Development of a risk matrix for the assessment of maintenance suppliers:
A study based on empirical knowledge

Katarzyna Antosz*, Dorota Stadnicka*, R.M. Chandima Ratnayake**
*Zeszow University of Technology, Al. Powstancow Warszawy 12, 35-959 Rzeszow
Poland (Tel:+48 178651452; e-mail: katarzyna.antosz@prz.edu.pl, dorota.stadnicka@prz.edu.pl).
** Faculty of Science and Technology, Department of Mechanical and Structural Engineering and Materials Science,
University of Stavanger, Norway. (Tel: +47 518 31 938; e-mail: chandima.ratnayake@uis.no)}

Abstract: The machinery maintenance plays a significant role achieving the final quality characteristics of the manufactured products. As the concept of quality covers tangible (e.g. dimensional tolerances) and intangible (e.g. lead-time), the assessment of maintenance suppliers is vital in maintaining the quality of a manufactured product at an anticipated level. As the maintenance suppliers play a significant role in the context of the availability of spare parts and other materials needed for the effective realization of the maintenance process in order to assure the overall quality of the manufactured products, it is vital to achieve the aforementioned via minimization of machinery down time and maintenance backlogs. This paper illustrates the adaptation of empirical-knowledge-based development for the assessment of spare parts and maintenance related other material suppliers. That development has been used only in the manufacturing material suppliers’ assessment so far. The criteria used in the case study manufacturing firm for the material suppliers’ assessment, as well as other relevant criteria published in the literature, are taken into consideration in the current study. The paper also presents a development of a risk matrix for the assessment of maintenance suppliers, which is the core for the risk based assessments, prioritization and control process.

© 2017, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.
Keywords: maintenance suppliers, manufacturing machinery maintenance, supplier evaluation, risk assessment, maintenance models and services, quality assurance

1. INTRODUCTION
Manufacturing firms, which are certified or to be certified according to ISO 9001, are required to ensure that externally supplied products and/or services meet the particular manufacturing firm’s requirements (Ingason, 2015; ISO 9001, 2015). In this context, it is a mandatory requirement to evaluate and select suppliers based on their ability to supply products and services depending on the particular manufacturing firm’s requirements and, thus, it involves specifying the criteria for the selection, evaluation, and re-evaluation of suppliers (Sumaedi, and Yarmen, 2015; ISO 9001, 2015). Moreover, it is necessary to establish and implement the control measures or other actions necessary to ensure that the purchased product or services meet the specified requirements (ISO 9001, 2015). Although the risk based criteria for the evaluation of manufacturing/production materials suppliers were reasonably established, such criteria have not been effectively adapted to the manufacturing-facilities related spare parts and maintenance support materials suppliers (Sheikhalishahi and Torabi, 2014; Ocampo et al., 2016). Hence, it is vital to investigate the possibility of adapting the risk based criteria for the manufacturing/production materials suppliers of spare parts as well as maintenance support material suppliers, and to develop risk matrices to perform the risk based assessments, prioritization and control (Antosz and Ratnayake, 2016).

The first part of this paper reviews the suppliers’ evaluation criteria in the published literature (see Hamdan and Cheaitou, 2017). Then, a case study was performed in order to examine the empirical-knowledge-based criteria that were developed for assessing the manufacturing/production materials suppliers. Based on the manufacturing/production materials suppliers’ assessment, the criteria in the case study manufacturing firm and the published literature, the authors propose a risk based set of criteria and a risk matrix for the assessment of maintenance process suppliers. The criteria weights were established based on the expert knowledge, which is a recognized method for establishing the criteria weights (see Stadnicka, Antosz, and Ratnayake, 2014). A risk matrix enables to estimate the risk of employing a certain supplier based on: supplier’s categorization, importance of the delivered product, and possibility for exchanging the supplier in case of absence and/or any other unacceptable circumstances. Such a risk matrix enables to make the risk based: assessments, prioritization and control of the maintenance related spare parts and support material for practicing engineers, as well as further related research and development tasks focusing on the minimization of variability (Ratnayake, 2014).
2. COOPERATION WITH SUPPLIERS AND SUPPLIERS’ ASSESSMENT

Table 1 illustrates the review of different criteria for the suppliers’ assessment in the published literature. It is revealed that most of the authors indicate: quality, price, delivery time, reputation as well as quality, environment and safety programmes within their criteria (Cagnin et al. 2016, Chen and Wu 2013). Moreover, many publications emphasized an environmental aspect as an important criterion (Govindan 2015).

| Criterion                                      | Work                                                                 |
|-----------------------------------------------|----------------------------------------------------------------------|
| Quality, customer satisfaction                | Dangi et al., 2014, Zhang et al., 2009, Lima-Junior and Carpinetti 2016, Bottani and Rizzi 2008, Erdem and Göçen 2012, Ö nú et al. 2009, Sevki et al. 2008, Ng 2008 |
| Price, cost                                    | Dangi et al., 2014, Lima-Junior and Carpinetti 2016, Erdem and Göçen 2012, Ö nú et al. 2009, Sevki et al. 2008, Ng 2008 |
| Production capacity                            | Dangi et al., 2014, Erdem and Göçen 2012                              |
| Technical capability and facility, technology  | Dangi et al., 2014, Erdem and Göçen 2012, Sevki et al. 2008, Ng 2008 |
| Service and delivery, service quality, logistic| Dangi et al., 2014, Zhang et al., 2009, Erdem and Göçen 2012, Sevki et al. 2008, Ng 2008 |
| Reputation, honesty, reference                 | Dangi et al., 2014, Lima-Junior and Carpinetti 2016, Ö nú et al. 2009, Sevki et al. 2008 |
| Geographical location, distance               | Dangi et al., 2014, Lima-Junior and Carpinetti 2016, Sevki et al. 2008, Ng 2008 |
| Delivery time                                  | Zhang et al., 2009, Lima-Junior and Carpinetti 2016, Segura and Maroto 2017, Ö nú et al. 2009, Sevki et al. 2008, |
| Quality, environmental and safety programs and certificates | Lima-Junior and Carpinetti 2016, Segura and Maroto 2017, Sevki et al. 2008, |
| Financial situation                            | Lima-Junior and Carpinetti 2016                                     |
| Technical and organizational capabilities, execution time, lead time, capacity | Bottani and Rizzi 2008, Ö nú et al. 2009, Sevki et al. 2008 |
| Design capability, product development         | Lima-Junior and Carpinetti 2016, Sevki et al. 2008                  |
| Responsiveness to demand change                | Lima-Junior and Carpinetti 2016                                     |
| Ease of communication                          | Lima-Junior and Carpinetti 2016                                     |
| Supplier’s willingness                         | Bottani and Rizzi 2008                                              |
| Company’s interest                             | Bottani and Rizzi 2008                                              |
| Size of enterprise                             | Sevki et al. 2008                                                   |
| Supply variety                                 | Ng 2008                                                            |

Different methods report a supplier selection together with a set of criteria (Ávila et al. 2015, Toloo and Nahligar 2011; Chu and Varma 2012; Cagnin et al. 2016, Chen and Wu 2013). Among others, AHP (Analytic Hierarchy Process) and FAHP (Fuzzy Analytic Hierarchy Process) methods are proposed (Liao et al. 2016, Galankashi 2016). Sheikhalishahi (2014) presented a methodology for a maintenance supplier selection. However, it is a challenge for industrial organizations to employ relatively complex methodologies for choosing their suppliers. Hence, it is vital to propose simple methodologies in the suppliers’ selection. Therefore, this study focuses on the risk based maintenance supplier selection approach that shall be used in a small or large industrial organization. It was adapted from the manufacturing/production material suppliers’ selection methodology.

Table 2. The criteria of supplier assessment.

| Criterion and its characteristics | Points |
|-----------------------------------|--------|
| Price ($P$)                        |        |
| Unacceptable – The highest price on the market | 1       |
| Very High – One of the highest price on the market | 2       |
| High – Very high price compared to the competition | 3       |
| Medium – Price compared to the competition | 4       |
| Low – Very favourable price        | 5       |
| Very Low – The lowest price in the market | 6       |
| Punctuality ($P_r$)                |        |
| Unacceptable – Very long delays    | 1       |
| Very Low – Goods are often not delivered on time | 2       |
| Low – Several times late in delivery (long delays) | 3       |
| Medium – Several times late in delivery (Short delays) | 4       |
| High – Deliveries on time, isolated cases of short delays | 5       |
| Very High – Deliveries always on time | 6       |
| Quality ($Q$)                      |        |
| Unacceptable – Supplier does not meet the requirements. | 1       |
| Very Low – Goods often do not meet the requirements | 2       |
| Low – Goods meet only some of the requirements | 3       |
| Medium – Goods meet most of the requirements | 4       |
| High – Goods meet all of the requirements, isolated cases of non-compliance | 5       |
| Very High – The best quality       | 6       |
| Payment conditions ($P_c$)         |        |
| Unacceptable – no possibility of negotiation, limited payment options | 1       |
| Unfavorable – no possibility of negotiation | 2       |
| Unfavorable - the possibility of negotiation, conditions in | 3       |
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات