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**Safety and Human Factors impacts of introducing
Quality Management into High-Risk Industries**
A field study

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Abstract. The Institute for Radiological Protection and Nuclear Safety has undertaken a study³ for getting a better understanding, especially in terms of Safety and Human Factors, of the changes caused by the progressive deployment of the Quality Management in French high risk industries. This study is based on both theoretical elements from the human sciences and management and practical elements from the field, collected from interviews in large French industrial sites involved in integrating this management method. The results show frequent discrepancies between theory, which is very positive and production-oriented, and reality, which is more complex and subtle, ever looking for trade-offs between production requirements and safety constraints. Thus, each step forward announced in the literature may be matched by possible steps backward in terms of safety on the ground. Where, in theory, processes enable practices to be mastered, in practice they can reduce autonomy and fossilize know-how. Where theoretically continuous improvement stimulates and strengthens performances, in reality it can also generate stress and deadlock. Where theoretically personal commitment and collective responsibility work towards all-out performance, in reality they can also operate to conceal safety deviations and infringements. The assessment of Quality Management processes in the nuclear field will benefit from these first results raised from theoretical review and confirmed by similar management changes.

1. Introduction

The French operator Electricité de France (EdF) has decided to gradually introduce a Quality Management policy throughout its facilities. It is an important organisational change that may have consequences, in terms of human factors, on the safety of nuclear installations. The Institute for Radiological Protection and Nuclear Safety (IRSN) has carried out a first study dealing with such managerial changes and their possible impact on safety from human factors point of view, through a bibliographical study and the analysis of experience carried out on ten or so French companies engaged in a similar approach.

2. The key points of quality management

Quality Management, as it is specified for instance by the EFQM⁴ defines a strategy of continuous improvement of all performances, focused on two broad areas: customers – or

³ Carried out under a contract with IRSN.

⁴ European Foundation for Quality Management. The EFQM Excellence Model is widely used as an organizational framework in Europe. It is a non-prescriptive framework that recognizes there are many approaches to achieving sustainable excellence in all aspects of performance. Excellence, defined as a practice in managing the organization and achieving results, is based on a set of eight fundamental concepts: Results orientation, Customers focus, Leadership and constancy of purpose, Management by processes and facts, People development and involvement, Continuous learning, innovation and improvement, partnership development, public responsibility. In this EFQM model, nine criteria can be used to assess an organisation's progress towards excellence. This information is an extract from the information available in <http://www.efqm.org>.

more generally, all the actors involved in the company's activity, whether shareholders, managers, employees, suppliers, intermediate customers or consumers – and results orientation.

The customer-oriented approach involves rethinking the workings of the company by describing all the processes that characterize the activity and seeking to rationalize them with the object of eliminating all wastage – of raw materials, equipment, time, services, activities, etc. This type of management gambles on optimally exploiting human resources, in all their dimensions, by promoting universally recognized values such as respect, loyalty, trust, personal commitment, rigour, effort, sense of community, transparency. All the actors, whatever their hierarchical level, are involved in the dynamics of continuous improvement, by contributing new ideas for improving performances and working conditions, by communicating, by training, by being responsible for the overall operation of the company. This dynamics is created around a charismatic leader, capable of mobilizing people, giving them a sense of responsibility and ensuring the group's cohesion while maintaining a constant, consistent vision of the results to be achieved.

The results approach consists in managing through processes and through facts. It requires the introduction of performance indicators enabling the company to measure, assess its own performances, to have an accurate view of its operation and the satisfaction of all customers, and to be able to anticipate, plan and set realistic objectives.

Applying these theoretically promising principles is certainly more complicated to carry out than is described in the specialist literature. Before undertaking the field study, the main strengths but also limits were raised from a bibliographical review (cf. References [1] to [22]). Because an organization that institutes Quality Management commits itself to a long-term process of profound change, since it affects the very values of corporate culture and of people, this review considered several typical changes caused by the introduction of Quality Management model (for instance: flattening out of the organization, redefinition of rules between actors and managers, setting up of working groups related to processes, evolution of values in the company, etc.). One very general conclusion of the review was that before arriving at a complete, total and really systematic stage of quality, the organization must necessarily go through periods of instability, even periods of crisis which may weaken it on all levels, including those of safety.

3. Field study

In February and March 2002, a field study was conducted on 12 French industrial sites⁵, predominantly Seveso classified, all characterized by strict safety constraints. On each of the sites, semi-directive interviews were conducted with actors of various levels of responsibility (Quality Managers, safety managers, senior management, shop foremen, field operators, etc.). In all, fifty accounts were collected regarding the introduction of Quality Management into a company and the consequences that arose from it, in terms of changes in the activity, in social climate, safety and corporate culture. All the information collected was supported by facts and was subjected to a cross-analysis carried out by three investigators to ensure the reality of the strong and weak points identified.

The methodology was based on semi-structured interviews. The framework for the interviews is built on fifteen main human and organizational dimensions raised from quality management

⁵ Société Nationale Maritime Corse Méditerranée SNCM, Hydro Agri France, BP chimie, Les Chantiers de l'Atlantique, Poitou Foundries, Donges Refinery, Airbus Industries, IN SNEC, Legris Autoline, Naphtachimie, Nitrochimie, Oxochimie.

model (for example self-control, redefinition of rules, commitment of managers, processes analysis, workload, communication, etc.). For each dimension, one or several hypotheses about the possible human factors impacts of the statement were made. A list of questions is associated to these hypotheses. For example, one dimension was the concept of continuous improvement, about which the following hypothesis was formulated: "in medium or long term, the continuous improvement leads to instability, that can generate a feeling of insecurity, even stress, for the company's staff, and will be no more accepted by actors, whatever their level in the hierarchy. They will try to maintain some stability in using indicators in a way to hide this stabilised situation". Six questions are associated with this dimension, concerning the improvements mechanisms, rhythm of change of the procedures, feeling of interviewees about the instability of the situation, etc.

Another dimension was the workload. Because of evolution and increase of quality requirements, results are more and more difficult to achieve, people have the feeling to run without end. A first hypothesis is: facing with such a situation, staff people will build strategies to saving time (to the detriment of safety?). A second hypothesis is that the different actors will share these strategies, they'll be tacitly accepted but they'll be hidden. Eight questions concerned these two hypotheses.

On the whole, the interviews were structured by a set of about 35 hypotheses and 100 questions.

4. Main results

The transition from a conventional type of management (pyramid structure, organization according to specialist activity logic, hierarchical control, vertical rules of communication), to Quality Management involves profound changes that are structural, strategic and cultural. The field survey identified the strong points of Quality Management, but also revealed negative effects for safety. A few results obtained from this field study are presented in this paper.

4.1 Structural Changes

Deploying Quality Management requires reorganizing the company by no longer necessarily following a specialist activity logic, but a customer-oriented, functional unit logic. Each unit guided by a customer process must determine who its customers and suppliers are and who is responsible for its results. Accordingly, organizations will pass more or less gradually from a pyramid structure to a flattened structure, like a rake, (see next figure No. 1).

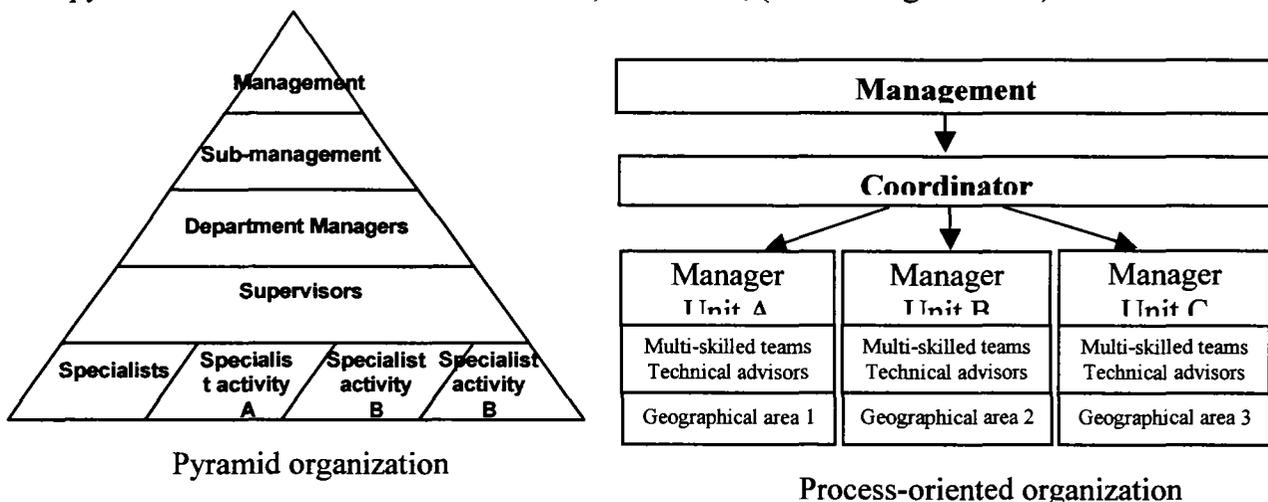


FIG. 1. Comparison of an example of pyramid organization (post-Taylorian) and an example of process-oriented organization.

Positive effects - Such a change may have a number of advantages. Thus, the formalization of processes and the search for better resource management strengthen the organization: they help the actors to have a better view of the overall operation of the company, give meaning to certain tasks, and especially to tasks associated with communications and the safety of the system. Furthermore, this work of construction makes the participants in the company aware of certain inconsistencies damaging to the company's operation, and sometimes to its safety. It also sometimes brings to light deviant (rules not applied, no respect of procedures, etc.) or illicit practices (fraudulent practices, embezzlement, etc.), which may have existed for a long time and threatened safety. This exposure can be accompanied by effective corrective measures. In addition, the autonomy given to teams in carrying out their assignments makes them more responsible, more involved in their work. The search for versatility within teams may help overcome some risks due, for example to absence, illness or other unusual circumstances.

Negative effects - On the other hand, a number of negative effects were noted. Thus, it was observed that the work of **formalizing processes** is almost routinely accompanied by a phase of rejection on the part of the field operators who do not subscribe to the objectives and fear a loss of autonomy. This resistance movement can cause deviant, inflexible behaviour and absences (especially sick leaves). The work of formalization is also accompanied by an initial phase characterized by an excess of procedures and bureaucratic functioning, not very compatible with the responsible activity that the actors have to perform in a system at risk. The rigid use of procedures can gradually break up an oral culture rich in lessons passed on to beginners by the most experienced. While they are criticized for complicating reality, procedures are actually bound to simplify it and do not cover all situations. For these reasons, they cannot completely replace human intervention in a complex incident context. Finally, some safety officers complain about the fact that safety procedures are merged with quality procedures, trivializing them and making them invisible, to the point of sometimes being regarded by the actors as pointless steps making an operating method more cumbersome.

The flattening out of the organization leads to a progressive withdrawal of middle management, thus eliminating a communications link between senior management and the shop floor. This withdrawal can help create a gap between management and shop floor and prevent the company from stepping back from its operations, necessary when dealing with safety problems. The risk is that of setting up an organization that operates with a management team directing far from the shop floor, via indicators, and shop floor teams too engaged in the work of production to stand back objectively, but responsible for self-inspection, etc. and endeavouring to make the indicators say what the management expects of them.

The **multi-skilled versatility** advocated by the approach poses serious problems. In order to standardize the skills within a team, training courses are generally given internally in the form of guidance or counselling by fellow workers, or externally with the issue of formal or informal qualifications. When badly administered, training may have very negative effects on safety. Very often, the coach / trainer does not have the resources (time, teaching equipment), or the training, or the reference framework, or the equipment for testing the skills acquired that would enable him to perform his work as a trainer suitably. Generally it takes up his working time to follow the progress of his "pupil", gives him responsibilities beyond his competence and makes him take risks. Moreover, such tutors sometimes teach deviant practices – by omitting to speak of the possible consequences of these practices – to meet the

demands of production. Badly managed training guidance has repeatedly been identified as the source of serious incidents or events. Versatility also poses the problem of loss of specialists in the company, actors possessing a highly specialized skill essential for sorting out an abnormal or incident situation. These specialists see their field of action widened, and they exercise their specialization increasingly rarely. Less used, the special skill loses its fine edge.

4.2. Strategic changes

The quality approach involves adopting a method of operation enabling the company to continuously plan for the future and anticipate situations. It makes the introduction of experience feedback inescapable (in theory).

Positive effects - This method of management favours risk prevention. When placed in general use, it can prove positive in tackling safety problems. In fact, continuous, honest reappraisal, which accepts making a true assessment, can lead the actors to embarking on their activity with a heightened awareness of the risks and a concern for safety that can place it at the same level as that of production.

Negative effects - In an economically and socially unstable context, if the improvement targets are over-ambitious, if the gap between the present situation and the objective to be attained in the short term is too wide, the actors are going to take risks to achieve it, stray from procedures and display deviant behaviour. In a more stable context, the risk is that of a deadlock, a refusal to join in, capable of ending up in a social crisis. In any case, if the context is too unsettled or the changes demanded are too great, the situation will quickly become untenable, being too unstable and causing stress. The actors will seek to introduce a routine "at any price" and will set out to redistribute roles and responsibilities by placing priorities where they may find recognition (generally in favour of production and at the expense of safety).

4.3. Cultural changes

Quality Management promotes a sense of personal commitment and collective responsibility. It advocates self-inspection based on the principles of trust and professionalism.

Positive effects - All the objectives of quality control are highly positive since they aim at excellence. Their strength lies first and foremost in their ambition to count on the quality of human relationships in the company and on recognized values outside the company. The key is to mobilize staff and give meaning to collective action. When it is really acknowledged and rewarded, personal commitment enables the actors to put great effort into the operation of the company, and it can produce excellent results. A team leader committed to his work carries his crew along, motivating them and drawing them together to achieve high levels of performance, in terms of both production and safety.

Negative effects - However, if production targets are very high, the team leader can also take his crew in the direction of accepted collective deviations and cover for the crew in the event of a problem. Personal commitment can lead to taking risks and deviant behaviour with respect to safety (deactivating a safety system to continue production, using non-compliant materials, taking short-cuts in restrictive operating methods, etc.). Collective responsibility is not always compatible with safety. That is to say that actors, at the limits of their competence, may hide behind the group and feel less concerned about safety. The principles of self-

inspection form no inducement to the company to take an outside look at itself. It has a tendency to check everything internally, without standing back, which is not compatible with safety. Moreover, the self-inspection system within a team may be very perverted and lead to deviant collective behaviour. Examples have been reported of concealment of negative safety results being accepted by all the actors in the company. The problems become even more acute when subcontracting is involved, which may combine quality management systems of differing levels of maturity.

5. Conclusion

Quality Management embraces far-reaching concepts. They can be interpreted and put into practice in many ways. The discrepancies that were discernable between theory and practice rest on the very basis of these concepts, which seem to ignore the variability of a company, a team or an actor. The grand ideals of total quality have been built upon the ideal representation of a company, existing over a long period, looking after its employees, trusting them and motivating them without recourse to financial incentives. On their side, individuals are seen as fundamentally good, capable of learning, but also capable of teaching, altruistic and trustworthy. The reality is much more complex. The area of quality is the scene of multiple compromises, which may sometimes take on the appearance of conflicts. The application of Quality Management can give amazingly positive results, but quite often comes up against cultural differences, conflicting interests and organizational routines, and generates deviations that are not always compatible with safety. In any case, it must never be lost sight of that this values-based system is fragile. A few inopportune discrepancies or "counter-actions" may suddenly destroy brilliant results.

One objective of the study was to bring out some impacts on safety from a human factors point of view, of the Quality Management approach. It was for the IRSN a first step for gathering information from experience in other industries than the nuclear industry. The results of this field study provided some positive facts in favour of the Quality Management approach, but also some difficulties that may have a negative impact on safety. Regarding the assessment of Quality Management application in the nuclear field, the study provided a number of important issues to be considered. A next step will be to carry out a more detailed qualitative analysis, to understand more precisely what happens during the application of management models. Another further step would be to extend this field investigation, using the same semi-structured interviews methodology, to other countries where risk industries are engaged in similar managerial changes, in partnership with national organisations involved in nuclear safety in these countries.

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