

# Principles of Total Quality Management - results of empirical research for testing and calibration laboratories functioning in Poland

**Abstract.** The aim of the article was to present the results of research carried out in testing and calibration laboratories functioning in Poland that had implemented the accredited management system. The identification of the degree of implementation of the principles of TQM in laboratories was pointed out. The quality factors in testing and calibration laboratories were described. Fulfilment of the principles of TQM vs the size, accreditation period, organisational form and type of laboratory was investigated.

**Streszczenie.** Celem opracowania było przedstawienie wyników badań przeprowadzonych na reprezentatywnej próbie laboratoriów badawczych i wzorcujących funkcjonujących w Polsce, posiadających akredytowany system zarządzania. Zidentyfikowano stopień wdrożenia zasad TQM w badanych laboratoriach. Wskazano czynniki projakościowe w laboratoriach badawczych i wzorcujących. Zbadano relację między spełnieniem zasad TQM a wielkością laboratorium, stażem akredytacji, formą organizacyjną i typem laboratorium. (**Zasady Kompleksowego Zarządzania przez Jakość – wyniki badań empirycznych dla laboratoriów badawczych i wzorcujących funkcjonujących w Polsce**).

**Keywords:** management system, accreditation, testing laboratory.

**Słowa kluczowe:** system zarządzania, akredytacja, laboratorium badawcze

## Introduction

What should be a natural consequence of the implementation in testing and calibration laboratories in Poland of accredited management systems based on standard PN-EN ISO/IEC17025 is gradual acquisition by employees of the laboratories of the manner of thinking in compliance with the Total Quality Management (TQM). The implementation of an accredited management system is the condition of credibility and reliability of research services offered, which are based in particular on standardisation of methods ensuring reproducibility and repeatability of research processes, while compliance with TQM (aware and systemic, or even intuitive) affects real and permanent improvement of quality in an organisation. Thus, it increases the organisation's reliability on the market and contributes to increased confidence of customers, constituting a significant factor of competitiveness in the conditions of dynamically changing surroundings [1, p.33].

TQM is based on six fundamental elements, also referred to in the literature as principles of total quality management or quality factors. They include: 1) customer-focus, 2) process-orientation, 3) continual improvement and learning, 4) delegation of powers and team work, 5) fact-based decision-making, 6) leadership and strategic planning. The literature supplements this standard with a systemic approach and relations with suppliers [2, quoted in: 3, p. 126]. The focus on the customer, identification of customers' present and future needs and expectations, adapting the organisation's offer to the customers' needs and expectations and periodic customer surveys are aimed to verify the solutions adopted in the organisation [3, p. 126]. Process orientation means that the desirable result is achieved more effectively if the activities and resources connected with them are managed as a process [4, p. 149]. Continual improvement is a part of management that is responsible for achieving the best results in an organisation, while learning means that contemporary organisations do not only have to learn on a permanent basis but they have to do it more quickly than the competition. Delegation of powers consists in giving employees power to make decisions but it also means delegation of responsibility for the decisions. Team work consists (inter alia) in delegation of temporary teams to solve particular problems. Fact-based decision-making means that effective decisions are based on gathering facts and analysing information [4, p. 149]. Leaders in the organisation have to adopt strategic

plans so as to meet the needs and expectations of the customers and other interested parties. The systemic approach means that the methods of performance and documentation of particular tasks are established, while good relations with suppliers mean a necessity to take suppliers into account in the process of shaping the quality in an organisation. In fact, to take into account all the principles mentioned above in practice, the organisation has to adopt the solutions related to total quality management [1, p.33].

In this context the purpose of this paper is to present the results of the research carried out in 2013 in testing and calibration laboratories operating in Poland, possessing an accredited management system. An assumption was made that the implementation of an accredited management system in an organisation also results in compliance with the principles of TQM. The research carried out allows to verify this thesis.

## 1. Research methodology, characteristics of the sample

The purpose of the empirical research was in particular to identify the degree of implementation of the principles of TQM in testing and calibration laboratories possessing accredited management systems. The research is a continuation and extension of the analyses made by A. Bieńkowska and P. Bieńkowski in 2009 [5], and by A. Bieńkowska in 2012 [6]. The issues related to the degree of fulfilment of the principles of TQM in an organisation were discussed, although to a slightly different extent, by Z. Zymonik [7] and N. Erginel [3]. The issue of the connection between the compliance with the principles of TQM and the results achieved by an organisation was also discussed by S. Rahman [8].

The research was carried out in January and February 2013 with the use of a survey questionnaire, containing 33 statements related to 6 key principles of TQM mentioned above. In this way the measurement scale was built for each principle. These statements allowed to measure the degree of compliance with the principles by the organisation taking part in the research. Respondents were asked to assume their attitudes, on the five-point Likert scale (1-5, from "No" to "Yes"), to the statements related to the laboratory, contained in the questionnaire. The survey also contained such questions as the size of the organisation, the accreditation period and the type of the laboratory.

The survey was directed by e-mail to all laboratories operating in Poland and possessing an accredited management system whose e-mail address was available on PCA website (general population (N) reaches ca. 1500). The sample was supplemented during inter-laboratory comparisons [9] held by the Electromagnetic Field Standards and Measurements Laboratory of Wrocław University of Technology. One survey could be done in one laboratory (in the event of more than one survey the average from the given laboratory was taken into account in the research). The statistical analysis of data was made with the use of IBM SPSS Statistics.

As a result of the undertaken activities, as many as 187 surveys were given back (including 145 surveys carried out electronically). 184 surveys were completed properly, thus, they were accepted for further analysis (n=184). Taking into account the general population of laboratories possessing an accredited management system as at 2013, with the confidence coefficient of 0.90 and the assumed maximum error of estimate of 5.5%, the sample number equal to 167 was obtained. Thus, the sample adopted for the analyses may be considered as a representative sample as regards the number.

The number of respondents in particular groups is presented in table 1. One should pay attention to the number in particular categories (lacks of data in surveys were taken into account).

Table 1. Number of laboratories in particular groups.  
Source: own study

Respondent groups according to characteristics:		Number of lab.	[%]
Laboratory's organisational form (n=177)	is an independent unit	62	33,7
	functions as part of a university	5	2,7
	functions as part of a R&D unit	54	29,3
	other	56	30,4
Laboratory type (n=184)	testing laboratory	165	89,7
	calibration laboratory	19	10,3
Laboratory accreditation period (n=181)	up to 5 years	53	28,8
	6 to 10 years	81	44,0
	more than 10 years	47	25,5
Employment rate in the laboratory (n=178)	up to 5 persons	60	32,6
	6 -10 persons	44	23,9
	11 -20 persons	29	15,8
	more than 20 persons	45	24,5

## 2. Quality factors in testing and calibration laboratories - general approach

The analysis of the implementation in laboratories of particular TQM systems required at first the analysis of reliability of the scales of variables defining the degree of fulfilment of particular principles of TQM (variables that do not contribute to building coherent scales were removed). What was used for the verification of the structure of the size of variables is the analysis of items based on Cronbach's alpha and the coefficients of discrimination for particular items. Table 2 contains particular items building the scale for each principle of TQM.

Table 2. Coefficients of internal cohesion of scales of variables composing the degree of fulfilment of particular principles of TQM (n=184) and averages for the partial criteria. Source: own study

<b>CUSTOMER FOCUS</b> (Cronbach's $\alpha = 0,524$ )	
1. We perfectly know our customers' needs and expectations.	4.67
2. We do a periodic survey on the customers' satisfaction with our services.	4.74
3. We gather, on an ongoing basis, our customers' critical remarks on the functioning of our laboratory.	4.74
4. We always carry out an analysis of reservations of our customers.	4.78
5. We carry out, on a periodic basis, systematised surveys of our customers' needs and expectations.	3.74
6. We adapt our offer to customers' needs and expectations on an ongoing basis.	4.31
<b>CONTINUAL IMPROVEMENT AND LEARNING</b> (Cronbach's $\alpha = 0,753$ )	
1. The top managers analyse, on a periodic basis, the degree of achievement of objectives in the scope of quality.	4.57
2. The laboratory's top managers coordinate the development and performance of permanent quality improvement schemes.	4.62
3. Each employee takes part in quality improvement processes every day.	3.85
4. Employees report irregularities detected in the organisation on an ongoing basis.	4.53
5. Employees take part in the development of programmes aimed to eliminate detected irregularities.	4.42
6. Employees' suggestions on quality improvement are often implemented in our organisation.	4.29
7. Our laboratory undertakes activities aimed to prevent irregularities.	4.70
8. In the quality improvement processes we use such tools as brainstorming, histograms, Pareto charts, Ishikawa diagrams, failure mode and effects analysis, etc.	3.07
9. In our laboratory employees take part in many trainings/conferences, etc.	4.04
<b>FACT-BASED DECISION-MAKING</b> (Cronbach's $\alpha = 0,462$ )	
1. In the analysis of gathered data we use such tools as check charts/diagrams, regression analysis, FMEA, six sigma, etc.	3.71
2. In the laboratory decisions are made on the basis of objective and precise qualitative data.	4.26
<b>LEADERSHIP AND STRATEGIC PLANNING</b> (Cronbach's $\alpha = 0,449$ )	
1. The quality policy and strategic quality objectives are clearly defined by the managers of our laboratory.	4.72
2. The quality policy and strategic quality objectives of our laboratory are clearly referred to particular positions.	4.27
3. We use such tools as balanced scorecard, SWOT analysis.	2.38
4. The managerial staff in our laboratory fulfil leadership roles more than supervisory roles.	3.37
<b>DELEGATION OF POWERS AND TEAM WORK</b> (Cronbach's $\alpha = 0,672$ )	
1. Superiors in the laboratory offer their subordinates an opportunity to make decisions related to their work areas.	3.97
2. In our laboratory superiors delegate powers to managers of lower rank.	3.83
3. In our laboratory employees are willing to take over powers and take responsibility for the work performed.	3.76
4. In our laboratory there are created temporary teams whose task is to solve a particular problem.	3.54
5. In our laboratory there is a good atmosphere for team work.	4.21
6. In our laboratory employees are motivated for work.	3.79
7. In our laboratory employees are deeply engaged in everyday work.	4.20
<b>PROCESS ORIENTATION</b> (Cronbach's $\alpha = 0,786$ )	
1. In our laboratory all processes have been formally identified.	4.48
2. In our laboratory process results are systematically measured.	4.10
3. In our laboratory there functions a process-based organisational structure.	3.82

Table 3. Evaluation of the degree of fulfilment of particular principles of TQM in the laboratories subject to the analysis.  
Source: own study

	N	Minimum	Maksimum	Average	Standard deviation
Customer focus	184	2,17	5,00	4,4995	0,44255
Process orientation	183	1,00	5,00	4,1439	0,99844
Continual improvement and learning	184	2,11	5,00	4,2335	0,51336
Delegation of powers an team work	182	2,14	5,00	3,9089	0,55786
Fact-based decision-making	184	1,00	5,00	3,9891	0,95950
Leadership and strategic planning	183	1,50	5,00	3,7008	0,69162

Table 4. Average score as regards the degree of fulfilment of the principles of TQM in particular laboratory groups (according to the employment rate, accreditation period, organisational form and type of laboratory). Source: own study

Accreditation period/ Employment rate in lab.	Customer focus	Process orientation	Continual improvement and learning	Delegation of powers an team work	Fact-based decision-making	Leadership and strategic planning
<b>„Accreditation period”</b>						
<b>up to 5 years</b>	4,4355	4,0566	4,2055	3,8841	3,9906	3,6038
<b>6-10 years</b>	4,5700	4,0823	4,2455	3,9132	3,9877	3,6728
<b>more than 10</b>	4,4894	4,3261	4,2287	3,9210	4,0319	3,8533
<b>statistical significance</b>	F(2)=1,623; p=0,200 no	F(2)=1,105; p=0,334 no	F(2)=0,096; p=0,909 no	F(2)=0,063; p=0,939 no	F(2)=0,035; p=0,966 no	F(2)=1,704; p=0,185 no
<b>Employment rate in laboratory</b>						
<b>up to 5 pers.</b>	4,3528	4,0056	4,1815	3,8916	3,7250	3,5000
<b>6-10 pers.</b>	4,5227	4,2500	4,0770	3,9123	3,7841	3,7614
<b>11-20 pers.</b>	4,5603	3,9425	4,3716	3,8424	4,2414	3,7241
<b>more than 20</b>	4,6000	4,3333	4,3833	3,9746	4,4000	3,8920
<b>statistical significance</b>	F(3)=3,263; p=0,023 yes	F(3)=1,456; p=0,228 no	F(3)=3,677; p=0,013 yes	F(3)=0,363; p=0,780 no	F(3)=5,982; p=0,001 yes	F(3)=3,033; p=0,031 yes
<b>Organisational form of laboratory</b>						
<b>independent unit</b>	4,5027	4,0699	4,1183	3,8476	3,6774	3,6008
<b>a part of univ.</b>	4,4000	3,6667	3,7222	4,0286	3,9000	3,9000
<b>a part of R&amp;D</b>	4,4892	4,5094	4,3297	3,8968	4,0648	3,8935
<b>other</b>	4,4792	3,8869	4,3234	3,9770	4,2857	3,6027
<b>statistical significance</b>	F(3)=0,094; p=0,963 no	F(3)=4,243; p=0,006 yes	F(3)=4,052; p=0,008 yes	F(3)=0,601; p=0,615 no	F(3)=4,224; p=0,007 yes	F(3)=2,400; p=0,070 no
<b>Laboratory type</b>						
<b>testing</b>	4,4833	4,2073	4,2362	3,9211	4,0606	3,7348
<b>calibration</b>	4,6404	3,5965	4,2105	3,8045	3,3684	3,4079
<b>statistical significance</b>	F(1)=2,158; p=0,144 no	F(1)=6,658; p=0,011 yes	F(1)=0,042; p=0,837 no	F(1)=0,742; p=0,390 no	F(1)=9,267; p=0,003 yes	F(1)=3,863; p=0,051 yes

Table 3 presents the evaluation of the degree of fulfilment of particular principles of TQM in the laboratories subject to the analysis.

With the use of the average measurement of the degree of fulfilment of particular principles of TQM (table 3) one may notice that it is the customer-focus that is characterised by the greatest degree of fulfilment, whereas the lowest degree is connected with leadership and strategic planning.

The average score as regards the fulfilment of all principles of TQM reaches more than 3.5, which may mean that in testing and calibration laboratories operating in Poland possessing an accredited management system the principles of TQM are complied with to a relatively large extent. When analysing the degree of fulfilment of particular partial criteria in the laboratories subject to the analysis (table 2) one may notice that the highest degree was obtained for the criterion "Quantitative data, also with regard to quality, is gathered in our laboratory" (average score: 4.91), which is the evidence of compliance with the provisions of standard PN-EN ISO/IEC 17025. The lowest scores were reached as a result of evaluation of the degree of use of advanced techniques and tools, in particular: balanced scorecard, SWOT analysis (i.e. strategic tools and tools related to the organisation as a whole) (average score - 2.38) as well as control charts/diagrams, regression analysis, FMEA, six sigma (average score: 3.71). Another criterion that was given a low score was the one related to the use of tools closely connected with quality improvement, i.e. brainstorming, histograms, Pareto charts, Ishikawa diagrams, failure mode and effects analysis, etc. (average score: 3.07). It means that the benefits resulting from the application of the instruments that may directly contribute to improvement of quality in the organisations subject to the research are underrated.

### 3. Fulfilment of the principles of TQM vs the size, accreditation period, organisational form and type of laboratory

What seems to be an interesting issue is the dependence between the degree of fulfilment of particular principles of TQM and the accreditation period, the size, organisational form and type of laboratory. The statistical analysis was carried out with the use of the General Linear Model - Univariate (Unianova). Table 4 presents the average score as regards the degree of fulfilment of the principles of TQM in particular laboratory groups.

On the basis of table 4 one might observe that the fulfilment of particular principles of TQM increases with the increase in the accreditation period (but these results are not statistically significant in any case). What is more, the fulfilment of the principles of Total Quality Management increases with the increase of the organisation size (here the results are statistically significant with regard to the customer focus, continual improvement and learning, fact-based decision-making and leadership and strategic planning). However, what is surprising is a lack of a clear increase tendency as regards the principle "delegation of powers and team work". In larger organisations the managerial staff should delegate powers to lower rank managers because of the leadership crisis and problems with coordination of tasks performed in the organisation. Interestingly enough, the customer focus and delegation of powers and work team are scored relatively low as regards the laboratories functioning as part of a university, but in these laboratories the process orientation and continual improvement and learning are scored the highest (in the event of process orientation and continual improvement and learning these differences are statistically significant). Testing laboratories implemented most principles of TQM to a larger extent than calibration laboratories taking part in the research.

#### 4. Conclusions

As a result of the analyses presented in the paper a conclusion may be drawn that the principles of TQM are complied with to a considerable extent in testing and calibration laboratories operating in Poland and possessing an accredited management system and that there are principles which are fulfilled to a much larger extent (such as customer focus) and the ones which are difficult for laboratories to fulfil (such as leadership and strategic planning). What can be also observed is a failure to use instrumental solutions, both as regards quality assurance and quality improvement. Another thing that may be pointed to here is an increase in the fulfilment of the principles of TQM with the increase in the laboratory size and the accreditation period. In particular, the last aspect mentioned above clearly indicates the significance of learning and gathering experience in the area of quality management in Polish testing and calibration laboratories.

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**Autorka:** dr inż. Agnieszka Bieńkowska, Politechnika Wroclawska, Instytut Organizacji i Zarządzania, ul. Smoluchowskiego 25, 50-372 Wrocław, E-mail: [agnieszka.bienkowska@pwr.wroc.pl](mailto:agnieszka.bienkowska@pwr.wroc.pl)