Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Author: Pia Oedewald
Elina Pietikäinen
Teemu Reiman

Research
2011:20

A Guidebook for Evaluating Organizations in the Nuclear Industry

– an example of safety culture evaluation

Report number: 2011:20 ISSN: 2000-0456
Available at www.stralsakerhetsmyndigheten.se

SSM perspective

According to the Swedish Radiation Safety Authority´s Regulations concerning Safety in Nuclear Facilities (SSMFS 2008:1) "the nuclear activity shall be conducted with an organization that has adequate financial and human resources and that is designed to maintain safety" (2 Chap., 7 §). SSM expects the licensees to regularly evaluate the suitability of the organization. However, an organizational evaluation can be based on many different methods.

Background

The regulator identified a few years ago a need for a better understanding of and a deeper knowledge on methods for evaluating safety critical organizations. There is a need for solid assessment methods in the process of management of organizational changes as well as in continuously performed assessment of organizations such as nuclear power plants.

The first stage in 2008 was to assign researchers at VTT to describe and evaluate methods and approaches that have been used or would be useful for assessing organizations in safety critical domains. The research task was also to propose a framework for organizational evaluations. The result was documented in the SSM Report 2009:12 Evaluating safety-critical organizations – emphasis on the nuclear industry. The report can be looked upon as a guideline on what to consider when evaluating safety critical organizations. However, SSM concluded that there was a need for testing the framework/model in a case example and to develop a more practical guideline.

The second and last stage in 2010 (see below) was to test the model and to develop a practical and useful tool for evaluation of safety critical organizations. It was decided that the test case should focus on evaluation of safety culture.

Objectives

The objective of this study was to:

- Continue the work on creating a framework, assessment criteria and guidelines for the execution of organizational evaluations at the nuclear industry. The framework and the guidelines should be applicable to various situations and needs in organizational evaluations
- Offer practical suggestions and examples to assist power companies, external evaluators as well as the regulator in carrying out valid organizational evaluations
- Provide guidelines for utilizing the framework created in the first stage of the project in a more practical manner and give information on the things to do and to avoid in particular organizational evaluations.

Results

A process for organizational safety evaluations has been developed and consists of five steps i.e. (1) Plan the scope of the evaluation and define the evaluation framework, (2) Select methods and collect data, (3) Structure and analyze data, (4) Interpret the findings according to the goals of the evaluation, and (5) Report the evaluation results and possible recommendations.

A case example of an organizational evaluation was conducted at a Nordic Nuclear Power Plant. The evaluation focused on safety culture.

Need for further research

No further research is identified.

Project information

Contact person SSM: Per-Olof Sandén
Reference: SSM 2009/4405

Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Author: Pia Oedewald, Elina Pietikäinen, Teemu Reiman
VTT, Technical Research Centre of Finland

2011:20

A Guidebook for Evaluating Organizations in the Nuclear Industry

– an example of safety culture evaluation

Date: June 2011
Report number: 2011:20 **ISSN:** 2000-0456
Available at www.stralsakerhetsmyndigheten.se

This report concerns a study which has been conducted for the Swedish Radiation Safety Authority, SSM. The conclusions and viewpoints presented in the report are those of the author/authors and do not necessarily coincide with those of the SSM.

SSM 2011:20

Contents

Summary

Organizations in the nuclear industry need to maintain an overview on their vulnerabilities and strengths with respect to safety. Systematic periodical self-assessments are necessary to achieve this overview. This guidebook provides suggestions and examples to assist power companies but also external evaluators and regulators in carrying out organizational evaluations.

Organizational evaluation process is divided into five main steps. These are:
1) planning the evaluation framework and the practicalities of the evaluation process,
2) selecting data collection methods and conducting the data acquisition,
3) structuring and analysing the data, 4) interpreting the findings and 5) reporting the evaluation results with possible recommendations. The guidebook emphasises the importance of a solid background framework when dealing with multifaceted phenomena like organisational activities and system safety. The validity and credibility of the evaluation stem largely from the evaluation team"s ability to crystallize what they mean by organization and safety when they conduct organisational safety evaluations – and thus, what are the criteria for the evaluation. Another important and often under-considered phase in organizational evaluation is interpretation of the findings.

In this guidebook a safety culture evaluation in a Nordic nuclear power plant is presented as an example of organizational evaluation. With the help of the example, challenges of each step in the organizational evaluation process are described. Suggestions for dealing with them are presented. In the case example, the DISC (Design for Integrated Safety culture) model is used as the evaluation framework. The DISC model describes the criteria for a good safety culture and the organizational functions necessary to develop a good safety culture in the organization.

Sammanfattning

Organisationer inom den kärntekniska industrin behöver vidmakthålla en översikt över sina svagheter och styrkor med avseende på säkerhet. Systematiska och återkommande egenutvärderingar är nödvändiga för att åstadkomma denna översikt. Denna handledning ger förslag och exempel till stöd för kärnkraftsföretag men också till stöd för externa utvärderar och myndigheter i att genomföra utvärderingar av organisationer.

Processen för utvärdering av organisationer är uppdelad i fem generella steg. Dessa är: 1) planering av referensramen för och de praktiska förhållandena i utvärderingsprocessen, 2) välja datainsamlingsmetoder och genomför datainsamling, 3) strukturera och analysera data, 4) tolka resultaten och 5) rapportera utvärderingsresultaten med möjliga rekommendationer. I handledningen betonas vikten av en solid och genomtänkt referensram/disposition för hantering av mångfacetterade fenomen såsom organisationsaktiviteter och systemsäkerhet. Validiteten och trovärdigheten hos utvärderingen kommer till största delen från utvärderingsteamets förmåga att beskriva vad de menar med organisation och säkerhet då de genomför organisatoriska säkerhetsutvärderingar – och sålunda, vilka kriterierna för utvärderingen är. En annan viktig och ofta underskattad fas i organisatoriska utvärderingar är tolkning av resultat.

I denna handledning presenteras en säkerhetskulturs utvärdering av ett nordiskt kärnkraftverk som ett exempel på organisationsutvärdering. Med hjälp av detta exempel beskrivs utmaningar i varje steg i utvärderingsprocessen. Förslag på hur dessa utmaningar kan hanteras presenteras också. I exemplet på utvärdering används DISC-modellen (Design for Integrated Safety Culture) som en referensram för utvärderingen. DISC-modellen beskriver kriterierna för en god säkerhetskultur och de organisatoriska funktionerna som är nödvändiga för att utveckla en god säkerhetskultur i organisationen.

1. Introduction

1.1 Background

The contemporary view on system safety emphasises that organisations should be able to evaluate and manage the safety of their activities proactively. Safety is a phenomenon that is hard to describe, measure, confirm and manage however. It is not possible to conclude whether an organisation is safe solely by looking at its accident or incident statistics. An organisation may have been able to avoid significant incidents and still have major safety challenges. The technical reliability and performance (production) records do not tell the whole truth about safety either, as they describe past outcomes. The purpose of an organisational evaluation is not usually to explain what has happened but to judge whether an organisation is capable of managing risks and creating sufficient safety in its activities. The focus of an organisational safety evaluation is on the future – to assess the *organisation's potential for safe performance.*

Deficiencies in organisational performance are often identified as major precursors of accidents. That is why safety-critical industries are increasingly becoming interested in understanding and assessing organisational performance. Production technology and safety systems can fail due to, for example, deficiencies in design, unsystematic preventive maintenance or an inability to detect a slowly developing hazardous phenomenon. Despite the significance of these organisational factors to system safety, organisational performance is not independent of the technical and economic context. For example, the organisational challenges in a nuclear power plant undergoing a major refurbishment with multiple subcontractors are probably different to those in a plant in its decommissioning stage. Thus, human and social phenomena cannot be evaluated independently of, e.g., technical and economic features of the system.

A well-conducted organisational evaluation provides new understanding of the vulnerabilities of the organisation as well as ways in which the organisation creates safety. It can serve as a practical aid to organisational development and management by:
- identifying the reasons for recurrent problems
- preparing for challenges in organisational change or development efforts
- justifying the suitability of organisational structures and organisational changes, e.g., to the regulator

In some cases, the validity and scope of the conducted organisational evaluations have been discussed within the nuclear industry, and the need for guidance on the theories and practices of organisational assessments has been evident.

1.2 Scope

This publication offers a framework, assessment criteria and guidelines for the execution of organisational evaluations. The work is based on the publication by Reiman and Oedewald (2009), which outlined the general challenges of and approaches to organisational evaluation. The current publication provides practical suggestions and examples to assist power companies, external

evaluators and the regulator in carrying out organisational evaluations. The guidebook aims to direct broad, overall evaluations of complex nuclear organisations. The approach developed at VTT is presented as an example of a safety-culture evaluation methodology. The basic text should also be applicable to other types of overall evaluations.

Reiman and Oedewald (2009) emphasised the importance of being aware of one"s own „working models" of safety and organisational behaviour in the planning phase of an organisational evaluation. What is safety? How do I know when safety is at an adequate level? What makes an organisation, what phenomena should be included in the assessment? In this publication, we describe a scientific model of organisational safety and illustrate its use with practical examples.

We carried out an organisational evaluation at one unit of a Nordic nuclear power plant between February and November 2010. The aim of the case study was twofold. First, it was an example case to produce material for this publication. The case study is presented as an example in Chapter 4. We describe the theory, data collection and analysis process to give readers practical examples of the challenges and solutions to conducting an organisational safety evaluation. Second, it served the purpose of learning for the case organisation.

2. Process for an organisational safety evaluation

The organisational evaluation process can be structured in five main steps, regardless of the evaluation approach (Fig. 1): 1) planning, which includes the definition of the evaluation framework (i.e., formulation of a shared picture of the background theories and basic assumptions) and the practicalities of the evaluation process; 2) selecting data collection methods and conduction the data acquisition; 3) structuring and analysing the data; 4) interpreting the findings; and 5) reporting the evaluation results with possible recommendations.

In addition to these five main steps, all organisational evaluations should result in decisions on how to take the findings into account in practice and how to follow up the development in the organisation in the future.

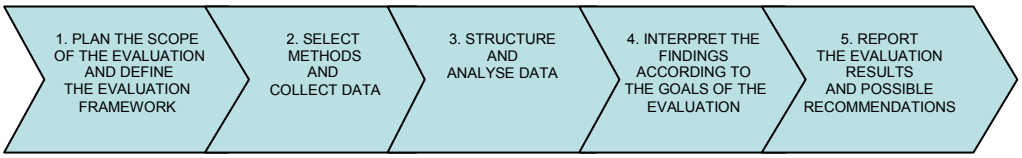


Figure 1. The five main steps of conducting an organisational evaluation

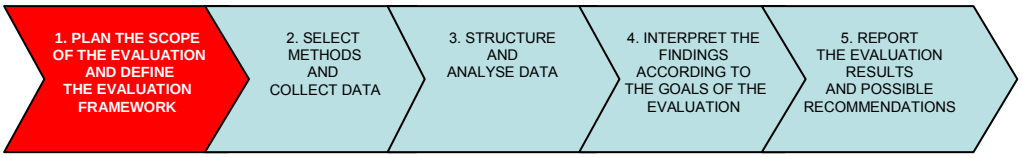
In practice, the evaluation process does not proceed in a completely linear manner; there is usually some iteration between the steps. For example, step 3 may reveal that further data are needed and thus the evaluation team needs to go back to step 2: the better the planning, the easier the rest of the evaluation process.

Our experience has shown that challenges in organisational evaluations usually stem from steps 1 and 4. A clear definition of the evaluation framework in step 1 will lay good foundations for all the other steps. The most challenging task in step 1 is probably to define the judgement criteria against which the evaluation will be made. Step 4 requires integration and interpretation of all the acquired data. We have observed that this step is sometimes skipped and that evaluators just present a set of separate findings that may leave the organisation with a vague picture of the main results of the evaluation. To help the readers tackle these challenges, we have paid extra attention to describing our solution to steps 1 and 4.

The main steps all include many different tasks depending on the specific scope, goals and methods of the evaluation. They are depicted in the following chapter.

3. Guidelines for conducting an organisational safety evaluation

3.1 Planning the evaluation and defining the evaluation framework



Organisational evaluations can be carried out internally or by outside evaluators. In both cases, there are four practical requirements to be considered before the actual data collection.

First, a *steering group* needs to be set up at the target organisation and *a contact person with sufficient resources* for that role appointed. The steering group participates in planning the evaluation process and provides access to the different organisational groups as well as the necessary documentation. The contact person should have the necessary time to arrange, e.g., interviews and answer the evaluators‟ clarifying questions during the course of the evaluation. Depending on the scope of the evaluation, the contact person may need to spend multiple days, even a couple of weeks, on this kind of background work, even though he/she is not part of the actual assessment team.

Second, the *evaluation team needs to have competence* in the data collection methods used and sufficient experience of analysing social and organisational phenomena to interpret the data. The latter is a major quality factor of organisational evaluations. Few experts in the companies in the industry possess competence in *interpreting and integrating* data that consist of, e.g., individual employees‟ and managers‟ perceptions and opinions. Behavioural or organisational scientists have been trained to do this. Thus, it is worth having that competence in the evaluation team. Knowledge and experience of the organisation‟s operating field is also important. The steering group and contact person are important context experts, especially when the evaluation is carried out by experts outside the organisation.

Third, *the purpose and policy of the evaluation need to be made clear*. The goals define the scope and extent of the evaluation. The goals also need to be explained to the members of the organisation to motivate them to provide all the necessary information and be open in the surveys and interviews. At this stage, the reporting style and, for example, the confidentiality issues, are specified.

Typically, organisational evaluations aim to answer one or several of the following questions:

- How well does the organisation perform according to criteria X?
- What is the level of safety in this organisation measured by tool Y?
- Is the organisation safe enough according to criteria X?
- What are the strengths and weaknesses of the organisation with respect to criteria X?

- What does the organisational culture/performance look like before reorganisation?
- What needs to be done to improve safety in this organisation?
- How aware is the organisation of its strengths and weaknesses?

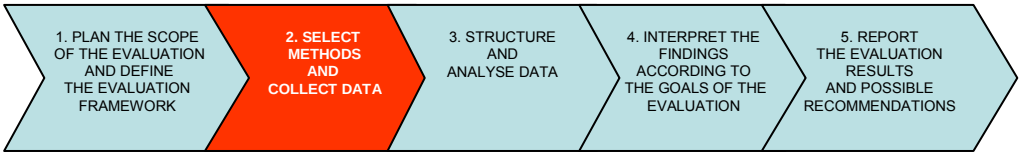
Fourth, the evaluation team needs to define the joint analysis framework. This means that *assumptions concerning* safety and organisational performance are made explicit in order to produce clear criteria for evaluation. Even though the evaluation team consists of industry practitioners, they always have „working theories" on safety and organisational performance. In other words, all evaluators have either tacit or explicit models on what is important to safety and what is most crucial to evaluate. Organisational evaluations sometimes produce confusing findings because the assumptions are not shared within the group or are not written to the report for others to see.

The evaluation team should use the existing safety models and assessment frameworks, as far as possible, as a starting point for the evaluation. Chapter 4 describes the basic premises of the organisational evaluation framework developed by VTT's researchers (Reiman & Oedewald 2009; Reiman, Pietikäinen & Oedewald 2010).

Evaluation preparation checklist

1. ***Is a steering group in place at the organisation?***
2. ***Has the contact person been named and allocated resources?***
3. ***Does the evaluation team have competence in organisational issues?***
4. ***Does the evaluation team have competence in data collection and analysis?***
5. ***Does the evaluation team have competence in the special characteristics of the nuclear domain (e.g., regulations, technology and the environment)?***
6. ***Is the purpose of the evaluation clear to all the parties involved?***
7. ***Are ethical and confidentiality issues discussed?***
8. ***Does the evaluation team have an explicit evaluation model?***

3.2 Selecting methods and collecting data



When selecting data collection methods, it is necessary to consider the following aspects.

First, *the scope of the data and the methods used should be in line with the theory and framework selected for organisational evaluation.* If, for example,

the evaluation team has decided to focus explicitly on employee safety attitudes, it is natural that it collects information on attitudes using an attitude survey. This would provide a rather narrow view on organisational safety however. It is important to realise that sometimes it may be sufficient to evaluate attitudes only, though these do not provide an adequate picture of the full safety potential. The main point is to make the framework and its constraints explicit. If the framework is not clear to the evaluation team, it may select interview schemes or surveys that do not produce all the necessary information, or it may generalise too much from the data. For example, some safety culture surveys do not measure safety culture in the sense that the nuclear power community tends to understand the concept. The survey may be developed to find development targets for *occupational* safety instead of reactor safety and it would then emphasise, for example, the use of personal protection equipment and housekeeping.

Second, for the validity of the evaluation, it is good if the data include *different types of material.* The official *descriptions of the organisation's structures,* resources, steering systems and work processes are crucial to an organisational evaluation. In addition, the employees" and managers" *perceptions*, opinions and feelings are also first-hand indicators of the actual functioning of the system. Research shows that these „subjective" opinions have predictive power concerning, e.g., the organisation"s financial or safety performance. Furthermore, an understanding of the *social norms and climate* in the organisation makes it easier to draw conclusions on the future development potential in the organisation.

To acquire all the above-mentioned data types, it is necessary to *use a combination of data collection methods.* These can include document analysis, personnel interviews and personnel surveys. If possible, observation of group situations (e.g., meetings, seminars, fieldwork) can be helpful in testing the evaluators" hypothesis.

Third, *interviews are important* even if another data collection method were to be chosen as the primary source of information. Interviews provide an opportunity to ask for examples, rationales and clarifications. Interviews can be executed in many ways. Organisational evaluation teams typically use semi-structured interviews in which the main questions to be discussed are defined based on the evaluation team"s model. A predefined structure helps to direct the discussions so that all important aspects are covered. It is also important to make interview situations natural and easy for the interviewee. It is then also easy to ask additional questions to clarify how the interviewee sees things.

Interviews serve three kinds of purposes for the evaluation. Interviewees function as:
- informants (giving information about organisational „facts" such as how certain work processes function in practice and the level of staffing for certain functions)
- representatives of the organisation (as living examples of the culture and representatives of the conceptions and opinions that exist in the organisation)
- reflectors of the organisation (describing how people reason, think and feel in the organisation and why the situation is like it is)

The selection of interviewees needs to be considered carefully. If the evaluation team has resources, it is good to interview representatives from all

organisational groups and levels of the organisation. As resources are usually limited, evaluators need to select which personnel groups need to be heard. This should be done based on the objectives and scope of the evaluation. In terms of the full-scale evaluation of the organisation"s safety culture, all major personnel groups should be represented. To gain a broad view of the organisation, the interviewees should represent different working experiences and educational backgrounds. A less sociable personality or critical attitude towards the work should not be exclusion criteria when interviews are designed. In many cases, persons with critical viewpoints have thought carefully about the work and organisational issues, and they can be valuable informants.

At the beginning of each interview, it is necessary to explain the purpose of the interview to the interviewee and describe how the interview data will be handled. It is often good to record the interviews so that the interviewer"s energy does not go into making notes. If the interviews are recorded, it is possible to return to some of the important issues later and check what the interviewee really said.

The fourth issue to consider in data collection is to *ensure adequate coverage of data across the organisation.* An evaluator needs to be open to new viewpoints and the possibility of distinct subcultures within the organisation. Even though the senior and middle management may have a good overall picture of the organisation, they are not necessarily aware of the cultural characteristics of different sub-units. Questionnaires are a good tool to acquire information from a large population.

The development of a set of questions that measures the themes that were originally intended is a challenging task. An organisational evaluation tackles themes that may be difficult to measure with single statements or to phrase accurately. Thus, it is advisable to *use existing and validated survey methods or special expertise* in survey development, if the development seems necessary.

Personnel surveys, such as safety culture or safety climate surveys, produce numeric data. Sometimes numeric, quantitative data are considered reliable and easy to interpret, whereas interview statements are seen more as subjective „opinions" and more prone to biases than the survey results. It is important to bear in mind that the survey responses are opinions and perceptions by the personnel in the same way as interview responses. They require as many interpretation skills from the evaluation team as other data types do.

Data collection checklist

1. ***Are the methods selected in line with the evaluation framework?***
2. ***Are at least two different types of material used in the evaluation?***
3. ***Does the evaluation include interviews?***
4. ***Does the data collection cover all areas of interest and all interest groups within the organisation?***
5. ***Is sufficient attention paid to storing data and observations that can be analysed and reanalysed later?***

3.3 Data analysis

Data analysis is typically described as a separate phase of an evaluation although, in practice, it is often intertwined with the data collection. The picture of the organisation slowly builds up during the data collection and analysis. It is important for the evaluators to be aware of this slowly evolving nature of interpretation. Each data entity (e.g., one document, one interview) provides one kind of picture of the organisation in question. It may also raise questions or help to formulate a hypothesis. The next data entity helps to complement and diversify the picture formed at the previous stage. It may also answer some of the questions that emerged from the earlier data entity, and verify or reject the preliminary hypothesis that was formulated based on the earlier data entity.

When there are two or more people in the evaluation team, it is useful for them to discuss explicitly the preliminary interpretations they are making during the evaluation process. By reflecting their thoughts on the specific data entities aloud to a colleague, evaluators can: a) become more aware of their conceptions concerning the organisation and b) test the validity of their interpretations.

When all the material is collected for the evaluation, it needs to be *structured and its quality reviewed.*

Qualitative data such as the interview material and documents from the organisation can be structured in many ways, for example, according to the measurement model or the evaluation criteria. This means that each interview is read (or listened to if the interviews are taped) with the measurement model dimensions or the final evaluation criteria in mind. Whenever there is an observation, definition or other comment that relates to these topics, it is extracted and wrote to an analysis table or other document. An example of such a table is Table 1on page 27. It is then easier to compare the differences

between interviewees, group the observations according to their contents and calculate the number of observations. Furthermore, systematic structuring of the interview reveals if additional information is needed on any topics.

Many surveys include open questions, i.e., questions to which the respondents can write their answers freely without predefined categories for the answers. These data are also qualitative in nature. If there are dozens of answers, they will need to be interpreted according to some analysis framework to cluster the answers. The same framework that was used for interviews can work in structuring the open answers, but, in many cases, the answers vary significantly in terms or their specificity. To avoid losing, e.g., specific development targets, it is usually good to categorise the answers with a grounded approach, which means that the natural clusters that arise from the data are used as the categories.

To analyse quantitative *survey data,* software is needed that is designed to analyse self-reported data and social phenomena, such as SPSS, SAS or similar. Obviously, no software is able to decide the kinds of analyses that are needed and produce interpretations of the results. For this reason, the evaluation team needs to have competence in statistical analysis when surveys are used. A basic review of the survey data includes, e.g., analysing the mean values, variation, standard deviations and normality of each of the individual items (questions). This gives first impressions on the topics that are disagreed or agreed on as well as those that are generally perceived positively and those that are viewed critically.

Most surveys are based on a measurement model that assumes that certain phenomena in the organisation or traits among the respondents cannot be grasped with only one question. Instead, interpretations of specific dimensions are based on multiple items. The organisational assessment survey data usually require factor analysis or formulation of summated scales based on some principle other than factor analysis. The purpose is to *sum up all the questions that measure the same phenomenon* (e.g., the survey may include four questions that all measure different aspects of one dimension, „safety leadership"). Summing up of the questions reduces the number of factors to a more manageable level and avoids interpretations being made from answers to single questions. In the next steps of the analysis, the summated scales are used instead of vast numbers of individual items.

The evaluation team needs to know *whether the survey answers are similar across* organisational units, personnel or age groups. It indicates if the opinions reported in the survey are shared cultural features. It is possible to analyse this using the ANOVA method if the survey material includes relevant background information on each of the respondents.

When analysing the survey data, it must be remembered that the numeric values represent the respondents" perceptions and that they are not objective facts about the organisational reality. Consider the survey statement „Management puts safety first". The employees are asked to judge the statement on a 6-point scale from 1, „Totally disagree", to 6, „Fully agree". If the mean score of a group of respondents is 5.2, for example, the evaluation team cannot conclude that the management actually emphasises safety as a first priority in its decision-making. Nor can the evaluation team judge that in this organisation safety is a higher priority than in an organisation that scores 3.3. A mean score of 5.2 only implies that with respect to its expectations and

knowledge, the employees‟ perception of the management‟s safety priorities is, on average, very positive. This may actually tell us more about the employees‟ expectations than the management‟s behaviour. Thus, the survey analysis should include analyses that provide additional information on the possible explanations of the first findings. These may include, for example, correlations and partial correlations, regression analysis or cluster analysis.

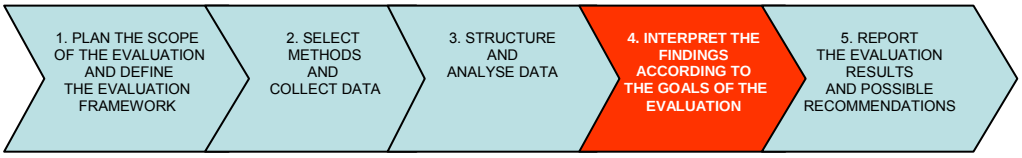
When all the above mentioned analysis is done, the evaluators have sufficient findings to start building up their overall picture of the organisation. At this point the evaluators should have a picture of topics that are covered well or neglected in the documents. Furthermore, an overview of the topics that were perceived positively or critically among the personnel has been produced, and the evaluators know the way these opinions are shared and whether any subgroups differ significantly from the others. Quite a strong hypothesis of the organisational performance probably exists in the evaluation team.

To validate the analysis, the findings and hypothesis can be presented to members of the organisation to check if the findings are meaningful to them. The purpose is not to change the results according to the needs of the organisation however. Instead, the aim is to verify the interpretations of the results and provide more information on specific issues that came up when the results were analysed and to make people in the organisation commit to the results and discuss ways to go forward. Moreover, the way that the organisation responds to critical findings provides further information on the change in the potential of the organisation as well as on the general openness and mindfulness of the organisation.

Data analysis checklist

1. ***Look at your own generic observations, questions and hypothesis during the data collection. Are they in line with the observations by the other evaluation team members?***
2. ***Have you systematically gathered findings from documents, interviews, observations or statistical analysis on tables or forms in which you can find them when you conclude your evaluation later on?***
3. ***Do you have an overview on the generalisability of your findings? Analyse whether the employees' opinions and perceptions differ with respect to the organisational subunit, task or tenure.***
4. ***Have you tested how the representatives of the organisation take the findings? How ready are they to accept critical or surprising findings? What is the climate of discussion around your findings? Which themes are difficult to communicate to the organisation?***

3.4 Drawing conclusions on the safety of the organisation



The final evaluation phase is driven by the goals of the evaluation and the framework of the analysis. As described in Chapter 1, organisational evaluations aim to answer one or several of the following questions:

- How well does the organisation perform according to criteria X?
- What is the level of safety in this organisation measured by tool Y?
- Is the organisation safe enough according to criteria X?
- What are the strengths and weaknesses of the organisation with respect to criteria X?
- What does the organisational culture/performance look like before reorganisation?
- What needs to be done to improve safety in this organisation?
- How aware is the organisation of its own strengths and weaknesses?

The task of the evaluation team is to integrate the findings to answer the questions. This requires interpretation of the significance of the findings and the relationship between different findings. To ensure the reliability of the interpretations it is necessary to *triangulate* different data, i.e., to cross-check whether a document analysis and survey give similar results to interviews. This stage may produce a need for new data analysis, e.g., analysing if a certain theme comes up in the interviews.

The challenges of interpreting the findings and judging the organisation may include the following:

- Interviewees have had different opinions and have given examples that could be interpreted as opposite results.
- The managers and the official documents describe safety goals and practices convincingly, but the personnel do not mention them and the personnel perceive e.g. the quality of safety management critically in a survey.
- One person brings up a very severe safety-related challenge but there is no other evidence of it.
- The interviewees do not mention any problems with certain organisational practices even though other data, e.g., documents on event investigations or observation data, suggest that there are major deficiencies.
- Survey results produce little variance. The mean scores are quite positive all along the line.
- The respondents and interviewees have produced many development ideas and safety concerns, even though there are organisational functions that work well and much on-going safety work.

The contradictory findings described above do not necessarily indicate that the methods or analysis are invalid. Instead, the material that does not include any contradictory findings may have been narrowly selected or the questions may have been insensitive to detecting the nuances of the organisational reality. While it is important to illustrate the way people in the organisation construct their view of safety and risks differently, organisational evaluations should be able to conclude which of the findings, opinions and observations characterise the organisation as an entity. Furthermore, the evaluation should clarify what the contradictory views mean to safety. If different findings are reported without these conclusions, there is a risk that occasional findings are overemphasised. The development initiatives may focus on topics that have a relatively small impact on the overall performance. Sometimes, however, a single finding may carry weight in the final evaluation because of its safety relevance. For example, a concern about a neglected accident scenario raised by a technical expert or an anecdote about a sensitive issue, such as fitness for duty problems or falsification of documents, need to be thoroughly considered and reported.

There are different types of variances and contradictions and they should be evaluated differently. The first type of contradiction relates to *sharedness* of the conceptions, practices or social norms within the organisation. The evaluation team may find, for example, a strong sense of personal responsibility for the plant‟s safety within the operations but the conception of responsibility for safety may be slightly different in the economic department. The feeling of being personally responsible for safety is thus not shared across the organisational units or across different tasks. Moderate variance between natural subgroups, such as different age groups, organisation units or task groups, is not necessarily a challenge to the safety of an organisation. The variance results from different viewpoints of the organisation, and they are very natural taken into account the different education and tasks of the different occupations. If different viewpoints seem to hinder the quality of the work or prevent joint development, they need to be tackled however. Some organisational groups may need additional attention to help them develop their understanding or practices to the desired direction.

The second type of contradiction relates to the *inconsistency* of the organisation‟s approach to relevant topics. In this case, variance does not exist between the organisational groups but rather between different organisational phenomena (this becomes evident when the evaluation team compares different data types). The official safety policy document may pinpoint, for example, that „everyone is responsible for safety and must immediately bring up even the smallest safety concerns‟. At the same time, however, the evaluators may hear from multiple interviews that the organisation has a practice that supervisors of a selected unit only have access to an incident reporting system and tackle possible incidents twice a month with their personnel in a meeting. This hypothetical example illustrates the organisation‟s internal inconsistency on certain safety topics. The policy and the developed practices are not in line with each other. This is a problematic situation from a safety point of view. Employees face a double standard; they do not know to which message they should listen. This may erode the personnel‟s commitment to policies and practices and make the organisational behaviour unanticipated. In some cases, the evaluation team finds inconsistency simply because organisational practices are being updated and are in a process of intentional development. This kind of stage

may be interpreted as positive development, but it must only be a short phase before the practices are harmonised.

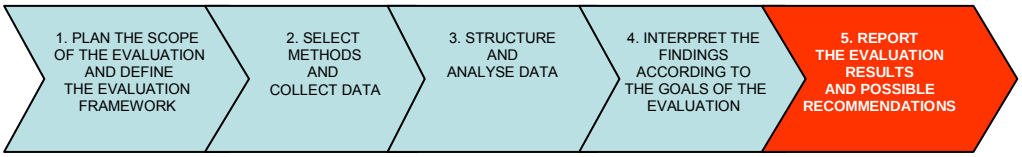
The third type of discrepancy between the findings relates to the *unclarity* of topics within the organisation. Safety, hazards and organisational performance are intangible and multifaceted themes. Thus, contradictory findings around these themes may reflect a lack of clear definitions and models within the organisations. For example, the responsibility of workers can be emphasised across the organisation, but the content of responsible behaviour varies: some emphasise strict compliance with rules and written work descriptions, while others think of flexibility and an innovative mindset. Like inconsistency within the organisation, a broad unclarity of concepts is a risk factor for organisational performance.

It has to be remembered, however, that different opinions, working theories and viewpoints are needed to maintain a mindful and alert culture. Many safety-critical organisations work with phenomena that involve uncertainties. Thus, the concepts used in the organisation cannot be too simplistic.

Checklist for concluding the evaluation

1. ***Look at the goals of the evaluation once again. What are the questions you need to answer?***
2. ***Does the evaluation team have a shared understanding of the scale for judging findings?***
3. ***Are the judgements based on iteration from multiple data sources and not just single observations?***

3.5 Presenting the results and recommendations



The results of the evaluation are reported for different audiences: line management, organisational developers, safety experts, senior management of the company or other stakeholders, such as regulators. The style and depth of reporting vary accordingly. The management usually prefers a simple depiction of the results: a numeric value, traffic light colour code or graphical presentation can be memorable and catchy. These compress immense amounts of information into a form that communicates the multidimensional nature of organisational performance, variance and tensions within the organisation poorly. This kind of presentation offers little information on the rationale behind the judgements that may undermine the credibility of the assessment. Thus, it is advisable to report the results with relevant arguments and examples, and to structure the findings according to the goals of the evaluation. If the goal of the evaluation was, e.g., to assess whether the

organisation is safe enough, the evaluation team must give a clear answer to that question.

Organisational evaluations are an opportunity to create an understanding of the way the organisation works and how it could be developed. The results are usually used to formulate some type of recommendations for the organisation. The role and style of the recommendations are dependent on the goals and scope of the evaluation and the independence or involvement of the evaluators. Some evaluation teams produce lists of detailed deficiencies and related recommendations. Sometimes, the evaluation team gives general guidelines to the steering group on which way to proceed, leaving it up to the management to discuss and decide the best way to go forward. Sometimes, the evaluation team will work on a long-term basis to develop things further in the organisation and to follow up the development in the next organisational evaluation.

Recommendations are usually generated in an interactive process between the evaluation team and the steering group (and between different representatives/units of the organisation). Ideally, the steering group will take responsibility for formulating concrete recommendations with the help of the evaluation team. This way, the understanding of the evaluation team"s main findings is transferred better to the steering group, and it can be communicated to all the necessary parties. In practice, the steering group or line organisation may pose questions like „What should we do to improve our performance?" or „Does this require some action from us?" Although an external evaluation team can formulate recommendations, it should be made clear that the organisation itself bears responsibility for what it will do based on the findings of the evaluation. Nobody outside the organisation can develop the activity on its behalf.

The steering group is also the best body to evaluate the types of initiatives that already exist in the organisation and the way they relate to the current recommendations. The recommendations may need to be prioritised depending on the other changes in the organisation. Too many parallel development projects become a burden to the organisation, even though their purpose is good.

It is often said that organisational evaluations should produce specific and concrete suggestions for corrective actions and even means to evaluate the success of the implementation. This conception has guided some organisations to avoid challenging, long-term and not-so-easy-to-measure development goals, even though they would be essential to improving the safety of the organisation. In safety-critical organisations that already have safety management practices in place, real safety improvements often depend on the development of the understanding and/or mindset in the organisation. These kinds of improvements are not executed through any single action. They need long-term work and multiple activities with harmonised goals. Sometimes, a wide range of organisational structures and systems require updates and rethinking to support the development of a correct understanding and mindset in the organisation. External organisations or societal structures may also need to be involved in the development (e.g., legislation may need to be changed) to obtain the intended results.

It is good to consider different types of recommendations: immediate corrective actions, local developments and large-scale or long-term

development directions. Large-scale development needs should be brought up in the report even though their implementation may be uncertain. We state that they need special emphasis, as they are often neglected because of the resources and commitment needed for their execution. One possibility to motivate the large-scale development suggestions is to divide them into small steps with more manageable objectives. When recommending immediate corrective actions or local developments, special attention should be paid to ensuring that the efforts will not conflict with each other and that they convey the same message and basic values.

To support organisational learning in the best way, the changes introduced by organisational evaluations should be followed up. The steering group, for example, can formulate a development plan with suitable indicators and schedule a new organisational evaluation in a suitable time. Indicators can be selected that facilitate the change in the intended direction, but the organisation also needs to monitor that the overall results of the gradual change continue in the intended directions. The indicators which are meant for driving change (e.g. the overtime hours may be measured to reduce overtime during the outages) may be different than the indicators which monitor the overall performance (e.g personnel"s sense of being in control over one"s work in terms of workload and competence requirements) of the organisation (Reiman & Pietikäinen 2010).

A follow-up evaluation needs to be scheduled according to the original goals of the evaluation. If the original evaluation was performed to gain a baseline status before large reorganisations, the next evaluations follow the schedules of the change process. A full-scale evaluation requires effort and resources, and changes take time to realise. Thus, it is reasonable to have more than a year between the evaluations.

Checklist for presenting the results and recommendations

1. ***Do the results give a clear answer to the goals of the evaluation?***
2. ***Can the organisation follow the rationale behind the judgements and communicate that to others?***
3. ***Are the steering group and the line organisation able to generate relevant recommendations for themselves or do they need the help of the evaluation team?***
4. ***Is the formulation of the recommendations correct in terms of their application scope, time frame and ambition level?***
5. ***Is there a follow-up plan?***

4. A case example of an organisational evaluation at a Nordic nuclear power plant

4.1 Planning the evaluation and defining the evaluation framework in the case study

The evaluation process at the case organisation started with a meeting with the management and safety experts in February 2010. The purpose of the meeting was to make the goals of the evaluation clear and to agree on how the evaluation process should proceed. We were also interested in hearing how organisational safety had been developed in the case organisation so far and in what kind of questions the organisation was interested. The representatives saw this evaluation as providing them with information on whether they were on the right track with their safety culture programme.

The contact person became our guide to the culture of the organisation. During the project, he helped us get in contact with the necessary people and documents and arranged a guided tour for us of the plant area. He also commented on the survey questions, encouraged people in the organisation to respond to the survey and provided us with a classification of personnel and organisational groups for grouping the survey answers.

Our evaluation team consisted of three researchers with backgrounds in psychology. Two of the team members had been involved in research and development projects in the nuclear industry for more than ten years and one for three years, so the work context was familiar to us. The team had worked closely together for years, and we had developed a shared evaluation approach with carefully discussed basic premises (Oedewald 2011), which are described next.

We had adopted a view that ***organisation*** includes the technology as well as the people using it. Organisational performance results from the interaction of humans with the object of their work and with each other in a certain environment with specified resources and technology. To obtain an overview of an organisation it is necessary to approach it from multiple viewpoints. We thought it was important to pay attention to: a) the kind of concrete and visible organisational systems and structures that exist, b) the way people perceive and experience the systems, technology and each other, and c) the way social interactions affect to the former.

We defined ***safety*** as an emerging property of an organisation. This rather abstract statement aims to emphasise that system safety develops in organisational activities and that it is a dynamic phenomenon. Safety is not something that can be brought into organisations along with technical solutions, management styles or new organisational structures; it emerges depending on the organisation"s activities and outside conditions. For

organisational evaluations, this is a challenging starting point. This view on system safety makes it impossible to decompose safety into a predetermined set of factors and to measure them. It is possible to measure the ***organisation's potential for safety*** however.

Organisations are systems and as such certain basic requirements can be set to control them (based on Reiman & Oedewald 2008; Rasmussen & Svedung 2007):

- The organisation has a defined objective.
- There is a willingness among the personnel and management to keep the organisation in line with its objective.
- The personnel and management are able to observe the current status and condition of the system (including its alignment with the objective).
- The organisation can be influenced and steered by carrying out certain activities and executing certain control measures.
- There is a model of the system (organisation) that describes the internal dynamics.
- Management is able to use the model of the system to anticipate proactively the way the organisation changes in time and the way the organisation responds to certain actions and control measures.

Following these principles, the management of organisational safety logically requires: a) that safety is part of the objective of the organisation and b) that people are willing and able to put effort into operating the system in a safe manner. Safety thus has to be a genuine value in the organisation and an integral part of the core task (1). An understanding of what safety is and how it is created is a necessary precondition of the model of the system (2). An understanding of the requirements of the work and the inherent hazards related to it are required in order to be able to observe the status of the system (3). Mindfulness is needed to anticipate the consequences of actions and potential risks (4). The willingness to put effort into this work stems from safety motivation and perceived responsibility for safety (5). The work has to be controllable in order to preserve the controllability of the system (6).

In terms of evaluating the organisational capability of safety, the previous list of requirements can be used as criteria for good safety potential. Thus, we concluded that an ***organisation has good potential for safety when the following criteria are met in the organisational activity:***

1. ***Safety is a genuine value in the organisation and that is reflected in the decision-making and daily activities.***
2. ***Safety is understood to be a complex and systemic phenomenon.***
3. ***Hazards and core task requirements are thoroughly understood.***
4. ***The organisation is mindful in its practices.***
5. ***Responsibility is taken for the safe functioning of the whole system.***
6. ***Activities are organised in a manageable way.***

We call this potential safety culture. If an organisation works as described above it has developed a culture that shows willingness and an ability to understand risks and manage the activities so that safety is taken into account.

We have developed the above evaluation criteria based on multiple case studies on organisational culture, change management and event investigations in the nuclear industry, e.g., in Finland and Sweden. We have also carried out similar projects for example in health care organisations and railways. In these case studies, we have constantly compared our practical experiences (see. e.g. Oedewald & Reiman 2007) with the latest safety theories, such as models on resilience (Hollnagel et.al 2006), high reliability organisations (La Porte, 1996) and safety culture (e.g., IAEA 1991). By doing so, we have been able to identify the six criteria described above that describe high organisational safety potential.

Our criteria for a good safety culture are unique in a sense that they integrate three different types of criteria (see Figure 2). We state that an organisation"s safety potential (safety culture) is much more than correct attitudes and a mindset that the safety culture models usually emphasise. The right mindset is necessary, but safety also requires well-designed and functioning structures and processes to ensure good preconditions to carry out the activities with sufficient quality. Some organisational evaluations, e.g., safety management audits focus on organisational structures and processes. They usually miss other types of evaluation criteria. The third cornerstone of safety culture, namely understanding the core phenomena and hazards, is missing from most of the other safety culture and safety management models. We pinpointed the importance of knowledge and understanding of system safety and the hazards inherent in the system. Without a thorough understanding of safety and risks, the organisation can focus on irrelevant challenges, make risky decisions or be blind to new threats.

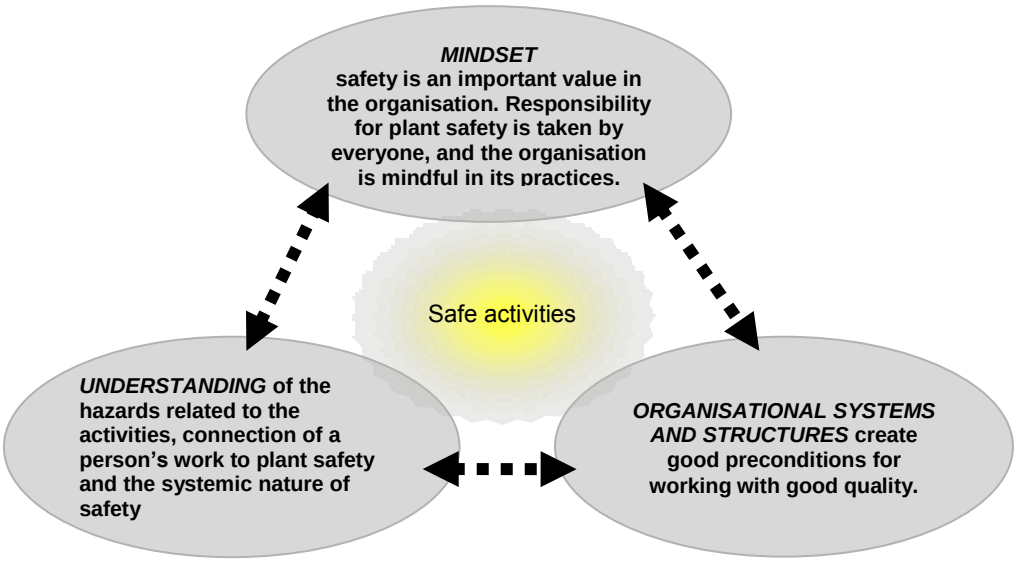


Figure 2. The six safety culture criteria proposed by VTT can be grouped into three cornerstones of safe activities: a correct mindset, well-functioning organisational systems and structures, and sufficient understanding of the hazards and safety. If all the criteria are met, the organisation has a high potential for safe socio-technical activities.

We emphasise that the ***employees' working practices*** are not guided directly by the official processes and visible control mechanisms but rather by their interpretations and feelings towards these organisational processes and control mechanisms. In the end, employees base their decisions and activities on their own understanding and reasoning. It is crucial to bear in mind that the

social workplace norms, climate and other social aspects also affect the activities. There may be, for example, historical reasons why certain practices are not considered worth executing or tacit norms not to bring up certain challenges. These social processes affect most of the members of the organisation, usually in a subconscious manner.

Despite the importance of the above-mentioned work, and psychological and social phenomena, we state that ***safety-critical organisations should realise certain organisational functions in their practices***. Based on safety culture and safety management studies, we maintain that certain organisational structures and practices are necessary to develop a high level of safety potential in an organisation. These include, for example, hazard management practices (such as risk assessments, redundancy of safety systems and personal protection equipment), competence management practices (such as training courses on the specific technologies used and on human factors and mentoring of newcomers), pro-active safety development practices (such as collecting and analysing operating experience, periodical organisational assessments) and work condition management practices (such as assessing the adequacy of the staffing and listening to the needs of end-users when purchasing tools and technical equipment). The organisational functions that we consider crucial are depicted in the DISC model (Design for Integrated Safety Culture) in Figure 3.

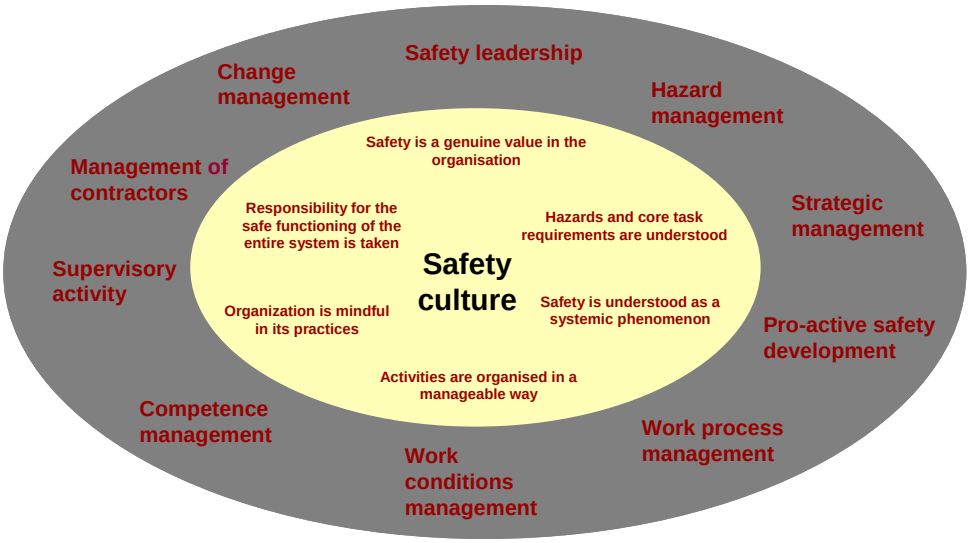


Figure 3. The DISC model describes the criteria for a good safety culture and the organisational functions necessary to develop a good safety culture in the organisation.

To sum up, our framework suggests that safety culture has organisational potential for safety. If an organisation fulfils all of the six safety culture criteria well, it has high potential for safe performance now and in the near future. The six criteria are organisational level criteria. The point is not to evaluate the individual worker‟s values or understanding as such but to evaluate whether these prevail in the organisation. For the criteria to be fulfilled, the safety culture should permeate through different elements of the organisation. It should manifest itself in the psychological aspects, such as feelings and conceptions of individual workers, and it should be evident in the social interaction of groups. It should also manifest itself in the way the organisational structures and systems are built.

4.2. Methods and data collection in the case study

There is no single ***method*** for evaluating the fulfilment of our evaluation criteria. Organisations are multidimensional phenomena and it is impossible to measure their performance validly solely by reading written documents of their activities. Neither is it possible to measure with a survey the fulfilment of our criteria – e.g. whether „responsibility for the entire functioning of the plant was taken" and if „safety is understood as a complex and systemic phenomenon". Thus, the necessary viewpoints and data gathering methods for evaluating the fulfilment of the criteria need to be agreed upon. These viewpoints for obtaining evidence on the fulfilment of our safety culture criteria are described in Table 1.

Table 1. In order to evaluate the fulfilment of each safety culture criteria, we collected different types of observations or evidence on the organisation"s culture.

Criterion	Evidence of organisational structures and systems	Evidence of employees" psychological experience	Evidence of social norms and practices	Overall judgement of the criterion
1. Safety is a genuine value				
2. Safety is understood				
3. Hazards are understood				
4. Organisation is mindful				
5. Responsibility is taken				
6. Activities are organised in a manageable way				

We used semi-structured interviews, a document analysis, a safety culture survey that we had developed and tested earlier, seminars and workplace observations that were carried out during walks around the plant to collect information on the safety culture.

We started the data collection by asking our contact person to send us certain documentation. We reviewed the organisation overview, policy and directives document, annual safety reporting, organisation charts, MTO event investigations, audit reports and documents that were intended to guide the performance of the personnel (e.g., workbook for culture development, expectations for those working on the case organisation).

During spring 2010, we carried out 12 semi-structured interviews. We interviewed managers, control room personnel, maintenance technicians and foremen as well as quality engineers. We selected the functions and managers we wanted to interview. All the other interviewees were selected by

our contact person and the function managers. We instructed them not to select the interviewees based on any specific criteria. The interviewees could be quiet or talkative, positive or critical. It was more important that they represented different groups or functions of the organisation.

We considered interviews an essential data source for evaluating the fulfilment of the six safety culture criteria. However, we did not think that the interview questions had to tackle the criteria directly. To gain rich and reliable data, we preferred to ask questions about the everyday work tasks of the interviewee, their perceptions of organisational practices and future development needs. We only asked directly about the understanding of safety and risks. Our questions were fairly general and open-ended to allow the interviewees to describe their ideas freely first, before asking additional questions. We did not want to guide their thinking too much; instead, we were interested in what kind of issues they themselves brought up. The interview schemes for key informants (such as managers and quality experts) and personnel are attached to this publication (Appendices 1 and 2).

In June 2010, we launched a web-based safety culture questionnaire for the personnel in the case organisation. Our survey did not measure opinions on the fulfilment of criteria directly because they would have been too abstract to be evaluated validly by a self-reporting survey. Typically respondents also tend to rate generic, safety-related survey questions in a positive manner because they knew that a positive relationship with safety is expected of them. The emphasis of our questionnaire was therefore on how the respondents perceived and felt about their work and their organisation at the time.

Our survey had two parts with 68 statements. The respondents were asked to judge using a six-point scale how well the statements described their work and organisation. *The first part* of the survey measured the respondent"s perceptions of his/her work. The questions were based on our criteria and work-motivation theory. We aimed to measure four dimensions:

- a sense of being in control of their work tasks (compare with criterion 6)
- safety motivation (compare with criterion 1)
- a sense of being responsible for the plant safety (compare with criterion 5)
- mindful working practices (compare with criterion 4)

It has proved difficult to develop measures for criteria 2 and 3 to measure the understanding aspects. In the survey we had individual statements connected to safety understanding, e.g., „Safety can only be developed further by technical means". We also tested a risk analysis scale for evaluating the understanding of the hazards. Respondents were asked to estimate the occurrence and significance of 11 risk factors. The scale was not as informative as we had hoped, because the answers had little variance.

The second part of our questionnaire measured the respondent"s opinions on the functioning of the organisation. The questions were based on the DISC model (see Figure 2 on page 25). We measured each of the organisational

functions using four or five questions. The dimensions in the last questionnaire version[1] were:

- hazard management
- safety leadership
- change management
- management of subcontractors
- supervisory activity
- competence management
- work condition management
- work process management
- pro-active safety development

We also had control questions, e.g., on general job satisfaction and workplace climate, because these phenomena can colour the answers throughout the survey. With the control variables, we can estimate how much, e.g., general job satisfaction explains the answers to other questions. Finally, we had an open question in the questionnaire: „What are the most significant development areas in your organisation?"

The total number of personnel responding to the questionnaire was 124 (response rate 52%). Of the respondents, 16% worked in a managerial position.

4.3 Data analysis in the case study

The data analysis started with a ***document analysis***. We received a large amount of different documentation for review. We read the documents from the point of view of our criteria and collected our findings in a table (see Table 1). We analysed and discussed the following questions:

- How were ideal organisational performance and safety depicted in the documents? Were the conceptions of ideal organisational performance and safety clear and adequate when compared to our criteria of good safety potential? In other words, did the organisation emphasise all the areas that we consider criteria.
- What means are there for improving organisational performance and safety in the documents? Was organisational performance and safety approached with a broad scope? Were all the functions of our DISC model covered in the key documents?

The analysis of ***the interviews*** started already during the interview process. We conducted the interviews so that two researchers were always present. After each interview, we briefly exchanged our first thoughts on the interview. We expressed out loud what was new or similar in the interview compared with other interviews we had conducted. We discussed whether the interview had produced a clear picture of the topics in which we were interested, i.e., the safety culture criteria. Our conceptions were often similar. Sometimes, one of us had paid attention to a detail that the other had not noticed. We also taped all the interviews in order to be able to analyse them in greater detail and more systematically later. After the interview process had been

[1] The survey has undergone revisions during its development and validations in different industries. The names and contents of the dimensions therefore vary slightly from previous versions.

completed, we listened to the interview tapes and picked up findings that provided evidence of the fulfilment of the six criteria in the table.

The survey was analysed according to its measurement model, after the basic review of the quality of the data had been performed. According to our measurement model, the questions in part 1 should produce four factors: safety motivation, sense of responsibility, sense of control and mindfulness (see page 28). We factor-analysed the data and confirmed that the survey had worked as expected. It produced the four factors, and we calculated summated scales according to the factors. The summated scales were done by first summing up the items that loaded together and then dividing the results by the number of items. The reliabilities of the four summated scales were satisfactory. Thus, we were able to simplify the data in part 1 into four new variables that helped us visualise and analyse the data further.

An example of one way in which we presented the survey findings to the case organisation is presented in Figure 4. The mean values of the summated scales in part 1 of the questionnaire are in one profile picture in order to visualise the relative strengths of each dimension compared to the others. Presenting the results in this way can also work as a means of reflection for the target organisation when it is asked to say how it feels about the result.

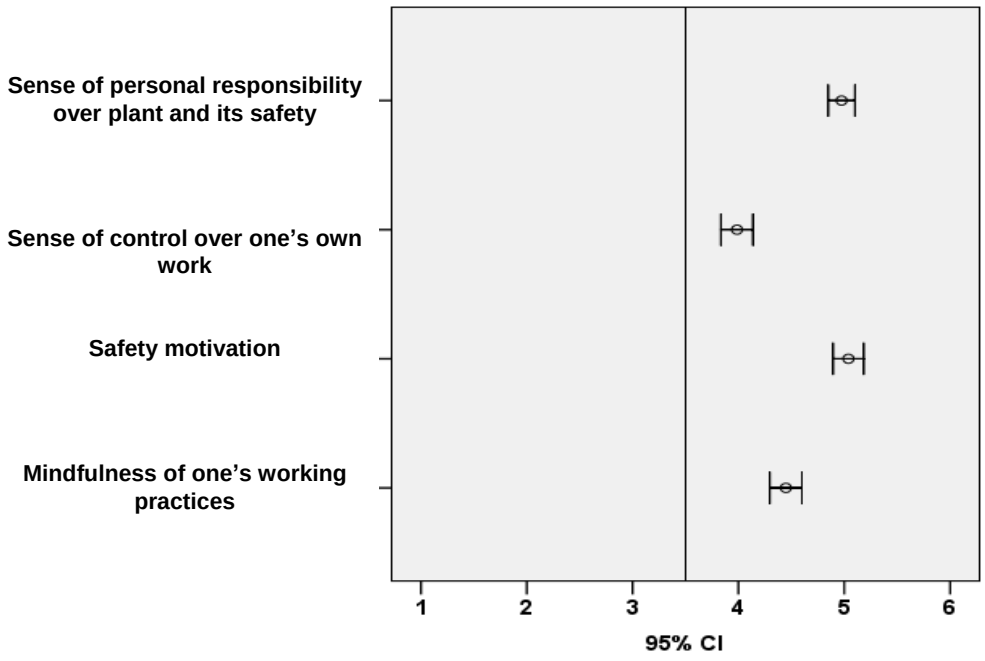


Figure 4. An example of the way we condensed and presented the survey findings. The 18 questions on the person"s work have been summed up in four dimensions. The mean scores of all the survey respondents to the four new variables are calculated and presented in a single graph. The figure can be interpreted to show that, on average, the employees feel responsible for the plant"s safety and consider safety a valuable and motivating factor, as they agreed on those statements. They consider their working practices quite mindful, but they feel they only have control over their own work to some extent. The mean score of the sense of control is above 3.5, which suggests that, on average, the work and workload are being managed, and it is not totally out of control.

The demographic questions in the survey provided us with an opportunity to compare the answers by different personnel groups such as organisational groups, age groups and position in the organisation. We discovered, for example, that the perceived workload differed between the maintenance fields (electrical, I & C, mechanical). Furthermore, we found out that some organisational functions that were measured in part 2 were evaluated quite positively by the management, while other personnel groups had a more critical view on the same function. An example of such a function is „management of change" (see Figure 5). All in all, our ANOVA analysis showed that the perception on a person"s work and organisation were quite similar across the organisation however.

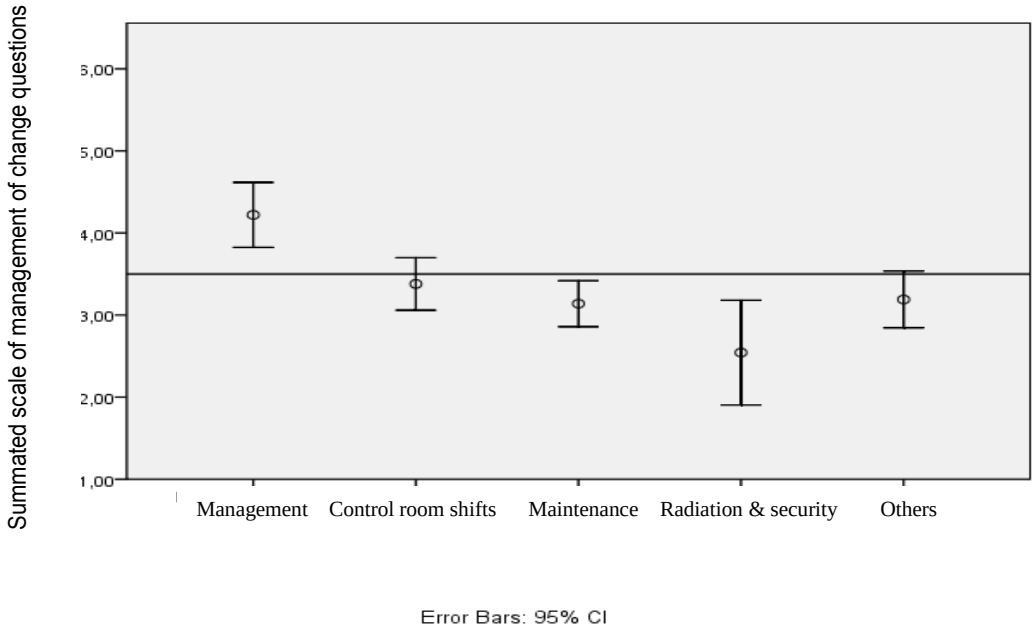


Figure 5. An example of how the survey can help inspect the sharedness of the perceptions in the organisation. We carried out the analysis of variance (ANOVA) for all the summated scales in the survey according to the age groups, personal groups and organisational subunits. When statistically significant differences between the groups were detected, we inspected which groups differed from the others and visualised this difference with an error bar graph. This figure shows that the management group perceives that the change management practices work better than, in particular, the maintenance personnel does.

The open question in the survey, „What are the most important development areas in your organisation?", yielded rich qualitative data on the areas that function poorly or need more attention. It also revealed the priorities of the respondents. The answers were either short and generic, or concrete and detailed, which is typical. We analysed the open answers according to the DISC model (see Figure 3 on page 26), which includes the organisational functions. Each answer was tagged to one or several of the organisational functions, or to one or several of the criteria, if it was evident from the answer. For example, the response *„the most important development would be to gain training on the new systems and their functions before they are taken into use'* was judged to be a suggestion related to the organisational function „competence management", but it was also judged to relate to one of the safety culture criteria, „understanding the core task demands and hazards". In most cases, it was quite easy to see on which of our organisational functions the development suggestion focused, but it was not always possible to

conclude reliably what the respondent thought about the fulfilment of the criteria in the organisation. In this case, we left it open. To increase the reliability of the evaluation, two researchers performed the classification independently and ended up with quite similar results.

To gain more information on the social norms and dynamics – and to validate our findings – we arranged a feedback seminar in September 2010 for the personnel of the case organisation. There we presented the preliminary results with examples of interview and survey findings. The audience commented on the results, either out loud in the seminar or by writing thoughts down on a piece of paper. In this feedback seminar, representatives from all the organisational groups were represented.

Furthermore, right after the personnel seminar, an extended management group meeting was arranged in which the managers discussed the results we have just presented and planned what to do about the challenges that had been identified. We also attended that meeting. The purpose of the feedback seminar and the management group discussion was to: a) verify our interpretations of the results and provide more information on some of the issues that had come up when analysing the results and b) make the people in the organisation commit to the results and discuss ways to go forward. The feedback seminar and the management group meeting confirmed and clarified our interpretations of the results.

4.4 Drawing conclusions on the safety culture of the case organisation

In the case study, our question was „What is the potential for safety in the case organisation, i.e. how well does the organisation fulfil the six safety culture criteria?" The fulfilment of each of the six criteria was evaluated on a four-point evaluation scale: very good, quite good, quite poor and unacceptable. A four-point scale was used because we wanted to avoid a "neutral mid point". We aimed to be clear on whether our judgement about each criterion was positively or negatively toned. On the other hand, in this case, there was no need to specify the level of safety culture in more detail.

In order to be consistent in the judgement, we described what the fulfilment of each of the criteria looks like in practice and when the performance should be judged as unacceptable. We also had written instructions for judging contradictory findings and other manifestations of safety culture (Appendix 3).

The evaluation was founded on all the findings we had analysed and structured as tables, graphs and memos. The fulfilment of each criterion was evaluated in light of three evidence categories (see Table 1 on page 27): organisational structures and systems, psychological experiences, and social norms and practices. The principle was that the criteria must be met in the official documents and shown in actual structures as well as in people's opinions. Furthermore, they needed to be present or plausible in the social climate of the organisation. Two researchers performed the evaluation phase independently with very similar results.

We found conflicting evidence with respect to certain criteria, for example, based on the interviews we hypothesised that the manageability of work was

very poor in some functions. The survey gave a much more positive picture of that aspect, however. Our instructions suggested that if the organisation"s predominant way of performing with respect to some of our criteria was good but not shared by all the personnel and age groups, we evaluated the criterion being fulfilled as quite but not very good. If we found inconsistency or unclarity in the way in which our case organisation performed with respect to a criterion (i.e., different data types suggested different things), we considered that criterion as being poorly fulfilled. Inconsistency and unclarity concerning the criterion theme means that the concrete organisational activities are hard for the management to anticipate because of double standards or imprecise expectations.

4.5 Reporting the results in the case organisation and giving recommendations

The final evaluation was provided to the case organisation management. In our presentation, we gave an explicit judgement of the fulfilment of each of the six criteria on a four-point scale: very good, quite good, quite poor and unacceptable. We listed our main arguments briefly below the evaluation statement. The case study organisation fulfilled all six criteria to a certain extent, i.e., none of the six areas was judged as unacceptable.

Our evaluation suggested a certain type of cultural profile in the case organisation. We thought it would be beneficial for the organisation to see a visualisation of its safety culture strengths and challenges even though the visualisation was a rough simplification. Therefore, we used the triangle picture of our safety culture criteria, which depicts the criteria of the three different types, to summarise our evaluation (Figure 6).

Our recommendations were quite open and generic on purpose because we judged that this case organisation would benefit from this kind of approach. When the management had familiarised itself with our evaluation results, it asked for a meeting to verify that it had understood them correctly and that its development ideas sounded sensible. The meeting was arranged and the evaluation team was satisfied with the ideas of the plant. The plant management also emphasised the need to follow up the development in the long run.

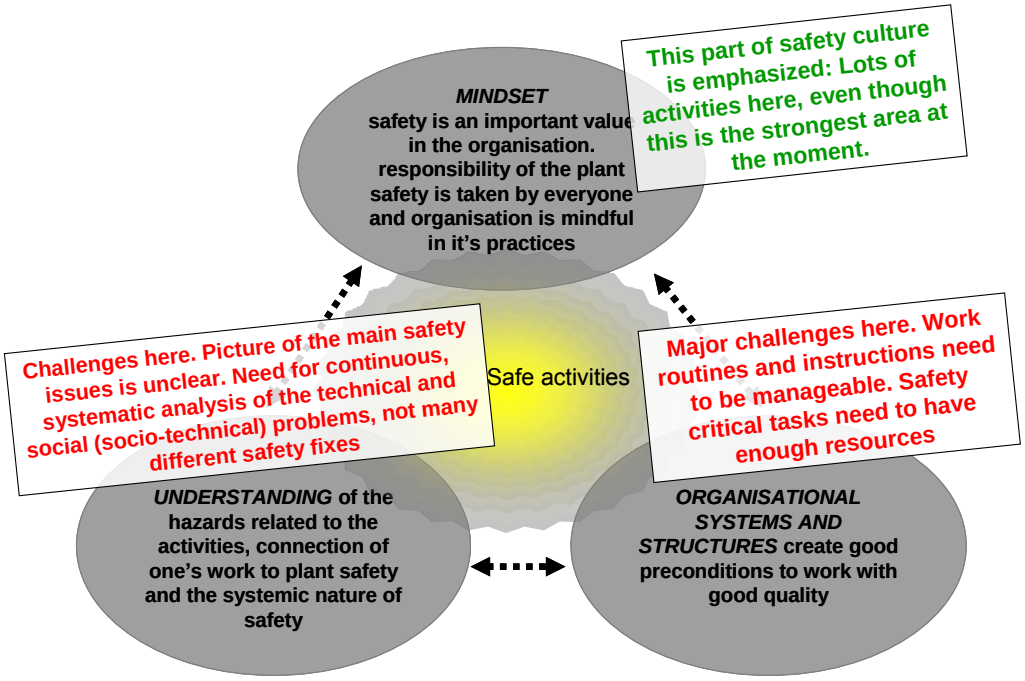


Figure 6. We used the simplified presentation of our safety culture criteria to communicate to the organisation that there was a certain pattern in the strengths and weaknesses of the safety culture. Current organisational development initiatives focus directly on working with the employees‟ mindsets. The picture aimed to ensure, for example, that the benefits of the current development initiatives are not reached fully if the problems in certain practices and their preconditions are not solved on an organisational level.

5. Conclusions

The process for conducting organisational evaluations described in this publication is constructed to support overall judgements of organisational performance in complex, safety-critical organisations, especially in the nuclear industry. The role of a solid background theory cannot be overemphasised when dealing with multifaceted phenomena like organisational activities and system safety. The validity and credibility of the evaluation stem largely from the evaluation team"s ability to crystallise what it means by organisation and safety when it conducts organisational safety evaluations. The data collection strategy follows logically from the previous stages.

Experience has shown that data analysis, especially interpretation and integration of employee"s conceptions, opinions and the work community phenomenon, is challenging if the evaluation team does not have members with behavioural or social science backgrounds. This guidebook illustrates the typical challenges in the analysis and provides assistance to the user to move on in the evaluation. It is advisable, however, to involve behavioural or social science experts in the evaluation process.

Nuclear industry organisations need to maintain an overview of the vulnerabilities and strengths of their organisation with respect to safety. Systematic periodical self-assessments are necessary to achieve this overview. The DISC framework presented as an example in this publication can be a basis for self-assessments too, even though in this case, the evaluation was performed by external experts. The DISC framework is designed to evaluate the organisation"s potential for safety in the near future. We call this potential safety culture.

References

Hollnagel, E., Woods, D. & Leveson, N. (Eds) (2006). Resilience Engineering: Concepts and Precepts. Aldershot, UK: Ashgate.

IAEA, Safety Series No. 75-INSAG-4. (1991). Safety culture. Vienna: International Atomic Energy Agency.

La Porte, 1996. High reliability organizations: Unlikely, demanding and at risk. Journal of contingencies and crisis management 4, 60-71

Oedewald, P. (2011). Safety management and organisational learning (MANOR) summary report. In Puska, EK & Suolanen, V. (2011) SAFIR2010. The Finnish Research Programme on Safety 2007-2010. Final Report. VTT Research Notes 2571. VTT. Espo, 27 - 35

Oedewald, P. & Reiman. T. (2007). Special characteristics of safety critical organizations. Work psychological perspective. VTT Publications 633. Espoo: VTT.

Rasmussen, J. & Svedung, I. (2000). Proactive risk management in a dynamic society. Karlstad: Swedish Rescue Services Agency.

Reiman, T. & Oedewald, P. (2008). Turvallisuuskriittiset organisaatiot – Onnettomuudet, kulttuuri ja johtaminen. Helsinki: Edita.

Reiman, T. & Oedewald, P. (2009) Evaluating safety critical organizations. Focus on the nuclear industry. Swedish Radiation Safety Authority, Research Report 2009:12. Stockholm: SSM.

Reiman, T. & Pietikäinen, E. (2010). Indicators of safety culture - selection and uilization of leading safety performance indicators. Swedish Radiation Safety Authority, Research Report 2010:07. Stockholm: SSM.

Reiman, T., Pietikäinen, E. & Oedewald, P. (2010). Turvallisuuskulttuuri. Teoria ja arviointi. VTT Publications 700. Espoo: VTT.

.

Appendix 1

A scheme of interview questions for key informants (managers and other key figures who have a valuable overview of the organisation)

The main aim is to gain background information about organisational structures, systems and history. Further the aim is to gain the opinions on safety, safety culture and development pressures. If you do not know the organisation very well beforehand, bring organisational charts and other material with you to the key informant interviews. Ask additional questions in order to understand the interviewee"s opinions and the organisations structures, etc.

BACKGROUND OF THE ORGANISATION'S SITUATION

1. Could you describe briefly your tasks, responsibilities and professional background?

2. What is your organisation/department?
   - What is the core task of your organisation?
   - Number of employees etc., basic figures
   - What are your organisation"s interfaces to other departments?

3. How has the organisation of the company developed over the years?

4. What are the pros and cons of the current way of organisation?

5. Have any recent pressures/changes affected the activities at the company?
   - How do they affect the activities now and how will they affect them in the near future?

THE KEY INFORMANT'S DEFINITIONS AND OPINIONS ON THE CORE CONCEPTS

6. How would you define *nuclear safety*?

7. How does your work contribute to nuclear safety?
   - How does it relate to overall plant safety?
   - Can you give practical examples?

8. If you had the task of assessing the strength of nuclear safety at a nuclear plant, what things would you consider?

9. What are the characteristics of a strong *safety culture*?

THE KEY INFORMANT'S OWN ASSESSMENT

10. What kind of safety culture does the organisation have?
    - How about the company as a whole?
    - Are there differences?

11. What challenges or development targets are there at the organisation?
    - How can the organisation improve its performance in the future?

Appendix 2

Interview scheme for personnel (includes experts and supervisors) from different departments

The main purpose is to meet representatives of the culture and to gain knowledge of their understanding, mindsets and perceptions of organisational structures and systems. Some interviewees are good at reflecting the culture of the organisation. Some informants are good on organisational practices and relevant technical changes.

PERSONAL BACKGROUND

1. Could you briefly describe your tasks and responsibilities?

2. At what department/function do you work?

3. How long have you been working here?

THE INTERVIEWEE'S PERCEPTIONS OF HIS/HER OWN WORK, SAFETY AND THE ORGANISATION

4. How well do the organisational practices and routines support your work?
   - Is it easy to carry out your work with high quality?

5. What is motivating in your work?

6. What is demanding in your work?

7. Does your work contribute to nuclear safety?

   - Can you explain how?

8. How would you define nuclear safety?

9. What kind of safety culture does the organisation have?

10. What challenges or development targets are there in the organisation?

    - How could the organisation improve its performance in the future?

Appendix 3

Description of the DISC criteria and judgement instructions used in the case study

1. Safety is a genuine value in the organisation and that is reflected in the decision-making and daily activities means that safety manifests itself, e.g., in the organisation‟s practices, documents and discussions, and in the individuals‟ self-reporting as a matter that is meaningful in a positive sense. Safety is meaningful and important because it is considered to be right, well and good. Improved safety motivates and energises.

Judgement instructions
Very good: The organisation works completely or almost completely as described above.
Quite good: The meaning and role of safety are not shared fully and thus they are moderately vague in the organisation. Perceptions of the meaning and role of safety in the organisation differ, e.g., between organisational units or personnel groups. Most of the findings suggest that safety is a genuine value in the organisation however.
Quite poor: The meaning and role of safety are definitely unclear or inconsistent in the organisation, e.g., the official statements and daily practices are in conflict, or safety is only considered an instrumental value to legitimise production. Double standards between written and executed values can be detected.
Unacceptable: There is no espoused safety work in the organisation (no safety goals, policy, safety management or similar evidence of the organisation's efforts to take safety into account systematically in its activities), or the organisation clearly shows a mindset in which safety is secondary to all other goals.

2. Safety is understood as a complex and systemic phenomenon means that the prevailing safety conception in the organisation encompasses the following aspects:

a. Safety is a dynamic **property of activity** that requires constant effort. It does not equal a lack of accident or good incident statistics and it cannot be decomposed into factors, or evaluated factor by factor, independently of other factors.
b. Safety is **influenced by interaction of multiple** stakeholders (individuals, groups, management, support functions, society). Each person and task has a potential to influence safety. This safety significance is clarified by different organisational practices so that each person can describe the effect on his/her work on safety. The interfaces of the actors are important to safety, thus the organisation aims to promote a good overview of work processes.
c. Smooth **interaction between humans and technology** is a precondition of safety. It is understood that people have a role in every stage of technology implementation.
d. There are **multiple types of safety** in addition to operational safety (e.g., occupational safety, information security, security, environmental safety). Their special requirements (e.g., knowing the different laws, different safeguarding measures) are taken into account.

Judgement instructions:
Very good: The organisation works completely or almost completely according to all the aspects (dynamism, complex interactions, socio-technicalness and versatility) of this criterion.
Quite good: There is moderate vagueness in the safety conception of the organisation due to the fact that the prevailing safety conception is not shared fully. There are differences in the way safety is perceived in relation to, e.g., the position or organisational groups. The majority of the findings suggest that safety is not oversimplified however.

Quite poor: There is broad unclarity or inconsistency in the safety conception. Official definitions of things that are needed to improve safety do not match the efforts that are carried out in reality to improve safety or safety development based quite narrowly on managing certain aspects of safety.
Unacceptable: There is no definition/slogan/picture of safety or things that are important to safety in the organisation, or the prevailing conception of safety is systematically oversimplified or skewed (e.g., 'technology is reliable and by removing human errors, we can develop safety at its peak' or 'safety means that we do not have serious incidents').

3. Hazards and core task requirements are thoroughly understood means that the organisation has a good outline of things that need to be managed in order to carry out the core task well and manage hazards that are part of the activity. A good understanding of hazards exists in all the organisation"s functions and at all the personnel levels. Each actor knows the possible risks embedded in his/her work in relation to all types of safety.

Judgement instructions:
Very good: The organisation works completely or almost completely according to the above description.
Quite good: There is moderate vagueness in the understanding of the core phenomena and the hazards due to the fact that the prevailing conception is not shared fully. There are differences in the way hazards and technical phenomena are perceived in relation to, e.g., position or organisational groups. The majority of the findings suggest that hazards related to the person's own work and the core tasks demands are known however.
Quite poor: There is broad unclarity or inconsistency in the knowledge and understanding of the core-task-related phenomena and hazards related to the organisation's activities. Official descriptions of these issues do not reach all the parties involved, or they are defined on a level that is too generic, or they are too unclear to communicate the understanding of relevant phenomena to all members of the organisation.
Unacceptable: There is no description of the core task of the organisation and the requirements it sets for controlling the hazards, or a clear fault conception of the core task requirements and hazards is widely shared in the organisation.

4. The organisation is mindful in its practices means that the organisation is capable of maintaining a mindset that views the knowledge and practices as maybe being imperfect, even though they are developed continually. The tolerance for expressing uncertainties is good, and organisational practices encourage questioning habits when they relate to identifying possible hazards. Risks are constantly monitored with the help of a variety of competencies and methods because the organisation is alerted to the possibility of new hazard mechanisms. The organisation uses, e.g., the field personnel, research and competence development to gain a better overview of the risks.

Judgement instructions:
Very good: The organisation works completely or almost completely according to the above description.
Quite good: There is moderate vagueness of mindfulness. Differences in the conceptions and practices concerning uncertainties in the nuclear plant and ways of acting in an alert way are perceived in relation to, e.g., the position or organisational groups. The majority of the findings suggest that the organisation shares a feeling of imperfect knowledge of the risks and thus puts effort into gaining more understanding.
Quite poor: There is broad unclarity or inconsistency concerning mindfulness of the practices. Official descriptions and statements emphasise competence, experience and management of activities more strongly than the need for questioning or expressing uncertainties.

Unacceptable: It is not permissible to express uncertainties related to risk assessment, management decisions or other relevant activities. Questioning of current practices is not allowed without concrete data of their inadequacy.

5. Responsibility is taken for the safe functioning of the whole system means that the organisation possesses an idea that every member has a possibility and responsibility to act for the safety of the whole system. Even though the official task descriptions are clear, there are practices and mindsets that encourage juridical accountabilities to be exceeded when safety may be affected for better or for worse.

Judgement instructions:
Very good: The organisation works completely or almost completely according to the above description.
Quite good: There is moderate vagueness on opinions of whether employees are responsible for the plant safety or only for their own tasks. Differences in the conceptions are perceived in relation to, e.g., position or organisational groups. The majority of the findings suggest that the organisation nurtures an idea that the responsibility is towards the whole plant however.
Quite poor: There is broad unclarity or inconsistency concerning responsibilities in the organisation. Official descriptions concerning responsibilities and expectations for employees are unclear or inconsistent, or they are not known or for some other reason do not guide the actual practices in a systematic way toward a broad responsibility of the plant's functioning.
Unacceptable: There are no descriptions concerning responsibilities for safety other than those in a situation in which someone needs to be held responsible for an event or the organisation employs a strict division of responsibilities based on juridical accountabilities when everyone only cares about his/her own matters.

6. Activities are organised in a manageable way means that there are sufficient resources for carrying out the jobs with good quality and according to the plans. Staffing level, competencies and work process knowledge are sufficient. In addition to the working conditions, timetables and tools are adequate for the work. Even exceptional work situations can be managed without total chaos.

Judgement instructions:
Very good: The organisation works completely or almost completely according to the above description.
Quite good: There is moderate and local vagueness with respect to planning and allocation of resources. The majority of the findings suggest that the organisation organised its activities in a manageable way, and tasks can be carried out with high quality.
Quite poor: The organisation struggles to organise its activities in a manageable way. In many activities, the actual course of action does not correspond to the plans or other descriptions due to the lack of personnel or material resources, or due to poorly designed work processes. The employees report mild or moderate difficulties of being in control of their tasks.
Unacceptable: The organisation has not defined the needed competencies, resources or work processes, or it has significantly failed in its estimates. The individuals' working practices determine the work processes on a situational basis. It acts in a fire-fighting mode because of insufficient resources and management.

2011:20

The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 270 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

SE-171 16 Stockholm
Solna strandväg 96

Tel: +46 8 799 40 00
Fax: +46 8 799 40 10

E-mail: registrator@ssm.se
Web: stralsakerhetsmyndigheten.se