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APPLICATION OF QUALITY SHAPING METHODS IN THE WORKENVIRONMENT IMPROVEMENT. A CASE OF THEORETICAL FRAMES

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Abstract:
Businesses, which typically operate in highly changeable settings, are forced to make constant adjustments to meet legislative requirements concerning employment and the performance of work. To that end, they need to identify tools for improving their work processes. By employing quality management methods to upgrade their working environments, enterprises gain the ability to satisfy the needs and expectations of their customers, including the internal customers who rely on the processes carried out by their employees. The effort not only helps them boost the quality, reliability, flexibility and cost-efficiency of their processes but also allows them to comply with legislative/regulatory requirements. In doing so, they bring their system into conformity with any safety policies that are in place in their organizations.
The article discusses the option of employing quality-oriented process design methods (FMEA, QFD and DOE) to improve working environments. The author describes some of the basic prerequisites for their use aimed at boosting the planning and deployment of improvement measures in areas related to the working environment.

Key words: *work environment improvement, shaping methods, FMEA, QFD, DOE*

INTRODUCTION

The working environment is essential for a business's ability to perform work. In keeping with the guidelines set out in the EN ISO 9001 standard [2], oversight over and, consequently, the improvement of the working environment should be seen as a management support process [11, 12, 19, 20]. The standard emphasizes the importance of recognizing that technological advances have a strong potential to harm the natural environment and, as such, should be monitored and adjusted wherever processes endanger worker safety and health [1, 9, 15, 18]. By keeping the working environment in conformity with legal requirements and stakeholder expectations, business organizations gain the ability to achieve their desired outcomes. Conversely, any businesses that fail to ensure such conformity are likely to suffer disruptions.

Working conditions must be designed to reflect the roles and significance of the workers who rely on processes as internal customers [6]. In accordance with the principles of quality management, this applies to processes and conditions, including the environment in which work is performed. The scope of the measures to be taken should reflect the system requirements laid down in occupational health and safety management standards. The implementation of "design for quality" tools should be seen as a way to grow and improve systems allowing an organization to shape its working environment. To employ such means, organizations need to define the nature and the specific features of the outcomes they seek to achieve in conformity with the characteristics of the processes they carry out [5, 14, 17].

QUALITY IMPROVEMENT GUIDELINES

Improvements in the systemic approach

In the systemic approach, modifications of the status quo should be seen as an improvement process. Such improvement is sought most commonly in designing new solutions [8, 14]. Improvement measures are aimed, among other things, at raising process efficiency allowing companies to grow and better satisfy stakeholder expectations. To gain an ability of grow, an organization needs to employ instruments which will allow it to:

- gather and process information on developments within its systems and in its immediate environment,
- make decisions based on valid data and information,
- motivate workers to engage in teamwork while ensuring team members are available to pursue specific tasks.

To achieve the desired outcomes in keeping with the principles of the systemic approach, organizations need to apply means which will allow them to influence quality at all stages of the improvement process [15]. Such means include improvement principles, methods and tools. The need to improve quality extends to the way organizations manage their working environments and to ensuring the achievement of a desired quality level in such environments. The use of improvement methods should be seen as a consistent informed pursuit of a specified goal [7, 8]. The primary purpose is to gain a greater ability to achieve any desired effects.

Before an organization can make its improvements, it should identify its issues. A central part of the improvement process is to define the cause of irregularities and find prac-

ticable improvement solutions [11]. To accomplish their intended outcome through proper actions, i.e. to eliminate or mitigate the impact of distortions, organizations need to [12, 20]:

- identify the persons at whom their measures are targeted and define their needs and expectations,
- ensure they rely on accurate and reliable input data,
- employ proper quality improvement tools.

Quality improvements should be recognized as a complex challenge requiring a specific sequence of measures in keeping with an adopted plan. To succeed in this process, an organization should begin by defining its specific concerns and identifying any casual relationships among them. One should not think of management methods as a guarantee of successful achievement of goals. The methods only support and facilitate the accomplishment of the desired objectives.

Quality improvement methods

The quality improvement methods in current use provide planning-driven science-based ways to consistently achieve compliance with any adopted requirements in areas covered by a systemic approach. Accordingly to the nature of the tasks performed, a crucial role in shaping the working environment is played by design methods [7, 8, 10, 12]. These include methods relying on process algorithms such as:

- Quality Function Deployment (QFD), which allows organizations to translate user expectations and demands into process specifications,
- Failure Mode and Effects Analysis (FMEA), used to recognize and detect process flaws and identify ways to eliminate them at an early stage,
- Design of Experiments (DOE), which involves the use of experimental methods to optimize factors that affect process quality.

All such methods come with their specific principles.

QFD

The QFD method allows organizations to translate user expectations and demands into technical process parameters. The method relies on identifying user needs, including those of which the user may be unaware. A complete QFD analysis involves three process stages:

- defining and evaluating relationships between the demands of workers and the specifications of the process at hand,
- linking process specifications with factor characteristics,
- evaluating measures aimed at creating a proper environment for carrying out the process.

The methodology employs the so called Quality House whose fields are defined accordingly to the nature and complexity of the tasks and goals to be achieved [8]. The criteria may include customer requirements, requirement validity, relationships among customer requirements, correlations among process parameters, definitions of the desired technical parameters and identification of the technical difficulty of the task to be performed.

FMEA

The FMEA allows organizations to eliminate failures consistently and durably by identifying their actual root causes and applying proper preventive measures [7, 12, 16]. The method can be used to identify novel solutions and improvements so as to boost process efficiency and effectiveness and detect the causes of material wastage, damage to means of work, the impairment of worker health and even worker fatalities.

The team assigned to employ the FMEA of irregularity estimation methodology needs to acquire proper knowledge and experience. In particular, they need to be knowledgeable and experienced in dealing with incompliance risks, in identifying their causes and effects and in proposing appropriate preventive measures. The method relies on a three-stage approach comprised of [8, 12, 19, 20]:

- preparation whereby organizations appoint a highly experienced team along with its leader and define analysis methodology. The number of levels to be analyzed depends on problem complexity. Proper insights into the system allow one to start the analysis at any level which is of particular importance when dealing with complex interactions [10],
- proper analysis to recognize problems in potentially a failure-prone process. To identify failures, one needs to define the "failure → effect → cause" relationship and assign proper indicator values to them – the indicators are S (for failure significance), F (for failure identifiability) and P (for the probability of failure occurrence). The organization is then in a position to name and subsequently rank the SFP priority indicator (for a specific relationship). The higher the indicator, the more critical a given cause or failure,
- adoption of and supervision over preventive actions intended to remove or mitigate the impact of failures.

The FMEA allows businesses to respond to problems at hand objectively.

DOE

DOE is a planning method designed of help identify the structure of relationships as a starting point for designing a process which best meets requirements and is highly immune to distortions [8, 12]. The persons assigned to plan improvements need to have a specified level of knowledge. In designing recommended actions, they should account for [8, 10, 12, 19]:

- controllable factors which can be influenced during the design process,
- uncontrollable factors or factors which can only be controlled to a limited degree,
- distortions which are either external (environmental) or internal (associated with reduced process effectiveness).

One consideration of particular importance during the analysis and in adopting the resulting improvements is to reduce the number of controllable factors to a few primary ones. In extreme cases, no factor can be employed to fully influence the analyzed object. The factors then need to be verified. Such verification is based on the knowledge and experience of the person in charge of developing the process concept and on the applied research methods (e.g. process sheets, pair comparisons or full or partial classic experiments).

WORKING ENVIRONMENT

The working environment is described in terms of the conditions in which work is performed. The working environment includes physical, social, psychological and environmental factors. Another inherent parameter of such

requirements are ergonomic criteria [3, 4, 5]. Descriptions of environmental factors shall be seen as significant for an enterprise's ability to fulfil customer needs and expectations and pivotal for an organization's operating effectiveness and its ability to carry out processes [5, 13].

To assess their ability to perform work, organizations should identify distortions in the working environment caused by factors which adversely affect workers. The impact of such factors can be described by reference to effects on worker health resulting from workers' exposures to hazards, or by defining the degree of discomfort at work. Such factors can be defined as [5]:

- dangerous, i.e. factors potentially resulting in injuries (accidents) or immediate impairment of worker health,
- deleterious, i.e. factors contributing to the gradual impairment of worker health (e.g. occupational diseases/conditions),
- strenuous, i.e. factors which may hamper the performance of work (e.g. causing discomfort) or reduce organizations' ability to perform work without causing permanent damage to worker health.

The primary outcome of work process improvements is to allow organizations to bring the impact of the above factors to an acceptable level and, as a consequence, retain the capacity to perform work safely and effectively.

EMPLOYING QUALITY IMPROVEMENT METHODS TO SHAPE WORKING ENVIRONMENT

The methods used to shape and improve the working environment allow organizations to identify factors which influence process conditions the most. Once they have identified such factors, enterprises are in a position to:

- design a process resistant to distortions, i.e. factors in the working environment which may impair worker health and safety,
- ensure that the working environment will comply with legislative requirements, standards and stakeholder expectations,
- control changes in the working environment during the work process.

Preventive methods make it possible to detect and remove any defects and irregularities, even during process design [7].

QFD

QFD facilitates the identification of market demands and their expression in ways easily understandable to designers and builders. With respect to the working environment, QFD enables organizations to define technical process parameters and, subsequently, the conditions in which such parameters can be achieved. In applying the QFD, designers need to account for the greatest number of factors which influence the process at hand and which are associated with securing conditions significant for the working environment. By ensuring compliance with working environment requirements, the QFD method allows organizations to define the technical parameters of the working environment and the requirements put to workers who are process users.

QFD analysis comprises the following three phases:

- Phase 1: identifying and evaluating relationships between customers (internal process users) and the technical parameters of the working environment,
- Phase 2: associating the technical parameters of the working environment with the individual aspects and areas of that environment,
- Phase 3: assessing each stage of work with proper account taken of their impact on the achievement of the desired parameters.

During each stage of the process, reference needs to be made to working environment characteristics, the nature of the process of achieving the required safety levels and internal customer expectations. A step-by-step breakdown of the planning process based on QFD guidelines with account taken of the specific demands of working environment design is shown in Fig. 1.

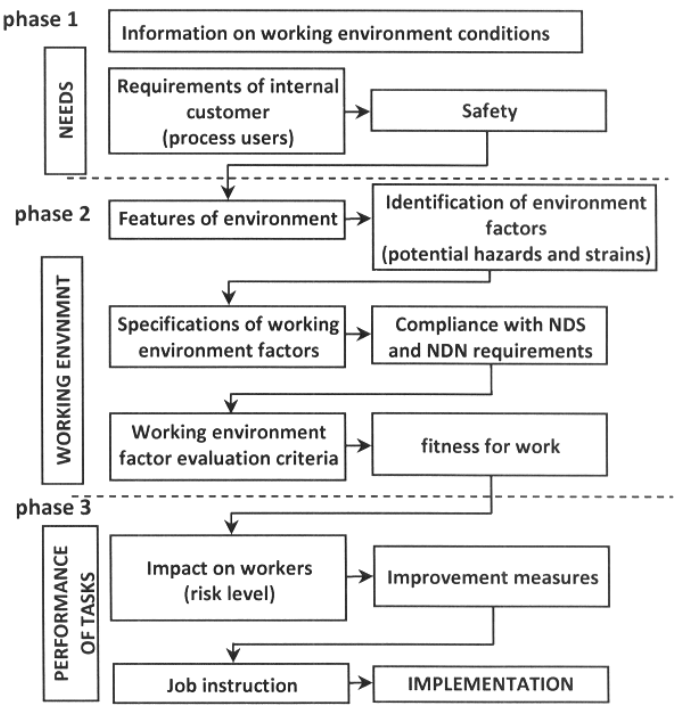

Fig. 1 Simplified representation of QFD methodology used to analyze and design working environment

Once carried out, the sequence of measures allows an organization to:

- define links between customer demands and the technical parameters that have been identified on the basis of functional analysis, experience, a record of events which took place in the environment, etc.,
- rank technical parameters in terms of significance and identify critical factors which contribute to process success or failure,
- describe correlations among technical parameters, especially those which hamper organizations' ability to satisfy customers and which are crucial for their ability to apply alternative solutions,
- compare organizations with their competitors highlighting the strength and weaknesses of specific solutions to allow organizations to select the best solutions in the circumstances they face,
- define the target levels of technical parameters to be achieved to meet customer requirements,
- define the levels of difficulty faced in trying to fulfil requirements and achieve desired states, such levels being a reflection of technical and organizational challenges.

To complete the above actions, organizations need to define significant factors which are crucial for achieving the ultimate outcomes. Of particular importance in this context are customer requirements, the weights of such requirements and their impact on workers, worker needs and demands which, in their turn, are crucial for organizations' ability to complete tasks and satisfy worker wishes, e.g. those concerning working comfort.

FMEA

The FMEA method allows organizations to recognize and eliminate factors which may stand in the way of fulfilling working environment related requirements. Such factors are tied to work methods and parameters, measuring instruments, technical equipment and work-flow design.

Evaluations relying on the FMEA method require following a three-phased sequence of actions whereby:

- at Phase 1 (Preparation), organizations appoint a team of highly experienced individuals along with their leader and specify ways to carry out the analysis. In such analysis, they can apply:
  - the problem-based approach in which analysis is limited to areas in which problems have been identified,
  - the systemic approach in which processes are viewed as systems comprised of lower level subsystems.

The features accounted for in applying the FMEA method to evaluate and improve working environments are summarized in Table 1.

- at Phase 2 (Proper Analysis), organizations gain the ability to:
  - indicate (for selected process actions) potential defects associated with the impact of the working environment on workers,
  - define defect → effect → cause relationships for the identified defects such as:

unfitness for work →
→ poisoning (illness affecting worker) →
→ leaky chemical installation

  - ascribe value S (defect significance), R (ability to recognize defect) and P (probability of the occurrence of defect) to every identified value,
  - define and rank WPR priority ratios for each identified of irregularity.

The information needed to define S, R and P ratios comes from evaluations of working environments and descriptions of accidents, occupational diseases and incidents. Table 2 summarizes key indicators critical for selecting the significance of specific defects linked to an analysis of the hazards encountered in the working environment.

- at Phase 3 (Adoption and Supervision Over Preventive Measures), the nature of measures taken and their scope result from an analysis and the related conclusions meant to mitigate the risk of failing to ensure proper working conditions for workers.

DOE

The DOE method allows organizations to define the structure and parameters of interactions and subsequently develop a process that best meets requirements and proves to be highly immune to distortions. DOE-based planning requires the use of mathematical statistics and the classic theory of experiment design. (As postulated in [7, 8]), the measures taken are designed to:

- identify controllable factors which best support ensuring proper working conditions,
- define optimal parameters for controllable factors to achieve the required quality of the working environment,
- identify factors which have negligible impact on the working environment and specifically on process quality and which make it possible to optimize burdens.

The above are key preconditions for carrying out the recommended measures. Table 3 presents some of the basic factors which influence working conditions seen as components of task implementation.

Table 1
Sample features accounted for in evaluating working environments by the FMEA method

Area	Feature description
evaluation criteria	– any working environment parameters which allow organizations to carry out processes in an efficient manner
subject matter of analysis	– working conditions which reflect worker needs and expectations
concerns which need to be addressed	– what issues (irregularities) may be encountered in the course of performing work and what impact they may have on the performance of tasks
sample identified irregularities	– impacts of chemicals exceeding NDS (The Highest Permissible Concentration), NDSP (The Highest Permissible Liminal Concentration) and NDSCh (The Highest Permissible Temporary Concentration) standards, – temperature in the working environment prevents safe performance of work (adverse impact of thermal discomfort experienced by workers)
sample identified causes of irregularities	– use of chemicals at workstation without proper ventilation, – air conditioning systems failing to maintain temperature within specified range whenever work areas are exposed to excessive sunlight

Table 2
Sample features accounted for in evaluating working environments by the FMEA method

Subjective opinion of defect's meaning	Severity of impact
Very low	The process user is unlikely to notice the irregularity. No risks in the working environment associated with failures to comply with applicable requirements affect the ability to perform work.
Low	The process user hardly notices the impact of the irregularity. The user will most likely only notice a slight deterioration in system operation. Risks in the working environment have only low impact on an organization's ability to perform work and do not significantly distort such performance.
Average	Irregularity having an average significance causing customer dissatisfaction. The process user feels its effects and is upset. Risks in the working environment noticeably impact an organization's ability to perform work causing distortions to processes.
High	A highly significant irregularity. Risks in the working environment cause worker dissatisfaction with working environment and significantly distort or fully hamper the performance of work.
Very high (critical)	An irregularity of very high significance adversely affecting safety levels. Risks in the working environment make it impossible to perform work.

Table 3
Sample features accounted for in evaluating working environments by the FMEA method

Factor category	Sample factors:
Controllable factors	– type and sequence of measures which affect working conditions, – impact of equipment on working environment, – process prices required to ensure proper operation and achieve desired outcomes, – worker competencies associated with their impact on working environment
Uncontrollable factors	– local conditions affecting working environment, – natural phenomena having impact on ability to perform work
External distorting factors	– heterogeneity of the materials which are subject to processing, – floor vibrations caused by workstation use, – improper use of work means
Internal distorting factors	– wear and tear of work means, – changeability of working conditions resulting from modifications made by organization

CONCLUSION

The working environment is part of the system which influences an organization's ability to carry out jobs properly and, consequently, affects its capacity to ensure continuous improvement. Such improvement should be seen as a way to satisfy the expectations of internal process users. In settings in which workers are viewed as a critical resource, such efforts prove to be of particular importance for a company's market survival. The decision to recognize specific circumstances as an irregularity requires access to the internal and external messages and information received by the organization. In the particular case of working environments, such signals involve safety-critical factors. For these purposes, safety is defined as an absence of any unacceptable risk levels.

By rationally using any available tools to influence core aspects of quality, organizations gain the capacity to effectively manage their working environments. To employ such tools, they need to identify the specific features of company operation and the specific areas that require improvement. In the process of choosing their method, organizations should utilize any information they receive on the operational areas in need of improvement. The solutions they employ allow them to prevent accidents, occupational diseases and other job-related incidents. Such measures should be seen as a way to achieve the intended outcome, i.e. ensure a lasting improvement in occupational health and safety. Proper improvements are a necessary prerequisite for satisfying all concerned parties.

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