

# Enhancing safety culture and safety leadership in the Swedish nuclear power industry

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## Introduction

This paper describes a project commissioned by the Swedish Nuclear Power Inspectorate (SKI) with the objective of enhancing safety culture in the Swedish nuclear power industry. The project arose following an international conference on safety culture held by the International Atomic Energy Agency in 2002, which yielded a conclusion that regulators should encourage a sincere interest in safety culture among licensed operators. In response to this recommendation, SKI began to explore a proactive path to safety culture enhancement, designed to gain a better understanding of the current safety culture status of the industry and to assess the extent to which human factors and safety culture issues were being understood and addressed within nuclear power facilities in Sweden. The project was intended to stimulate action by senior managers to review and enhance the safety culture and practices at their facilities, and to provide the regulator with an understanding of the strengths and possible opportunities for improvement relating to safety culture in this industry. The first of these objectives was met through a series of data collection and analysis phases, culminating in Management Workshops at each of the participating sites. The second objective was achieved by drawing together data from different sites into a report for the regulator of industry-wide findings regarding safety culture and the application of human factors principles (see Lowe & Hayward, 2006).

## Project Overview

The research assignment, entitled *Safety Culture Enhancement: A Field Study on Approaches to Enhancement of Safety Culture*, was undertaken by consultants from Dédale Asia Pacific between 2004 and 2006. The ultimate aim of the project was to enhance safety culture within the Swedish nuclear industry. The specific objectives were:

1. To understand the safety perspectives of senior managers at designated nuclear power sites, and the nature of their influence on the local safety culture;
2. To provide feedback to the senior management group at these sites on these issues and to suggest ways of improving the safety culture in their organisation; and
3. To give the regulator an industry-wide perspective about future requirements and opportunities for safety culture enhancement.

The initial phase of the project was conducted as a pilot study, involving the senior management group at one Swedish nuclear power-producing (NPP) site nominated by SKI. The pilot study was conducted to trial the proposed methodology and to confirm that the intended outcomes could be delivered. Satisfied with the results of the pilot study, SKI then extended the project and invited the remaining Swedish nuclear facilities to participate. The methodology was subsequently repeated in another NPP site and one nuclear fuel production facility. One NPP facility chose not to participate in the study because of internal constraints.

Confidentiality was an important condition of the project. All parties agreed that SKI was not to be provided with any specific or identifiable information, positive or negative, about the safety practices

or culture of any participating site. Detailed feedback was given to each site in their own summary report, but only general observations and conclusions were reported in the final project report to SKI.

## Methodology

The method used to achieve the objectives of the project involved: (i) a data collection phase to develop an understanding of the current status of the safety culture in the industry; (ii) an analysis phase; and (iii) a feedback stage in which findings and future action plans were discussed. A model of the elements that make up a safety culture was used as a framework to guide the project.

### *Project Framework*

The term ‘safety culture’ was first used by the International Nuclear Safety Advisory Group (1986) following a review of the Chernobyl nuclear plant accident. It has come into widespread use since that time to help explain why some organisations appear to be ‘safer’ than others, even though they may conduct equally hazardous operations. The International Nuclear Safety Advisory Group (1991) subsequently defined safety culture as ‘that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance’.

One review of the concept of safety culture notes that various definitions are now used within and across a range of industries (Zhang et al, 2002). In the present project, six characteristics of a safety culture were defined and described, as a basis for structuring the findings of the project. These are shown in Figure 1 below.



**Figure 1**  
**The elements of safety culture**

Of critical importance to a positive safety culture is management *commitment* to safety. Safety culture has been described as the aspects of an organisation’s reliability that depend on ‘shared values and norms of behaviour articulated by senior management and translated with high uniformity into effective work practices at the front line’ (Gaba et al, 2003). This definition emphasises the direct and powerful influence of an organisation’s leadership group on the safety attitudes and behaviour of employees. The critical importance of management commitment is also noted by Hopkins (2002), who states:

‘It is *management* culture rather than the culture of the workforce in general which is most relevant here. If culture is understood as mindset, what is required is a *management* mindset that every major hazard will be identified and controlled and a *management* commitment to make available whatever resources are necessary to ensure that the workplace is safe.’

Formal management accountability is also implicit in the other elements of safety culture, as characterised by Reason (1997) and Hudson (2003). They suggest an organisation's safety culture is defined by the following attributes:

- *Informed Awareness* – managers know what is going on in their organisation and the workforce is willing to report their own errors and near misses;
- *Wariness* – the organisation as a whole and its employees individually are on the lookout for unexpected events, and maintain a high degree of vigilance;
- Capacity for *Learning* – the organisation is ready to learn and has the will to implement reforms when they are required;
- *Flexibility* – the organisation reflects changes in demand and continues to operate effectively in high tempo and unusual circumstances as well as routine conditions; and
- Commitment to a *Just Culture* – the organisation has a 'no blame' approach to errors, but applies the appropriate penalties to unacceptable actions (violations).

The safety culture enhancement project was undertaken to determine the current status of these safety culture elements within Swedish nuclear facilities, and to suggest appropriate strategies or practical actions to overcome any identified gaps or deficiencies.

An interesting challenge to the project arose from the fact that the Swedish nuclear power industry already has a reputation for being very safe, and as having a positive safety culture. This industry has not experienced a major accident, has had very few significant incidents, has a good lost time injury rate, and has a reputation for being well run by competent and conscientious employees. The objective of the project was not, therefore, to address known deficiencies, but rather to suggest ways of enhancing safety in an already safe industry.

The approach adopted was based on the premise that the senior managers at a nuclear site have a significant influence over the organisation's culture. It would therefore be important to understand their collective attitudes and behaviour on safety issues, and the impact of these on the organisation as a whole. In addition, it is known that industries and organisations that have been sufficiently fortunate to avoid having a serious accident are often at risk of becoming complacent and less wary about the potential for a safety occurrence to take place. A defined objective of the project was thus to detect any sense of such complacency and to draw this to the attention of managers. A number of the activities discussed below were designed specifically to re-focus managers' attention to safety objectives.

The methodology at each site visit involved the same three phases (data gathering, data analysis, and Management Workshop), although these activities were refined as the project progressed. The personnel asked to participate in these activities were given information in writing explaining the objectives of the projects, the methodology to be followed, the deliverables and the confidentiality guarantees. During the project, the Dédale team worked closely with SKI's human factors personnel (known locally as Man Technology Organisation or MTO experts) to ensure the project resulted in minimal disruption to site activities.

The intention of the project was not to perform a formal, non-technical audit of the nuclear facilities. Although a relatively structured and consistent process was followed, the approach adopted did not employ formal audit tools or validated survey instruments. The priority concern was to provide feedback and ideas on best practice to industry managers in regard to human factors and safety culture that might be useful to them when planning future safety enhancement activities.

### *Step 1 ~ Data gathering*

The data gathering stage involved semi-structured interviews (of approx 90 minutes each) with all available members of the senior management group at each site, to ascertain managers' views on a range of standard operational safety and human factors issues. A total of 46 managers were interviewed across the three sites, representing all operational units and key functional areas.

Focus groups were also conducted with operational staff to provide a worker perspective on local safety practices and safety culture issues. The focus groups were designed to elicit opinions about topics such as the prevailing organisational culture as it impacted on safe behaviour, the extent to which errors and incidents are reported and the behaviour of managers in emphasising safety as a priority. Five focus groups were conducted, involving in total 45 employees. These included control room operators, engineering and maintenance workers and other production staff. The opinions of

operational staff could then be compared and contrasted with those of senior management in the subsequent data analysis stage to gain an understanding of the safety culture status both in principle and in practice.

The focus groups and interviews were conducted by the same two consultants from Dédale, providing additional standardisation in the data gathering phase. Participants were notified in advance of the project objectives and the nature of their involvement, and were advised that all interview notes and records would be kept confidential with observations reported in a way that did not identify any individual.

### *Step 2 ~ Data analysis*

Following the data gathering stage, the information from the interviews and focus groups was collated off-site, with care taken to ensure that the source of any comments was not identifiable. Key observations regarding local safety culture issues at each site were summarised and integrated into material that was used for feedback and discussion in the Management Workshops.

### *Step 3 ~ Management Workshops*

The key focus of this project was on senior managers who, as noted above, have a strong influence over the safety culture of an organisation. Workshops were held over two consecutive days at each of the participating sites, involving the senior managers who had been interviewed in the data gathering phase. The workshops were facilitated by three consultants and had the following objectives:

1. To provide site management with a 'snapshot' of topical issues, concerns, beliefs and attitudes related to their safety culture;
2. To stimulate creating thinking and action by managers about the importance of continuous enhancement in safety culture; and
3. To provide managers with practical advice that would support future safety promotion activities.

To achieve these objectives, the Management Workshops were designed around six core activities, involving a blend of presented information, facilitated discussion and structured exercises. The six activities are described below.

*Activity 1 – Safety Culture Principles and Observations.* The first activity involved presenting distilled information from the senior management interviews and operational staff focus groups to the managers. This feedback was structured around the six elements of the safety culture model illustrated in Figure 1. Each safety culture element was defined and explained. Local observations and examples of activities, actions and attitudes relating to each item were then presented and discussed. Finally, a number of site specific 'discussion issues' were raised, identifying areas where it was felt the potential existed for the site to consider further aspects of the element and to review their current strategies. This activity was designed primarily to address the first objective listed above, by presenting site management with feedback on the key themes and observations from the data gathering phase.

*Activity 2 – Management Safety Culture Perceptions.* The purpose of this activity was to build awareness of safety culture issues by comparing and discussing managers' different impressions about the safety culture at their site. A brief 'Safety Culture Perceptions' questionnaire was given to the managers at the beginning of the workshop. The questionnaire asked, for example, how often employees report their errors and violations, and about the extent to which recommendations were implemented following an incident investigation. Individual responses to the questionnaire were kept confidential but group results were progressively reported back and discussed throughout the workshop under the appropriate safety culture element.

This activity was created to highlight differences of opinion among the managers regarding how well their site was demonstrating key attributes of safety culture. The results clearly indicated a diversity of opinions and perceptions amongst managers at each site about the safety practices and levels of commitment to safety within their organisation. This realisation was intended to prompt the managers to re-evaluate their collective appreciation of, and approach to safety leadership, given that a positive culture must be based on *shared* understanding and common practices.

*Activity 3 – Safety Investigation.* A specific topic of discussion in the Management Workshops was the incident reporting and investigation practices and processes within each site. The extent to which employees report safety occurrences and the way an organisation tracks, investigates and acts to prevent these, are important aspects of safety culture. However it is known that, for a variety of reasons, few organisations are consistently able to apply ‘best practice’ systemic investigation processes and maximise learning from safety occurrences. The current practice of safety investigation, and possible areas for improvement, were explored within the Workshops.

*Activity 4 – Management Safety Competencies.* The actions of an organisation’s leaders are critical in influencing the behaviour and attitudes of employees in regard to safety. This activity involved a practical exercise, conducted during the workshops, to develop a list of ‘Management Safety Competencies’. These were defined as descriptors of the behaviour that managers would display if they were demonstrating a strong and obvious commitment to safety. The process involved a group ‘brainstorming’ session in which managers were guided to generate a list of such behaviours. The aim was to challenge individual managers to compare the behaviours they currently exhibited in regard to safety with the different and desired behaviours suggested by the group. This activity addressed the third objective of the Management Workshops by delivering practical guidance on the definition and performance of safety leadership,

*Activity 5 – Accident Scenario Exercise.* A considerable portion of each workshop was devoted to the accident scenario exercise. In this activity the senior managers worked in small groups to develop a hypothetical scenario under which a nuclear accident could feasibly occur at their site, and to develop recommendations to prevent such an occurrence. The managers were provided with a structured method for creating their accident scenarios and reporting their findings, based on the Reason Model of organisational accidents (Reason, 1997).

The aims of this exercise were to consolidate understanding about how accidents occur and how they can be prevented, to identify systemic risk factors that could potentially contribute to an accident or incident, and to provide insight regarding the threats to operational safety at each site.

Each group was guided to produce a structured systemic analysis of their chosen hypothetical scenario, incorporating identification of the factors that would contribute to the event and a set of realistic recommendations to address those factors and prevent the occurrence. The recommendations were to address specifically the (latent) organisational deficiencies that contributed to the event, and the controls or barriers that failed.

The major practical benefit from this exercise is that it stimulates thinking about the organisational decisions, local hazards and conditions, and human actions (errors and violations) that contribute to a serious incident. This enables useful safety lessons to be learned without the cost of having a real accident.

The more important outcome from this exercise is to heighten unease about the potential for a serious event at the site. Wariness is a tenuous attribute of organisations, typically stimulated only after the ‘fright’ of a near miss. Wariness tends to decay imperceptibly when a safe organisation has no active memory of such an event. Asking managers to contemplate a hypothetical but realistic catastrophe in their jurisdiction is a compelling means of re-focussing their attention on safety and promoting a sense of constructive unease.

Since the workshop, at least one participating site has adopted this process of ‘hypothetical incident investigation’ and extended it to other employee groups to raise awareness of the potential for accidents and to anticipate safety improvements.

*Activity 6 – Open Discussion Sessions.* At regular intervals throughout the workshops managers were invited to raise questions or issues relating to safety culture or safety management. The topics raised were incorporated into general group discussion and commented on by the facilitators, with reference to practice in other industries and relevant research.

The deliverables from the project included three confidential Site Reports, providing written feedback from the initial interviews, focus groups and workshops, and a Final Report to SKI outlining the methodology adopted, overall findings on positive attributes observed within the safety culture of the industry and opportunities for improvement, and recommendations for future actions.

## Enhancing Safety Leadership

One of the general recommendations for improvement provided to SKI related to safety leadership. A finding from the project was that, while the observed management commitment to safety in the industry could be described as generally strong, there was variability within and across sites regarding the extent to which managers exhibit the behaviours that reflect a strong commitment to safety. It was suggested that some managers could express interest in safety more effectively and could show more visibility, accessibility and responsiveness to the views of the workforce on safety-related matters. In addition, it was noted that relatively young managers tended to be promoted to senior roles in the industry on the basis of having sound technical competence, but without necessarily having a deep understanding of, or formal training in, their safety leadership responsibilities. Given that effective safety leadership is a key determinant of safety culture, one of the recommendations from the project was to introduce formal processes to ensure the ongoing development of safety-related competencies amongst industry managers.

To support this process, the management competencies generated in Activity 4 of the Management Workshops were integrated into a set of draft safety leadership competencies for nuclear power industry managers. These were produced in the form of short, precise descriptors of observable behaviour ('behavioural markers') grouped into a series of competency elements to form a behavioural marker system. The competency areas and example behaviours are set out below.

- *Showing commitment*: Demonstrates interest in safety activities/matters; Shows persistence in addressing safety issues and deficiencies; Displays enthusiasm regarding safety checks and activities
- *Promoting safety*: Communicates about safety/delivers safety culture messages; Highlights past investments in safety; Promotes safety as a top priority
- *Clarifying safety goals*: Explains organisational goals and vision regarding safety; Expresses clear expectations about safe behaviour; Sets and communicates clear safety goals
- *Being actively involved*: Is systematically visible; Is seen around by staff, regularly interacts with people; Coaches and leads staff via dialogue
- *Setting an example*: Follows safety rules, sets a positive example; Leads by example in acting safely; Ensures that own behaviour is consistent with words
- *Listening to concerns*: Listens to, acknowledges and values employee inputs/opinions; Encourages staff to be open and express any concerns about safety; Listens to input from employees regarding safety issues
- *Implementing improvements*: Acts to correct safety deficiencies, unsafe behaviours and circumstances; Communicates lessons from safety events; Identifies, records and rectifies safety hazards; Shows concern/acts to fix safety problems, and reports back on results.
- *Acting justly*: Communicates understanding that humans are fallible and will make errors; Treats people consistently and fairly – follows a 'just culture' policy
- *Seeking to understand*: Asks 'how is safety?' (enquires about safety 'health'); Enquires about the reasons for 'inappropriate' behaviour; Asks why incidents happened
- *Shaping behaviour*: Reacts appropriately when good/bad safety behaviour is observed; Challenges people about inappropriate actions/behaviour; Corrects inappropriate actions/behaviour promptly; Recognises positive safety behaviours, e.g., reporting of events
- *Being wary*: Seeks information on future risks; Displays a questioning attitude about the way we do things here; Follows up to ensure safety responsibilities are being carried out; Demonstrates a desire to learn from safety events.

It was recommended that this draft safety leadership framework be extended and further refined to produce a Safety Leadership Competency model for the industry. This model could then be used as a standard to help align the behaviour of all managers and, more importantly, could provide a benchmark for developing the competence of newly promoted or less experienced managers in the non-technical skills required for effective safety leadership.

## Recommendations

Eight additional recommendations to support the further enhancement of safety culture in the industry emerged from the analysis of data gathered during the initial interviews, focus groups and management workshops. These were as follows:

*Utilising Human Factors Expertise.* A recommendation was made to strengthen the resources, contribution, value and profile of human factors / MTO expertise within nuclear sites, in order to promote a better understanding of human performance issues, and enhance error management and accident prevention capabilities.

*Embedding Positive Safety Culture.* It was proposed that nuclear power plant operators identify ways to permanently embed existing positive safety culture attributes. This recommendation was considered important given the increasing use of contractors in the industry and the fact that a large proportion of the workforce is now reaching retirement age, having joined the industry at its commencement. Ways to implement this recommendation were suggested, involving the use of formal policy statements, discussions, training and promotional information on safety culture, as well as reinforcing safety culture principles, behaviour and language during safety meetings, training sessions and operational debriefings.

*Standardised Investigation Methodology.* The need identified here was to standardise and improve aspects of the incident and accident investigation processes and analysis methodologies currently used within the industry, in order to improve information sharing and optimise learning. Implementing this recommendation would involve ensuring adherence to a 'no blame' investigation philosophy and a systemic approach to accident analysis, as well as incorporating a distinct focus on human factors issues. It would also require use of a reliable, structured analysis technique incorporating a logical basis for safety recommendation development and a common 'language' for communicating lessons learned to all relevant parties.

*Human Factors Awareness Training.* The project suggested there would be benefit from implementing harmonised human factors / MTO awareness training programs at appropriate levels for all nuclear industry personnel. Such an approach would ensure minimum human factors knowledge and skill standards at entry level as well as in progression to higher roles.

*Team Resource Management Training.* Following the example of industries like aviation and healthcare, a recommendation was made to extend and formalise the use of applied teamwork training (as per principles of Crew Resource Management (CRM) training in aviation) for control room operators, maintenance workers and other employees working in safety-critical teams. It was observed that a process similar to CRM training was being used at some locations with control room operators, but not with all employee groups for which effective team performance is critical to safety. It was suggested that such training be integrated within the wider umbrella of human factors training and promoted as part of a 'universal operating philosophy' based on identifying and using all available resources to achieve safe outcomes.

*Non-technical Team Simulation Training.* An opportunity was identified to increase the use of simulation training to enhance non-technical team problem-solving and decision-making skills. It was suggested that Line Oriented Flight Training (LOFT) style training or desktop exercises could be used to assess and develop skills in cooperation, communication, teamwork under pressure and problem identification, analysis and resolution.

*Defending Against Complacency.* This recommendation addresses a perennial threat for 'ultra-safe' industries, that of becoming complacent about good safety performance and reducing the attention given to accident prevention. It was suggested that techniques for recognising complacency and maintaining wariness, such as those trialled during the Management Workshops, could be utilised for this purpose.

*Measuring Safety Culture.* This recommendation proposed that a process be implemented to provide regular quantitative measures of the industry safety culture, as a guide to future enhancement actions. A questionnaire approach was recommended for measuring elements of safety culture, aggregating data to identify particular areas of concern for the industry, and repeating the survey annually to provide trend information and early detection of changes in safety culture attitudes or behaviour.

The nine recommendations from the project incorporated opportunities for action at both the site and industry levels. The final report delivered to regulator (Lowe & Hayward, 2006), on which this paper is based, describes in further detail the observations that led to these recommendations, and

suggests strategies for implementing them. The report also includes additional information on the project methodology, as well as providing a comprehensive qualitative picture of safety practices across the participating Swedish nuclear facilities.

## Conclusions

Some time after the final project report was delivered, SKI sought informal feedback from the participating sites. SKI's impression from this feedback was that the project was very useful overall in assisting the licensed operators to progress their own safety culture activities. In particular, two of the facilities reported using the inspiration and momentum created by the project as a lever for their own safety culture programs. SKI also observed that it has taken some time to bring into focus the notion of safety leadership amongst the licensed operators. The project highlighted the importance of improving safety leadership, and helped establish this as a clear priority for the Swedish nuclear power industry.

The project also yielded a number of important lessons regarding safety culture enhancement that can be generalised to other industries. First, even 'ultra-safe' organisations can benefit from an independent analysis of their cultural constitution, and use this to identify opportunities for improvement. Second, management thinking, attitudes and behaviour are critical determinants of safety culture. Cultural change or enhancement is best enacted by working through the organisation's senior management group. Third, activities that disrupt complacency and promote 'constructive worrying' can be beneficial in organisations that are fortunate to have not experienced accidents. Finally, traditional models of safety culture were relevant and meaningful to people in the Swedish nuclear power industry, and provided a useful framework for organisational analysis and improvement.

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