

Management systems and safety culture; reflections and suggestions for research

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Abstract— Management systems can be seen as the software of an organisation. Present views on managements systems have emerged from several sources and have now been integrated into the guiding documents produced by IAEA. A discussion of the new documents has in Sweden been initiated within the Vattenfall Nordic Production Safety Management Institute (NSMI), which recently has been established to support the production units in Sweden. The paper starts with a brief description of NSMI and its main tasks. Management systems are then discussed in more detail to suggest research needs within management systems and safety managements. A conclusion of the paper is that a better understanding of the structure and management systems is needed to remove present difficulties in the application of management systems at the nuclear power plants.

I. INTRODUCTION

Present views on management systems have emerged from QA/QC considerations in the early 1980ies through total quality management (TQM) to the integrated management systems of today. This development is also reflected in the new IAEA documents that do not anymore speak in separation of safety and quality, but integrates these views into a more general management view (cf. [5], [6]). The new documents also strongly advocate an integration of the concept of safety culture as a concept within the management system. One can actually argue that more attention should be given to the management systems when the safety influences of human and organisational factors are considered. The present paper discusses recent activities in Sweden to provide a frame for suggesting research needs in the area of management systems and safety culture.

II. AN INITIATIVE WITHIN VATTENFALL

Vattenfall Nordic Generation has established a new institute Vattenfall Nordic Generation Safety Management Institute (NSMI), which has been given the task of supporting Vattenfall production plants with training and R&D activities connected to safety management. The nuclear power plants at Forsmark and Ringhals as well as the within Vattenfall Hydropower Generation have joined forces in the institute.

A. A training course in safety management

After its inauguration in April 2006 the institute put a major effort in establishing its strategy. The training of senior and coming young managers was identified to be one of the major

tasks of the new institute. The reason was that training in safety management of the type here considered was not offered by any other organisation in Sweden. This task led to the proposal to give a pilot course with a relatively rapid schedule. From the beginning an important recognition was that the course should provide a broad and deep scope to give the managers not only methods and tools, but also an understanding of the basics in the construction of safety at the nuclear power plants.

The pilot course took place in Ringhals during two weeks in November 2006 and consisted of a total of thirty hours of presentations and discussions. In the presentations basic concepts of risk analysis and safety engineering were presented as well as typical characteristics of human and organisational factors. Among the more specific subjects major accidents, risk ethics, organisational culture, systems complexity and international organisations were discussed. A continuous interplay between the lecturers and the participants in the course was considered valuable. The intention is that a similar course will be run at the Forsmark plant during the autumn of 2007.

B. Research tasks identified

An important part of the activities of the institute are directed towards selected research tasks. During 2006 a small task aiming at surveying plant needs in the development of their management systems was initiated. Some of the insights given below are an outcome of this activity.

In 2007 a larger research study on methods to carry out the review of various documents at the nuclear power plants will be initiated. It will in its first phase be restricted to plant modifications, which are expected to increase in the modernisations of the Swedish nuclear power plants. In addition to these tasks there is a continuing follow up on literature on high risk organisations, safety culture and safety management.

III. MANAGEMENT SYSTEMS

Management systems have an important component, which is directed towards safety. This component provides a businesslike approach to safety, which offers a systematic, explicit and comprehensive process for managing safety risks. The management system includes processes for goal setting, planning, and assessing performance. A management system is woven into the fabric of an organization and it becomes part of the organisational culture, i.e. the way people do their jobs.

A. Safety management – a brief historical perspective

Present views on safety management systems can be traced to three different sources. Firstly the quality systems were undergoing a considerable development during the last century. The second component was the TMI accident, which provided an understanding of the role of instructions in nuclear operation. Finally the Chernobyl accident brought in the consideration of safety culture into the discussion.

1) Quality systems

A scientific approach to quality and quality control goes back to the early decades of the last century, when the building industry used collective experience to achieve high quality through repeatability in work processes [8]. After the Second World War quality was introduced into Japanese management thinking by pioneers such as Deming. Later this development led to concepts such as Kaizen and Total Quality Management (TQM), which were used extensively in the Japanese car industry. The quality thinking was adopted gradually in the rest of the world through quality associations and the use of quality circles.

The nuclear industry joined the development of formal quality systems in the late 1960ies and early 1970ies. Initially the driving force was connected to the requirements for pressure vessels, but it was soon realised that the systems had larger applications. The concern for nuclear safety and the need for establishing systematic methods, by which a high repeatability in operations could be achieved, also contributed to this development. A working basis of quality assurance (QA) was first established in the nuclear field through early American legislation. The next step was that national regulatory bodies required quality systems to be implemented at nuclear power plants, largely in line with recommendations given by the IAEA [2].

2) Instructions

The TMI accident has had a very large influence on safety thinking within many areas of nuclear power of which the instructions were only one. The recognition of the importance of the instructions that are used in the nuclear power plants was actually only a part of the larger recognition of the importance of human factors on nuclear safety. The TMI accident pointed to two problems in the use of instructions, the limitations of event based instructions and the n+1 instruction syndrome. These problems have been remedied in the development of the so called symptom oriented instructions for the handling of events.

The focus on instructions led to the writing of instructions for most activities at the nuclear power plants. A common approach was also that instructions were seen as the panacea for almost any problem that was detected. The result was that the number of instructions increased rapidly to a point where they needed to be integrated into some more general framework. At that point of time the first integrated management systems started to be written.

3) Safety culture

The concept of safety culture was introduced after the Chernobyl accident. International interests in the concept lead to the publication of a report making the first attempt to its

definition in a nuclear context [1]. IAEA has since then been very active in developing guidance for the assessment and improvement of safety culture [3], [4].

Over the years IAEA has seen a mounting need to update earlier guidance on quality systems. This has been channelled into a complete revision of the IAEA Safety Standards where a thematic area of management systems has been identified. In that area already two new documents have been published, which give guidance for building management systems at the nuclear power plants [5], [6]. These publications will be followed with another, which is intended to be even more concrete [7]. Safety culture has very clearly been brought into these new documents.

B. Integrated management systems

A common approach for many nuclear power plants some twenty years ago was to have two major guiding documents, the quality and the organisational handbooks. At the end of the 1990ies quality considerations had been brought in as a response to needs within nuclear, environmental and labour safety [9]. The division between all these documents brought in the need to establish an integrated management system to encompass all these aspects.

1) The organisational handbook

Nuclear legislation usually places a requirement to have an appointed manager who is responsible for the operation of a plant. These requirements together with the needs to have clear lines of delegation were brought in organisational handbooks already in the late 1970ies. Over the years the organisational handbooks have expanded to include all major positions in the organisational structure in use at the nuclear power plants. The organisational handbooks typically included rather specific job descriptions, which defined authority and responsibilities for the positions.

There have been early examples from the beginning of the 1980ies, where the organisational and quality handbooks have been combined into one single system of documents. One of these systems was taken into operation at the Forsmark plant in Sweden and it was structured around two major chapters of which one defined the requirements set on the organisational units and the other described the means these units had implemented to ensure that the requirements were met.

2) A process oriented view

The concept of process orientation as a way to structure work activities was introduced in the conventional industry many years ago [10]. This view has transferred to the ISO 9000 series of standards and it is also the major structuring principle in the new IAEA guidance on management systems. A process view helps in detecting and correcting bottlenecks in handing over results from one work activity to another and can therefore help in achieving a smooth flow of errands over organisational borders.

There are many work activities at nuclear power plants, which fit well into the concept of processes, but there are also important activities that are more difficult to force into this frame. Operations management and various support functions may be better to organise in a traditional line organisational manner. The adoption of a process organisation as parallel to

the line organisation also has the problem of two superiors, which is common in all matrix organisations.

C. Requirements on management systems

The management system has a profound influence on work practices and therefore also on safety. It is therefore prudent to consider what kind of requirements that should be placed on the management systems. It seems however that this kind of systematic assessment has not taken place, but instead that the development of present guidance has taken more an emergent path where opinions and beliefs have provided guidance in decision taken.

1) General requirements

Considering very general requirements to be set on management systems one may list the following issues to be taken into account

- there should be a management system in place, which is documented, regularly reviewed and updated when considered necessary,
- the management system should be understood, embraced and used in the daily activities,
- the management system should cover all important activities and it should be internally consistent,
- the management system should have a graded approach to safety.

The management system could metaphorically be seen as the software, which makes it possible for the organisation to meet all external and internal demands. According to the principle of requisite variety it means that the management system should be at least of the same complexity as the organisation it is supposed to control. The management system will therefore have a complexity, which makes it difficult to fulfil the general requirements above.

2) The need for a line organisation

Matrix organisations are one organisational innovation that carries the need for a kind of multiple responsibilities and coordination, which often is seen in organisations. Project organisations can be considered as one example, where a traditional line organisation is borrowing resources to an ad hoc organisation, which is set up for a sole purpose. Process oriented organisations introduce two lines of responsibility, one oriented towards the processes and the other oriented towards functional areas of work. There are examples of three dimensional matrix organisations and one could argue that they at least in principle should be even better adapted to handle a large variety of tasks.

The traditional line organisation has one large advantage over matrix organisation in that respect, that it has a clear line of command and reporting. In the line organisation conflict resolution is also straightforward in moving issues to the next organisational level. The perhaps most important argument for maintaining a clear line organisation at the nuclear power plants comes from operations management. The span of decisions, which have a direct influence on the day-to-day operation, may range from long term strategic considerations to immediate operational actions. To ensure that this large span of decisions are given the appropriate weight in comparison with their

possible safety influences it is necessary that they are re-examined thoroughly both before and after they are taken.

3) A need for reviewability

One important requirement is that the management system should be reviewable. Basically that implies that they are verified against some norms and validated at a more general level in relation to requirements on safety and efficiency. On a general level the requirement on reviewability will split into two parts, firstly the structure and content of the management system itself and secondly how the system is seen and used in the organisation.

Considering the guidance on management systems as given in the IAEA documents, it seems that this need for reviewability has been understood implicitly, but without providing a clear guidance on how the review should be carried out. It may also be beneficial to separate a review of how the management system is seen and used in the organisation from a review of safety culture, to make it more targeted and easier to extract things to be improved.

IV. RESEARCH NEEDS

Research to support the construction of management systems has been scarce and scattered. It would be however be important to consider requirements to be placed on management systems from a human and organisational factors point of view. One possible path forward may be to consider organisational controllability and the real and imagined influences that managers and the management system can and will have on applied work practices and organisational performance.

A. Organisational structures

One important research subject would be to identify organisational structure to be used in safety oriented organisations. For operations management in nuclear power plants a simple line structure seems to be the best, but can this belief be verified. For the support activities such as maintenance and technical support it is perhaps possible to have a larger flexibility in selecting the organisational structure, but what are the pros and cons with different alternatives. At some nuclear power plants a matrix based organisational structure has been utilised to separate between the needs to consider technical issues on one hand and personnel based issues on the other.

On a general level each organisational structure most likely has its own benefits and drawbacks. Research could try to identify what they are and what kind of arrangements can be used to minimise the drawbacks. The selected organisational structure most likely has an influence on training needs for different positions in the organisation.

B. Adapting the management system to people

It is evident that the management systems in use at the nuclear power plants today would need a better structure to help people finding the references they need in their daily work. To some extent this demand may at least partly be resolved by the help of information technology to create links between different parts of the management system. This technology could also be used to trace the interfaces between systems at different levels to support the identification of possible interactions.

A more difficult question however, is to find ways to ensure a broad commitment to the management system. The view, which is expressed in many guides, that this should be sought through the commitment of senior managers is most likely too simplistic. If people do not understand the management system or the why's behind it, it is not very likely that it will be used. A crucial component in the acceptance of a management system is also how it is marketed by the management and what kind of training is given in its use.

C. *The construction of safety*

The management system should evidently give a thorough account of the most important goals and how they can be reached. For nuclear power plants this means that the part of the management system that can be considered important for safety should be well described. Basically it means that the management system should contain a description of how safety is constructed at the plant in terms of technical, human and organisational provisions. The difficulty here is to adapt this description to different needs people have in different positions.

To some extent it may be possible to explain how safety is constructed in the training and retraining of people, this may require some pedagogical efforts to be able to explain the why's behind the provisions of the management system. One step in these pedagogical efforts may be to extend the safety classification, which now is restricted to the technical systems, more generally to instructions and work practices.

D. *Individuals and the system*

A final research question in the area of management system could be directed towards finding a proper balance between responsibilities of the individuals and the system. It is clear that the individuals that work at a nuclear power plant should commit themselves to certain virtues such as openness, honesty, accountability, loyalty and effectiveness. In a similar way the organisation should pursue worthy goals such as impartiality, fairness, trust, support and long term profitability. It may help in making the distinction between individual and organisational responsibilities in the management system.

Finally the perhaps most difficult thing on which to give general guidance is to find a proper level for what is explicitly written into the management system and what can be taken for granted. This has to do on the assumptions on knowledge and education the people have when they are entering the

organisation and what kind of formalised training they will get as new employers and in a continuing retraining mode.

V. CONCLUSIONS

It would be important to create a better understanding of the structure and content of management system and how they influence the safety of nuclear power plants. The perhaps most important issue in this context is to understand the difficulties, which have been observed in the application of present management systems. It would be important to view the management systems as a tool that should be adapted to its purpose by taking into account what is known regarding human and organisational factors.

Safety of nuclear power can never be built on prescriptive instructions, but has always to rely on knowledgeable people. Still it is important to understand the difference between situations, where it is better to use pre-planned and analysed actions as compared to ad hoc responses with the best intents. The management system and the consideration of safety culture should be able to address this question.

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