SOME ASPECTS OF EXPLOITATION CULTURE

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Summary: In the paper, there attempt to systematize key aspects of exploitation culture. Based on analysis of the literature, the author concluded that in the existing publications relating to the problems of maintenance, not enough space was given to the exploitation culture, Most scientific work in this area focuses mainly on technical aspects of the operation of technical facilities and functioning of the maintenance organization. Later in this article, the author has identified the scope of that term, saying that culture influences significantly on three key aspects of performance: principles, quality and safety of the operating and maintenance work. These aspects have been discussed in detail here. The final part of the article is carried out by the author's assessment of exploitation consciousness in the opinion of maintenance staff of selected industrial enterprises.

Keywords: exploitation, maintenance, organization culture, maintenance culture, safety, human reliability in work processes.

1. Introduction

Exploitation definition [7, 14, 31] and exploitation objectives [30, 9, 7] indicate clearly that the description of a typical maintenance organization is multifaceted. Therefore it is necessary to define the pattern according to which such a description is made. One of these patterns can be a model of areas and tasks related to the performance of management functions, which allows to carry out an orderly analysis of key aspects of the maintenance organization. The shape of the model results from a very useful definition of maintenance management, which was presented in [7]. Under this definition, maintenance management includes a set of activities based on the maintenance strategy, carried out under appropriate structures (organizational, decision-making and information) and performed with the intention of achieving the objectives of exploitation policies efficiently and effectively. Information resulting from this definition can be ordered according to the scheme shown in Fig. 1.

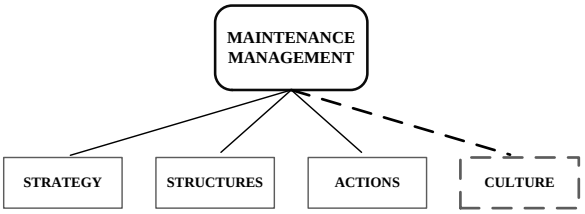

Fig. 1. Model of areas and tasks related to the performance of management functions [7]

At this point it is worth paying particular attention to the exploitation culture. It is complementary to the first three elements of "technical" aspect of maintenance management (strategy, structure, activities).

Technical and organizational analysis which are intended to assess exploitation processes and maintenance organizations (described e.g. in [7, 9, 17]), most frequently marginalize exploitation culture, focusing on the first three aspects of the model.

The reason for the marginalization of that culture is its non-technical and multi-faceted nature, which sources should be sought in various related domains. There can however say, that culture is an important part of maintenance management. In the given here technical and organizational nature of the maintenance works, it performs the role of humanizing and affects such features as:

- quality of the servicing and repair maintenance work,
- effectiveness of activities of users and maintenance staff,
- technical safety with regard to workers, machinery and equipment.

Therefore, the author attempts to systematize the key aspects of culture which significantly affect exploitation processes and maintenance organization.

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2. Characteristics of the industrial culture

The culture of industrial organization is the subject of research in various fields, including: anthropology, sociology or psychology. large number of publications is dedicated to this issue, resulting ambiguity of the term (a valuable overview is contained e.g. in [2, 12, 13, 24]).

According to [2], organizational culture is a set of values, that help its members understand what the organization stands for, how it works, what considers to be important. In this context, culture is an abstract, that clearly difficult to measure or observe. According to [12] activities of the organization identified by its culture result from standards of behaviour, expressing certain ideologies, myths, rituals and beliefs. In sociology and psychology, culture includes the norms and values defining the specific behaviour of the participants of the organization which differ from that organization and other [24]. The publications in the field of organization and management [8, 13], it proposed valuation of culture in terms of different criteria, including accepted cultural patterns, that affect the proper functioning of organization or level at which the hierarchy of formal objectives is reflected in the awareness and action of employees.

One of the most popular ways of illustrating the components of the organization culture is the Schein model [23]. According to this model, culture is a hierarchical system consisting of levels distinguished based on their consciousness and visibility (Fig. 2).

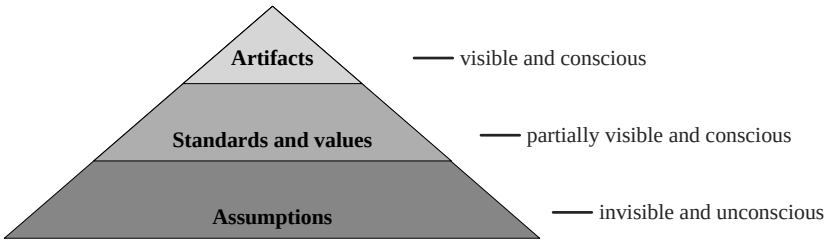

Fig. 2. Schein model of organizational culture [23, 13]

This model looks like an iceberg, consisting of three levels:

- visible artifacts, including language artifacts (language, myths, legends), behavioral artifacts (ceremonies, customs) and physical artifacts (technology, material objects),

- partially recognized standards and values, in the form of declared and that observed,
- unconscious basic culture assumption, which are the foundation resulting from such features as: human and environment nature, relationships, nature of the organization, relations with the environment.

Another approach to the issue discussed here is the model presented in [28], according to which the culture of industrial organization consists of four components (Fig. 3):

- values, that represent assumptions and beliefs of industrial workers as a set of guidelines of the objectives and strategic decisions,
- role models, which represent a collection of people who carry out specific tasks in the company in a dignified manner and worthy of imitation,
- rites and rituals, which are fundamental processes of work carried out every day in the company, where rituals are ways of dealing with problems and tasks, rituals are the rules that reinforce specific behaviors and rituals,
- cultural infrastructure, which is an casual set of processes, carried out in the background in the form of information exchange, gossip transfer, influence determining, etc.

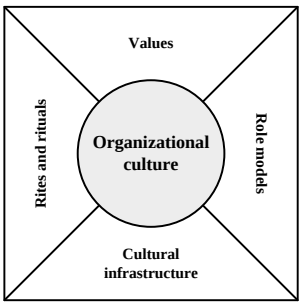

Fig. 3. Thomas model of organizational culture [28]

Culture is usually dependent on a number of internal conditions of industrial organization, as well as external factors. The most important features influencing the culture of industrial organization are summarized in Tab. 1.

Tab. 1: Internal and external factors of organizational culture (own elaboration based on [13])

Internal factors	**External factors**
Features of organization: • history • size • leadership • administration system • structure	**Type of organization:** • market situation • products and technology • trade
Characteristics of participants: • attitudes • education • sex • age • profesional experience • life experience • emotional ties	**Type of environment:** • national culture • value system society • community value system of the region • local system of values

Internal factors form two groups of features: features of the organization and characteristics of participants in this organization. External factors, such as type of organization and environment, are the characteristics of the organization in relation to a closer or further environmental.

3. Culture in the maintenance organization

With regard to the maintenance organization, it seems appropriate approach presented in [24], by which culture can be considered as one of the subsystems of the maintenance organizations (Fig. 1). This allows you to explore the relationship between patterns of behavior of employees, and other subsystems, components and characteristics of organizations which, in relation to the maintenance organization include: maintenance policy, organizational, decision-making and information links, management methods and technologies.

The most important aspects that describe the culture of maintenance organizations can be distinguished within the model of key requirements, which was proposed in [19]. The model is presented on Fig. 4.

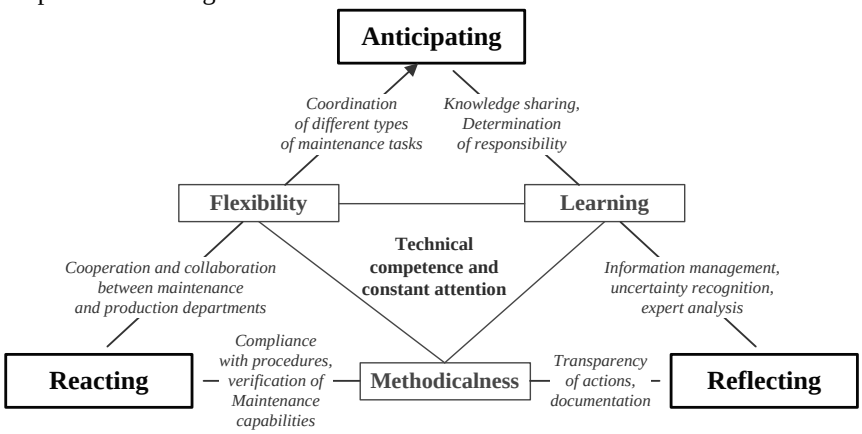

Fig. 4. The maintenance core task model [19]

The model presents a set of maintenance tasks in terms of the relationship between the three classes of dependents to each core demands:

a. critical demands, (placed in particular corners of the triangle) balancing between anticipating and reacting is that of flexibility,
a. instrumental demands (placed in each side of the triangle) corresponding to the links between flexibility, methodicalness and learning,
b. demands for the working practices (placed outside the triangle) representing links between critical and instrumental demands.

Each of the above groups of requirements can form the basis for identifying the features that affect the value of maintenance culture in enterprise (for example, high or low). However, the objective should be to maintaining a stable balance between the requirements of a particular type, rather than strengthening or weakening of the individual single components.

For example, the balance between the prediction of future behaviour of people in relation to individual technical objects a response to an event occurring (usually unintended), allows for the formulation of objectives and criteria included in the exploitation policy. In response to the newly developed and implemented procedures for activities that result from the accepted or modified objectives and maintenance criteria, there is a need to analyze the effects of these activities and ways of their implementation, thereby forming a valuable exploitation information. In the process of learning, for

example, by comparing the information with previous experiences and by sharing it with others, the information is converted into knowledge that is essential for companies exploitation condition. This allows you to predict future behaviour of employees in relation to technical objects.

A set of instrumental requirements is the most expressive collection, from the perspective of identifying features of the exploitation culture. Three instrumental requirements shown in Fig. 4 (flexibility, methodicalness, learning) are expressed in organizational culture in different ways. The differences result from particular perceptions of learning about objects and maintenance processes, flexibility needs sources and causes of methodicalness.

In practical terms, the problem exploitation culture is more a subject to the improvement operations, rather than the identification and evaluation. Valuable approach is represented by S. Thomas [29], including eight key elements that are the subject of monitoring and possible changes in their efforts to optimize the exploitation culture, in particular: leadership, work process, structure, education, technology, communication, interdependence, awards. However, these elements are a valuable basis for optimizing the exploitation culture, when they are associated with elements of industrial organization culture (Fig. 2), resulting matrix can be presented in Fig. 5.

The values placed inside the matrix represent the importance of particular relationships, and so: the value of 1 means high interaction, a value of 0 means low or no interaction. The model has in any case, a dedicated nature, meaning differences in the system of matrix values for particular maintenance organization. Every relationship defined here has its own interpretation, taking into account individual characteristics of each maintenance organization, where you can define a standard schema of interpretation of each relation, which is the basis of individual practical conclusions. For example:

	Leadership	Work Process	Structure	Group learning	Technology	Communication	Interrelationships	Rewards
Values	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Role models	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**
Rites and rituals	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**
Cultural infrastructure	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**

Fig. 5. The matrix of relationships of elements of industrial organizational culture and optimization components of organizational culture (own elaboration based on the [29])

1. Relationship Values - Communication, may specify the way and scope of influence of method of interpersonal communication (e.g. in the supervisor - subordinate) on the value system of employees. If, for example, in the company it seeks to change from reactive to proactive way of maintenance work organizing, then message from managers who denies the usefulness of the changes and actions taken, resulting from a mistaken sense of experience and comfort, can significantly impede the process of change carried out.
2. Relation Cultural infrastructure - Structure, may indicate an influence on the structure of corporate culture (organizational, decision-making, information flow). Assuming, that we aim to optimize the activities to improve the exploitation effectiveness based on the agreed strategy, conclusions, which are interpretations of this relationship can help this

process by identifying positive and negative interpersonal dependencies resulting from e.g. formally taken business dependency and cooperation between organizational units.

Constructed in such a way other relationships referenced to features of maintenance organization in a particular industrial enterprise, allow you to define exploitation culture and take account of this key aspect in the improvement activities.

4. Some aspects of the technical safety culture

One key area that is directly related to the maintenance culture is safety in the environment of the servicing and repair tasks. It focuses the requirements due from the construction and operation of technical facilities, specifics of the maintenance tasks as well as psycho-physical capabilities of the technical workers. Relationships between these factors can be analyzed in terms of human behaviour during the performance of certain exploitation work (functional and repair), calling it a safety culture.

It is assumed, that man, as part of anthropotechnic system, cannot perform the provided tasks or perform them incorrectly, but he also can do things in ways that lead to degradation of the system's ability to fulfil its functions. Based on research carried out in different areas of technology, it is possible to specify the elements of the interaction between technical objects and the human in the realization of specific works (Tab. 2).

Tab. 2. The relationship between a human and a technical object in maintenance work

The advantage of man over the technical object	The advantage of a technical object over the man
• ability to abstract and induction, generalization and forming concepts and conclusions, • greater ability to appropriate responses in emergency cases, • greater sensitivity to stimulation (interference), especially at weak signals, • greater self-adjusting ability of the senses to achieve maximum receive.	• greater strength and speed (especially during accounting activities) and accuracy, • ability to work without tiredness, and greater resistance to external conditions, • greater capacity and reliability of memory, • possibility of simultaneous (multichannel) take many actions, • ability to quickly registration of signals, • possibility of strengthen activities.

Tab. 2 shows, that human is a more flexible "element" of the anthropotechnic system, because:

- he can perform multiple functions, including new, not previously foreseen,
- he is able to adapt himself and performed functions to changing conditions.

Technical object is the "element" more effective and reliable in certain narrow functions.

These conditions may be a basis for the selection and classification of methods used to evaluate human behaviour in antropotechnic terms, in the realization maintenance work as a key technical aspect of safety culture.

In this regard they are very useful methods for human reliability analysis - HRA (Human Reliability Analysis), which consist of a systematic evaluation of factors influencing the behaviour of the users (machine operators) maintenance personnel, for tasks which require a specific safety rules. Where definition of human reliability (by [22]) is different than the reliability of technical system, in particular: human reliability in the work process is the ability to perform the tasks entrusted to him with minimal risk. Thus formulated object determines the scope for models and methods used in the area.

The base approach to the issues discussed here are the results of research team led by J. Rasmussen, who in the report [21] who classified and ordered the incorrect behaviour in the

work processes in relation to defined complex technical objects. This classification, which is now called the model of Rasmussen, defines three levels of error-prone of human [11, 20]:

- skill level (practice) that requires exercise and training,
- level of rules requiring the understanding and use of regulations and rules,
- level of knowledge, which requires the basis carry out specific work, especially in new and unknown situations.

The consequence of Rasmussen's model is used extensively sets of activities and procedures related to the observed human behaviour in companies and methods of analysis and evaluation of the effects of their introduction into industrial practice. An example might be human reliability assessment methods, the most important features are presented in Tab. 3.

Tab. 3. Description of selected methods for assessment of human reliability in work processes [11, 20, 25, 26]

Human reliability assessment method	**Description of the method**
TESEO (the italian Tecnica Empirica Stima Errori Operatori)	The Teseo method assumes that the probability of human error depends on five factors: the type of action taken (K_1), the available time to perform the action (K_2), practices, and professional training (K_3), emotional state of employee (K_4), ergonomic the characteristics of environment (K_5Factor values are determined quantitatively based on the contents of certain tables. Probability of making a mistake by an employee: $$Q_0 = K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5 \quad (1)$$
HCR (Human Cognitive Reliability)	The HCR method determines the probability of error as a function of lack of time to complete the task: $$P(t) = e^{\left(-\frac{\frac{t}{t_{0,5}} - C_{a,j}}{C_{g,i}}\right)^{B_i}} \quad (2)$$ where: t - time available to complete the task, $t_{0,5}$ - average time enough for the task, $C_{a,j}$, C_{gi}, B_i - factors depend on the type of activities
HEART (Human Error Assessment and Reduction Technique)	HEART method consists in determining the likelihood of human error based on a set of ergonomic and environmental factors, that influence negatively on performance of the tasks. The procedure in this case is as follows: • every factor that potentially influences the quality of human action, is determined quantitatively based on a collection of tables, • calculates the probability of human error, as the product of the factors influencing the value of consideration on a case by case analysis.

5. Exploitation consciousness in the opinion of maintenance staff of selected industrial enterprises

The attitude of machine operators and maintenance personnel has an has a significant impact on the level of exploitation culture in the industrial enterprise. The appropriate value system of the staff is driven by:

- permanent acquisition of knowledge in the field about objects and exploitation processes,
- acquisition from practical experience and skills in typical situations, as well as differing from the standards,
- influence on exploitation policy-making with a simultaneous increasing conviction of the rightness of the solutions and directions of activities,
- individual personality traits, including the level of intelligence and education features, which influence on aspects of attitude, such as: manners, willingness to take on new or difficult tasks, common sense.

These considerations are reflected in industrial practice in the approach of staff to carry out specific, often complex and custom work and implement new organizational, technical and information solutions. Undertaken new challenges are aimed at improving the overall efficiency (technical and / or economic) exploiting of facilities and operation of the maintenance organization. With appropriate commitment of staff it can affect the success of the project or the effectiveness and quality of its implementation.

For many years, regular research among employees of maintenance departments are conducted. They are designed to know their opinion on various aspects of the maintenance organization. Further in this point, there will be presented selected results and conclusions from surveys and personal observation. Surveys were carried out on target groups of representatives of several hundred of industrial enterprises of various sectors and there have been documented in form of articles and reports (e.g. [18, 19, 27]). The personal observations resulted from the research projects and implementations (e.g. [4, 5, 6, 15, 16] organizational, technical and IT solutions of activities of maintenance in industrial enterprises.

Among many aspects analyzed, it is particularly note the following points:

1. level of awareness and acceptance in relation to failures and the response to it in exploitation activities,
2. level of awareness and acceptance in relation to modern strategic and methodological solutions in maintenance management,
3. level of awareness and acceptance in relation to solutions supporting the maintenance work.

5.1. Level of awareness and acceptance in relation to failures and the response to it in exploitation activities

This problem is carried out for many years the discussion of the superiority of exploitation policy, in particular:

- reactionary approach, which assumes specific rather high level of failure, relatively technically and economically safe and is characterized by the waiting for an event; this approach is not limited to failure, but rather improves the procedures for removing their consequences (repair),
- proactive approach, which assumes a continuous struggle with unintended events in the context of their causes and ways of appearance; this approach avoids the failures, by carrying out extensive preventive work.

Taking the results of previous studies and many years of practical experience, which indicate the unquestionable advantage of a proactive approach to maintenance work, this problem can be considered on two levels:

- formal level, associated with the need to apply certain rules of maintenance tasks during the operation,
- informal level, associated with the beliefs of individual employees about their rations, which in certain situations relate to the formal level.

These considerations confirm the results of surveys of selected employees for the reaction to the failures and the importance of methods and diagnostic tools in their daily work exploiter. The results of the survey, there are two key issues:

- there is rather weak interest in total or almost total elimination of certain failures (more than half of the respondents draws attention to recurring failures that cause unplanned downtime),
- nearly 60% of respondents do not use any indicators of failure and there is no need,

– among the methods used and diagnostic tools, more than 90% are the simplest visual solutions.

These conclusions of the study clearly show a strong commitment of maintenance organizations to simple diagnostic methods, which include only the identification of the current technical condition of objects, without taking into account future changes (forecasting). This is due to three reasons:

a. firstly, the use of advanced methods of technical diagnostics requires specialized measuring equipment and tools for data collection and processing, which requires additional costs,
b. secondly, the use of diagnostic methods require appropriate educated staff, particularly in the field of diagnostic inference; good diagnostician should have great knowledge, experience and intuition,
c. thirdly, the currently applied maintenance management strategies (eg, TPM) assume a very broad and widespread use of simple (low-cost) diagnostic work, which largely influence on results of the survey.

Despite the widespread use of modern maintenance strategies targeted at prevention and technical and organizational assessment and elimination of failures, there are fairly common critical failures that stop the production company's principal. Particularly it is worth noticing of the scale of individual problems (downtime short - up to 2 hours, only 10% of cases), It may indicate a common practice to focus on minor aspects, which the solve and prevention requires a smaller involvement of staff and resources, while leaving the major problems that require complex approach that goes beyond the competence of the maintenance. Additionally, not the best is the distribution of answers on the use of indicators of failure. Assuming that in almost half of the surveyed companies, there not be made quantitative evaluation of the events occurring, this points to acceptance of failure as a natural, fully reasoned the property of exploitation process, and more than 25% of respondents use the reactive approach (intervention), rather than proactive.

5.2. Level of awareness and acceptance in relation to modern strategic and methodological solutions in maintenance management

Interesting are the views of and hence consciousness in possibility and advisability of applying modern exploitation strategies and support techniques of maintenance management. In particular, the, 49% of the surveyed people said they do not use any modern-defined exploitation. In addition, they believe that they have no need and no plans to implement such solutions in their companies. In this context, approximately 25% of the respondents has defined their strategy as mixed, and only 20% knew how to clearly specify the name of the implemented organizational solutions (eg, TPM, PM, CBM, RTF).

The presented results are independent of the size of the company, because in all groups (up to 50, from 50 to 250, over 250 persons employed in the maintenance organization), the distribution of responses was very similar.

In addition to research results presented can be information on the performance of maintenance activities by external (e.g. in the form of outsourcing). In this regard, over 80% of respondents mentioned the way or expressed such a need (in relation to more than 50% of the amount of machines and equipment in the machine park).

The presented results show the typical problems closely related to the exploitation culture. These problems are the subject of many studies in the area of change management, including authors [1] indicate three spheres which are barriers and resistance, as an effect of such results. These are: the sphere of the material (equipment, funds), the sphere of values (socio-psychological), the sphere of power (management style, rules of conduct). In this regard, quantitative solutions are formulated in determining the degree of adaptation to

changes in employee. Dependencies included, among others in [3, 7, 10] present more methodological approach rather than a tool ready for use, due to the ambiguity of interpretation of individual factors.

5.3. Level of awareness and acceptance in relation to solutions supporting the maintenance work

Assessment of possibilities and expectations with regard to computer techniques to can be considered in the context of:

- availability and / or need for access to modern IT tools,
- assessment of knowledge and usefulness of the most important functions of IT tools,
- ergonomics of IT tools.

The first aspect relates to all those involved in maintenance management, in practice, the other two aspects relate to those people who have experience in the use of certain tools (e.g. CMMs/EAM systems).

Opinions of workers of industrial enterprises concerning IT solutions are rather surprising, in particular assuming a high level of technical knowledge of service staff in comparison with employees of other. Nearly 70% of the representatives of the maintenance services do not use specialized IT tools to maintenance management [18]. This result complemented by the distribution of responses in the area of size of companies, indicates that modern IT systems are the domain of large enterprises, in particular:

- over 41% of large enterprises use information technology solutions in maintenance activities,
- among medium-sized enterprises - 23% supports their maintenance activities,
- only 18% of small enterprises use computer systems in the above mentioned works.

This distribution of responses can be only partly justified by economic considerations, as further results show low levels of knowledge about such solutions, and consequently small interest in them. This is indicated by the conclusions of a survey among maintenance workers who on a daily basis use computer systems, in particular:

- wide variety and dispersion of responses concerning key functions / modules of the computer system [18],
- more than 38% of respondents do not understand purpose and expected effects of computer systems in maintenance work [27],
- over 53% of respondents concludes that the computer system allows the maintenance planning and realization, but few of these people link it with aspects of labor costs, spare parts, services, and specialized tools control [27].

Assessment of ergonomics of computer system also has a significant impact on level of awareness and acceptance in relation to solutions supporting the maintenance work. There are representative and typical studies that have been carried out in a water and sewerage enterprises [27]. Most of the respondents (75%) said that the user interface is not very clear and friendly, those who have expressed positively in relation to this aspect, were not to be fully. distribution of answers concerning the intuitiveness and simplicity of operation was very similar. The vast majority of employees engaged to work with support system, assessed the negatively aspects of the internal logic and convergence with current maintenance activities (both in terms of time, cost and results achieved). The same group of employees, which negatively assessed the current computer system shows rather medium interest in replacing it with another.

These results, confirmed by practical experience the author originating in scientific research and implementation in the area of computer-aided maintenance management, point to a high resistance before any change. Employees are not interested in any changes, and usually assume its current high efficiency. The possibility of improving the quality and effectiveness by applying advanced IT solutions, is received by the technical service, as new unnecessary obligations that cause lengthening the time needed to carry out maintenance activities.

6. Summary

In summary, in order to identify culture of the maintenance organizations in the enterprise, you can highlight the following key aspects:

- in terms of social engineering, maintenance activities in the enterprise are complex, this complexity causes changes in the environment, which is reflected back in the form of the development of exploitation procedures,
- optimal concept of maintenance management should take into account key requirements, which means the absolute execution of specific tasks and invariably adhere to established principles in all situations in order to maintain appropriate interactions with the environment,
- effective system of social engineering (which include the operating system in industrial enterprise) must ensure the safety, productivity.

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