

**Dorota Bartochowska**

Lodz University of Technology  
Faculty of Mechanical Engineering  
Institute of Mechanical Tools and Mechanical Engineering Technology  
Institute of Management, Economy and Legal Sciences

**ORGANIZATION OF MAINTENANCE MANAGEMENT  
DIRECTED ON PRODUCTIVITY IMPROVEMENT****Abstract**

*One of the essential factors deciding on enterprises competitiveness is **an effective organization of maintenance management process**. In contemporary literature on maintenance management you can more often meet the notion of management and organization and the significance of some factors is emphasized such as planning, rationalization of organization of structures, changes in quality and quantity of staff, labour system improvement, control etc., in realization of usage and economic aims of businesses.*

*Observations of activities and maintenance management of technical objects should be an inspiring factor for undertaking research activity. It is the management (that is directing) of maintenance systems which is the essential problem of contemporary operations.*

*The author of the article presents the issues of organization of maintenance management on the basis of 20 selected building-construction businesses located on Poland premises. The studies describe current condition of organization systems of maintenance management and indicate on possibilities of organizations improvements in order to increase machines productivity.*

*In the work the elements significant for productivity of machine and devices organization maintenance system were distinguished. The author makes the machine effectiveness improvement conditional on **current and long-term activities included in the framework of coherent organization and management system of the business which convey the productivity potential of the studied enterprises**.*

Economic development and the increase of highly advanced technologies and enhancing competitive potential makes the companies search of new methods of economic results improvement and analyzing these results. "Fast transformations of global economy pose the developmental challenges to societies, corporations, single entrepreneurs, and also managers. They refer to the

phenomena of keeping the pace to those we compare ourselves in order to maintain the competitive position” (Kunert O. 2008)<sup>1</sup>. That is why the survival of many companies nowadays depends on the ability of effective competing, products quality and costs level. This effectiveness should be shaped in all activities in the company.

One of the essential area of company activity of whose efficient functioning results in, a remarkable degree, to company’s aims achievements and influences the shaping of its financial results, is the area of maintenance management. In recent years we have been observing significant increase of the role the maintenance management plays in conducting the effective financial policy of an enterprise, It also has its implications in systems of maintenance management. The change of economic system and the necessity of competing forced the rationalization of activities in the range of machine and devices maintenance management.

Evolution of the attitude towards effective management of the maintenance started a development of organizational systems aimed to productivity increase. Technical and technological development supported by progress in IT poses new challenges to theoreticians and practitioners involved in this science. Apart from changes of the technical nature there are also few trends in the management which changed point of view on operating science. New philosophies of management, such as JIT, Lean, TPM, RCM emphasize the significance of effective maintenance management which when integrated with the company strategy, can become a very important element **in shaping of competitive advantage**.

It is to be expected that increasing interest, in Poland and the world, in issues connected with management of maintenance will beneficially affect the effectiveness of machine usage, quality products and productivity results.

In the world of advancing technology development and specialization of production, high class rivalry and creation of new solutions is a necessity for companies. .Observing of global economy phenomena indicates that we have to do with a “new economy” in a quality sense posing developmental challenges. (Kunert O., 2008)<sup>1</sup> Searching ways of costs limiting by companies, increasing products quality, realizations of deliveries on time cause needs resulting from globalization. Undoubtedly, growth of competition caused a rapid evolution of technology and the increase of customers’ demands – at the same time resulting in the development of science on operating.

Observations of new phenomena and processes evoke a lively discussion of scientists, also in Poland, on the subject of revising many assumptions as to usage of machines and organization of these processes. Different business

---

<sup>1</sup> O. Kunert, *Budowa kompetencji innowacyjnych wyzwaniem rozwojowym polskich przedsiębiorstw*, Wydawnictwo Politechniki Łódzkiej, Łódź 2008.

practices used in this area justify the need of researches and analyses referring to a correct operating in different economic sectors.

According to Downarowicz O.<sup>3</sup> "The rank given to usage issues and, consequently, detail of analyses and shaping usage problems, as 'proper', depends on *the significance of usage objects for operating activity, its costs and results, value of objects, level of threat they pose, risk connected with its usage, degree of wear and tear and other specific factors*".

Science of equipment operating demonstrates solutions in the range of procedure with technical objects which should be maintained in utility ability so that to provide optimum conditions of their activity. Accuracy of these analyses and solutions in usage depends on taking into account in studies and operating practice the variety of particular branches of industry, age, technical condition and differentiation of the machines under usage and paying attention to economic conditioning and concrete applied values.

Currently science offers a lot of models as referred to operating, as well as it gives the possibility of their commercial application. Usage of the above mentioned solutions is becoming more difficult, due to the advance in production system technology and automation of devices of very precise steering systems. The mentioned development caused that diagnosis and solution of problems concerning technical objects has become more complicated and because of economy scale can become more and more expensive. As a result of above discussed issues it is very important to adjust not only technical activities but organizational, economic, social and legal as well to concrete technical problems.

In practice, these activities are often performed intuitively, they often are popularization of positive and negative experiences of workers. It happens, though, that they are undertaken basing on operating science, which is still rare in Poland. Recently Polish companies have started to take part in this more demanding market and started to mark new dynamics of activities of strategic range. More and more companies notice the chances of improvement of their competitiveness, and, what's more, machine productivity in effective usage of devices in accordance with certain rules, realizing that the lack of operating science causes negative economic results.

High level of transformation pace in operating made IT indispensable, as an essential tool supporting organization and making decisions. This fact, to a high degree, makes this science younger where new concepts substitute the old ones because they are newer and they act better in this varied technically environment.

Operating management is supported by using computer devices in different problems of maintenance. Contemporary companies, in many cases, use IT systems offered on the market. Multifunctional IT systems cause deep changes in company functioning, both in organization of particular processes as well as in the area of staff teams.

It is quality change which disturbs a total subject structure of the enterprise and due to this demands a special attitude in management<sup>2</sup>. These systems are known as CMMs and based on transactional data bases where the information on operating objects and their surrounding is gathered. The need of processes computerization of maintenance significantly affects the degree of organizing the maintenance, complexity of technical apparatus and enterprise environment<sup>5</sup>.

In the library of 'eksploatyka'<sup>6</sup> a new notion of modern literature appeared describing existing changes and characterizing new trends, strategies and proposals, the application of which is to rationalize operating process, to lengthen to maximum the period of operating technical objects, taking into account the effectiveness of this process<sup>7</sup>. This literature bases on characteristics in discussion of selected notions and conceptions, not mentioning their applied values and practical application.

Recent years have brought essential changes in the approach of companies to machine and device maintenance management. It has been noticed that the machine maintenance system and its suitable organization can be a source of many profits for the company, financial included. Evolutionary changes, so far seen in many other fields,, have started to contain the maintenance management as well.

In seventies accessibility of the device, safety, competence are gaining new dimensions. The production companies are becoming more and more automated and organizationally complex. The response to the above changes was shaped in the area of maintenance management conception, such as TPM (total maintenance management oriented on productivity) and RCM (maintenance management directed on reliability – strategy according to reliability), whose key element was to ensure failure-free work of machines and devices during the period of operating. Automation and development in Information technology have made new techniques of maintenance easy to use in industry.<sup>8</sup>

High turbulence of surrounding, non-continuity of events and globalization of processes and structures are basic features of contemporary economic world and the response to them, not only in the sphere of management, but also in the "field" of maintenance management was to be a concept of strategic management.<sup>9</sup>

Approximate dynamics of maintenance development plays a huge role in shaping strategies concerning maintenance management. Stormy surrounding conditioned by big and changeable transformations of a market, technique and evolving societies, all these need, from managers, skillful and fast adjustment of potential, structure, and culture of the company to new conditions.<sup>10</sup>

Maintenance management in majority of companies experiences „strategic” crisis. Majority of activities is of a pure operational character, often reactively oriented. The evolution of maintenance management described earlier and rising growth of quality demands in this field should result in tendency of taking care

of machines in companies, and activities of maintenance management can not be of a temporary intervention character. Ensuring a proper functioning of machines and a full control over technical condition, as well as rising reliability are the instruments of improvements of machine service efficiency and also clues of possible ways of productivity improvement.

That's why the lack of strategy of maintenance and other analyses of technical condition of machines can not characterize the company the aim of which is to maintain the competitive position on the market, taking care of a customer and economic effects.

Good strategy of maintenance management must be connected with the remarkably more general strategy referring to material resources and processes. It demands co-existence of many forms and using many methods of maintenance management in the very same company. In such process anticipation and preventive activities must dominate, at the extent of limiting the activities consisting in reacting to inefficiency results (failure, stoppage...).<sup>11</sup>

In order to successfully connect the efficiency and effectiveness of activities of maintenance it is necessary to establish "proper" strategies of maintenance management. The maintenance management demands application of flexible strategies which take into account dynamics of developmental changes in productive systems and also specificity and variety of technical objects in these systems.<sup>12</sup>

Strategy of maintenance management is a way of behaviour in reference to machines and devices, as a result of which it is possible to achieve a desirable condition of maintenance management system. Creation of strategy thus needs thorough theoretical knowledge and practical skills in using theory in practice and vice versa, enriching theory in new experiences empirically achieved in practice. It should be modified or exchanged depending on some factors, for example quantity.

Development in the range of maintenance management systems and output of management science pose huge challenges to managerial staff of management maintenance in a company. Practical knowledge and skills of analyzing and designing of systems of maintenance add to a profile of people managing technique resources. The discussed challenges, activities and directions of progress both in maintenance management and in organization science depend on operating problem scale in a company, on the size and significance of technique resources being at the disposal of an organization.

In late sixties accelerated growth of interest in issues of maintenance was reported in Poland. There appeared new conceptions and methods of maintenance management organization. More and more often a significant influence on properly organized maintenance on productivity started to be emphasized. All these made the author undertake the empirical trial of verification of these views.

In 2006-2009 studies were performed on maintenance management organization in 20 construction enterprises located in different parts of Poland, looking for essential factors which are to guarantee desirable availability of machines at the optimum usage of possessed resources. **The aim of the studies was to diagnose with the aid of a survey questionnaire the quality of maintenance management organization in selected companies and defining which elements of organization system of machine and device maintenance management significantly influence on the growth of machine productivity.** Applied research tools were directed on the diagnosis of maintenance management systems and their rationalization.

Issues of effective maintenance management are specially essential in the case of building-engineering machines whose improper usage can lead to faster wear and tear processes, unexpected natural damages (breakage), can cause increase of acute corrosion processes, which consequently leads to remarkable increase in costs. In order to monitor maintenance management organization efficiently and to study its influence on shaping productivity in a company it is necessary to begin with diagnosis of its condition, evaluation of quality of its activities in maintenance management and to establish the category in organization which form this productivity.

The author of this article distinguished endogenic factors of productivity construction and made organizational efficiency conditional on quality of organizational activities in the range of seven categories describing maintenance management organization existing inside a company: i.e. in organization strategy, in organization structure and labour division/sharing, in planned activities of maintenance management, procedures and specifications, system of information flow, technical infrastructure and organizational culture.

For more precise analysis of influence of the influence of particular categories on productivity increase, in the range of each of 7 indicated categories, factors best characterizing given category were isolated. This concept bases on such defining and describing the strategy, procedures and forming the structure, the proper dependencies and forms of which lead to productivity increase.

#### Results of quality evaluation studies of maintenance management organization

As a result of studies the evaluation of actual operations range of the maintenance management realized in companies was performed. The following were assessed: existing strategy of maintenance management, procedures, documents in accordance with completeness, familiarity and usage by staff, the degree of really realized activities resulting from the assumptions formulated both in a formal (documented), and informal way – but declared by organization management.

The aim of the study stage was the evaluation of improvement factors of productivity according to 98 factors.

## 1. Strategy

One of the essential categories affecting productivity growth is organization strategy in maintenance management. This strategy should be a part of complex organization strategy or strategic plan accepted in a given company and it should consist a basis of a built systemic solution of issues of maintenance management, called **maintenance management system**

In majority of studied organizations the lack of strategic conceptions was stated, only in one case a strategic conception was characterized by completeness of strategy preparation process and internal logic and coherence in documents.

Operations in maintenance management in majority of studied companies are performed intuitively or on the basis of experiences of people working there.

Only one organization possessed a strategy as a part of maintenance management, others possess only its fragmentary elements, as a rule not preceded by any earlier implementation analysis.

There exists, though, in companies, a conviction as to the necessity of establishing the maintenance management strategy in which it could be necessary to take into consideration the direction of evolution of maintenance management and consciousness of benefits which can result from an effective organization in a studied area.

Only in one company TPM systems, 5 S were introduced whose task is to improve company productivity.

Table 1. The number of companies studied in the category strategy, which achieved particular point evaluations

	Studied factors within category maintenance management strategy	Number of companies – point scale				
		0	1	2	3	4
1.	Quality of diagnostics material preceding strategy building and current, directed on its modification suitable to changes	15	1	2	2	
2.	Basis for strategy establishing	14		4	1	1
3.	Issues perspective of maintenance in company's operations strategy	14		2	3	1

4.	Coherence of strategy of maintenance management with strategic assumption of the whole company and other implemented systems	14		4	1	1
5.	Proper criteria of strategy choice	15		4	2	
6.	Type of applied strategy of maintenance management	14		1	4	1
7.	Ability for dynamic change of strategy on the background of changes in the environment	14		3	3	
8.	Legibility of the strategy	14		2	4	
9.	Correct monitoring of realization of strategy and its modifying according to new, changing conditions.	14		2	3	1
10.	Detail of the strategy, strategy correlation on concrete operation programs	14		4	2	
11.	Reliability of processes of strategy realization monitoring	14		5		1
12.	Advance of strategy realization	14		2	4	
13.	Familiarity with the strategy by staff	14		3	3	
14.	Full or fragmentary application of Lean, 5S, TPM programmes	14		5	1	

*Source: author's own study.*

## 2. Organizational structure and work share

In majority of studied companies the issues of maintenance management is not clearly reflected in a studied organization system, and the organization structure as a part of maintenance management is not adjusted to realization of particular functions this maintenance management is supposed to fulfill. Number of workers employed in maintenance management services or performing related tasks is, from the point of view of realized functions, not sufficient; it is also not adjusted to current needs resulting from the range of subject tasks. Studies confirmed legitimacy of creating effective structures taking into account strategies, key competences, eliminating wastage through limiting number of hierarchical ranks, delegating entitlements to lower ranks, decreasing the participation of team staff workers, reduction of unnecessary activities within coordination, controls, agreements, task interpretations.



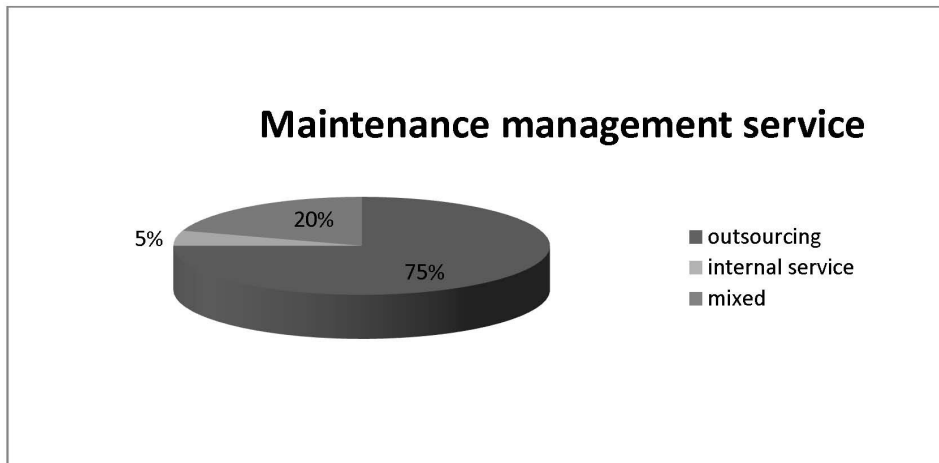
Table 2. Number of companies in a category organizational structure and work division/share, which achieved individual point evaluations

	Studied factors within category organizational structure and work division/share	Number of companies – point scale				
		0	1	2	3	4
1.	Issues perspective in organizational system of a company	1	7	6	5	1
2.	Adjustment of organizational structure within MM to realized functions	1	2	11	6	
3.	Number of maintenance management workers		4	11	5	
4.	Scope of services realized outside the company (outsourcing)		3	10	6	1
5.	Competence of maintenance management service workers		5	7	8	0
6.	Formal qualifications (for operator as well)			12	7	1
7.	Accuracy of responsibilities and performed jobs MM		3	12	5	
8.	Formalization scope		2	12	6	
9.	Responsibilities range and entitlements for workers participating in maintenance management processes (operator included)		2	11	6	1
10.	Knowledge of responsibilities and entitlements by workers		4	10	5	1
11.	Range of responsibilities for an operator		6	7	4	3
12.	Trainings		2	12	5	1
13.	Decision-making entitlements on managerial posts		4	10	6	
14.	Entitlements and skills of outer companies ' workers used by a company.		6	8	5	1

Source: author's own study.

In seven organizations under the study the range of outsourced services was basically adjusted to aims and possibilities of an organization; in 13 companies isolation of services within maintenance management was considered as non-economical and improper.

In some of the studied companies the maintenance management department in the firm was isolated on an externalized basis. The externalized companies (“daughters”), at the beginning, provide services nearly exclusively for a “mother” company. Such behavior led to, first of all, transferring of “personal costs” of maintenance management to “outsourced services” position – so the result is ostensible. The choice of outsourcing company as to its promptness and quality of services in 6 companies was considered as proper.



Graph 1. Results of studies of maintenance management services organizing in selected companies

*Source of the study: author's own.*

Managerial staff in majority of studied companies recognized external isolation of maintenance management services or a form of temporary preservation as the most proper and most economical way of functioning. In 8 companies competence of maintenance management services workers was assessed as proper, whereas in 12 – as insufficient. In 15 companies a partial lack of responsibility cover and performed work in maintenance management was reported, then in the rest of companies no divergences were stated

Scope of responsibilities and entitlements for workers (operator included) in companies was defined in a sufficient degree and the workers know their duties and responsibilities.

Formalization scope (for example legible organization scheme, organizational rules) in only 6 companies was assessed as proper – they were mainly companies possessing ISO 9001 system.

In 7 companies scope of responsibility and entitlements for workers, documents defining entitlements and responsibility were stated in a precise way; in the rest it was described as general. In 6 enterprises workers know their responsibilities and entitlements.

In 7 companies majority of maintenance procedures are performed by operators (multifunctioning) – they realize current technical service and participate in repairs. Operators themselves repair small breakdowns, whereas more serious damages are reported to maintenance management workers or to outsourcing services. Machine operator participates in appointed servicing performed by external organizational units or workers of internal maintenance management.

In 14 studied enterprises decision-making entitlements of companies' managers were unsuitable; company's board decide on many issues connected with maintenance management.

Trainings in maintenance management were assessed in 6 companies as suitable (adjusted to needs and machine specificity); in other enterprises trainings are rare as they are costs-consuming.

## **2. Formalization and planning maintenance management operations**

Fundamental task of a rational maintenance management is, first of all, planned activity which is to ensure reliable machine and technical devices work. Achieving of this aim is possible by establishing and performing proper operations in maintenance management. In 12 companies the selection of performed servicing activities in these firms turned out to be improper, ill adjusted to machine specificity and current condition of the company, MM activities were not clearly defined or are realized in an insufficient degree. Deadlines of servicing plans are not always met (12). In 8 studied companies a schedule of servicing was appointed, and operations performed to the plan. In 14 enterprises lack of proper servicing was stated, and consequently – fast and efficient reaction to breakdown.

Time limits for technical servicing of machines and technological devices are set by workers and outsourcing companies' workers themselves (12). Other autonomous activities within maintenance management are rather occasional and rarely are of a worker's initiative.

Table 3. Number of companies studied in the category planned operations in maintenance management which gained individual point evaluation

	Studied factors in category planned maintenance management activity	Number of companies – scale point				
		0	1	2	3	4
1.	Selection of servicing operations		6	6	8	
2.	Promptness in completion of maintenance management		5	7	7	1
3.	Establishing and realization of servicing schedule		7	5	7	1
4.	Planned, preventive repairs		6	7	7	
5.	Speed of performed repairs	9		5	6	
6.	Other autonomous MM activities		1	15	3	1
7.	Organization of renovation		1	7	6	6
8.	Planned controls		10	2	8	
9.	Basis of defining technical service time limits of machines and technological devices		9	3	7	1
10.	Basis of defining frequency of servicings		8	4	7	1
11.	Range of damage, stoppage time and cost		9	7	4	
12.	Regularity in MM tasks realization		9	5	6	
13.	Anti-corrosion protection plan and set actions	1	10	4	5	
14.	Registration and analysis of work time and costs of UR	1		13	3	3

Source: author's own study.

As the study shows, the organization of renovations (refurbishments) in a company is poor – there is a lack of technical and economical evaluation of usefulness of the renovation, study and establishing of renovating standards and suitable quality and acceptance of renovations. Activities of maintenance management have a key significance for company productivity but still many firms do not pay enough attention to this problem – in none of the studied organization any analysis or registration is made as to the time of machine stoppage, and activities performed in case of breakdown are less then efficient and very rarely analyzed.

In none of the companies active time of machine work during individual months is analyzed, as well as some tendencies in using nominal time of machine work degree connected to temporary work in companies is not taken into account. This is extremely essential from the point of view of organization of maintenance management operations, as these operations can be properly incorporated into company's work rhythm.

In ten companies ranges of individual current services (everyday, weekly, etc.) were defined, but in others it was stated that there is a divergence in defining the range of current services and frequency of these actions. Anti-corrosion protection plan, so essential in long-term usage, exists only in 5 companies. As many as in 14 enterprises there is no analysis and registration of work time and costs of MM, which has a significant importance on measurements of productivity in studied companies.

#### 4. Procedures and specifications

Studied companies are characterized by a low degree of formality of tasks and procedures.

Table 4. Number of companies in category of procedure and specifications which achieved individual point evaluations

	Studied factors in category procedure and specification	Number of companies – point scale				
		0	1	2	3	4
1.	Description of MM functioning		12			3
2.	Organizational procedures in defined MM processes		12	5	2	1
3.	Specification of detailed action for machines and devices		13	3	3	1
4.	Realization degree (or realization) of organizational procedures			5	3	1
5.	Monitoring of procedure realization in MM		12	5	2	1
6.	Protection degree of procedures in operational materials		9	8	2	1
7.	Delivery effectiveness		1	16	1	2
8.	Defining and contents of control lists of machine critical points		11	6	2	1
9.	Documentation of procedure realization		11	5	3	1

10.	Contents of procedures of analyzing renovations and repairs quality		11	5	3	1
11.	Specification of spare parts		10	7	1	2
12.	Protection procedure degree in spare parts		10	5	3	2
13.	Manuals enabling checking of technical conditions and safety measures prepared by co-workers of Work Standards Inspectorate and Office of Technical Inspection		13	4	2	1
14.	Control of devices in accordance to EU		12	5	2	1

Source: author's own study.

In majority of studied companies there are only single organizational procedures in concerning defined processes. Realization degree of organizational and technological procedures is not big. In none of the companies there is a monitoring of procedures concerning the maintenance management. In companies there is a lack of detailed specification of spare parts. As a rule, parts are ordered without any procedures, in companies there are not qualifying lists of suppliers classified as to services, spare parts and operating materials providers, and rules of their evaluation and qualifying. In 15 companies the protection degree of procedures in spare parts section was recognized as insufficient. In 3 plants there are specifications of spare parts; realization time guaranteed by a supplier was also defined there.

In 17 studied companies contents of control lists of machine critical points was not defined. In companies lack of machine and device control in relation to EU demands was stated, together with defects in manuals enabling checking of technical condition and safety measures prepared by Work Standard Inspectorate and the Office of Technical Inspection (17).

## 5. System of information flow

Table 5. Number of studied companies in category information flow system, which achieved individual point evaluation

	Studied factors in category information flow system	Number of companies – point scale				
		0	1	2	3	4
1.	Documentation of activities and results in the range		14	3	3	
2.	Detail and usefulness of information		11	6	3	

3.	Reliability and completeness of information from the point of view MM system effectiveness		13	4	3	
4.	Presence of feedback information in MM		11	6	3	
5.	Information flow in hierarchical systems		10	7	3	
6.	Damages registration		12	4	4	
7.	Protocols of machine technical condition (servicing)		10	6	4	
8.	Documentation of service acceptance		11	5	4	
9.	Records of performer services and the method of their documentation		11	6	3	
10.	Manuals availability on posts (post, organizational, technological)		12	6	1	1
11.	Taking into account recommendations in records concerning the range and time limit of next service		11	4	2	3
12.	Checking of records of periodic services performed by staff		12	5	2	1
13.	Condition of technical – mobile and technical documentation for all devices of the company and its availability		12	5	3	
14.	The range of informative systems application for effective realization of tasks and service		12	4	4	

Source: author's own study.

In 15 enterprises documentation of activities and results concerning maintenance management was described as partial, unclear and inaccurate. Part of documents is rarely used by workers and it is incomplete.

There is also lack of detailed descriptions of all breakdowns, actions connected with operating and warnings claimed by workers.

In majority of enterprises there are no records providing evidence of realization of any activities for maintenance management or these records are not regular, unclear and inaccurate. In some enterprises breakdown registration is conducted on the basis of breakdown cards. These records and causes of breakdowns are not practically analyzed in detail in any organizations. These records are conducted carelessly and irregularly, they are difficult to analyze and it is impossible to draw credible conclusions. Technical-movable documentation of machines was in a good condition, mainly in new companies, whereas in some older enterprises it was not easily available or it was absent.

Companies do not conduct registration and analyses of computer data; some of enterprises plan to create reference data base in order to gather and analyze information concerning maintenance management. Paper documentation is often stored in bad conditions and places, and is more susceptible to damage.

## 6. Infrastructure

Table 6. Number of companies studied in category infrastructure, which gained individual point evaluation

	Studied factors in category infrastructure	Number of companies – point scale				
		0	1	2	3	4
1.	Equipment of warehouse in spare parts and tools		12	2	6	
2.	Supervision on spare parts economy and tools condition		11	6	3	
3.	Economy of lubricating materials		8	7	5	
4.	Quantity and quality of lubricating and oil materials		9	3	8	
5.	Quantity and condition of additional, for example, diagnostic equipment of maintenance management		11	6	3	
6.	Monitoring of water and energy usage		11	4	4	1
7.	Supervising of equipment usefulness being at the disposal of service maintenance management workforce		10	7	3	
8.	Documentation of equipment and warehouse		7	9	4	
9.	Workplace equipment		6	7	7	
10.	Methods of assembling parts		6	7	6	1
11.	Location of (reference) warehouse		8	5	6	1
12.	Evaluation of material suppliers and condition of devices (infrastructure)		10	8	2	
13.	Degree of organizational correctness and ergonomomy of posts		10	8	2	
14.	Measurements of current machine efficiency, control of contemporary settings with producer's parameters	17		1	2	

Source: Author's own study.



Equipment of warehouse in spare parts was too modest, mainly due to costs reduction. In companies possessing own repair workshop, technical objects and tools for measurements being on warehouse disposal, were under very poor supervision (they were inventoried and their status was defined).

During repairs, if it is possible, replaceable parts are applied, not original spare ones. On the basis of records it is impossible to state objectively if such action is economically justified

In none of studied companies, fast-wearing out parts were defined in a formal way, and a minimum stock of these parts was also not defined. In reference warehouses stocktaking is not performed. Many purchases are probably not justified (before order is placed to a supplier nobody checks if this part is in a warehouse).

New and worn-out part of technical objects being in reference warehouses are not gathered separately (70% of studied enterprises). Only in reference to very expensive parts of technical objects, operating materials recommended by a producer are applied, for the rest – substitutes are used.

In many companies no responsibility for operating materials economy was assigned and there are not any settlements of accounts of their usual wear and tear in reference to particular technical objects.

## **7. Organizational culture**

In 6 studied companies involvement and self discipline of maintenance management workers was assessed as big. Only in 5 studied enterprises it was recognized that workers are sensitive to all symptoms of threats which can be due to maintenance management. In 13 companies workers do not improve their professional skills. In only 2 companies team work was pointed as an important element of quality improvement in maintenance management. Workers in majority of companies are not allowed to express their opinions freely. In 8 studied firms workers can expect support and help from their superior, Self control and self discipline of workers in jobs referring to maintenance management is moderate. In the workplace the atmosphere is relatively honest and open.

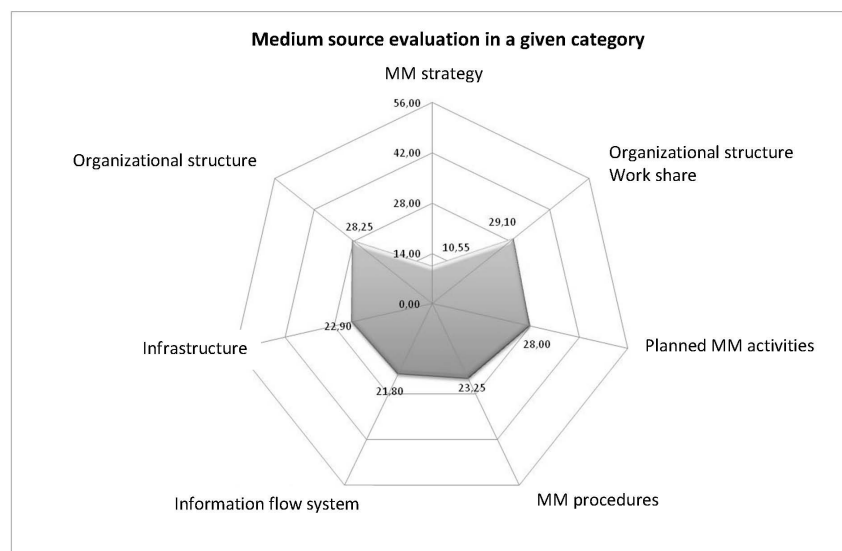
On the basis of the researches the evaluation of particular companies was achieved, in the form of a list of source points being the total sum of particle evaluations (98 factors). In the source points ranking, 8 companies achieved the value higher than medium, and three enterprises respectively stood out from others. 14 enterprises achieved results between 26 and 38% of maximum number of points. It means that the evaluation of these companies in this list is exceptionally low. Existing condition of companies in the category organizational structure and work share was assessed the highest. Not very high

medium evaluations were in the category infrastructure, information flow and procedures. Analysed data are demonstrated on Graph 2.

Table 7. Number of studied companies in category organizational culture, which gained individual evaluation points

	Studied factors in category organizational culture	Number of companies – point scale				
		0	1	2	3	4
1.	Involvement and self-discipline of MM workers		3	11	2	4
2.	Self consciousness of dangers in MM		2	13	4	1
3.	Tolerance to all negligence both on the side of managers and workers		1	11	4	4
4.	Improvement of skills and development of knowledge by workers			13	6	1
5.	Assurance of information, resources and stimuli for workers enabling achievement of necessary skills		8	8	4	
6.	Improvement of team work skills in order to improve quality of MM products		5	13	2	
7.	Delegating of entitlements by a superior		10	8	1	4
8.	Knowledge on evaluation rules on a superior's own work			14	5	1
9.	Worker's access to strategic assumption and information of a company		7	8	5	
10.	Support and help from a superior		3	9	7	1
11.	Freedom at expressing opinions		8	10	1	1
12.	Cult of active creative approach		6	8	5	1
13.	Atmosphere at the workplace		5	9	4	2
14.	Pride from being a part of a company		8	7	4	1

Source: author's own study.



Graph 2. Medium source evaluation in a given category

Source: author's own study.

The fact that is worth mentioning is that in the category “Maintenance management strategy”, 14 companies did not get any point. It means the lack of functioning of any systemic solutions referring to formation of strategic visions of maintenance management of a company.

As a part of an accepted model factors affecting company productivity and activities and resources used for realization of the process were identified. With the help of market research, ability of selected factors for productivity increase was assessed. The aim of these studies was to indicate the dependence on selected factors and functions of productivity increase, organizational system included.

The result shows that among all studied categories the biggest influence on productivity increasing in maintenance management are, subsequently, formalization and planning of MM operations, then organizational structure and work share and organizational culture.

Diagnosis of condition of maintenance management organization and finding elements in which activities connected to organization and management could give the best results in increasing productivity, are the indispensable pieces of information in a proper realization of maintenance management processes.

More attention paid to maintenance management as an essential process in organization and conviction as to its remarkable share in shaping economic results of a company caused the rise of the rank given to **activities of productivity improvement in this subject area.**

Efforts in order to improve productivity **are more effective due to application of management good processing tools, systems and programmes supporting services activity of maintenance management** of a company. In order to analyze and diagnose of studied factors of productivity improvement in companies, information tools for registration and data processing could be created. Two-theme approach to this problems will be appropriate:

1. Creating the database application for registration of data and emission of basic results indispensable for analysis, lists referring to data analysis method applied included.
2. Export of data from the base to a designed spreadsheet in such a form, as to enable the multi-surface evaluation of partially processed data and emission of graphs and lists of suitably selected composition, illustrating a studied phenomenon at its best.

In Picture 1, a form, enabling operating of base categories and introducing criteria of evaluation of productivity factors in an accepted scale, was shown.

ocena	opis oceny
0	Brak strategii, brak monitoringu
1	Monitoring w dużej mierze akcyjny
2	Monitoring akcyjny, wymuszony sytuacją
3	Monitoring nieregularny, ale wystarczający
4	Cykliczny monitoring, oprócz powyższych jako zróżnicowana karta wyników
9	

Picture 1. Criteria of productivity improvement

*Source: author's own study.*

For evaluation of productivity, indicative analysis was used parallel. From the palette of possible to calculate factors, it is necessary to choose those which show productivity in a given research area the best.

Productivity expressed as measures in the form of a quotient, where in a numerator there is any productive effect (number of goods produced and

delivered to a recipient, value of sold production, produced added value, etc.) and in a denominator – a size of used or worn out resources in order to achieve this effect (for example, effective time of machine work, production quantity, etc.).

For supporting analysis and diagnosis of studied factors of productivity improvement in companies, a spreadsheet, casually named as “productivity cockpit”, can be used.

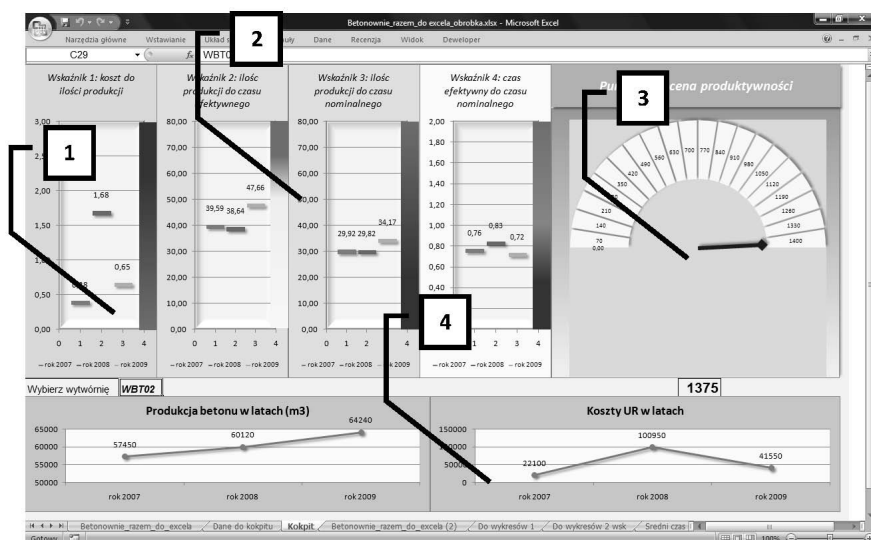
The spreadsheet allows for monitoring of a process of achieving productivity level in any chosen 3-year time compartments and to show it on the background of point evaluation of productivity referring to the last year of functioning.

In the spreadsheet, graphs showing a change of selected productivity indicators were collected. The graphs were designed in such a way as to make visual estimation of an indicator condition on the background of values recognized as bad (red), relatively good (yellow), good (green) possible.

On the right side in a “cockpit”, disc graph was placed showing values of achieved point according to an accepted method. The graph is calibrated up to maximum values achieved in this study:

- graph showing the size of production in some years (3 years),
- graph showing suitably costs of maintenance management in some years.

Its construction was designed in such a way as to collect, on one picture, the most important summary results and all other data allowing for evaluation if the applied method performs well in economic practice.



Picture 2. Productivity cockpit

Source: author's own study.

Four vertical measures showing productivity indicators are designed in such a way as to let individual colors show (1) values in subsequent years 2007, 2008 and 2009. They were marked by colors: blue, red and green. Along the scale (vertical axis) colored strips were placed (2), formatted to show the dependence of color to evaluation of indicator value. The color of a strip changes from red through yellow to green. Red shade of a strip indicates that indicator values are bad, yellow – average, whereas green indicates good values. Such data visualization is to make fast localization of indicators easy in areas not demanding activities (good) or demanding interest or intervention (average or bad).

The discussed measurement and productivity analysis shows where to look for improvement possibilities in organization and how this improvement is done. The response to these studies should be an effective plan of productivity improvement of companies with the lowest number of points.

In economic practice different methods of productivity evaluation are used, usually they are based on multi-indicative models combined with application of profitability indicators, often too complicated to use them in a company.

**The described method refers to productivity problems in a different way than financial and allows for monitoring the quality of organizational activities and a real condition in this range.** It was possible now to work out a method of direct measurement of productivity for maintenance management in building-construction companies, presented in this work in a form of a “Productivity Cockpit”. So far, productivity has been calculated only on the basis of historical data from accepted periods of measurement (a month, quarter, year) within the number of manufactured product and the costs, without possibility of influence on achieved results. Productivity cockpit can consist a tool to steer production in industrial companies.

Improper strategy and organization system of maintenance management not only in building enterprises but also in other firms, can consequently result in accelerated processes of wear and tear and unexpected natural damages (breakdown), and production of vague quality can lead to huge loss.

Productivity improvement is a fundamental duty of company managerial staff as they are responsible for economic results. Due to the fact, that productivity calculation mainly plays the role of a diagnostic tool, its natural complement is a productivity improvement strategy (PIS). Its aim is to find ways of elimination of unnecessary costs and rationalization activities.

Strategy of productivity improvement is generally directed to rational usage of productive factors, both by organizational changes and personal and technical-productive ones. Productivity calculation plays the fundamental role for PIS study, as it provides indispensable analytical information to managerial staff of a company, it transfers a result of diagnostic researches and improvements designs as well.

## Bibliography

1. Chauvet A.: *Metody zarządzania*, Poltext, Warszawa 1997.
2. Downorowicz O.: *System eksploatacji: Zarządzanie zasobami techniki*, Wydawnictwo i Zakład Poligrafii Instytutu Technologii Eksploatacji, Gdańsk – Radom 2000.
3. Lewandowski J.: *Zarządzanie środkami trwałymi i gospodarką naprawczą w przedsiębiorstwie*, Wydawnictwo Marcus, Łódź 1997.
4. Krupski R.: *Zarządzanie strategiczne. Koncepcje-metody*, Wydawnictwo Akademii Ekonomicznej im. Oskara Langego we Wrocławiu, Wrocław 1999.
5. Kunert O.: *Budowa kompetencji innowacyjnych wyzwaniem rozwojowym polskich przedsiębiorstw*, Wydawnictwo Politechniki Łódzkiej, Łódź 2008.
6. Niziński S., Żółtowski B.: *Informatyczne systemy zarządzania eksploatacją*, ISBN-83-916198-0-X. Olsztyn – Bydgoszcz 2000.
7. Mc Kone K., Elliott W.: *TPM: planned and autonomous maintenance: bridging the gap between practice and research*, Production and Operations Management 7 (4), 335-351, 1998.
8. Moubray J.: *Reliability Centred Maintenance*, Butterworth Heinemann, Oxford, UK, 1991.
9. Penc-Pietrzak I., Berliński L.: *Inżynieria projektowania strategii przedsiębiorstwa*, Wydawnictwo Key-Text, Warszawa 1999.
10. Swanson L.: *An information-processing model of maintenance management*, Int. J. Production Economics 83 (2003).
11. Waeyenbergh G., Pintelon L.: *A framework for maintenance concept development*. International Journal of Production Economics 77, 2002.
12. <http://pl.wikipedia.org/wiki/Eksploatyka>