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ORGANISATIONS AND THEIR SAFETY PROCESSES

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Abstract

Organisational factors have in many incidents and accidents proved to be one of the most important contributors to human errors at nuclear power plants (NPP). The problem with this finding is that very few methods exist for the identification of organisational deficiencies which may contribute to high error probabilities. Methods for the support of managing high reliability organisations have been the target of research efforts in VTT Automation. The paper gives a brief reference to some research which has been carried out in connection to the LURI- and ORINT-projects.

1. Introduction

It is widely recognised that safe and reliable operation of high risk industrial systems depends not only on technical excellence, but also on individuals and the organisation. An efficient management of safety and availability implies an in-depth understanding of behavioural characteristics of the operated system. including technological, human and organisational aspects of operation. Systems have grown larger and more complex which has made their control more difficult. One remedy is to design the systems to be better adapted to their users and another is to make managers better aware of couplings between technical and organisational performance.

VTT Automation has been involved in nuclear safety research since the early seventies. The projects have included control systems, human factors, reliability assessments, training simulators and operator training. Partners in the project

have been the nuclear power plants (NPP) both in Loviisa and Olkiluoto as well as STUK, the Finnish regulatory body. In addition VTT Automation has been involved in several international project within the Nordic nuclear safety research (NKS) and in co-operation with international organisations. The research has been based on a fruitful combination of systems engineering and behavioural sciences. The close co-operation with the nuclear utilities in Finland and also to some extent in Sweden has provided a fruitful combination of theoretical and practical challenges. Various activities with an application to high reliability organisations have recently been brought together to form a central research theme within VTT Automation.

2. Nordic nuclear safety research

Control room design, human reliability and operator training were selected as major themes in the Nordic nuclear safety research (NKS) when the research was started in 1976. Later programmes addressed among others themes such as organisational influences on human reliability, information support in emergency management and human interactions in PSAs. Several organisations in Denmark, Norway and Sweden have together with VTT Automation been actively engaged in the projects. These organisations include the Risø National Laboratory in Denmark, the OECD Halden Reactor Project in Norway and the Swedish Nuclear Power Inspectorate. The work has over the years contributed to an improved understanding of various safety issues connected to nuclear power.

The last Nordic four year research programme in nuclear safety was completed in 1997. The inputs from VTT Automation to this programme were co-ordinated closely with the two RETU projects LURI "Reliability and risk analyses" and ORINT "Human factors in NPP operations". One of the projects NKS/RAK–1 "Strategies for reactor safety" addressed various safety aspects, including management and organisations. In the subproject NKS/RAK–1.1 "A survey and an evaluation of safety activities in nuclear power" a broad investigation of various safety activities was made. In the subproject NKS/RAK–1.5 "Modernisation for safety in Nordic NPPs" the plant modification processes and the ongoing modernisation projects were studied and assessed. In both subprojects a special consideration was placed on a comparison of safety

practices in Finland and Sweden. A large number of people from Finnish and Swedish utilities and regulatory bodies were interviewed as a part of work.

The general impression from the studies is that the safety activities at the NPPs in Finland and Sweden are efficient and well targeted. One problem in the industry is that the work load of people generally is high with occasional peaks of extremely high work load. This problem seems to be partly connected with a high ambition in the work and partly with mounting economic pressures caused by the deregulation of the electricity market in the Nordic contries. Experience from the studies point to the benefit of comparisons of practices as a method to identify important components of organisational safety and possibilities for improvements. The interviews proved to be an efficient way of rapidly acquiring an impression of the performance of an organisation. Specific problems can be followed up by more detailed studies.

3. The organisation seen as a control system

The organisation of a NPP can with an analogy be seen as a control system which ensures that activities and work processes are carried out appropriately and efficiently. This control system is implemented by people and through people, which means that it is both self-structuring and adaptive. Important questions are how organisational structures and work procedures influence the quality of work and which measures are needed to achieve an acceptable level of safety. Various evidence from NPP operations gives an impression that some work processes and practices are more efficient than others. The challenge is to identify and rectify unsafe practices before they result in incidents or accidents.

Control systems rely on the concepts of *set point*, *control action* and *feedback*. Organisations can similarly be said to rely on the concepts of *goals*, *means* and *experience*. Goals have to be defined and further specified according to the line structure of the organisation. Means for achieving specified goals have to be selected among best available practices. Experience has to be collected and used to improve applied practices and to reconsider the goals. To be efficient the considerations of goals, means and experience should be an integral part of each organisational unit of a NPP.

Two other important concepts are *quality* and *barriers*. The quality concept relies on a defined quality and a description of how this quality can be reached. Regular audits to ensure that defined methods are used in the work processes are parts of the quality system. Barriers are used in technical systems to prevent unsafe excursions. Administrative barriers are used in a similar way to prevent work of a low quality to proceed within the system. One important barrier is an independent safety assessment which is carried out both within a NPP by the utility itself and by the regulator as an outside activity.

4. Decision making in NPP organisations

There are many similarities between organisations in general and organisations managing NPPs, but there also important differences. The most important difference is the very high safety requirement which is due to the fact that the reactor requires a continuous attention and that failures in this respect can lead to radiological hazards. The high safety requirement leads to conservatism and reliance on proven solutions. A NPP is very complex system which for its operation demands high skills in several different disciplines. The complexity of the interaction between various technical systems on one hand and between the technical systems and the human and organisational systems on the other hand, makes it very difficult to predict in detail how a NPP will behave in a specific situation.

Hands on operational decisions are made in the main control room. The control room operators depend on convenient information presentations which support the detection of deviations in main plant variables and the selection of correct actions for handling disturbances. Preventive and corrective maintenance is carried out according to plans and in response to failures. The yearly planning process identifies plant modifications to be implemented within the planning period of operation and outages. Strategic planning has a longer time horizon in which needs for investments are considered in the context of both technical improvements and development of human resources.

Models of a rational decision making are based on expected utility theory. According to the theory the utility of an outcome of a decision is weighted with the probability of achieving that outcome. The normative decision rule is to

select the option which gives the highest expected utility. The theory often gives useful insights, but a strict normative approach is seldom practical in real world decisions. The problem is that in practice it is not possible elicit individual utility functions and obtain probability estimates with a necessary accuracy. In real time decision making the theoretical framework has to be reduced to simple rules of thumb to be practical. The consideration and resolution of conflicting objectives pose their own problems.

5. Components of organisational excellence

A definition of organisational excellence has to rely on some model. The problem in finding a suitable model is to balance between a model which is too simple to give only trivial answers and a model which is too complex to be practical. The model should also be understandable for those who are expected to use it. A model can be used to help in collecting information on the performance of an organisation as well as for improvements. Before a model can be used it has to be validated.

A model consisting of six basic principles important for an efficient management of safety has been suggested. The principles can be described by the concepts of *organisation*, *planning*, *models*, *information*, *feedback* and *priorities* which reflect interconnected resources and activities. An organisation is built through the allocation of responsibility and authority which should be balanced, structured and described. Systematic planning including a definition of goals and an allocation of resources is a prerequisite for good performance. Efficient concepts, models and processes should be utilised to support safety activities. Correct and timely information in all operational situations and work processes requires an efficient information system. Systematic feedback and use of operational experience for organisational learning is crucial for a continuing improvement of performance. Setting of priorities requires methods for assessing costs and benefits of various actions.

The six basic principles can be used to generate an idealised organisational model of activities to be reviewed. This model can in a second step be used to formulate questions by which assessments of an activity can be obtained. In a first set of questions a check can be performed that all important components are

covered in the activity. In a second set of questions the functional efficiency of these parts can be investigated. A third set of questions can interrogate the interactions of the components and the efficiency of the interactions. A final set of question is concerned with the documentation of the activity and its parts.

6. Performance shaping factors

Performance shaping factors have been used in PSAs to predict the likelihood of human errors. Performance shaping factors can be used more generally to understand situations where decision makers make their decisions. It is evident that stress and a heavy work load will make decisions more vulnerable for errors. The difficulty in using performance shaping factors is that their actual influence for instance on error probabilities is difficult to assess, but they can still give clear indications for areas where improvements are needed.

Performance shaping factors can be divided e.g. into environmental factors, task related factors, individual factors and organisational factors. Among the environmental factors are things like noise, temperature, radiation, etc. Task related factors are concerned with availability and quality of information and instructions, time for task, time of the day, etc. Individual factors include skills, competency, attitudes, beliefs, etc. Organisational factors include authority, responsibility, structure, communication, etc. Performance shaping factors can be assessed in various ways using both objective and subjective measuring methods.

The influence of unfavourable performance shaping factors can be reduced in several ways. The influence of environmental factors can be reduced by shields and protecting wears or the task in consideration may be automated in parts or completely. Task related factors can be influenced by a re-allocation of resources, by improving man-machine interfaces, by re-writing procedures, introducing various support systems, etc. Individual factors can be influenced by selection and training of personnel. Organisational factors are determined by management styles and practices. Already an awareness of the influence of various performance shaping factors on human reliability can, together with an understanding of the criticality of certain decisions, give a good list of safety related topics that deserve special attention.

7. Performance indicators

Performance indicators are used when performance itself is too complex to be measured directly. Performance indicators are also valuable where actual performance builds on several interdependent characteristics inter-connected by long time constants. Performance indicators can in a way be said to provide feedback on future performance before trends can be seen in actual performance. NPPs use various systems of performance indicators which include mainly "hard" technical indicators. In the consideration of organisational factors the possibility to define "soft" performance indicators, i.e. indicators suitable for assessing individual commitment and organisational efficiency is an interesting possibility..

The definition of performance indicators has to build on actual and assumed relationship between real performance and the suggested indicators. Sometimes it may be difficult to establish a valid causal coupling between an indicator and performance, but that does not necessarily render the indicator useless. Performance indicators should be accepted within the organisation, they should be difficult to deceive, they should reflect true performance and they should be changed whenever needed. A continuous recording of performance indicators can help in detecting weak signals of organisational deterioration. The benefit of well defined performance indicators is that they make it easier to set priorities through the quantification of important aspects of safe operation. Performance indicators can to some extent be used to compare the efficiency of various parts of an organisation. Performance indicators are well suited to normal situations, but they are not adapted to an analysis of incidents. Depending on the indicator, the necessary data for its calculation can be collected either by continuous measurements or by taking samples at regular intervals.

One way of taking the full advantage of performance indicators is to integrate them into the management processes. They can and ought to be incorporated into the process of defining goals and targets and they should form the backbone of the feedback of experience. Ideally performance indicators should be linked to company values which can give them a valuable position in internal discussions on goals and priorities. Performance indicators are sometimes used to create additional incentives within the organisation through a bonus system. The indicator system should be the object of a continuous assessment and

redefinition to ensure that real performance, and not the indicators, is controlling the path of organisational development.

8. Benchmarking safety

A comparison of work practices, a benchmark, can give valuable information on different ways of designing and conducting safety related activities. A benchmark builds on some similarity between the work processes compared, but it also benefits from the differences. If differences are found in the practices, the question is which practices are better and why. A benchmark can be brought to a quantitative level e.g. by comparing the allocation of resources and the efficiency of concerned work processes.

A benchmark carries several difficulties. Practices may be difficult to compare, because they are too different. Findings may also be difficult to transfer between different cultural settings, because they may have been produced by different socio-economic environments and/or legislative systems. There is also an inherent expectation in a comparison that one of the practices is the best, which is not necessarily true, because each practice has evolved in a process of adaptation to a specific situation. Nevertheless, observed differences have to be interpreted and understood in detail before conclusions can be drawn.

One issue in every benchmark exercise is to identify topics to be addressed. A second issue is to agree on the depth of the exercise. A decision to go deeply into the activities may involve a large effort, but a shallow study may not bring up the important questions. Activities with a large influence on safety are always more important to investigate. For a benchmark between several organisations it is often necessary to involve outsiders to ensure independence in interpretations and recommendations. It may also be easier to achieve the necessary openness in interviews when they are carried out by persons outside the organisations. In the evaluation of impressions from interviews it is necessary to understand that there always are tensions in organisations. The existence of tensions should therefore not be interpreted as an indicator of problems. Such tensions are typically handled within regular management processes and one may even claim that they are an important ingredient in maintaining a continuing safety.

9. Conclusions

The consideration of organisation and management issues as contributors to nuclear safety is becoming increasingly important. One of the difficulties is the absence of a theoretical framework within which organisational factors and their causal relationship can be handled. Such an theoretical framework could also support data collection and organisational development. In a comparison with the technical systems it seems evident that new modelling methods for organisation and management will be required.

Safety is a fundamental prerequisite for the use of nuclear power. The extreme safety requirements of nuclear power will need special precautions and methods. The consideration of high reliability organisations as an object for research may help in this endeavour. A fruitful combination of theory and practice is a necessary precondition for success. A close interaction between systems and behavioural sciences is another where VTT Automation has been involved. If these efforts will succeed nuclear power can remain as a realistic energy option also in the future.