Note:
This is a translation of the RSK statement entitled
"Leitfaden für die Durchführung von ganzheitlichen Ereignisanalysen"
In case of discrepancies between the English translation and the German original, the original shall prevail.

RSK recommendation
(470th meeting of the Reactor Safety Commission on 6 November 2014)

(Replaces RSK recommendation "Guideline for the performance of integrated event analyses"
of 14/15 October 2008)

Guideline for the performance of integrated event analyses ("Root Cause Analysis")

1 Task

The feedback of experience ("Root Cause Analysis") is an important element within the safety management system. Part of the experience feedback is also to systematically record and evaluate events and to define measures for their prevention. The integrated event analysis of the operator is based on an approach that considers the topic of man-technology-organisation (MTO).

Results of event analyses performed were presented to the RSK on several occasions. These were discussed within the RSK Committee on REACTOR OPERATION (RB). Following these presentations, some applications of the MTO analysis methods led to discussions with regard to the following issues:

- sufficient depth and completeness of the analysis,
- plausible derivation of the analysis results based on the event sequence,
- comprehensible derivation of corrective measures from analysis results (technical, organisational, personnel),
- comprehensive presentation of the results, and
- confidential handling of person-related information.

The conclusions from these discussions led to the present guideline, which should be used as a basis for the preparation of integrated event analyses. The RSK discussed and adopted the guideline at its 411th meeting on 15 October 2008.

2 Requirements for integrated event analyses

2.1 Objectives of integrated event analyses

The objectives of event analyses are to learn from operating experience and to derive safety-oriented optimisation measures.

An integrated event analysis is a comprehensive examination of an event to be analysed by an analysis team using a systematic approach to determine what happened and why it happened. The objective is to identify all factors contributing to the event as far as possible so that appropriate measures can be derived to prevent recurrence or occurrence of similar events. In this context, “integrated” means the consideration of all contributing factors from the areas of man, technology and organisation and their interrelationships. Moreover, integrated event analyses give the staff the opportunity to make generic considerations beyond a specific event in order to contribute to an overall increase in safety.

2.2 Criteria for initiating integrated event analyses

As a general rule, it is a management task and an integral part of safety management to analyse and evaluate each occurrence and each relevant finding from plant operation.

The plant manager specifies criteria whose fulfilment initiates the performance of an integrated event analysis in the sense of this guideline in the case of an event.

These criteria take at least the following aspects into account as far as they may be of importance for the event sequence:

- safety relevance,
- personal injuries,
- significant contamination of persons and exceeding of dose limits,
- release of radioactive substances,
- common-mode failures of redundant systems or components,
- violation of limits, conditions and requirements for operation,
- exceeding of design limits,
- unclear or particularly complex sequences, and
- human factor or organisational relevance
  - relevant contribution of persons taking actions in the course of the event, and
  - relevant problems in the cooperation of different organisational units.

2.3 Requirements for the analysis methods

2.3.1 Basic requirements

The method to be chosen for integrated event analyses should meet the following requirements:

- It must be integrated, i.e. the contributing factors from all areas (man-technology-organisation) and their interrelationships must be comprehensively analysed.

- It must identify the interactions between the behaviour of the plant and the actions of the operating personnel.

- It must clarify the event-relevant technical and organisational processes as well as the causes and contributing factors for the event-relevant actions of the personnel.

- It must be designed in such a way that it can provide findings for implementable measures to increase safety.

- It must be learnable for the user, in particular for the practitioner in the nuclear power plant (NPP), and must be applicable by qualified analysts of the NPP under their own responsibility with reasonable effort.

- It must be systematic, i.e. a planned and controllable procedure must be ensured.

- It must be derived from theoretical basics.

- It must be verified in practice. The following boundary conditions should be observed when applying the chosen method:

- Prompt application: event analyses must be performed immediately after the occurrence of the event.

- Open and unbiased approach: the analysis must not be prejudiced by target and analysis expectations by the plant management or other internal or external personnel.

- Event analyses serve exclusively to analyse the conditions under which failures occur.

- In terms of experience feedback, no isolated consideration/analysis of the event to be investigated should be performed, instead results of operating experience / experience with comparable events must be considered accordingly. The results of event analyses (see Section 2.5) must be integrated into the experience feedback process.

2.3.2 Scope and depth

The analysis comprises at least the following steps (see Integrated event analysis scheme):

1 definition of the event framework to be considered (in terms of time and content),
2 reconstruction of the event sequence (ACTUAL sequence),
3 determination of the event-relevant EXPECTED sequence,
4 deviation analysis,
5 identification, analysis and justification of the factors contributing to the event,
6 derivation of corrective measures, and
7 implementation of corrective measures / effectiveness assessment.

In general, the respective analysis steps already passed need to be critically considered for the entire process of the event analysis. If, in the course of processing the individual steps, findings are obtained which indicate the need to adjust the scope of the analysis or work results determined in advance, corresponding adaptation in the sense of an iterative procedure is to be performed.

The analysis should be carried out in close interaction with the experience feedback system, i.e. on the one hand, existing experience are already be taken into account in the analysis (e.g. in the definition of the event framework to be considered) and, on the other hand, the findings obtained in the course of the analysis represent an essential input for the experience feedback system.

Step 1: Definition of the event framework to be considered (in terms of time and content)

Definition of the starting and end point of the event to be considered and the scope of analysis. In the course of the analysis, an adaptation/extension of the period/analysis scope to be considered may be necessary. The subsequent steps then need to be adapted accordingly.

Step 2: Reconstruction of the event sequence (ACTUAL sequence)

The event sequence (ACTUAL sequence) is to be reconstructed in an open and unbiased manner by evaluating the identified event-relevant documents, in particular records, the technical data as well as by interviews with the personnel involved in the event. As far as reasonable, fact finding and reconstruction of the event sequence is to be performed on site by the analysis team in cooperation with the staff involved in the event. Depending on the complexity of the event, it should be broken down into individual sub-events/event sections. The description should include all relevant processes (initial conditions, technical processes, human actions and action outcomes). If possible, a graphical representation (chronological sequence, interrelationships) of the event or event sections should be performed. It is recommended to verify and discuss these results with the staff involved in the event to avoid misunderstandings or misinterpretations before starting the further analysis.

Step 3: Determination of the event-relevant EXPECTED sequence

This includes the following:

- identification of all specifications and regulations valid at the time of the event for the processes in question, e.g. from the operating manual (BHB), quality assurance manual (QSH), organisation manual (OHB), instructions, etc,
- identification of the specified system-related boundary conditions/processes,
- identification of the specified working conditions,
- identification of the expected behaviour of the plant or of the plant components concerned in the event and derivation of the tasks implicating personnel actions, and
- determination of the organisational and procedural organisation existing at the time of the event (event-relevant areas).

Based on this, the event-relevant EXPECTED sequence for the processes concerned is to be derived.

Step 4: Deviation analysis

The deviation analysis is to be performed by a complete and systematic comparison of the event sequence (ACTUAL) determined within the framework of event reconstruction with the determined EXPECTED sequence (ACTUAL/EXPECTATION comparison).

At this point, all deviations are to be listed and assessed with regard to their relevance for the event.

Step 5: Identification, analysis and assessment of the factors contributing to the event

For each relevant deviation, the causes and the factors contributing to the event are to be identified. In this respect, it is decisive to apply an integrated approach, i.e. consideration of all human, technical and organisational factors and their interdependencies.

For each deviation, the chain of causes, i.e. the cause of the cause of the cause is to be traced back until the causes that can be influenced are found.

It may turn out that the existing specifications for the EXPECTED sequence or for the EXPECTED behaviour of the personnel themselves are not suitable or have led to sub-optimal technical results. They thus

become factors themselves for which the causes have to be identified. The same applies if the technical design turns out to be unsuitable.

All contributing factors identified are to be weighted in a justified manner with regard to their relevance for the event.

They are to be assessed in terms of experience feedback with comparable events (= generic evaluation). For example, the repeated occurrence of event-contributing factors in different contexts/events may indicate generic weaknesses, i.e. improvement potential that is not event-specific.

Step 6: Derivation of corrective measures

On the basis of the determined, assessed and weighted contributing factors, appropriate event-specific corrective measures as well as, if applicable, generic improvement measures should be identified that are not event-specific.

When deriving measures, both the NPP staff and the NPP management should be involved. The measures should be prioritised and classified (short-, medium- and long-term measures) and documented with corresponding responsibilities, implementation dates and success indicators.

If the corrective measures resulting from the analysis are not fully congruent with the corrective measures finally determined for implementation, the deviations are to be defined and justified.

Step 7: Implementation of corrective measures / effectiveness assessment

The implementation of the corrective measures and assessment of the effectiveness of measures are not part of the analysis of a specific event but, for the purpose of an effective feedback of experience, are part of a generic analysis and classification of the specific event with the measures taken.

In the sense of the PDCA cycle (**p**lan-**d**o-**c**heck-**a**ct), the implementation of the measures derived from the integrated event analysis should be monitored and verified according to the specified implementation dates and success indicators. Should measures prove to be impracticable in the course of implementation, it may be necessary if applicable, to adjust the corrective measures by applying step 6. If it can be assumed that corrective measures have not been sufficiently effective due to subsequent similar events, the cause of the ineffectiveness is to be analysed (e.g. wrong corrective measure or wrong implementation/communication of the corrective measure) by applying steps 3 to 6, and provisions are to be made for appropriate adjustments of the corrective measures. The results of the integrated event analysis should be transferred to the experience feedback system in parallel to the analysis and/or after completion of the event analysis.

2.4 Organisational requirements

2.4.1 General

The event analysis is to be integrated into the safety management system.

The licence holder has to specify clear requirements regarding the performance of event analyses and the handling of the results and communicate this company policy to the company staff adequately.

For the performance of an event analysis, an appropriate expert team is to be established which has to include experienced members in the required areas of responsibility for each case.

The management provides the event analysis teams with the necessary competences to perform event analyses.

2.4.2 Human resources

A sufficient number of staff with knowledge and skills is to be provided for the performance of event analyses. It is to be ensured that the competence of the staff is maintained. If the requisite qualifications are not available within the own organisation, external expertise may be drawn upon. When using external experts, it is to be ensured that

- their activities are adequately specified, accompanied and assessed by the operator, and
- the external experts have the necessary competence and qualification to perform event analyses in a nuclear facility.

Personnel entrusted with the performance of event analyses in nuclear facilities must have knowledge and skills in the application of the analytical methods applied. The required knowledge includes knowledge of work and organisation theory as well as ergonomics. In addition, members of the analysis team must be familiar with the specifics of the nuclear facility, in particular with the internal and external rules and regulations and guidelines to be considered, and must have comprehensive internal know-how. Furthermore, in-depth knowledge of the technology affected by the event is required.

The size of the team depends on the complexity of the event to be investigated.

In addition to technical qualifications and methodological skills, the team must have particular social skills. These include in particular communication skills, team player skills and trustworthiness.

2.4.3 Tools and infrastructure

Analysis tools are to be provided in accordance with the requirements in Section 2.3.

The analysis team is to be provided with the necessary tools to ensure performance of the event analyses without delay (means of communication, access to documents, software, etc.).

2.4.4 Organisational integration and boundary conditions

The analysis team is to be led by a qualified person.

It is to be ensured that the analysis team acts independently of operational line functions during performance of the analyses.

It is to be ensured that the analysis team has access to all necessary information and persons within the organisation regardless of their hierarchical position.

The analysis team must be free from external or internal instructions regarding the event analyses.

2.4.5 Timeframe

Integrated event analyses are to be initiated at an early stage, since experience shows that the most valuable findings are obtained shortly after the event. The event analyses (steps 1 to 6) should be completed in the short term, at the latest within a period of 45 days, and documented that at this point in time at least one initial analysis is available in which any open items (e.g. outstanding results of commissioned analyses, etc.) are identified. The initial results of the essential analysis elements should be described, the basic safety assessment of the event should have been performed and the main corrective measures identified. In particular, the EXPECTED/ACTUAL comparison of the actions that have directly led to the event should be available at this time. Independent of this, timely information on intermediate results of the integrated event analysis should be provided to the NPP staff (not only to the staff involved in the event).

2.5 Results and documentation

The integrated event analysis of the plant operator is to be fully documented and summarised in the form of a report on the results. It should include at least the following aspects:

- methodological approach applied,
- subject-specific composition of the analysis team,

- scope and depth of the integrated event analysis (i.a. timeframe for the analysis, past experience included) [see Section 2.3.1, step 1],

- reconstructed complete event sequence by referencing the underlying documents/information with the specified sub-events/event sections and the graphical representation [see Section 2.3.1, step 2],

- information on the event that is not contained in the analysis report (e.g. computer logs, recording strips, indication records) is to be archived in such a way that it can be assigned to the analysis report,

- results of the determined event-relevant EXPECTED sequence with reference to the underlying EXPECTATION specifications [see Section 2.3.1, step 3],

- results of the deviation analysis (ACTUAL/EXPECTED comparison) [see Section 2.3.1, step 4],

- identified event-related factors with weighting and assessment as well as improvement potential not being event-specific [see Section 2.3.1, step 5],

- the derived corrective measures with a conclusive assignment to the identified contributing factors as well as the identified generic improvement measures (including the prioritisation of measures and presentation of the time horizons for implementation); deviations between the corrective measures proposed by the analysis team and the finally specified corrective measures are also to be identified and justified [see Section 2.3.1, step 6],

- the measures taken to monitor/verify the implementation of the proposed corrective/improvement measures,

- full references of the documents used, and

- all function designations necessary for understanding the event analysis.

For the purpose of experience feedback, the results of the monitoring/verification of implementation of the intended corrective/improvement measures [see Section 2.3.1, step 7] are to be evaluated and documented. The documentation of the integrated event analysis is to be archived.

Figure: Integrated event analysis scheme