting point of the investigation is the identified direct cause (latent weakness and contributors to personnel, equipment or procedure deficiency) responsible for the occurrence analyzed.

- Whatever the origin of the latent weakness is (poor preparation prior to operation or degradation during operation), an effective plant surveillance programme should be capable of detecting any latent weakness and of restoring the level of quality required for safe operation.

- The root cause of any occurrence is therefore a failure to eliminate the pre-existing latent weakness in due time.

- The root cause of an occurrence is precisely a deficiency of the plant surveillance programme (detection and restoration) in operation which did not play its expected role of ultimate barrier regarding prevention of incidents.
LATENT WEAKNESS OF THE ELEMENT THAT FAILED TO PERFORM AS EXPECTED

IDENTIFICATION OF THE DEFICIENCY OF THE PLANT SURVEILLANCE PROGRAMME THAT DID NOT ELIMINATE THE LATENT WEAKNESS

POOR DETECTION PROGRAMME DURING OPERATION

POOR RESTORATION PROCESS AFTER DETECTION OF WEAKNESS

IDENTIFICATION OF THE CONTRIBUTORS TO DEFICIENCY OF SURVEILLANCE
- MANAGEMENT OF DETECTION PROGRAMME
- MANAGEMENT OF RESTORATION PROCESS
The deficiency of surveillance of personnel proficiency, of procedure usability or of equipment operability is always related to:

- either poor detection capabilities
- or a poor restoration process

Identification of the deficiency of the plant detection programme is carried out by referring to the characteristics required for timely detection of any latent weakness:

- Testing
- Trending of performance
- Criteria of acceptability

Identification of the deficiency of the restoration process is carried out by referring to the characteristics required for prompt and relevant correction of any latent weakness:

- analysis of detected latent weaknesses
- determination of improvements
- implementation of improvements

The existence of a deficiency of the plant surveillance programme is due to various contributors which are identified among the following areas:

- management of the detection programme
- management of the restoration process

The various contributors to the deficiency of the plant surveillance programme are usually a combination of human factors under plant management control.
3.4 Determination of corrective actions related to an occurrence

- Corrective actions should aim at addressing all the occurrences of the event sequence.

- The objectives of the corrective actions related to a specific occurrence are:
  
  o to eliminate the actual consequences of the occurrence (damage, etc.)
  
  o to eliminate and prevent reappearance of the latent weakness (direct cause) of the element that failed to perform as expected
  
  o to eliminate and prevent reappearance of the deficiency of the plant surveillance programme (root cause) that failed to eliminate the latent weakness in due time.

- Elimination and prevention of the latent weakness (direct cause) is achieved:
  
  o by restoring the level of quality of the element which failed to perform as expected (personnel, procedure, equipment)
  
  o by preventing reappearance of latent weakness which led to failure to perform as expected through
    + improvement of the quality assurance programme prior to operation, and
    + mitigation of the contributors to degradation of the level of quality during operation.

N.B.: The above corrective actions may provide reasonable assurances that the level of quality required is reached and will be maintained. However, it cannot be ignored that due to unforeseen reasons quality may not reach the level expected prior to operation or may degrade during operation. Safety requires therefore an effective tool of surveillance to timely detect and promptly correct any latent weakness to achieve an effective prevention of incidents at nuclear power plants.
MITIGATION

ELIMINATION OF THE ACTUAL CONSEQUENCES OF THE EVENT

CORRECTION

ELIMINATION OF THE LATENT WEAKNESS
- RESTORATION OF THE LEVEL OF QUALITY OF THE ELEMENT THAT FAILED TO PERFORM AS EXPECTED
- MITIGATION OF THE CONTRIBUTORS TO EXISTENCE OF LATENT WEAKNESS (QUALITY ASSURANCE AND MAINTENANCE)

PREVENTION

ELIMINATION OF THE SURVEILLANCE DEFICIENCY
- ENHANCEMENT OF THE DETECTION PROGRAMME AND RESTORATION PROCESS
- MITIGATION OF THE CONTRIBUTORS TO SURVEILLANCE DEFICIENCY (MANAGEMENT OF THE DETECTION PROGRAMME AND OF THE RESTORATION PROCESS)
Elimination and prevention of the deficiency of the plant surveillance programme (root cause) is achieved:

- by improving the detection programme in order to make it capable of detecting any latent weakness among personnel proficiency, procedure usability and equipment operability
- by improving the restoration process in order to make it capable of implementing appropriate corrective actions
- by preventing reappearance of the deficiency of plant surveillance that led to the non elimination of the latent weakness through
  + improvement of the general surveillance policy related to personnel proficiency, procedure usability and equipment operability, and
  + mitigation of the contributors to ineffective surveillance (detection and restoration) during operation

Selection of areas needing improvements is based on the logic tree including the latent weakness with its contributors and the deficiency of surveillance with its contributors.

Selection of areas needing improvements to eliminate the latent weakness and possibility of recurrence includes all the contributors identified

- to poor preparation prior to operation under plant management control such as recruiting, training, licensing personnel, preparing, validating procedure, maintaining, qualifying equipment.
- to degradation in operation due to management, environmental and ageing conditions.

Selection of areas needing improvements to eliminate the deficiency of the surveillance programme and possibility of recurrence includes all the contributors identified

- to poor management of the detection programme
- to poor management of the restoration process.
Determination of corrective actions aim at enhancing quality of the element which failed and at enhancing surveillance of the quality of this element.

Corrective actions are implemented indifferently in the software or the hardware area.

3.5 Generic lessons

Generic lessons from the event under investigation are drawn in connection with the general policy of prevention of incidents at the plant.

- Good practices that have prevented the event to be worse and that will prevent recurrence of similar events
- Suggestions for enhancement of appropriateness and completeness of corrective actions to prevent recurrence of similar events.

Generic recommendations to the nuclear community are prepared and disseminated to stimulate:

- Elimination of existing latent weakness among personnel, procedure and equipment through more effective surveillance during operation (detection and restoration)
- Prevention of appearance of latent weakness among personnel, procedures and equipment through more effective:
  + preparation prior to operation (quality assurance) and
  + prevention of degradation during operation (maintenance)
### Generic Lessons

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<tr>
<th>IAEA</th>
<th>GENERIC LESSONS</th>
<th>ASSET</th>
</tr>
</thead>
</table>

**Policy of Prevention of Incidents at NPPs**

**Policy of Elimination of Latent Weaknesses Among**
- Personnel
- Procedures
- Equipment

**Surveillance in Operation**
- Detection and Restoration

**Policy of Prevention of Latent Weaknesses Among**
- Personnel
- Procedures
- Equipment
- Preparation Prior to Operation
  - Quality Assurance
- Prevention of Degradation
  - Maintenance
4. SELECTION OF THE OCCURRENCES TO BE ANALYZED WITHIN THE EVENT SEQUENCE

4.1 Objectives

The objectives of this review are:

1) to provide independent identification of the occurrences among the event sequence, that are most significant to safety and should be analyzed in depth.

2) to assess the adequacy of the operating organization's process and results in identifying the most safety significant occurrences.

4.2 Preparatory work

- Collect and review the procedures available at the plant related to identification of occurrences significant to safety (assessment techniques and ranking criteria).

- Collect and review the regulatory body reporting criteria and/or the event severity scale relevant for the considered plant.

- Collect and review the narrative description of the event under investigation.

4.3 Investigations

In order to identify the occurrences most significant to safety which should be submitted to an in-depth review for direct and root causes the following steps should be followed:

- identification of occurrences as reported in the narrative description of the event.

- establishment of the chronological sequence of these occurrences.

- establishment of the logical interdependence of the occurrences by building a logic tree of occurrences.
- assessment of the safety significance of each occurrence.

- selection of the occurrence most significant to safety for further in-depth review.

Note: The assessment of the operating organization's process and results of determining the most safety significant occurrences can be done in parallel with this effort - see section 4.4.

4.3.1 Identification of the occurrences

The starting point of this investigation is the narrative description of the reported event.

At a nuclear power plant, the activities are governed by a work process. According to the ASSET methodology this work process has three basic elements: people, procedures and equipment. If an error arises in the performance of a work process, it can be attributed to one of the two following categories:

(1) equipment failure i.e. an equipment fails to perform as expected during the course of the event under investigation.

(2) inappropriate action also sometimes called personnel error (not be confounded with personnel deficiency) i.e. a person makes an error during the course of the event; this error can be attributed to lack of proficiency of the individual involved or to a deficiency in the procedural guidance related to the task involved; this difference between deficiency of personnel proficiency or deficiency of procedural guidance is already the subject of a more in-depth analysis introducing the search for direct causes and will be addressed in section 5.3.0.

According to the ASSET methodology these errors are called occurrences.

Review the event report and identify errors arising during the course of the event which can be attributed to one of the two abovementioned categories.

List these occurrences according to the sequence of reporting.
4.3.2 Establishment of the chronological sequence of occurrences

The starting point of this investigation is the list of occurrences as identified at the end of section 4.3.1.

The sequence according to which the identified occurrences are reported in the original narrative description of the event, is not necessarily a chronological one.

The establishment of a chronological sequence of occurrences is the first step of analysis of the event under investigation.

Review the event report or any other documentation related to the event for any indication of the chronological sequence of events (e.g. time schedule attached to the occurrences in the course of the event, other time indications in the narrative part of the event report). Review process computer output if necessary and review involved plant staff interview records if available.

Check the obtained chronological sequence of occurrences for logical consistency.
EVENT (INCIDENT OR ACCIDENT)
EXAMPLE OF CHRONOLOGICAL SEQUENCE OF OCCURRENCES

<table>
<thead>
<tr>
<th>Time</th>
<th>Occurrences</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Initial occurrence of the event sequence</td>
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<tr>
<td></td>
<td>Occurrence</td>
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<tr>
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<td>Occurrence relates to reported situation</td>
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<tr>
<td></td>
<td>Occurrence</td>
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<tr>
<td></td>
<td>Occurrence relates to reported situation</td>
</tr>
<tr>
<td></td>
<td>Occurrence relates to reported situation</td>
</tr>
<tr>
<td></td>
<td>Last occurrence of the event sequence</td>
</tr>
</tbody>
</table>

Reportable situation according to reporting criteria
EVENT (INCIDENT OR ACCIDENT)

EXAMPLE OF LOGIC TREE OF OCCURRENCES

Last occurrence

Reportable situation according to reporting criteria

Occurrence

Occupance

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence

Occurrence not related to event

Occurrence not related to event

Initial Occurrence
4.3.3 Establishment of the logic tree of occurrences

The establishment of the logic tree of occurrences, by searching for the logic (causal) interdependence of reported occurrences is the next step of the analysis process. The aim is to force the analyst to think in a logical and structured way when describing the event. This structuring process is helpful when an assessment of the safety significance of occurrences will be made and is essential when this assessment will be done on the basis of Probabilistic Safety Assessment (PSA) (see section 4.3.4).

Consequently the analyst can more easily identify any relevant missing information. The event reports as presented to the ASSET members will not always contain all information necessary for a complete understanding of the event, including the identification of all causal links between the reported occurrences or the identification of underlying occurrences contributing to the present situation (e.g. status of equipment) that are not reported in the event report and related cause analysis reports. This missing information should be obtained by interviews of plant staff, review of relevant plant operation records, review of examination reports of failed equipment, on-site visits of plant systems and equipment, etc.

The starting point of this investigation is the chronological sequence of occurrences as obtained in section 4.3.2. The result is a graphical display of the event as shown in the next figure.

Additional guidance for the establishment of the logic tree of occurrences is provided by the following instructions:

- Review if a logic tree of occurrences is available in the event report.

- Identify the initiating occurrences i.e. those occurrences, for which no other occurrences, leading up to the occurrences under consideration, can be identified.

- Identify logical (causal) interdependence between reported occurrences, respecting chronological sequence, and establish independent branches. Identify in this process the nodes (if any) of the logic event tree:
  
  o where independent occurrences are necessary conditions to lead up to the next occurrence.
or where an occurrence leads up to two or more independent
occurrences.

- Verify that the occurrences range from beginning to end of the event
  sequence.

- Verify that each occurrence is based on valid information.

4.3.4 Assessment of safety significance of the occurrences

General remarks:

The assessment of safety significance of the occurrences within a
reported event sequence is generally a "comparison" of the characteristics of
the observed occurrences with available reference material e.g. Tech. Specs,
operating limits and conditions, regulatory body reporting criteria.

Dependent on the available reference material seven different
"comparisons" are possible and very often questioned (see Fig. 4.3.1).

FIG. 4.3.1. Different options (A to G) for 'comparisons' for the assessment of the safety significance of different
occurrences
A: A qualitative comparison between the occurrences and the Regulatory Body Reporting Criteria or an "Event Severity Evaluation Scale" relevant for the given plant.

B: A qualitative comparison between the occurrences and the plant specific accepted safety standards (e.g. Tech. specs, operational limits and conditions) based on the licensing procedure.

C: A qualitative comparison between the occurrences and the codified international, type specific IAEA safety guides and standards.

D: A quantitative comparison between the occurrences on the basis of risk measures (e.g. core damage frequency, system availability, individual risk) derived from a plant specific Level 1 to 3 Probabilistic Safety Assessment (PSA).

E: A quantitative comparison between the occurrences on the basis of risk measures derived from probabilistic "Safety Goals" or "System Targets").

F: A qualitative comparison between occurrences in different event sequences of the questioned plant, based on the plant specific accepted safety standard.

G: A quantitative comparison between occurrences in different event sequences on the basis of importance measures (e.g. risk achievement worth) calculated in a plant specific PSA.

For practical application three different options for comparisons, namely A, B, and D will be discussed in more detail.

The decision which option should be used is case dependent. If no plant specific PSA is available then the qualitative options A or B must be used. If a PSA is available then the probabilistic approach enables a quantitative assessment in one model and therefore a real importance ranking of different occurrences.

First Option: Assessment of safety significance of the occurrences based on comparison with Regulatory Body Reporting (RBR) Criteria and/or an Event Severity Scale (see Fig. 4.3.1., A).
The RBR-Criteria in the different countries are mainly focused on actual radioactive release, and/or actual failures on safety systems, and/or actual harm to workers or public. In some countries (e.g. Japan, France), there exist activities setting up a so-called Event Severity Scale. In such a multi-dimensional scale a criterion related to the status of the reactor facility is included. If such a scale is used then subjective judgment by an experienced system engineer will be necessary to classify the different occurrences in a given event sequence (e.g. to classify between: an occurrence which does not affect the safety of the reactor facility but may be related to it, and, an occurrence which does not affect the safety of the reactor facility but is related to it). Finally, the scale of classified occurrences answers the question related to the safety significance.

The assessment in this context is a straightforward check of the observed occurrences versus the RBR Criteria.

For assessment of safety significance some important questions are listed below.

- Which criteria and/or scale were used?
- Was an assessment of significance to safety carried out for each of the occurrences?
- Was potential significance to safety considered?

Second Option: Assessment of safety significance of the occurrences based on the plant specific accepted safety standards (see Fig. 4.3.1, B)

If no Event Severity Scale and no plant specific PSA are available then the assessment must be done on the basis of the deterministic licensing procedure represented by design basis accident concept, tech-specs and the operating limits and conditions. In this context, scaling examples are:

- A failure in a safety system is more severe as in a non-safety system.

- Double failures are more severe as a single failure.

- A failure in a Class I component (see ASME-code definition e.g. Reactor Pressure Vessel) is more severe as a failure in a Class II component (e.g. Residual Heat Removal Pump).
A failure of a component (element) involved in the course of a design basis accident is more severe as a failure of a component (element) involved in a no-name sequence.

All these examples are not outcomes of an overall risk model (PSA model) and therefore this procedure has some weaknesses. A typical example for these weaknesses is the first example. From PSA we know today that a failure of one non-safety system (e.g. a ventilation system) is also safety significant if this non-safety system interacts with different safety systems.

For assessment of safety significance some important questions are listed below:

- Was the event sequence similar to a sequence taking into account in the design basis accident evaluation?
- Which tech-specs and/or operational limits and conditions were considered?
- Which additional insights from PSAs were used to assess the significance of the occurrences?
- Do operational limits and conditions address in addition to equipment but also personnel and procedures?
- Was potential significance to safety considered?

**Third Option:** Assessment of safety significance of occurrences based on plant specific PSA insights (see Fig. 4.3.1, D).

For many NPPs (about 80) exist a PSA and in some countries, it is decided to prepare for each plant - as a minimum - a Level 1 study (e.g. FRG, Sweden). Therefore, this approach has a great potential to be in future the leading one for the assessment of safety significance of occurrences.

If a PSA is available for the considered plant then the following tasks are necessary.

- Structuring the event sequence

It is of utmost importance to fully understand the event sequence, including the operation of the systems involved as well as their intended function. A logical structuring of the event sequence is then accomplished in a PSA compatible way, which means the identification of systems and functions
involved and the definition of the initiating event. It is likely that some information is missing from the event report, preventing a thorough listing of logical steps. It is important to recognize that the structuring phase, depending on the event, could go in two ways: towards, identifying the consequences, which is normally done, and in a counter-current manner, backwards, identifying the causes. This is a sort of interface between event tree and fault tree logic (see Fig. 4.3.2).

The typically used logic and definitions in PSA are summarized in Fig. 4.3.2. Initiating events, normally analyzed in PSA, are listed in Table 4.3.1.

- Selection of applicable PSA event trees

If the event being analyzed involves the initiating event (which is usually the case) and the initiating event is being identified in the previous step, then an applicable event tree from the PSA can be selected. Usually each of the PSA event trees covers a number of individual initiating events which are grouped in accordance with the plant response.

There is a possibility that the PSA available for the plant considered does not cover all chains making up the event sequence being analyzed. In that case a reasonable compromise is necessary in choosing an
Table 4.3.1 In PSA typically analyzed event scenarios (event trees)

Initiating Event:

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-break</td>
<td>loss of coolant accident</td>
</tr>
<tr>
<td>Medium-break</td>
<td>loss of coolant accident</td>
</tr>
<tr>
<td>Large-break</td>
<td>loss of coolant accident</td>
</tr>
<tr>
<td>Interfacing system</td>
<td>loss of coolant</td>
</tr>
<tr>
<td>Steam line break</td>
<td></td>
</tr>
<tr>
<td>Feedwater line break</td>
<td></td>
</tr>
<tr>
<td>Loss of off-site power</td>
<td></td>
</tr>
<tr>
<td>Loss of heat sink</td>
<td></td>
</tr>
<tr>
<td>Station black out</td>
<td>&quot;TRANSIENTS&quot;</td>
</tr>
<tr>
<td>Loss of feedwater</td>
<td></td>
</tr>
<tr>
<td>Anticipation transient without scram</td>
<td></td>
</tr>
</tbody>
</table>

Comment: This list can be slightly different in the various PSAs. Additional assumption of a system function failure creates sometimes slightly modified initiating events (e.g. steam line break with steam generator heating tube rupture, loss of coolant via pressurizer relief valves).

Event tree which describes the event sequence as good as possible for assessing the safety significance of occurrences.

- Overlaying the structured event sequence on the selected PSA event tree/fault tree

At this point the failed component(s) (equipment or human) should be located as basic occurrence in the fault trees for the chosen event sequence. In some cases when the component is not found in the pre-established fault trees of the plant specific PSA one can make some reasonable compromise. For example, the faulty element might be an element of a larger component (element) which is included in the PSA.
Quantification of the event sequence

Assumed that the missing information had been provided, it would now be possible to overlay the structured event sequence on the pre-established fault tree(s)/event tree. The probability of the basic occurrences that has really happened are changed to "1" e.g. they are in a failed state during quantification. The result is then a new top event unavailability figure which reflects the plant degradation during the considered event sequence. Based on this quantification, it should be possible to identify which occurrence in the considered event sequence is quantitatively dominant. Such an identification process is normally done by using so-called importance measures (e.g. risk achievement worth, risk reduction worth, Vesely-Fussel importance, Birnbaum importance).

For assessment of the safety significance of the occurrences some important questions are listed below:

- Which PSA-type logic model(s) (e.g. cause-consequence diagram, event tree/fault tree) were used?
- Does this logic model take into account the contribution to risk of all three basic elements: personnel, procedure, equipment?
- Which risk measures were considered:
  o risk of harm to public
  o risk of harm to plant personnel
  o risk of radioactive releases
  o risk of core damage
  o unavailability of a safety function
  o failure probability of an operational system
  o etc.
- If a fully quantitative assessment was done, which importance measures were used:
  o risk achievement worth
  o Fussel-Vesely importance
- If common mode failures were observed, which model was used in the quantitative assessment.

It should be remarked that this assessment method requires sometimes an iterative evaluation process. After identification of direct causes and root causes of the selected occurrences, it can become necessary to update the initial assessment if different assumptions were made.
4.3.5 Selection of the occurrences most significant to safety

The occurrences most significant to safety should be selected on the basis of the assessment above. Some additional questions can support this process.

- Is the selection of the occurrences most significant to safety based on criteria?

- Are there criteria for potential significance to safety?

- Are these criteria quantitative such as thresholds on margin to risk?

- Are these criteria qualitative such as level of severity (gravity scales).

- Are there criteria for actual significance to safety?

- Are these criteria quantitative such as operational limits and conditions?

- Are these criteria qualitative such as reporting criteria?

- Which is the occurrence of the highest potential significance to safety?

- What is the occurrence of the highest actual significance to safety?

- Which is the occurrence of the highest potential and actual significance to safety?

- Which occurrence was selected for in depth analysis?

- Was the occurrence selected for in-depth analysis identified on the basis of the judgement of
  o the analyst
  o the plant safety committee
  o the plant management
  o the safety authority
On which criteria was based the judgement which led to the selection
- Impact on environment (death, injury, irradiation)
- Uncontrolled radioactive releases (I-131, gas and aerosols, liquids)
- Core melting (fuel element)
- Loss of safety functions (reactor shutdown, cooling of fuel, confinement)
- Loss of support functions (off-site power, on-site power, cooling water, instrumentation)
- Significant degradation of a safety system
- Violation of operational limits and conditions (Tech. Specs).
- Degradation of fuel cladding
- Degradation of reactor coolant boundary
- Common cause or common mode failures
- Unforeseen system interaction
- Others

4.4 Conclusions on the process of selection of the occurrences to be analyzed

Was the occurrence or the combination of the highest actual and potential significance to safety selected by the operating organization for in-depth analysis?

If the answer is not fully affirmative, what could have enhanced the effectiveness of the selection process?

- Better identification of all occurrences involved in the event through the establishment of thorough chronological sequence of occurrences.
- Better understanding of the interconnection between occurrences through the establishment of a detailed logic tree of occurrences.
- Quantitative assessment of both potential and actual significance to safety through a probabilistic approach evaluating margins to risk of occurrence of unacceptable situations.
- Precise selection through the use of quantitative criteria for ranking the significance to safety.

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5. IDENTIFICATION OF THE DIRECT CAUSE OF AN OCCURRENCE

5.1 Objectives

The objectives of the review are:

1) to provide independent identification of the direct cause of the occurrence, and

2) to assess the adequacy of the process for identifying the direct cause, as already performed at the nuclear power plant.

5.2 Preparatory work

For each selected occurrence to be investigated:

- collect and review all available documentation at the plant which can help in identifying the direct cause of the occurrence (operating and maintenance logs, drawing charts, process computer outputs, applicable administrative and task oriented procedures, work authorization documents, quality assurance manual and quality assurance procedures, personnel records, inspection records, material evidence etc.)

- collect and review all available plant procedures and analysis reports that deal with the identification of the direct cause of the occurrence

- collect list of plant personnel to be interviewed at the plant in connection with the occurrence

- collect and review past history of the plant to identify any precursors or contributors to this occurrence (equipment failure history records, incident records and analysis reports, etc.).
5.3 Investigations

For each occurrence selected for in-depth review, the following should be investigated:

- the nature of the occurrence
- the latent weakness which directly caused the deficiency
- the contributors to the existence of the latent weakness.

According to the determination of the nature of the occurrence made in section [5.3.0] methodology described in the following sections should be used:

5.3.1 Equipment deficiency
5.3.2 Personnel deficiency
5.3.3 Procedural guidance deficiency

5.3.0 Identification of the nature of the occurrence

At a nuclear power plant, the activities are governed by a work process. According to the ASSET methodology, this work process has three basic elements: people, procedures and equipment. If an error arises in the performance of a work process, the reason for that error must be a deficiency in one, or several of these basic elements.

The idea of the ASSET methodology is to break up the event under investigation in logically connected occurrences which can each be attributed to a single failure of one out of those three basic elements. The nature of the occurrence, which was selected for in-depth investigation, is determined in accordance to the basic element of the work process that failed. The identification of this nature is the starting point for the investigation process of the direct cause of the occurrence.

To help the investigator in this identification process, a flowchart is provided which guides the reviewer in following an elimination process. Additional guidance at each step of this elimination process is given in sections 5.3.0.1 to 5.3.0.3 which should support and confirm the result of this process. The investigator should be aware that the proper identification of the real nature of the occurrence can be an iterative process. Further in-depth investigation of the weak aspects of the basic elements considered,
as performed in section 5.3.1, 5.3.2 or 5.3.3, could induce the investigator to reconsider the initially chosen nature according to this section.

5.3.0.1 Identification of operability of the equipment

To investigate the operability of the equipment involved at the time of the event, data from all available sources should be gathered and reviewed.

- Interview plant operators involved with the occurrence and have them provide their observations regarding the behaviour of the equipment before, during and after the event.
- Review all plant data and identify those that could provide insight to the equipments' behaviour (for example annunciator points, computer inputs, operator's logs, recorder data, sequence of events, etc.).

- Also review the operating organization's report for the observed failure they have identified.

- Personally inspect the failed equipment, if available. When possible, inspect the location where the equipment operated in order to assimilate the operating surroundings of the equipment. View photographs and other pertinent data of the failed equipment.

5.3.0.2 Identification of the nature of the inappropriate action

If no evidence for an equipment failure can be found according to section 5.3.0.1, attention should be turned to the possibility of the involvement of an inappropriate action. This inappropriate action could be of a double nature: a performance error was committed due to the inadequacy of the procedural guidance involved, or the procedures were adequate but the individual involved made nonetheless a mistake (incorrect action or error in judgement). Guidance to the initial assessment of procedural guidance adequacy is given in section 5.3.0.3. This section helps the investigator to look for the involvement of a pure personnel deficiency. In this respect the following classification should help, which is illustrated by some non exclusive examples:

- training deficiency
  - failing to detect situation
  - misinterpreting or improper diagnosis
  - making inadequate decisions
  - inadvertent operation of manual control
  - selecting wrong controls

- procedure non compliance
  - failing to use procedure
  - failing to follow procedure
  - omitting steps or substeps in procedure
  - taking action not required by procedure
- failing to respect operational rules or limits
- failing to respect technical specifications
- failing to follow maintenance work request
- taking two actions at the same time

- lapse of mental attention
- forgetting to take action
- a correct action on wrong equipment
- a correct action performed at the wrong time
- using wrong procedure

To investigate personnel deficiency involvement at the time of the inappropriate action, data from all available sources should be gathered and reviewed.

- interview plant personnel involved with the occurrence and have them provide their observations regarding the sequence of events
- review all plant data and identify those that could provide insight into the nature of the considered inappropriate action (involved plant procedure, sequence of events, etc.)
- review the operating organization's report for the observed personnel deficiencies they have discovered.

5.3.0.3 Identification of adequacy of procedural guidance

To investigate the adequacy of procedural guidance at the time of the inappropriate action, data from all available sources should be gathered and reviewed.

- interview plant operators involved with the occurrence and have them provide their observations regarding the adequacy of guidance provided by the concerned procedure(s).
- review all plant data and identify those that could provide insight to the nature of appliance and the adequacy of the procedural guidance (for example: verify check off of involved procedures, review frequency of procedure revisions, computer inputs, operator's logs, recorder data, sequence of events, etc.).
- also review the operating organization's report for the observed procedure deficiencies they have identified.

- review the organization of operating and administrative procedures at the plant. Locate the procedures under investigation in this organization.

5.3.1 Identification of the direct cause of an equipment deficiency

When it is determined (in accordance with section 5.3.0) that the occurrence involved an equipment deficiency, the following should be considered in the process of identifying the direct cause of the deficiency:

1. The latent weakness in the operation of the equipment that led to its failure to perform as expected.

2. The contributors to the existence of this weakness.

Note: The assessment of the operating organization's process and results of determining the direct cause of the occurrence can be done in parallel with this effort - Section 5.4.

5.3.1.1 Identification of Equipment Latent Weakness

The starting point is the observed failure of the equipment. From there, proceed to find the true latent weakness that caused the failure by identifying the weak aspects of equipment operability.

5.3.1.1.1 Basic characteristics of equipment operability

For the purpose of systematic investigation of the equipment operability and the process of identification of the direct and root causes of the observed equipment failure, the following basic characteristics of equipment operability should be analyzed.

A. Reliability
   A1. Availability
   A2. Endurance
   A3. Performance limitations
<table>
<thead>
<tr>
<th>IAEA</th>
<th>DIRECT CAUSE OF AN EQUIPMENT DEFICIENCY</th>
<th>ASSET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OCCURRENCE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROOT CAUSE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DIRECT CAUSE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEAKNESSES OF EQUIPMENT OPERABILITY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTRIBUTORS TO THE EXISTENCE OF A WEAKNESS IN EQUIPMENT OPERABILITY</td>
<td></td>
</tr>
</tbody>
</table>

**Failure of Equipment to Perform as Expected**

**Ineffective Surveillance of Equipment Operability**

**Latent Weakness in Equipment Operability**

**Inadequate Reliability**
- Availability
- Endurance
- Performance Limitations

**Inadequate Working Conditions**
- Operational and Control Mode
- Auxiliary and Support System Conditions
- Environmental Conditions

**Inadequate Function Qualification**
- Installation and Maintenance
- Manufacturing and Storage
- Design

**Degradation of Operability During Operation**
- Degradation of Reliability
- Degradation of Working Conditions
- Degradation of Qualification

**Inadequate Preparation of Equipment Prior to Operation**
- Uncomprehensive Verification of Operability
- Inadequate Operability Criteria
- Ineffective Restoration of Operability
B. Working conditions
   B1. Operational and control mode
   B2. Auxiliary and support system conditions
   B3. Environmental conditions

C. Function qualification
   C1. Installation and Maintenance
   C2. Manufacturing and storage
   C3. Design

5.3.1.1.2 Weak aspects of equipment operability

Proceed to identify the equipment weaknesses that led to its failure by reviewing for inadequacies in all aspects of equipment operability related to the basic characteristics as summarized in section 5.3.1.1.1.

For this purpose review documentation and perform interviews of plant staff as specified in section 5.2 and 5.3.0.1. Additional guidance is provided by the following instructions.

A. Reliability of the equipment

A1. Availability
   - Check past history of the equipment from operation logs, maintenance records and surveillance test data to determine its past availability and reliability.

A2. Endurance
   - Check equipment data (e.g. operation records, maintenance data, inspection records, etc.) for any trends to indicate degradation in performance due to aging, change in operation or maintenance programs, inadequacies in installation, modification or design, etc.

A3. Performance limitations
   - Check equipment specifications against actual data to determine whether the equipment operated beyond specifications or rating and how these affected the reliability (e.g. environmental conditions, loading conditions like flow rates, pressure ranges, voltage, amperes, temperature, etc., auxiliary and support system conditions like cooling water flow, lube oil temperatures and pressures, instrument air pressure, etc.).
B. Working conditions of the equipment

- Review operation logs and other data related to the equipment to identify from recent operational history any inadequacies in its operational history.

B1. Operational and control mode

- operational mode (e.g. continuous operation, standby operation, frequent starts, returned from a maintenance outage, etc.)
- control mode (e.g. auto or manual, local or remote, test and restoration from test, etc.)

B2. Auxiliary and support system conditions

- Review behaviour of HVAC, cooling water, electric power, instrument air, lube oil and lube oil cooling systems, instrument and control power, and other relevant systems that could interact with the failed equipment.

B3. Environmental conditions (e.g. - ambient temperature, humidity)

C. Function qualification of the equipment

Cl. Installation and maintenance

- Review available equipment documentation related to its installation to identify any inadequacies in this area like
  - incorrect installation (e.g. valves in reverse direction, pumps in reverse rotation, equipment incorrectly bolted down, insufficient bracing of pipes, etc.)
  - interference with other equipment (e.g. valve stem leak impinging on cables, vibration affecting instrument piping, etc.)

- Review available equipment documentation related to its maintenance to identify any inadequacies in this area like
  - inadequate maintenance procedure
  - inadequate post-maintenance test
  - incorrect maintenance
C2. Manufacturing and storage

- Review available equipment documentation related to its manufacturing to identify any inadequacies like
  - incompatibility (e.g. heat exchange tube compatibility with salt water, etc.)
  - deficiency in quality assurance at manufacture (e.g. defective component)

- Review available equipment documentation related to its storage in the spare part shop at the plant, if applicable, to identify any inadequacies like storage condition not in accordance with related manufacture specifications.

C3. Design

- Review available equipment documentation related to its design in order to verify
  - adequacy of design specifications when compared to actual operation requirements of capacity, flow, voltage, amperes, pressure temperature, etc. (i.e. is the equipment the right one for the job?)
  - compatibility of design requirements with actual working conditions like modes of operation (frequent starts, intermittent operation, low flow operation, frequent testing, etc.), environment (ambient temperature ranges), and auxiliary support system (cooling water temperature and flow variations, on system conditions, etc.)
  - reliability (is the required reliability achievable by design?)

5.3.1.1.3 Conclusions on the latent weakness of the equipment

Note: If no weak aspects were identified for the equipment involved please reconsider the nature of the occurrence.

As a result of completing the review according to sections 5.3.0.1 and 5.3.1.1.2, the involvement of equipment failure can be confirmed and the weak aspects of equipment operability can be determined.
If more than one weak aspect is identified, then consider a relative weight (based on engineering judgement) for each weak aspect according to its contribution to the failure.

Based on the combination of these weighted weak aspects, establish the latent weakness in equipment operability.

5.3.1.2 Identification of the contributors to the latent weakness in equipment operability

The starting point of this investigation is the latent weakness identified at the conclusion of the review done in accordance with section 5.3.1.1. The end result of this review will be to establish the direct cause of the equipment failure based on the review of the following contributors to the latent weakness:

- inadequate preparation of the equipment for operation
- degradation of the equipment during operation.

5.3.1.2.1 Inadequate preparation of the equipment for operation

- Review all the contributors that affect operability of the equipment prior to its operation. Identify inadequacies in the following areas:

  - Verification of the equipment operability
  - Detection of discrepancies in the equipment operability
  - Correction of detected discrepancies

5.3.1.2.1.1 Inadequacies in verification of operability of the equipment

- Verify that records are available at the plant proving that the equipment passed successfully the test of operability prior to operation.

- Review those records and verify that the demonstration of operability deals with the basic characteristics of equipment operability as specified in section 5.3.1.1.1.
- Review the content of each specific test data regarding the weak aspects identified in operability of the equipment involved (section 5.3.1.1.2) and verify its adequacy.

5.3.1.2.1.2 Inadequacies in detection of discrepancies in equipment operability

- Verify that criteria are available at the plant to detect possible discrepancies in equipment operability prior to operation.

- Review the list and definition of the criteria related to the weak aspects identified in operability of the equipment (section 5.3.1.1.2).

  o Are the criteria adequate to ensure readiness for operation?

  o Were any discrepancies detected in the operability of the equipment involved? If so, were they forwarded to the correction process?

5.3.1.2.1.3 Inadequacies in the correction of discrepancies detected in the operability of the equipment

- Verify that procedures are available at the plant that provide guidance on correction of discrepancies detected in equipment operability.

- Review these procedures and review specifically the proposed actions undertaken regarding the weak aspects identified in operability of the equipment (section 5.3.1.1.2).

- Verify that those actions are appropriate and complete to ensure operability of the equipment.
5.3.1.2.2 Degradation of operability of the equipment during operation

Review the unforeseen contributors that might degrade operability of the equipment involved. The contributors to be considered are in the area of

- Reliability of the equipment
- Working conditions of the equipment
- Function qualification of the equipment

Concentrate your effort according to the weak aspects identified in section 5.3.1.1.2.

Note: The intent here is to look for contributors which may not have been considered in the original design and operation of the equipment.

Review equipment history records and modification records, applicable operation, testing and maintenance procedures, staff history records if necessary. Review successive procedure versions. Interview plant staff on this matter.

5.3.1.2.2.1 Degradation of reliability of the equipment

- Were there any changes in operation, testing, or corrective maintenance activities that could have affected the availability, endurance, or performance of the equipment?

5.3.1.2.2.2 Degradation of working conditions of the equipment

- Were there any changes in operating procedures or personnel training that could have affected the operational mode of the equipment (e.g. continuous operation, standby, emergency operation, etc.)?

- Were there any changes in the equipment environmental conditions that contributed to degradation of the equipment during operation?

- Were there any changes in the equipments auxiliary support system conditions that could have affected equipment operation (e.g. HVAC, cooling water, tube oil, electric power, instrument air, etc.)?
5.3.1.2.2.3 Degradation of function qualification of the equipment

- Were there any adjustments or modifications that affected the installation of the equipment?

- Was the manufacturing of the equipment affected by any modification, like spare parts, specification change, etc.?

- Was the design of the equipment affected by any modifications of the equipment, its operation or testing?

5.3.1.2.3 Conclusion on the contributors to the latent weakness in equipment operability

As a result of completing the review according to section 5.3.1.2.1 and 5.3.1.2.2, the contributors to the latent weakness in the equipment operability can be determined.

- List the contributors to inadequate preparation of the equipment for operation.

- List the contributors to the degradation of equipment operability during operation.

- Consider a relative weight (based on engineering judgement) to each contributor.

5.3.1.3 Determination of the direct cause of the occurrence

Logically combine the findings of the latent weakness (conclusions in 5.3.1.1.3) and of the contributors to the latent weakness (conclusions in 5.3.1.2.3), to establish the direct cause of the occurrence.

5.3.2 Identification of the direct cause of a personnel deficiency

When it is considered (in accordance with section 5.3.0) that the occurrence involved is a personnel deficiency, the following should be considered in the process of identifying the direct cause of this deficiency:

1) the latent weakness in the proficiency of the individual leading to the inappropriate action.
the contributors to the existence of this weakness.

Note: The assessment of the operating organization's process and results of determining the direct cause of the occurrence can be done in parallel with this effort (see section 5.4).

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5.3.2.1 Identification of the latent weakness of personnel proficiency

The starting point is the observed inappropriate action for which a lack of personnel proficiency has been determined (or is suspected). From there, proceed to find the true latent weakness that caused the inappropriate action by identifying the weak aspects of the proficiency of the individual(s) involved.

5.3.2.1.1 Basic characteristics of the individual proficiency

For the purpose of the systematic investigation of the individual proficiency at work and the process of identification of the direct and root causes for the evolving inappropriate action taken by the individual, the following basic characteristics of proficiency should be analyzed.

A. Reliability at work
   A1. Vigilance
   A2. Endurance
   A3. Self capabilities awareness

B. Fitness for duty
   B1. Attitude toward job, task or procedures
   B2. Psychological aptitude
   B3. Physiological aptitude

C. Qualification to perform the task
   C1. Competence
   C2. Training
   C3. Educational background

5.3.2.1.2 Weak aspects of personnel proficiency

Proceed to identify the weak aspects of the proficiency of the individual(s) involved at the time of the inappropriate action. This can be done by reviewing for inadequacies in all aspects related to the basic characteristics as summarized in section 5.3.2.1.1. For this purpose review
documentation and perform interviews of plant staff as specified in sections 5.2 and 5.3.0.2. Additional guidance is provided by the following instructions.

A. Reliability at work

A1. Vigilance

- Check that appropriate attention was given by the operator to the situation in progress during the execution of the task involved. Verify that his attention was not distorted by other actions in progress.

- Check that the operator had the plant safety objectives in mind.

- Verify that the operator was conscious of the importance of his actions.

- Verify that operator's vigilance was not affected by too frequent execution of the same task.

A2. Endurance

- Verify that the performance of the operator was not affected by one of the following elements

  o unusual tiredness
  o excessive workload
  o specific stress conditions

A3. Self Capabilities awareness

- Verify that quality of task performance was not affected by the operator

  o being unconscious of his capabilities or limits
  o relying too much on the control of his supervisors or colleagues
  o underestimating the difficulty of the task involved
Analyze the situation and tasks involved, at the time of the inappropriate action, and interview involved plant personnel to judge on abovementioned aspects.

B. **Fitness for duty**

B1. **Attitude toward job, task or procedures**

- Verify that operator performance was not affected by a general lack of interest toward his job (i.e. considering his job uninteresting, boring, not essential for successful plant operation or feeling himself too frequently supervised without apparent reasons).

- Verify that the quality of task performance was not infirmed by a specific operator attitude aspect towards the task involved (i.e. operator considering the task unnecessary, boring, requested at an improper time, causing personnel inconveniences, suggesting a loss of status, insensitive, etc.).

- Verify that the attitude of the involved operator toward the applicable procedure, guiding him in the execution of his tasks, was appropriate (i.e. check that the operator did not consider the procedure to be inadequate, not helpful, not necessary, not to be used strictly, too specific, not specific enough, etc.

B2. **Psychological aptitude**

- Verify if psychological factors in the behaviour of the individual involved could have affected the adequate execution of his tasks.

Was the operator
- particularly stressed
- reacting emotionally to the situation
- having personal relationship difficulties
- nervous in performing specific actions due to latent fear of inadequate performance.
B3. Physiological aptitude

- Check the physiological conditions of the individual involved at the time of the inappropriate action, if possible (i.e. health, use of medications, use of drugs or alcohol, etc.).

Interview the individual involved and his supervisors on his attitudes. Review personnel records, if available or accessible, and interview his supervisors and colleagues on matters of psychological and physiological aptitudes.

C. Qualification to perform the task

C1. Competence

- Verify that the individual involved was formally qualified for the task under consideration. Check appropriate proficiency examination before task assignment.

- Verify that the individual involved was aware of the potential consequences of his inappropriate action.

C2. Training

- Verify that the individual involved was appropriately trained and retrained for the specific task under consideration.

- Verify that the operator was aware of requirements concerning specific tools and procedures to use in performing the task. Did training also include use of plant administration procedures?

- Check if the operator was aware of the steps to be taken to verify proper task completion.

C3. Educational background

- Verify that basic education of the individual involved was suitable for the job and tasks assigned to him.
- Verify that the individual had been properly educated in understanding safety aspects of nuclear power plant operation.

- Verify that the individual had a sufficient general knowledge of nuclear power plant operation and basic nuclear technology.

- Verify that the individual had a good understanding of basic physical phenomena.

Consider the task involved and review personnel history records (basic education data, training and retraining programmes, implementation and performance).

5.3.2.1.3 Conclusions on the latent weakness in personnel proficiency

Note: If no weak aspects were identified in personnel proficiency, please reconsider the nature of the occurrence.

As a result of completing the review according to sections 5.3.0.2 and 5.3.2.1.2, the nature of the inappropriate action can be confirmed and the weak aspects of personnel proficiency can be determined.

- If more than one weak aspect is identified, then consider relative weight (based on engineering judgement) for each weak aspect according to its contribution to the inappropriate action.

- Based on the combination of these weighted weak aspects establish the latent weakness in the proficiency of the individual(s) involved.

5.3.2.2 Identification of the contributors to the latent weakness in personnel proficiency

The starting point of this investigation is the latent weakness identified at the conclusion of the review done in accordance with section 5.3.2.1. The end result of this review will be to establish the direct cause
of the inappropriate action based on the identified latent weakness and the review of the following contributors to the latent weakness:

- inadequate preparation of personnel prior to job assignment.
- degradation of the proficiency of personnel during employment.

5.3.2.2.1 Inadequate preparation of personnel prior to job assignment

Review all contributors that affect proficiency of personnel prior to job assignment. Identify inadequacies in the following areas:

- Verification of proficiency of personnel
- Detection of discrepancies in the proficiency of personnel
- Correction of detected discrepancies.

5.3.2.2.1.1 Inadequacies in verification of the proficiency of personnel

- Verify that records are available at the plant demonstrating proficiency of personnel prior to job assignment.

- Review those records and verify that the demonstration of proficiency deals with all basic characteristics of personnel proficiency as specified in section 5.3.2.1.1.

- Review the content of each specific test regarding the weak aspects identified in the proficiency of the individual involved (section 5.3.2.1.2) and verify its adequacy.

5.3.2.2.1.2 Inadequacies in detection of discrepancies in personnel proficiency

- Verify that criteria are available at the plant to detect possible discrepancies in proficiency of personnel prior to job assignment.
- Review the list and definition of the criteria related to the weak aspects of the proficiency of the individual involved as identified in section 5.3.2.1.2.

  o Are the criteria adequate to ensure sufficient proficiency before assignment to the tasks under consideration.

  o Were any discrepancies detected in the proficiency of the individual(s) involved? If so, were they forwarded to the correction process?

5.3.2.2.1.3 **Inadequacies in the correction of discrepancies detected in the proficiency of personnel prior to job assignment**

- Verify that procedures are available at the plant that provide guidance on correction of discrepancies in the proficiency of personnel.

- Review these procedures and review specifically the proposed actions regarding the weak aspects identified in the proficiency of the individual(s) involved (section 5.3.2.1.2). Verify that those actions are appropriate and complete to ensure proficiency of the individual(s) involved.

5.3.2.2.2 **Degradation of the proficiency of personnel during employment**

Review unforseen contributors that might have degraded the proficiency of the individual(s) involved. The contributors to be considered should relate to the following areas:

- Reliability at work
- Fitness for duty
- Qualification to perform the task.

Concentrate your effort according to the weak aspects identified in section 5.3.2.1.2.

**Note:** The intent here is to look for contributing factors which may not have been considered at the time of initial job assignment of the individual involved.
Review staff history records (such as regular medical reports and psychological tests, if available and accessible), retraining programmes and their implementation, work environment measurements. Interview plant staff on this matter.

5.3.2.2.2.1 Degradation of reliability at work

- Verify if there were any factors such as task duration, evolution in the number of tasks assigned to the individual, number of tasks to be performed at the same time, degradation of motivation to meet plant safety objectives, that could have affected the vigilance of the involved individual(s).

- Verify if there were any factors such as continuous fatigue (due to excessive workload or other reasons), change in work organization, task rescheduling or changes in work environment that could have affected the endurance of the individual(s) involved.

- Verify if there were any factors such as buildup of over-confidence, a general tendency to omit to detect alarms or to respond to alarms that could have affected the awareness of limited personal capabilities by the individual(s) involved.

5.3.2.2.2.2 Degradation of fitness for duty

- Verify if there were any factors such as degradation of motivation, duration of the same job assignment, work reorganization or rescheduling, over-confidence buildup, complacency, that could have affected the attitudes of the individual(s) involved toward job, task or procedures.

- Verify if there were any factors such as work reorganization or work rescheduling inducing insecurity (e.g. unsuccessful adaptation to introduced team work) or stress (e.g. due to work overload), communication problems with other shift personnel, appearance of social environment problems, or general loss of self-confidence for any reason, that could have affected the psychological aptitude of the individual involved to the assigned tasks.
- Verify if there were any factors such as changes in physical environment (i.e. illumination, temperature, humidity, noise, vibration, radiation, number of people in the working area; need to use respiratory equipment, anti-contamination clothing, industrial safety equipment), changes in shift - duties cycle, illnesses showing-up after initial job assignment, that could have affected the physiological aptitude of the individual involved to the assigned tasks.

5.3.2.2.2.3 Degradation of qualification to perform the task

- Verify if any factors such as task assignment, reorganization, inadequate frequency of retraining programmes, changes in social behaviour (e.g. use of alcohol, drugs), could have affected the competence of the individual involved.

- Verify that any factors such as changes in equipment, procedures, tools not properly taken into consideration in the updating process of retraining programmes could have affected the efficiency of training and retraining of the individual(s) involved.

- Verify that any factors such as introduction of new technology, lack of retraining in basic knowledge, could have affected the adequacy of the educational background of the individual(s) involved.

5.3.2.2.3 Conclusion on the contributors to the latent weakness in personnel proficiency

As as result of completing the review according to sections 5.3.2.2.1 and 5.3.2.2.2 the contributors to the latent weakness in personnel proficiency can be determined.

- List the contributors to inadequate preparation of personnel prior to job assignment.

- List the contributors to the degradation of the proficiency of personnel during employment.
- Consider a relative weight (based on engineering judgement) to each contributor.

5.3.2.3 Determination of the direct cause of the occurrence

Logically combine the findings of the latent weakness (conclusions in 5.3.2.1.3) and of the contributors to the latent weakness (conclusions in 5.3.2.2.3), to establish the direct cause of the occurrence.

5.3.3 Identification of the direct cause of a procedural guidance deficiency

When it is determined (in accordance with section [5.3.0]) that the occurrence involved is a procedural guidance deficiency, the following should be considered in the process of identifying the direct cause of this deficiency:

1) the latent weakness of the guidance provided by the procedure leading to the inappropriate action

2) the contributors to the existence of this weakness.

Note: The assessment of the operating organizations process and results of determining the direct cause of the occurrence can be done in parallel with this effort - see section 5.4.

5.3.3.1 Identification of the latent weakness of procedural guidance

The starting point is the observed inappropriate action for which a lack of adequate procedural guidance has been determined (or is suspected). From there, proceed to find the true latent weakness that caused the inappropriate action by identifying the weak aspects of the guidance provided by the applicable procedure(s).
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5.3.3.1.1 Basic characteristics of the procedural guidance

For the purpose of the systematic investigation of the procedural guidance efficiency and the process of identification of the direct and root causes for the evolving inappropriate action, the following basic characteristics of procedural guidance efficiency should be analyzed.

A. Reliability in appliance

A1) Availability to the intended user
A2) Up-to-date assurance
A3) Scope limitations

B. Adaptation to working conditions

B1. Utilization mode
B2. Ergonomy
B3. Environment adaptation

C. Task qualification

C1. Task orientation
C2. Adequacy of content
C3. Background support

5.3.3.1.2 Weak aspects of procedural guidance

Proceed to identify the weak aspects of the guidance provided by procedures at the time of the inappropriate action. This can be done by reviewing for inadequacies in all aspects related to the basic characteristics as summarized in section 5.3.3.1.1. For this purpose review documentation and perform interviews of plant staff as specified in sections 5.2 and 5.3.0.3. Additional guidance is provided by the following instructions.

A. Reliability in appliance

A1. Availability to the intended user

Consider the complexity of the task involved and verify the nature of the procedure available to execute this task (written
or verbally communicated instructions). Is this nature in accordance to the observed complexity?

- Verify that the procedure was accessible to the intended user and clearly identified by the work authorization permit or other document.

- Verify that the applicable procedure was effectively used to perform the task.

- Verify appropriate identification information on each page of the procedure and appropriate identification of the last page.

A2. **Up-to-date assurance**

- Consider the task involved and verify the adequacy of the type of procedure to execute the task (permanent procedure, procedure established specifically for the task or temporary procedure).

- Check that no outdated procedure was used to perform the task. Review document control policies at the plant in this respect (is an up-to-date index of procedures available at the plant?).

- Verify that the procedure was recently reviewed (verified and validated). Check approval status of the procedure.

A3. **Scope limitations**

- Check presence of a clear statement on the purpose for which the procedure or instruction is intended.

- Verify that the procedure or work order clearly describes the scope of work, the boundaries of the work area, access to the work area and particular safety hazards to be avoided.

- Check presence of a clear statement on the applicability of the procedure (depending on plant status).
- Check presence of indications in the procedure of the personnel qualification needed to perform the task.

Review the document control policies at the plant.

Review the Quality Assurance manual and consistency with Quality Assurance procedures in this respect, if necessary.

Review the concerned procedure(s) with respect to the abovementioned characteristics.

Analyze the tasks to be performed, in which the inappropriate action occurred and interview involved plant personnel to judge on the adequacy of nature and type of the available procedure.

B. Adaptation to working conditions

B.1 Utilization mode

Review the procedure and verify that it was adequately designed to be used in the working conditions at the time of the event:

- Check that the procedure provides the necessary job planning information (prior action or procedures to be executed; plant, system or equipment conditions which must exist prior to use; precautions to be observed; the specific equipment to which the procedure is applicable; special tools and test equipment required; other documents required).

- Check that the procedure and user aids as well as indicated communication equipment, instrumentation and tools were adequate and adapted to the operating conditions encountered at the time of the event.

- Analyze the complexity of the tasks involved and verify if the procedure was written in accordance to this complexity, and adapted to the level of staff training.
Verify the adequacy of the communication means as specified by
the procedure, in order to coordinate the activities if two or
more persons are required to perform the procedure or monitor
instrumentation or alarms.

Verify the legibility of the used procedure (poor copy) at the
time of the event.

Verify that graphs, charts, tables and data sheets were
adequate for readability and interpolation or extraction of
values if applicable.

Verify that worksheets are designed to facilitate required
computations if applicable.

Verify that proper attention is paid in the procedure to
aspects such as operability of redundant safety systems,
requalification of affected safety related systems when
returned to service, proper permission from shift supervisor to
defeat or test safety systems.

Verify appropriate procedure identification information
(procedure title, revision number, page numbering).

B2. Ergonomy

Review the procedure and verify that its presentation and content is
adequate to induce clear understanding and effective performance:

- Verify the adequacy of the format of the procedure
  (e.g. quick location of desired information, clear mechanism
  for conveying information and instructions)

- Verify the adequacy of reference and branching (including
  assessment of risk overlooking important information such as
  notes and cautions).

- Verify that instructions are written in short, concise,
  identifiable steps instead of into multiple step paragraphs.
- Verify absence of unclear or complex wording or grammar.

- Verify that presented symbols in the procedure are commonly used and were understandable to the intended user.

- Verify that necessary graphs, charts, tables and illustrations were provided and properly integrated into the procedure.

- Verify the provision of acceptance criteria and necessary formulas for calculation on data and work sheets.

- Verify that the expression of setpoint tolerance did not require performance of mental calculations.

- Verify that when quantitative acceptance criteria are used, they are stated as a range and not as a point value.

B3. Environment adaptation

Check on the material aspects of the concerned procedures, support equipment, instrumentation and tools and verify their appropriateness for the use made of them, taking into consideration all aspects of the environmental condition at the working place. When possible, inspect the location where the inappropriate action took place in order to assimilate the operating surroundings.

C. Task qualification

Cl. Task orientation

Review the procedure and analyze the task involved and verify the adequacy of the procedure to guide effectively personnel in performing this task:

- Verify that separate instructions are provided.

- Verify that instructions were presented in the same sequence as the task was to be performed.
- Verify that cautionary and supplemental information was presented prior to applicable instructions.

- Verify that conditional logic words preceded the required action.

- Verify adequacy of alignment instructions when applicable (item specification and identification, position specification and verification).

- Verify the level of specificity of the procedure by reviewing the specificity of required actions, the quantification of limits and verifying that equipment or parts are completely identified.

- Verify that check-off features of successive steps are provided in the procedure.

C2. Adequacy of content

Review the procedure, Technical Specifications and other applicable reference documents and verify if the content of the procedures was technically appropriate:

- Check for inconsistencies with reference documents (other procedures, Technical Specifications, vendor manuals and recommendations, FSAR, etc.).

- Check for presence of technical inaccuracies. Check that acceptance criteria and limits are stated in quantitative terms.

- Check if relevant information was omitted such as references (drawings and other design documents, operational limits and conditions), prerequisites and precautions.

- Check that the procedure was sufficiently detailed so that the intended user could perform the procedure without obtaining additional information from persons or documents not specified by the procedure, or without obtaining direct assistance from persons not specified by the procedure.
- Verify appropriate instructions for follow-on actions upon the completion of this procedure, if applicable.

- Verify that the procedure provides instructions for reasonable contingencies (e.g. actions to take in case of out of range operation of equipment).

C3. Background support

Review the procedure and background documents and verify the consistency of the procedure with those background documents that provide the technical justifications of the process followed in performing the intended task.

5.3.3.1.3 Conclusions on the latent weakness in procedural guidance

Note: If no weak aspects were identified in procedural guidance, please reconsider the nature of the occurrence.

As a result of completing the review according to sections 5.3.0.3 and 5.3.3.1.2, the nature of the inappropriate action can be confirmed and the weak aspects of procedural guidance can be determined.

- If more than one weak aspect is identified, then consider relative weight (based on engineering judgement) for each weak aspect according to its contribution to the inappropriate action.

- Based on the combination of these weighted weak aspects, establish the latent weakness in the procedural guidance.

5.3.3.2 Identification of the contributors to the latent weakness in procedural guidance

The starting point of this investigation is the latent weakness identified at the conclusion of the review done in accordance with section 5.3.3.1. The end result of this review will be to establish the direct cause of the inappropriate action based on the identified latent weakness and the review of the following contributors to the latent weakness:

- inadequate preparation of the procedure prior to appliance in operation.
degradation of procedural guidance during operation.

5.3.3.2.1 Inadequate preparation of the procedure prior to appliance in operation

Review all contributors that affect efficiency of the procedural guidance prior to its operation. Identify inadequacies in the following areas:

- Verification of the procedural guidance [efficiency]
- Detection of discrepancies in the procedural guidance efficiency
- Correction of detected discrepancies.

5.3.3.2.1.1 Inadequacies in verification of the efficiency of the procedural guidance

- Verify that records are available at the plant demonstrating the [efficiency] of the procedure prior to appliance in operation

- Review those records and verify that the demonstration of efficiency deals with all basic characteristics of the procedural guidance as specified in section 5.3.3.1.1

- Review the content of each specific test regarding the weak aspects identified in the procedural guidance (section 5.3.3.1.2) and verify its adequacy.

5.3.3.2.1.2 Inadequacies in detection of discrepancies in procedural guidance efficiency

- Verify that criteria are available at the plant to detect possible discrepancies in procedural guidance efficiency prior to procedure appliance

- Review the list and definition of the criteria related to the weak aspects identified in section 5.3.3.1.2
o Are the criteria adequate to ensure sufficient readiness for appliance?

o Were any discrepancies detected in the efficiency of the procedure(s) involved? If so, were they forwarded to the correction process?

5.3.3.2.1.3 **Inadequacies in the correction of discrepancies detected in the efficiency of the procedural guidance prior to appliance**

- Verify that procedures are available at the plant that provide guidance on correction of discrepancies in procedural guidance efficiency

- Review these procedures and review specifically the proposed actions regarding the weak aspects identified in procedural guidance (section 5.3.3.1.2). Verify that those actions are appropriate and complete to ensure efficiency of the procedure.

5.3.3.2.2 **Degradation of efficiency of the procedural guidance during operation**

Review unforeseen contributors that might degrade the efficiency of the procedural guidance involved. The contributors to be considered should relate to the following areas.

- Reliability in appliance
- Adaptation to working conditions
- Task qualification of the procedure.

Concentrate your effort according to the weak aspects identified in section 5.3.3.1.2.

**Note:** The intent here is to look for contributing factors which could not have been considered in the original writing or intended appliance of the procedure [at the time of initial preparation for appliance].

Review equipment history records and applicable modification records, staff history records, (administrative) procedures history records if necessary and available. Review successive procedure versions. Interview plant staff on this matter.
5.3.3.2.2.1 Degradation of reliability in appliance of the procedure

- Verify if there were any factors in operation, document control organization, task organization, procedure manipulation, staff discipline and motivation, staff training, etc, that could have affected the availability of the procedure to the intended user.

- Verify if there were any factors such as change of nature of the task (temporary instruction versus periodical task), breakdown of document control organization, breakdown in verification, validation and formal approval process of procedures, administrative staff proficiency, that could have affected the up-to-date assurance of the involved procedure.

- Verify if there were any factors in task reorganization, procedure reorganization, work area or environment modifications, task rescheduling, staff reorganization, equipment modification that could have affected the appropriateness of the originally defined scope definition.

5.3.3.2.2 Degradation of adaptation to working conditions

- Verify if there were any factors in task rescheduling equipment modification, support equipment, communication equipment or tool modification, reference document modification, task reorganization, staff training that could have affected the [utilization mode] of the involved procedure.

- Verify if the successive reviewing process of the procedure in itself did not contribute to a degradation of the ergonomic aspects of the procedure.

- Verify if there were any changes in the environmental conditions in which the task had to be performed that could have affected the suitability of the procedural hardware aspects as well as the appropriateness of chosen support equipment, instrumentation and tools.
5.3.3.2.2.3 Degradation of qualification for the task

- Verify if factors such as equipment or system modifications, task reorganization or rescheduling, could have affected the adequacy of the initial orientation to the task.

- Were there any modifications in reference documents, equipment, staff training practices, task organization, task scheduling that could have affected the adequacy of the technical content of the procedure.

- Verify if any factors such as design changes, improved technical insight, experience feedback could have affected the technical justification of the procedure.

5.3.3.2.3 Conclusion on the contributors to the latent weakness in procedural guidance

As a result of completing the review according to sections 5.3.3.2.1 and 5.3.3.2.2 the contributors to the latent weakness in the procedural guidance can be determined.

- List the contributors to inadequate preparation of the procedure prior to appliance

- List the contributors to the degradation of procedural guidance efficiency during operation

- Consider a relative weight (based on engineering judgement) to each contributor.

5.3.3.3 Determination of the direct cause of the occurrence

Logically combine the findings of the latent weakness (conclusions in 5.3.3.1.3) and of the contributors to the latent weakness (conclusions in 5.3.3.2.3), to establish the direct cause of the occurrence.
5.4 Conclusions on the process of identification of the direct cause

Provide conclusions on the process followed and the results obtained by the operating organization in identifying the direct cause of an occurrence.

The review of the process was being performed in parallel with the investigation in sections 5.3.1, 5.3.2 or 5.3.3 and the conclusions of sections 5.3.1.3, 5.3.2.3 or 5.3.3.3 are the starting point for this section.

Determine if the direct cause identified by the operating organization is consistent with the conclusions reached by this review.

If discrepancies exist in this area, explain the reasons why and offer suggestions when necessary.
6. IDENTIFICATION OF THE ROOT CAUSES OF AN OCCURRENCE

6.1 Objectives

The objectives of the review are

1. to provide independent identification of the root causes of the occurrence, and

2. to assess the adequacy of the process for identifying root causes, as already performed at the nuclear power plant.

6.2 Preparatory work

For each selected occurrence to be investigated:

- collect and review all available documentation at the plant which can help in identifying the root causes of the occurrence (plant surveillance programme, organization and related procedures, quality restoration programme, organization and procedures, surveillance data records, etc).

- collect and review all available plant procedures and analysis reports that deal with the identification of the root causes of the occurrence.

6.3 Investigations

The starting point of the investigation of the root causes of the occurrence is the latent weakness and its contributors, which were identified as the direct cause of the occurrence in sections 5.3.1.3, 5.3.2.3 or 5.3.3.3.

For each latent weakness the following should be identified:

- the deficiency of the surveillance and/or the deficiency in the restoration of the required level of quality

- the contributors to the existence of these deficiencies addressing the management of the surveillance programme and the management of the quality restoration activities.
According to the determination of the nature of the occurrence, as established in section 5.3.0 and further confirmed by the identification of the latent weakness in that particular area in sections 5.3.1 to 5.3.3, use the methodology described in the following sections:

6.3.1 Equipment deficiency
6.3.2 Personnel deficiency
6.3.3 Procedural guidance deficiency

6.3.1 Identification of the root cause of an equipment deficiency

The starting point for this review is the latent weakness in equipment operability and its contributors identified as the direct cause of the occurrence (section 5.3.1).

This section is to guide in determining the root cause of this direct cause. The root cause is directly correlated to deficiencies in the plant equipment surveillance programme which includes the equipment, personnel, and procedures associated with equipment surveillance. The root cause gives an answer to the question why the identified latent weakness was not eliminated earlier by this surveillance programme. The root cause also includes the potential contributors to these deficiencies. Potential contributors are inadequacies in the management of the surveillance (detection) and quality restoration (correction) programmes.

Note: The assessment of the operating organization's process and results of determining the root cause of the occurrence can be done in parallel with this effort (see section 6.4).
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<th>IAEA</th>
<th>ROOT CAUSE OF AN EQUIPMENT DEFICIENCY</th>
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<td>OCCURRENCE</td>
<td>FAILURE OF EQUIPMENT TO PERFORM AS EXPECTED</td>
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<td>ROOT CAUSE</td>
<td>INEFFECTIVE SURVEILLANCE OF EQUIPMENT OPERABILITY</td>
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<td>CONTRIBUTORS TO THE EXISTENCE OF THE DEFICIENCY OF SURVEILLANCE</td>
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<td>LATENT WEAKNESS IN EQUIPMENT OPERABILITY</td>
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6.3.1.1 Weak aspects of the programme for Detection of the weaknesses in equipment operability

Review the plant equipment surveillance programme, data, procedures and practices for the detection of the identified equipment latent weaknesses.

The following items should be reviewed:

- Nature of testing of equipment operability or status.
- Trending of equipment performance.
- Acceptance criteria for operability.

6.3.1.1.1 Nature of testing of equipment operability

- Review the means used at the plant for periodic surveillance of the basic aspects of equipment operability as defined in section 5.3.1.1.1 (i.e., the complete programme, including recent test data, for monitoring equipment reliability, working conditions, and function qualification). Determine the adequacy of test frequency, parameters monitored, data accuracies, etc.

- Review the qualification of personnel in charge of the programme.

- Review if the periodic test data are properly analyzed, documented, updated and transmitted to hierarchy.

- Review methods of feedback and coordination of test results and findings.

- Determine the inadequacies in any of these above areas of review, which can be directly linked to the identified latent weakness in equipment operability.

6.3.1.1.2 Trending of equipment performance

- Review the techniques used at the plant to detect slow degradation of equipment performance in the areas of equipment reliability, working conditions, and function qualifications.
- Review if trends are used to trigger improvements in equipment performance.
- Verify the usefulness and adequacy of the program (use a set of recent trend data of the equipment under review), with special attention to the identified weak aspects in equipment operability.

6.3.1.1.3 Acceptance criteria for equipment operability

- Review all acceptance criteria used in the equipment surveillance programme.
- Verify the completeness of the criteria against the equipment performance requirements of section 5.3.1.1.1.
- Verify the adequacy of the criteria corresponding to the equipment latent weakness under consideration.

6.3.1.2 Weak aspects of the programme for correction of the equipment operability

Review the plant equipment surveillance programme, procedures, and data with respect to weakness analysis, determination and implementation of corrective actions, all related to the field of equipment operability.

- Identify that provision exists for analysis of weaknesses and their contributing factors, detected by the surveillance program.
- Review the methods used for determination and implementation of corrective actions to restore the desired equipment performance.
- Verify that provision exists for testing the equipment after implementation of corrective actions.
- Verify that for the identified weakness in equipment operability and its contributors, the programme includes the above provisions of determination, implementation and testing of the corrective actions.
- Determine if the corrective actions implemented on this equipment have been adequate to prevent the possibility of recurrence of the same latent weakness (i.e.: Has the equipment experienced repeated failures of the same type?).
6.3.1.3 Conclusions on the deficiency in the equipment surveillance programme

As a result of the reviews performed according to the guidance in sections 6.3.1.1 and 6.3.1.2, the weak aspects of the detection and/or correction programmes related to equipment operability are identified.

Consider a relative weight (using engineering judgement) to each weak aspect identified.

Combine these weighted aspects to establish the deficiency of the equipment surveillance programme.

6.3.1.4 Identification of contributors to the deficiency in the surveillance of equipment operability

The starting point of this section are the findings of section 6.3.1.3 which identified the deficiency of the equipment surveillance programme.

The objective of this review is to identify those contributors (if any) that could combine with the identified surveillance deficiency, and thus provide the root cause of the equipment problem.

The contributors are related to the management of the surveillance program for detection and correction of inadequacies in equipment operability.

Both these programmes have already been reviewed for identification of weak aspects of plant surveillance for equipment operability (sections 6.3.1.1 and 6.3.1.2). Therefore, possible contributors which are under plant management control could be identified from the conclusions of those reviews. Review specifically the organizational aspects of the considered surveillance programme. Review related procedures and interview plant management in this respect. The contributors should address some major weaknesses such as:

- inadequate attention by plant-management towards the equipment surveillance programmes.

- inadequate available resources (financial, staff,...) to establish a sufficiently performing surveillance programme.
- inadequate system for coordination of the various elements of the program and between the various plant disciplines.

When the contributors are identified, consider a relative weight to each of them (based on engineering judgement).

### 6.3.1.5 Determination of the root cause of the occurrence

Combine the findings of 6.3.1.3 and 6.3.1.4 by establishing a logical combination of the identified deficiencies in the equipment surveillance program and any identified contributors to obtain the root cause of the latent weakness of the equipment operability under consideration.

### 6.3.2 Identification of the root cause of a personnel deficiency

The starting point for this review is the latent weakness in the proficiency of the individual(s) involved and its contributors, identified as the direct cause of the occurrence (section 5.3.2).

This section is to guide in determining the root cause of this direct cause. This root cause is directly correlated to deficiencies in the plant personnel proficiency surveillance programme and gives an answer to the question why the identified latent weakness was not eliminated earlier by this surveillance programme (including detection and proficiency restoration). The root cause also include the potential contributors to these deficiencies. Potential contributors are inadequacies in the management of the surveillance (detection) and proficiency restoration (correction) programmes.

**Note:** The assessment of the operating organization's process and results of determining the root cause of the occurrence can be done in parallel with this effort (see section 6.4).
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<th>IAEA</th>
<th>ROOT CAUSE OF A PERSONNEL DEFICIENCY</th>
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<td>INEFFECTIVE SURVEILLANCE OF PERSONNEL PROFICIENCY</td>
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<td>CONTRIBUTORS TO THE EXISTENCE OF THE DEFICIENCY OF SURVEILLANCE</td>
<td>INADEQUATE RESTORATION OF PERSONNEL PROFICIENCY</td>
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6.3.2.1 **Weak aspects of the programme for detection of weaknesses in personnel proficiency**

Review the plant surveillance programme, procedures and practices for the detection of latent weaknesses in personnel proficiency.

The following items should be reviewed:

- Nature of personnel proficiency testing
- Trending of personnel performance
- Acceptance criteria for personnel proficiency

6.3.2.1.1 **Nature of personnel proficiency testing**

- Review the means used at the plant for periodic surveillance of the basic characteristics of personnel proficiency as defined in section 5.3.2.1.1 (i.e. the complete programme, including test records, for monitoring personnel reliability at work, fitness for duty and qualification).

- Determine the adequacy of test frequency, parameters monitored, etc.

- Review the qualification of people in charge of performing personnel proficiency testing.

- Review if findings of periodic proficiency testing are properly documented and transmitted to hierarchy.

- Review methods of feedback and coordination of test results and findings.

- Determine the inadequacies in any of these above areas of review, which can be directly linked to the identified latent weakness in the proficiency of the individual(s) involved.

6.3.2.1.2 **Trending of personnel performance**

- Review the techniques used at the plant to detect slow degradation of personnel performance in the areas of personnel
reliability, fitness for duty and qualification for the assigned job.

Identify systems used at the plant such as
- human performance evaluation system (INPO-HPES)
- human performance indicators
- other (specify!)

- Review if trends are used to trigger improvements in personnel performance.

- Verify the usefulness and adequacy of the trending programme with special attention to the identified weak aspects in the proficiency of the individual(s) involved.

6.3.2.1.3 Acceptance criteria for personnel proficiency

- Review all acceptance criteria used in the personnel proficiency surveillance programme.

- Verify the completeness of the criteria against the personnel performance requirements of section 5.3.2.1.1.

- Verify the adequacy of the criteria corresponding to the latent weakness in personnel proficiency under consideration.

6.3.2.2 Weak aspects of the programme for restoration of the required personnel proficiency level

Review the plant personnel proficiency surveillance programme, procedures and practices with respect to weakness analysis, determination and implementation of corrective actions, all related to the field of personnel proficiency.

- Identify that provision exists for analysis of weaknesses and their contributing factors, detected by the plant surveillance programme.

- Review the available means and methods for determination and implementation of corrective actions to restore the desired level of personnel proficiency.
- Verify that provision exists for testing the effectiveness of the implemented improvements.

- Verify that for the identified weakness and its contributors in personnel proficiency, the programme includes the above provisions of determination, implementation and testing of corrective actions.

- Determine if the corrective actions implemented onto the involved individual(s) or onto all plant staff in general, have been adequate to prevent the possibility of recurrence of the same or similar inappropriate actions.

**6.3.2.3 Conclusions on the deficiency in the personnel proficiency surveillance programme**

As a result of the review performed according to the guidance in sections 6.3.2.1 and 6.3.2.2, the weak aspects of the detection and/or correction programmes related to personnel proficiency are identified.

Consider a relative weight (using engineering judgement) to each weak aspect identified.

Combine these weighted aspects to establish the deficiency of the personnel proficiency surveillance programme.

**6.3.2.4 Identification of contributors to the deficiency in the surveillance of personnel proficiency**

The starting point of this section are the findings of section 6.3.2.3 which identified the deficiency of the personnel proficiency surveillance programme.

The objective of this review is to identify those contributors (if any) that could combine with the identified surveillance deficiency and thus provide the root cause of the proficiency problem of the individual(s) involved.
The contributors are related to the management of the surveillance programme with respect to detection and correction of inadequacies in personnel proficiency.

Both these programmes have already been reviewed for identification of weak aspects of plant surveillance for personnel proficiency (sections 6.3.2.1 and 6.3.2.2). Therefore, possible contributors which are under plant management control could be identified from the conclusions of these reviews. Review specifically the organizational aspects of the considered surveillance programme. Review related procedures and interview plant management in this respect.

The contributors should address some major weaknesses such as:

- inadequate attention of plant management towards the personnel proficiency surveillance programmes.

- inadequate available resources (financial, staff...) to establish a sufficiently performing surveillance programme.

- inadequate system for coordination of the various elements of the programme (documentation, reporting and experience feedback).

When the contributors are identified, consider a relative weight to each of them (based on engineering judgement).

6.3.2.5 Determination of the root cause of the occurrences

Combine the findings of sections 6.3.2.3 and 6.3.2.4 by establishing a logical combination of the identified deficiencies in the personnel proficiency surveillance programme and any identified contributors to obtain the root cause of the latent weakness of the proficiency of the individual(s) involved, which is under consideration.

6.3.3 Identification of the root cause of the procedural guidance deficiency

The starting point for this review is the latent weakness in procedural guidance and its contributors, identified as the direct cause of the occurrence (section 5.3.3).
### Root Cause of a Procedure Deficiency

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<tbody>
<tr>
<td><strong>Occurrence</strong></td>
<td><strong>Failure of Procedure to Provide Guidance as Expected</strong></td>
</tr>
<tr>
<td><strong>Root Cause</strong></td>
<td><strong>Ineffective Surveillance of Procedural Guidance</strong></td>
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<tr>
<td><strong>Deficiency of Surveillance of Procedural Guidance Efficiency</strong></td>
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<tr>
<td><strong>Contributors to the Existence of the Deficiency of Surveillance</strong></td>
<td><strong>Latent Weakness in Procedural Guidance</strong></td>
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<tr>
<td><strong>Direct Cause</strong></td>
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**Inadequate Restoration of Procedure Quality**
- Analysis of Weaknesses Detected
- Determination of Improvements
- Implementation of Improvements

**Inadequate Detection of Weaknesses of Procedure**
- Nature of Testing of Guidance Efficiency
- Trending of Procedure Performance
- Criteria of Acceptable Quality

**Policy of Surveillance of Procedural Guidance**
- Management of the Detection Programme
- Management of the Restoration Process
This section is to guide in determining the root cause of this direct cause. This root cause is directly correlated to deficiencies in the plant procedure surveillance programme and gives an answer to the question why the identified latent weakness was not eliminated earlier by this surveillance programme (including detection and quality restoration). The root cause also includes the potential contributors to these deficiencies. Potential contributors are inadequacies in the management of the surveillance (detection) and quality restoration (correction) programmes.

Note: The assessment of the operating organization’s process and results of determining the root cause of the occurrence can be done in parallel with this effort (see section 6.4).

6.3.3.1 Weak aspects of the programme for detection of weaknesses in procedural guidance

Review the plant procedure surveillance programme, procedures and practices for the detection of latent weaknesses in procedural guidance.

The following items should be reviewed:

- Nature of testing (verification) of the efficiency of procedural guidance
- Trending of procedural guidance performance
- Acceptance criteria for procedural guidance efficiency.

6.3.3.1.1 Nature of testing the efficiency of procedural guidance

- Review the means used and the approach at the plant for periodic surveillance of the basic characteristics of procedural guidance as defined in section 5.3.3.1.1 (i.e. the complete programme, including test records, for monitoring procedural guidance reliability in appliance, adaptation to working conditions and task qualification).
- Determine the adequacy of test (verification) frequency.
Assess the adequacy of support tools (including simulators) and of personnel, used to perform the tasks as described in the procedure, in this verification process.

Review the qualification of personnel in charge of the programme.

Review if the findings of periodic procedure verifications are properly checked, documented and transmitted to hierarchy.

Review methods of feedback and coordination of verification findings.

Determine the inadequacies in any of these above areas of review, which can be directly linked to the identified latent weakness in the procedural guidance.

6.3.3.1.2 Trending of procedural guidance performance

- Review the techniques used at the plant to detect slow degradation of procedural guidance performance in the areas of procedural guidance reliability, adaptation to working conditions and task qualification.

- Review if trends are used to trigger improvements in procedural guidance performance.

- Verify the usefulness and adequacy of the trending programme with special attention to the identified weak aspects in procedural guidance.

6.3.3.1.3 Acceptance criteria for procedural guidance efficiency

- Review all acceptance criteria used in the procedural guidance surveillance programme.

- Verify the completeness of the criteria against the procedural guidance performance requirements of section 5.3.3.1.1.
- Verify the adequacy of the criteria corresponding to the procedural guidance latent weakness under consideration.

### 6.3.3.2 Weak aspects of the programme for restoration of the quality level of procedural guidance

Review the plant procedure quality restoration programme, procedures and practices with respect to weakness analysis, determination and implementation of corrective actions, all related to the field of procedural guidance.

- Identify that provision exists for analysis of weaknesses and their contributing factors, detected by the plant surveillance programme.

- Review the available means and methods used for the determination and implementation of corrective actions to restore the desired level of quality of procedural guidance.

- Verify that provision exists for testing the procedures after implementation of corrective actions (validation process).

- Verify that for the identified weakness and its contributors in procedural guidance, the programme includes the above provisions of determination, implementation and validation of the corrective actions.

- Determine if the corrective actions implemented into the considered procedures have been adequate to prevent the possibility of recurrence of the same or similar inappropriate actions.

### 6.3.3.3 Conclusions on the deficiency in the procedural guidance efficiency surveillance programme

As a result of the review performed according to the guidance in sections 6.3.3.1 and 6.3.3.2, the weak aspects of the detection and/or correction programmes related to procedural guidance efficiency are identified.
Consider a relative weight (using engineering judgement) to each weak aspect identified.

Combine these weighted aspects to establish the deficiency of the surveillance programme for procedural guidance efficiency.

6.3.3.4 Identification of contributors to the deficiency in the surveillance of procedural guidance efficiency

The starting point of this section are the findings of section 6.3.3.3 which identified the deficiency of the procedural guidance efficiency surveillance programme.

The objective of this review is to identify those contributors (if any) that could combine with the identified surveillance deficiency and thus provide the root cause of the procedural guidance problem.

The contributors are related to the management of the surveillance programme with respect to timely detection and correction of inadequacies in procedural guidance.

Both these programmes have already been reviewed for identification of weak aspects of plant surveillance related to procedural guidance (sections 6.3.3.1 and 6.3.3.2). Therefore possible contributors which are under plant management control could be identified from the conclusions of these reviews. Review specifically the organizational aspects of the considered surveillance programme. Review related procedures and interview plant management in this respect.

The contributors should address some major weaknesses such as:

- inadequate attention by plant management towards the procedural guidance efficiency surveillance programme (lack of safety culture).

- inadequate available resources (financial, staff, ...) to establish a sufficiently performing surveillance programme (including detection and correction of weaknesses).
- inadequate system for coordination of the various elements of the programme (documentation, reporting and experience feedback).

When the contributors are identified, consider a relative weight to each of them (based on engineering judgement).

6.3.3.5 Determination of the root cause of the occurrence

Combine the findings of sections 6.3.3.3 and 6.3.3.4 by establishing a logical combination of the identified deficiencies in the procedural guidance surveillance programme and any identified contributors to obtain the root cause of the latent weakness of the procedural guidance under consideration.

6.4 Conclusions on the process of identification of the root cause

Provide conclusions on the process followed and the results found by the operating organization in identifying the root cause of the occurrence.

The review of the process and results were being done in parallel with sections 6.3.1 to 6.3.3 and the conclusions in sections 6.3.1.5 to 6.3.3.5 are the starting point of this section.

Determine if the root cause obtained by the operating organizations review is consistent with the conclusions of this investigation (sections 6.3.1.5, 6.3.2.5 or 6.3.3.5).

If discrepancies are identified explain the reasons for them and offer suggestions as necessary.
7. DETERMINATION OF CORRECTIVE ACTIONS

7.1 Objectives

The objectives of this review are:

(1) to provide independent identification of the needed corrective actions, and

(2) to assess the adequacy of corrective actions, as already performed at the nuclear power plant.

7.2 Preparatory work

Review direct and root causes, as identified in accordance to sections 5 and 6, for the selected occurrences under investigation.

Review the sections of the analysis report of the event under investigation dealing with corrective actions.

7.3 Investigations

The starting point of the determination of the necessary corrective actions is

(a) the latent weaknesses and their contributors, which were identified as the direct causes of the selected occurrences in accordance to sections 5.3.1.3, 5.3.2.3 and 5.3.3.3.

(b) the deficiencies in the surveillance programmes and their contributors, which were identified as the root causes of the selected occurrences in accordance to sections 6.3.1.5, 6.3.2.5 and 6.3.3.5.

The purpose of this investigation is threefold:

(1) to eliminate the actual consequences of the event.
(2) to restore the level of quality required for the deficient basic elements involved (i.e. equipment operability, personnel proficiency and procedural guidance).

(3) to prevent that any degradation of this level of quality will result in future recurrence of the occurrences under investigation or similar occurrences.

Note: The assessment of the operating organization's process and results of determining corrective actions can be done in parallel with this effort (see section 7.4).

7.3.1 Elimination of the actual consequences of the event

The starting point is the determination of the observed actual consequences of the event under investigation. Review the narrative description of the event in this respect and interview plant personnel.

Review and assess immediate actions taken by plant staff to restore the plant operating conditions during or shortly after the reported event, addressing the actual consequences.

7.3.2 Restoration of the level of quality of the deficient basic elements

The starting point is the latent weakness and their contributors which were identified as direct causes of the set of occurrences, selected for in-depth investigation.

The purpose of this investigation is twofold:

(1) to determine corrective actions that remove the latent weakness of the basic elements (equipment, personnel, procedures) which failed.

(2) to determine corrective actions that address or consider the identified contributors to the existence of those latent weaknesses.

By implementing these corrective actions, the required level of quality of the basic elements under consideration (equipment operability, personnel proficiency, procedural guidance) is restored in the short term.
Review the corrective actions planned or implemented at the power plant to eliminate the identified latent weakness of each basic element which failed to perform as expected during the event.

Verify that corrective actions (planned or implemented) take all identified contributors to the latent weakness into consideration:

- verify that any inadequacy of preparation prior to equipment operation, job assignment of personnel or procedure field appliance is corrected.

- verify that any reason for degradation of equipment operability during operation, of personnel proficiency during employment or of procedural guidance during in field appliance is appropriately identified and corrected.

Review the implemented corrective actions in retrospect, in order to assess their efficiency in restoring the required level of quality of the basic elements involved.

Make suggestions for further improvements if this quality is not restored to full satisfaction.

7.3.3 Prevention of recurrence

The starting point is the deficiencies of the surveillance programmes and their contributors which were identified as root causes of the set of occurrences, selected for in-depth investigation.

The purpose of this investigation is twofold:

(1) to determine corrective actions that remove the deficiencies of the plant surveillance programmes which failed to detect and/or restore in a timely manner the latent weakness of the basic elements involved (equipment, personnel, procedures).

(2) to determine corrective actions that address the identified contributors to the existence of those deficiencies.

By implementing these corrective actions, the required level of quality of the basic elements under investigation (equipment operability, personnel proficiency and procedural guidance) is maintained in the long term. By detecting and restoring in a timely manner any minor degradation in
quality, major degradations can be avoided resulting in a prevention of recurrence of the observed or similar occurrences.

Review the corrective actions planned or implemented at the power plant to eliminate the identified deficiencies of the plant surveillance programmes for each basic element which failed to perform as expected during the event (detection programmes and restoration process).

Verify corrective actions planned and implemented that address the contributing factors to the existence of those deficiencies. Verify if aspects of management of the plant surveillance programme (including management of the detection programme and the restoration process) were considered and that corrective actions were taken to improve management control.

Review implemented corrective actions in retrospect in order to assess their efficiency in maintaining the required level of quality of the basic elements involved.

Make suggestions for further improvements if this quality was not maintained to full satisfaction.

7.4 Conclusions on implemented corrective actions

Provide conclusions on the process followed and the solutions found by the operating organization in determining the necessary corrective actions to:

- eliminate the actual consequences of the event.

- restore the level of quality required for the deficient basic elements involved.

- maintain that quality and prevent any degradation resulting in recurrences.

Assess the appropriateness and completeness of these corrective actions planned and implemented.

Review of the process and solutions was being performed in parallel with the investigations in section 7.3.
8. GENERIC LESSONS AND SUGGESTIONS
FOR THE ENHANCEMENT OF THE POLICY OF PREVENTION OF INCIDENTS

8.1 Objectives

The objectives of this review are:

(1) to draw generic lessons and identify good practices from the review of the population of events under investigation, and

(2) to assess the policy of prevention of incidents at the nuclear power plant.

8.2 Preparatory work

Review corrective actions implemented at the nuclear power plant following the events under investigation, as identified in accordance to section 7.

Review actions undertaken by the regulatory body as a result of the events under investigation.

Review suggestions made in accordance to sections 7.3.2 and 7.3.3 for all events under investigation.

Collect and review the documents available at the plant related to the policy of prevention of incidents.

8.3 Generic lessons and good practices

The starting point is the result of the review of

(a) the corrective actions implemented at the nuclear power plant as a result of an analysis of direct and root causes of the events under investigation.

(b) the actions taken by the regulatory as a follow up on those events.
(c) additional corrective actions suggested in section 7.

Draw generic lesson and identify good practices that are of interest to the nuclear community from the actions undertaken by both the operating organization and the regulatory body.

These generic lessons should address the following fields:

- actions of improvement of preparation prior to equipment operation, personnel job assignment and procedure field appliance.

- actions of mitigating degradation of quality of equipment, personnel and procedures.

- actions to improvement of detection capabilities of any quality degradation.

- actions to improve timely restoration of the level of quality of each of the basic elements (equipment, personnel, procedures).

- any other action taken by the operating organization or the regulatory body of general interest.

8.4 Suggestions for further enhancement of the policy of prevention of incidents

The starting point is the result of the review of suggestions made to improve the level of quality of deficient basic elements and to maintain that level of quality during future operation of the nuclear power plant. These suggestions were the result of the assessment of corrective actions planned or implemented by the operating organization following the events under investigation.

Determine the weak points of the plant policy of prevention of incidents and offer suggestions for enhancement of this policy in view of achieving the required level of quality for all basic
elements involved in nuclear power plant operation (i.e. equipment, personnel and procedures):

- by adequate preparation prior to operation, assignment or appliance of those basic elements (quality assurance programme).

- by mitigation of all contributors susceptible of leading to degradation of the level of quality reached prior to operation (quality maintenance programme).

- by establishing a powerful detection programme capable of detecting in a timely manner any potential degradation of the level of quality.

- by establishing an accurate restoration programme capable of prompt correction of any latent weakness detected.
9. OUTLINES OF THE FINAL ASSET REPORT

REPORT OF THE

ASSET

(ASSESSMENT OF SAFETY SIGNIFICANT EVENTS TEAM)

MISSION

AT THE

(NAME) NUCLEAR POWER PLANT

COUNTRY?

DATE?
PREAMBLE

This ASSET Report presents the results of the IAEA Assessment of Safety Significant Events Team (ASSET) investigations carried out on the operational events reported on (PLANT) during (YEARS) at the (NAMES) nuclear power plant located in (COUNTRY). The results, conclusions and suggestions presented herein reflect the views of the experts carrying out the investigation. They are provided for consideration by the responsible (COUNTRY) authorities. The ASSET views contained in this report are based on the documentation made available by the operating organization concerned, on oral communical with plant personnel, and promote enhancement of (PLANT) operational safety by addressing the policy of prevention of incidents.

Distribution of the ASSET report is left to the discretion of the Government of (COUNTRY); this includes the removal of any initial restriction. The IAEA makes the report available only with the express permission of the Government of (COUNTRY).

Any use of or reference to the views expressed in this report that may be made by the competent (COUNTRY) organizations is solely their responsibility.
The IAEA Assessment of Safety Significant Events Team (ASSET) programme assists Member States by advising them on ways of enhancing operational safety through an effective policy of prevention of incidents at nuclear plants. Although good design, manufacture and construction are pre-requisites, safety ultimately depends on the ability of operating personnel and the attitude and conscientiousness with which they carry out their responsibilities. ASSET missions focus on these aspects when assessing the policy of prevention of incidents in comparison with those used successfully in other countries and when exchanging, at the working level, ideas for improving its effectiveness.

An ASSET mission is undertaken on request of operating or regulatory organizations of a Member State and is not a regulatory type of inspection to determine compliance with national requirements. However, an ASSET review can complement national efforts by providing an independent, international assessment that may identify areas for potential improvement which may have been overlooked.

An ASSET mission affords an opportunity for ASSET members and operating personnel to exchange knowledge and experience, to update the knowledge of regulatory personnel of the host country assigned to follow the ASSET review, and to train personnel through observation of the experts involved in the ASSET review process. This can contribute to the attainment of an international standard of excellence for the prevention of incidents, not through regulatory requirements, but through an exchange of information on, and voluntary acceptance of, successful efficient practices.

The IAEA Safety Series document, including the Nuclear Safety Standards (NUSS) for nuclear power plants and the Basic Safety Principles for Nuclear Power Plant (Safety Series No.75-INSAG-3) and the expertise of the ASSET members themselves, form the point of departure for an ASSET review. The ASSET review is performed according to a detailed and systematic methodology which ensures thoroughness of the analysis for identification of the root causes and determination of appropriate corrective actions.

The scope of an ASSET review is tailored to the specific needs of the particular facility. Depending on individual needs, the ASSET review concentrates on areas of special interest for the development of the plant management policy related to the prevention of incidents at Plants.

In formulating their views, the ASSET members discuss their observations with their utility counterparts and consider further comments made by the other team members. They record their observations and conclusions to prepare for their oral presentation at the concluding meeting with utility and regulatory management. These notes are also input to the ASSET Report highlighting the more significant matters for utility response, which is prepared after completion of the ASSET mission and submitted to the hosting organization through official channels.

The ASSET Report conveys the conclusions of the mission and the proposals for improvement to the operating organization, which review and analyses them in order to determine what further actions may be appropriate. The proposals made may carry different weights. Their substance rather than their number determines their contribution to the operational safety improvement process. Response priorities may be indicated by the operating organizations. No assessment of the plant's overall safety status is made, however.
CONTENT OF THE REPORT

I. INTRODUCTION

II. REVIEW OF THE OPERATIONAL EVENTS REPORTED
IN (DATES) UNITS {

2.1 Description and conclusions on significance
of the events
2.2 Conclusions on the occurrences (failures) that led
to the safety significant events selected
2.3 Conclusions on the direct causes of the significant
events selected
2.4 Conclusions on root causes of the significant
events selected
2.5 Conclusions on corrective actions related
to the significant events selected
2.6 Conclusions on generic lessons and policy of
prevention of incidents
2.7 Suggested actions plan

III. ANALYSIS OF A SPECIFIC EVENT: (TITLE)

3.1 Description and significance of the event
3.2 Selection of the occurrences to be analyzed
3.3 Identification of the direct cause of each
occurrence
3.4 Identification of the root cause of each
occurrence
3.5 Determination of corrective actions
3.6 Generic lessons on prevention of incidents
at the plant
3.7 Suggested actions plan

IV. GENERAL CONCLUSIONS OF THE ASSET MISSION

4.1 Plant performance
4.2 Restoration of quality following events
4.3 Prevention of incidents
4.4 Generic lessons
4.5 Summarized actions plan

V. RESPONSE OF THE OPERATING ORGANIZATION

ACKNOWLEDGEMENTS

ANNEX 1: List of Participants
ANNEX 2: Schedule of activities
I. INTRODUCTION

At the invitation of the Government of (COUNTRY) [the operating organization (COMPANY)] the IAEA Assessment of Safety Significant Events Team (ASSET) held its (COUNTING NUMBER) working session at the (NAME) Nuclear Power Plant, (COUNTRY) from to 19 .

The objective of this session was to provide an assessment of plant operational safety regarding policy of prevention of incidents at (PLANT).

The scope of the ASSET mission was defined as follows:

+ To review the operational events reported in (DATES) in Units and to provide conclusions on significance, causes, implemented corrective actions and generic lessons.

+ To deeply analyze (NUMBER) events significant to safety and to provide conclusions on the appropriateness and completeness of corrective actions:
  1) EVENT TITLE
  2) EVENT TITLE
  3) EVENT TITLE

The task was carried out jointly by (PLANT) staff and external experts members of the ASSET according to the systematic analysis methodology developed by the IAEA for the ASSET programme. The IAEA team was composed of (NUMBER) participants specifically recruited for their long experience of nuclear power plant operation in different countries, their knowledge of analytical techniques and their sensitivity to the importance of human contribution to incidents.

The Company
Owner of the Plant?
Operator?
Number of plants operated by the company? (Type, power, etc....)?

The Nuclear Power Plant
Location?
Situation of the plant in the local environment?

History of Operation
- Diagram of operation?
- Total production and capacity factor?
- Main problems encountered and corrective actions implemented?
- Present situation of plant?
The ASSET Approach

The ASSET approach is based on the following:

EVENTS (PROBLEMS, INCIDENTS OR ACCIDENTS) occur always because of a
FAILURE (OCCURRENCE) to perform as expected due to a
LATENT WEAKNESS (DIRECT CAUSE) [preparation and maintenance] which was
not promptly eliminated due to
SURVEILLANCE DEFICIENCIES (ROOT CAUSE) [Detection and Restoration] on
quality of equipment, personnel or procedures.

As the primary goal of any operating organization is to strive for safe
and reliable operation, the main concern of the ASSET approach is therefore
the effectiveness of the incident prevention policy at nuclear power plants
visited.

The ASSET approach is based on commonly shared principles, as outlined
for example in Safety Series document No.75-INSAG-3 Basic Safety Principles.
Safe operation and good performance at nuclear power plants require basic
elements of high standard: proficient personnel, operable equipment and
useable procedural guidance.

The ASSET recognises that personnel, equipment or procedures should not
necessarily be held responsible for not performing as expected during on-line
operation. Incidents may demonstrate only that these basic elements were
poorly prepared, maintained or restored to ensure safe and reliable
operation. Plant management control is decisive, and human performance is
crucial in the carrying out of important off line activities such as:

- Careful preparation of personnel, equipment and procedures prior to
  plant operation, through an effective plant quality assurance programme.
- Prevention of any degradation of the level of quality of personnel,
  equipment and procedures during plant operation through an effective
  plant maintenance programme.
- Timely identification of any latent weakness or degradation of quality
  of any of these three elements, by use of an effective detection
  programme; and
- Prompt correction of weaknesses detected through an effective
  restoration process.

The ASSET systematic analytical methodology

The events selected are reviewed according to the ASSET guidelines and
the ASSET operating instructions provide both, practical guidance for
dismantling the mechanism of events and consistent basis for conclusions on a
population of events.

The ASSET investigation is carried out according to the 7 following
steps:
1. Description and significance of the event:

   How was the event detected? What were the consequences and the actions
taken? What is the actual and potential significance of the event?
2. Selection of the occurrences to be analysed:

What is the occurrence or the combination of occurrences most significant to safety in the sequence of the event?

3. Identification of the direct cause:

What was the latent weakness which was affecting the element (personnel, equipment or procedure) that failed to perform as expected?

4. Identification of the root cause:

Why was the latent weakness (of the element which failed to perform as expected) not eliminated earlier by the plant surveillance (detection or restoration) programme?

5. Determination of the corrective actions:

What are the areas of improvements and the corrective actions needed to enhance both, quality and surveillance of quality, of the element which failed to perform as expected?

6. Generic lessons:

What are the generic lessons learned for further enhancement of prevention of incidents?

7. Suggested actions plan:

What are the specific actions that are suggested for implementation to enhance safe operation? What are the alternatives and the schedule for implementation?

II. REVIEW OF THE OPERATIONAL EVENTS REPORTED IN 19__19
IN UNITS

2.1 Description and conclusions on significance of the events

2.1.1 Conclusions on the reporting criteria
   o Nature and requirements of the operating and regulatory organizations

2.1.2 Description of the population of events
   o Nature of events
   o Number of events
   o Recurrence of events

2.1.3 Conclusions on the significance to safety of the operational events selected
   o use the international severity scale for this assessment (see definitions)
   o conclusions on events below or out of scale
   o conclusions on event categorized in scale (to be selected for the review)
2.1.4 Conclusions on consequences of the operational events selected
   - off-site impact
   - on-site impact
   - in-depth defence degradation

2.1.5 Conclusions on immediate actions taken related to the operational events selected
   - immediate actions taken
     + to interrupt the sequence of the event
     + to restore safety
   - final status of the plant

2.2 Conclusions on the occurrences (failures) that led to the safety significant events selected

2.2.1 Conclusions on Equipment failures

2.2.2 Conclusions on Personnel failures

2.2.3 Conclusions on Procedure failures

2.3 Conclusions on the direct causes of the significant events selected

2.3.1 Conclusions on the latent weakness which were affecting personnel, equipment or procedure when they failed to perform as expected.
   + Were the latent weaknesses identified in all cases?
   + Were they related to a problem:
     of reliability in operation?
     of fitness to specific working conditions?
     of qualification for the task?

2.3.2 Conclusions on the contributors to the existence of these latent weaknesses
   + Was it due to inadequate preparation prior to operation (quality assurance)?
   + Was it due to degradation during operation (maintenance)?

2.4 Conclusions on the root causes of the significant events selected

2.4.1 Conclusions on the deficiency of the plant surveillance programme that did not eliminate the latent weakness before the event occurs.
   + Was it due to a inadequate detection programme?
   + Was it due to a inadequate restoration process once the latent weakness was detected?
2.4.2 Conclusions on the contributors to the deficiency of the plant surveillance programme.

+ Was the plant surveillance policy appropriate?

+ Was management of the plant surveillance programme adequate for timely detection and prompt restoration?

2.5 Conclusions on corrective actions related to the significant events selected

2.5.1 Conclusions on immediate actions taken to eliminate the actual consequences of the event.

2.5.2 Conclusions on actions taken to eliminate the latent weakness of the elements that failed to perform as expected

+ to restore the level of quality of the elements that failed

+ to mitigate the contributors to existence of the latent weakness.

2.5.3 Conclusions on actions taken to eliminate the deficiency of the plant surveillance programme

+ to improve the plant detection programme

+ to improve the plant restoration process

+ to mitigate the contributors to deficiency of the plant surveillance programme (policy and management)

2.5.4 Conclusions on appropriateness and completeness of corrective actions implemented by the operating organization

2.6 Conclusions on generic lessons and policy of prevention of incidents

2.6.1 Conclusions on generic lessons and good practices

2.6.2 Conclusions on plant quality assurance programme to qualify equipment, personnel and procedure prior to operation

2.6.3 Conclusions on plant maintenance programme to prevent degradation of quality of equipment, personnel and procedure during operation

2.6.4 Conclusions on plant surveillance programme to detect and restore any degradation of quality of equipment, personnel and procedure during operation
2.7  **Suggested actions plan**

2.7.1  Short term and long term actions

2.7.2  Improvement of quality of equipment
-  design, manufacturing, installation
-  qualification tests
-  periodic testing

2.7.3  Improvement of quality of personnel
-  recruiting criteria
-  training, retraining, licensing
-  periodic testing

2.7.4  Improvement of quality of procedures
-  content and format
-  validation
-  periodic review

2.7.5  Improvement of management of
*  quality assurance programme on activities directed to the achievement of the required level of quality for equipment, personnel, procedures
*  maintenance programme to keep at the level required quality of equipment, personnel and procedures
*  surveillance programme to timely detect and promptly restore any degradation of the level of quality of equipment, personnel and procedures

III.  **ANALYSIS OF A SPECIFIC EVENT:** (TITLE?)

3.1  **Description and significance of the event**

3.1.1  Initial status of the plant

3.1.2  Detection of the event

3.1.3  Brief description of the event

3.1.4  Final status of the plant
3.1.5 Actual consequences of the event

(A) Off-site impact

+ Impact on the public
  - deaths
  - injuries
  - irradiation
  - etc.

+ Impact on the environment
  - contamination of soil and water
  - etc.

+ Radioactive releases
  - noble gases
    - I 131
  - aerosols
  - liquids
  - solids
  - etc.

(B) On-site impact

+ Impact on plant personnel
  - deaths
  - injuries
  - irradiation
  - contamination
  - etc.

+ Impact on plant safety functions performance
  - safety functions (barrier, protection, supply) did not perform as expected when requested
  - etc.

+ Impact on plant structures
  - irradiation fields
  - surface or atmospheric contamination
  - fires on safety related features
  - etc.

(C) Degradation of in-depth defence

+ Degradation of the safety function "BARRIER" (passive features)
  - fuel cladding
  - primary envelop
  - containment

+ Degradation of the safety function "PROTECTION" (active features)
  - reactor shutdown
  - cooling of fuel
  - confinement of radioactive products

+ Degradation of the safety function "SUPPLY"
  - electrical power (off-site and on-site)
  - cooling water
  - instrument air
3.1.6 Immediate actions taken
  o to interrupt the event sequence
  o to restore safety

3.1.7 Assessment of the severity of the event based on actual consequences
  o according to the international severity scale
  o comments on severity of the off-site impact (actual significance)
  o comments on severity of the on-site impact (potential significance regarding possible off-site impact)
  o comment on severity of degradation of the in-depth defence of the plant (potential significance regarding possible on-site and off-site impact)

3.2 Selection of the occurrences to be analyzed

3.2.1 Establishment of the chronologic sequence of occurrences related to the reported event

EVENT (INCIDENT OR ACCIDENT)
EXAMPLE OF CHRONOLOGICAL SEQUENCE OF OCCURRENCES

<table>
<thead>
<tr>
<th>Time</th>
<th>Occurrences</th>
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<tr>
<td></td>
<td>Occurrence</td>
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<tr>
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<td>Occurrence relates to reported situation</td>
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<td>Occurrence</td>
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<td>Occurrence relates to reported situation</td>
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<td>Occurrence relates to reported situation</td>
</tr>
<tr>
<td></td>
<td>Last occurrence of the event sequence</td>
</tr>
</tbody>
</table>

Reportable situation according to reporting criteria
3.2.2 Establishment of the logic tree of occurrences

EVENT (INCIDENT OR ACCIDENT)
EXAMPLE OF LOGIC TREE OF OCCURRENCES

3.2.3 Assessment of the safety significance of each occurrence

3.2.4 Selection of the occurrences to be analyzed

3.3 Identification of the direct cause of each occurrence

3.3.1 Identification of the nature of the occurrence (personnel, equipment, procedure failure)

3.3.2 Identification of the latent weakness which was affecting personnel, equipment or procedures when they failed to perform as expected due to poor:

* reliability in operation?
* fitness to working conditions?
* qualification for task?
3.3.3 Identification of the contributors to the existence of this latent weakness.
* Inadequate preparation prior to operation (quality assurance)?
* Degradation during operation (inadequate preventive maintenance)?

3.3.4 Conclusions on the direct cause identified by the operating organization

3.4 Identification of the root cause of each occurrence

3.4.1 Identification of the deficiency of the plant surveillance programme that did not eliminate the latent weakness before incident
* Inadequate detection programme?
* Inadequate restoration process following detection of weakness?

3.4.2 Identification of the contributors to the deficiency of the plant surveillance programme
* Surveillance policy appropriate?
* Management of surveillance programme adequate for timely detection and prompt restoration

3.4.3 Conclusions on the root cause identified by the operating organization

3.5 Determination of corrective actions

3.5.1 Elimination of the actual consequences of the event

3.5.2 Repair: Elimination of the latent weakness (direct cause) of the elements that failed to perform as expected
- by restoring the level of quality of the elements that failed
- by mitigating the contributors to the existence of the latent weakness

3.5.3 Remedy: Elimination of the deficiency of the plant surveillance programme (root cause) that did not eliminate the latent weakness
- by enhancement of the plant detection programme
- by enhancement of the plant restoration programme
- by mitigation of the contributors to the deficiency of the plant surveillance programme (policy and management)
3.5.4 Conclusions on the appropriateness and completeness of the corrective actions implemented by the operating organization.

3.6 **Generic lessons on prevention of incidents at the plant**

3.6.1 Conclusions on generic lessons and good practices

3.6.2 Conclusions on plant quality assurance programme to qualify equipment, personnel and procedure prior to operation

3.6.3 Conclusions on plant maintenance programme to prevent degradation of quality of equipment, personnel and procedure during operation

3.6.4 Conclusions on plant surveillance programme to detect and restore any degradation of quality of equipment, personnel and procedure during operation

3.7 **Suggested actions plan**

3.7.1 Short term and long term actions

3.7.2 Improvement of quality of equipment
   - design, manufacturing, installation
   - qualification tests
   - periodic testing

3.7.3 Improvement of quality of personnel
   - recruiting criteria
   - training, retraining, licensing
   - periodic testing

3.7.4 Improvement of quality of procedures
   - content and format
   - validation
   - periodic review

3.7.5 Improvement of management of
   * quality assurance programme on activities directed to the achievement of the required level of quality for equipment, personnel, procedures
   * maintenance programme to keep at the level required quality of equipment, personnel and procedures
   * surveillance programme to timely detect and promptly restore any degradation of the level of quality of equipment, personnel, and procedures
IV. GENERAL CONCLUSIONS OF THE ASSET MISSION

4.1 Plant performance
- capacity factor
- operational events
- significance to safety

4.2 Restoration of quality following events
- achieving the required quality level
- maintaining the required quality level

4.3 Prevention of incidents
- Detection of degradation of quality
- Restoration of quality when degradation detected

4.4 Generic lessons

4.5 Summarized actions plan

V. RESPONSE OF THE OPERATING ORGANIZATION

This section is provided by the operating organization on the basis of the conclusions and suggestions of the ASSET team
The operating organization and its (NAME) nuclear power plant provided valuable support to the ASSET. The traditionally close co-operation of (COUNTRY) with the IAEA in all nuclear safety activities, had already established many personal contacts and a common basis for continuing work. In accordance with the discussions at a preparatory meeting, well selected and prepared information was made available in advance to familiarize the ASSET members with their assignments. Throughout the whole mission, plant counterparts were open-minded, cooperative and helpful in locating persons and information. They were instrumental in establishing a highly effective working relationship with the ASSET members. It extended occasionally beyond working hours and will not be terminated with the submission of the report. The efforts of the liaison officer and the secretarial support were outstanding. The (PLANT) ASSET wishes to express its gratitude to all concerned for the prior efforts and for the excellent working conditions during the review.
# LIST OF PARTICIPANTS

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ANNEX 2

SCHEDULE OF ACTIVITIES

2. Preparatory meeting with regulatory body and plant management ..........
3. Recruitment of external experts ..........
4. Technical preparation of the ASSET mission ..........
5. Meeting for final preparation ..........
6. ASSET investigation at the (NAME) nuclear power plant ..........
7. Submission of the final report ..........
Appendix 1

ASSET GLOSSARY

EVENT: Problem, issue, abnormality, incident, accident that is reported according to reporting criteria.

OCURRENCE: Failure to perform as expected of equipment of personnel, of procedure.

Several occurrences may usually be identified in the sequence of an event.

DIRECT CAUSE OF AN OCCURRENCE It is the latent weakness which was pre-existing in the element that failed to perform as expected under adverse circumstances.

LATENT WEAKNESS: It is the potential for an occurrence.

CONTRIBUTORS TO EXISTENCE OF A LATENT WEAKNESS: Weaknesses among equipment, personnel, procedure are due to 2 main contributors:

+ The level of quality required for operation was not achieved prior to operation due to poor quality assurance programme.

+ The level of quality achieved for operation was not maintained during operation due to poor maintenance programme.

ROOT CAUSE OF AN OCCURRENCE: It is the deficiency of the plant surveillance programme that did not timely eliminate the latent weakness (detection and restoration).

SURVEILLANCE DEFICIENCY: It is the incapacity of the plant surveillance to play its role of ultimate barrier of the in-depth defence system such as:

+ Degradation of the level of quality required was not detected due to poor detection programme.

+ Restoration of the level of quality when degraded was not effective due to poor restoration process.

CONTRIBUTORS TO DEFICIENCY OF SURVEILLANCE: Deficiencies of the plant surveillance programme on equipment, personnel and procedures are due to 2 main contributors:

+ Plant surveillance policy is inappropriate.

+ Management of the plant surveillance programme is inadequate.
Appendix 2

THE INTERNATIONAL NUCLEAR EVENT SCALE

The International Nuclear Event Scale
For prompt communication of safety significance

ACCIDENT

7 MAJOR ACCIDENT

6 SERIOUS ACCIDENT

5 ACCIDENT WITH OFF-SITE RISKS

4 ACCIDENT MAINLY IN INSTALLATION

INCIDENT

3 SERIOUS INCIDENT

2 INCIDENT

ANOMALY

BELOW SCALE
NO SAFETY SIGNIFICANCE
Background

The International Nuclear Event Scale is a means for promptly communicating to the public in consistent terms the safety significance of events reported at nuclear power plants. By putting events into proper perspective, the Scale can facilitate a common understanding between the nuclear community, the media, and the public.

The Scale was designed by an international group of experts convened jointly by the International Atomic Energy Agency and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development. The group was guided in its work by the findings from a series of international meetings held to discuss general principles underlying such a scale. The Scale also reflects the experience gained from the use of similar scales in France and Japan and from considerations of possible scales in several other countries.

The Scale is being applied initially for a trial period of about one year, during which the international agencies and user countries will monitor its progress. It would be revised, as necessary, based on user experience and feedback from the nuclear community, the media, and the public. The Scale is designed for use initially at nuclear power plants, but its application to events at other nuclear installations is desirable. To that end, the international agencies and user countries will consider what modifications might be needed to encompass the wider range of conditions which can prevail at other nuclear installations.

The Scale is designed for prompt assessment following an event. Internationally agreed guidance is available to assist those classifying events, but engineering judgement must play a role in fixing the appropriate level. Those using the Scale can also draw on validation experience gained by classifying events previously reported in several countries for different types of nuclear power reactors. Where necessary, justification for classifying an event at a particular level can be given. An event can be recategorized at a later date based on further analysis or developments, but reclassification should be kept to a minimum.

The Scale does not replace criteria adopted nationally and internationally for the reporting, description, definition, and technical analysis of nuclear events. Nor should it be used to compare safety performance in different countries. If a radiological emergency occurs in the vicinity of a nuclear power plant, existing national emergency planning will take precedence over the use of the Scale.

Although broadly comparable, detailed nuclear safety criteria and the associated terminology may vary from country to country. Although the Scale is designed to allow for this variance, a user country may wish to clarify it in the national context.

Using the scale

Events classified on the Scale (see back page) relate only to nuclear or radiological safety. These are classified at seven levels. The levels, their descriptors and detailed criteria are shown opposite, together with examples of classified nuclear events which have occurred at nuclear power plants. The lower levels (1–3) are termed incidents, and the upper levels (4–7) accidents. Events which have no safety significance are classified as Below Scale/Level Zero. Industrial accidents or other events which are not related to nuclear plant operations are not classified on the scale; these are termed Out of Scale.

As a rough guide, it might be expected that about ten times fewer events would be classified at each successively higher level of the Scale.

Examples of classified nuclear events

- The 1986 accident at the Chernobyl nuclear power plant in the Soviet Union had widespread environmental and human health effects. It is thus classified as Level 7.
- The 1957 accident at the air-cooled graphite reactor at Windscale (now Sellafield) facility in the United Kingdom involved an external release of radioactive fission products. Based on the off-site impact of this event, it is classified as Level 5.
- The 1979 accident at the Three Mile Island nuclear power plant in the United States resulted in a severely damaged reactor core. The off-site release of radioactivity was very limited. The event is classified as Level 5, based on the on-site impact.
- The 1980 accident at the Saint-Laurent nuclear power plant in France resulted in partial damage to the reactor core, but there was no external release of radioactivity. It is classified as Level 4, based on the on-site impact.
- The 1989 incident at the Vandellós nuclear power plant in Spain did not result in an external release of radioactivity, nor was there damage to the reactor core or contamination on site. However, the damage to the plant's safety systems degraded the defence-in-depth significantly. The event is classified as Level 3, based on the defence-in-depth criterion.
- From experience in validating the Scale, the majority of reported events were found to be below Level 3. Although no examples of these events are given here, countries using the Scale may wish to provide examples of events at these lower levels.
Underlying logic of the scale

(Criteria given in matrix are broad indicators only)

<table>
<thead>
<tr>
<th>LEVEL/DESCRIPTOR</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OFF-SITE IMPACT</td>
</tr>
<tr>
<td>7 MAJOR ACCIDENT</td>
<td>MAJOR RELEASE: WIDESPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
</tr>
<tr>
<td>6 SERIOUS ACCIDENT</td>
<td>SIGNIFICANT RELEASE: FULL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
</tr>
<tr>
<td>5 ACCIDENT WITH OFF-SITE RISKS</td>
<td>LIMITED RELEASE: PARTIAL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
</tr>
<tr>
<td>4 ACCIDENT MAINLY IN INSTALLATION</td>
<td>MINOR RELEASE: PUBLIC EXPOSURE OF THE ORDER OF PRESCRIBED LIMITS</td>
</tr>
<tr>
<td>3 SERIOUS INCIDENT</td>
<td>VERY SMALL RELEASE: PUBLIC EXPOSURE AT A FRACTION OF PRESCRIBED LIMITS</td>
</tr>
<tr>
<td>2 INCIDENT</td>
<td></td>
</tr>
<tr>
<td>1 ANOMALY</td>
<td></td>
</tr>
<tr>
<td>0 /BELOW SCALE</td>
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</tr>
</tbody>
</table>
The International Nuclear Event Scale
for prompt communication of safety significance

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTOR</th>
<th>CRITERIA</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCIDENTS 7</td>
<td>MAJOR ACCIDENT</td>
<td>• External release of a large fraction of the reactor core inventory typically involving a mixture of short and long-lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands terabecquerels of iodine-131) Possibility of acute health effects Delayed health effects over a wide area possibly involving more than one country Long term environmental consequences</td>
<td>Chernobyl USSR 1986</td>
</tr>
<tr>
<td>6</td>
<td>SERIOUS ACCIDENT</td>
<td>• External release of fission products (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131) Full implementation of local emergency plans most likely needed to limit serious health effects</td>
<td>Windscale, UK 1957</td>
</tr>
<tr>
<td>5</td>
<td>ACCIDENT WITH OFF-SITE RISKS</td>
<td>• External release of fission products (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131) Partial implementation of emergency plans (e.g., local sheltering and/or evacuation) required in some cases to lessen the likelihood of health effects • Severe damage to large fraction of the core due to mechanical effects and/or melting</td>
<td>Three Mile Island, USA, 1979</td>
</tr>
<tr>
<td>4</td>
<td>ACCIDENT MAINLY IN INSTALLATION</td>
<td>• External release of radioactivity resulting in a dose to the most exposed individual off-site of the order of a few millisieverts • Need for off-site protective actions generally unlikely except possibly for local food control • Some damage to reactor core due to mechanical effects and/or melting • Worker doses that can lead to acute health effects (of the order of 1 Sievert) **</td>
<td>Saint-Laurent, France, 1980</td>
</tr>
<tr>
<td>INCIDENTS 3</td>
<td>SERIOUS INCIDENT</td>
<td>• External release of radioactivity above authorized limits resulting in a dose to the most exposed individual off-site of the order of tens of millisieverts • Off-site protective measures not needed • High radiation levels and/or contamination on-site due to equipment failures or operational incidents Overexposure of workers (individual doses exceeding 50 millisieverts) ** • Incidents in which a further failure of safety systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if certain initiators were to occur</td>
<td>Vandelllos, Spain 1989</td>
</tr>
<tr>
<td>2</td>
<td>INCIDENT</td>
<td>• Technical incidents or anomalies which, although not directly or immediately affecting plant safety, are liable to lead to subsequent re-evaluation of safety provisions</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ANOMALY</td>
<td>• Functional or operational anomalies which do not pose a risk but which indicate a lack of safety provisions This may be due to equipment failure, human error or procedural inadequacies (Such anomalies should be distinguished from situations where operational limits and conditions are not exceeded and which are properly managed in accordance with adequate procedures These are typically &quot;below scale&quot; )</td>
<td></td>
</tr>
<tr>
<td>BELOW SCALE/ZERO</td>
<td>NO SAFETY SIGNIFICANCE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The doses are expressed in terms of effective dose equivalent (whole body dose). These criteria where appropriate also can be expressed in terms of corresponding annual effluent discharge limits authorized by National authorities.

** These doses are also expressed for simplicity in terms of effective dose equivalents (sieverts), although the doses in the range involving acute health effects should be expressed in terms of absorbed dose (grays).
Appendix 3

'SUMMARY OF THE EVENT ROOT CAUSE ANALYSIS' FORM

<table>
<thead>
<tr>
<th>IAEA</th>
<th>&quot;SUMMARY OF THE EVENT ROOT CAUSE ANALYSIS&quot;</th>
<th>ASSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUCLEAR POWER PLANT</td>
<td>DATE OF THE EVENT</td>
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</tr>
<tr>
<td>Ø. EVENT TITLE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I. SIGNIFICANCE OF THE EVENT

<table>
<thead>
<tr>
<th>LEVEL OF SEVERITY ACCORDING TO INTERNATIONAL SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF-SITE IMPACT</td>
</tr>
<tr>
<td>7. MAJOR RELEASE - WIDE SPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
</tr>
<tr>
<td>6. LIMITED RELEASE - PARTIAL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
</tr>
<tr>
<td>5. VERY SMALL RELEASE - PUBLIC EXPOSURE AT A FRACTION OF PRESCRIBED LIMITS</td>
</tr>
<tr>
<td>4. SEVERE CORE DAMAGE</td>
</tr>
<tr>
<td>3. MAJOR RELEASE - WIDE SPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
</tr>
<tr>
<td>2. LIMITC RELEASE - PARTIAL IMPLEMENTATION OF LOCAL EMERGENCY PLANS</td>
</tr>
<tr>
<td>1. MAJOR RELEASE - WIDE SPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
</tr>
</tbody>
</table>

II. OCCURRENCES SELECTED FOR ANALYSIS

<table>
<thead>
<tr>
<th>PERSONNEL FAILURE</th>
<th>PROCEDURE FAILURE</th>
<th>EQUIPMENT FAILURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DID NOT ACT</td>
<td>NO GUIDANCE FOR TASK</td>
<td>DID NOT WORK</td>
</tr>
<tr>
<td>DID ACT BUT WRONGLY</td>
<td>WRONG GUIDANCE FOR TASK</td>
<td>DID WORK BUT NOT PERFORM AS EXPECTED</td>
</tr>
<tr>
<td>DID ACT RIGHTLY BUT NOT TIMELY</td>
<td>WRONG SEQUENCE FOR TASK</td>
<td>DID WORK BUT NOT WHEN REQUESTED</td>
</tr>
</tbody>
</table>

N.B.: For each occurrence selected, please fill in the 4 following sheets (Direct Cause, Root Cause and Corrective Actions) to record the conclusions of your investigation.
### Direct Cause of a Personnel Deficiency

<table>
<thead>
<tr>
<th>IAEA</th>
<th><strong>Direct Cause of a Personnel Deficiency</strong></th>
<th>Asset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OCCURRENCE</strong></td>
<td>Failure of personnel to perform as expected</td>
<td></td>
</tr>
<tr>
<td><strong>ROOT CAUSE</strong></td>
<td>Ineffective surveillance of personnel proficiency</td>
<td></td>
</tr>
<tr>
<td><strong>DIRECT CAUSE</strong></td>
<td>Latent weakness in personnel proficiency</td>
<td></td>
</tr>
</tbody>
</table>

#### Weaknesses of Personnel Proficiency

- Inadequate reliability
  - Vigilance
  - Endurance
  - Self capabilities awareness
- Inadequate fitness for duty
  - Attitude towards task and procedures
  - Psychological aptitude
  - Physiological aptitude
- Inadequate qualification
  - Competence for task
  - Training for task
  - Educational background

#### Contributors to the Existence of a Weakness in Personnel Proficiency

- Degradation of proficiency during employment
  - Degradation of reliability
  - Degradation of fitness
  - Degradation of qualification
- Inadequate preparation of personnel prior to employment
  - Uncomprehensive verification of proficiency
  - Inadequate proficiency criteria
  - Ineffective restoration of proficiency

### III. Direct Cause of an Occurrence

- Licensing tests
- On the job training
- General training
- Periodic remotivation
- Periodic exercises
- Refresher training
- Reaching personnel proficiency required
- Maintaining personnel proficiency required

- Identification of plant activities that failed to maintain the level required for personnel proficiency (preventive maintenance)
- Identification of plant activities that failed to ensure that the level required was reached for personnel proficiency (quality assurance)
**IAEA**

**DIRECT CAUSE OF A PROCEDURE DEFICIENCY**

<table>
<thead>
<tr>
<th>OCCURRENCE</th>
<th>DIRECT CAUSE</th>
<th>WEAKNESSES OF PROCEDURAL GUIDANCE</th>
<th>CONTRIBUTORS TO THE EXISTENCE OF A WEAKNESS IN PROCEDURAL GUIDANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAILURE OF PROCEDURE TO PROVIDE GUIDANCE AS EXPECTED</td>
<td>INEFFECTIVE SURVEILLANCE OF PROCEDURAL GUIDANCE EFFICIENCY</td>
<td>INADEQUATE RELIABILITY&lt;br&gt;- AVAILABILITY TO THE INTENDED USER&lt;br&gt;- UP-TO-DATE ASSURANCE&lt;br&gt;- SCOPE LIMITATIONS&lt;br&gt;- INADEQUATE ADAPTATION TO WORKING CONDITIONS&lt;br&gt;- UTILIZATION MODE&lt;br&gt;- ERGONOMY&lt;br&gt;- ENVIRONMENT ADAPTATION&lt;br&gt;- INADEQUATE TASK QUALIFICATION&lt;br&gt;- TASK ORIENTATION&lt;br&gt;- ADEQUACY OF CONTENT&lt;br&gt;- BACKGROUND SUPPORT</td>
<td>INADEQUATE PREPARATION OF PROCEDURE PRIOR TO APPLICANCE&lt;br&gt;- UNCOMPREHENSIVE VERIFICATION OF USABILITY&lt;br&gt;- INADEQUATE USABILITY CRITERIA&lt;br&gt;- INEFFECTIVE RESTORATION OF USABILITY</td>
</tr>
</tbody>
</table>

**ASSET**

- **VALIDATION TESTS**
  - **VERIFICATION OF DRAFTING**
    - **INITIAL DRAFTING**
    - **UPDATING FROM ERGONOMY**
    - **UPDATING FROM OPERATING USE**
    - **UPDATING FROM STUDIES**

- **REACHING PROCEDURE USABILITY REQUIRED**
  - **MAINTAINING PROCEDURE USABILITY REQUIRED**
    - **IDENTIFICATION OF PLANT ACTIVITIES THAT FAILED TO MAINTAIN THE LEVEL REQUIRED**
    - **FOR PROCEDURE USABILITY (PREVENTIVE MAINTENANCE)**
    - **IDENTIFICATION OF PLANT ACTIVITIES THAT FAILED TO ENSURE THAT LEVEL REQUIRED WAS REACHED FOR PROCEDURE USABILITY (QUALITY ASSURANCE)**

- **DEGRADATION OF EFFICIENCY DURING APPLICANCE**
  - **DEGRADATION OF RELIABILITY**
  - **DEGRADATION OF ADAPTATION**
  - **DEGRADATION OF QUALIFICATION**

- **IDENTIFICATION OF PLANT ACTIVITIES THAT FAILED TO MAINTAIN THE LEVEL REQUIRED**

- **IDENTIFICATION OF PLANT ACTIVITIES THAT FAILED TO ENSURE THAT LEVEL REQUIRED WAS REACHED FOR PROCEDURE USABILITY (QUALITY ASSURANCE)**
### Direct Cause of an Equipment Deficiency

<table>
<thead>
<tr>
<th>IAEA</th>
<th>Direct Cause of an Equipment Deficiency</th>
<th>Asset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence</td>
<td>Failure of equipment to perform as expected</td>
<td></td>
</tr>
<tr>
<td>Root Cause</td>
<td>Ineffective surveillance of equipment operability</td>
<td></td>
</tr>
<tr>
<td>Direct Cause</td>
<td>Latent weakness in equipment operability</td>
<td></td>
</tr>
<tr>
<td>Weaknesses of Equipment Operability</td>
<td>Inadequate reliability</td>
<td></td>
</tr>
<tr>
<td>Contributors to the existence of a weakness in equipment operability</td>
<td>Degradation of operability during operation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate preparation of equipment prior to operation</td>
<td></td>
</tr>
</tbody>
</table>

#### Inadequate Reliability
- Availability
- Endurance
- Performance limitations
- Inadequate working conditions
  - Operational and control mode
  - Auxiliary and support system conditions
- Environmental conditions
- Inadequate function qualification
  - Installation and maintenance
  - Manufacturing and storage
  - Design

#### Degradation of Operability During Operation
- Degradation of reliability
- Degradation of working conditions
- Degradation of qualification

#### Inadequate Preparation of Equipment Prior to Operation
- Uncomprehensive verification of operability
- Inadequate operability criteria
- Ineffective restoration of operability

#### Performance Tests
- Manufacturing, installation
- Design

#### Reaching Equipment Operability Required
- Replacement of used parts
- Mitigation of influence of environment
- Modifications from operational feedback

#### Maintaining Equipment Operability Required
- Identification of plant activities that failed to maintain level required for equipment operability (preventive maintenance)
- Identification of plant activities that failed to ensure that level required was reached for equipment operability (quality assurance)
IV. ROOT CAUSE OF AN OCCURRENCE

FAILURE OF PERSONNEL TO PERFORM AS EXPECTED

INEFFECTIVE SURVEILLANCE OF PERSONNEL PROFICIENCY

INADEQUATE RESTORATION OF PERSONNEL PROFICIENCY
  • ANALYSIS OF WEAKNESSES DETECTED
  • DETERMINATION OF IMPROVEMENTS
  • IMPLEMENTATION OF IMPROVEMENTS

INADEQUATE DETECTION OF WEAKNESSES OF PERSONNEL
  • NATURE OF TESTING OF PERSONNEL PROFICIENCY
  • TRENDING OF PERSONNEL PERFORMANCE
  • CRITERIA OF ACCEPTABLE PROFICIENCY

POLICY OF SURVEILLANCE OF PERSONNEL PROFICIENCY
  • MANAGEMENT OF THE DETECTION PROGRAMME
  • MANAGEMENT OF THE RESTORATION PROCESS

LATENT WEAKNESS IN PERSONNEL PROFICIENCY

CORRECTIVE ACTIONS WERE NOT COMPLETE

CORRECTIVE ACTIONS WERE NOT RELEVANT

CORRECTIVE ACTIONS WERE NOT EFFECTIVE BECAUSE POORLY IMPLEMENTED

TESTING DOES NOT COVER ALL ASPECTS OF PERSONNEL PROFICIENCY

TESTING IS NOT PROPERLY CARRIED OUT

ACCEPTANCE CRITERIA ARE INADEQUATE

PLANT MANAGEMENT DID NOT CONSIDER SURVEILLANCE AS THE ULTIMATE BARRIER FOR PREVENTION OF INCIDENTS

PLANT SURVEILLANCE POLICY WAS NOT BASED ON FEEDBACK FROM OPERATING EXPERIENCE

SURVEILLANCE PROGRAMME WAS NOT MANAGED IN A COORDINATED MANNER
FAILURE OF PROCEDURE TO PROVIDE GUIDANCE AS EXPECTED

INEFFECTIVE SURVEILLANCE OF PROCEDURAL GUIDANCE

INADEQUATE RESTORATION OF PROCEDURE QUALITY
- ANALYSIS OF WEAKNESSES DETECTED
- DETERMINATION OF IMPROVEMENTS
- IMPLEMENTATION OF IMPROVEMENTS

INADEQUATE DETECTION OF WEAKNESSES OF PROCEDURE
- NATURE OF TESTING OF GUIDANCE EFFICIENCY
- TRENDING OF PROCEDURE PERFORMANCE
- CRITERIA OF ACCEPTABLE QUALITY

POLICY OF SURVEILLANCE OF PROCEDURAL GUIDANCE
- MANAGEMENT OF THE DETECTION PROGRAMME
- MANAGEMENT OF THE RESTORATION PROCESS

DIRECT CAUSE
LATENT WEAKNESS IN PROCEDURAL GUIDANCE

CONTRIBUTORS TO THE EXISTENCE OF THE DEFICIENCY OF SURVEILLANCE

RESTORATION OF PROCEDURE USABILITY
- CORRECTIVE ACTIONS WERE NOT COMPLETE
- CORRECTIVE ACTIONS NOT RELEVANT
- CORRECTIVE ACTIONS NOT EFFECTIVE BECAUSE POORLY IMPLEMENTED

DETECTION OF LATENT WEAKNESS IN PROCEDURE USABILITY
- TESTING DOES NOT COVER ALL ASPECTS OF PROGRAMME USABILITY
- TESTING IS NOT PROPERLY CARRIED OUT
- ACCEPTANCE CRITERIA ARE INADEQUATE

PLANT MANAGEMENT DID NOT CONSIDER SURVEILLANCE AS THE ULTIMATE BARRIER FOR PREVENTION OF INCIDENTS
- PLANT SURVEILLANCE POLICY WAS NOT BASED ON FEEDBACK FROM OPERATING EXPERIENCE
- PLANT SURVEILLANCE PROGRAMME WAS NOT UPDATED REGULARLY

MANAGEMENT OF PLANT SURVEILLANCE
- SURVEILLANCE PROGRAMME WAS NOT MANAGED IN A COORDINATED MANNER

IDENTIFICATION OF PLANT ACTIVITIES THAT FAILED TO ELIMINATE THE LATENT WEAKNESS IN PROCEDURE USABILITY (DETECTION OR RESTORATION)
### IAEA
#### ROOT CAUSE OF AN EQUIPMENT DEFICIENCY

<table>
<thead>
<tr>
<th>OCCURRENCE</th>
<th>FAILURE OF EQUIPMENT TO PERFORM AS EXPECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOT CAUSE</td>
<td>INEFFECTIVE SURVEILLANCE OF EQUIPMENT OPERABILITY</td>
</tr>
<tr>
<td>DEFICIENCY OF SURVEILLANCE OF EQUIPMENT OPERABILITY</td>
<td>INADEQUATE RESTORATION OF EQUIPMENT OPERABILITY</td>
</tr>
<tr>
<td>CONTRIBUTORS TO THE EXISTENCE OF THE DEFICIENCY OF SURVEILLANCE DIRECT CAUSE</td>
<td>LATENT WEAKNESS IN EQUIPMENT OPERABILITY</td>
</tr>
</tbody>
</table>

#### Contributors to the Existence of the Deficiency of Surveillance
- Policy of Surveillance of Equipment Operability
  - Management of the Detection Programme
  - Management of the Restoration Process

#### Deficiency of Surveillance of Equipment Operability
- Inadequate Restoration of Equipment Operability
  - Analysis of Weaknesses Detected
  - Determination of Improvements
  - Implementation of Improvements

#### Direct Cause
- Latent Weakness in Equipment Operability

#### Root Cause
- Ineffective Surveillance of Equipment Operability

#### Root Cause of An Equipment Deficiency

#### Policy of Surveillance of Equipment Operability
- Analysis of Weaknesses Detected
- Determination of Improvements
- Implementation of Improvements

#### Contributing Factors to the Deficiency of Surveillance
- Corrective Actions Not Complete
- Restorative Actions Not Relevant
- Corrective Actions Not Effective Because Poorly Implemented
- Inadequate Detection of Weaknesses of Equipment
- Nature of Testing of Equipment Operability
- Trending of Equipment Performance
- Criteria of Acceptable Operability

#### Identification of Plant Activities That Failed to Eliminate the Latent Weakness in Equipment Operability
- Detection or Restoration

#### Plant Surveillance Policy
- Comprehensiveness
- Appropriateness
- Implementation

#### Plant Surveillance Policy
- Plant Management Did Not Consider Surveillance as the Ultimate Barrier for Prevention of Incidents
- Plant Surveillance Policy Did Not Address the 3 Essential Elements Personnel, Procedures, Equipment
- Plant Surveillance Policy Was Not Based on Feedback from Operating Experience
- Surveillance Programme Was Not Reflecting Plant Surveillance Policy
- Surveillance Programme Was Not Updated Regularly
- Surveillance Programme Was Not Managed in a Coordinated Manner

---

**Diagram:**
- Corrective Actions Not Complete → Restoration of Equipment Operability
- Inadequate Detection of Weaknesses of Equipment → Detection of Latent Weakness in Equipment Operability
- Inadequate Detection of Weaknesses of Equipment → Testing Does Not Cover All Aspects of Equipment Operability
- Inadequate Detection of Weaknesses of Equipment → Testing is Not Properly Carried Out
- Inadequate Detection of Weaknesses of Equipment → Acceptance Criteria Are Inadequate
- Inadequate Detection of Weaknesses of Equipment → Plant Management Did Not Consider Surveillance as the Ultimate Barrier for Prevention of Incidents
- Plant Management Did Not Consider Surveillance as the Ultimate Barrier for Prevention of Incidents → Plant Surveillance Policy
- Plant Surveillance Policy → Comprehensiveness
- Plant Surveillance Policy → Appropriateness
- Plant Surveillance Policy → Implementation
- Plant Surveillance Policy → Surveillance Programme Was Not Reflecting Plant Surveillance Policy
- Plant Surveillance Policy → Surveillance Programme Was Not Updated Regularly
- Plant Surveillance Policy → Surveillance Programme Was Not Managed in a Coordinated Manner
- Identification of Plant Activities That Failed to Eliminate the Latent Weakness in Equipment Operability
<table>
<thead>
<tr>
<th>OCCURRENCE TITLE:</th>
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</thead>
<tbody>
<tr>
<td>ELIMINATION OF THE DIRECT CAUSE:</td>
</tr>
<tr>
<td>I. ELIMINATION OF THE LATENT WEAKNESS:</td>
</tr>
<tr>
<td>II. ELIMINATION OF THE CONTRIBUTORS TO LATENT WEAKNESS:</td>
</tr>
<tr>
<td>- CONTRIBUTOR NO. 1:</td>
</tr>
<tr>
<td>- CONTRIBUTOR NO. 2:</td>
</tr>
<tr>
<td>V. CORRECTIVE ACTIONS</td>
</tr>
<tr>
<td>- CONTRIBUTOR NO. 2:</td>
</tr>
<tr>
<td>ELIMINATION OF THE ROOT CAUSE:</td>
</tr>
<tr>
<td>III. ELIMINATION OF THE SURVEILLANCE DEFICIENCY:</td>
</tr>
<tr>
<td>IV. ELIMINATION OF THE CONTRIBUTORS TO SURVEILLANCE DEFICIENCY:</td>
</tr>
<tr>
<td>- CONTRIBUTOR NO. 1:</td>
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<tr>
<td>- CONTRIBUTOR NO. 2:</td>
</tr>
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</table>
**CONCLUSIONS ON**
**APPROPRIATENESS AND COMPLETENESS OF**
**CORRECTIVE ACTIONS IMPLEMENTED**

<table>
<thead>
<tr>
<th>OCCURRENCE TITLE:</th>
<th>NEEDED</th>
<th>APPROPRIATE</th>
<th>COMPLETE</th>
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</thead>
<tbody>
<tr>
<td><strong>REPAIRS</strong> (DIRECT CAUSE)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I) CORRECTIVE ACTIONS TO ELIMINATE LATENT WEAKNESS(ES) OF ELEMENT(S) THAT FAILED TO WORK AS EXPECTED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II) CORRECTIVE ACTIONS TO MITIGATE CONTRIBUTING FACTORS TO LATENT WEAKNESS(ES) (Quality control and/or preventive maintenance)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>REMEDIES</strong> (ROOT CAUSE)</td>
<td></td>
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<tr>
<td>III) CORRECTIVE ACTIONS TO ELIMINATE DEFICIENCY OF PLANT SURVEILLANCE PROGRAMME (DETECTION PROGRAMME OR RESTORATION PROCESS)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>IV) CORRECTIVE ACTIONS TO MITIGATE CONTRIBUTING FACTORS TO DEFICIENCY OF PLANT SURVEILLANCE (Surveillance policy and/or management of plant surveillance programme)</td>
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VI. GENERIC LESSONS ON PLANT POLICY FOR PREVENTION OF INCIDENTS

6.1 GOOD PRACTICES

6.2 EFFECTIVENESS OF PLANT QUALITY ASSURANCE PROGRAMME
   (PREPARATION PRIOR TO OPERATION)

6.3 EFFECTIVENESS OF PLANT MAINTENANCE PROGRAMME
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6.4 EFFECTIVENESS OF PLANT SURVEILLANCE PROGRAMME

   6.4.1 PLANT DETECTION PROGRAMME

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7.1 IMPROVEMENT OF OPERABILITY OF EQUIPMENT

7.2 IMPROVEMENT OF PROFICIENCY OF PERSONNEL

7.3 IMPROVEMENT OF PROCEDURAL GUIDANCE

7.4 IMPROVEMENT OF MANAGEMENT

7.4.1 QUALITY ASSURANCE PROGRAMME

7.4.2 PREVENTIVE MAINTENANCE PROGRAMME

7.4.3 SURVEILLANCE PROGRAMME
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