



EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



QUALITY AND METROLOGY

Petr Briš

Strategic project of TBU in Zlin, No. CZ.02.2.69/0.0/0.0/16_015/0002204

„Tento výstup lze užít v souladu s licenčními podmínkami Creative Commons BY 4.0 International (<http://creativecommons.org/licenses/by/4.0/legalcode>).“



EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



1. QUALITY

Most manufacturers have to respond to this situation by trying to reduce costs in the company to the lowest possible level so that the product on the market can withstand price. In terms of reducing costs by improving the organization of processes in the company and increasing productivity, this is absolutely all right. However, if the procedure is such that the manufacturer is trying to deceive the quality somewhere and in various refined ways to conceal this degradation of quality to the customer, of course, it is no longer in order. (Blecharz, 2015).





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Quality is defined according to ISO 9000 as "degree of compliance with a set of inherent features".

The definition of a character according to the same standard states that it is a "characteristic, distinguishing property." While this definition is absolutely accurate, it is too theoretical and not entirely understandable.

Looking as a user and manufacturer quality, we find different definitions of quality, with both parties insisting on the correctness of their definition.





1.1. Quality Management

Quality management can be expressed, for example, by Juran's "Trilogy of Quality", whose essence is that quality management consists of three processes that are universal in nature and are implemented with a fixed sequence of activities.

Last but not least, this includes the "Juran's Quality Spiral", which is a way of gradually and in a coordinated way to realize the goals of comprehensive quality management in an enterprise.





Basic of a quality

The essence of quality management, focused on quality, consisting of three processes, which are universal in nature and are implemented with a fixed sequence of activities. They are:

- A) Planning of quality:
- B) Quality control in points:
 - Choose what to check
 - Select units for a measurement
 - Choose a method for measure
 - create performance standards,

(Nenadál, 2016)





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



C) Quality improvement:

- Demonstrate the need for improvement
- identify a specific improvement program
- organize project management
- organize a root cause
- measure real performance
- identify the difference between plan and reality
- create an action plan according to the problem
- create root cause analysis (Ishikawa diagram, 5x Why)
- provide corrective action
- demonstrate the effectiveness of corrective actions in serial condition
- ensure control to maintain the benefits you gain. (Bris, 2010)





1.2. ISO 9000 series standards

In today world, it can be stated that standards have become an integral part of the trade that is required between all trading partners. The ISO 9000 series of standards is important for intra-European trade and has helped facilitate the free movement of goods and services. It is a tool that tends to emphasize systems and procedures rather than outputs and results. Quality is thus guaranteed for the product delivery process, which does not guarantee the quality of the product itself. This can mean that a perfect system will be developed to produce goods and services that no one wants or needs.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Quality management using ISO standards is based on eight basic principles:

- 1) customer focus
- 2) leadership
- 3) involving people
- 4) process approach
- 5) system approach to management
- 6) continuous improvement
- 7) fact-based decision-making
- 8) win-win strategy with supplier





ISO 9000 series standards are described into three blocks:

- ☒ Instructions for using ISO 9000 standards**
- ☒ guidance for the development of quality management in the area of self-responsibility (ISO 9004)**
- ☒ required criteria (ISO 9001)**

An organization does not necessarily carry out certification. Standards can only be used as an inspiration and save considerable funds that could be generated by certification. In order to further improve quality, ISO standards need to be combined with other tools such as CAF, benchmarking, BSC, etc. to create so-called integrated management systems.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The currently valid ISO 9001: 2015 standard consists of the following chapters:

- 1. Norm standards**
- 2. Cited documents**
- 3. Terms and definitions**
- 4. Organization context**
- 5. Leadership**
- 6. Planning**
- 7. Support**
- 8. Help (support)**
- 9. Monitoring, measurement analysis and evaluation**
- 10. Improvement**





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



An organization context is a combination of internal and external aspects that can affect an organization's approach to developing and achieving. Although the aspect is not defined by the norm, it can be taken as: factor, viewpoint, consideration....

The standard ČSN EN ISO 9001: 2016 in chapter 4.1 entitled Understanding the organization and its context states:

“An organization must identify internal and external aspects that are relevant to its purpose and strategic focus and that affect its ability to achieve the intended outcome of its quality management system. The organization shall monitor and review information on these external and internal aspects. ”





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Stakeholder needs and expectations

The second subchapter of the Organization Context chapter is subchapter 4.2 Understanding Stakeholder Needs and Expectations.

The new edition of ČSN EN ISO 9001: 2016 says:

"In view of the impact or potential impact of needs and expectations on the organization's ability to continuously provide products and services that meet customer and applicable laws and regulations, the organization shall determine: interested parties that are relevant to the quality management system, and the requirements of those interested parties that are relevant to the quality management system.





Stakeholders may include:

- External providers (raw material suppliers, service providers, design or design studios, laboratories and testing rooms, etc.),
- Customers (end users and intermediaries)
- Owners (shareholders, parent company)
- State administration (customs office, hygiene station, labor office, testing institute, etc.)....
- State administration (customs office, hygiene station, labor office, testing institute, etc.)....
- Identifying, monitoring and reviewing stakeholder requirements that are relevant to the quality management system is not a “new” or “extra” requirement. This is a requirement that every organization normally does today and give some examples:





Organization context and quality policy

Quality policy is also a required document in the new edition of the standard. Norma says: “Senior management must establish, implement and maintain a quality policy that:

1. provides a framework for setting quality objectives;
2. it is appropriate for the purposes and context of the organization and supports its strategic focus
3. contains a commitment to the relevant requirements
4. contains a commitment to continuous improvement of the quality management system. "(Nenadál, 2016)





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The reissue of the suitability review has been dropped from the new edition of the standard, which has generally been addressed in the management review.

Newly, therefore, the context of the organization must be taken into account when designing the quality policy.

The standard does not say whether to focus on all aspects or on selected, It is recommended to organize quality policy as follows:

Head, Body, Heel





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Head - contains the strategic intentions of the organization

Body - contains principles and obligations of the organization with respect to selected important aspects. Stakeholder choices can be taken into account, for example.

Heel - commitment to Law and Regulation and Commitment to Continuous Improvement of the Quality Management System.

An integrated system policy can also be developed within this structure. That is, one policy (as one document) can be common to systems according to ISO standards, only the requirements of these standards have to be taken into account.

This quality policy enables easy creation of quality objectives that are transparent to employees, customers, auditors...





At present they are formed in the world standards according to the so-called High Level Standard, which is briefly described below under the text:

- 1. Scope defines the intended outputs of the management system. The results are sector specific and should be in line with the context of the organization (Article 4).**
- 2. Normative References: Provides details of reference standards or publications relevant to a particular standard.**
- 3. Terms and definitions provide common terms and basic definitions**
- 4. Organization context**
 - 4.1 Understanding the organization and its context**
 - 4.2 Understanding stakeholders' needs and expectations**
 - 4.3 Determination of the scope of the management system**
 - 4.4 Management system**





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



5. Leadership

5.1 Leadership and engagement

5.2 Principles

5.3 Organizational roles, responsibilities and powers

6. Planning

6.1 Measures to address risks and opportunities

6.2 Objectives of the management and planning system to achieve them

7. Support

7.1 Resources

7.2 Competence

7.3 Awareness

7.4 Communication

7.5 Documented information





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



8. Operation

8.1 Operational planning and management

9. Performance evaluation

9.1 Monitoring, measurement, analysis and evaluation

9.2 Internal audit

9.3 Conduct control

10. Improvement

10.1 Nonconformity and corrective actions

10.2 Constant improvement (CIP)





1.3. EFQM Excellence Model

The model of excellence is to be used for self-assessment or as a basis for external evaluation. The European Model of Excellence has become a widely used tool in various Western European countries. However, the commonly used self-assessment tool for public institutions has become CAF, which has been specially created for public administration. In contrast to the European Excellence Model, CAF is less demanding and therefore more suitable for organizations that are just starting to implement TQM.





The Excellence model can be used in all types of organizations, regardless of their size, products or processes. It consists of an extensive set of criteria, 9 of which are the main and 32 sub-criteria.

Figure 1 shows the Model Excellence scheme. The first five criteria indicate what tools, methods and procedures an organization should use to maximize its results.

The remaining four show what the organization has already achieved in important areas of activity. Feedback from “results” helps to improve and better understand the necessary “tools and resources”. The points or percentages for each criterion define the weight of each criterion. (Nenadál, 2016).



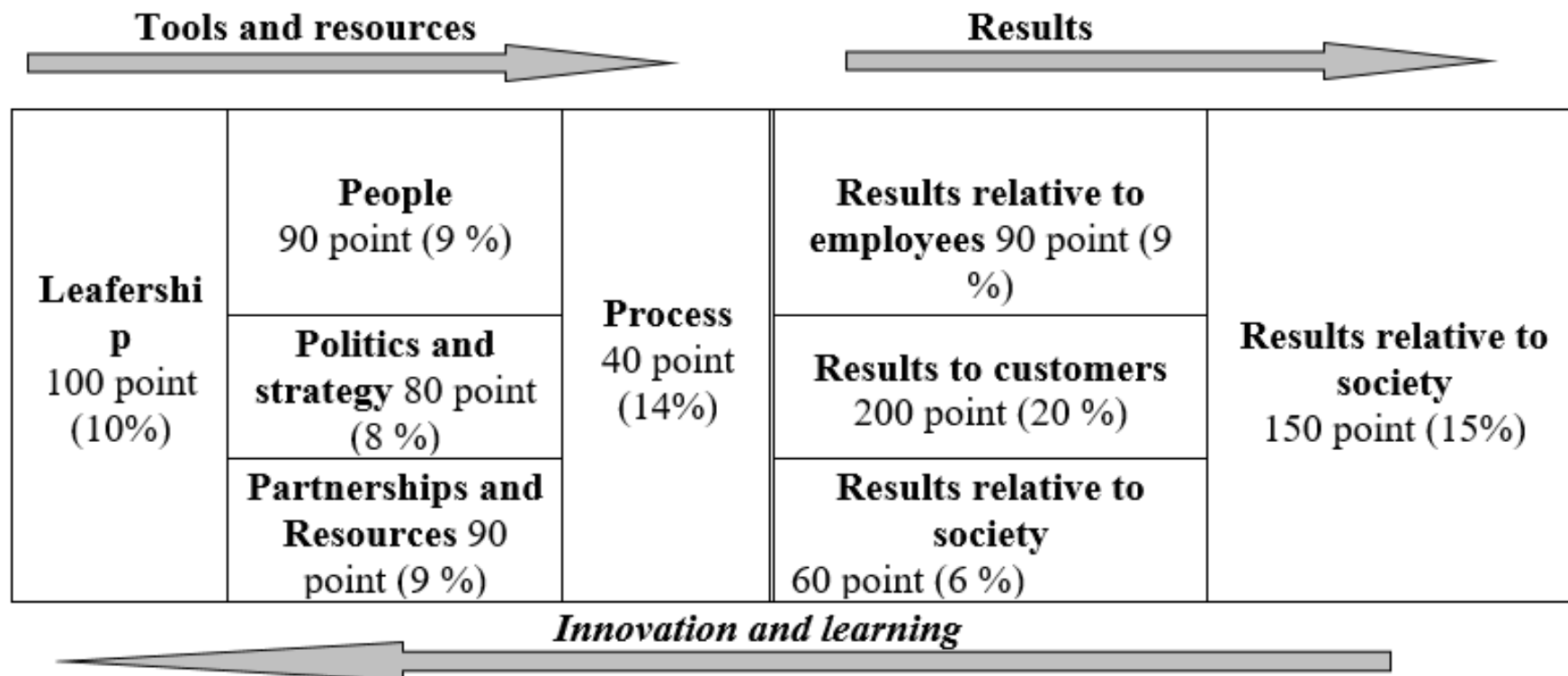


Image 1 EFQM Excellence model
(Briš, 2010)





The European Foundation for Quality Management (EFQM) defines the individual criteria of the Excellence Model as follows:

☒ Leadership - leaders using the model have the ability to develop and facilitate vision and mission. They can create values and systems that lead to the desired sustained success and, if necessary, change the direction of the organization and inspire others to follow.

☒ Policy and Strategy - all policies, plans, tools and processes within the organization are developed to enable them to pursue strategies that focus on the markets or sectors in which the organization operates.

☒ People - organizations focus on developing the potential of their employees. They are considered to be independent, capable and team-based individuals. Managers have an individual approach to them and delegate certain powers to them, thereby involving them in all activities of the organization. Workers are rewarded in a way that motivates them, so they use all their knowledge and skills for the benefit of the organization.





☒ Partnerships and Resources - Relationships that support policies and strategies are planned and managed within the organization. These are external partnerships as well as relationships with suppliers that influence the effective performance of processes. They take into account the current and future needs of the organization when planning and managing partnerships and resources, society and the environment.

☒ Processes - the fifth criterion is the processes that are managed and improved within the organization to create increasing values and fully meet customer requirements. The first five criteria focus on tools and resources and how they are to be used in the organization. The following four criteria address the results, ie what has already been achieved.





- ☒ **Customer Results** - This section includes measurement and achievement of exceptional results with respect to customers.
- ☒ **People Results** - the organization respects its employees.
- ☒ **Society Results** - this criterion reflects society as a whole, eg behavior towards citizens or the impact of production on the environment.
- ☒ **Key Performance Results** - The last criterion takes into account the organization's policy and strategy.





According to EFQM methodology, any organization is recommended to be viewed in four ways:

- ☒ **Approaches** - monitors what means and methods the organization uses to achieve its goals. It is considered whether this choice is appropriate in view of the defined processes or interests of all stakeholders.
- ☒ **Enlargement** - this way of looking at how the selected approaches are extended and the systematic implementation of individual means and methods in certain areas.
- ☒ **Assessment and Review** - addresses how the previous two points are regularly assessed and the impact on planning and further improvement.
- ☒ **Results** - evaluation of the level and scope of the results. Effective feedback on the actual results is important here. (Nenadál, 2016)





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The use of the Model Excellence is a matter of not achieving the goal of excellent results immediately. It is a long-term process in which quality can be understood as a process of continuous improvement of the environment, activities and performance to achieve predetermined goals.

In the area of public administration, there can be a problem with this "long-term" problem.

Not only because the higher financial investment will take effect after a few years, but rather because of the time constraints of the parliamentary term.

This affects and limits the long-term planning in public administration required by the EFQM model.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The application of this model can be awarded by the European Quality Management Foundation (EFQM), The EFQM Excellence Award. This prize is awarded annually and is considered the most prestigious award for excellence of the organization.

There are several categories of competitions, but it is necessary to complete several steps before the competition. It begins with completing the application form, paying the fee, conducting a self-assessment and establishing an Action Plan for self-assessment. The test will then be conducted by a certified individual authorized by EFQM. If the organization passes the test, it will receive a certificate to meet the “requirements for recognition of excellence”. Subsequent higher levels after this recognition are 'recognition of excellence', 'award finalist', 'award winner' and 'award winner'.

EFQM members pay € 8,000, € 12,000 or € 15,000 depending on the size of the assessment team. For non-members, they will pay the above amount plus the EFQM membership fee. It is clear from this that detailed information is mainly available to EFQM members and not to the general public.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



CAF (Common Assessment Framework)

The CAF model, or 'Common Assessment Framework', is a quality management method developed specifically for the public sector. It was presented for the first time in 2000 in Lisbon, where presidents of states such as Austria, Germany, Finland and Portugal held a major conference on best practice in quality and development of the CAF method.

Depending on the content and use of this method, the country follows a comparative approach with an emphasis on the experience of other EU Member States, but it also follows the experience of candidate and non-member countries.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The main task of the CAF method is to help public sector organizations serve government officials for whom it will be a tool to improve the performance of organizations. It is intended to facilitate benchmarking between organizations and act as a bridge over certain models that are used in quality management.

The procedure for introducing the CAF model is, according to its authors, very simple and easy to use. It is appropriate to use it for self-evaluation of all types of organizations in the public sector at national, regional or local level. The CAF pilot projects were originally intended for territorial public administration; over time, the interest to extend the model to all supervisory authorities and central government authorities has become increasingly important. (Nenadál, 2016)





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The CAF basic scheme looks like the EFQM Excellence Model scheme. The Excellence model is much more developed than the CAF model. On the contrary, it is easier and suitable especially for obtaining a first idea of how the organization works. As a reminder, it also consists of nine criteria, of which the first five relate to assumptions and the other four to the results of the activities. For each of the nine criteria, there are certain sub-criteria that define and define the criteria in more detail. The number of questions asked using the CAF method is usually about 250.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



There have been changes in the new version of the CAF compared to the original version, especially in the area of criteria and sub-criteria evaluation. Two evaluation methods have been developed, the "classic CAF score" and the "fine resolution" CAF score. Both are based on the PDCA cycle, which is the Deming cycle for improvement. This cycle is part of the Assumption Assessment panel and includes four parts: P - Plan, D - Do, C - Check and A - Act. In essence, it is a simple method of improvement which has universal application, with the individual phases being enclosed in a circle. This means an endless process of organizational improvement. (Nenadál, 2016)





Classic point score

Phase	Prerequisites panel	points
	We are not active in this area. We have no information or we have only partial information without a broader context.	0 – 10
PLAN	Activities are planned	11 – 30
DO	The planned activities are implemented and implemented.	31 – 50
CHECK	We verify / review the correctness of the activities and the way they are carried out (ie whether we do the right things in the right way).	51 – 70
ACT	Based on the examination / examination, we adapt (correct) our activities if necessary.	71 – 90
PDCA	Everything we do is planned, performed, reviewed, continuously adapted and learned from others. We are in a cycle of continuous improvement.	91 – 100

Table 1: Prerequisite panel - “classic rating” (Nenadál,2016).







Results panel	points
Results are not measured and / or are not no information available.	0 – 10
The results are measured and show negative trends and / or the results do not meet the objectives set	11 – 30
The results show slight or mild trends progress and / or certain objectives are met.	31 – 50
The results show increasing trends and / or most of the objectives set are met. 	51 – 70
The results show considerable progress and / or all the objectives set are met. 	71 – 90
Excellent and sustainable results have been achieved. All set goals are met. Comparing all key results with comparable ones organizations is positive.	91 – 100

Table 2: Results panel - "classic rating" (Nenadál,2016)

shows the results panel. For this panel, it is important to consider trend or goal achievement, or both, in addition to allocating points.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



„Fine“ resolution CAF scoring

The new version of CAF, this method of evaluation better describes the reality, for example, when an organization carries out a certain activity (Do) without sufficient prior planning (Plan). The emphasis is on the PDCA cycle where improvement can occur at any stage of the circle. This type of evaluation can give you more insight into which areas need improvement. The results panel also shows whether the organization should focus on accelerating the trend or achieving its goals.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



In fact, there are many other issues with the CAF that can be summarized as follows:

- ☒ The Board or the management of the Authority will decide on the CAF, but no one is willing to create the conditions for the team to conduct a self-assessment.
- ☒ Inadequate training of the CAF coordinator or team is not provided.
- ☒ Unclear whether the city or the authority is being evaluated (better start by the authority).
- ☒ Leadership pressure to achieve higher ranking at all costs (we do not "shame") without real interest in improving something.
- ☒ Misunderstanding of questions, misunderstanding of some concepts.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



- ☒ No vision. The city's vision is impersonated by the office's vision.
- ☒ Something is being done, but there is no proof. Nevertheless, the evaluators assign a higher grade.
- ☒ Absolute misunderstanding of the meaning of the review.
- ☒ Any observations referred to as benchmarking.
- ☒ Nearly nothing is measured, if measured, it is not clear whether these are key results.
- ☒ Satisfaction, progress towards sustainability or quality of life are not measured.





2. METROLOGY

The history of metrological processes is incredibly long. The death penalty threatened those who forgot or neglected their obligation to calibrate their length gauge on each full moon. This was the risk of the royal architects responsible for building temples and pyramids for the pharaohs in ancient Egypt three thousand years BC. The first royal elbow was defined as the length of the forearm from the elbow to the tip of the outstretched middle finger of the reigning pharaoh, plus the width of his hand. The initial measurement was transferred to black granite and carved into it. Granite or wooden copies were handed over to site workers and the architects were responsible for maintaining them.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



There is trade and authorities that are no less dependent on weights and measures. The pilot carefully monitors the height of his aircraft, course, fuel consumption and speed, food inspection measures bacteria content, maritime authorities measure displacement, industry buys raw materials according to weights and measures and then specifies their products with the same units. Measuring and weighing costs in Europe today 6% of total gross national product. Metrology has become a natural part of our daily lives. We buy wooden boards and coffee according to size and weight. We measure the consumption of water, electricity and heat, and the consequences are felt in our wallets. Weights in the bathroom spoil our mood, as well as the police controlling speed and possible financial penalties.



Petr Bris, Tomas Bata University in Zlin
Faculty of Management and Economics



Univerzita Tomáše Bati ve Zlíně
Fakulta humanitních studií





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The amount of active substances in the medication, the measurement of the blood sample and the effect of the surgeon's laser must be absolutely accurate in order not to endanger the patient's health. It is almost impossible to find something that is not associated with weight and measure: sunshine time, chest size, alcohol content, weight of letters, room temperature, tire pressure, etc. Just for the sake of interest - try a conversation without you would use words referring to weights or measures.

Production processes are regulated and alarms are triggered by measurement. Systematic measurement with a known degree of uncertainty is one of the foundations of quality management in industry. Generally speaking, in the modern industry, the cost of measuring 10 to 15% of the manufacturing cost.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Finally, science is totally dependent on measurement. Geologists measure the shocks of the gigantic earthquake forces, astronomers patiently measure the light coming from distant stars to determine their age, and nuclear physicists cheer when they finally confirm the presence of an infinitely small particle by measuring a millionth of a second. The existence of measuring instruments and the ability to use them is essential for scientists to objectively document the results achieved. Measurement science - metrology - is probably the oldest science in the world, and the skill to apply it is an essential necessity in virtually all science-based professions. (Howarth,2003)



Petr Bris, Tomas Bata University in Zlin
Faculty of Management and Economics



Univerzita Tomáše Bati ve Zlíně
Fakulta humanitních studií





2.1. Division of metrology

1. Scientific (fundamental) metrology deals with the organization and development of standards and their preservation (highest level).
2. Industrial metrology shall ensure the proper functioning of measuring instruments used in industry and in production and test processes.
3. Legal metrology deals with the accuracy of measurements where those measurements affect the transparency of economic transactions, health and safety.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



In Table 3, Fundamental Metrology is divided into 11 fields:

mass, electricity, length, time and frequency, thermometry, ionizing radiation and radioactivity, photometry and radiography, flow, acoustics, mass and interdisciplinary metrology (interdisciplinary metrology is not understood as technical field, deals with general issues).





FIELD	SUBFIELD	Important standards
WEIGHT AND RELATED QUANTITIES	Weight measurement	Ethalon of weight, standard weights
	Force and pressure	Load cells, load cells with direct load, force, torque and torque sensors, piston manometers (liquid or gas), load cells (standard or calibration)
	Volume and density	Glass areometers, laboratory glassware, vibrating densimeters, glass capillary viscometers, rotary viscometers, viscometric scales
	Viscosity	





LEN GT H	Wavelengths and interferometry	Stabilized lasers, interferometers, interferometric laser systems, interferometric comparators
	Metrology of lengths (dimensions)	Basic gauges, line gauges, graduated gauges, ring gauges, cylindrical gauges, height micrometers, dial gauges, measuring microscopes, optical surface standards, coordinate measuring machines, laser scanning micrometers, depth gauges
	Angular measurements	Autocollimators, rotary tables, angle gauges, polygons, leveling instruments
	Deviations in shape and surface	Straightness, flatness, parallelism, square, standards of roundness, standards of cylindricity
	Surface quality	Stage elevation and groove standards, surface roughness standards, surface roughness measuring equipment





TIME and FREQUENCY	Measuring time	Cesium atomic clock, a device for measuring or generating a time interval
	Frequency	Atomic clocks, oscillators, lasers, electronic counters and synthesizers
	Thermometry	Gas thermometers, fixed points of temperature scale ITS 90, resistance thermometers, thermocouples
THERMO METRY	Contact temperature measurement	High temperature black bodies, cryogenic radiometers, pyrometers, silicon photodiodes
	Non-contact temperature measurement	Dew-point mirrors or electronic hygrometers, combined pressure / temperature humidity generators
	Humidity	





IONIZIN G RADIATI ON AND RADIOA CTIVITY	Absorbed dose	Calorimeters, calibrated chambers for high dose rates, Double chrome dosimeters (Fricke)
	Absorbed dose - healthcare	Calorimeters, Ionization chambers
	Radiation protection	Ionization chambers, Reference beams and fields, proportional and other counters, TEPC - tissue equivalent proportional counters (Rossi), Bonner neutron spectrometers
	Radioactivity	Ionization chambers, Certified radioactive sources, Gamma and alpha spectroscopes, 4P detectors
PHOTOM ETRY and RADIOM ETRY	Optical radiometry	Cryogenic radiometer, detectors, stabilized laser reference sources, reference materials; Au fibers
	Photometry	Visible light detectors, silicon photodiodes, quantum efficiency detectors
	Colorimetry	
	Optical fibers	Reference materials - Au fibers



PHOTOMETRY and RADIOMETRY	Optical radiometry	Cryogenic radiometer, detectors, stabilized laser reference sources, reference materials; Au fibers
	Photometry	Visible light detectors, silicon photodiodes, quantum efficiency detectors
	Colorimetry	Reference materials - Au fibers
FLOW	Optical fibers	Reference materials - Au fibers
	Gas flow rate	Bell testers, rotary gas meters, turbine gas meters, transfer meters with critical nozzles
	Liquid flow out of water	Volumetric standards, Coriolis mass standards, gauges, induction flowmeters, ultrasonic flowmeters
	Anemometry	Anemometry

Table 3: Fields, subspecies and typical standards for individual important levels of measurement. Only 10 technical fields are listed. (Howarth,2003)





2.2. Traceability and calibration

Traceability is a property of a measurement result or of a standard value that can be used to determine the relationship to these references, usually national or international standards, through an uninterrupted comparison string (traceability chain).

For industry in Europe, continuity at the highest international level is ensured primarily through the use of accredited European laboratories and national metrology institutes.





Calibration

The basic means of ensuring the continuity of measurement is the calibration of gauges. This calibration involves determining the metrological characteristics of the instrument. This is done by direct comparison with standards. A calibration certificate is issued and (in most cases) the label is attached to the calibrated gauge. Based on this information, the user can determine if the device is suitable for the application. There are three reasons why instruments need to be calibrated:

- Ensure that instrument data is consistent with other measurements.
- Determine the accuracy of the data provided by the instrument.
- Determine the reliability of the device, i.e. whether it can be relied upon.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



The following can be achieved by calibrating the instrument:

The result of the calibration will either allow the values of the measured quantities to be associated with the indicated values or to determine the corrections to the indicated values.

The calibration can also determine other metrological properties, such as the effect on the magnitude.

The result of the calibration can be recorded in a document, sometimes called a calibration certificate or calibration report.





BIPM
(International Bureau of Weights
and rates)

Primary laboratories
(in most countries national
metrology institutes)

Accredited Labs

Companies

Customers

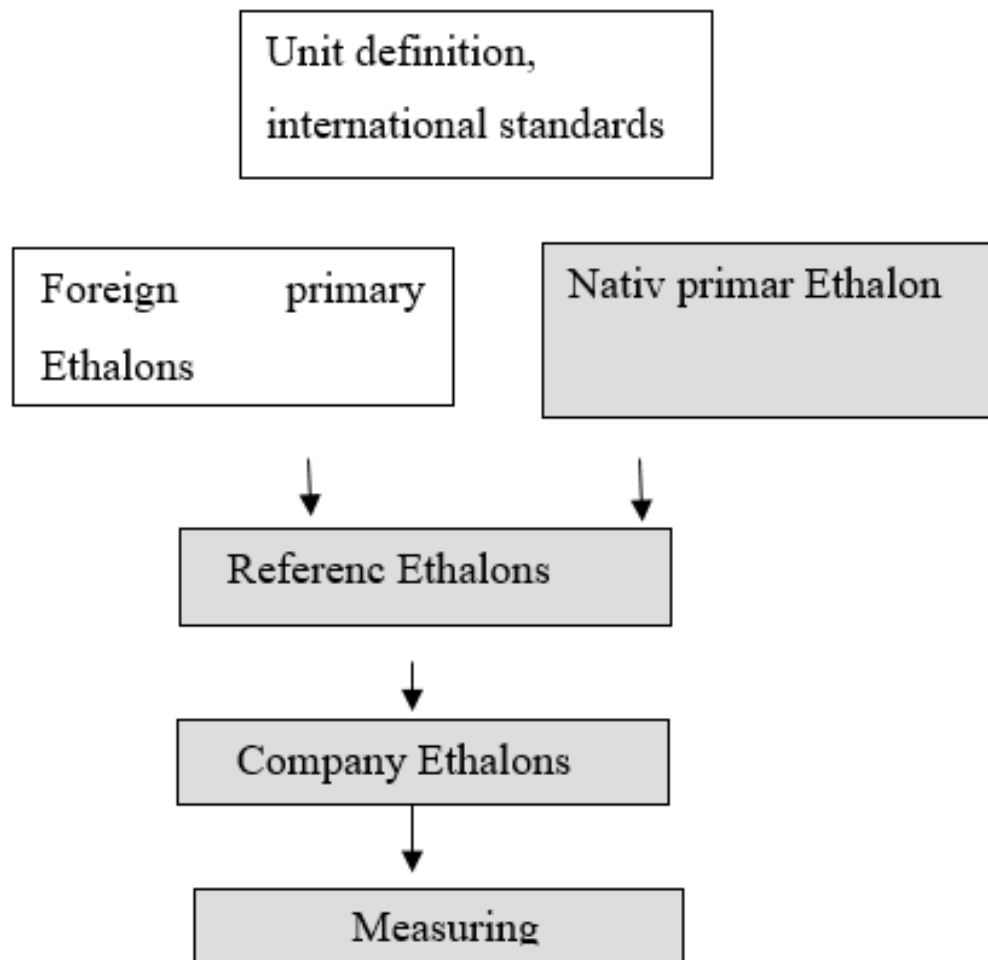


Image 2 Traceability chain (standard levels) (Howarth,2003)





2.3. Metrological order of organization

The metrological order of an organization is a set of regulations, technical means and activities, the implementation of which ensures the necessary accuracy of measuring instruments and measurements in the organization. The principles of creating metrological orders are specified in the methodological instruction of the metrological UNMZ. Metrological order is a prerequisite for the organization's ability to achieve and document the quality of its production. The core of the metrological order is the incorporation of the organization's work gauges into a continuous sequence of transmission of the measured values from the standards of the highest metrology level to objects that bear the characteristics of the quality of its production.





The essence and purpose of the metrological order is to maintain the instruments in such a condition that complies with the requirements for their capability to measure and monitor the variables constituting the organization's product quality and production process characteristics.

It serves to ensure that employees of the organization acquire their duties and rights in the field of metrology. Metrological supervision bodies assess, according to the metrological order of the organization, the fulfillment of its obligations arising from Act no. 505/1990 Coll.

Metrology Act. In a quality management system, the metrological order of an organization is a prerequisite for the rational management of production processes.

The instruments used by the organization to measure product quality characteristics are work gauges and must be subject to metrological order. Each instrument must have its own record card with records of regular calibrations





The organization of metrological order is based mainly on:

- 1. Quality management system in the organization.**
- 2. Act no. 505/1990 Coll. Metrology Act**
- 3. ČSN EN ISO 10012 (010360) Measurement management systems - Requirements for measurement processes and measuring equipment**
- 4. ISO 9001 (Quality management systems. Requirements).**
- 5. Measuring instruments used in the organization.**
- 6. Competences of measuring users.**
- 7. Influences of surroundings and time.**





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



In the metrology order, the instruments are to be distinguished at four levels:

- 1. standards**
- 2. established (working) gauges,**
- 3. working gauges,**
- 4. reference materials.**
- 5. Indicative (informative) gauges**





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



2.3.2. Structure of metrological order of organization

- A. Introduction**
- B. General Part**
- C. Organizational security**
- D. Technical support**
- E. Final provisions**
- F. Attachments**





2.4. Metrology and quality audit

System of measurement management, metrological confirmation and system analysis and improvement of Measurement management is determined by the standard ČSN EN ISO 10012 (010360), Requirements for measuring procedures and measuring equipment. The standard specifies general requirements and provides guidance on:

1. measurement process management; and
2. metrological confirmation of measuring equipment, used to ensure and demonstrate compliance with metrological requirements. It determines the quality management requirements of a measurement management system that a measurement organization can use as part of an overall management system and to ensure that metrological requirements have been met. It should be noted that the above International Standard is not to be used as a list of requirements for demonstrating compliance with ISO 9001, ISO 14 001 or other standards. It is also not intended to replace or extend the requirements of ISO 17 025. (Petrík, 2014)





2.4.1. Measurement management system requirements

The measurement management system shall ensure that specified metrological requirements, which are derived from the product requirements and are required to:

1. measuring equipment
2. measurement processes

Requirements can be expressed as:

1. the maximum permissible error
2. allowable uncertainty
3. range
4. stability
5. Resolution
6. environmental conditions
7. operator skills





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



2.4.1. Measurement management system requirements

The measurement management system shall ensure that specified metrological requirements, which are derived from the product requirements and are required to:

1. measuring equipment
2. measurement processes





2.4.2. Management responsibility

The organization shall define the tasks of the metrology department. The top management of the organization must ensure the availability of the resources needed to establish and maintain the metrology unit.

Metrological function is a unit with:

1. administrative
2. the technical responsibility for defining and implementing the measurement management system.

The management of the metrology department must:

1. create
2. document
3. maintain measurement management system and continuously improve efficiency.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



2.4.3. Resource management

Human resource

Information resources

Material resources

External suppliers



Petr Bris, Tomas Bata University in Zlin
Faculty of Management and Economics



Univerzita Tomáše Bati ve Zlíně
Fakulta humanitních studií





2.4.4. Metrological confirmation and implementation of metrological processes

Metrological confirmation is the set of actions required to ensure that a measuring device conforms to the requirements for its intended use.

Metrological confirmation generally includes calibration and verification, however necessary adjustment or repair and subsequent recalibration, comparison with the metrological requirements for the intended use of the equipment, as well as any seal and marking required. Metrological confirmation shall not be achieved until the suitability of the measuring equipment for its intended use has been demonstrated and documented.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



2.4.5. Measuring process

The measurement processes that are part of the measurement management system shall:

1. plan
2. validate
3. introduce
4. document
5. Check

(Petrík, 2014)



Petr Bris, Tomas Bata University in Zlin
Faculty of Management and Economics



Univerzita Tomáše Bati ve Zlíně
Fakulta humanitních studií





2.4.6. Measurement uncertainty and traceability

For each measurement process included in the measurement management system, the measurement uncertainty shall be estimated. Uncertainty estimates must be recorded. The measurement uncertainty analysis shall be carried out before the metrological confirmation of the measuring equipment and the validation of the measurement process. All known sources of measurement variability shall be documented.





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



2.4.7. Improvement

Based on the results of audits, management reviews, and other related factors such as customer feedback, the metrology department must plan and manage the continuous improvement of the measurement management system. The metrology department must investigate and identify potential opportunities to improve the measurement management system and modify it as necessary.





2.5. Measurement quality

The basic feature of measurement quality is the correctness of the result, characterized the credibility of its value. The following parameters can be used to assess the quality of metrological activities:

1. Uncertainty
2. Accuracy
3. Best Measurement Capability (BMC)
4. Capability index of the measurement process (Petrík, 2014)





EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání



Thank you for your attention



Petr Bris, Tomas Bata University in Zlin
Faculty of Management and Economics



Univerzita Tomáše Bati ve Zlíně
Fakulta humanitních studií





References

Blecharz, P. (2015). *Kvalita a zákazník*. Ekopress, s. r. o.

Briš, P. (2010) *Management Kvality*. UTB ve Zlíne. Zlín, Tribun EU, s.r.o.

Howarth, P., & DFM, L. (2003). *Metrologie v kostce*. Dánsko, Překlad z anglického originálu „Metrology–in short“, ČMI Praha.

Howarth, P., Redgrave, F., Germany, P. T. B., Madsen, S., & Grafisk, S. (2008).
“*Metrology–in short*” 3rd edition. EURAMET project, 1011.

Nenadál, J. (2016). *Systémy managementu kvality: co, proč a jak měřit?*.
Management Press.

Petrík, J.(2014) *Metrológia v riadení kvality : učebný text pre poslucháčov
Hutníckej fakulty Technickej univerzity v Košiciach*, Košice : TU.





EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



QUALITY AND METROLOGY

Petr Briš



2020

Authors:

Petr Briš, doc. Ing. CSc.

Tomas Bata University in Zlín

Faculty of Management and Economics

bris@utb.cz



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



CONTENTS

CONTENTS	3
INTRODUCTION	0
1. QUALITY	1
1.1. QUALITY MANAGEMENT	2
1.2. ISO 9000 SERIES STANDARTS	3
1.2.1. New version of ISO 9001: 2015.....	5
1.3. EFQM EXCELLENCE MODEL	14
1.4. CAF (COMMON ASSESSMENT FRAMEWORK)	18
2. METROLOGY	23
2.1. DIVISION OF METROLOGY	24
2.2. TRACEABILITY AND CALIBRATION	26
2.3. METROLOGICAL ORDER OF ORGANIZATION	28
2.3.1. Procedure of creating metrological order	30
2.3.2. Structure of metrological order of organization	31
2.4. METROLOGY AND QUALITY AUDIT	35
2.4.1. Measurement management system requirements	37
2.4.2. Management responsibility	38
2.4.3. Resource management.....	39
2.4.4. Metrological confirmation and implementation of metrological processes.....	42
2.4.5. Measuring process	43
2.4.6. Measurement uncertainty and traceability	43
2.4.7. Improvement	43
2.5. MEASUREMENT QUALITY.....	44
SUMMARY	45
REFERENCES	46
LIST OF ABBREVIATIONS	47
LIST OF IMAGES	48
LIST OF TABLES	49





INTRODUCTION

Quality, Quality Management, Metrology are the key competitive factors to be considered or prioritized in each organization. Today's customer can choose from many comparable products or services, supply exceeds demand, so manufacturers and service providers compete to offer new, innovative products and new customer services. To reach high quality cannot be achieved randomly, through the intuitive management of an organization, but only by systematic quality management, ie quality management at all stages of the reproduction cycle, in all business processes and activities. This requires a great effort and knowledge of all employees in the organization.

The situation is similar in the field of metrology. Metrology is an integral part of quality management today and its importance is growing. Metrology creates continuous vessels with quality management. Metrology must be understood as a dynamic science that constantly responds not only to scientific and technological development, but also to legislative changes. It is the duty of each technically advanced country to ensure the uniformity, accuracy and necessary accuracy of meters and measurements on the territory of that state and abroad. The uniformity of measuring means is effectively ensured by standards. Nowadays, all technically advanced nations strive to ensure accuracy (meters and measurements) worldwide. The uniformity of the measuring means is ensured by means of a successive series of means called standards. In addition to measuring instruments, uniformity concerns the definition of units, their implementation of standards, methods of reproduction, establishing verification, comparison, processing of measurement results.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





1. QUALITY

The concept of quality belongs to every person's vocabulary today. But under this word everyone does not perceive the same thing. Everyone understands well according to their own standards, who often have common subject, who are money. He sees other people as something else that fulfills the usual predicted criteria and as far as possible connects or fully meets personal criteria, but all for affordable money.

Most manufacturers have to respond to this situation by trying to reduce costs in the company to the lowest possible level so that the product on the market can withstand price. In terms of reducing costs by improving the organization of processes in the company and increasing productivity, this is absolutely all right. However, if the procedure is such that the manufacturer is trying to deceive the quality somewhere and in various refined ways to conceal this degradation of quality to the customer, of course, it is no longer in order. (Blecharz 2015). An example of such a misconception is evident from the DieselGate affair (the US Environmental Agency took the distinction between the emission that Volkswagen's diesel engines showed on the road and in the laboratory in 2014). The cars recognized that the engine was in test mode, the biggest business scandal of the last decade (12 million cars, fines and indemnity amounting to 800 billion CZK. Several company managers were sentenced to prison).

Quality is defined according to ISO 9000 as "degree of compliance with a set of inherent features". The definition of a character according to the same standard states that it is a "characteristic, distinguishing property." While this definition is absolutely accurate, it is too theoretical and not entirely understandable.

Looking as a user and manufacturer quality, we find different definitions of quality, with both parties insisting on the correctness of their definition.

The user defines quality as fitness for use. The manufacturer understands the quality as conformity with the specification. Priority should be given to the user's requirements, since the use of the product only makes sense for its existence.

The manufacturer must transform the customer's wishes into technical specifications and then comply with them. It depends very much on the correctness of the transformation.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





The basic mistake is to believe that a quality product is a product that meets specifications, or even a product that meets a technical standard. A product complying with a technical standard acquires the right to call it the product it is, not the right to call it a quality product.

1.1. Quality Management

Quality management can be expressed, for example, by Juran's "Trilogy of Quality", whose essence is that quality management consists of three processes that are universal in nature and are implemented with a fixed sequence of activities. Last but not least, this includes the "Juran's Quality Spiral", which is a way of gradually and in a coordinated way to realize the goals of comprehensive quality management in an enterprise.

Basic of a quality

The essence of quality management, focused on quality, consisting of three processes, which are universal in nature and are implemented with a fixed sequence of activities. They are:

A) Planning of quality:

B) Quality control in points:

- Choose what to check
- Select units for a measurement
- Choose a method for measure
- create performance standards,

C) Quality improvement:

- Demonstrate the need for improvement
- identify a specific improvement program
- organize project management
- organize a root cause
- measure real performance
- identify the difference between plan and reality



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





- create an action plan according to the problem
- create root cause analysis (Ishikawa diagram, 5x Why)
- provide corrective action
- demonstrate the effectiveness of corrective actions in serial condition
- ensure control to maintain the benefits you gain. (Bris, 2010)

1.2. ISO 9000 series standarts

ISO standards are a tool that has been developed in the private sector and is being implemented in various areas of the public sector. When using them, it is not possible to distinguish whether they are production or non-production, profitable or non-profit organizations. In general, they focus on achieving the goals the organization has set itself.

In today world, it can be stated that standards have become an integral part of the trade that is required between all trading partners. The ISO 9000 series of standards is important for intra-European trade and has helped facilitate the free movement of goods and services. It is a tool that tends to emphasize systems and procedures rather than outputs and results. Quality is thus guaranteed for the product delivery process, which does not guarantee the quality of the product itself. This can mean that a perfect system will be developed to produce goods and services that no one wants or needs.

Certified quality assurance systems are very expensive to implemet, and especially to maintain, and may put small organizations at a disadvantage that cannot afford to certify standards. There is a great risk that the documentation process (ie a large part of the popular ISO 9000 quality assurance system) will “steal” and this will lead to the return of a grueling bureaucracy. Employees may feel that they are losing the ability to create creativity and use professional judgment through these standards.

It may also be a problem that the International Organization for Standardization does not issue individual certificates (ISO standards). Certification organizations that are independent of ISO are engaged in this activity. There is no official logo to assess quality or poor quality certification organizations. It is possible to use the trademark, but only in case of ISO authorization.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Regarding ISO standards as a tool for quality evaluation in public administration, certain objectives that the authorities pursue need to be considered. Above all, to increase the clarity of management, which focuses on better operation and efficiency of individual departments of the Office. This is related to better availability of information for citizens and greater satisfaction. As public administration differs in some respects from the private sector, certain differences need to be taken into account when implementing ISO

standards:

- Compared to the private sector, the governance of public administration is precisely defined by law, so all management structures and responsibilities are more complex.
- There is no competitive environment between the authorities, there are no other institutions for which the customer could choose and so we can basically look at public administration as a monopoly, which is also connected with obvious shortcomings.
- Customers (clients) have no choice between a number of institutions as it works in the private sector.
- The incentive of the authorities is not to generate profits, which means that it can be difficult to persuade management and employees to implement quality systems and strive to meet customer needs.

Quality management using ISO standards is based on eight basic principles:

- 1) customer focus
- 2) leadership
- 3) involving people
- 4) process approach
- 5) system approach to management
- 6) continuous improvement
- 7) fact-based decision-making
- 8) win-win strategy with supplier

The system of the above standards must be certified and registered. Both of these things cannot be separated according to ISO. (Bris, 2010)

ISO 9000 series standards are described into three blocks:



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





- Instructions for using ISO 9000 standards
- guidance for the development of quality management in the area of self-responsibility (ISO 9004)
- required criteria (ISO 9001)

To conclude on the selected types of ISO standards, it should be emphasized that an organization does not necessarily carry out certification. Standards can only be used as an inspiration and save considerable funds that could be generated by certification. In order to further improve quality, ISO standards need to be combined with other tools such as CAF, benchmarking, BSC, etc. to create so-called integrated management systems.

1.2.1. New version of ISO 9001: 2015

Its advantages over the “old” version are primarily the easier use of this standard in service-oriented organizations. There is more emphasis on leadership and process approach, there is also increased customer focus, the new version should also be more compatible with other ISO standards, supply chain management and thinking, which is risk-based. The main differences between the "old" and "new" versions are:

- Article Management responsibility in the new version is divided into two articles: 5 Management and 6 Planning
- The measurement, analysis and improvement article is now divided into two separate articles: 9 Measurement and 10 Improvement.
- Article 4 Organization context has been added for new versions
- The term products and services replaces the term product
- The standard no longer relies on prescribed documentation. Much more emphasis is placed on process management to ensure the effectiveness of QMS and thus meet customer requirements
- Instead of a specifically required quality manual, the standard now requires documented information intended for the organization as necessary for the effectiveness of the quality management system, but this does not mean that the organization can no longer use the quality manual





- Instead of requiring the organization to appoint management representatives, the standard now requires the organization to identify the people necessary for the effective functioning of the SMK. The standard also newly requires senior management to designate a person to be responsible for communicating the performance of the SMK, the opportunities and the necessary changes and innovations
- The concept of preventive measures has been replaced by risk analysis and subsequent opportunities for improvement.
- Article 6 Planning addresses measures where there is a need to respond to risks and opportunities for improvement

The currently valid ISO 9001: 2015 standard consists of the following chapters:

1. Norm standards
2. Cited documents
3. Terms and definitions
4. Organization context
5. Leadership
6. Planning
7. Support
8. Help (support)
9. Monitoring, measurement analysis and evaluation
10. Improvement

An organization context is a combination of internal and external aspects that can affect an organization's approach to developing and achieving goals. Although the aspect is not defined by the norm, it can be taken as: factor, viewpoint, consideration....

The standard ČSN EN ISO 9001: 2016 in chapter 4.1 entitled Understanding the organization and its context states:



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





“An organization must identify internal and external aspects that are relevant to its purpose and strategic focus and that affect its ability to achieve the intended outcome of its quality management system. The organization shall monitor and review information on these external and internal aspects. ”

It is practical to create an overview of aspects, for example in the form of a table, where:

aspect, distinction whether internal or external impact on the organization's quality management system, including risks, is relevant to the quality management system and also to the functioning of the organization, which should be expressed in numerical value, percentage, or. verbal evaluation.

The review and eventually re-evaluation of the significance of the aspects is then carried out within the periodic review of the quality management system by the management, which is also required by the ČSN EN ISO 9001: 2016 standard in Chapter 9.3.2.

The context of the organization is one of the innovations in the new edition of ISO 9001. However, it is not difficult. It is not necessary to create complicated documents that are incomprehensible to most people in the organization and only for presentation to auditors. It needs to be approached rationally and simply, so that it is understandable to employees of the organization and can identify with it.

Stakeholder needs and expectations

The second subchapter of the Organization Context chapter is subchapter 4.2 Understanding Stakeholder Needs and Expectations.

The new edition of ČSN EN ISO 9001: 2016 says:

"In view of the impact or potential impact of needs and expectations on the organization's ability to continuously provide products and services that meet customer and applicable laws and regulations, the organization shall determine:

interested parties that are relevant to the quality management system, and the requirements of those interested parties that are relevant to the quality management system.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





The organization shall monitor and review information on these stakeholders and their relevant requirements. ”

In the new edition of ISO 9001, there is a greater requirement than in the previous edition to meet the requirements of laws and regulations. And this is one of the chapters where this requirement is mentioned. It is an approximation to reality, since the marketing of a product or service means meeting many legal requirements (from the purchase and storage of certain raw materials, through the requirements for testing and demonstrating compliance, through customs proceedings to the rules for complaints procedures). (Nenedál, 2016)

It is also not difficult to deal with the requirement to identify interested parties and it is enough to mention them in the Quality Manual (if you keep it) or to prepare a simple list.

Stakeholders may include:

- External providers (raw material suppliers, service providers, design or design studios, laboratories and testing rooms, etc.),
- Customers (end users and intermediaries)
- Employees
- Owners (shareholders, parent company)
- State administration (customs office, hygiene station, labor office, testing institute, etc.)....
- State administration (customs office, hygiene station, labor office, testing institute, etc.)....
- Identifying, monitoring and reviewing stakeholder requirements that are relevant to the quality management system is not a “new” or “extra” requirement. This is a requirement that every organization normally does today and give some examples:

Customer requirements are reviewed - this is standard. In the original edition of the standard the requirement of chapter 7.2, in the new edition of the standard this is addressed in chapter 8.2.3.





If a supplier of raw materials has a delivery time of 5 days, or has a minimum quantity for collection, this information is taken into account by the organization when selecting and evaluating the supplier. If the supplier is the only one, the quantity and deadline

For the supply of raw materials, the organization has to take into account in production planning to ensure that the required delivery date of the product to the customer is met. The new edition of the standard addresses this in chapters 8.4.1; 8.4.2; 8.4.3.

It is common in companies that if an employee comes to his / her manager that he / she needs a tool for his / her work, better illumination or knowledge expansion, the relevance of this requirement is checked. If relevant, this requirement is then ensured. If you can prove that you are doing this, you can also use the results as evidence to meet the requirements of chapters 7.1.2; 7.1.3; 7.1.4; 7.2. new edition of the standard.

Organization context and quality policy

Quality policy is also a required document in the new edition of the standard.

Norma says: "Senior management must establish, implement and maintain a quality policy that:

1. provides a framework for setting quality objectives;
2. it is appropriate for the purposes and context of the organization and supports its strategic focus
3. contains a commitment to the relevant requirements
4. contains a commitment to continuous improvement of the quality management system. "

The re-issue of the suitability review has been dropped from the new edition of the standard, which has generally been addressed in the management review.

Newly, therefore, the context of the organization must be taken into account when designing the quality policy.

The standard does not say whether to focus on all aspects or on selected, It is recommended to organize quality policy as follows:



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



Head - contains the strategic intentions of the organization

Body - contains principles and obligations of the organization with respect to selected important aspects. Stakeholder choices can be taken into account, for example.

Heel - commitment to Law and Regulation and Commitment to Continuous Improvement of the Quality Management System.

An integrated system policy can also be developed within this structure. That is, one policy (as one document) can be common to systems according to ISO standards, only the requirements of these standards have to be taken into account.

This quality policy enables easy creation of quality objectives that are transparent to employees, customers, auditors...

Integrated Management System Policies (Example)

In order to develop the quality management system, environmental management system and occupational health and safety system, the company management decided in accordance with the corporate strategy to adopt the following principles and principles of the integrated management system:

Quality of products and activities

1. Make the company a sought-after partner in the production of dedicated pressure equipment for a wide range of customers.
2. Design, manufacture and supply quality products, reliably ensure related activities while respecting the requirements and expectations of customers and legislation;
3. Permanently create conditions for further development of society itself.

Satisfaction of customers

Create a sense of security for their customers on the quality and timeliness of product delivery, ensuring environmentally friendly processes and processes and consistent in ensuring occupational health and safety,

4. to systematically and purposefully seek incentives and information to provide a deeper understanding of customer satisfaction needs and requirements.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Attention to suppliers

5. pay constant attention to the quality of supplies, the services provided and the selection of suppliers at all levels of the company.

Continuous improvement of the quality management systém

Continuously improve process performance and product reliability v odpovídající míře realizovat vhodná opatření k nápravě pro dosahování optimálního využívání všech zdrojů.

Education of employees

To pay constant attention and care to education and qualification of employees, their education to responsibility, reliability and positive motivation at work.

Management commitment:

1. The company management fully agrees with the requirements of ČSN EN ISO 9001, ČSN EN ISO 14001 and ČSN OHSAS 18001 standards with the principles of effective implementation and continuous improvement of process management affecting product quality, environment and occupational health and safety,
2. The management of the company constantly creates the necessary organizational, personnel and financial resources for the implementation, development and improvement of the quality management system, environmental management system and occupational health and safety management system,
3. Company management is committed to raising employee awareness and awareness of other stakeholders with ISM Policy and its policies and systematically improving the efficiency of the entire integrated management system.
4. The permanent objective is to ensure compliance with the relevant legal requirements and other requirements to which the company is committed, relating to its environmental aspects and to the OHS hazards,



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



5. The permanent objective is the continuous improvement and prevention of pollution and the prevention of accidents and injuries to health, managementu bezpečnosti a ochrany zdraví při práci a zvyšování jejich účinnosti,
6. The permanent goal is to develop cooperation with suppliers to create the quality of the products provided, to respect the environmental system and to observe the principles of occupational health and safety, to require suppliers of materials, products and work and other services to respect working with us on similar principles of environmentally friendly attitudes to health and safety at work,
7. The permanent goal is to educate and educate its employees to implement his policy in practice.

Commitment of employees:

1. The permanent commitment of the whole society is to minimize the generation of **waste and emissions within the technical and economic possibilities as well** as to prevent waste of raw materials and energy by tightening the control of material inputs and technological processes.
2. A permanent commitment of the whole company is to strictly observe safety regulations **by employees to minimize the occurrence of work-related accidents and illnesses.**

At present they are formed in the world standards according to the so-called High Level Standard, which is briefly described below under the text:

1. Scope defines the intended outputs of the management system. The results are sector specific and should be in line with the context of the organization (Article 4).
2. **Normative References:** Provides details of reference standards or publications relevant to a particular standard.
3. **Terms and definitions** provide common terms and basic definitions
4. Organization context
 - 4.1 Understanding the organization and its context
 - 4.2 Understanding stakeholders' needs and expectations



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





- 4.3 Determination of the scope of the management system
- 4.4 Management system
- 5. **Leadership**
 - 5.1 Leadership and engagement
 - 5.2 Principles
 - 5.3 Organizational roles, responsibilities and powers
- 6. **Planning**
 - 6.1 Measures to address risks and opportunities
 - 6.2 Objectives of the management and planning system to achieve them
- 7. **Support**
 - 7.1 Resources
 - 7.2 Competence
 - 7.3 Awareness
 - 7.4 Communication
 - 7.5 Documented information
- 8. **Operation**
 - 8.1 Operational planning and management
- 9. **Performance evaluation**
 - 9.1 Monitoring, measurement, analysis and evaluation
 - 9.2 Internal audit
 - 9.3 Conduct control
- 10. **Improvement**
 - 10.1 Nonconformity and corrective actions
 - 10.2 Constant improvement (CIP)



1.3. EFQM Excellence Model

The models of excellence were originally developed for the private sector and transferred to the public sector as a result of the change that has been made to public administration in western countries. In Europe, it is the **European Model of Excellence** (Briš, 2010)

The model of excellence is to be used for self-assessment or as a basis for external evaluation. The European Model of Excellence has become a widely used tool in various Western European countries. However, the commonly used self-assessment tool for public institutions has become CAF, which has been specially created for public administration. In contrast to the European Excellence Model, CAF is less demanding and therefore more suitable for organizations that are just starting to implement TQM.

The logic of the Model Excellence is very simple. Essentially, it is about achieving excellent organizational results through customer, employee and neighborhood satisfaction. In order to achieve excellent results, it is necessary to manage the processes in the organization precisely, which includes mainly effective management of all kinds of resources, appropriate definition and development of strategies and policies, and last but not least, building strong partnerships.

The Excellence model can be used in all types of organizations, regardless of their size, products or processes. It consists of an extensive set of criteria, 9 of which are the main and 32 sub-criteria. Figure 1 shows the Model Excellence scheme. The first five criteria indicate what tools, methods and procedures an organization should use to maximize its results. The remaining four show what the organization has already achieved in important areas of activity. Feedback from “results” helps to improve and better understand the necessary “tools and resources”. The points or percentages for each criterion define the weight of each criterion. (Nenadál, 2016).



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



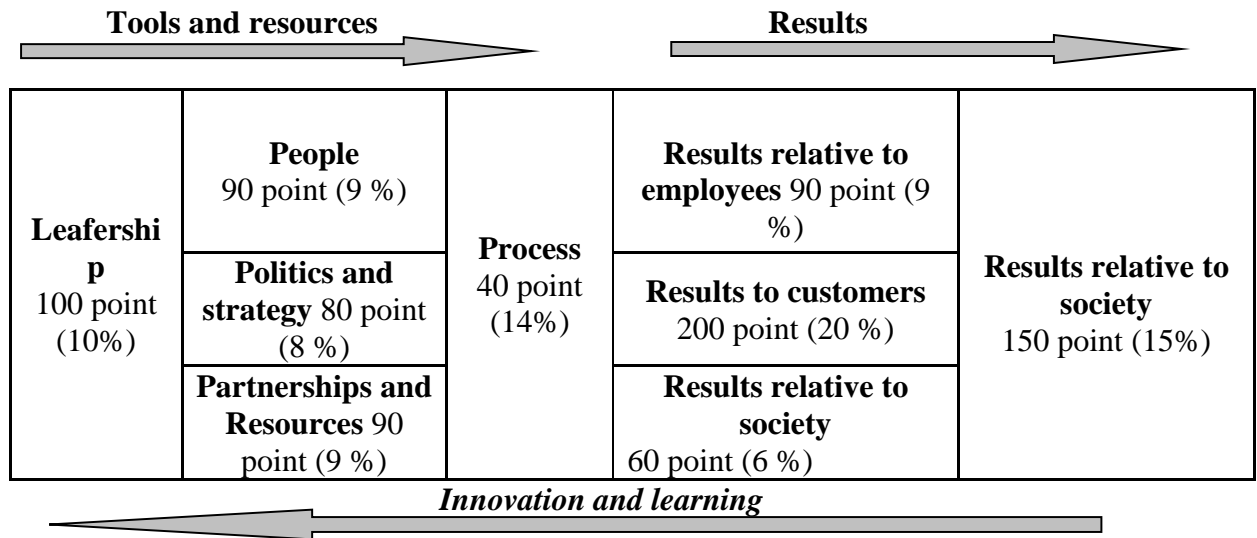


Image 1 EFQM Excellence model (Briř, 2010)

The European Foundation for Quality Management (**EFQM**) defines the individual criteria of the Excellence Model as follows:

- **Leadership** - leaders using the model have the ability to develop and facilitate vision and mission. They can create values and systems that lead to the desired sustained success and, if necessary, change the direction of the organization and inspire others to follow.
- **Policy and Strategy** - all policies, plans, tools and processes within the organization are developed to enable them to pursue strategies that focus on the markets or sectors in which the organization operates.
- **People** - organizations focus on developing the potential of their employees. They are considered to be independent, capable and team-based individuals. Managers have an individual approach to them and delegate certain powers to them, thereby involving them in all activities of the organization. Workers are rewarded in a way that motivates them, so they use all their knowledge and skills for the benefit of the organization.
- **Partnerships and Resources** - Relationships that support policies and strategies are planned and managed within the organization. These are external partnerships as well as relationships with suppliers that influence the effective performance of processes.



They take into account the current and future needs of the organization when planning and managing partnerships and resources, society and the environment.

- **Processes** - the fifth criterion is the processes that are managed and improved within the organization to create increasing values and fully meet customer requirements.

The first five criteria focus on tools and resources and how they are to be used in the organization. The following four criteria address the results, ie what has already been achieved.

- **Results– Customer** - This section includes measurement and achievement of exceptional results with respect to customers.
- **People Results** - the organization respects its employees.
- **Society Results** - this criterion reflects society as a whole, eg behavior towards citizens or the impact of production on the environment.
- **Key Performance Results** - The last criterion takes into account the organization's policy and strategy.

According to EFQM methodology, any organization is recommended to be viewed in four ways:

- **Approaches** - monitors what means and methods the organization uses to achieve its goals. It is considered whether this choice is appropriate in view of the defined processes or interests of all stakeholders.
- **Enlargement** - this way of looking at how the selected approaches are extended and the systematic implementation of individual means and methods in certain areas.
- **Assessment and Review** - addresses how the previous two points are regularly assessed and the impact on planning and further improvement.
- **Results** - evaluation of the level and scope of the results. Effective feedback on the actual results is important here. (Nenádál, 2016)

Explained ways of looking at an organization are known as RADAR, Results, Approach, Deployment, Assessment and Review. RADAR is by far the most sophisticated, but also the most demanding, maturity scheme of the management system developed by EFQM. Individual elements are the basis of a special RADAR card, which each assessor has in self-assessment. This card guides the objectivity in assessing the reality of the model in the range





of 0-100%. The resolution is given at 5%. Reusing RADAR allows you to track changes and improve the management system.

The assessment of the EFQM Excellence Model is based on self-assessment of the assumptions and achievements within the organization. Another method is benchmarking. Assessments made within an organization may seem subjective, but this subjectivity disappears when applying the model because each criterion has a different weight. The next stage is team evaluation and unification of the view of the evaluated area.

The use of the Model Excellence is a matter of not achieving the goal of excellent results immediately. It is a long-term process in which quality can be understood as a process of continuous improvement of the environment, activities and performance to achieve predetermined goals. In the area of public administration, there can be a problem with this "long-term" problem. Not only because the higher financial investment will take effect after a few years, but rather because of the time constraints of the parliamentary term. This affects and limits the long-term planning in public administration required by the EFQM model.

Using this tool, the organization runs the risk that the model will serve only as a management tool that is not linked to all parties involved. It risks being implemented without an adequate understanding or involvement of employees and the public, and therefore the Excellence model needs to be linked.

The application of this model can be awarded by the European Quality Management Foundation (EFQM), The EFQM Excellence Award. This prize is awarded annually and is considered the most prestigious award for excellence of the organization. There are several categories of competitions, but it is necessary to complete several steps before the competition. It begins with completing the application form, paying the fee, conducting a self-assessment and establishing an Action Plan for self-assessment. The test will then be conducted by a certified individual authorized by EFQM. If the organization passes the test, it will receive a certificate to meet the "requirements for recognition of excellence". Subsequent higher levels after this recognition are 'recognition of excellence', 'award finalist', 'award winner' and 'award winner'. Participation in this competition is not free. EFQM members pay € 8,000, € 12,000 or € 15,000 depending on the size of the assessment team. For non-members, they will pay the above amount plus the EFQM membership fee. It



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



is clear from this that detailed information is mainly available to EFQM members and not to the general public.

The awards organizations can receive essentially serve as a substitute for market competition in the public sector. Competition between participants in valuation programs serves to motivate public institutions to improve their quality. If an organization wins a prize, it is seen as a role model for others, if it does not win it, it learns again how to improve and how to win it in the future. Once awarded, it is important to continue to strive for quality improvement and to continue to meet the requirements of excellence.

Research conducted on the use of the EFQM model shows the implications of the model in the public sector. The investigation focused more on the processes and problems of model implementation and its impact on the organization, but not on the effects of its use on the quality of the services produced. Results for the public sector were not yet available and could not be evaluated.

1.4. CAF (Common Assessment Framework)

The CAF model, or 'Common Assessment Framework', is a quality management method developed specifically for the public sector. It was presented for the first time in 2000 in Lisbon, where presidents of states such as Austria, Germany, Finland and Portugal held a major conference on best practice in quality and development of the CAF method.

Depending on the content and use of this method, the country follows a comparative approach with an emphasis on the experience of other EU Member States, but it also follows the experience of candidate and non-member countries. This first version of the model is sometimes referred to as CAF 2002, depending on the year in which it was launched. Based on the experience of dozens of public sector organizations, a new version has been created to respond to the suggestions and comments that have emerged in the application of the original model in practice. EU ministers in charge of public administration in the revision of the CAF model called for greater links with the Lisbon Strategy. This requirement was taken into account when changing the method. Greater emphasis is placed on modernization and innovation. This is particularly evident for Criteria 1 (Leadership) and 2 (Strategy and Planning). Criterion 5 (Processes) requires continuous process innovation.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



The main task of the CAF method is to help public sector organizations serve government officials for whom it will be a tool to improve the performance of organizations. It is intended to facilitate benchmarking between organizations and act as a bridge over certain models that are used in quality management.

The procedure for introducing the CAF model is, according to its authors, very simple and easy to use. It is appropriate to use it for self-evaluation of all types of organizations in the public sector at national, regional or local level. The CAF pilot projects were originally intended for territorial public administration; over time, the interest to extend the model to all supervisory authorities and central government authorities has become increasingly important. (Nenadál, 2016)

The **CAF model includes the main features of the EFQM model**. The basic appearance of the “framework” is based on two principles:

1. **Relevance and appropriateness** of specific characteristics of public administration organizations
2. **Compatibility** with the main organizational models used in both public administration and private organizations in Europe.

The CAF basic scheme looks like the EFQM Excellence Model scheme. The Excellence model is much more developed than the CAF model. On the contrary, it is easier and suitable especially for obtaining a first idea of how the organization works. As a reminder, it also consists of nine criteria, of which the first five relate to assumptions and the other four to the results of the activities. For each of the nine criteria, there are certain sub-criteria that define and define the criteria in more detail. The number of questions asked using the CAF method is usually about 250. When evaluating the CAF model, it is first necessary to identify the group of workers who will participate in the evaluation. Each member of this group carries out an individual evaluation according to each sub-criterion and assigns him / her points according to a given scale as best and objectively as possible. Within the main criteria, the arithmetic average of points accumulated for each sub-criteria is usually made. Once this individual assessment has been completed, the group should meet to conduct a group-wide assessment. In order to achieve the end result, it is necessary to discuss at the same time as



submitting or justifying the evidence of its arguments. It is important to incorporate the results of the discussion into an action plan that will lead to improvements throughout the organization.

There have been changes in the new version of the CAF compared to the original version, especially in the area of criteria and sub-criteria evaluation. Two evaluation methods have been developed, the "classic CAF score" and the "fine resolution" CAF score. Both are based on the PDCA cycle, which is the Deming cycle for improvement. This cycle is part of the Assumption Assessment panel and includes four parts: P - Plan, D - Do, C - Check and A - Act. In essence, it is a simple method of improvement which has universal application, with the individual phases being enclosed in a circle. This means an endless process of organizational improvement. (Nenadál, 2016)

a) Classic point score

This way of scoring is cumulative compared to the old version, helping the organization to familiarize itself with the PDCA cycle to guide it towards a quality approach. This accumulation means that in order to reach eg level C, the previous levels, P and D, must first be met. , i.e. 91 - 100 points, benchlearning activities would have to be part of the cycle.

Phase	Prerequisites panel	points
	We are not active in this area. We have no information or we have only partial information without a broader context.	0 – 10
PLAN	Activities are planned	11 – 30
DO	The planned activities are implemented and implemented.	31 – 50
CHECK	We verify / review the correctness of the activities and the way they are carried out (ie whether we do the right things in the right way).	51 – 70
ACT	Based on the examination / examination, we adapt (correct) our activities if necessary.	71 – 90
PDCA	Everything we do is planned, performed, reviewed, continuously adapted and learned from others. We are in a cycle of continuous improvement.	91 – 100

Table 1: Prerequisite panel - "classic rating" (Nenadál,2016)

Table 2 shows the results panel. For this panel, it is important to consider trend or goal achievement, or both, in addition to allocating points.



Results panel	points
Results are not measured and / or are not no information available.	0 – 10
The results are measured and show negative trends and / or the results do not meet the objectives set	11 – 30
The results show slight or mild trends progress and / or certain objectives are met.	31 – 50
The results show increasing trends and / or most of the objectives set are met. 	51 – 70
The results show considerable progress and / or all the objectives set are met. 	71 – 90
Excellent and sustainable results have been achieved. All set goals are met. Comparing all key results with comparable ones organizations is positive.	91 – 100

Table 2: Results panel - "classic rating" (Nenadál,2016)

b) „Fine“ resolution CAF scoring

According to the authors of the new version of CAF, this method of evaluation better describes the reality, for example, when an organization carries out a certain activity (Do) without sufficient prior planning (Plan). The emphasis is on the PDCA cycle where improvement can occur at any stage of the circle. This type of evaluation can give you more insight into which areas need improvement. The results panel also shows whether the organization should focus on accelerating the trend or achieving its goals.

Final evaluation of the method

The deployment and use of the CAF model is a long-term issue that needs to be repeated regularly and continuously monitored. There are organizations that carry out regular assessments on a yearly basis to identify changes over the past year and what needs to be improved. Thanks to its simplicity and clarity, CAF has become a very popular quality improvement tool used by an increasing number of organizations in public administration. In the Czech Republic, the National Quality Award of the Czech Republic, which has been fully harmonized with the European Quality Award Model (EFQM Excellence Model), can



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





be obtained from CAF. Here, too, it is possible to obtain awards in several stages, essentially the same as the EFQM model.

Because it is a model compatible with other more detailed models, it can be considered as the first step, followed by the choice of another additional method. Such a method may be, for example, the Balanced Scorecard, with which key results in the CAF model can be more easily determined. When applying the CAF model, as with the EFQM model, there is a risk that the organization will only carry out a self-assessment and will not continue to identify positives and negatives. They will only try to get awards and do not pursue quality. In fact, there are many other issues with the CAF that can be summarized as follows:

- The Board or the management of the Authority will decide on the CAF, but no one is willing to create the conditions for the team to conduct a self-assessment.
- Inadequate training of the CAF coordinator or team is not provided.
- Unclear whether the city or the authority is being evaluated (better start by the authority).
- Leadership pressure to achieve higher ranking at all costs (we do not "shame") without real interest in improving something.
- Misunderstanding of questions, misunderstanding of some concepts.
- No vision. The city's vision is impersonated by the office's vision.
- Something is being done, but there is no proof. Nevertheless, the evaluators assign a higher grade.
- Absolute misunderstanding of the meaning of the review.
- Any observations referred to as benchmarking.
- Nearly nothing is measured, if measured, it is not clear whether these are key results.
- Satisfaction, progress towards sustainability or quality of life are not measured.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





2. METROLOGY

The history of metrological processes is incredibly long. The death penalty threatened those who forgot or neglected their obligation to calibrate their length gauge on each full moon. This was the risk of the royal architects responsible for building temples and pyramids for the pharaohs in ancient Egypt three thousand years BC. The first royal elbow was defined as the length of the forearm from the elbow to the tip of the outstretched middle finger of the reigning pharaoh, plus the width of his hand. The initial measurement was transferred to black granite and carved into it. Granite or wooden copies were handed over to site workers and the architects were responsible for maintaining them.

There is trade and authorities that are no less dependent on weights and measures. The pilot carefully monitors the height of his aircraft, course, fuel consumption and speed, food inspection measures bacteria content, maritime authorities measure displacement, industry buys raw materials according to weights and measures and then specifies their products with the same units. Measuring and weighing costs in Europe today 6% of total gross national product. Metrology has become a natural part of our daily lives. We buy wooden boards and coffee according to size and weight. We measure the consumption of water, electricity and heat, and the consequences are felt in our wallets. Weights in the bathroom spoil our mood, as well as the police controlling speed and possible financial penalties. The amount of active substances in the medication, the measurement of the blood sample and the effect of the surgeon's laser must be absolutely accurate in order not to endanger the patient's health. It is almost impossible to find something that is not associated with weight and measure: sunshine time, chest size, alcohol content, weight of letters, room temperature, tire pressure, etc. Just for the sake of interest - try a conversation without you would use words referring to weights or measures.

Production processes are regulated and alarms are triggered by measurement. Systematic measurement with a known degree of uncertainty is one of the foundations of quality management in industry. Generally speaking, in the modern industry, the cost of measuring 10 to 15% of the manufacturing cost.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Finally, science is totally dependent on measurement. Geologists measure the shocks of the gigantic earthquake forces, astronomers patiently measure the light coming from distant stars to determine their age, and nuclear physicists cheer when they finally confirm the presence of an infinitely small particle by measuring a millionth of a second. The existence of measuring instruments and the ability to use them is essential for scientists to objectively document the results achieved. Measurement science - metrology - is probably the oldest science in the world, and the skill to apply it is an essential necessity in virtually all science-based professions. (Howarth,2003)

2.1. Division of metrology

1. Scientific (fundamental) metrology deals with the organization and development of standards and their preservation (highest level).
2. Industrial metrology shall ensure the proper functioning of measuring instruments used in industry and in production and test processes.
3. Legal metrology deals with the accuracy of measurements where those measurements affect the transparency of economic transactions, health and safety.

In Table 3, Fundamental Metrology is divided into 11 fields: mass, electricity, length, time and frequency, thermometry, ionizing radiation and radioactivity, photometry and radiography, flow, acoustics, mass and interdisciplinary metrology (interdisciplinary metrology is not understood as technical field, deals with general issues).

FIELD	SUBFIELD	Important standards
WEIGHT AND RELATED QUANTITIES	Weight measurement	Ethalon of weight, standard weights
	Force and pressure	Load cells, load cells with direct load, force, torque and torque sensors, piston manometers (liquid or gas), load cells (standard or calibration)
	Volume and density Viscosity	Glass areometers, laboratory glassware, vibrating densimeters, glass capillary viscometers, rotary viscometers, viscometric scales





ELECTRICITY and MAGNETISM	Direct current	Cryogenic current comparators, quantum standards of el. quantities, Josephson and Hall quantum effect, von Klitzinger constant, Zener references, potentiometric methods, comparator bridges
	Alternating current	AC and DC converters, standard capacitors, air capacitors, inductance standards, compensators
	High-frequency electric current	Heat transducers, calorimeters, bolometers
	High currents and high voltages	Current and voltage transformers, high-voltage reference sources
LENGTH	Wavelengths and interferometry	Stabilized lasers, interferometers, interferometric laser systems, interferometric comparators
	Metrology of lengths (dimensions)	Basic gauges, line gauges, graduated gauges, ring gauges, cylindrical gauges, height micrometers, dial gauges, measuring microscopes, optical surface standards, coordinate measuring machines, laser scanning micrometers, depth gauges
	Angular measurements	Autocollimators, rotary tables, angle gauges, polygons, leveling instruments
	Deviations in shape and surface	Straightness, flatness, parallelism, square, standards of roundness, standards of cylindricity
	Surface quality	Stage elevation and groove standards, surface roughness standards, surface roughness measuring equipment
TIME and FREQUENCY	Measuring time	Cesium atomic clock, a device for measuring or generating a time interval
	Frequency	Atomic clocks, oscillators, lasers, electronic counters and synthesizers
THERMOMETRY	Contact temperature measurement	Gas thermometers, fixed points of temperature scale ITS 90, resistance thermometers, thermocouples
	Non-contact temperature measurement	High temperature black bodies, cryogenic radiometers, pyrometers, silicon photodiodes
	Humidity	Dew-point mirrors or electronic hygrometers, combined pressure / temperature humidity generators





IONIZING RADIATION AND RADIOACTIVITY	Absorbed dose	Calorimeters, calibrated chambers for high dose rates, Double chrome dosimeters (Fricke)
	Absorbed dose - healthcare	Calorimeters, Ionization chambers
	Radiation protection	Ionization chambers, Reference beams and fields, proportional and other counters, TEPC - tissue equivalent proportional counters (Rossi), Bonner neutron spectrometers
	Radioactivity	Ionization chambers, Certified radioactive sources, Gamma and alpha spectrometers, 4P detectors
PHOTOMETRY and RADIOMETRY	Optical radiometry	Cryogenic radiometer, detectors, stabilized laser reference sources, reference materials; Au fibers
	Photometry Colorimetry	Visible light detectors, silicon photodiodes, quantum efficiency detectors
	Optical fibers	Reference materials - Au fibers
FLOW	Gas flow rate	Bell testers, rotary gas meters, turbine gas meters, transfer meters with critical nozzles
	Liquid flow out of water	Volumetric standards, Coriolis mass standards, gauges, induction flowmeters, ultrasonic flowmeters
	Anemometry	Anemometry

Table 3: Fields, subspecies and typical standards for individual important levels of measurement. Only 10 technical fields are listed.
(Howarth,2003)

2.2. Traceability and calibration

Traceability is a property of a measurement result or of a standard value that can be used to determine the relationship to these references, usually national or international standards, through an uninterrupted comparison string (traceability chain).

For industry in Europe, continuity at the highest international level is ensured primarily through the use of accredited European laboratories and national metrology institutes.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Calibration

The basic means of ensuring the continuity of measurement is the calibration of gauges. This calibration involves determining the metrological characteristics of the instrument. This is done by direct comparison with standards. A calibration certificate is issued and (in most cases) the label is attached to the calibrated gauge. Based on this information, the user can determine if the device is suitable for the application. There are three reasons why instruments need to be calibrated:

Ensure that instrument data is consistent with other measurements.

Determine the accuracy of the data provided by the instrument.

Determine the reliability of the device, i.e. whether it can be relied upon.

The following can be achieved by calibrating the instrument:

The result of the calibration will either allow the values of the measured quantities to be associated with the indicated values or to determine the corrections to the indicated values.

The calibration can also determine other metrological properties, such as the effect on the magnitude.

The result of the calibration can be recorded in a document, sometimes called a calibration certificate or calibration report.

Note: In the Czech Republic “calibration certificate”



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



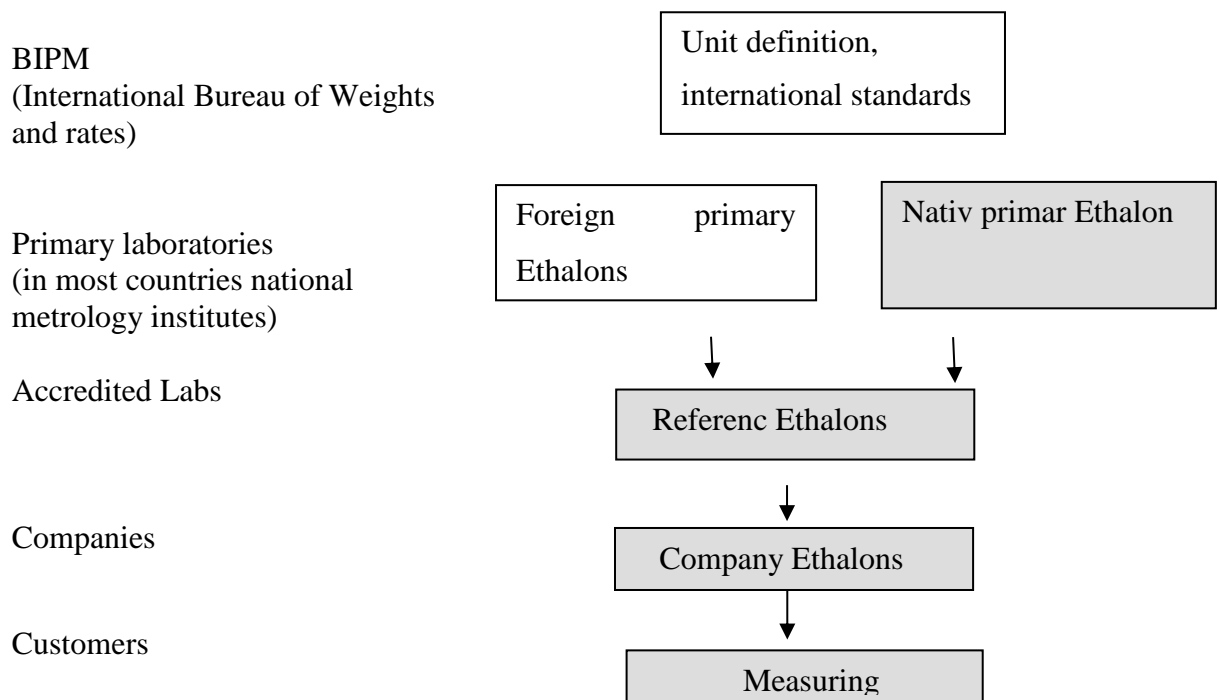


Image 2 Traceability chain (standard levels) (Howarth,2003)

 Elements of the national metrology infrastructure are identified by background

2.3. Metrological order of organization

The metrological order of an organization is a set of regulations, technical means and activities, the implementation of which ensures the necessary accuracy of measuring instruments and measurements in the organization. The principles of creating metrological orders are specified in the methodological instruction of the metrological UNMZ.

Metrological order is a prerequisite for the organization's ability to achieve and document the quality of its production. The core of the metrological order is the incorporation of the organization's work gauges into a continuous sequence of transmission of the measured values from the standards of the highest metrology level to objects that bear the characteristics of the quality of its production.

Metrological operations belonging to the metrological order may be ordered by the organization to any extent in accredited calibration laboratories.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





It is fully within the competence of each organization to establish such a metrological order that

satisfies the requirements of the credibility of measurements and at the same time meets the conditions of economy of its operation.

The organization may do all the maintenance activities on its own,
or contracted by an external metrology specialist delivery organization.

Most organizations do so by using larger-scale gauges for themselves and hiring external services for less and more demanding measurements.

The essence and purpose of the metrological order is to maintain the instruments in such a condition that complies with the requirements for their capability to measure and monitor the variables constituting the organization's product quality and production process characteristics. It serves to ensure that employees of the organization acquire their duties and rights in the field of metrology. Metrological supervision bodies (metrological inspection) assess, according to the metrological order of the organization, the fulfillment of its obligations arising from Act no. 505/1990 Coll. Metrology Act

In a quality management system, the metrological order of an organization is a prerequisite for the rational management of production processes. The instruments used by the organization to measure product quality characteristics are work gauges and must be subject to metrological order. Each instrument must have its own record card with records of regular calibrations.

The organization of metrological order is based mainly on:

1. Quality management system in the organization.
2. Act no. 505/1990 Coll. Metrology Act
3. ČSN EN ISO 10012 (010360) Measurement management systems - Requirements for measurement processes and measuring equipment
4. ISO 9001 (Quality management systems. Requirements).
5. Measuring instruments used in the organization.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





6. Competences of measuring users.
7. Influences of surroundings and time.

The desired result is:

1. Eligible measuring instruments.
2. Evidence of measuring instruments' eligibility.
3. Competence of users and meters.

2.3.1. Procedure of creating metrological order

The first step of the organization in the creation of metrological order is the analysis of its own needs in the field of metrology as well as the needs of partner organizations. The analysis shall determine:

- measured quantities,
- measuring instruments,
- measuring ranges,
- uncertainty of measuring instruments and measurement results.

In the metrology order, the instruments are to be distinguished at four levels:

1. standards
2. established (working) gauges,
3. working gauges,
4. reference materials.
5. Indicative (informative) gauges

All gauges used by the organization to identify products and processes have the characteristics of working gauges. They must be kept in a register established within the metrological order and regularly calibrated.

The status of the measuring instrument shall be appropriately marked in order to check that:



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



use only properly scaled instruments. Preservation of measuring instruments in an eligible state includes, in addition to calibration, other activities which must be documented by the metrological order, namely:

- verification of specified measuring instruments and standards,
- sealing,
- Establishment of measuring instruments
- maintenance of measuring instruments,
- repair of measuring instruments
- adjustment of measuring instruments,
- measuring instruments and other activities. (Petrík, 2014)

The second step of the organization is the determination of metrological tasks resulting from the needs analysis and from the Act no. 505/1990. and its implementing regulations.

The head of the organization shall determine the organizational framework and technical means for performance

metrological tasks. It is recommended that the head of measures be issued as a separate management document. It is the responsibility of the head of the organization to organize all activities related to the credibility and effectiveness of the measurement, who may delegate this activity to another person - the metrologist of the organization.

It is generally accepted that the level of measurement and monitoring is an unmistakable indication of level organization as a whole.

2.3.2. Structure of metrological order of organization

- A. Introduction
- B. General Part
- C. Organizational security
- D. Technical support
- E. Final provisions
- F. Attachments



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Ad. A .: In the introductory part, the binding nature of the document, the consequences of non-compliance with a obligations of workers. In addition, the link to other metrological orders of organizations (departmental, company-wide, etc.) will be stated. Abbreviations and terms used shall be explained (in accordance with the nomenclature standards used)

Ad. B .: In the general part, the legal status of the organization and eventual relations of the organization to the higher organizational unit are mentioned. This section contains a list of binding regulations relating to the metrological code, both national regulations and internal regulations of the organization. The relevant general rules (eg administrative and offense proceedings or legal documents for international cooperation) shall also be included in this section.

The following is a list of normative technical documents: ČSN, metrological regulations TPM (technical metrological regulations), MPM (Methodological guidelines for metrology), international and international metrology regulations, internal technical regulations (eg calibration methods). (Petrík, 2014)

During the use of specified measuring instruments, metrological control shall carry out subsequent verification of designated measuring instruments (hereinafter referred to as “subsequent verification”).

Ad. C. The section describing the organizational arrangements shall state:

1. Organization of metrology in the Czech Republic - links to the ÚNMZ, organizations established by the Office (designated organizations), entrepreneur or other legal entities authorized by the Office's decision (authorized person) and at the CMI (Czech Metrological Institute).

2. The organizational rules shall specify the competences, duties and responsibilities of: the head of the organization, his representative in the field of metrology, head of the department in charge of metrology management, respectively. metrologist of the organization, heads of laboratories and control measuring centers, administrators and users of measuring instruments, employees of related departments.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





3. Procedure for verifying and calibrating measuring instruments: If an organization is authorized as a state metrology center or accredited as a calibration service center or has an established calibration center in an organization, it shall be indicated in the following section:

- procedure for setting up a workplace,
- organization security,
- competences, duties and responsibilities of workers,
- internal control,
- Regulation numbers,
- procedures for ensuring the accuracy of measurements - organizational arrangements for measurement, competencies, duties and responsibilities of workers, document numbers, keeping records of measurements,
- method and criteria for purchasing maintenance or repair of measuring instruments, metrological provision of manufactured or repaired measuring instruments (manufacturers and repairers - under the Metrology Act), metrological provision of imported measuring instruments (importers of measuring instruments - according to Metrology Act)
- installation of measuring instruments in the measuring system - according to the Metrology Act,
- metrology education - qualification prerequisites for posts, and level of knowledge, ways of acquiring and completing qualifications.

Ad. D .: The technical security section shall categorize the instruments:

- standards,
- follow-up character,



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





- method of linking to standards of higher metrological order,
 - specification of the place of storage and use, including the worker responsible for their functionality,
 - designated measuring instruments, to be broken down by quantities or measuring methods,
 - place, method and interval of verification (organization, time limits), place storage and use,
 - responsible worker,
- working gauges (calibrated and others), calibrated indicating the method calibration, measurement and calibration sites (calibration intervals, if applicable) and location storage,
- reference materials (Czech, certified and others),
 - the purpose of use, place of use and storage, verification, calibration,
- for certified reference materials, the manufacturer and the certifying authority.

Note: In the case of a large number of measuring instruments, their list may be included in the Annex, or as an extract from the register on a computer.

Traceability of measuring instruments (citation of traceability schemes and calibration methodologies,

uncertainty determination procedures, number of measurements, calibration interval, calibration certificate template or its contents) and measurement methods (with methods for determining uncertainty of measurement results).

Ad. E.: The final provisions include eg. the date of entry into force;

Ad. F. The following may be added to the annexes:

- lists of regulations, standards and documents,
- responsibility matrix, resp. organizational schemes for fulfilling the metrological order,



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





- an overview of qualifications,
- lists of measuring instruments and reference materials,
- own traceability schemes,
- own calibration methodologies,
- a model of the registration card for the instrument.

It is the responsibility of the organization to keep only records of the designated measuring instruments used, indicating

date of their last verification. The requirements for these measures result from the organization's quality management system, which also includes ensuring their continuity.

2.4. Metrology and quality audit

System of measurement management, metrological confirmation and system analysis and improvement of Measurement management is determined by the standard ČSN EN ISO 10012 (010360), Requirements for measuring procedures and measuring equipment.

The standard specifies general requirements and provides guidance on:

1. measurement process management; and
2. metrological confirmation of measuring equipment,

used to ensure and demonstrate compliance with metrological requirements. It determines the quality management requirements of a measurement management system that a measurement organization can use as part of an overall management system and to ensure that metrological requirements have been met. It should be noted that the above International Standard is not to be used as a list of requirements for demonstrating compliance with ISO 9001, ISO 14 001 or other standards. It is also not intended to replace or extend the requirements of ISO 17 025.

An efficient measurement management system ensures that measuring equipment and measurement processes are suitable for the intended use. It is important for achieving product quality objectives and managing risk from incorrect measurement results.

A measurement process is a set of actions aimed at determining a value



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





values. Measurement processes should be seen as specific processes designed to promote the quality of products produced by the organization. In the standard ČSN EN ISO 10012 (010360) the term measurement process refers to physical measurement activities (design, testing, in production ...)

A measurement management system is defined as a number of interrelated or interconnected elements needed to achieve

1. metrological confirmation
2. permanent control of measurement processes

The aim of the measurement management system is to manage the risk of that

1. measuring equipment; and
2. measuring process

could give incorrect results that affect the quality of the organization's product.

The methods used in measurement management systems cover the range from verification basic equipment after applying statistical methods in controlling the measurement process

References to EN ISO 10012 can be made by:

1. Customer to specify required products
2. the supplier when specifying the products offered
3. the legislative or regulatory authority
4. assessor or auditor of quality management systems

The standard ČSN EN ISO 10012 includes requirements for the implementation of the measurement management system

and can be helpful in improving measurement activities and product quality.

Organizations are responsible for determining the level of equipment required and for specifying the requirements for measurement management systems to be applied as part of their overall management system. With the exception of agreed exceptions, EN ISO 10012 is not intended to replace, supplement or limit the requirements of other standards. Respect for the





requirements of the International Standard will facilitate compliance with the measurement and control requirements for measurement processes, such as those described in ISO 9001 Art. 7.6, ISO 14001, p. 4.5.1.

2.4.1. Measurement management system requirements

The measurement management system shall ensure that specified metrological requirements, which are derived from the product requirements and are required to:

1. measuring equipment
2. measurement processes

Requirements can be expressed as:

1. the maximum permissible error
2. allowable uncertainty
3. range
4. stability
5. Resolution
6. environmental conditions
7. operator skills

The organization shall identify the measurement processes and measuring equipment subject to the provisions of ČSN EN ISO 10012. When deciding on the subject and scope of the measurement management system, the risks and consequences of non-compliance with metrological requirements shall be taken into account.

The measurement management system consists of:

1. Control of specified measurement processes
2. The necessary support processes





The measurement processes contained in the measurement management system shall be controlled (for more details, see ISO 9001, clause 7.2) and all measuring equipment in the measurement management system shall be configured (for details, for example ISO 9001, clause 7.1). (Petrík, 2014)

2.4.2. Management responsibility

The organization shall define the tasks of the metrology department. The top management of the organization must ensure the availability of the resources needed to establish and maintain the metrology unit.

Metrological function is a unit with:

1. administrative
2. the technical responsibility for defining and implementing the measurement management system.

The management of the metrology department must:

1. create
2. document
3. maintain

measurement management system and continuously improve efficiency.

The management of the metrology unit shall ensure that:

1. determine customer measurement requirements and convert them into metrological requirements
2. the measurement management system met the metrological requirements of customers
3. compliance with customer-specific requirements has been demonstrated

The metrology department management shall define and determine measurable system quality objectives of measurement management. Target performance criteria and procedures for measurement processes as well as their management must be defined.

The top management of the organization must ensure systematic at planned intervals



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





reviewing the measurement management system to ensure that it is consistently adequate, effective and appropriate. Top management must provide the necessary resources for the review. The results of the management review must be used by the management of the metrology department to eventually modify the system, including improving measurement processes and reviewing the quality objectives. The results of any reviews and any measures taken shall be recorded

2.4.3. Resource management

Human resource

The management of the metrology department shall define and document the responsibilities of all personnel included in the measurement management system. Responsibility can be defined in:

1. organizational charts
2. job descriptions
3. working instructions
4. procedures

The management of the metrology department must ensure that the personnel involved in the system

management have demonstrated their ability to perform the assigned tasks. It shall ensure:

1. providing training for identified needs;
2. Maintaining preparation records
3. evaluation
4. recording the effectiveness of the preparation

Workers must be aware of the extent of their responsibilities and powers as well as the influence of their own activities on measurement management system efficiency and product quality.

Information resources



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





The procedures of the measurement management system shall be documented to the extent necessary and validate to ensure their correct implementation, consistent application and validity of the results. New procedures or changes to documented procedures must be automated and managed.

The procedures shall be:

1. valid
2. available
3. they must be provided on request

The technical procedures may be based on published standards of measurement practice or written instructions from customers or equipment manufacturers.

The software used in measurement processes and in result calculations must be documented, identify and manage to ensure its suitability for continued use. The software and its revisions must be tested and validated, approved for use and archived prior to use. Testing shall be performed to the extent necessary to ensure valid measurement results. (Nenadál, 2016)

Records containing information required for the operation of a measurement management system (eg confirmation results, measurement results, purchase records, operating data, non-conformance data, customer claims, preparation, qualifications...) shall be maintained. Documented procedures shall ensure:

1. labeling
2. imposition
3. protection
4. search
5. archiving time
6. disposal of records

The measuring equipment and technical procedures used in the measurement management system shall be clearly identified individually or collectively. There must be an indication of





the metrological confirmation status of the device. Equipment which has been confirmed to be used only in a special measurement process or special measurement processes shall be clearly labeled or otherwise controlled to prevent unauthorized use. The equipment used in the measurement management system shall be different from other equipment.

Material resources

All measuring equipment necessary to meet the specified metrological requirements shall be available and shall be marked in accordance with the measurement management system. The measuring device shall have a valid calibration status before confirmation. The measuring equipment shall be used in an environment that is controlled or known to the extent necessary to ensure valid measurement results. The measurement equipment used for monitoring and recording influencing quantities shall be included in the measurement management system.

It should be noted that the metrological requirements for a measuring device derive from determined product or equipment requirements to be calibrated, verified or confirm. The maximum permissible error may be determined by reference to a specification published by the instrument manufacturer or metrology department. The measuring device may be calibrated by an organization different from the metrology unit that performs metrological confirmation.

The metrology department management shall identify, maintain and use documented procedures for:

1. communion
2. manipulation
3. transport
4. storage
5. dispatch of measuring equipment to prevent:
 1. abuse
 2. unauthorized use
 3. damage



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





4. change their metrological characteristics

Procedures must be in place to include a meter in the metering management system and to remove it from the system.

It is essential to document the environmental conditions required for effective operation measurement processes within the measurement management system. The environmental conditions affecting the measurements shall be monitored and recorded. Repairs caused by environmental conditions shall be recorded and included in the measurement result.

External suppliers

The metrology department management shall define and document the requirements for products and services to be delivered by the external contractors to the measurement management system. Outer suppliers must be evaluated and selected on the basis of their ability to meet the documented requirements. The selection, monitoring and evaluation criteria must be defined and documented and the evaluation results recorded. Records of products and services provided by external suppliers must be maintained.

If an external contractor is used for testing or calibration, it should be able to demonstrate its technical competence in accordance with a laboratory standard such as ISO / IEC 17025. Products and services provided by external contractors might require verification under specified conditions.

2.4.4. Metrological confirmation and implementation of metrological processes

Metrological confirmation is the set of actions required to ensure that a measuring device conforms to the requirements for its intended use.

Metrological confirmation generally includes calibration and verification, however necessary adjustment or repair and subsequent recalibration, comparison with the metrological requirements for the intended use of the equipment, as well as any seal and marking required. Metrological confirmation shall not be achieved until the suitability of the measuring equipment for its intended use has been demonstrated and documented.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





Requirements for intended use include aspects such as:

1. range
2. resolution
3. maximum permissible errors

To ensure that the metrological characteristics of the measuring equipment comply with metrological requirements for the measurement process, metrological confirmation consisting of:

1. calibration of the measuring equipment
2. its verification

2.4.5. Measuring process

The measurement processes that are part of the measurement management system shall:

1. plan
2. validate
3. introduce
4. document
5. check

2.4.6. Measurement uncertainty and traceability

For each measurement process included in the measurement management system, the measurement uncertainty shall be estimated. Uncertainty estimates must be recorded. The measurement uncertainty analysis shall be carried out before the metrological confirmation of the measuring equipment and the validation of the measurement process. All known sources of measurement variability shall be documented.

2.4.7. Improvement

Based on the results of audits, management reviews, and other related factors such as customer feedback, the metrology department must plan and manage the continuous improvement



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





of the measurement management system. The metrology department must investigate and identify potential opportunities to improve the measurement management system and modify it as necessary.

If the relevant element of the measurement management system does not meet the specified requirements or if the relevant data show an unacceptable composition, corrective action shall be taken to identify the cause and remove the non-compliance. The correction and corrective action must be verified before the measurement process returns to use. Criteria for corrective action must be documented.

The metrology department shall identify actions to eliminate the causes of potential measurement or confirmation mismatches to prevent their recurrence. Preventive actions must be commensurate with the importance of potential problems. A documented procedure shall be developed to define the requirements for:

1. identify potential non-conformities and their causes and assess the need for action prevents inconsistencies
2. identifying and implementing the necessary action
3. record the results of the action taken
4. review of the preventive action taken

2.5. Measurement quality

The basic feature of measurement quality is the correctness of the result, characterized the credibility of its value. The following parameters can be used to assess the quality of metrological activities:

1. Uncertainty
2. Accuracy
3. Best Measurement Capability (BMC)
4. Capability index of the measurement process (Petřík, 2014)





SUMMARY

The work briefly describes the basics of quality management and business metrology, which is now an integral part of it. In the introductory part is defined product quality, quality management as well as metrology. Then are described three very often used approaches to quality management. This is management using ISO 9001 and CAF standards and then the management using the EFQM excellence model. especially on practical business metrology.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



REFERENCES

- Blecharz, P. (2015). *Kvalita a zákazník*. Ekopress, s. r. o.
- Briš, P. (2010) *Management Kvality*. UTB ve Zlíne. Zlín, Tribun EU, s.r.o.
- Howarth, P., & DFM, L. (2003). *Metrologie v kostce*. Dánsko, Překlad z anglického originálu „Metrology–in short“, ČMI Praha.
- Howarth, P., Redgrave, F., Germany, P. T. B., Madsen, S., & Grafisk, S. (2008). “*Metrol-ogy–in short*” 3rd edition. EURAMET project, 1011.
- Nenadál, J. (2016). *Systémy managementu kvality: co, proč a jak měřit?*. Management Press.
- Petrík, J.(2014) *Metrológia v riadení kvality : učebný text pre poslucháčov Hutníckej fakulty Technickej univerzity v Košiciach* , Košice : TU.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





LIST OF ABBREVIATIONS

CAF	Common Assessment Framework
ČSN	Czech Technical Standard
EFQM	European Foundation for Quality Management
ISO	International Organization for Standardization
MPM	Methodological guidelines for metrology
TPM	Metrological technical regulations



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





LIST OF IMAGES

Image 1 EFQM Excellence model (Briš, 2010)	15
Image 2 Traceability chain (standard levels) (Howarth,2003)	28



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education





LIST OF TABLES

Table 1: Prerequisite panel - “classic rating” (Nenadál,2016).....	20
Table 2: Results panel - "classic rating" (Nenadál,2016).....	21
Table 3: Fields, subspecies and typical standards for individual important levels of measurement. Only 10 technical fields are listed. (Howarth,2003)	26

