QUALITY MANAGEMENT SYSTEMS – SHAPING THE QUALITY OF PRODUCTS AND SERVICES

Introduction

The globalization of the market entails the process of border obliteration between countries in the face of common unification of requirements within the scope of quality management. This thesis is related to the research conducted in 2014 on the sample of specific enterprises – suppliers for the automotive industry in Poland, Russia and Ukraine. The research embraced production enterprises among which a group of suppliers for the automotive industry was distinguished. The selection in this regard was well-grounded as it was linked with the research conducted in 2007. In addition, the significance of separate elements of a quality management system was examined. The present chapter includes selected parts of the results of a research in shaping the quality of products and services in Central and Eastern Europe.
Quality management systems for automotive industry suppliers are an interesting example of an industrial QMS. Companies seek the status of qualified supplier of OE/OES (OE/OES – original equipment/original equipment services) components as this gives them prospects of expanding and being able to render their services for car manufacturers (OEM). Because of that, quality management plays a very important role. Quality management is based on several sets of requirements, which differ considerably in their level of detail and possible implementation problems.

Vehicle manufactures, and car manufactures in particular constitute a group of customers who are considered to be particularly demanding. This results from the thoroughness of requirements they set, e.g. in relation to quality management. Thus, automotive industry is quite interesting for quality management experts. It is abound in a significant number of both pioneer and established solutions. Many of them have been incorporated into other branches of industry. Nevertheless, the number of methodologies, techniques, identified key process and components used is an answer to numerous requirements which OE/OES suppliers have to meet. Requirements – the criteria for establishing, implementing and developing QMS. But they are also the basis for QMS evaluation (Burill and Ledolter, 1999) as far as their conformity and efficiency are concerned. Evaluation is realised by means of audit by customers, potential customers or certification bodies, and quite often accreditation authorities such IATF (International Automotive Task Force).

Companies – OE/OES suppliers for the automotive industry - supply components exclusively and directly to OEM; many companies cooperate with customers from other industries, including also cooperation under OE/OES contracts. In every day practice of quality assurance the fundamental question is that of significance of particular sets of requirement and of specific requirements. Evaluating the significance of QMS criteria can enable more efficient planning at the stage of implementing, maintaining and developing management systems. An effective QMS in this case means a QMS which enhances gaining and maintaining the statute of OE/OES supplier for automotive industry. A research question defined in such a way has a very pragmatic dimension, because of a significant number of criteria automotive industry suppliers have to meet. In most cases, an OEM customer presents a substantial set of additional requirements on quality management, i.e. CSR – customer specific requirements.

Research hypotheses formulated in the following article have been verified by the designed and performed research.

1. Research objectives and hypotheses

The target research problem has been formulated in the question about the significance (defined as importance, not statistical validity) of particular quality management system requirements. This question is significant when we think about the substantial number of requirements and 'good practices' in the field of quality management in the automotive industry. Thus, in practice we have to assume that some of the requirements are more important and that the quality management system should be based on them and concentrate on them.

Explaining the research problem was possible thanks to formulating and realising research objectives which were limited to determining the requirements set in the automotive industry in relation to OE/OES supplies as well as evaluating the significance of particular requirements.

To realise the research objective it was necessary to perform the following tasks:

- verifying the criteria, which do not have a formal expression, but make up criteria in the QMS – very often in the form of solutions typical of the industry, or industrial know-how,
- evaluating the significance of these requirements on a sample of Polish, Ukrainian and Russian companies which have undergone comprehensive assessment – including both the point of view of

certification bodies, or customers and requirements according to which own projects are carried out – aimed at evaluating the efficiency and effectiveness of management systems.

Finally, a practical objective complemented the research objective. That practical objective was to prepare a list of most crucial requirements as far as QMS were concerned for the said suppliers on the basis of audit criteria significance and conclusions drawn based on them.

The following scientific hypotheses had to be verified to realise the objective of the research work:

1. Key requirements which have to be met by OE/OES suppliers in the automotive industry concentrate on designing and establishing a production process, particularly by means of risk analysis of production (assembly) flaws as well as sanctioning methods and tools for process supervision,
2. Key components of QMS of an OE/OES supplier are Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP).

Thus, in practice the basis of QMS is the ability of an organisation to prepare collective and interdisciplinary flow diagrams, PFMEA, control plans as well as safeguarding their consequent resultant relation.
Both APQP and PPAP are collections of necessary actions which comprise of a wide spectrum of Quality Management methods and techniques; they are most crucial as comprehensive elements of Quality Management System, but also due to the significance of their component parts (partial requirements).
Review of literature in this field indicates that research question defined in such a way has not been investigated earlier (except J. Łuczak, 2008). The significance of requirements in QMS has not been analysed. Neither have been some practical questions concerning the direction of maintaining and developing systems to ensure effective and efficient functioning on the market. Research has been made as far as key factors in TQM are concerned (Sila and Ebrahimmpour 2003; Claver et al. 2003; Karuppusami and Gandhinathan 2006) and there are many publications concerning selected aspects of Quality Management Systems – materials of theoretical and practical (research) character and case studies (Theodorakioglou et al. 2006; Kartha 2004; Zacharatos et al. 2007; Ahire and O`Shaughnessy 1998).

2. Requirements set in the automotive industry concerning OE/OES suppliers

When we take into consideration the practical operation of OE/OES suppliers a number of different requirements can be indicated. These include the following:

- standards which are the basis of QMS certification – first of all ISO/TS 16949 (but also VDA 6.1 and other standards),
- environmental management and environmental protection, patent rights and intellectual property protection,
- rules on performing production process audits as well as product audits, required in ISO/TS 16949, but described in VDA 6.3 and VDA 6.5,
- legal regulations; related to human rights protection in particular,
- key tools in systems of the automotive industry – described in QS-9000 manual – advanced product quality planning (APQP), production part approval process (PPAP), statistical process control, measurement system analysis (MSA), failure mode and effect analysis (FMEA) (Łuczak and Matuszak-Flejszman, 2007),
- interpretation of ISO/ TS 16949 requirements and certification rules determined by International Automotive Task Force (IATF),
- and finally customer specific requirements (CSR).

Supplier quality management system in the automotive industry is shaped above all by customers who determine the requirements for quality management. Customers can either be car manufacturers or 1^{th} tier or 2^{nd} tier suppliers. At the same time, the criteria are defined by certification bodies, which are supervised by the accreditation authority

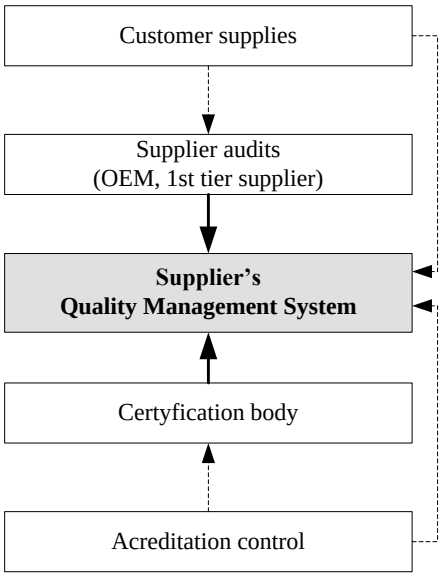

Figure 1. Shaping supplier QMS by direct and indirect influence of external units
Source: Own preparation

The automotive industry confirms distinctly the success of the idea of universal standardisation as far as quality management proposed by ISO is concerned. The basic ISO series 9000 standards have turned out to be very popular as basis for independent certification process. By the end of 2013 more than 1 129 446 (as cited in The ISO Survey – 2013) ISO 9001 compliance certificates were awarded Statistics concerning certificates in the automotive industry were published for the tenth time. 53723 ISO/TS 16949 certificates (2013) is a stable 7 % increase. Certifications to motor industry standard ISO/TS 16949 went from strength to strength with Asia claiming over 60 % of certificates issued, reflecting the region's healthy market for automotive parts. The top three countries for the total number of certificates were China, the Republic of Korea and India, while the top three for growth in the number of certificates in 2013 were China, India and the Republic of Korea. China (20355), India (4220) and the Republic of Korea (4696) are the leaders in the automotive industry as far as the number of certified QMS is concerned. There are ISO/TS 16946 certificates (2013) in Poland (538), Russian Federation (237), Ukraine (33).

Customer specific requirements (CSR[12]) play a special role here, as they are determined by almost every customer in the industry – always by car

[12] Selected customer specific requirements: Quality Cap Suppliers (Audi), Supplied Parts Quality Mgmt (BMW), TS 16949:2002 Customer Specific Requirements (DaimlerChrysler), Honda Supplier Quality Manual (Honda), SMITQA-003 (Mitsubishi), Supplier Quality Manual

manufacturers and manufacturers of other vehicles and very often by 1st tier suppliers to 2nd tier suppliers. Such requirements usually take the form of formal documents which most often are interpretation or extension (sometimes very extensive) of requirements of the base standard for QMS (ISO/ TS 16949).
Even superficial analysis indicates that the number of requirements is substantial. These requirements in practice become obligatory for suppliers who seek the status of OE/OES supplier. However, it is not possible to meet all requirements and consider them all a priority. So the question which of them is the most significant and should be the foundations of quality management system seems to be justified. Such foundations should be universal for a company operating in the automotive industry and to be able to gain new customers.

3. Literature review

As the research objectives were defined and study scenario was determined literature research in the same field of interest as the research question was conducted. First of all, the main objective was to collect all materials related to evaluating the significance of requirements which suppliers in the automotive industry have to meet. Secondly, literature research went beyond automotive industry and was not restricted to standardised management systems.
Collecting literature in this field was carried out by means of searching according to keywords (QMS & automotive, automotive components industry, automobile & customer specific requirements, automotive & supply chain management, auto parts industry & management, ISO/ TS 16949, QS-9000, core tools, automotive industry, QM factors, QM criteria, audit criteria, critical factors, critical success factor), going through literature databases (WDI (World development Indicators), GMID (GLOBAL MARKET INFORMATION DATABASE), ProQuest, ECONLIT, ACADEMIC SEARCH PREMIER, BUSINESS SOURCE COMPLETE MASTER FILE PREMIER, EMERALD, and going through library collections of many Polish and American universities.
Several hundred articles were searched and analysed which were within the author's scope of interest as part of the research performed: The articles can be divided into following groups:

- informative articles on systematic quality management in the automotive industry,

(Firestone), General Motors Customer Specifics – ISO/ TS 16949 (General Motors), Suppliers Manual (Weweler).

- articles on selected aspects of QMS,
- articles related to supply chain management,
- articles on evaluation of factors connected with QMS, or quality management in particular.

The author was not able to find any publications in which the significance of QMS requirements would be evaluated; not only in relation to the automotive industry, but also to other areas. Analysis of this type is connected with many doubts as far as defining the general population, or its homogeneity is concerned. As far as significance evaluation is concerned the importance of factors connected with quality management as well as components of QMS in conformity with ISO 9001 have been taken into consideration.

In the publishing market, there are several dozen publications connected with quality management in the automotive industry. Most of them are of informative character – they discuss and comment on the requirements. Predominantly, they are publications on ISO/TS 16949, by Hoyle, D. (Hoyle 2002), James C.W. (James and Peach 2005), Lupo Ch. (Lupo 2002) and other inudstrial standards related to quality management in the automotive industry, such as Smith R.M (Smith 1996), Stamatis D.H. (Stamatis 2004; Stamatis 1996). Other articles discuss the implementation of an industrial QMS (e.g. Rudin B., Heinloth S.) (Rudin 2004; Heinlot 2000) its implementation and development (e.g. Rogers H., Bennett D., O`Kane J., Delbridge R, Barton H.) (Rogers 1998, Bennett and O'Kane 2006; Delbrigde and Barton 2002).

Many articles discuss selected components of QMS on basis of which key requirements for the automotive industry can be determined. The following publications concentrate, among others, on FMEA, Six Sigma, benchmarking, team work, 8D, PPAP, TPM (Teng et al. 2006; Kymal 2006; Lanigan 2004; Girard 2005; Chen 1997).

Authors also present case study articles – with corporate, national or international scope on quality management in the automotive industry (e.g. Correa H.L., Martes de Miranda N.G.; Yosof S.M., Aspinwall E.; Zadry H.R., Yosof S.M.; Nepal B., Chinnam R.B., Petrycia J., Brush E., Chishoim C., Hearn M., Meixner M.; Lin W., Liu Ch., Lai Ch.) (Correa and Martes de Miranda 1998; Yosof and Aspinwall 2001; Zadry and Yosof 2006; Nepal et al. 2007; Lin et al. 2004), very often related to supply chain management and supplier evaluation (Bandyopadhyah J.K.; Clifton N.; Purdy L., Astad U., Safayeni F.) (Bandyopadhyah 2005; Clifton 2001; Purdy et al. 1994).

As far as the following article is concerned, publications discussing quality management related factors, are crucial (Sila and Ebrahimmpour 2003; Claver et al. 2003; Karuppusami and Gandhinathan 2006). However, they are not directed at any particular industry in any case.

4. Scope, subject and object of the research

In order to realise research objectives and verify formulated research hypotheses a proper study were first designed and then performed. The main point of interest of the author in the research was the criteria on which quality management systems which were implemented, maintained and developed by automotive industry OE/OES suppliers are based on. The two studies were designed to evaluate the requirements of quality management system for the suppliers in the automotive industry.

As a result of QMS criteria verification a questionnaire was compiled. The questionnaire was the tool for proper research.

Proper study was performed on a population of homogenous character – as far as quality management is concerned. These organisations from Poland, Ukraine and Russia were awarded an ISO/TS 16949 compliance certificate which was tantamount to cooperation with customers under OE/OES contracts. On one hand, these companies (successfully) underwent certification audit performed by an accredited certification body. On the other hand, they have cooperated with at least one customer under OE/OES contract.

To present how the studies were conducted, synthetic data is presented in table 1. The objective of the study was determined, as well as the study population/group, sample size, responsiveness, research method, research tools and data collection methods.

Table 1. Characteristics of performed research; Source: Own preparation

Objective of the study	Study population	Sample size/responsiveness	Study method	Tool	Data collection method
Evaluating the significance of particular requirements (criteria) of supplier QMS for in the automotive industry	Companies with quality management systems certified against ISO/TS 16949 headquartered in Poland, Russia and Ukraine.	538/ 42% (Poland), (33/ 51%) Ukraine; 237/ 17% Russia	Categorised questionnaire form	Questionnaire form	the Internet

5. Compliting study questionnaire

As result of verification a study questionnaire was compiled. Drawing up the questionnaire was aimed at determining and arranging the requirements set in the automotive industry as well as preparing a tool to perform the proper study.

As successive versions of the questionnaire were discussed the following issues were covered:

- environmental management (implementing an Environmental Management System conforming to ISO 14001 and particular actions taken in this respect),
- TPM (Total Productive Maintenance),
- modern customer communication programs,
- best-practice programs based on benchmarking,
- Kanban supply planning systems,
- team work,
- risk management,
- production workers engagement programs (kazein type),
- quality cost management,
- quality planning in relation to business planning (codified planning system based on indicators, very often flag system planning, hoshin planning, BSC),
- business processes monitoring,
- 5S system,
- information security management, maintaining data confidentiality,
- approving production details; production part approval process (PPAP), ISIR plans,
- advanced product quality planning (APQP),
- mistake-proofing and fool-proofing systems (e.g. poka-yoke, baka-yoke),
- 8D reports,
- production process algorithm (flow diagram),
- relation between FMEA results and control plans,
- emergency response plans,
- verifying QMS efficiency and effectiveness,
- purpose/intended use and control plan availability,
- role of operational instructions,
- documented repair procedures,
- FIFO rotation system,

- legal protection of technological solutions,
- business continuity management plans,
- production process audit and product audit (according to VDA 6.3 and VDA 6.5 requirements),
- selected quality management method and techniques.

In course of discussion some of the aforementioned requirements were thought of as individual questions in the questionnaire, some others not - for example, if they were considered to be a part of another criterion, or if they were not considered to be a characteristic component of quality management in the automotive industry.
The ultimate goal of the preliminary study was to compile a questionnaire (Appendix A – questionnaire form), which was conceived as a collection of grouped requirements (criteria) of quality management system. In concept the layout of the questionnaire form was not only to facilitate the order proposed in the ISO/TS 16949 technical specification, but also take into consideration other criteria – typical of the automotive industry, to perform OE/OES equipment supplies.

To evaluate the significance of all criteria a ten-grade, evaluative scale was used. It was recognised that due to the objective of the research there was no need to make use of an odd scale or a scale used, for example in schools (Brace 2004; Kaczmarczyk 2002; Hague 2006). A comprehensive 10 grade scale was supposed to give a wider spectrum of evaluation, and show diversity in the evaluation. In result analysis, significance analysis was used – based on the arithmetic mean and by accepting particular ranges – indicating the most and the least significant requirements.

6. Proper study

6.1. Proper study description

The proper study was carried out to evaluate the significance of quality management system requirements for suppliers in the automotive industry. The study was carried out on a group of companies headquartered in Poland, Russian and Ukraine and certified against ISO/TS 16949 requirements. The study was performed on whole population; gained responsiveness was equal to 42% (Poland), 51% (Ukraine), 17% (Russia) and other statistical parameters enabled inference for the whole study group.

To verify the obtained results in each and every case the following indicators were calculated: arithmetic mean, modal, median, coefficient of variation, Pearson's correlation coefficient and Spearman's rank correlation coefficient.

The study was carried out as a questionnaire form and the data obtained was analysed and subject to statistical inference to verify the hypotheses formulated in this research work.

6.2. Study methods and data collection techniques

The objective of the conducted study was to evaluate the significance of audit criteria for quality management system.

The subject matter of the research is ISO/TS 16949 compliance certified companies – 1st tier OE/OES equipment suppliers for OEM. The subject matter is quality management systems, audit criteria in particular – requirements which are set for system requirements.

A questionnaire form was used to conduct the research. It was distributed by electronic way (by means of e-mail) and was specially fitted for the means of internet study (Kaniewska-Sęba et al. 2006; Mazurek-Łopocińska 2005; Pociecha 1996; Mącik 2005).

To complete the base of respondents – companies which certified against ISO/TS 16949 requirements – a multi stage process based on one basic source of data and completion of databases was performed. The basis to determine the general population was a list of certified companies supplied by IATF. The author verified the list and complemented the database based on the following sources:

- certification units operating in Poland, in Russia, in Ukraine,
- consulting units providing consulting and training services on quality management in the automotive industry,
- national register of companies holding certified management systems run by Department of Industrial Policy of the Ministry of Economy in the Promocja Jakości (Quality Promotion) programme,
- data obtained from Automotive Market Research Institute SAMAR,
- data obtained from the Polish Chamber of Automotive Industry.

6.3. Study group description

Proper study was carried out on all companies located in Poland, Russia, Ukraine, which at the time of the research had ISO/TS 16949 compliance certificates (companies with Conformance of applicability status were not

included in the group of companies participating in the research). The general population amounted to 808 companies. All properly completed questionnaire forms were returned. Then, the questionnaires were analysed and inference was based on them.
Holding a certificate by the respondent was a sufficient and at the same time best criterion as it was tantamount to:

- the company meeting ISO/TS 16949 requirements, i.e. a specific and most common standard, dedicated for the automotive industry,
- the respondent having been subject to audit performed by auditors representing a certification unit, accredited by IATF,
- the organisation rendering services as OE/OES equipment supplier for customers in the automotive industry who determine their own customer specific requirements (CSR); and providing services for at least one such customer, cooperating with car manufacturers of first tier suppliers (possibly second tier suppliers) or such companies being 1st and 2nd tier suppliers for OEM vehicle manufacturers.

Certified management systems indicates also with high probability that such companies have been audited by their customers, which is characteristic of the automotive industry as far as OE/OES equipment supply is concerned. Apart from that such companies cooperate with their customers on planning and OE/OES contract realisation. Thus they realise some components of APQP/PPAP.
It can lead to an assumption that in each and every case such organisations actively cooperate with the automotive industry as OE/OES equipment suppliers.
Thus, in practice certified companies have to meet the requirements of their customers, a certification unit, an accreditation authority and their own – determined by the companies themselves, but also quite often by a superior structure – head office. Many of the studied companies are divisions, or parts of bigger corporations, or capital groups – which determine the policy of certified organisations.

What is also significant here, it can be assumed that a quality management system of the suppliers for automotive industry is determined by factors connected to quality management in the automotive industry. It stems from the opinion that both the criteria and procedures of audit evaluation are most restrictive. And moreover it is the result of the interest in the credibility of certificates and efficiency of system solutions, by the parties directly involved – car manufacturers, as they are IATF signatories.

The study group is finite and homogeneous in character. Finiteness (numerical criterion) – as the group is represented by companies holding IATF status – certified against ISO/TS 16949 requirements and headquartered in Poland, Russian, Ukraine; thus it is a countable – closed collection of organisations. The studied population is also homogenous – as the respondents are characterised by a constant feature – holding quality certificates.

To a significant extent the studied group is homogeneous, taking into consideration all the factors of importance to the formulated objectives/aims and research hypotheses. At the same time the author deemed it necessary when inferring to take into consideration the following:

- some organisations had corporate certificates, i.e. they were only a production centre – so in their localization they realised only some of the aspects of quality management, and what is more they did not realise significant elements of PPAP,
- the share of OE/OES equipment supply in the general turnover of the certified companies varies from a couple of per cent to 100% of realised supplies,
- the respondents cooperate with different number of OE/OES customers, what in consequence is connected with respecting as part of the management system a smaller or bigger number of requirements set in CSR (customer specific requirements),
- respondents have quality management systems or integrated management systems, built from different modules – including industrial modules (e.g. dedicated for aeronautics),
- suppliers can only realise supplies to OEM or to 2^{nd}, or even 3^{rd} tier suppliers – what is more distant from the model of OE/OES supplier.

However, the above remarks do not inhibit inference in any way, and the knowledge of them enhances more detailed analysis as far as the company's profile is concerned. The size of the company or its legal status does not bear any significance as far as verification of the hypothesis is concerned. They have been taken into consideration, though as an informative element.

Data from the metric part of the questionnaire provided information about the respondent constituting the study population. More than 50% of the studied companies are large corporations – regarding employment size. However, there are also representatives of small and medium-sized enterprises.

The size of turnover – total and related to automotive industry complements the classification by the size of the company. The results of the study from the metric confirm categorisation of company (respondent) size. The

highest value of turnover of the companies was in the bracket/range less than 2 mln euro and over € 50 million (Figure 3).

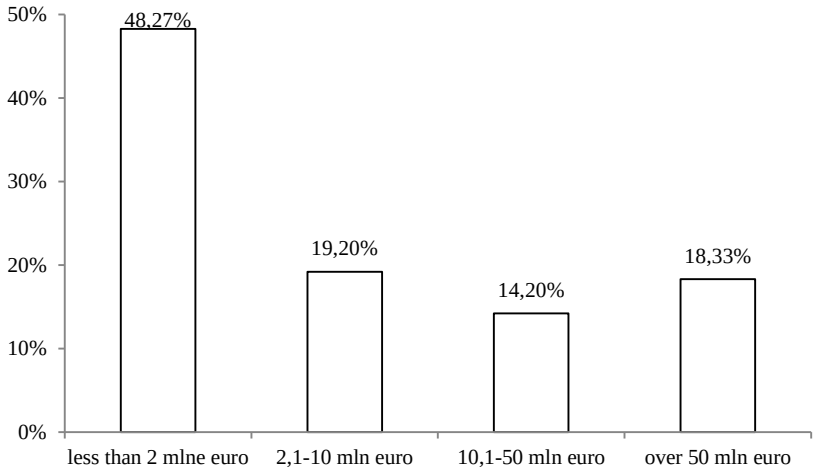

Figure 2. Respondent total turnover value in proper study as of 2013 (%)
Source: Own preparation

The level of turnover of respondents from the automotive industry is significant regarding the objective of the analyses. Information which was provided in this respect indicates that the share of turnover with consumer from this industry is huge (Figure 4). Collating this data with the characteristic of respondent cooperation is purposeful, as it indicates, as they provide services for the automotive industry, but also for customers from other sectors (Figure 5).

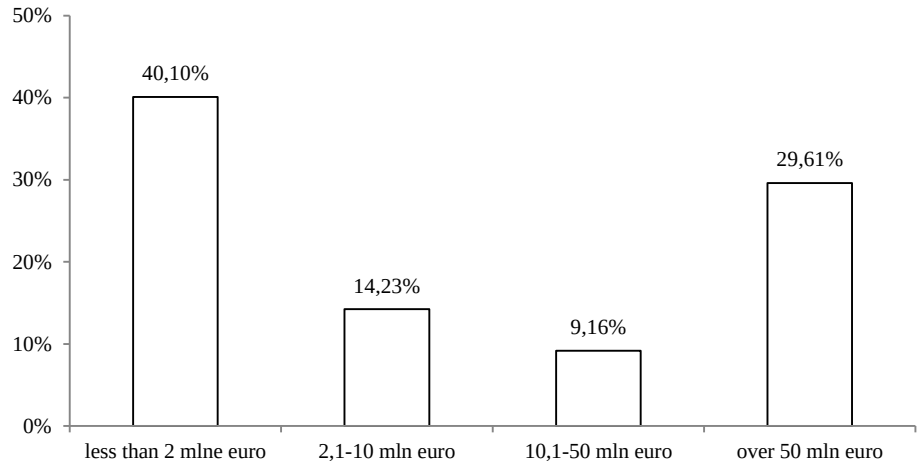

Figure 3. Respondent turnover value for the automotive industry in proper study as of 2013
Source: Own preparation

The data shows that more than 40% of suppliers observe turnover up to € 2 million within cooperation with automotive customers. This indicates huge industrial diversification of customers. The second range of turnover (equal to 29,61%) in the automotive industry amounts to more than € 50 million; 14,23% of respondents indicated turnover in the range between € 2.1 million and € 10 million.

The above results are also reflected in the profile of customers of the respondents – presenting other industries in relegation to the automotive industry.

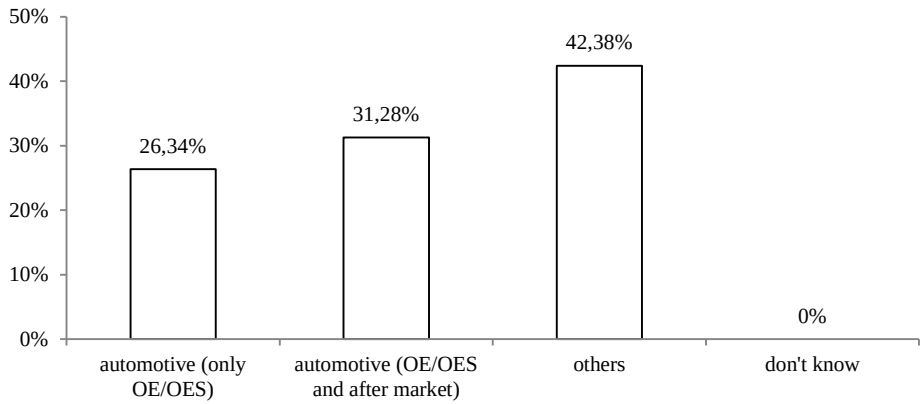

Figure 4. Cooperation with customers within the automotive industry and other industries (%)
Source: Own preparation

More than 40% of respondents deliver equipment to customers from different industries and almost 60% exclusively for the automotive industry. However, only 26,34% of them are OE/OES equipment suppliers and 31,28% deliver equipment both to OE/OES and for after market. The fact that respondents deliver equipment for other industries is worth noting; however it will not be subject to any detailed analysis. It agrees with the principle that for production in the same locations using the same production lines, more strict regulations on quality management has to be met. As far as the study population is concerned these are the criteria of the automotive standard which is the basis of QMS. It can be also assumed that quality management systems of the respondents are subject to management rules determined by regulations in the automotive industry.

Regarding result analysis and inference the knowledge of the kind of automotive customers suppliers cooperate with is crucial. Respondents were asked to indicate whether they were direct suppliers to car manufactures (1st tier suppliers), or 2nd tier suppliers. As many as 33.78% of respondents were 1st tier suppliers and exactly as many 2nd tier suppliers. It means that the first group may have a less significant role in other contracts, but they certainly deliver equipment for OEM. A considerable share of respondents, namely 18.67%, chose the I don't know answer. This can be explained by the fact that some of the products are marked with OEM signs, but formally are delivered to an intermediary. Very often such contracts are based on meeting the requirements of the manufacturer, but the technical and trade contact are carried out by the intermediary (e.g. Severep, Reqent, Visscher-Caravelle).

A necessary condition to classify the company in the study population was holding ISO/TS 16949 compliance certificate. Many respondents hold compliance certificates on other standards, which confirms implementing systems built from different modules, meeting different standards on quality management, environmental management, information security and health and safety at work (Figure 5).

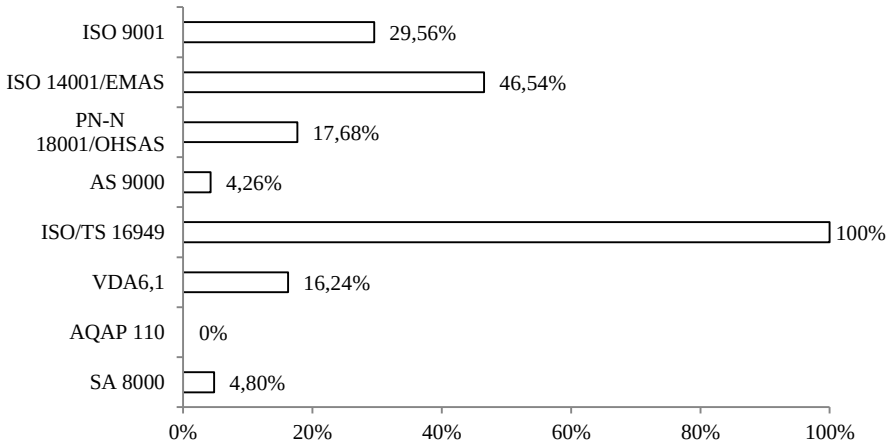

Figure 5. Conformity certificates held by respondents in proper study (autonomic and corporate) (%)
Source: Own preparation

The study showed that the respondents also meet the requirements of other basis for standardised management systems, not only industrial which are related to automotive industry. They confirmed that within their scope of interest there are not only automotive standards, and other industrial standards (AS 9000, AQAP 110), but also standards related to environmental management (ISO 14001/ EMAS) and health and safety at work management (PN-N 18001/ OHSAS 18001) and social responsibility of business (SA 9000).

Apart from compliance certificates on most popular automotive standards, the respondents also indicated holding VDA 6.1 requirements compliance certificates – 16,24% respectively.

29,56 % of the respondents holds a basic certificate on quality management, namely ISO 9001 certificate, which shows that such companies cooperate not only with the automotive industry, or at least have an intention of cooperating with a company from outside the automotive industry.

Among the automotive industry suppliers, there are also suppliers or potential suppliers for the aeronautic industry which is reflected by AS 9000 certificates (4,26 %) or armaments industry; AQAP 110 (0%). Among the study group more than 45% had integrated systems – quality management, environmental management and almost 18% quality management and safety at work management.

6.4. Automotive industry supplier requirements significance evaluation

The most important study results are related to QMS criteria significance evaluation, irrespective of the category, or subcategory they were assigned to (the following article does not present study results in relation to category, subcategory and range of requirements). According to the respondents the most important QMS requirements are:

- relation between FMEA and control plans,
- production part approval process (PPAP),
- control plans,
- customer-designated special characteristics,
- 8D reports,
- quality management systems,
- advanced product quality planning (APQP),
- determination of requirements related to the product,
- preventive actions,
- product requirement review,
- team work.

The top ten requirements reflect the specificity of quality management in the automotive industry. Requirements which are not typical of ISO 9001 but specific for supplier management systems in the automotive industry are dominant here. This confirms also that the choice of study objective was right and that its results may be of importance to companies planning expansion on OEM customers. Within these systems stress must be put on components which were unknown to many companies, even if they held ISO 9001 certificates.

Table 2. Significance of QMS requirements (average marks) – proper study.

No	Requirements	Average mark	Median	Modal	Gap	Coefficient of variation
1.	Customer-designated special characteristics	9,61	9	10	6	19,11%
2.	FMEA – control plans	9,19	9	10	5	11,80%
3.	Control plans	8,86	9	10	4	12,44%
4.	PPAP – production plan approval process	8,84	9	9	5	12,46%
5.	Determination of requirements related to the product	8,56	9	9	7	17,30%
6.	Preventive actions	8,45	9	9	7	22,82%
7.	Quality management system	8,44	9	9	6	17,37%

8.	8D	8,30	9	9	7	18,05%
9.	Team work (problem solving methods and techniques)	8,36	9	9	8	25,10%
10.	APQP – advanced product quality planning	8,25	9	8	8	21,49%
11.	Corrective actions	8,20	9	9	4	15,99%
12.	Acceptance criteria	8,08	9	9	7	22,84%
13.	Review of requirements related to the product (organization manufacturing feasibility).	7,40	9	10	6	17,36%
14.	Control of nonconforming product (incompatibility suspicion, control of reworked product, customer waiver)	7,35	8	9	6	19,10%
15.	Communication with customer	6,14	9	10	7	20,33%
16.	Monitoring and measurement of product	6,10	8	8	7	21,43%
17.	Manufacturing process improvement	6,07	8	9	9	26,84%
18.	Supplier qualification and continual supplier monitoring (supplier quality management system development)	6,01	8	8	7	28,81%
19.	Maintenance. Preventive and predictive maintenance	5,86	8	8	7	21,88%
20.	SPC (identification of statistical tools, knowledge of basic statistical concepts)	5,66	8	8	6	21,12%
21.	5S	5,54	6	9	7	41,27%
23.	Monitoring and measurement of processes	5,45	8	8	8	24,76%
24.	Cleanliness of the premises	5,30	8	9	8	22,40%
25.	Process management (COM, MOP, etc.)	5,21	8	9	7	24,13%
27.	Audit of the production process.	5,20	8	8	8	27,86%
	Plant, facility and equipment planning	5,11	8	7	9	27,46%
28.	Customer satisfaction study	5,07	8	9	8	24,22%
31.	Responsibility, authority and communication (responsibility for quality)	5,04	8	8	9	27,20%
32.	Audit of the quality management system	5,00	8	8	7	24,32%
33.	Management representative (customer representative)	4,90	8	8	7	23,13%
34.	Audit of the product	4,82	7	9	7	22,05%
35.	Identification and traceability	4,76	8	7	8	26,44%
	Continual improvement of the organization	4,72	8	9	9	27,16%
36.	Production scheduling	4,68	8	9	8	25,64%
37.	Customer focus	4,60	8	8	8	28,51%
	Internal communication	4,53	7	8	7	29,73%
39.	Planning (quality objectives, business objectives correlation)	4,50	8	8	8	31,26%
40.	Contingency plans	4,43	7	7	7	25,86%
41.	Storage and reserves	4,39	7	7	9	32,52%

42.	Validation of production process and service provision	4,39	8	8	9	29,35%
43.	Information security	4,38	8	7	9	35,99%
44.	Training courses (position trainings, in taking back to customer's requirements)	4,30	8	8	8	30,02%
45.	Data analysis (analysis and use of data on the company level)	4,24	7	7	7	27,14%
46.	Control of records (customer records retention)	4,20	7	8	8	27,58%
47.	Measurement system analysis	4,17	7	8	8	28,91%
48.	Verification of purchased product (incoming product quality)	4,10	8	8	9	37,84%
49.	Employee motivation and empowerment	4,07	7	8	8	29,23%
50.	Staff competence	4,01	7	8	8	27,82%
51.	Management commitment (process effectiveness)	3,59	6	5	6	25,39%
52.	Work instructions	3,50	7	8	9	31,71%
53.	Regulatory conformity	3,40	7	7	9	39,15%
54.	Control of documents (engineering specifications)	3,36	6	7	9	28,91%
55.	Management review	3,32	7	7	9	28,07%
56.	Confidentiality	3,28	7	8	9	35,43%
57.	Preservation of products	3,20	7	5	8	24,46%
58.	Personnel safety	3,16	7	8	8	33,23%
59.	Quality policy	3,10	7	8	7	30,45%
60.	Change control	3,08	6	5	8	35,85%
61.	Risk management	3,06	6	4	8	47,30%
62.	Quality costs	3,01	9	9	8	43,18%
63.	Management of production tooling	2,97	7	8	9	38,91%
64.	Customer-owned production tooling	2,90	7	2	9	46,84%
65.	Completeness of required documentation	2,81	6	7	8	25,72%
66.	Benchmarking	2,67	7	9	9	57,47%
67.	Feedback of information from service	2,60	6	3	9	57,74%
68.	Verification of set-ups	2,58	6	6	8	32,46%
69.	Customer property (raw materials, resources, production in progress)	2,45	6	9	9	61,81%
70.	Configuration management	2,30	5	4	9	45,33%
71.	Customer-approved sources	2,30	7	8	9	56,75%
72.	Calibration records	3,20	5	3	9	48,12%
73.	External laboratory	2,17	5	1	9	65,05%
74.	Internal laboratory	2,10	6	2	8	50,63%
75	Quality Manual	2,01	7	7	9	30,32%

Source: Own preparation

Among the first ten criteria considered to be most significant both PPAP and APQP and their key elements, i.e. control plans, FMEA, specific

characteristics, and team work were indicated. Coefficient of variation for all requirements considered to be of importance is in the range from 0% to 35% which suggests small dispersion, and the arithmetic mean characterises the average level of significance value in a proper way.

Among the most important criteria supplier QMS in the automotive industry have to meet there are key elements vital to the production and delivery process. The designed production process, presented in the form of a flow diagram (APQP/PPAP requirement) should be subject to risk analysis. The analysis should be carried out by means of and obligatory tool – FMEA. In this case each stage of the process presented on the flow diagram must be assessed according to FMEA rules. Finally, the relation between FMEA report and control plan is essential. It is a document, which in a synthetic and comprehensive way describes how the production process should be supervised, as it reflect the requirements of the standard and customer specific requirements. All the same, compiling and implementing the control plan is not as important as process risk assessment, which is connected to the control plan. Such an approach requires experience and knowledge directly related to team work, using quality management methods and techniques, 8D, SPC, inconsistency management and other criteria. For example, for each complaint related to OE/OES, an 8D report needs to be compiled; FMEA report needs to be verified. Moreover, interference in the flow diagram and control plans is also possible. Likewise, control plans have to be verified in case of any changes in BOM, technological and technical changes. In every case safeguarding mutual relation between exit data form those system components.

Conclusion

Based on the study results inference was performed in relation to formulated study hypotheses. It can be concluded that:

- ISO/TS certificate is a requisite element; it does not guarantee, however, cooperation with customers under OE/OES contracts,
- any QMS should be based on advanced product quality planning (APQP) and production part approval process (PPAP),
- communication with the customer and the ability to solve problems, especially 8D also turned out to be very important,
- the most important QMS system requirement are customer specific requirements and not requirements of the standard which is basis for certification (ISO/TS 16949),

- for QMS it most important to ensure resulting relationship in control plans related to risk assessment results from FMEA results, compiled earlier based on previously designed production processes (presented in the form of flow diagrams),
- other significant requirements are most often components of APQP and PPAP, or are strictly related to them; i.e. control plans, FMEA, specific characteristics, team work.

It is possible to determine the priorities in shaping QMS based on the results of the study and the conclusions. They indicate that the key requirements are specific in relation to an industry. This in turn necessitates the use of the industrial specific vocabulary by the personnel, knowledge of procedures and using them in practice. Apart from that knowledge of specific methodologies for an industry is also crucial. We cannot conclude that there are universal experts on quality management. In this case general knowledge is not sufficient. Key requirements QMS have to meet are not present in quality management systems based on ISO 9001. Similarly, specific components are essential to industrial management systems, e.g. in the food, pharmaceutical, aviation, armaments or IT industry.

Respondents regarded the relation between FMEA and control plans to be crucial. Control plans are compiled as result of preceding process (PFMEA) or design (DFMEA) risk assessment. That is why this relation is so significant to the respondents. In every case, these requirements should be treated in direct relation. In other words FMEA should not be performed, and control plans should not be designed and practiced independently. However, mistakes in this respect are common practice. They may be committed consciously and deliberately or unconsciously, as the requirement are not understood properly. Thus, maintaining direct relation between the designed process, risk assessment results using FMEA and process supervision solutions reflecting the identified risks.

All components indicated by the respondents to be most significant are strictly related and are component parts of advanced product quality planning (APQP) and production part approval process (PPAP). APQP and PPAP methodologies recommend control plans, FMEA, special characteristics, determining product requirements, verifying manufacturing feasibility and determining acceptance criteria. It has to be noted that for QMS in the automotive industry the abovementioned processes and their components are in the first place connected with the planning process made jointly with the customers and for them for specific designs. Delivery realisation process and

cooperation with the customers should be performed within the framework of implemented QMS, for which the most crucial elements, according to the respondents are: 8D reports, preventive actions, and control of nonconforming products, process management (including monitoring and process measurement). High average results were observed for the following interrelated factors: maintenance, cleanliness of the premises, production process audit and layout. This shows how big significance is attached to engineering and technology in organisational culture. Workplace cleanliness was considered to be more significant than the 5S method which is industry specific.

Process management, including process monitoring are directly connected to methods of statistical process control considered to be important and of course with control of nonconformity, and first and foremost with corrective and preventive actions.

According to the respondents, production process audit is the most important among the three kinds of audit required in the QMS. Product audit is the second most important and the most common quality management system audit is the third in turn. Audits which are considered to be important are directly related to control of nonconforming product, corrective and preventive actions, which are considered to be important as well.

Study results contradict the widespread opinion that the only condition to gain the status of certified supplier of OE/OES equipment in the automotive inudstry is the ISO/TS 16949 certificate. Reducing the research question to the need of implementing and certifying QMS based on ISO/TS 16949 standard is a simplification of the subject, which does not reflect the real picture of requirements which have to be met in the industry. The analysis of both theory and study results indicates that shaping delivery quality for OE/OES equipment is connected with meeting a great number of requirements and very mature attitude in this respect. ISO/TS 16949 is just one group of requirements. It is important in many respects, especially when formal requirements related to the need of holding compliance certificates are concerned.

Requirements presented in QS-9000 manuals, VDA standards on process audit and design audit, legal regulations play a significant role in shaping QMS of OE/OES equipment suppliers in the automotive industry. However, customer specific requirements are most crucial. A quality management system must be a dynamic system, with a structure based on essential components, i.e. requirements, but at the same time flexible, as each and every customer has their own customer specific requirements. Taking into consideration the above, QMS of suppliers of OE/OES equipment have to be well-planned, effective and efficient. Certification audits and controls will

confirm that only to some limited extent. International Automotive Task Force (IATF) supervises the systems by means of variety of supervision measures, such as internal audits (system, production process, and product), management reviews directed at business efficiency and first and foremost supervision by customers - realised by audits and cooperation within APQP/PPAP framework.

A quality management system is a necessary condition for the supplier to cooperate with customers (OEM, 1st tier suppliers) to whom OE/OES equipment is delivered. However the following system should not be understood and implemented as a collection of independent conditions, which are independent answers to the requirements. A QMS has to take account of priority requirements and mutual relations between particular solutions.

The overall image of systematic quality management is provided by the analysis of the research results in individual countries. In accordance with the assumed thesis related to the lack of differences within OE/OES supplier requirements, independently of the supplier's location, it is necessary to emphasize some dissimilarities. However, there is also a significant difference in the number of samples, or more accurately: in the size of population (certified enterprises). Beyond doubt the leader in this regard is Poland due to the number of suppliers for the analyzed industry. Moreover, these enterprises have much bigger turnovers related to OE/OES as well as cooperate with multiple clients (car manufacturers and first party suppliers).

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