MAINTENANCE MANAGEMENT ISSUES IN THE PROCESS OF SUPPLIER ASSESSMENT

Małgorzata JASIULEWICZ-KACZMAREK, Piotr SZAFER

Abstract: If somebody asked a manufacturer 20 years ago how they selected a supplier of ingredients, they would have likely said "it was based on price, flavour or the supplier location and preference". However, as industry put a stronger emphasis on quality, time delivery and risks associated with supplier selection, evaluating and selecting the right supplier today has become much more critical and complex. The objective of the supplier selection process is to reduce risk and maximize the total value for the buyer. This paper aims to find out what criteria are adopted by companies to assess their suppliers, and how maintenance management issues contributed to the decision of the right supplier selection.

Key words: Maintenance management, supplier assessment, on-site audit

1. Introduction

In today's highly competitive environment, an effective supplier selection process is very important to the success of any manufacturing organization. The cost of purchasing raw materials and component parts is significant in most manufacturing companies [28]. Therefore, selecting the right suppliers is the key to procurement process and represents a major opportunity for companies to reduce costs across its entire supply chain. Choosing the right method for supplier selection effectively leads to a reduction in purchase risk [9,11]. For many years, the traditional approach to supplier selection has been to select suppliers solely on the basis of price. However, as companies have learned that the sole emphasis on price as a single criterion for supplier selection is not efficient, they have turned into to a more comprehensive multi-criteria approach. Recently, these criteria have become increasingly complex as environmental, social and customer satisfaction concerns have been added to the traditional factors of quality, delivery, cost, and service [12, 29]. The realization that a well-selected set of suppliers can make a strategic difference to an organization's ability to provide continuous improvement in customer satisfaction drives the search for new and better ways to evaluate and select.

Hence, this paper aims to find out what criteria are adopted by companies to assess their suppliers, and how maintenance management issues contributed to the decision of the right supplier selection.

2. Literature review

2.1. Suppliers' evaluation and selection criteria

Supplier selection and evaluation is one of the most critical activities in purchasing or procurement process. Supplier selection is generally considered as five phase process: identification of the need for a new supplier; determination and formulation of decision criteria; pre-qualification; final supplier selection; monitoring of the supplier's performance. At first,

evaluation and assessment task needs the identification of decision characteristics against which the potential suppliers are to be assessed. Next evaluation seals are selected in order to measure the appropriateness of a supplier. The next step is to assign weight to attributes to identify the significance and contribution of each criterion to the supplier evaluation and assessment. Then an attribute may comprised of several sub attributes. The last stage is to evaluate potential suppliers against the characteristics identified at the beginning.

The literature on supplier evaluation and selection includes some surveys that: focused on problem criteria (multi-attribute decision making models, mathematical programming techniques) and proposed methods for the selection process.

To qualify the prospective suppliers, the effective defining of selection criteria is necessary [30]. A great deal of research has been conducted to determine what criteria should be used to evaluate suppliers. According to many authors [6, 13, 31], cost/price is one of the most crucial, factors to take into account when selecting a supplier. Purchasing prices can be considered as a major determinant of a company's ability to achieve competitiveness, and its ability to achieve high profit margins. Quality is a second criterion which has deserved an abundant amount of attention in the supplier selection literature [1, 6, 13, 31]. As stated in the literature review [1], quality can be assessed by methods categorized in two different groups: qualitative methods (continuous improvement programs, quality of customer and support services, certifications, technical and design level, capability of handling abnormal quality, ease of repair) and quantitative methods (reliability, rate of rejects , yield rate, process capability indices, loss functions). Delivery is yet another one of the most frequent used criteria in supplier selection [13]. This criterion reflects on supplier reliability issues such as "compliance with predetermined due date" and "compliance with predetermined order quantity". As the concept of the agile supply chain received an increasing amount of attention among both academics and company supply chain managers to cope with complex and dynamic environments, increasingly supplier selection criteria related to flexibility and responsiveness are adopted [5]. The next criterion is "technical capability". This factor has been measured on the basis of the importance of the following technical dimensions: compliance with quantity, compliance with due date, compliance with packaging standard, production planning systems of suppliers, maintenance activities of suppliers, plant layout and material. The next criterion considered in the literature is "financial stability" [2]. Both suppliers and buyers seek supply chain partners, which have the ability to positively contribute to their relationship, especially in the case of longer term relationships. A supply chain partner who is financially unstable will be less able to do so. Therefore, it is important to consider the financial position when selecting a suppliers. The other criterion is to "supplier's reputation". A supplier's reputation reflects on both a supplier's "performance history" [6], which is based on own experiences with a known supplier, and a supplier's "reputation in the industry" [4]. Company reputations have many aspects (e.g., are multidimensional) and vary with different stakeholder groups (e.g., are stakeholder specific). With the purpose of keeping the positive reputation, many corporations have requested suppliers to adopt the social accounting, auditing, and reporting indicators (e.g. Accountability's AA1000, SAI's SA8000) to disclose suppliers' social and environmental effects of their economic actions to society [3,27]. Traditionally, the selection of the supplier is based on the ability of the supplier to meet economic aspect such as quality, delivery and cost. Due to the globalization in business, competitive market situations and changing of customers' demands, organizations should add environmental and social aspects to the supplier selection criteria. The criteria are communicated to suppliers the most often by introducing the so called Suppliers Code of Conduct. That Code is a popular

tool by which buyers manage and monitor their suppliers' ethical and socially responsible practices. Development and providing the code to suppliers is an important step to change the way customers build relationships with their suppliers. Importance of social and environmental aspect of sustainability in supplier selection criteria is evident in the relevant literature [10, 14, 17]. Good product, its price and delivery terms are no longer sufficient criteria for suppliers evaluation. The exemplary criteria of suppliers assessment and interdependencies between them are introduced in the Figure2.

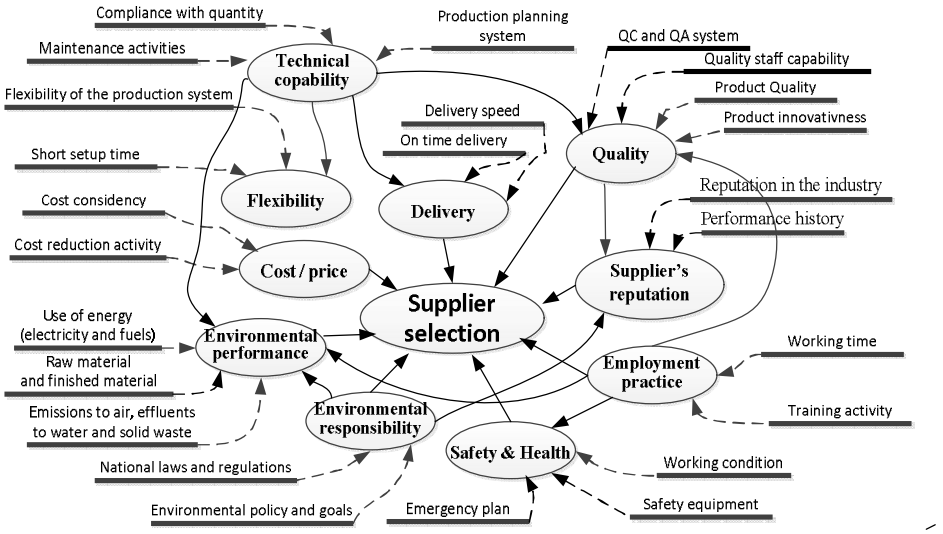


Fig. 2 Interdependency between supplier selection criteria [17]

The right supplier selection process encompasses different functions such as purchasing, quality etc. within the company; it is a multi-objective problem, encompassing many tangible and intangible factors in a hierarchical manner. In practice, any set of criteria must be considered in light of real-life constraints, making the supplier selection a complicated decision problem that involves balancing many trade-offs and satisfying conflicting desiderata.

2.2. Supplier On-Site Audit

The proper selection of suppliers (in case of new partners) and their continuous, regular evaluation make achievable the reduction of wastes and as an end-result the risk of losing customers. There are many supplier selection methods based on different criteria that were employed for solving the supplier selection problems. Organizations need to choose an approach to evaluating suppliers. Approaches may include:

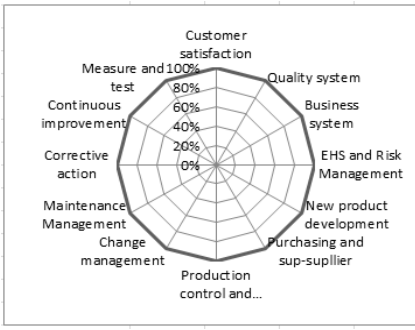
- accepting a third-party standard, such as ISO 9001 and its sector specific derivatives or good manufacturing practices.
- benchmarking performance against industry leaders.
- developing KPIs and scorecards based on system data or internal customer feedback.
- developing own certification or evaluation and measuring performance against it.

The supplier audit (on-site audit) in one of the most proactive and thorough means of assessing an supplier's ability to fulfil buyer requirements reliably and consistently. It gives the chance to look not only the supplier's product but also its processes. Business processes and practices can be reviewed to see how a supplier runs its business and provides a product or service at the best value, on time and exactly as required his buyer. This information is typically best practice based and focused on processes. Business processes and practices information can be obtained through questionnaires or surveys or during site visits to suppliers. This information is critical for creating and maintaining mutually beneficial long-term relationships. The purposes of the on-site audit are:

- to evaluate an existing or new supplier's compliance to, and ability to, effectively execute quality processes/procedures required by customer
- to facilitate improvement in a supplier's quality system by driving corrective action in areas of non-conformance
- to provide input regarding supplier's quality performance to the enterprise
- to provide an overall estimate of the level of customer support required in bringing a supplier to acceptable status

Whether the buyer is to benefit from the on-side audit to assess the suppliers depends on the type of relationship with the supplier and the risk associated with the material or the service purchased (influence of material / service on the final product of the buyer). If buyers are procuring material of minor risk and on occasional basis, the process of on-site audit would prove to be a time and money consuming exercise. In such a case, increased attention should be paid to the quality of material being procured. However, in case of suppliers with whom buyer intend to build long term relationship for regular / high value and risk contracts, positive outcome of on-site audit should be a necessary pre-requisite.

The on-site audit process has to be as objective as possible requiring the use of a standardized process and scoring approach to guarantee transparent and assure the credibility of results. This method of suppliers performance assessment, carried out by a cross-functional team, covers various areas and includes corresponding sub-sections. Each sub-section comprises a list of questions that guides the team members during the audit and uses a scoring system to record supplier performance (fig. 3). Sub-section scores are tabulated and performance gaps are identified at the end of the audit. The audit team draws out a performance improvement contract and assigns a final audit score based on sub-section scores (tab. 1).



Section	Points			Score
	Total	Possible	Percentage	
Customer satisfaction				
Quality system				
Business system				
EHS and Risk Management				
New product development				
Purchasing and sup-supllier				
Production control and planning				
Change management				
Maintenance Management				
Corrective action				
Continuous improvement				
Measure and test				

Fig. 3 Final audit score card

Table 1 On-site assessment scoring – an example

Level 1 – Strategic all > 79 %	Current Supplier – supplier is currently performing at a Level 1 – recommend strongly
	New Supplier – performance is consistent with Level 1 performance – recommend strongly
Level 2 – Preferred all min 60 – 79 %	Current Supplier – not currently performing at a Level 1 but has the potential with minimal improvements. Existing business can continue and the supplier can be considered for new business – recommend with corrective action
	New Supplier – has the potential to perform at a Level 1 with minimal improvements required – recommend with corrective action
Level 3 – Maintain all min 40 – 59 %	Current Supplier – corrective action are needed for the supplier to improve performance. During this time, business can continue upon review of corrective – not recommended – source with risk
	New Supplier – significant corrective actions needed be bring the performance to an acceptable level – not recommended – source with risk
Level 4 – Non Performing < 39 %	Current Supplier – performance not consistent with minimum Buyer standards – not recommended for new business. A corrective action plan must be provided and implemented within 60 days.
	New Supplier – no new business will be awarded – not recommended – do not source

The audit score is used to determine audit frequency and to motivate the supplier to achieve world-class status by providing a road map in the form of a performance improvement contract. Follow-up audits are scheduled based on these factors: business priority, supplier classification tier, performance improvement contract, and audit score. The audit score and the performance improvement contract are updated at the end of each audit.

3. Maintenance management

As a consequence, of the implementation of advanced manufacturing technologies and just-in-time production systems, the nature of the production environment has changed during the last two decades. This has allowed companies to massively produce products in a customized way. But the increase in automation and the reduction in buffers of inventory in the plants clearly put more pressure on the maintenance system [23]. The term "maintenance" is defined in Polish standard PN-EN 13306:2010 as the "Combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (function or a combination of functions of an item which are considered necessary to provide a given service)."

Maintenance is set in an agreed business context to which it has to contribute and the maintenance function needs to cope with multiple forces and requirements within inside and outside the organization boundaries. The tasks of maintenance are complex, including a combination of management, technology, operations and logistics support elements. Kelly [35] gives the following generic expression for the maintenance objective: "...to achieve the agreed plant operating pattern, availability and product quality within the accepted plant condition (for longevity) and safety standards, and at minimum resource cost".

Maintenance management is defined in PN-EN 13306 as all activities of the management that determine the maintenance objectives, strategies, and responsibilities and implement them by means such as maintenance planning, maintenance control and supervision, improvement of methods in the organisation including economical aspects. [22] expresses that maintenance management must align with business activities at strategic, tactical, and operational levels. The awareness of maintenance as a strategic factor within a company is established in literature. In recent years, maintenance has been considered as an activity contributing efficiently to the companies' strategic objectives in profitability and competitiveness. Kans [18] has described maintenance management as activities in order to reach the goals of efficiency,

effectiveness and cost-effectiveness in the maintenance area and where the overall goal is to contribute to company's profitability and competitiveness (fig.4).

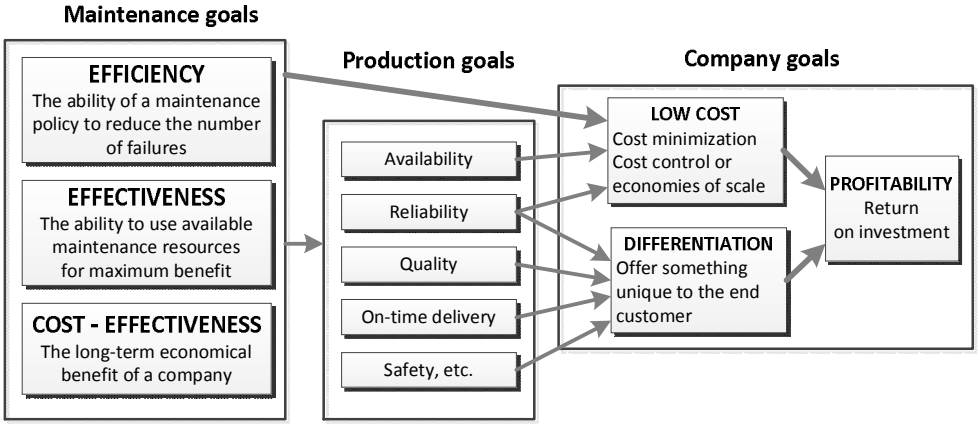


Figure 4. Connection between maintenance and profitability [19]

Many maintenance strategies have been developed in the last decades and applied to a large array of industries. An extensive classification of maintenance policies is found in [28]. The author describes six policies for single-unit systems with several examples of each category: age-dependent, periodic, failure limit, sequential, repair limit and repairs counting. A quite different perspective on the term policy is found in [20]. The author describes, from his point of view, the traditional division of maintenance policies into following categories: technology oriented (Reliability Centred Maintenance, RCM), human factors oriented (Total Productive Maintenance, TPM) and monitoring and inspection oriented (Condition-Based Maintenance, CBM). The strategies listed above are widely discussed in the literature. However, in the enterprises there are many "individualized maintenance strategies" that refer to "knowledge-based enterprise". The main objective of such methods is to use the immaterial resources of each organization in order to increase the economic benefit resulting from the construction of a maintenance strategy adapted to the requirements and resources of each organization [15].

Creating a sustainable production environment requires, among other things, the elimination of breakdowns and other sources of energy waste [26]. The inadequate maintenance can result in higher levels of unplanned equipment failure, which has many inherent costs to the organization including rework, labor, and fines for late order, scrap, and lost order due to unsatisfied customers [25]. The cost of breakdown in the production system can be very high, not only in the direct financial terms but also in poor moral of production staff and in unpleasant impact on the customers, environment and society. The implications of poor maintenance clearly reach far beyond a company's bottom line. The interdependencies between poor equipment maintenance and societal, delivery and quality company reputation are characterized in [32] (fig. 5).

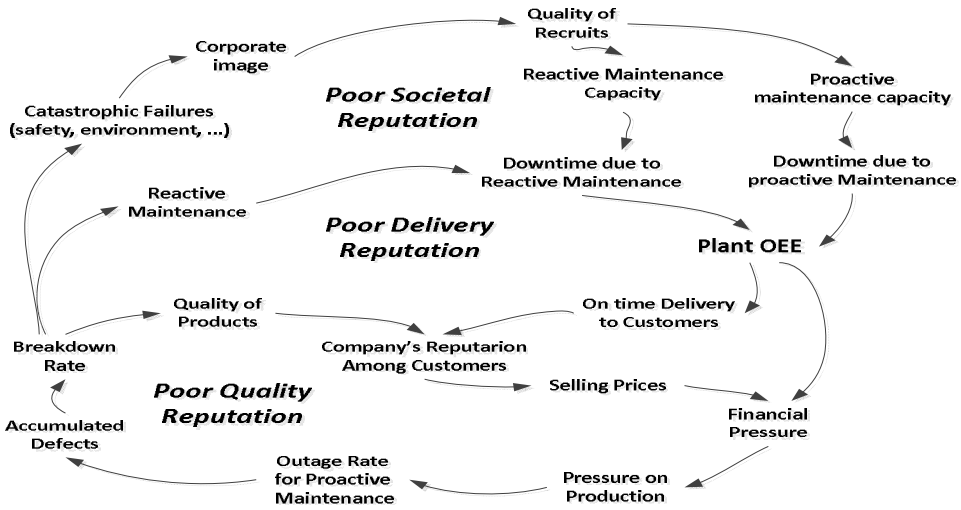


Fig. 5. Company's reputation will decrease over time due to frequent breakdowns (based on [32])

Poor equipment maintenance has an enormous impact on product quality and consumer trust. Frequent breakdowns cause unplanned downtimes, which hinder delivery of products to customers. Persistent delivery delay gives the company a poor delivery reputation. Customers penalize the company by paying less for the same product, which creates further financial problems for the company. Management will pressure the plant managers to cut costs and increase output which results in fewer resources for preventive maintenance tasks (Poor delivery reputation). A similar dynamic emerges in product quality. The quality of a product is related to the quality (i.e. the condition) of the machine. When the machine condition is kept on a high level, the outcome will be high quality products. In many industries, breakdowns introduce product defects. Defective products damage a company's reputation, reducing the selling price and the number of customers. Finally, because of the unpredictable and uncontrollable nature of breakdowns, they are typically the main source of safety and environmental hazards. Companies with low safety and high environmental hazard rates also lose status in society and in the labour market (Poor societal reputation). Highly competent job applicants prefer companies with good reputations or demand higher salaries if they are asked to work for companies with an unfavourable image. Over time, this will reduce the quality of the recruits and add to the company's problems

In general maintenance process is seen as supporting the main processes implemented in the company, and hence working only for production and at its cost. Nevertheless, the complexity of modern manufacturing systems and their dependence on a large number of both internal and external factors resulted in the extension of the group interested in the effects of maintenance work. These effects are being recognized not only in economic terms (increase or decrease of financial outlays), but also environmental (eg. use of exploitation materials or media) and social ones (eg. safety of people) [16]. The above presented relationship shows that the effectiveness of maintenance is observed not only by internal stakeholders, but also by company's clients. Increasingly, therefore, the maintenance area is an important criterion in the evaluation and selection of suppliers.

4. Maintenance issues in the supplier on - side audit

The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long term relationships between buyers and suppliers. As part of supplier development program and supplier control process, all approved suppliers may be subject to an on-site supplier verification audit. Selected suppliers will be audited as necessary to verify product / process conformance. Physical on-site audits represent the most rigorous assessment of a supplier's processes and capabilities. These are typically undertaken for the most critical and highest risk-profile suppliers. The examples of issues assessed within the audit are presented in the table 2, and issues referring directly to maintenance are marked with D, while issues referring indirectly to maintenance are marked with ID.

Table 2 The examples of issues assessed on the supplier's on-side audit

Food industry			Automotive industry			Foundry industry		
Section	D	ID	Section	D	ID	Section	D	ID
Administration & regulatory compliance	X		Documentation	x		Strategy & planning		x
HACCP management		X	Tooling & equipment	x		Purchasing		x
Facilities & equipment	X		Processes	x		Control of production	x	
Sanitation & hygiene	X		Human resources & organization	x		Monitoring & measurement	x	
Pest control		X	Product qualification		x	Identification & traceability		x
Approved suppliers		X	Logistic		x	Maintenance	x	
Process & product evaluation	X		Continuous improvement	x		Calibration	x	
Packaging & labeling		X	Quality asurance	x		Documentatio control & record management	x	
Storage & shipping		X	Implementation of quality		x	Corrective action & improvement	x	
Trainning requirements	X					Personal training	x	
Continuous improvement	X							

The assessment of the activities carried out in the area of maintenance is presented on the basis of audit reports. The analysis included 12 reports prepared after the audit in food manufacturing companies. In each of the twelve companies it was the first client audit, and its goal was to provide objective evidence that food safety management system works and meets regulatory and customer requirements. In every company the scope of the audit (the company received a self-assessment questionnaire) and the deadline for its implementation was predefined (at least two months in advance). Although the audits were conducted by different clients, and each of them used their own list of criteria and audit questions, in the area of maintenance questions dealt with the same issues. Analysis of the reports allowed for the isolation of 15 non-compliances identified during audits and relating to (Fig. 6): (1) planning preventive maintenance services; (2) preventive maintenance plans accuracy; (3) planning maintenance with respect to the criticality of the equipment for the product; (4) records of realized planned maintenance; (5) The records on the failures; (6) failure analysis; (7) procedures for approving machines for further use after repairs; (8) the

availability of spare parts for key machines; (9) the lists of key suppliers of spare parts / services; (10) The procedures and instructions accuracy; (11) conducted training for employees of external service company on the procedures implemented in the company; (12) The training of maintenance personnel; (13) surveillance over the tooling for machines; (14) application of appropriate measures for maintaining machinery (eg. lubricants, fluids); (15) The workshop equipment and surveillance over the equipment.

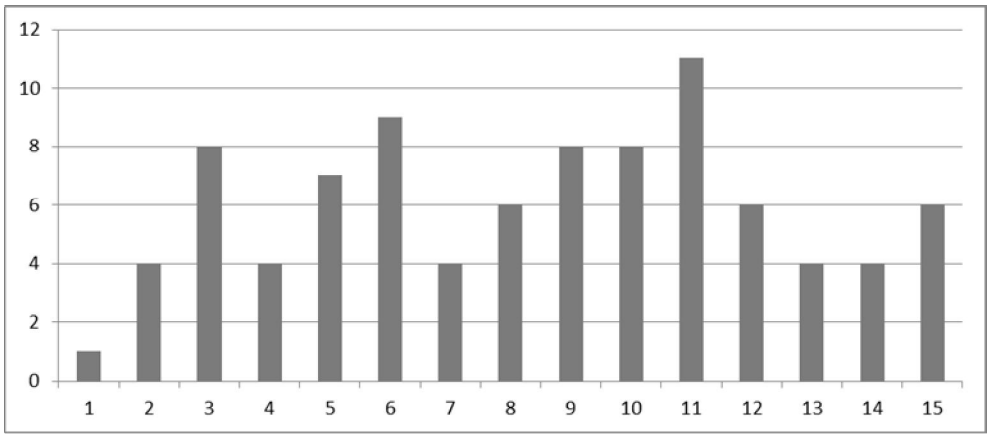


Fig. 6. Distribution of nonconformity in maintenance activities identified in the audit.

In the 11 companies lack of training on the procedures in force for workers of external maintenance company was not found, in 9 companies there were no analyzes of failure conducted, in 8 companies planning maintenance did not take into account the impact of machine breakdown on product (no formal analysis), there was no list of spare parts suppliers, procedures and instructions used were outdated / inadequate.

The final conclusion of the report was as follows: 4 enterprises achieved a positive result and a recommendation to cooperate, 5 companies have been conditionally approved for co-operation, while three were rejected (in two cases the reason for the rejections were substantial inconsistencies relating to the maintenance)

5. Summary

Supplier selection has become one of the fastest growing areas of management especially in the last few years. The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long term relationships between buyers and suppliers. The criticality of supplier selection is evident from its impact on firm performance and, more specifically, on final product attributes such as cost, design, manufacturability, quality, and so forth. The efficiency of supplier selection depends on how practical the evaluation criteria are managed to be chosen, what the evaluation procedure (timeliness) is and the background support. Proper results can be expected if the evaluation framework based on continuously updated database, and it is accompanied by rigorously check the supplier's capabilities. To rigorously check the supplier's capabilities the buyer might: (i) request samples of supplier products and test the m to ensure conformance to the buyer's requirements. (ii) on-site audit

- visit the supplier's production facility and interview line workers and engineers to ensure that all members of the supplier team understand the critical features of the product in their charge. By on-site audit buyer have the opportunity to observe how supplier conducts business and to determine what good practices he has in place to ensure his consistent ability to fulfil requirements.

The article presents examples of areas which customers pay attention to when evaluating suppliers with the on-site audit. Regardless of the industry (food, foundry, automotive, etc.), an important element of the assessment of suppliers is to supervise the production equipment (machinery, equipment, installations). Maintenance is increasingly critical to assessing the quality of suppliers and in the audit has the same meaning (rank of criterion) as other areas audited in the company. Inaccuracies in this area may result in the resignation of cooperation with the supplier (excluding them from the list of qualified suppliers if such list was applied), or not initiating cooperation (in the case when it was the preliminary audit - the first).

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Dr inż. Małgorzata JASIULEWICZ-KACZMAREK
Katedra Ergonomii i Systemów Projakościowych
Politechnika Poznańska
60- 965 Poznań, ul. Strzelecka 11
tel./fax: (0-61) 6653374
e-mail: malgorzata.jasiulewicz-kaczmarek@put.poznan.pl

Dr inż. Piotr SZAFER
Wyższa Szkoła Bankowa
61-874Poznań, ul. Al. Niepodległości 2
tel./fax: (0-61) 6553333
e-mail: piotr.szafer@wsb.poznan.pl