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Quality management

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PREFACE

Over the past two decades, quality issues have undergone multiple transformations due to the cybernetic behaviour of the technical systems themselves, but also due to the effects of the external environment.

Essentially, there has been a change in the concept of quality, ranging from the direct assessment of the quality of a product, to the interference aspects of the quality system with other systems with which it collaborates in various situations; all these are the result of a very sensitive "balance" between customer requirements, in a continuous diversity, and the response of producers, confronted with the need to use creativity as a daily work tool. In the business world and beyond, in areas such as health, arts, sports, culture, education, social life, activities or hobby activities, quality is used to highlight work done to highlight the value of work for ourselves, but also for others who are interested in it.

Quality has been transformed from a specific technical indicator into a "barometer" with a social tide, evolving in time and space, contributing to the definition of the quality of national societies; he is no longer an instrument of technicians; in the parameters of quality are reflected the economic effects, the effects specific to the ambient social environment, economic / political conjunctures effects.

"Quality is all about us!" *Is a proposition that we take on as best we can, as quickly, as deeply and as constantly as possible; we are bound to implement quality in our entire work so that we can value our work to convey the value of "our customers" assimilated as students! Quality implementation is possible in every type of activity, from engineering executive management to customer service.*

This book attempts to address at least two relevant issues:

- ✓ *To highlight as much as possible the evolution of the quality concept over time, and to present multiple possible connections that occur and develop between the quality of products and services engineering.*
- ✓ *Be an additional source of information to participate in the training of students, managers, and staff working in the field of quality in order to integrate them into the present and future economies.*

This book summarizes a volume of information needed to implement the quality concept. Where I thought it was necessary the text was accompanied by figures, examples; at the end of each chapter are presented comments, which will be developed at the seminars, explanations and clarifications of the issues that are harder to assimilate.

The presentation of the material is focused on a useful issue for students, teachers, quality management specialists and managers concerned with this field: ***Quality****!*

This teaching material keeps in view the correspondence with the learning outcome-based approach, the prescribed and expected professional competencies, competence-elements, the formation of which the subject typically contributes to, thus the student:

a) regarding his/her knowledge, it can be said that:

- knows the quality processes, the ways, limits and possibilities of their running.
- is familiar with the operating principles and structural features of machine systems suitable for the implementation of conscious technological processes.
- knows the basics, limits and requirements of quality management, quality insurance which are directly connected to his/her area of interest.

- is familiar with the methods of learning, acquiring and collecting data on quality management, their ethical limits and problem-solving techniques.
- is familiar with and capable to apply independently the tools and methods of quality improvement.
- knows the fundamentals of quality improvement and quality management.
- is familiar with the conscious ways to solve practical problems.

b) as a result of the development of his/her skills

- is able to comprehensively evaluate and differentiate between the importance of each quality problem based on the risks.
- is able to overview, analyse complex systems, also to identify quality issues.
- is able to size up and select quality improvement solutions adequate to the exposed problems.
- is able to influence the people around him/her to promote quality awareness.
- is able to apply the computational and modelling principles and methodologies related to quality processes.
- is able to interpret and characterise the elements of quality processes, and their relationship, role and significance in the whole process.
- is able to organise and manage the operation of systems according to process approach.
- is able to manage and control the processes having quality insurance and quality regulation in sight.
- is able to detect errors in the quality system and to select the response operations.
- is able to plan, organise and realise self-study.
- is able to comprehend and use the specialised literature of the field of quality management, and its sources in informatics and libraries.
- is able to apply the acquired IT-knowledge in solving problems emerging in his/her field of interest.
- is able to use his/her knowledge in a creative way to manage the workplace resources efficiently and in a quality-oriented way.
- is able to communicate in a professionally adequate manner both verbally and in writing according to his/her field of interest.
- is able to make decisions with full consideration of laws and ethical standards even in situations requiring complex approach or unexpected arrangement.

c) his/her atitude is expected to change favourably,

- is committed to the quality goals, represents the complex approach of quality management.
- is interested in risk and environmental pollution of new products and technologies; initiates technical and technological innovations which reduce emissions of the existing technologies.
- initiates the introduction of processes of quality improvement.
- aspires to monitor changes in processes related to quality goals.
- seeks to apply processes of waste management which guarantee protection of both the environment and human health; keeps an eye on the aspects of both the environment and human health.
- aspires to consider environmental aspects in industrial developments; by means of his/her complex attitude regards by-products and wastes as values; initiates to recycle by-products and wastes of food industry in greater proportion.
- is committed to the principles of sustainable development.

d) his/her autonomy and responsibility develops,

- makes autonomous and professional decisions even in unexpected situations.

- performing his/her professional duties, he/she cooperates responsibly with the employees.
- reveals the shortcomings of the applied technologies and the risks of processes, and initiates measures to reduce them.
- is aware of the legal, economic, security, social, health and environmental consequences of his/her work and decisions.
- in accordance with the instructions of his/her work manager, directs the work of the personnel assigned to him/her, supervises the operation of processes and equipment.
- evaluates the effectiveness, efficiency and safety of the work done by the employees.

The Authors

1 THE HISTORY OF THE DEVELOPMENT OF THE QUALITY CONCEPT (Part 1)

1.1 Historical approach

The first quality information comes from the primitive commune;
they aimed at:

- ✓ **selection of food** - difference between consumable / poisonous food
- ✓ **constructions** - protect against environmental viscosity / wild
- ✓ **manufactured** - the first commodity / community commodity exchanges.

In ancient times, the Cities appeared.

CITIZENS: Forms of organization, communication / protection / existence of population in a given area. They were located on the banks of the rivers (Ulm, Siegen), or by the sea (Tomis, Calatis, Genova).

THE FIRST SAFETY ELEMENTS needed by the population in an area, generated aspects specific to the concept of quality:

- **Building group** building needs of defense fortresses, river dams, aqueducts;
- **Defense needs** defense towers, forts, military ships, military equipment.
- **The first exchange relations** with superfluous products, warehouses with essential products (salt, oil, skins) placed near the waterways (Istria);
- **The products → the goods** by valuing their value in exchange for other products (The Polish Kingdom salt, the Toledo steel guns (Italy), were transported to the Middle East for the spices, skins, wool made in Europe by the city's sailors of Geneva.
- **The first technical specifications**
    - brick burning, wall / house / aqueduct / channel dimensions, correlated, thus defining the first standardization elements.
    - the first constructions aimed at protecting the collections of people, in the form of the thresholds, of "wooden clips", appeared in the Germanic peoples of Sigului (Germany).
- **The first specific instruments** - the lead wire, the air bubble level, the flatness for flatness, the echer found in the tombs of the Valley of the Kings.
- **The first crafts**
    - the quality inspector in construction, which was responsible for building security, but also for the protection and health conditions of slaves working in large collections, were found in a tomb in Teba.
    - The Maternity Workshop, discovered in the tomb inside the Meketre pyramid (1800 BC), consisted of 2 tortes, 2 bucklers, 1 weaver, and a quality cloth controller, and also the organizer of the workshop activities.
    - At the tomb of Artaxerses I (429 BC), in Nippur, tablets were found which included the following in the cuneiform writing:

"*As for the emerald gold ring, we guarantee that for 20 years the emerald will not fall out of the gold ring. If, however, the emerald falls from the ring, before we pass the 20 years, we will pay to Bel-Nadinshumu a compensation of 10 silver. Signed with fingerprints of Bel-Ahiddina, Belshunu and Hattin*"

In the 18th century in Europe, BRESLELE appeared as organizational structures promoting products of a certain quality, and training activities were provided for the staff of the workshops belonging to the guilds.

INDUSTRIAL REVOLUTION was the result of the discovery of steam power (Pappin's Owl) as a source of drive for various machinery and equipment. Using steam as a driving force has generated some benefits for society:

- ✓ Ensured the people's independence from the water source as the main tool of the machinery
- ✓ Ensured a more dynamic development of crafts, generated new manufacturing technologies (lace in France, weapons in Germany, etc.)
- ✓ Has led to the amplification of the concept of quality (through the development of management especially in, wars)
- ✓ There is a reunion of the world in which the first come (England, the Netherlands, France) share the areas of influence at the table
- ✓ In 1864 Simon North laid the foundations of the London Arsenal and elaborated the first document on the need to organize arms activities through the book "Inter-changeability of Parts in the British Arms Industry"
- ✓ 1929-1930 Henry Ford - establishes the first car assembly line, called at that time "mechanical carts" (USA)

1.2 Significant moments on the evolution of the concept of quality

The dynamics of the level of quality, salary levels, the degree of process automation and the dynamics of the capacity to adapt to the market requirements over the past five decades (Fig. 1.1)

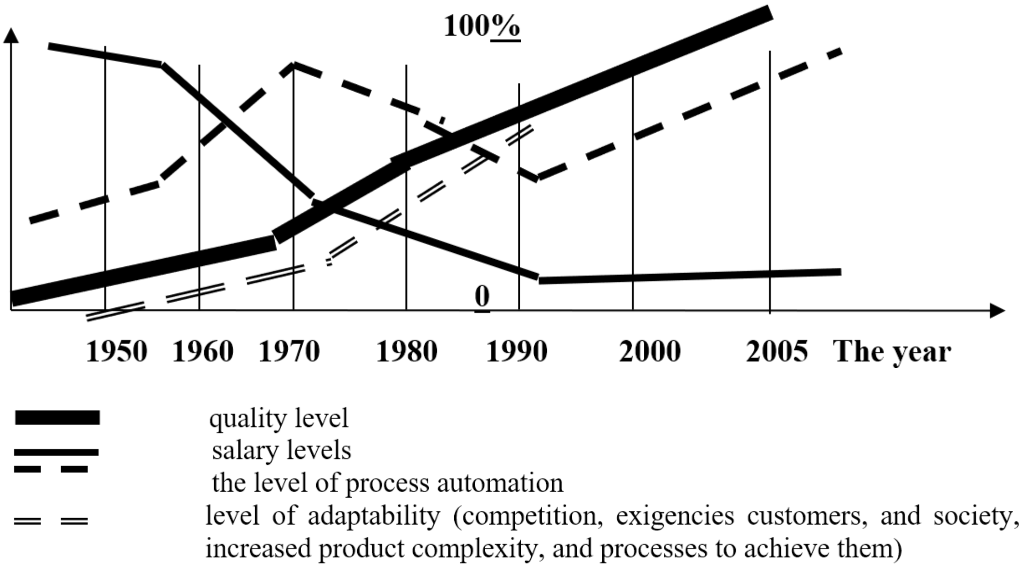

Fig. 1.1. Market requirements

It is very clear that since 1990, the increasing trend in quality has forced manufacturers to diversify their capacity to adapt to customer requirements, while increasing the degree of automation of manufacturing processes; the ultimate effect being to maintain or even reduce the salary fund by using highly automated equipment.

Aspects regarding the possibilities of recovering investments taking into account the quality of the product is presented in Fig. 1.2. It is noted that with the increase of the quality of the products produced, the possibilities of recovering the investment necessary for the realization of the products are also increasing. Moreover, by realizing quality products, the company has the possibility to increase the percentage of investment recovery, in proportion to its market share (Fig. 1.3.).

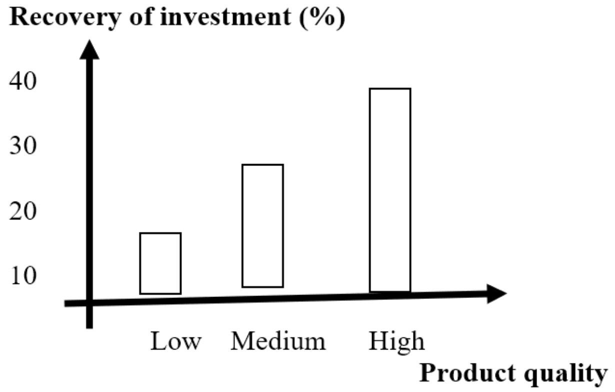

Fig. 1.2. Opportunities to recover the investment

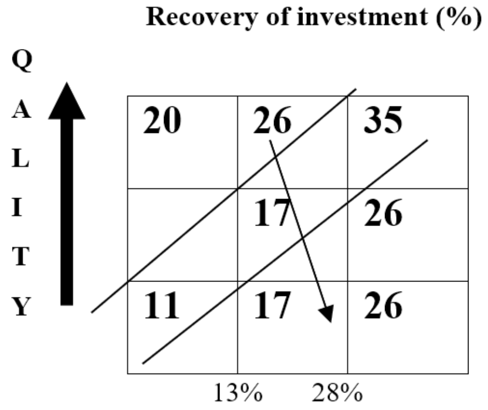

Fig. 1.3. Market share

1.3 Evolution of system / system engineering

In antiquity times, systematic research on the world around us has been geared toward the basic elements of human existence. Earth, fire, water, air or combinations thereof. When the phenomenon was being penetrated, the researchers were experiencing difficulties:

- ignorance of the complexity of human existence,
- limited knowledge of nature / phenomena that were reported,
- limited capabilities of conscious information processing (max. 16 bits / sec).

The intuitive approach of science to environmental knowledge has been replaced by sequential approach, which has led to the emergence of new, more and more particular sciences capable of deepening the phenomenon of knowledge. ***This kind of evolution*:**

- **(private sciences)** was followed by researchers until the end of the nineteenth century. The volume of accumulated knowledge has generated a new evolution in the scientific field, oriented towards.
- **synthetic sciences**, which is currently addressing, globally, in various aspects, the whole reality, in its complexity. Here's how:

CIBERNETICS, as well as science, was developed by St. Odobleja (1938) and R. Wiener (1945). The word comes from the Greek kibernetes = which means rudders; is a science of synthesis that studies the behaviour of self-regulation systems (technical, economic, social, natural) over time. The models developed take into account only the information flows and the effects of information resulting from the action of material and energy flows.

The General System Theory (TGS) (Foundations of this science were put by Stefan Bertalanffy 1942, 1950, 1957) The word "sxtem" comes from the Latin System = system, complex, ensemble, synthesis). It is a synthesis science with the ultimate object of formulating principles, laws and methods valid for any system, regardless of the specifics of the system classes. TGS takes into account the influences of all flows (information, substring, energy from a system) at a certain moment given.

SCIENTIA (Bernal 1957, Price 1963) (Latin origin, scientia = science, science of science); is a scientific discipline that deals with science as a social / economic phenomenon. It studies the development and structure of the sciences, the methodologies used, the management and optimization of the research activities.

ECOLOGY (Odum 1975) (Greek origin, oikos = household, logos = science). It is a scientific discipline that has as object of research the study of the interactions of population-type units, ecosystems, biosphere), in a dynamic evolution over time, in the context of the integration of these units into a natural / artificial way.

SINERGETICA (Haken 1977) (Greek origin, synergy = collaboration). It is a scientific synthesis discipline, which has as its object the self-organization of open systems, separated from the equilibrium area, to which the component elements continuously interact.

SISTEMOLOGY **-** is a science of synthesis valid in any field of everyday reality, the most valuable tool of knowing and mastering the complexity of the processes that take place within different types of systems. With a relatively small number of concepts, with unitary methods, with own laws, using a mathematical apparatus based on computational modeling, simulation and optimization, the system is a common theory for very different entities: a living organism, an enterprise, equipment, a group of operators, a political party, a psychology assimilated by a collection.

In the current vision, **SCIENCE** is **-** a systematic set of terrestrial knowledge about: nature, society, thinking, affection. It is constituted when the multitude of knowledge in a realm of reality reunites, based on the same concepts, principles, laws, in a self-contained, self-contained theory. The structural - functional elements of any science are:

- **FAPTIC MATERIAL** - result of observation/ experiments
- **IPOTHES** - confirmed or denied
- **CONCEPTS, LAWS, THEORIES** - confirmed by practice
- **GENERAL CONCEPT ON THE FIELD**
- **METHODOLOGY** - Summary of general and specific methods research in the field
- **THEORETICAL / PHILOSOPHICAL INTERPRETATIONS** of the scientific solutions of the phenomena
- **DESCRIPTIVE / EXPERIMENTAL DEVELOPMENT / AXIOMATIC-DEDUCTIVE STAGE.**

At present, sciences are integrated into a homogeneous system, uniquely called the **SYSTEM OF SCIENCES (SS)**, which has four distinct groups in its structure.

1. The science group about existence:

1.1. G. natural sciences (physics, chemistry, biology, geology, astronomy, astrophysics, with distinct branches and sub-branches);

1.2. Social sciences (sociology, history, politics, law, economy, demography, ethics, aesthetics, with its branches and sub-branches);

1.3. G. thinking (logic, linguistics);

2. The Action Sciences Group:

2.1. Engineering sciences (industrial, agricultural, construction, electro-technical, urbanism, transport, telecommunications);

2.2. Management Sciences: (M. strategic, M. Tactic, M. Operative, macro-management, mezzo-management, micromanagement);

2.3. Medical sciences (preventive medicine, curative, work, sports);

2.4. Education (pedagogy, civic education).

3. The group of border sciences: (biophysics, physical chemistry, bionics, psychology, anthropology, ecology, bioengineering).

4. The group of synthetic sciences: (mathematics, systemology, systems engineering industrial engineering, economic engineering).

System Engineering - A science that focuses on the practical application of systemology and other sciences).

Industrial Engineering - A synthetic science dealing with the design, improvement and application in practice of integrated systems made up of people, materials, equipment, working in a specific environment.

Bioengineering - application of engineering in biology and medicine.

Economic Engineering - integrates engineering, management / economy of production / service delivery / marketing systems.

The first Industrial Engineers promotion graduated at the University of Pennsylvania in the United States in 1908.

REVIEW QUESTIONS

1. How would you describe the development of the concept of quality? 7
2. What where the significant moments of the evolution of the concept of quality? 8
3. What were the phases of the evolution of system and system engineering? 9

2 THE HISTORY OF THE DEVELOPMENT OF THE QUALITY CONCEPT (Part 2)

2.1 Ideas and concepts specific to the system

1. SYSTEM (S) - is the relevant element in system characterization.

S can be defined as a set of elements (components) that, within specific time / space / resources / environment conditions, cooperate / interact / function, with the goal of achieving a concrete result. (AWARE!) The structure of a system is given in Fig. 2.1., has three groups of distinct elements:

- System inputs / subsystems / systems (S) (EI)
- System Output Elements (EI)
- System elements (S)

E1, E2, E3, E4 - elements of the system structure; they can be in different phases:

- ✓ grouped into subsystems, which subsystems in turn are system S components, or
- ✓ can be distinct, individualized components within the S system.

From the point of view of the functions they have in the system the elements can be distinct, individualized components within the S system.

- ✓ structural elements in the system. (The integrating structure of elements can be a management structure or execution structure.)
- ✓ items with certain functions in S (observer, system setting element, system compensation element)

Position of elements within the system may vary from one element to another and may change over time.

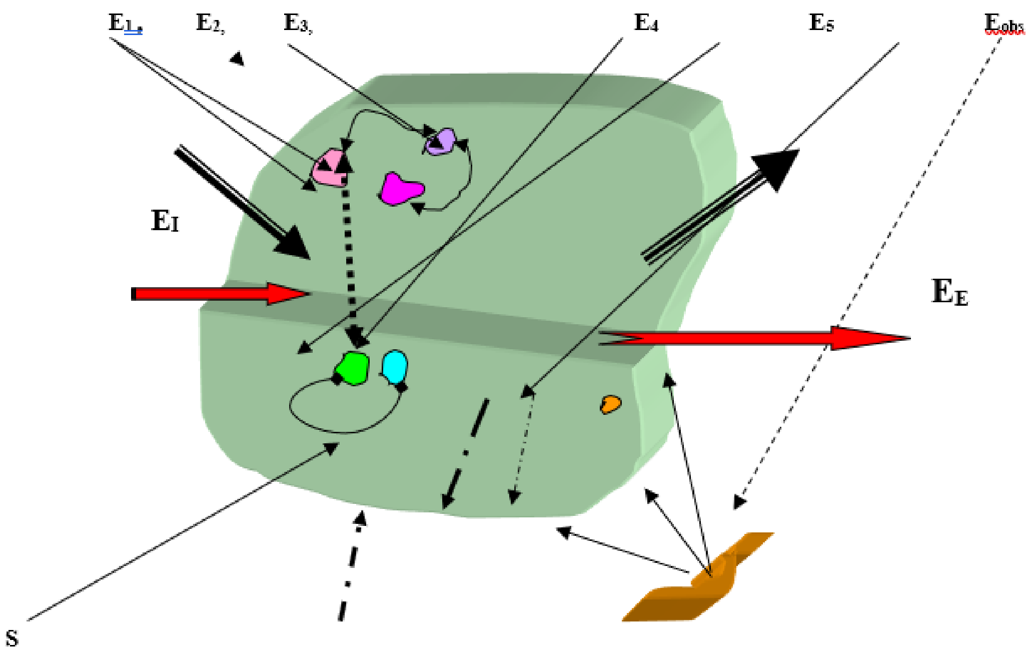

Fig. 2.1. Structure of a system

***2. HIERARCHY* S -** given the relative position of elements in structure S, analyzed against one or more criteria taken into account. Because the hierarchy criteria are unlimited, the hierarchy is practically INFINITE.

3. INTEGRALITY S - given by the system-specific properties of the properties of its component elements, by specific properties → Σ / Π / (any other type of assembly) of system components, generating new properties.

4. OBSERVER S - Element / system / subsystem active, conscious, placed inside / outside S, provider of necessary information (external environment). The observer has the role of transmitting / retransmitting information, coding / decoding it, for use in making system-level decisions.

5. FRONTIER S - is the element in the S-structure that delimits the S of the Environment; this, in turn, may be: internal environment / external environment. Depending on the strategy of the management subsystem, applied to S, the frontier may be permissive, non-permissive, or partially permissive, with an opening towards the inside or outside.

6. THE ENVIRONMENT / THE ENVIRONMENTS are defined as domains of space / time / resources / in which S functions, delimited functionally / structurally by:

- Connection interfaces (action / confrontation - cooperation / compromise),
- Borders / structured / defined by an observer.

RELATIONS WITH EXTERNAL ENVIRONMENT. It operates under the auspices of a system of laws, ordinances, pre-established rules, accepted by S.

INSERT RELATIONS / ELEMENTS are characterized by the fact that the environment is acting on the system.

RELATIONSHIPS AND OUTPUTS are characterized by the fact that the system acts on the environment or connects elements from the external environment.

The actions / connections - are ensured through specific interfaces to each S.

7. STRUCTURE S. It is given by COMPONENT AMOUNT / SUM OF RELATIONS / INTERCONNECTIONS AT THE LEVEL S. The structure determines: Identity S, Connectivity S, and Functionality S in the life cycle.

8. RESOURCES S are of several categories:

- Resources. INTERNET (Materials, Primitives, Materials, Subassemblies, Components, Resources, Human Resources, Inventory Objects, Specialized Software).
- Resources. EXTERNAL (Purchased Materials, Energy / Fuel) RESERVE resources, used in special cases.

An S can be declared ACTIVE if EXTERNAL RESOURCES turn into VALUABLE FINISHED PRODUCTS. To be active, an S must have internal resources of a certain quality, plus an efficient, flexible, adaptable management, so S must have cybernetic behavior over time.

8. The LIFE CYCLE of S is given by the temporal sequence of four distinct periods in the life of a system, according to Fig.2.2.

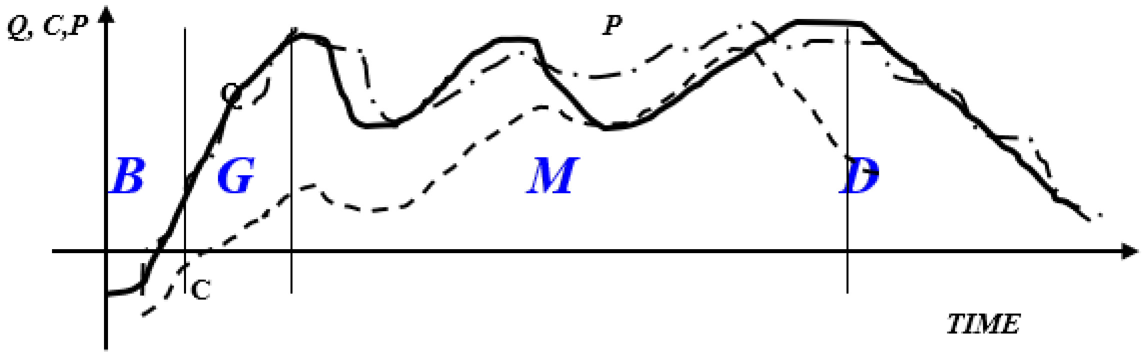

Fig. 2.2. The life cycle of the system

The four periods are:

- Birth S - in the external environment, by generic systems with specific information programs.
- Growth / structuring S - operation based on structuring programs.
- Maturity S. the period of operation of S according to some programs structured in order to ensure the required performance S within certain limits.
- Decline S. The involution period of operation, completed by destruction.

S-destruct creates poisons for new, one or more systems, is the specificity of Systems Theory, under conditions different from previous ones, and with objectives identical to the original objective, or new objectives, different from the original ones.

9. GLOBAL FUNCTION OF S. - consists of the set of properties used / usable according to the requirements of consumers, the external / internal environment, and the finality of the considered system. (Transformation of inputs to outputs according to the requirements of the external environment.)

10. QUALITY S - The sum (S) of the characteristics (properties) of an S which represents its state more or less distant from an average level (average value), determined to meet the needs of consumers, at the different life stages of system. The position S in relation to the external environment depends on the ratio: n_c / c_r (quality level / consumption of resources required to achieve quality S).

2.2 Quality relationship – competitiveness

- Quality generates competitive advantages.

In the 1980s, Japan produced 46% of the European TV market. In 2000, Japan occupied 32% of the European market and 26% of the US automobile market. Such situations have generated some specific effects:

- ✓ Intensifying competition by creating "ECONOMIC UNIONS" (European Union, EFTA, North American Free Trade Treaty).
- Increased customer demand. A model of the dynamics of exigencies is the KANO Model (Fig.2.3.). He is imposed as a multifactor model, which has several considerations:
  - Customers' needs have a strong individual touch
  - Needs have a different weight over time for the same customer
  - Customers' needs are divided into 3 distinct categories:
    - ✓ 1 primary needs - (customers have but rarely express them),

- ✓ 2 performance requirements - (formulated when the customer is concerned about the product),
- ✓ 3 needs of delight (they present themselves to clients only to delight their customers).

An analysis of customers' time behavior over these needs highlights the fact that their attitude changes so that needs shift from one category of interest to another, even to the same product. Also the same feature can be viewed differently from the point of view of requirements for different customers.

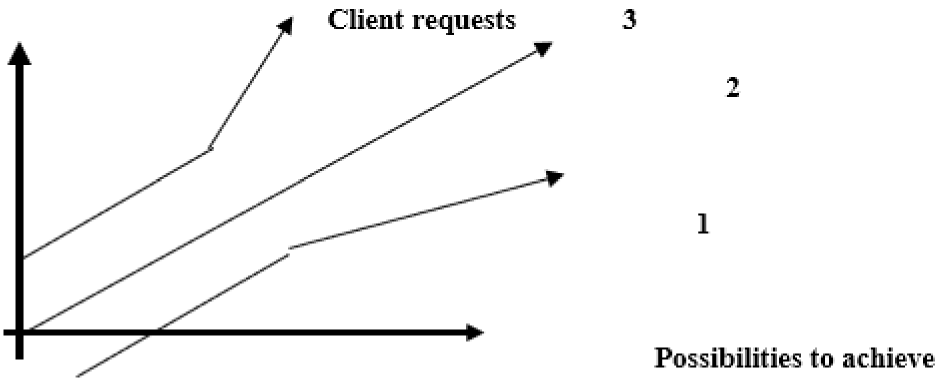

Fig. 2.3. The Kano model

The quality - competitiveness relationship is based on two distinct elements, as it results from Fig. 2.4.:

• customer requirements in time diversification. They depend on the ability to pay, the level of education / knowledge of customers, the goals that customers propose and their social condition; the finality of their evolution is concretized by increasing the complexity of products by multiplying their functions. This element is a specific quality generator, embodied by more complex, performing cheaper / cheaper products / services if possible.

• producers' response to these requirements, materialized by developing the complexity of the technological equipment, able to ensure the quality of the new products / services demanded by the customers. This dynamic relationship over time also takes into account the specific aspects related to the competitiveness of the market segment of the producers. (For example: specific technologies for the manufacture of silicon microprocessor.) This element ensures the competitiveness of the product but also of the manufacturer in the market.

An in-time analysis highlights the fact that the two distinct elements are interdependent over time, generating new aspects both in terms of increasing the quality level and in terms of increasing the complexity of the equipment involved in the process.

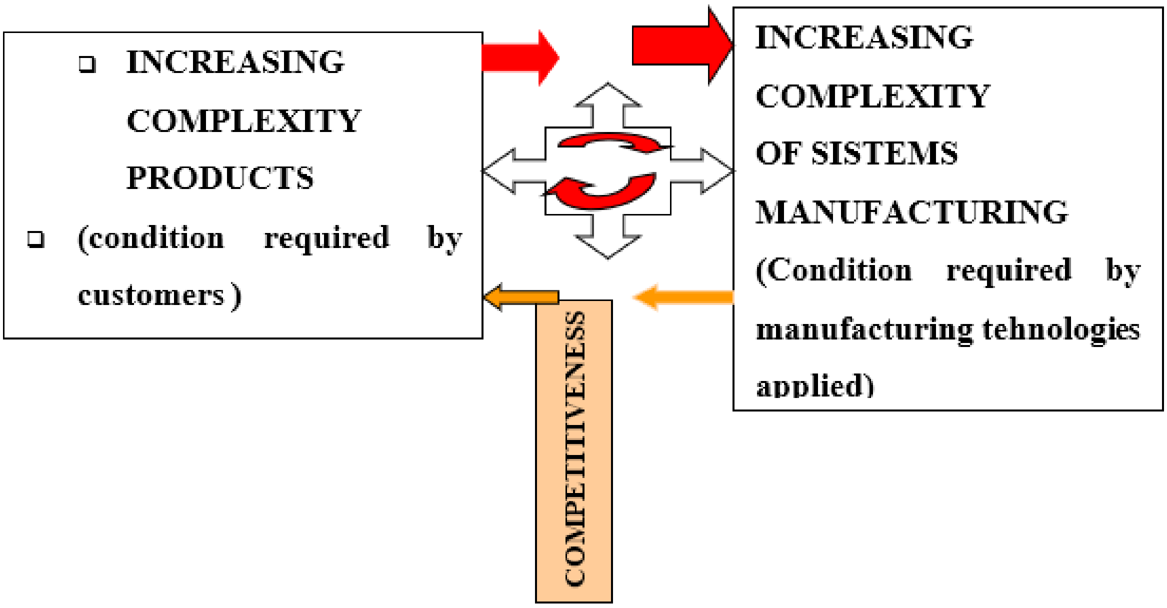

Fig. 2.4. Quality - Competitiveness Relationship

The quality of manufacturing systems refers to:

- The specific quality of the manufacturing process itself.
- Accuracy of the components needed to achieve a product.
- Quality / multitude of services related to a product.
- Reliability of components in the product structure or provided service.
- Shortening of the intervention time in the detection of defects in the operation of a product.
- Redundancy of components in the product structure.
- The level of complexity of the maintenance process.

Assuring the quality of production systems requires two well-defined conditions:

- Reduce the time required to research, design related products / services, and to develop manufacturing / control processes.
- Ensuring full responsibility for the intangible realization of the product or service. The principal manufacturer will draw up separate contracts with each supplier of materials / components / subassemblies / services, in order to carry out the initial programs according to the customer's final terms.

! The delivery terms and / or the quality conditions set forth will be strictly respected!
!! The sanctions to be given / the way of their application will be determined in case of non-observance of the agreed terms.
!!! In order to be easier to track the deadlines of the initial programs, it is practiced:

PROJECT MANAGEMENT - if the product is of a high degree of complexity and has many components (bridges, power plants, special constructions, drilling installations, airplanes, missiles and military and logistics complex equipment, large applicative programs and great complexity). Each project participant is responsible for the quality of the delivered work or service, along with the project coordinator.

MANAGENET EXCEPT, for production with a high degree of repeatability, to which the control program is ensured by distinct operations placed in the manufacturing process structure. The preventative control plays an important role in avoiding the occurrence of exceptions.

BUDGET MANAGEMENT for costly, cost-consuming products. Process quality control is the result of optimization processes to ensure a balance between product quality required by the customer and manufacturing costs imposed by a certain quality of technological processes.

- Addressing high-performance technologies that require special dimensional precision, pre-simulation of processes to prevent negative effects and reduce manufacturing costs (retards used for chemical analyzes, parallelization of operations to reduce working times, use of modern norming methods such as MTM or MOST).
- Continuous analysis of how the system performs the functions for which it was designed; the elaboration of complex control and countdown schemes to cover control both in space (number of operations, their logical sequence, control operations), and over time (the duration of the control operations, their sequence over time, the use of some specific statistical interpretation of results, such as the CASQ it 9000 program).

2.3 Current guidelines on the quality of a complex system

1. The **TRANSCENDENT GUIDANCE FROM THE TARGET OF PERFECTION TO THE PERFECTION OF THE GUEST**. Between customer wishes and the ability of manufacturers to provide the required services, there is a continuous connection where the desire for perfection is a particularly active engine.

2. Orientation **FOR THE PRODUCT**. Manufacturers are oriented towards the realization of products. We offer customized services to the requirements / payment possibilities of customers in different markets (products: car, carpet, craft, dwelling, consumer goods, are made in variants of the same product, requested on various markets).

3. Orientation. **PROPORATION / PRODUCTION PROCESS. The CHARACTERISTICS SYSTEM DEFINING A PRODUCT** is relevant to the customer's appreciation of the product. **DEMING**, referring to this kind of guidance, gave as an example the fact that a score performed by the London Philharmonic differs from the same score played by another philharmonic.

4. COSTS QUALITY. QUALITY IS A COST FUNCTION (One of the parameters that condition the quality of a product is its cost. It includes in its direct or indirect structure the manufacturer's overall concern to achieve a product that best suits the wishes of the customer of the market).

5. Orientation. **HEIST** and **FROM M** have shown that the quality concept can be developed according to customer requirements, such as: **DELIVERY, PRICE, SAFETY, RELIABILITY, COMPATIBILITY WITH ENVIRONMENT, SERVICE.**
INDIVIDUAL OF THE OPTION OF THE ORIENTATION OF THE SYSTEM, THERE IS A CIBERNETIC BEHAVIOR AT THE TIME in the sense that:

- HAVE A COORDINATION OF INTERNAL ACTIVITIES IN ORDER TO ENSURE A LEVEL OF QUALITY AT THE TIME.
- ASSIST A COLLECTION AND SELECTION OF THE RELEVANT DATA IN THE PREVIOUS PERIODS.
- ADAPTATION, REMODELLING OF DATA RELEVANT TO THE TERMS OF THE ACTUAL PERIOD, IN ASSURANCE OF A QUALITY STANDARD QUALITY. (Fig. 2.5.)
- SPIRIT OF THE QUALITY EVOLUTION OF JURAN.

- ➢ THE ISHIKAWA CONCEPT OF QUALITY DEVELOPMENT.

The figure shows that:

- ➢ DYNAMICS OF QUALITY LEVEL IS DETERMINED BY THE DYNAMICS OF EACH ACTIVITY IN PART;

$$\eta_{Nc} = \Sigma N_{ci} + \varsigma \qquad (2.1)$$

In relation were noted: $\boldsymbol{\eta_{Nc}}$ - the quality of the product / service finite; **NIC** - the quality level of the activities that contributed to the accomplishment of the finished product / service; - the increase of the product quality level due to the system's synergy.

- ➢ EVERY ACTIVITY MEETS THE SYSTEMS SETTLEMENTS;
- ➢ QUALITY LEVEL refers to two distinct directions:

-THE LEVEL IMPACTED BY THE PROJECTORS OF THE PRODUCT SHALL BE CONSIDERED A MINIMUM IMPACT LEVEL IN CONFORMITY WITH THE REQUIREMENTS OF THE BENEFICIARIES.
- EFFECTIVE LEVEL IN MANUFACTURING PROCESSES.
It will sit at the impressed level.

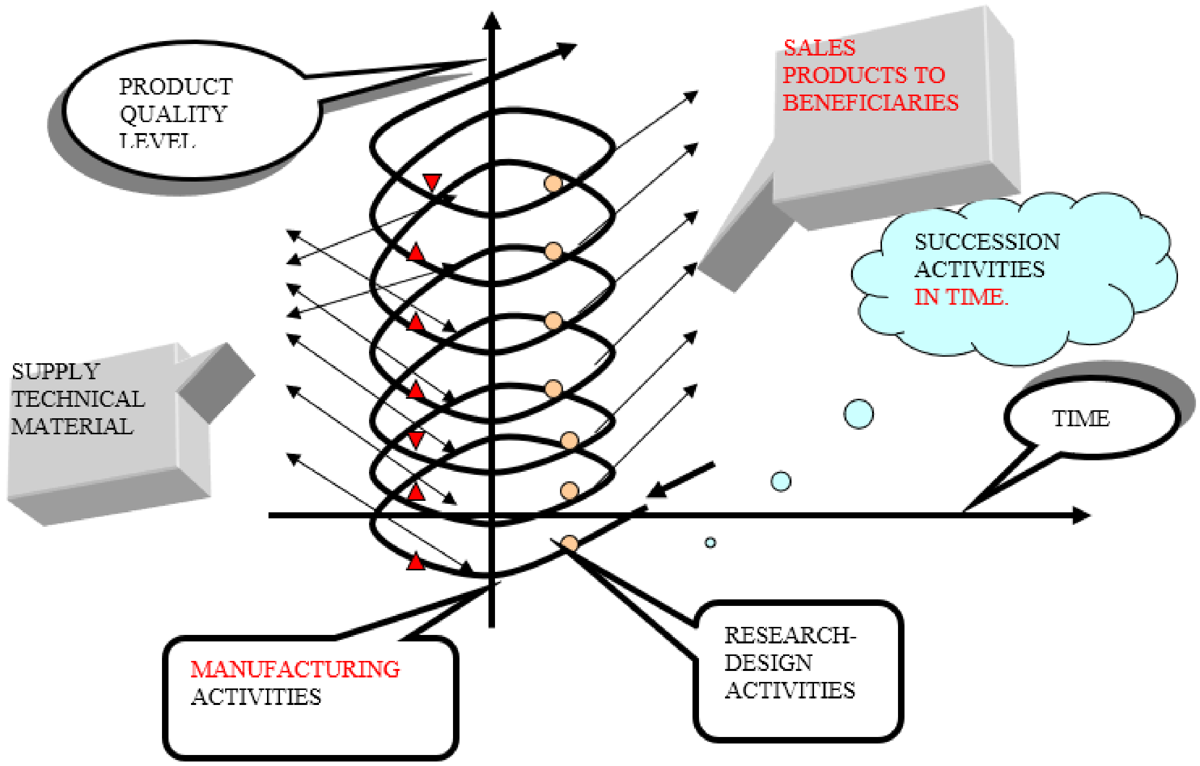

Fig. 2.5. Quality Spirit – Elaborated by Juran J.M.

2.4 Strategies in the field of quality

1. ORIENTATION TO CUSTOMER REQUIREMENTS; the manufacturer will meet customer wishes, trying to quantify these (technical) requirements**.**

In the short term: Develop a program to increase the use of robust production capacities. (Intensive use: unused capacities, devices, automation of manufacturing and control processes, intensification of individual work by providing a flexible pay system;
(Extending use: use of available time reserves, at the level of the production system, the provision of semi-finished products of a quality according to the provisions of the documentation.)

In the medium term: Customer satisfaction through superior quality products / services by providing a "service" for warranty and post-warranty periods; sale by attractive methods (attractive prices, lasing, monthly rates, ancillary services).

Long-term: Implementing products in growing market segments up to the maximum market absorption limit, multiplying distribution channels, improving product distribution processes.

2. ORIENTATION TO OUR POSSIBILITIES TO INSURANCE ANY PRODUCTS / SERVICES CONFORMING WITH CUSTOMER REQUIREMENTS

In the short term: Ensuring the market with quality products that will provide the maximum impact on the market segment in as short a time as possible.

In the medium term: Providing an information system through which the quality - marketing connection is to be carried out continuously.

Long term: Customer loyalty, endowment with high performance manufacturing and control equipment; ensuring "**service**" for all products on the market, increasing reliability ratios for purchased products!

OBJECTIVE - a certain realistic result, which can be achieved in a certain field of activity, and which can serve as a reference for future activity.

Required conditions:

- Quantitative expression allows a further comparison with actual indicators.
- Possess the ability to stimulate, direct action to organization level.
- To ensure unification, a uniformity of the way of thinking those are integrated into the work process.

Quality objectives in industry were first defined by J.M Juran, who specified the following, defining the policy of controlling the activities of the US Department of Defence:

- ✓ THE QUALITY CONTROL PLANS AND PROCEDURES ARE THE RESULT OF A PROVISION AND A GOOD CHALLENGE PLANNING.
- ✓ QUALITY CONTROL OPERATIONS MUST HAVE A CAPABLE OF BUILDING TO PROTECT IN ANY EVENT PREVENTION OF DEFECTS.

3. FOR THE DETERMINATION OF CONFORMITY OF PRODUCTS, THE QUALITY CONTROL DEPARTMENT MUST USE DATA OBTAINED IN THE CONTROL OF INSPECTIONS AND TESTS PERFORMED ON THE PRODUCTION OPERATIONS.

FROM THE POINT OF VIEW OF THE FINALITY OF PRODUCTION ACTIVITY (RESEARCH-DESIGN, PRODUCTION, DEFECTION) OBJECTIVES MAY BE:

- OBJECTIVES THAT ARE CHANGED BY CHANGING THE QUALITY LEVELS AND PERFORMANCE (RADICAL CHANGES / MODIFICATION OF AN EXISTING STATE OF THE FACTS).

- OBJECTIVES WHICH WANT TO MAINTAIN A STATUS OF FACTS, OR MAINTAIN A CERTAIN EXISTING PERFORMANCE LEVEL.

AT THE LEVEL OF AN ORGANIZATION: (Percentage of defects, maintaining a level of costs, a level of performance).

REVIEW QUESTIONS

1. How would you describe the structure of a system? 12
2. What is the life cycle of a system? 13
3. What is the relationship between quality and competitiveness? 14
4. What does the quality of a manufacturing system mean? 16
5. What are the current guidelines on the quality of a complex system? 17
6. What are the three main strategies in the field of quality? 18

3 THE QUALITY CONCEPT BASIC NOTICES, DEFINITIONS, TERMINOLOGY (Part 1)

3.1 Quality Functions

In 1911, F.W. Taylor began an article in "Scientific Management," with the following observation: "In the past man was the first, in the future the system will be the first." It is one of the first written observations that are aware of the role of quality in human activity. Quality is part of our lives, occupying virtually any field of activity: quality is present when we judge works of art, when we evaluate things made by us or others when describing our experiences; quality is the one that highlights the value of something that makes our lives easier, simpler and more efficient in the future, with earlier periods.

3.1.1 Quality ↔ Civilization, culture, history

Quality is part of the lives of people, their culture, history they have lived for generations.

The examples are numerous: the Gfiza Sphinx, made 11,000 years ago, symbolizes the power of the generations that have built it; at the same time, the beauty of the architectural lines, the way of realization, the materials used, highlights the qualitative aspects of construction activities, and the quality of solving the operational management problems that made that realization possible.

The Pyramids of the Valley of the Kings are presenting aspects of the social, cultural, religious life of the Egyptian civilizations of five millennia ago; but we cannot neglect the aspects of engineering knowledge, and the level of organization at that time that made such achievements long-lasting.

The cave paintings made 20,000 years ago show successive specific aspects of the life of the Australian nomadic tribes, today they are considered "historical frescoes" by the nomadic tribes, who periodically added to the existing paintings new information about culture, civilization, and moments relevant tribes of the entire tribe in a given period of time; the solutions used to preserve images over time are still unknown to chemists.

The great civilizations have created numerous architectural monuments, sculptures, specific constructions, in which they attempted to present the essence of philosophy (usually the essence of tradition or religious inspiration) that underpinned the respective culture: the Hindu - temples and statues; Hebrews – The Temple and synagogues, Northern civilizations - Stonehenge stones, Buddhists - spaces for religious events and Buddhist temples, Christians - cathedrals and statues with religious motives, Muslims - Masks. Through their uniqueness, beauty, greatness, these symbols, which have become representative of the respective culture, crossed millennia, proving a perennial culture, perceived today, imposed by the quality of the ideas promoted, but also by the quality of the technical and management aspects made these achievements possible.

Today's civilization transmits a new meaning to the concept of quality through remarkable technical achievements in all areas of activity; the difference with previous civilizations is that these remarkable achievements are designed to serve people's spirits; suspended bridges, bulky cities, large urban agglomerations, high-speed trains, supersonic airplanes represent today's people, which represents temples and monuments for those in earlier civilizations; they, however, contribute to the achievement of a relevant quality leap in the field in which they are achieved, the quality is complemented by utility, functionality and performance.

3.1.2 *Quality → Technological advantages*

Certainly, new materials, new technologies, new technological and structural visions produce profound changes in achieving these goals, but the answer to the aesthetic aspect, the beautiful looking in the design, the value of the durability of the goal in time, and other engineering qualities remain unchanged; we can even say that they become more relevant today for our civilization.

Fig. 3.1. Connection of quality technological advantages

The concept of quality is perceived at the level of the members of a society through the perception of the factors that ensure well-being; often the level of welfare is assimilated to the technological advantages, the volume of production and so on, found in the quality functions; the connection between quality as a concept and technological advantages is biased over time; Fig. 3.1. highlights this type of connection.

An example of this connection is the measuring units of the radiological protection system are in Table 2.1.

Table 3.1. Units of measurement for the radiological protection system.

U/M for:	**Period 1960/ 1970**	**Period 1992/ 2007**	**Order of U / M size between the two periods:**
AN ABSORBENT DOSE	**RAD (RAZI)**	**GRAY**	**100/ 1**
AN EQUIVALENT DOSE	**REM (REMI)**	**SIEVERT**	**100/ 1**

It is clear that technological development has enabled measurement / control equipment to measure radiation levels 100 times less intense than in the sixth decade; this, in turn, has allowed for a much more sensitive Radiological Protection System tailored to the new millennium-specific situation.

At the same time, the increase in quality has allowed the development of new technologies, generating new industries, horizontally; an example in this respect is the evolution over time of the "washing of clothes with specific equipment" process, as shown in Fig. 3.2.

Each stage used has led to the development of new technologies. Specific in the materials industry, chemical industry, light industry, garment industry, etc., are highlighting new quality functions.

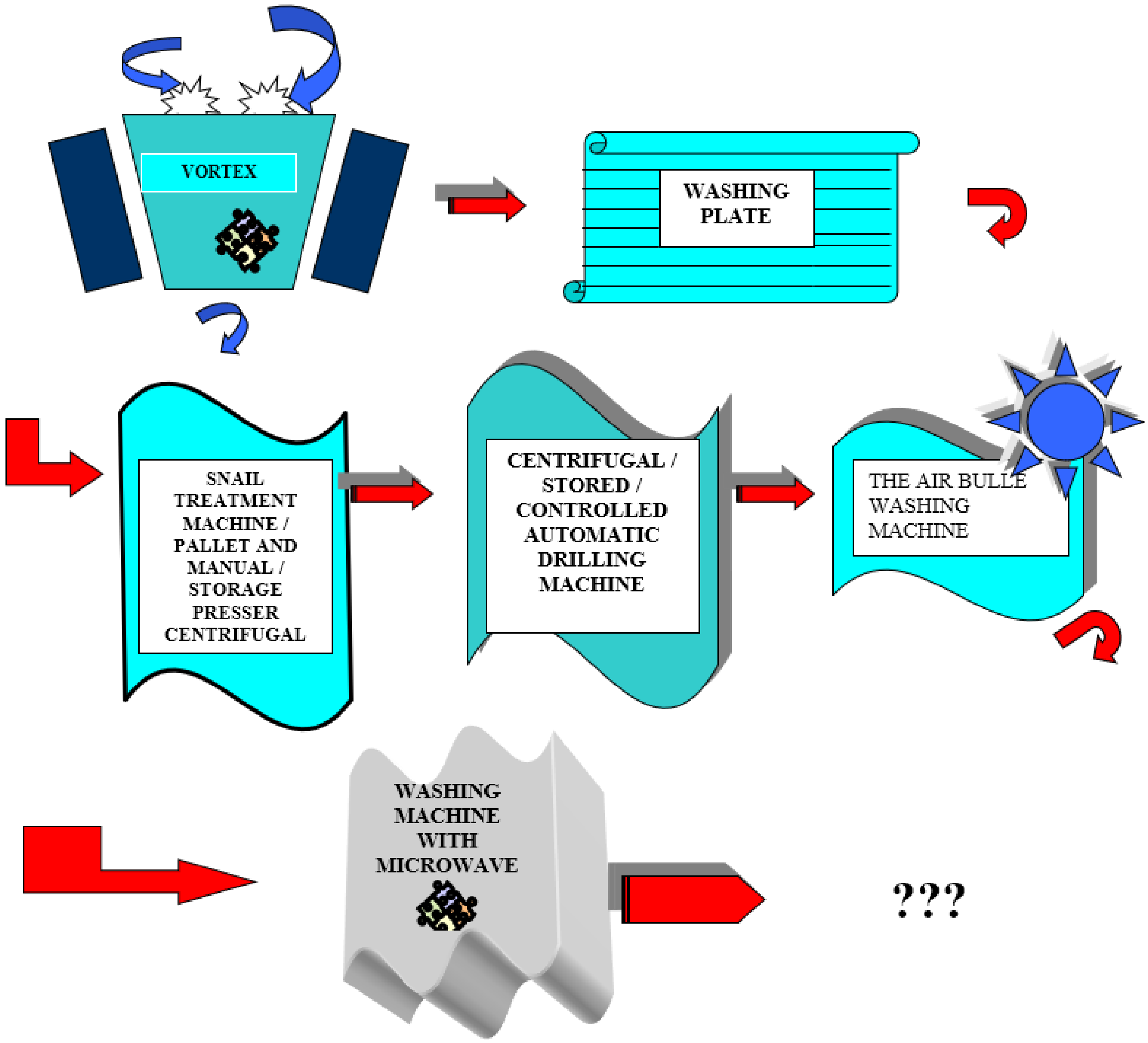

Fig. 3.2. The main moments of the process of washing clothes with specific equipment

3.1.3 Quality → Volume of production

Another function of the quality perceived by the members of society as a necessity, in the conditions of the development of the consumer society, is the volume of production; the quality vector is differentiated according to the volume of production. For:

UNIQUE PRODUCTION - QUALITY OF MANUFACTURE OF PROCESSING (here from the multitude of components defining the concept of quality, the emphasis is on: the quality of the prototype concept, the quality of the project, the quality of the materials included in the project, the quality of the human resource used, the quality of the user).

SERIES PRODUCTION - QUALITY OF TECHNOLOGICAL PROCESSES (here from the multitude of components defining the quality concept, emphasis is placed on the quality of the project with reference to: inter-changeability, reliability, delivery times, the quality of the materials used, according to the project requirements, the quality of the operations carried out as a meeting / succession of activities certain degree of repeatability).

PRODUCTION OF TABLE QUALITY OF PRODUCT PERFORMANCE AT THE TIME ACCORDING TO THE DOCUMENTATION TAKEN

(here from the multitude of components defining the quality concept, the emphasis is on the product's durability, according to the conditions imposed in the project, the evaluation of the reliability of the components in the structure of the product, in order to ensure a more economical, low-inter-changeability of durability; execution / assembly expressed through the synchronization of the assembly operations, by synchronizing the operations of supplying the intermediary deposits with the related components, by observing the mounting graphs at the level of each work place, by using trained human resources, performing with a working power and self-control process quality management refers to the issues of the need to ensure total quality control using specific methods or operations: the zero-defective method of controlling product components, statistical processing to keep the process under control; the operational workplaces will be alternated with control jobs, in order to prevent the defective components from entering the upper phases, in order to reduce the continuous and constant costs, the value analysis / engineering will be applied).

3.2 The notions of quality and control

THE ORIGIN of the word **QUALITY** comes from **Greek:**
QUALITAS (QUALIS) QUALITY WAS TO BE
What adds value to a product? What is Quality? How can it be defined?

The quality, according to some, cannot be defined, but we can always perceive its effects on products - theory found in ancient philosophy (Plato - 500 BC), but also in contemporary philosophy (Robert Pirsing - 1975).

THE DEFINITIONS existing at this time in the literature (over 200 definitions) take into account the various relevant aspects with reference to the concept of quality:

TUDOR BARON:

- EXPRESSION OF THE DEGREE OF SOCIAL UTILITY OF THE PRODUCT,
- THE MEASURE WHICH BY THEIR TECHNICO-FUNCTIONAL, PSYCHOSENZORIAL, AND ECONOMIC PARAMETERS - SATISFACES THE NEED FOR WHICH IT HAS BEEN CALLED AND
- RESPECT THE CONDITIONS IMPOSED BY THE SOCIETY'S GENERAL INTERESTS IN SOCIO-ECONOMIC EFFICIENCY, NATURAL AND SOCIAL ENVIRONMENTAL PROTECTION.

W. GEIGER:

- A RECOGNITION THAT IS RECOGNIZED / IDENTIFIED

WHO IS ENTITLED, OR WHO IS DEBATED BY ANOTHER ENTITIES.

D. GARWIN:

- DIMENSION QUALITY CAN BE CONSIDERED A LIST OF SPECIFIC CHARACTERISTICS WITH REFERENCE TO THE QUALITY OF THE PRODUCT OR SERVICE. (Fig. 3.3.)
- THE MOST RELEVANT QUALITY CHARACTERISTICS ARE:
  - BASIC CHARACTERISTICS - basic functions of the product
  - COMPLEMENTARY CHARACTERISTICS - product functions

- RELIABILITY, CONFORMITY, SUSTAINABILITY, MENTABILITY - product behaviour over time
- AESTHETIC CHARACTERISTICS - design, fashion, product-related
- DIMENSION OF CLIENT PERFORMANCE QUALITY

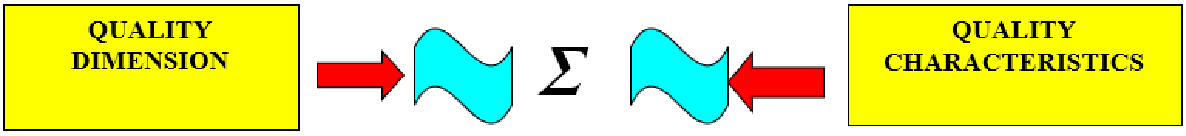

Fig. 3.3. Quality dimension relationship - Quality features of a product.

M. OLARIU:
PROPERTY (ASSETS) OF THE ENTITIES THE INTERMEDIATE, WHOSE EVALUATION IS AT A DATE, CLASSIFYING THE CUSTOMS NEEDS, REGARDING THE CATEGORIES OF QUALITY CHARACTERISTICS.

O. SENZA:
THE QUALITY OF A PRODUCT IS DEFINED BY: CHARACTERISTICS OF THE TECHNICAL-FUNCTIONAL, CONSTRUCTIVE, AVAILABLE, AESTHETIC, ECONOMIC AND ECOLOGICAL FEATURES.

GH. VASILIU:
DEFINES QUALITY: BY NATURE QUALITY CHARACTERISTICS: FUNCTIONAL (TECHNICAL AND ECONOMIC) CHARACTERISTICS, PSYCHOSENZORIAL CHARACTERISTICS, SOCIAL CHARACTERISTICS AND AVAILABILITY CHARACTERISTICS.

N. GHEORGHIU:
DEFINES THE QUALITY CONCEPT THROUGH THE TECHNICAL, ECONOMIC, SOCIAL AND USE QUALITY CHARACTERISTICS SID KEMP, PMP QUALITY EXPERIMENTS EVIDENTIFY FOUR LEVELS WHICH DETERMINE THE EXISTENCE OF QUALITY OR QUALITY FREQUENCY: UNIVERSAL LEVEL, CULTURAL LEVEL, SOCIAL LEVEL AND PERSONAL LEVEL.

K. ISHIKAWA:
ANY DIMENSION, CHEMICAL PROPERTY, OR ORGANOLEPTIC (GUST, MIROS) THAT PROVIDES PRODUCT ATTRIBUTE TO BE COMPLIED WITH USE. (DURATION OF SERVICE, RELIABILITY, MENTENABILITY, AVAILABILITY AND REDONDANCE).

JM. JURAN:
DEFINES THE QUALITY CONCEPT THROUGH THE CAPACITY OF A PRODUCT / SEVICE TO BE APPROPRIATE FOR USE.
For the first time the development of the quality concept Juran introduces the notion of QUALITY FUNCTION defined as: **THE SET OF ACTIVITIES / CHARACTERISTICS WHICH RECEIVED GOODS FOR USE.**

JM. JURAN:
THE FOUNDATION THAT IS BUILT THE QUALITY CONCEPT OF A PRODUCT IS BASED ON THE MULTIPLE QUALITY CHARACTERISTICS OF THE PRODUCT;

THESE DIVIDED ON THREE DISTINCTIVE LEVELS: (QUALITY TETRAHEDRRON (Fig.3.4.).

For the first time in the literature, **QUALITY**, as a concept, is approached at system level (supplier - producer - user - environment), Fig. 3.4.:

- **User Level** - Operational safety of the product, the environmental conditions. (≈ 5%);
- **Intermediary level** - Behaviour in time product - reliability, durability, convenience and the behaviour of the environment generated by user- (≈ 10%)**;**
- **Producer Level** - Constructive, technical, economic, genetic, ecological, aesthetic, etc. (≈85%); the manufacturer's input is complemented by the quality of the direct / indirect suppliers' activity.

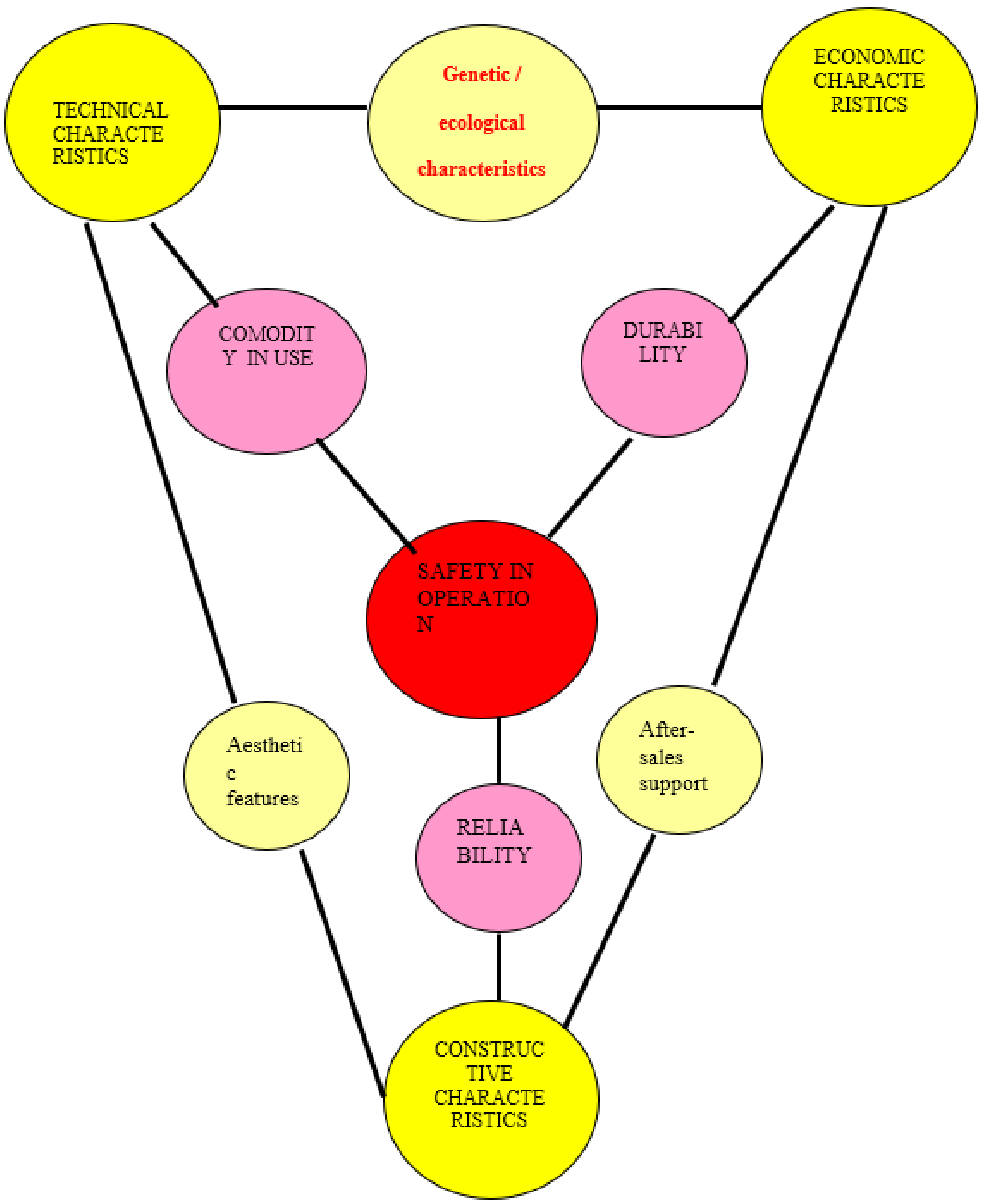

Fig. 3.4. The quality tetrahedron

REVIEW QUESTIONS

1. What is the relationship between quality and civilization, culture or relationship? 21
2. What is the relationship between quality and technological advantages? 22
3. How does quality affect the volume of production? 23
4. How is quality and control defined by experts? 24
5. What is the quality tetrahedron? 26

4 THE QUALITY CONCEPT BASIC NOTICES, DEFINITIONS, TERMINOLOGY (Part 2)

4.1 Control activities at a manufacturing structure

At the level of a manufacturing structure, where the activities are structured on compartments, specific control activities are carried out by specialized personnel with universal, specialized or specific control instruments, equipment, depending on the requirements of the manufacturing process.

Depending on the specifics of manufacturing processes, control operations may be grouped or grouped by operators, by product groups, or by the types of equipment and frequency of use.

Along with increasing work speeds and production volumes, manufacturing systems, tracking process quality issues and product quality results, it is becoming an important issue in many ways:

- Control must ensure that defects occur at any point in the manufacturing process.
- The control should allow measurements to be made at the optimum time.
- The control must allow the statistical processing of the resulting data and the elaboration of the decision to correct the defect generating process.
- The control should have an informational role, in the sense that it must be integrated into a quality assurance system, which allows to reduce / eliminate the occurrence of defects in a short time, it is recommended that the system to be operated "off line" in relationship with process operators.

There are currently **ERP** (Enterprise Resource Planning) control systems that meet the four conditions above. This is the **CASQ-it 9000** system, which contains:

- 5 programs to prevent defects (centralized process data, advanced production quality planning, **FMEA** defect analysis, control planning, process measurement planning).
- 6 programs targeting actual measurements (measurements made on specially designed stamps, measurements made at the final assembly of the product, possibly during customer assembly, interoperability measurements, inlet measurement measurements, process output measurement, system data entry into the database).
- 3 programs aimed at defect management (analysis of customer complaints and costs, analysis of process characteristics analysis, audit analysis).
- 3 programs to provide information on process quality (quality management information system, quality management monitoring, quality management documents).

Regardless of the complexity of the quality assurance system, at the level of a manufacturing structure, the control activities are identical in terms of the objective achieved, as shown in Fig.4.1., NOTES used:

E.I. - Deposits for: inputs to the process (materials, fuel, documentation, **SDVs**, new or reused equipment.

IOP - Interoperability depots for: components required for production processes.

PF - Deposits for finished products / parts / subassemblies for sale.

A - Packaging processes and protection.

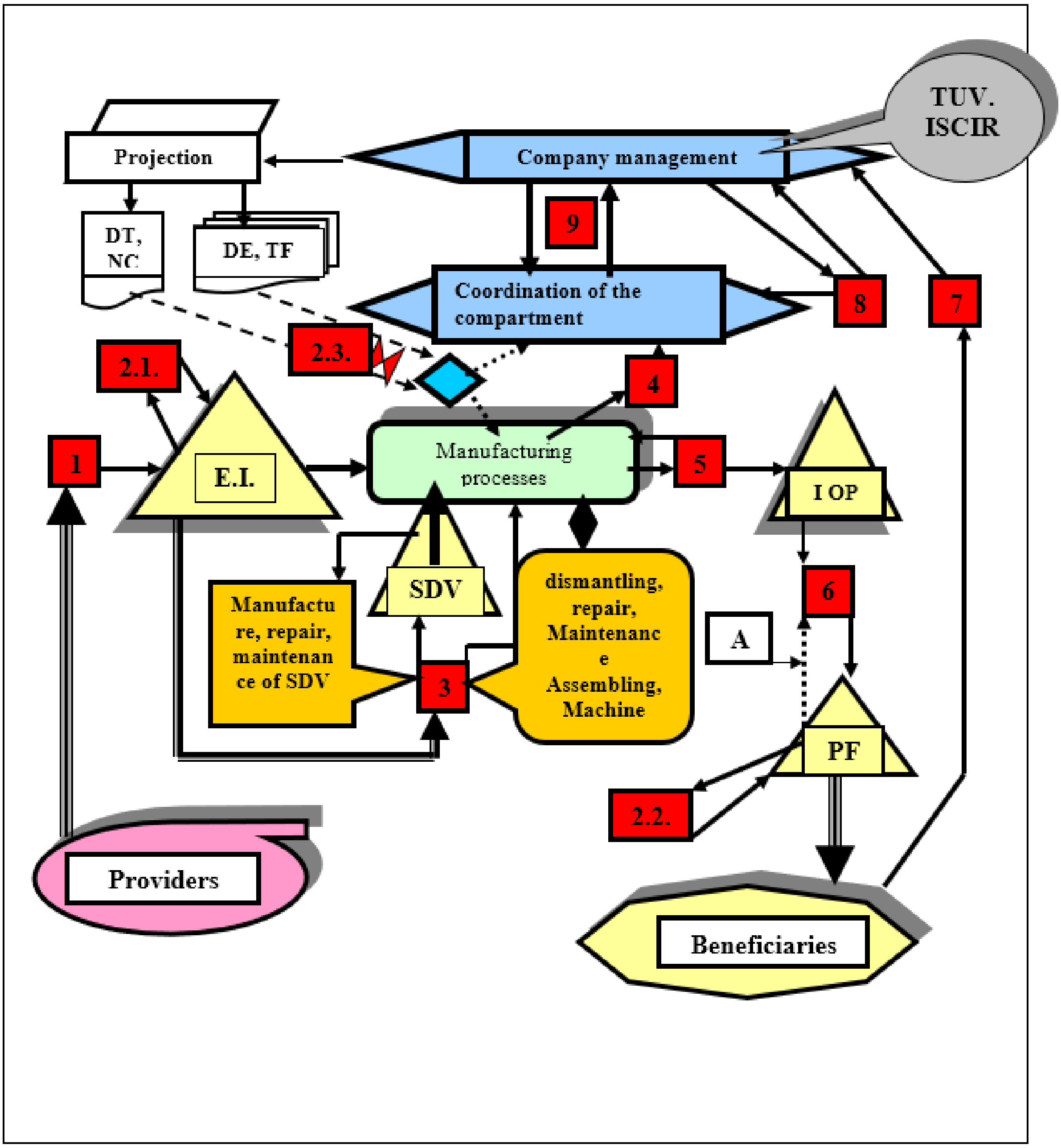

Fig. 4.1. Control activities at manufacturing structures

1. EI control

The materials are received in terms of number, quantity, volume of material, storage conditions, according to the accompanying documentation (invoice, quality certificate, material quality analysis bulletin issued by the supplying company or specialized structures for carrying out analysis) agreed by the vendor and the user.

The quality of the delivered energy, of the fuels related to the manufacture of the products is established through firm contractual terms.

2.1. Control of materials brought without quality documentation

In this case the quality assurance is done by the user, according to the contractual provisions. The entire responsibility for the introduction of a material in the manufacturing process, without any documents attesting to the quality, rests with the manufacturer.

2.2. Control of finished goods for shipment

The accompanying documentation of the finished product will contain separately information about the quality (s) of the product, its maintenance, the warranty periods, the commissioning and the service of the user, it is the responsibility of the producer with reference to commissioning, provided in the documentation; he must apply them exactly if he wishes not to lose the benefits offered by the manufacturer's warranty.

2.3. The control of the technical and technological documentation is provided in three distinct phases, mentioned on each document;

a) self-control of the designer,

b) the control of the project leader, or the head of the team, who, by signature, becomes responsible for the document drawn up,

c) compliance control with the provisions of the applicable standards, with reference to the represented product (technical standards, environmental standards, etc.).

3. Control of SDVs, equipment.

The tools, devices and verifiers are classified into three levels, depending on how they are used:

- Level 1 SDVs that are used in high-frequency current production processes; depending on their partiality durability and the frequency of the measurements, determine the time period of operation and, implicitly, the timing of the mandatory checks.
- Level 2: SDVs that are used to verify the quality and accuracy of Level 1 SDVs.
- Level 3: SDVs on top of the top management team to use for precision checks and top level 1 inventory

4. Controlling the development of manufacturing processes.

5. Interoperability control is the compliance check of the operations performed within each workplace, with the appropriate execution documentation.

6. Final product control, refers to the parameters imposed by the product designer (we mention here that the parameters in the technical documentation have minimum values in relation to the actual controlled parameters); here are also included the controls with regard to product appearance, design, colour, qualitative performance, utility level, assured safety level, minimum reliability level, maintenance program parameters.

7. Control of product behaviour to the beneficiary, the manufacturer follows the behaviour of the delivered products; is the case for complex products such as: electrical generators, technical equipment / aggregates, ships, airplanes, automobiles. The handling of operation in operation involves various methods, including: providing a warranty period for the delivered product, periodically collecting information reference to user mode of operation, periodic inspection of the product's technical condition by the manufacturer or his representative.

8. The quality control of human resources is a continuous activity at the level of a production structure, because the quality of the human resource involved in the process depends on the whole of the manufacturing process.

9. Financial control of the company is ensured by the continuous control of the budgets that condition the production activity. The technical component of this control is that the manufacturer, after negotiating with the customer, and set a firm price for the product, when manufacturing the product, initiates a reduction of manufacturing costs using specific methods that stimulate creativity.

CLASSIFICATION OF CONTROL OPERATIONS is in relation to certain criteria of appreciation:

1. IN REPORT ON THE NUMBER OF CONTROLLED PARTS:

1.1 INTEGRAL CONTINUATION - (ABOUT PRODUCTION VOLUME)

1.2. CONTROL THROUGH SURVEY

1.3. CONTROL FOR THE FIRST PRODUCT

2. IN THE RELEVANT PERSONNEL REPORT:

2.1. AUTOCONTROL

2.2. CONTROL COMPLETED WITH CONTROLLERS IN THE ENTERPRISE

2.3. CONTROLS WITH SPECIALIZED CONTROLLERS
INCLUDING SPECIALIZED DECONTROL ORGANISMS.

2.4. CONTROL PERFORMED BY THE CLIENT ON THE IMPROVEMENT OF LOT

3. IN THE REPORT ON THE PLACE OF PERFORMANCE:

3.1. CONTROL TO WORKPLACE

3.2. CONTROL IN THE CONTROL POSTED POSTS
THE LENGTH OF THE MANUFACTURING FLOW.

3.3. CONTROL IN SPECIAL SPACES FOR THE CONTROL OF THE TECHNICAL PARAMETERS OF THE PRODUCT (STANDS)

4. AFTER THE CONTENT CONTROL ACTIVITY:

4.1. ANALYZES PERFORMED IN THE LABORATORY

4.2. DIMENSIONAL CONTROL, GEOMETRIC, ASPECT, DESIGN

4.3. EXTERIOR CONTROL, PAINTING, NICHELARE

4.4. TECHNOLOGICAL PROJECTS, TESTING ON STANDS, STATIONS PILOT

4.5. CONTROL OF THE TECHNOLOGY DISCIPLINE'S RESPECT

4.6. PRODUCTION CONTROL MANUFACTURED IN OPERATION

5. IN THE REPORT WITH THE PERIOD OF PERFORMANCE:

5.1. CONTROL PRELIMINAR

5.2. INTERMEDIATE CONTROL

5.3. FINAL CONTROL

6. AFTER THE DEFECTS EVALUATION:

6.1. Control. PREVENTIVE

6.2. Control CURENT

6.3. Control VOLANT

6.4. STATISTICAL CONTROL

7. AFTER THE DEGREE OF DESTRUCTIVENESS:

7.1. Control DESTRUCTIVE

7.2. Control SEMIDISTRUCTIVE

7.3. Control NONDISTRUCTIVE

4.2 Standards for management and quality assurance of products and services

QUALITY is defined as**:** ***ASSEMBLY OF THE CHARACTERISTICS OF A ENTITIES WHICH GIVE THEIR SKILLS SATISFACE NEEDS EXPRESSED IMPLIED of users.***

Over time, there is a successive / iterative process of meeting customer needs by modifying / adapting product features / functions (Fig. 4.2.).
According to this definition:

1. Quality is expressed by a set of characteristics,
2. Quality can only be highlighted in relation to customer needs,
3. Qualified is a continuous and not discrete variable,
4. Quality not only expresses the needs but also the explicit ones. (In the nuclear field, needs are specified in detail and in the long run).

ENTITY → ACTIVITY, PROCESS, PRODUCT, ORGANIZATION,
SYSTEM, PERSON, OR A COMBINATION OF THEM;

PRODUCT → RESULT OF ACTIVITIES OR PROCESSES
(MATERIAL, OR IMMATERIAL OR A COMBINATION);

Insert 4 categories of classification of products:

- HARDWARE (COMPONENTS, SUBANSAMBLE)
- SOFTWARE (PROGRAMS, PROCEDURES, INFORMATION, DATA)
- PROCESSED (MATERIALS)
- SERVICES (BANKING, INSURANCE, TRANSPORT)

HARDWARE- COMPOSITION SIN THE STRUCTURE OF A PRODUCT, INTERCONNECTED IN ORDER TO ENSURE THE FUNCTIONS FOR WHICH IT WAS DESIGNED / PROJECTED.
SOFTWARE SR ISO 9000 - 3/1955 INTELLECTUAL CREATION COVERING PROGRAMS, PROCEDURES, RULES AND ANY DOCUMENTATION ASSOCIATED ON THE OPERATION OF A DATA PROCESSING SYSTEM.
"SOFTWARE PRODUCT"- COMPLETE SET OF PROGRAMS, PROCESSES, COMPUTED DOCUMENTATION FOR COMPUTER AND DATA FOR DELIVERY TO A USER.
PROCESSED MATERIALS - FINISHED OR INTERMEDIATE PRODUCTS, REALIZED BY TRANSFORMATION, CONTAINING SOLIDS, LIQUIDS, GASES OR COMBINATIONS THEREOF, INCLUDING PULVERULATIVE MATERIALS, LUGGAGE, FRAMES OR LAMINATED.
SERVICES - RESULTS OF THE ACTIVITIES CARRIED OUT BY THE SUPPLIER / CLIENT INTERFACE AND THE PROPRIETOR'S INTERNAL ACTIVITIES, TO SATISFY CUSTOMER REQUIREMENTS.
PROVIDER / CLIENT INTERFACE (F / C):

- PARTICIPANTS AT F / C MAY BE PRESENT, OR CAN BE REPRESENTED BY EQUIPMENT;
- ACTIVITIES AT F / C MAY BE ESSENTIAL OR SERVICE PROVIDED;
- THE PROVISION OF THE SERVICE MAY INCLUDE THE PROVISION OR USE OF SOME MATERIAL PRODUCTS;
- A SERVICE MAY BE ASSOCIATED WITH THE MANUFACTURING OR DELIVERY OF MATERIAL PRODUCTS.

RECOMMENDS THAT THE QUALITY TERM IS TO BE USED IN A GLOBAL CONTEXT TO EXPRESS A COMPARATIVE / RELATIVE CONTEXT:

RELATIVE QUALITY
QUALITY LEVEL
THE QUALITY MEASURE

QUALITY CLASS (GRADE) - *THE RANGE ALLOWED TO ENTITIES FULFILLING THE SAME FUNCTIONS, BUT ALL UNDER REQUIREMENTS RELATING TO QUALITY. (AUTO-LEADER POSITION).*

REQUIREMENT FOR QUALITY - *EXPRESSIONS OF THE CLIENTS' NEEDS (REQUEST FOR REQUIREMENTS) EXPRESSED IN QUANTITATIVE OR QUALITATIVE TERMS ON THE CHARACTERISTICS OF AN ENTITY*.

NON-CONFORMITY - *BREAKDOWN OR ABSENCE OF ONE OR MORE QUALITY CHARACTERISTICS OR QUALITY SYSTEM ELEMENTS IN ACCORDANCE WITH SPECIFIED REQUIREMENTS.*

FAULTS - Failure to comply with a requirement or a reasonable expectation of the intended use, including security.

The appearance of a defect in a product generates legal liability for the product.

PRODUCT LIABILITY - *THE GENERAL TERMS AND CONDITIONS OF WHICH SPECIFY THE OBLIGATIONS OF THE MANUFACTURER OR ANY OTHER PARTY TO LOSE FOR LOSSES DUE TO CORPORAL, MATERIAL OR OTHER NATURAL DAMAGE CAUSED BY A PRODUCT OBTAINED.*

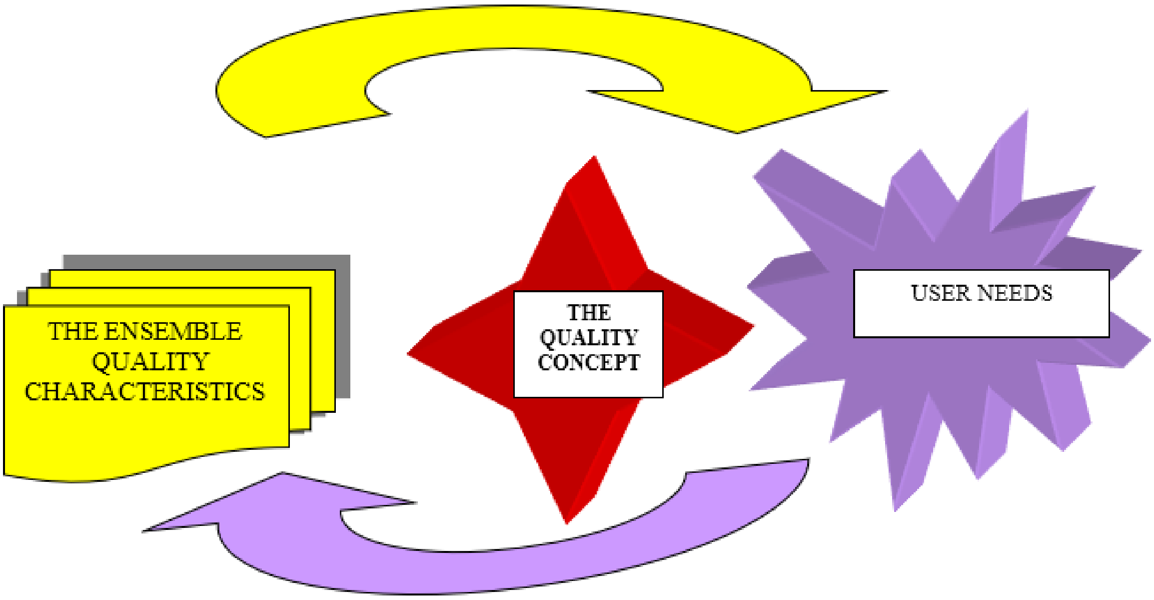

Fig. 4.2. The iterative process of meeting customer needs by modifying / adapting product features

Standards for quality management and assurance of products / services have been the elements of a national quality strategy that has as main objective the development of quality standards for products / services of a general nature that align with the same time, at EU standards, once this stage has been completed, the stage has begun to develop standards and technical norms that address specific activities such as environmental standards, standards for the automotive industry, standards for the food industry; Table 2.2. presents the synthesis of the main standards that are the basic structure for the implementation of the quality management system in our country; standards are structured into three essential areas (categories):

- Standards in the category of guides for selection and use.
- Modelling standards for external quality assurance.
- Guide standards for quality management system.

Table 4.1. Standards used in Romania in accordance with U.E.

Guide standards for selection / use	Modelling standards for external quality assurance	Guide standards for implementing the quality management system.
1.ISO 9000-1/ 1994 (SR / 1996) Standards for management / quality assurance, Part 1. Guidelines for selection and use	**1. ISO 9001/1994 (SR /1995)** Quality systems. Model for quality assurance in design / development, production, installation and servicing	**ISO 9004/ 1994**. Quality management and elements of the quality system; part 1 of the guide line
2.ISO 9000-2/ 1997 (SR 1995, (edition of 1993) Standards for Quality Management and Quality - Part 2. Guidelines for Application of ISO 9001, ISO 9002 and ISO 9003	**2.ISO 9002/1994 (SR 1995)** Quality systems, model for quality assurance in production, installation and service.	**1.ISO 9004-2/ 1991 (SR 1995)** Quality management and elements of the quality system; Part 2 Guidelines for Services
3. ISO 9003/1995 (SR 1995 edition of 1991) Standards for Management and Quality Assurance - Part 3. Guidelines for the application of ISO 90001 in the development, delivery and maintenance of software.	**3. ISO 9003/ 1994 (SR 1995)** Quality systems, model for quality assurance in inspection, and final testing.	**3.ISO 90004-3 / 1991)SR 1995)** Quality management and elements of the quality system; Part 3. Guidelines for processed materials.
4. ISO 9000-4/ 1993 (CEI 300-1) Standards for Management Quality Assurance- Part 4. Guidelines for Safety Management in Operation CEI/DIS 300-2 Safety Management in Operation Part 2. Elements and tasks of the operational safety program.		**1. ISO 9004/ 1993 (PSR 1998)** Quality management and elements of the quality system; Part 4: Guidelines for Quality Enhancement.

From the point of view of the scope, the following standards are currently used as guides specific to the following areas.

1. GUIDELINES FOR THE IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEMS (QMS):

- ISO 8402/1994 (SR / 1995); Management and quality assurance-Vocabulary;
- 1.2. ISO 10.013 / 1995 (SR / 1997); Guide to the development of quality manuals.

2. STANDARDS FOR QUALITY MANAGEMENT:

- ISO 10005/1995 Quality Management. Guide to Quality Plans;
- ISO / DIS 10006/1995 Quality Management. Guide to Quality of Project Management;
- ISO 10007/1995. Quality Management, Guide for Configuration Management;
- BS 7000/1985 Product Concept Management Guide;
- MIL - STD - 882C / 1993 System security system chips;
- MIL - STD - 1521B / 1985 Technical analysis and audits of systems, equipment and software;
- ISO / DIS 10014 The economic effects of quality;
- ISO / DIS 10015 Continuous training;
- ISO / DIS 10016 Quality Documents.

3. STANDARDS FOR QUALITY AUDIT:

- ISO 10011-1 / 1990 (SR / 1993) Guidelines for SQ Auditing. Part 1. Auditing;
- ISO 10011-2 / 1991 (SR 1993) Guidelines for SQ Audit. Part 2 - Qualification Criteria for SQ Auditors;
- ISO 10011-3 / 1991 (SR 1993) Guidelines for auditing SQ Part 3 - conducting audit programs.

4. Standards for quality assurance of metering equipment:

- ISO 10012-1 / 1992 (SR EN 30012-1 / 1995) Requirements for AQ Measuring Equipment Part 1. Metrological Confirmation of Measuring Equipment;
- ISO / DIS 10012-2 AQ measurement requirements. Part 2 - Requirements for control of the measurement process.

REVIEW QUESTIONS

1. How would you describe the control activities at a manufacturing structure? 28
2. What are the seven groups of control operations? 30
3. What are the standards for management and quality assurance of products and services? 31

5 QUALITY OF PRODUCTION AND EQUIPMENT SYSTEMS (Part 1)

5.1 Basics of product quality / control

A product, assailable to a system, can be defined as a set of components (elements) that, within certain time and space conditions, interact and function, ensuring that a result is obtained.

The quality of a system, such as the production equipment, is given by the totality of its properties or characteristics - more or less close to an extremely favourable level - that determines the system's ability to differently meet the requirements of the internal environment, the external environment or users within stages of its life cycle.

The quality of a piece of equipment (a machine or a productive machine) represents the totality of the property (s) through which a given social need is met.

The level of quality is an illustration of the degree of utility in meeting a social need. It can be defined as a function of the quality characteristics seen in correspondence with the parameters for identifying the social need.

The quality characteristics of an equipment can be quantitative (measurable, also referred to as quality indicators or parameters of the equipment), in which case it is controlled by means of technical measuring or measuring methods, or qualitative (not measurable, also called attributes) equipment "good" or "appropriate", respectively "defective" or "inadequate" depending on the result of quality control or expert's expertise - [P.02] Technical quality is given by all the potential technical characteristics existing at a given time (t), and if the technical characteristics are tracked over a time interval (0; t), the availability characteristics of the system are defined.

Commercial quality incorporates into its structure non-technical features, which conditions the sale of the equipment on the market, it sums up the aesthetic and economic characteristics.

The overall quality of a piece of equipment integrates the values of all the equipment's quality characteristics (properties). They are precisely the performance variables of the system, its processes, the relative consumption of resources to the producer and the users.

Taking into account the structure of the lifecycle of equipment, the overall quality is determined by:

a) the quality of the concept;

b) quality of compliance;

c) availability;

d) customer service (the extent to which the manufacturer and the outlet provide repair or restoration of the equipment in the event of failure).

Quality of design or quality class is the extent to which the design of the equipment, the technological process and the organization ensure the satisfaction of the users' needs and the social-economic environment.

Quality of compliance reflects the extent to which a particular product or service is consistent with the original design or not. Compliance presupposes the consistency between the prescribed quality and that is resulting from the quality control performed according to the technical documentation of the execution and the technical documents (specification, state standard, technical norms, etc.), being the determining factor of the manufacturing quality.

In general, the qualitative characteristics of the equipment are carried out at the manufacturer during the production process, and in this case the quality of production can be defined.

The quality of production includes: the quality of the equipment, the quality of the constructive, technological, organizational design, the quality of the production and the qualitative aspects related to the reshuffle, waste and complaints.

Particularly important is the quality of operation, defined by the degree of achievement of the correct use and maintenance of the equipment, prescribed in the technical documentation for its operation.

The availability of a product or service is expressed qualitatively as the ability of a product to perform its specified global function at a given time or within a given time frame.

The five principles underlying the application of total quality are:

1. Quality compliance;
2. Preventing defects through organization;
3. Intrinsic quality;
4. Measurement of quality;
5. Responsibility and optimization in quality.

<u>1. Quality compliance</u> is defined as the ability of a product or service to respond to specified and customer needs. This compliance is the action of a long line of intermediaries, customer / internal couples (C / F), who must cooperate to correct any errors – Fig. 5.1.:

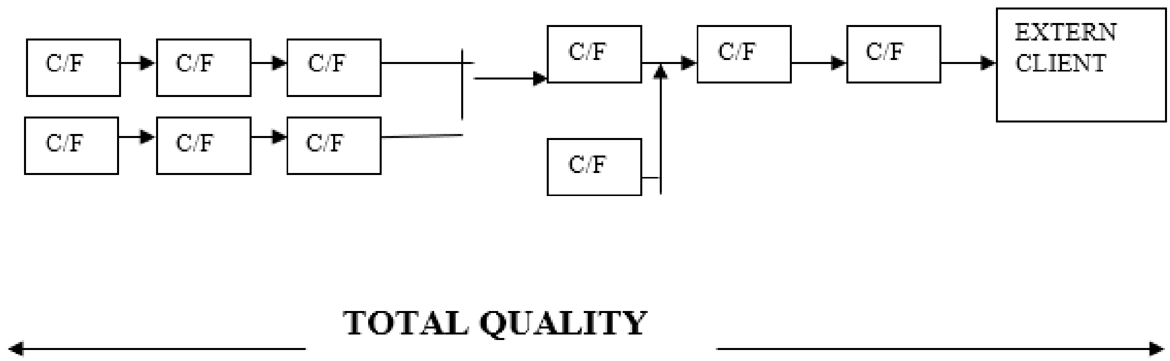

Fig. 5.1. The customer / supplier relationship within the firm

An enterprise-wide amount of client / supplier reports is made. These successive client / supplier relationships imply collaboration in the development of specifications, execution conditions and features to be achieved and controlled among production centres (workplaces, workshops, offices, sections, compartments). The partnership in these relationships requires the supplier to present the means at his / her disposal, analysing together with the client the solutions adopted for the components and the assembly. Quality compliance has the ultimate goal of working to meet the needs of the user, to which all actions are subordinated.

<u>2. The prevention of defects through organization</u> includes a set of principles, systems and organizational ways to achieve the goal of the first attempt. Principles, regardless of the company profile, should serve to increase the value of the equipment or service.

Prevention consists of taking the necessary measures to avoid unforeseen events and additional cost increases. The faster the control runs over time, the more extra production costs are, as shown in Table 3.1.

Table 5.1. COST OF DIFFERENT TYPES OF CONTROL

TYPE OF CONTROL	EXAMPLE	COSTS
PREVENTIVE CONTROL	CHECKS	1
CONTROL IN TIME OF MANUFACTURE	VOLTAGE CONTROL	10 Times
FINAL CONTROL	CONTROL BEFORE EXPEDITION	100 Times
BENEFICIARY CONTROL	MAINTENANCE AND SERVICE	1000 Times

Prevention and control are two opposing notions: control, by definition, acknowledges the existence of defects to be found and eliminated; prevention essentially aims at eliminating defects. For prevention, there are several ways to remember:

- analysis of the way of defects, their effects and their size - practically a technique of analysis and prevention of potential defects;
- Review of projects (rechecking), which consists of any type of important industrial project in the reanalysis and discussion of the project by an independent team from the one that conceived it.
- Stopping chaining consists of designing a mechanical or electrical element in the project, which in the event of an accident is blocking the propagation of the fault to other elements of the system.

3. Intrinsic quality is based on the "zero defects" concept, which means compliance of the equipment with customer specifications.

The zero-defective philosophy is virtually the dynamics of perfection, but if the level of quality of similar equipment of competition increases, we are forced to design new equipment with superior quality characteristics. This is achieved through the qualitative improvement of all the activities carried out within the enterprise on the basis of the implementation of an action plan.

4. Measurement of quality: "What cannot be measured does not exist, and what is not measured is not in progress" is the expression of Henri Faure - director of the research department of Renault Uzine - and defines the concept of quality measurement.

Everything is measurable and can be evaluated by man, not representing precision of counting or control, but the desire to count and progress.

Measurement stimulates action, and displaying measurements can result in falls. All measurements are being expressed in figures. The first consequence of error measurement and defect identification is their diminution.

5. Responsibility and optimization in quality are two terms that complement each other.

Responsibility, which is not synonymous with culpability, implies:

- a policy of trust in the subordinates (even if: "the boss is responsible 80 % of the collaborators' errors" - [J.01.];
- participatory management;
- an information and communication policy;
- a human resources training and development policy;
- the ability to act in your own field.

Quality optimization is a concept that will be discussed in the following chapters. Ensuring an upward quality level for equipment and services within an enterprise is done as a "quality spiral", according to which business activities resume cyclically based on information gathered in earlier periods.

5.2 Analysis of the value applicable in the field of quality

The value analysis was established after 1950 as a complex, creative, systemic design method, particularly effective in reducing production costs and increasing the quality of production. It can be applied successfully in the field of quality, because of classical design methods consider equipment as an assembly that works to transform objects subjected to processing into desired equipment, value analysis considers productive equipment as a materialized ensemble of F functions to be accomplished in the most efficient way, with the simplest and most ingenious structures that would provide the lowest possible C_{fi} costs of those functions in the global function F_g.

Generally, a function expresses the transformation of certain X inputs of an S system into certain Y outputs, i_e what it does (can do), or performs (can accomplish) the system.

The global function of a product (F_{gp}) is defined as a synthesis of the specific end-user functions required by the user. The global function of a type of equipment is confused with the use value of the equipment, defined as the totality of the properties that gives the ability to meet certain human needs. It consists of all the F realizable / realized elementary functions of the type of equipment and corresponds to the highest number of quality characteristics (y_{fc}).

Global Function (F_{gp}) includes:

- Performance features that directly determine the value of the equipment, which can be:
  - Final functions (structural and transformation characteristics), for which the equipment was actually designed and demanded by consumers.
  - Collateral functions (ecological, ergonomic, aesthetic features) required by the natural environment and the human environment for which the equipment is not specially designed.
- Intermediate functions (material features, reliability, maintainability) that indirectly define the value of the equipment and are required by the system itself to perform its performance functions throughout its service life.

One of the essential components of an enterprise's overall function is the quality issue, through which a piece of equipment or service can be "fit for use". The phrase "appropriate for use" is the essence of the word quality. Their equipment and their y_c quality features must meet, to the fullest extent possible, the ever-changing demands of users.

- Ideal use value of the type of equipment or group of equipment, corresponding to the global function (F_{gp}), achievable with extremely favourable quality characteristics (y_{cf} ext).
- The actual use value (asset) of the assortment and equipment, corresponding to the global function (FGI), achieved with y_{cf} ext (y_{cf} ext) quality characteristics (y_{ci}) more or less distant.

For both new equipment and services and for old equipment and services, it is necessary to determine the optimal correlation to function costs (C_{fi}), expressed as a percentage of the full cost (C_{ci}) of the equipment or service and the weight of the functions (p_{fi}) that meet them.

This can be done by applying the methods of value analysis and engineering, and aims to obtain an optimum of the cost of the equipment and the functions it performs.

The correlation of the functions of equipment with the quality categories is presented in Table 3.2. Analysing the data in the table it can be observed that the objective functions of the equipment correspond to measurable quality characteristics with well-defined units in the technical quality, respectively the subjective functions aesthetic quality characteristics. Meaning: S - system in general; S.U. - user system; M. N. - the natural environment; M.U. - the human environment; M.E. - the economic environment [P.02].

Analysing the functions of an equipment (engineering system), it is noted that:

- the functions of an equipment must not be confused with the field of use or the human need for which the equipment was created;
- the functions must not be confused with their structure or with the process variables made by the system;
- a performance function is distinct from another function, being independent of it;
- elementary functions are those functions that can no longer be broken down into several functions;
- an intermediate function satisfies two conditions simultaneously: determines the existence of performance functions and expresses relations between the system and its environment;
- for the objective functions, for which the corresponding variables are measured with specific units of measurement, one can express the level of performance measured in the existing system or the values established by the socio-economic needs for a new system.

Table 5.2. QUALITY CORRELATION - FUNCTIONS FOR ENGINEERING SYSTEMS

<table>
<tr><th colspan="2" rowspan="3">CATEGORIES OF QUALITY</th><th colspan="3">GRASSES OF QUALITY CHARACTERISTICS OF THE "S"</th><th colspan="3" rowspan="3">CATEGORIES OF FUNCTIONS</th></tr>
<tr><th colspan="2">TYPE OF CHARACTERISTICS</th><th rowspan="2">REQUEST FOR</th></tr>
<tr><th>POTENTIAL</th><th>AVAILABILITY</th></tr>
<tr><td rowspan="6">QUALITY OF THE ENGINEERING SYSTEM "S"</td><td rowspan="4">TECHNICAL QUALITY</td><td>MATERIAL AND CONNECTION CHARACTERISTICS</td><td>RELIABILITY + MAINTAINABILITY</td><td>S.</td><td colspan="2">FUNCTIONS INTERMEDIATE</td><td rowspan="5">THE GLOBAL FUNCTION OF "S"</td></tr>
<tr><td colspan="2">DEFINITIVE STRUCTURAL AND TRANSFORMATION CHARACTERISTICS OF "S"</td><td>S.U.</td><td>FUNCTIONS FINAL</td><td rowspan="4">PERFORMANCE FUNCTIONS</td></tr>
<tr><td colspan="2">ECOLOGICAL CHARACTERISTICS OF "S"</td><td>M.N.</td><td rowspan="3">FUNCTIONS COLLATERAL</td></tr>
<tr><td colspan="2">ERGONOMIC CHARACTERISTICS OF "S"</td><td>M.U.</td></tr>
<tr><td rowspan="2">COMMERCIAL QUALITY</td><td colspan="2">AESTHETIC CHARACTERISTICS OF "S"</td><td>M.U.</td></tr>
<tr><td colspan="2">ECONOMIC CHARACTERISTICS OF "S"</td><td>M.E.</td><td colspan="3">COSTS AND PRICES DETERMINED AT THE PROVIDER AND USE BY REALIZING THE GLOBAL (Fg) FUNCTION OF "S"</td></tr>
</table>

A particularly important stage in achieving the quality correlation - the cost of functions is that of determining the weight of functions (p_f) in the global function (F_g) of the equipment. It requires comparison of elementary values of different nature, the correspondence of which is measured by different units of measurement. As a practical means of determination, a square matrix is used in which each function is compared with the others by assigning different weights (0 and 1) [P.02].

If a function is more important, it will be given a value of 1 and the function with which the value 0 was compared.

When comparing the function to itself, it will be given a value of 1. If it is estimated that a function has the same weight (as important) as the one with which it is compared to, the function value 1 is assigned, which is chronologically performed first.

The weights of the functions are obtained by summing up the columns, verifying consistency in thought by the continuity of the weighting range. An example is presented in Table 3.3. For an electric motor that performs six important functions marked with A, B, C, D, E, F:

A. Reliability assurance, characterized by specific indicators, average running time, failure rate, etc.;
B. Developing torque forces on the rotary motor shaft or forces at the linear motor's stator with imposed speeds or speed ranges;
C. Ensure environmental protection and aesthetic features;
D. Achieving efficient transformation of electricity, characterized by efficiency and power factor;
E. Ensuring maintainability, characterized by its specific indicators;
F. Ensuring user protection, measurable by insulation resistance and external aperture dimensions;

For the correct determination of the weight of the functions, the point of view of the largest number of beneficiaries of the equipment is required, on the basis of which a subsequent statistical processing of the results is made.

Table 5.3. WEIGHT FUNCTIONS IN GLOBAL FUNCTION (Fg)

	A	**B**	**C**	**D**	**E**	**F**	**TOTAL**
A	1	1	0	1	0	1	4
B	0	1	0	0	0	0	1
C	1	1	1	1	1	1	6
D	0	1	0	1	0	1	3
E	1	1	0	1	1	1	5
F	0	1	0	0	0	1	2
Points	**3**	**6**	**1**	**4**	**2**	**5**	**21**
p_{fi}	**14,3%**	**28,6%**	**4,8%**	**19%**	**9,5%**	**23,8%**	**100%**

After determining function weights, we determine the cost of each function (ie. the cost of the structures that perform the functions of the equipment S) using a table with two inputs, in which all the functions of the equipment S are marked horizontally and vertically all components (parts, subassemblies, etc.) and manufacturing (especially processing and assembling) operations involved in the performance of those functions. For the electric motor "New torque increased 1 NCM 22/3000" the following values were obtained: total cost of engine 853,224 lei, function cost A = 113,479 lei, function cost B = 247,434, function cost C = 32,423 lei, cost of function D = 176,617 lei, the cost of the function E = 79,350 lei, the function cost F = 203,921 lei.

The quality level of the equipment obtained with the requirements of the beneficiaries and similar equipment made world-wide is further compared. If the equipment meets the requirements of the beneficiaries with a consolidated sales market, the critical function and cost analysis is proceeding from the optimal correlation between the function costs (C_{fi}), the weight of functions (p_{fi}) and quality, against which it is identified unfavourable deviations, as exemplified in Fig. 5.2.

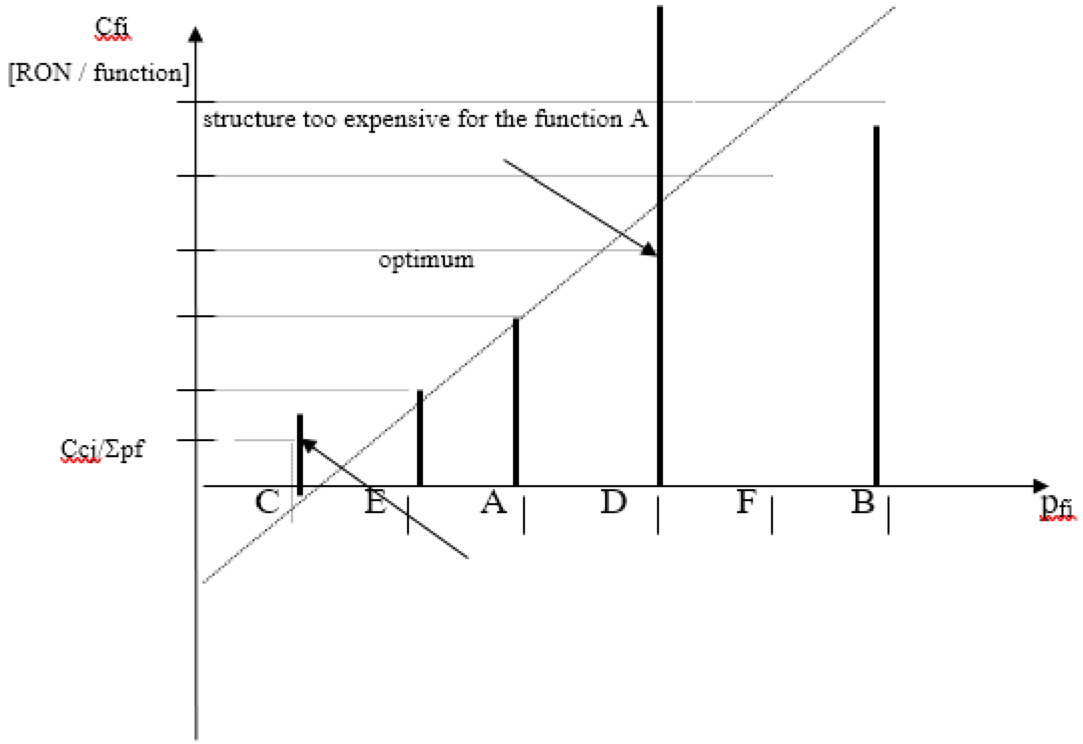

Fig. 5.2. Optimal / real weights of A - F functions in the global function of the equipment

The critical analysis goes through the following phases - [P.02]:

A) Determination of unnecessary functions in absolute terms or only for a part of S-users, based on the processing of information on the socio-economic necessity to be met. This information is obtained from the design of the equipment, which is confronted with the real needs, corrected and completed, finally achieving the optimum level of performance variable values.

On the basis of marketing studies, statistical surveys, equipment tracking, forecasts, the statistical distribution of the beneficiaries' requirements is correlated with the provisions of the standards in force; the maximum and minimum values of the variables that characterize the functions, taking into account the needs of the beneficiaries and the technological possibilities in a five-year perspective; the probable volume of demand over the next five years for equipment and the family of equipment.

If unnecessary functions are identified, they are retained and removed.

B) The criticism of the technical level and the quality level of the equipment is made in comparison with the social-economic needs identified at the previous point or with standard equipment from the same world assortment.

C) Determine the cost / weight correlation of functions by comparing the function weight in the global function (F_g) of the equipment S with the function cost (C_{fi}) in the full cost (C_{ci}) of the system. The optimal correlation is given by the identity of the weight of functions with the function cost, which can be represented by a diagram – Fig. 5.2. - with equipped subdivisions, when the bisector represents the ideal weight curve.

Based on the evaluation in the example in Table 3.3, the global function (F_g) of the equipment is quantified at 21 points ($\sum_{pf} = 21$). The weight of each element is given by the ratio:

$p_f / \sum_{pf}$ and the cost of a function in the cost of the equipment is C_{fi} / C_{ci}. Equalizing the two ratios yields the ideal cost of a function:

$$C_{fi.ideal} = p_f \times \frac{C_{ci}}{\sum p_f} \quad \text{(RON / function)} \tag{5.1}$$

Applying this formula we obtain the following values: $C_{fi.ideal\ A}$ = 121,889 lei; $C_{fi.ideal\ B}$ = 243,778 lei; $C_{fi.ideal\ C}$ = 40,630 lei; $C_{fi.ideal\ D}$ = 162,519 lei; $C_{fi.ideal\ E}$ = 81,259 lei; $C_{fi.ideal\ F}$ = 203,149 lei.

Functions that cost exceeds the optimal weight D (176,617 lei compared to 162,519 lei), F (203,921 lei versus 203,149 lei), B (247,434 lei versus 243,778 lei), the equipment in Fig. 5.2, are made with too expensive structures must be redesigned. The same is true if the qualitative level does not match (higher or lower) with the requirements of the beneficiaries, or stable outlets are not conquered.

Based on the results of the critical analysis, a series of proposals are being developed to improve the processes and structures of S equipment and its production processes, with the object of redesigning the equipment:

- solutions to eliminate unnecessary functions in absolute terms or only for some users;
- proposals to eliminate, simplify, modify, combine, etc., relating to the processes and structures of S equipment or to its production at lower costs, without lowering the technical and qualitative level.

Regardless of the complexity of the equipment, based on the design theme, several solutions are developed for its specific processes and structures, from which the optimal variant is selected, which is projected then at a detailed level in the basic documentation and the execution of the system.

In order to achieve the optimal correlation functions - cost - quality, we can combine the optimization methods with the creativity development methods in the engineering and value analysis, thus ensuring all the conditions for the optimal design of highly competitive and quality equipment.

The most used methods of developing creativity in value analysis are: associative methods, morphological method, tree of possibilities, method "6, 3, 5", etc.

REVIEW QUESTIONS

1. How would you interpret product quality and control? 36
2. What is quality compliance? 37
3. What are the costs of different control types? 38
4. What method is used to analyse the value applicable in the field of quality? 39

6 QUALITY OF PRODUCTION AND EQUIPMENT SYSTEMS (Part 2)

6.1 Product quality level

6.1.1 Quality quantification indicators

Quality planning, design, analysis and optimization require the design and use of an aggregated system of quality indicators, including a comprehensive complex quality level indicator and an objective estimation of the level of equipment or production quality.

Quantification of the N_i level of the quality of I assortment is done by aggregation, comparing the quality analytical indicators (y_{ci}) of the studied system with the analytical indicators (y_{co}) of a reference assortment. On the basis of the aggregation principle we can quantify the partial levels of N_{hi} quality (h = 1, 2, ..., 6), respectively the structural-functional quality (h = 1), the ecological quality (h = 2) (H = 5), the economic quality (h = 6), the technical quality (h = 1 + 2 + 3), the economic and social quality (h = commercial quality, h = 2 + 4 + 6) – [Popa H., Dumitrescu C., Sabău C., et al. – 1993].

The absolute level of N can be determined by calculation - [C.05], [B.01], [P.02] - using different methods, of which the fidelity of reflection is preferred, the arithmetic mean (index "a", recommended for y_{ci} / y_{co} or y_{co} / y_{ci} values that do not differ greatly) or the geometric mean (index "g", recommended at much different values of the characteristic reports):

$$\mathbf{N_a = K} \times \left(\sum \mathbf{g_c} \times \frac{\mathbf{y_{ci}}}{\mathbf{y_{co}}} + \sum \frac{\mathbf{y_{co}}}{\mathbf{y_{ci}}} \right) \quad \text{(points)} \tag{6.1}$$

$$\mathbf{N_g = K} \times \prod \left(\mathbf{y_{ci} / y_{co}} \right)^{\mathbf{gc}} \times \prod \left(\mathbf{y_{co} / y_{ci}} \right)^{\mathbf{gc}} \quad \text{(points)} \tag{6.2}$$

in which:

K - constant that defines the N level of the quality of the reference assortment (usually K = 1000 is adopted, for convenient gradients from the world level);

c = 1, 2, ..., v - the quality characteristics taken into account for the Ni quality of the total quality (v = z), Nti of the technical quality (v = t; t <z) k; k <t), etc.

c = 1, 2, ..., m - indices for analytical quality indicators whose value increases with the increase in the absolute quality level;

c = m + 1, ..., v - indices for analytical quality indicators whose value decreases with the increase in the absolute quality level;

$\mathbf{g_c}$ - the influence of indicator c on the absolute level of quality determined by experts by rigorous methods, including by comparing, obviously $\prod g_c = 1$, $g_c > 0$;

$\mathbf{y_{ci}}$ - e for the quality indicator c proposed / achieved in the assortment and studied;

$\mathbf{y_{co}}$ - the value for the quality indicator c made for the o range.

The degree of confidence in the knowledge of quality indicators is required to exceed a limit - [P.01]:

$$\mathbf{d_i} = \sum \frac{\mathbf{n_{coi}}}{\mathbf{n_{pi}}} * \mathbf{g_c} > \mathbf{0{,}6} \tag{6.3}$$

in which:

$\mathbf{n_{coi}}$ - number of indicators with known values in both compared assortments;

$\mathbf{n_{pi}}$ - number of indicators foreseen for the assortment and studied.

Total equipment quality can be estimated with several types of integral indicators:

- the overall average quality level indicator;
- the overall indicator established in relation to the standard size of the characteristics;
- the degree of utility of the equipment;
- the composite indicator of economic efficiency.

Absolute quality level (No) can be:

- anticipated at the level of design and technical design;
- nominal at the level of the basic documentation by technical norm, specification, provisions conforming to standardized norms;
- real determined by processing the observed values of several specimens in the assortment i to both the producer and the user.

The relative quality level (N_r) is calculated according to the absolute level (No) of the reference assortment (having average global quality in the market or market segment considered), respectively the absolute level of the standard assortment (Not having the highest world quality level in the market or market segment considered):

$$\mathbf{N_{roi} = \frac{N_i}{N_o} \quad ; \quad N_{rei} = \frac{N_i}{N_e}} \tag{6.4}$$

The evaluation of the total or partial quality level of the assortment imposes a very good documentation and a constant updating of the database necessary to determine the level of the equipment quality, and it can have the following results:

- equipment below the world level,
- global average equipment,
- high global equipment,
- world-class high-end equipment,
- equipment above the world peak.

The level of industrial production quality can be estimated by the following categories of indicators: analytical indicators, synthetic indicators and complex indicators.

1. Analytical indicators define essential aspects of quality: technical, aesthetic, economic, ergonomic, social, exploitation and use qualities. Some examples: the indicators of complaints (number of complaints in the time unit, the value of the equipment claimed, the share of equipment claimed in the total equipment delivered, the dynamics of the number of complaints), the indicators of the scrap (the value and dynamics of the scrap, their weight in the total cost of quality) the renewal of production (the number of new equipment and upgrades introduced in the manufacturing, the share of the value of new equipment production in total turnover, etc.).

2. Synthetic indicators correspond to the quality characteristics of the equipment. Examples: average utility grade of production, evolution of production quality, indicators on the number and causes of defects.

3. Complex indicators express the correspondence between the actual characteristics of the equipment and the parameters for identifying the social need for which it was created.

6.1.2 Optimizing the quality level

3.3.2.1. Principles in optimizing quality level

To **optimize the quality level**, you can use several methods based on different criteria:

a) optimization of total quality, partial quality, technical quality and its components;

b) optimization by economic criteria: benefit, economic efficiency, quality of the producer and the user.

Any industrial equipment can be made in several variants in terms of quality level, satisfying differently the requirements imposed by producers, users and the national economy - Fig. 6.1.

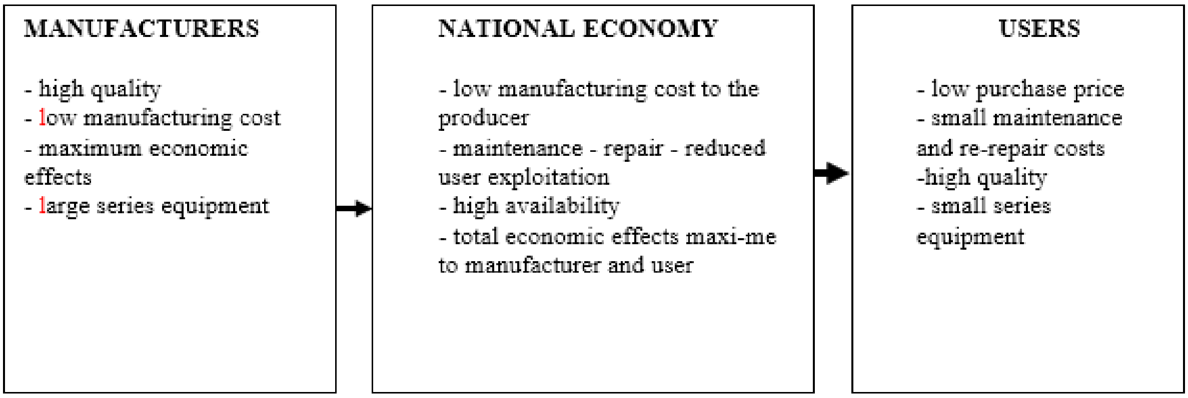

Fig. 6.1. Equipment quality level requirements

The partners who create, respectively use and confirm the quality of the equipment have contradictory tendencies imposed by the interests of the companies they represent. The quality of the equipment must reach an **optimum level** determined by current and future perspective.

In terms of quality optimization, the most commonly used criteria are:

- maximizing net income or some form of income (benefit, financial results);
- maximizing net production;
- minimizing total consumption of resources by introducing total productive maintenance;
- maximizing economic efficiency;
- minimizing the cost of quality.

These conditions for optimizing the cost of equipment quality to the manufacturer and to the user can be mathematically expressed as follows:

$$\mathbf{N_{i\,opt}\,(C_{Npi}) = N_{i\,opt}\,(C_{Nui})} \tag{6.5}$$

$$\mathbf{C_{Npi} = C_{pai} + C_{ci} + C_{pci}} \qquad \textbf{minimal} \quad \text{(RON/PIECE)} \tag{6.6}$$

$$\mathbf{C_{Nui} = P_{li} + C_{memi}} \longrightarrow \textbf{minimal} \quad \text{(RON/PIECE)} \tag{6.7}$$

in which:

N_i eight (C_{Npi}) = the optimum level of equipment quality costs at the manufacturer
E_{ight} (C_{Nui}) = the optimal level of user equipment costs
C_{Npi} = the cost of equipment to the manufacturer
P_{ay} = cost of defect prevention and quality assurance
C_{ci} = cost of quality control
C_{pci} = cost of loss (non-quality) due to quality
C_{nui} = Cost of user equipment quality
P_{li} = the delivery price of the equipment
C_{memi} = cost of fitting, operation, maintenance of the equipment

It is noted that if the cost of quality equipment from the manufacturer consists of: the cost of defect prevention and quality assurance, cost control quality, cost losses (of poor quality) by virtue, user determined are the two components of the cost: the price of delivery equipment, the cost of installation , exploitation, maintenance of the equipment. Both categories of cost are the basis for optimization, each having a complex structure that is further explained:

A. The cost of manufacturing the equipment at the manufacturer includes:

a. Cost of defect prevention and quality assurance (Cpai)

- expenditure on constructive and technological redesign of new equipment with superior features;
- expenditure on the purchase of equipment, stands and apparatus for measuring and checking quality;
- expenditures for improving the professional training of the execution and control personnel;
- expenses (a share of about 30 % of them) for the design and execution of SSDs;
- expenditure on handling equipment;
- expenditure on mechanization and automation of manual operations in the production and control process;
- expenditure on packaging for the protection of finished equipment, transport and storage (a share of about 85% of them);
- expenses for storage of finished equipment (a share of about 30 % of them).

b. Quality Control Cost (C_{ci})

- wages and salaries of the staff of the CTC;
- materials and energy consumed for CTC activity;
- expenditure on periodic checking of measuring and control apparatus,
- expenditure on the periodic inspection of finite equipment under the conditions required by the beneficiaries, restoration of type samples.

c. Cost of loss (non-quality) due to quality (C_{pci})

- the amount of scrap;
- expenditures with reshuffled equipment;
- expenditure on equipment replaced within warranty and service terms during this period;
- the amount of delays in the payment of invoices;
- bonuses and other expenses for extinguishing complaints;
- repairs to faulty equipment by the beneficiaries;

B. The cost of equipment to users is reflected by two elements**:**

- Delivery price of the equipment (P_{li})
- The cost of installing, operating, maintaining the equipment (C_{memi}) including production losses due to non-operation of the equipment.

The optimum of the level obtained by minimizing the cost can be achieved in two ways: statistically and analytically, as shown in Fig. 6.2.:

It should be noted that the identification of these cost components is difficult to determine. The solutions obtained (the areas of N_{iopt}) are essential information for the organization's activity.

Quality influences the economic aspects of business activity in two fundamental ways:

1. By achieving superior quality, the company can ensure greater market participation, stronger prices, a higher percentage of offers with satisfactory results and additional income**-side benefits**. This effect gives **value** to quality.

2. Obtaining quality equipment, its control, damages to be paid for damage have an **effect on the cost**.

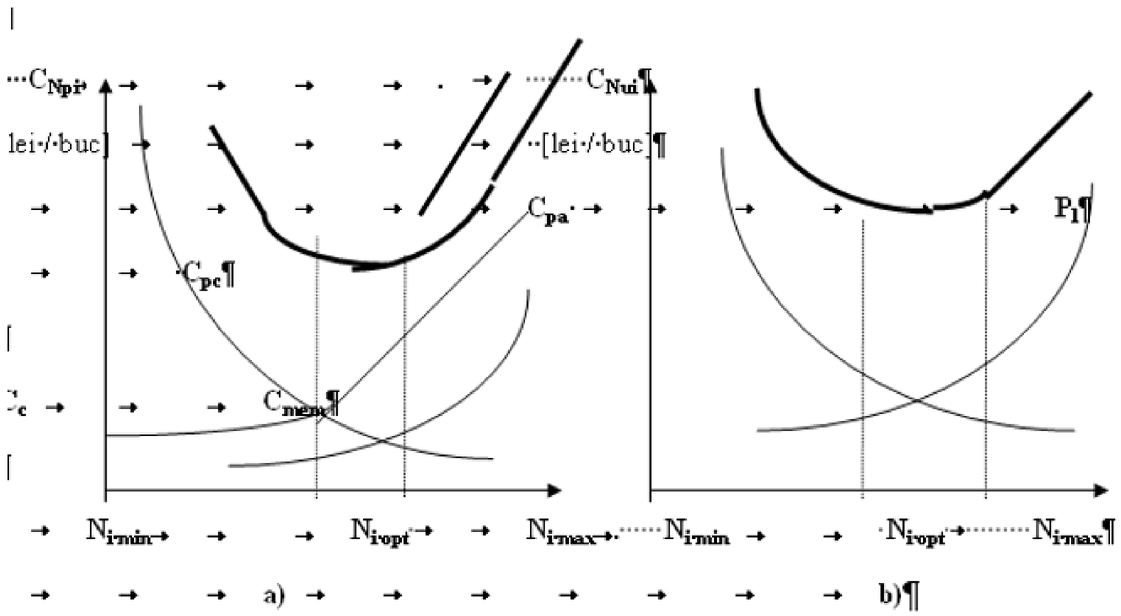

Fig. 6.2. Variation of equipment quality costs to manufacturer (a) and user (b)

3.3.2.2. Balance between quality cost and quality value

Effect on income or value
Revenues from the sale of products, BEFORE the implementation of the Quality Management System (QMS):

$$\mathbf{V = Q(P-C)} \tag{6.8}$$

Revenue from the sale of products, AFTER QMS implementation:

$$\mathbf{V^* = Q^*(P-C)} \tag{6.9}$$

A COMPARATIVE ANALYSIS OF THE TWO SITUATIONS EVIDENCES:

If $Q^* > Q$ it follows that end $V^* > V$, $\Delta V >= 0$

So, the QMS implementation has resulted in an increase in production volume**, so the quality of the production process has increased by increasing the value of production, which has made it possible to quantify the quality.**

Effect on the cost of manufacturing
Costs can be reduced by the following measures:

- Technical / organizational measures (specialization of jobs, use of more intense cutting regimes, use of better thermal treatments);
- By applying an efficient management (eliminating parallelism in the planning / management of manufacturing processes, elimination / diminution of auxiliary times, informing operators about the characteristics of the operations they will perform, the use of intensive work regimes, the decomposition of complex operations in operations simple, application of the "just in time" work system for large series production and mass);
- By using cheaper materials (if possible and not affecting the quality of the product);
- By redesigning the product to diversify its functions, keeping unchanged / reasonable limits the manufacturing costs (this reduces costs per function).

As a result, the income will increase according to the relationship:

$V = Q (P-C)$ prior to the implementation of the measures provided by **QMS** and

$V^* = .Q (P-C^*)$ after applying the measures provided by **QMS**.

If $C^* < C$, provided that P, Q are constant, it follows that **$V^* > V$**, and $\Delta V \geq 0$

Notes used:

V / V * = Production value produced before / after QMS implementation;

Q / .Q * = Production volume produced before / after QMS implementation;

C / C * = Cost of product manufacture before / after QMS implementation;

The time-based behaviour of the manufacturing structure makes it necessary to have a continuous balance between the characteristics that determine the value of the manufacturing process. These characteristics are divided into two relevant groups:

Important / relevant features that make the company's strategy relevant to the product; occupies 15-20% of the total process characteristics, is the field of analysis of senior managers.

Examples: (change of sales volumes according to customers' ability to pay, introduction of serial products / mass of new products according to customer requirements, modification of the assortment program according to a new strategy of the management team, aiming at overcoming competition, improving continuous quality.

Non-relevant, non-significant features, many in number (80-85% of the total product / process characteristics); may be modified by hierarchical leadership - section heads, workshops heads, team leaders).

Examples: supplier change, client complaints analysis, reduction of manufacturing costs, modification of working regimes, compliance with execution deadlines, structuring of the process on execution phases.

The more the project encompasses more quality features in its structure, the higher its quality, but also the costs associated with this project are increasing.

For manufacturers, it is imperative, as a constant necessity, to develop solutions to reduce costs:

in design - value analysis,

in production - production planning,

- operative programming of production;
- specific control programs - bad defect, six sigma analysis;

in sales - promotional activities, distribution of disks at the sale;

- filling potential customers, accessing new dice.

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The decision on the optimal level of quality of a product in relation to the costs of its manufacture covers the following two distinct aspects:

- *While higher quality of a project costs more, a quality of compliance (in line with the requirements / market payment capacity) costs less.*
- *All departments within the organization will participate in determining the quality of a project or product; but the decision on the quality level adopted for the product / process lies with top management; it will have to be respected by all staff; more, further care will be taken to maintaining / improving quality value over time. However, this activity has a different character depending on the design quality of the product as follows:*
- *If the product is in the early stages of development (zone A), ensuring an increase in quality value (AAV) requires a certain increase in quality related costs (AAC). Specific to this area is that, with relatively low costs, relatively high-quality values can be obtained, as shown in fig. 6.3.*
- *If the product is in advanced development phases (zone B), ensuring an increase in quality value (ΔBV) requires a significant increase in product quality (ACB) costs.*
- *The cost increase in Phase B is far more pronounced than the costs associated with Phase A; as a result the manufacturer will opt for:*
- Intensifying activities to increase quality value by specific methods such as value analysis, redesigning product functions according to new market requirements, or
- Selling the product defragmentation license to another manufacturer, and directing the activities to another new product.

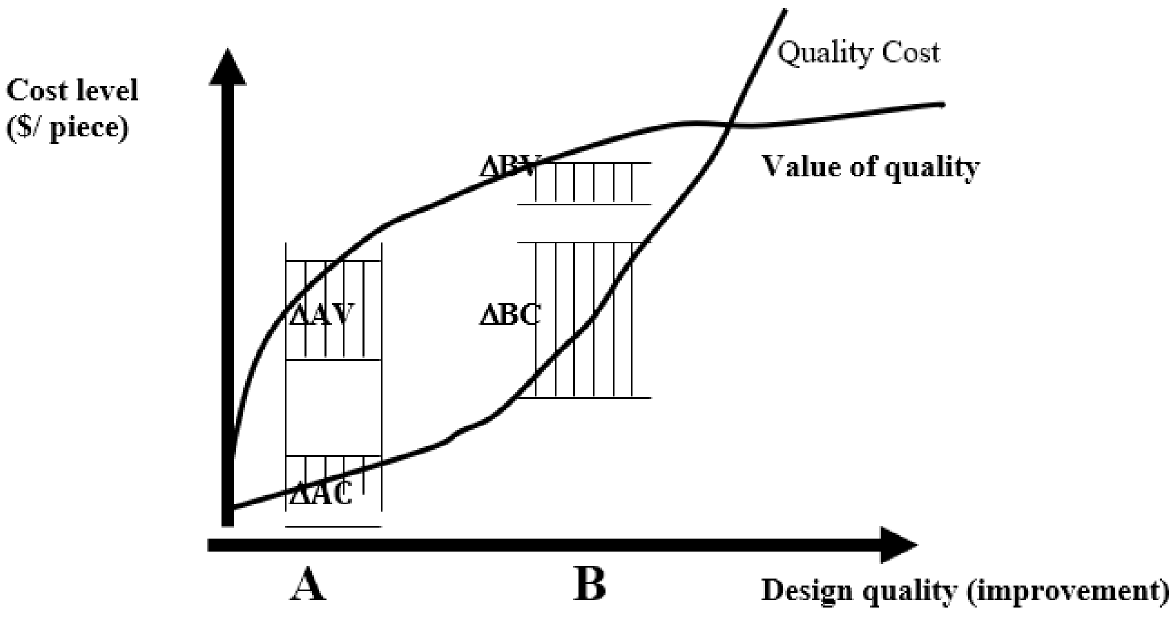

Fig. 6.3. Relationship Cost Level - Design Quality of a Product

The problem of finding a balance between the cost of quality and the value of quality is particularly important. It does not refer to quality in general, but to every characteristic of it.
J.M. Juran identified four cost categories: prevention costs, evaluation costs, costs of internal defects, costs of external defects, among which it is necessary to establish a balance that is reflected in the value of equipment quality:

1. Prevention costs related to:

- quality planning and planning of process control;
- quality control of the technological process: part of the compensation and the costs incurred by the implementation of the quality control plans and procedures;
- designing and developing equipment for quality measurement and control;
- quality planning by compartments other than quality control;
- the training program in the field of quality;
- other expenditure related to preventive actions.

2. Evaluation costs that occur at:

- tests and inspection on receipt of purchased equipment;
- laboratory acceptance tests;
- the quality records;
- verification and control work;
- technical endowment for inspection and control activities;
- granting approvals;
- maintenance and calibration of test and inspection equipment;
- analysis of test and inspection data;
- tests carried out under normal operating conditions;
- valuation of stocks and spare parts.

3. Costs of internal defects illustrated by:

- scrap;
- repairs;
- breakdown;
- inspection and secondary tests;
- remittances and defaults from the supplier's fault;
- material analysis activity;
- reduction of the quality class.

4. Costs of external defects occurring in:

- complaints;
- services for equipment or consumer;
- retrieving the returned material;
- repairs of returned material;
- warranty replacements;
- errors in engineering activity;
- faults in manufacturing or installation work on customers.

Concluding, we can say that a set of quality cost categories should also include that part of the work done by marketing or design-design departments, which basically confers the equipment to being 'fit for use.

6.1.3 The importance of measurement fidelity in quality assessment

The fidelity of measurement is of particular importance in control and quality assurance. Starting from the prevention concept within the quality function, the scope of the measurement objectives has been broadened, as illustrated in Fig. 6.4.

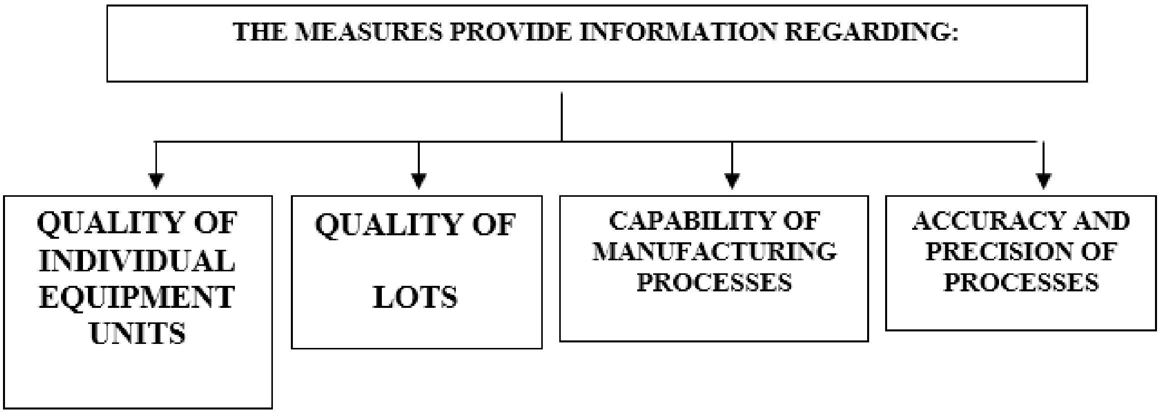

Fig. 6.4. Use of measurements to obtain data, statistical calculation

It is noted that the measurement provides information or decisions not only about individual equipment units, but also about batches, technological processes and measuring instruments themselves. For this reason, the choice of measurement systems should be based on the total cost and the cost necessary for preventive operations.

These objectives make it possible to choose the measurement systems not only on the basis of the actual cost of the system but also on assessing the total cost of obtaining the necessary data for preventive actions. It is necessary in this case to compare the measurement systems by attributes and variables as shown in Table 3.4.

Table 6.1. COMPARISON BETWEEN ATRIBUTE AND VARIABLE MEASURING SYSTEMS

CHARACTERISTICS OF THE MEASUREMENT SYSTEM	THE ATTRIBUTES SYSTEM	THE VARIABLE SYSTEM
The cost of measuring instruments	Low	High
Operator Category	Unskilled	Qualified
Usage speeds	Rapid	Slow
Data recording	Simple	Complex
The general cost of an observation	Reduced	High
The value of the information of an observation	Low	High
The number of observations needed to obtain viable data	Many	Few

Analysing the data in the table, it seems more profitable to use the variable measurement system. However, the variable measurement system is generally preferred due to the savings obtained at the cost of obtaining the correct data (complex data recording, high information value of a remark or the small number of necessary observations).

A measuring instrument, even if used correctly, may not provide a reading equal to the true value of the measured magnitude. Thus the problems of fairness and fidelity of the measuring instrument arise.

The accuracy of a measuring instrument is the degree to which the average of a long series of repeated measurements made by an apparatus on a single piece of equipment differs from the true value of that equipment.

The fidelity of a measuring device is the degree to which the apparatus repeats its results when repeated measurements are made on the same piece of equipment.

Measurement error is the difference between the true value and the measured value. This error can affect decisions regarding the quality of equipment and production.

Industrial controversies generally arise due to differences in measurement. Production departments disagree with the results of the control compartment, laboratory tests often result in contradictory results, and the measurements made by the beneficiaries and the producer do not match due to the differences between the means and the measurement procedures.
In order to resolve these differences, it is necessary to perform double readings with the two devices on identical equipment and to analyse the differences in both fairness and fidelity. Average averages and mean square deviations will be calculated to determine the significance level.

Another solution would be to develop a new measurement system, based on the participation of several enterprises in the same field of activity. Under this system, a series of tests are carried out to ensure that appropriate data are provided, each company knowing its relative control over other firms and initiating programs to maintain fairness of the measuring equipment.

In order to achieve the expected results, it is necessary to create a coordination committee recognized by a formal standardization body.

6.1.4 Methodological norms for the calculation of quality indicators

At present, in Romania, some methodological norms regarding the calculation of the quality indicators of industrial equipment have been experienced in industry, with the aim of creating a mechanism for stimulating the increase of employees' accountability for the quality of the equipment. The tracked indicators [B.01] are:

a) The share of high quality production in total output (I_1), which represents the proportion of Q_s (Q_s) in total production (Q_t):

$$\mathbf{I_1 = \frac{Q_s}{Q_t} \times 100} \qquad (6.10)$$

b) The share of production without quality defects in the total production (I_2), which is calculated as the ratio between the production without quality defects (Q_b) and the total production quantity (Q_t):

$$\mathbf{I_2 = \frac{Q_b}{Q_t} \times 100} \qquad (6.11)$$

By product without defects of quality is meant any piece, subassembly, semi-finished product, finished product and service that meet the quality parameters included in the technical documentation.

c) The defect score (I_3) is a complex quality indicator of the manufacturing, which takes into account the number and severity of the defects and evaluates on the basis of a score, the quality of the equipment performed according to the possible defects classification occurred at the control of the equipment: main (50), secondary (10) and minor (1):

$$\mathbf{I_3 = \frac{100N_c + 50N_p + 10N_s + N_m}{n}} \qquad (6.12)$$

where N_c, N_p, N_s, N_m represents the number of critical, main, secondary and minor defects identified at control, and n is the number of controlled equipment.

d) The share of production without quality defects received by the internal beneficiary divisions in the total output delivered by the supplying departments (I_4) is determined on the basis of the ratio between the value of production without quality defects received by the beneficiary sections (Q_r) and the total value of the delivered output by supplying departments (Q_f).

$$I_4 = \frac{Q_r}{Q_f} \times 100 \qquad (6.13)$$

The share of the value of equipment without quality defects received by users in the country or abroad in the value of output (I5) is the ratio of:

$$I_5 = \frac{V_{P\,(l)} - V_{PR}}{V_P} \times 100 \qquad (6.14)$$

where:

$V_{P\,(l)}$ = value of delivered output delivered;
V_{PR} = the value of the claimed well-founded equipment;
V_P = the value of the output produced.

Share of physical output without quality defects in total physical output (I_6). The value of physical output is the value of all equipment, semi-finished products and services of an industrial nature delivered outside the firm and consumed within it, valued in production prices. I_6 is calculated as the ratio between the value of the $V_{PF\,(b)}$ physical quality output (from the total value decreasing the value of the equipment, parts, sub-assemblies claimed within the warranty period) and the total value of the actual output produced by the $V_{PF\,(e)}$:

$$I_6 = \frac{V_{PF\,(b)}}{V_{PF\,(e)}} \times 100 \qquad (6.15)$$

g) Global quality score (I_7) is a complex quality indicator at the level of the industrial firm, which takes into account the value of the equipment claimed within the guarantee period by the beneficiaries (Vpr), the value of the losses by scrapped and downgraded equipment (Vpd) (Vcr), the value of the equipment rejected by the final quality control by Vpf and the severity of these deficiencies, assessed on a scoring system:

$$I_7 = \frac{10V_{pr} + 5V_{pd} + 2V_{cr} + V_{pf}}{V_{PF}} \qquad (6.16)$$

These indicators can be used to assess the activity of different categories of staff as follows:

- for workers, foremen, technical staff productive in workshops, sections, factories and staff of the CTC of the manufacturing flow from enterprises performing differentiated production by quality classes, indicator I_2 or I_3 adjusted to the work-place;
- the quality of the work carried out by the working staff of the CTC compartments, which attests the quality of the deliveries, is appreciated by the indicator I_5;
- the quality of the staff of the management of the units, the staff of the other functional departments of the enterprise is measured by the indicators I_6 or I_7.

In order to establish a level of comparison of the values of these quality indicators, the analysis of the achievements in the last 12 months of the previous year, corrected by the peak achievements, with the exception of the indicators I_3 and I_7.

6.2 Principles and methods in quality optimization

Optimization is a process of conceiving, realizing and applying in practice an optimal (best, most favourable) solution for a system that resolves (maximizes or minimizes) performance by one or more criteria under restrictive conditions imposed by the external or internal environment of the system.

For any S (technical, technological, production) equipment, there may be partial optimizations or global optimizations, presented in Table 3.5., which materialize entirely to the product or its component, in terms of the variables and parameters considered - [P.01] -.

Elaborating optimal global or partial solutions for the quality of S equipment can be done in three ways:

1. Experimentally, processing the results of measurements with appropriate methods for the number of variables and optimization criteria: experimental high charts, regression and correlation analysis, factorial experiences, evolutionary operation, etc.;

2. Theoretically, using either practical methods with simple algorithms or procedures, or mathematical methods that appeal to a wide variety of mathematical methods:

• **multi-attribute optimization methods** that determine the solution that exits the performance of S equipment in the case of a finite number of possible solutions,

• **multi-object optimization methods** that determine the solution that exits the performance of S-equipment in an infinite number of possible solutions,

• **mono-object optimization methods**.

3. Automatically, when equipment S consists of optimal process control sub-systems for optimal elaboration / selection of engineering programs and structures of S.

From the point of view the possibility of qualitative or quantitative optimization appears. Designers have generally been able to optimize the correlations between variables, but as the complexity of the simple systems increases, the qualitative optimization analysis becomes difficult and inconclusive. The many correlations that exist between the variable parameters of complex systems make the quantum optimization attempts difficult. Quality parameter optimization methods aim at narrowing uncertainty areas, offering the opportunity to evaluate alternative solutions for reliability, maintainability, availability related to the cost of equipment.

In the quality optimization activity, an important factor is the phase in which this optimization begins, this being **the design stage**, because it is much more economical to design and realize an optimal quality system from the very beginning than to re-optimize it during its production or use. For the design, organization, operation and management of the systems, there are special theoretical methods of optimization, which allow optimal decision-making.

Table 6.2. OPTIMIZATIONS IN EQUIPMENT DESIGN

SPHERE OBJECT		OPTIMIZATIONS	
		PARȚIAL	**GLOBAL**
Processes carried out by physico-chemical transformations phases, k operations.		**-Type k: phenomenon, method, process;** **-Working mode parameters for k;** **- Variables y, u, x.**	- itinerary k: type, number, interconnection; - concentration k; - activation k.
Equipment and process programs		- Types j and quantities q_j; - Batch size n_j; - Succession / parallelization k_j	- typo-dimensions i, quantities q_i - batch size n_i; - succession / parallelization k_{ij}
Equipment resources	Inputs	- Input characteristics	- level of input quality / quantity
	Inside	- The transformation capacity	- production capacity
Structures of the equipment	Components	- Physical and chemical materials and characteristics	- typo-dimensions; - number; - degree and level of mechanization / automation.
	Interconnections	- characteristics of the links between the components	- substantial, energetic, informational links between components
	Summation	- component structure; - degree of component specialization; - component type rating	- the structure; - specialization degree; - degree of typing
Equipment		- technical level; - quality level; - ergonomic level; - Ecological level.	- technical level; - quality level

When developing the mathematical model needed to optimize an engineering system, the following elements must be determined - [P.01.] -:

- the decision maker or decision maker who evaluates, analyses and decides on the process or phenomenon;
- the set of variables on which the decision can be made by the decision-maker: structural-functional characteristics of the equipment, parameters of the technological regime, etc.;
- the set of essential restrictions imposed on the engineering system;
- the set of comparison criteria for variants, criteria that are performance variables of the system;
- the set of objectives for optimizing the engineering system, defining for each criterion the favourable end of performance;

- the set of conditions of nature, that is to say, the set of conditions that determines that a variant corresponds to a certain consequence from more than one possible within the internal or external environment of the equipment.

In order to optimize the quality of a theoretical system, it is proposed to apply the method of optimization of multi-criteria decisions by deterministic modelling, a practical example being presented in the following. It comprises the following steps:

- there are several constructive options for realizing the system;
- several criteria for assessing variants are established;
- determine the order of importance (weight) of the criteria using a comparison matrix as shown in Table 3.6., by which:
- 1 point of each criterion is given ex officio (diagonally),
- compare each criterion with each, giving 2 points for the criterion considered to be more important, 0 points for the less important criterion, 1 point if the two benchmarks are equally important;
- determine the weight of each criterion by summing the awarded points.

The evaluation criteria may include: system reliability, system maintain-ability, system availability, system cost, manufacturing control, system redundancy, spare part inventory management and reconditioning, sample periodicity and cost, cost of pre-maintenance, cost of tracking the system's operation to the beneficiaries, costing the necessary personnel to implement the quality assurance system, etc.

Table 6.3. MATERIAL OF COMPARISON OF EVALUATION CRITERIA

CRITERIA	A	B	C	D	E	F	G	SCORE
A	1	2	2	2	2	0	2	***11***
B	0	1	1	0	2	0	2	***6***
C	0	1	1	0	2	0	2	***6***
D	0	2	2	1	2	0	2	***9***
E	0	0	0	0	1	0	1	***2***
F	2	2	2	2	2	1	2	***13***
G	0	0	0	0	1	0	1	***2***

- determine the level of satisfaction of the criteria by the proposed variants if all the criteria are quantifiable by using a scale from 0 to 100 as follows:
- identify, in relation to each criterion, the variants that best meet the weakest criterion;
- 100 points are assigned to the maximum level variation and 0 points to the minimum level variation;
- for variants located at intermediate levels to meet the criterion considered, the scores are determined by interpolation;
- the deterministic model for selecting the optimal version of the system quality, as illustrated in Table 3.7.;
- finally select the optimal option.

Analysing the above mentioned example we can see that the first variant is the optimal variant, $\boldsymbol{\Sigma}$ **K x** $\mathbf{N_1}$ **= maxim**.

If the evaluation criteria cannot be quantified (partially or totally), the variation of the variants is to be done by establishing levels of steps to meet the criteria from "very poor" to "very good", marked from 1 to 5 or 2 to 10, which are explicitly defined for each criterion.

Table 6.4. DETERMINING MODEL OF SELECTING THE OPTIMAL VARIANT

EVALUATION CRITERIAS	WEIGHT	CONSTRUCTIVE OPTIONS							
		N_1	**K x N_1**	**N_2**	**K x N_2**	**N_3**	**K x N_3**	**N_4**	**K x N_4**
A	11	38	418	75	825	100	1100	0	0
B	6	60	360	40	240	0	0	100	600
C	6	0	0	100	600	100	600	0	0
D	9	40	360	0	0	52	468	100	900
E	2	100	200	45	90	0	0	72	144
F	13	100	1300	69	897	0	0	83	1079
G	2	100	200	0	0	50	100	50	100
$\sum$ K x N_i	-	-	2838	-	2652	-	2268	-	2823

Experimental optimization can be achieved by: progressive control during installation and commissioning of equipment, maintenance policy optimization, improved performance of existing equipment, and reduction of human errors occurring in operations, maintenance and repair.

A. Progressive control during installation and commissioning of equipment, equipment, machinery

It mainly consists of participating with the representatives of the manufacturers and the service team, who will ensure the maintenance of the equipment during its use as shown in Fig. 6.5.

Method has a double advantage: on the one hand, it allows the equipment manufacturer to identify the problems, installation difficulties and causes of falls before the actual equipment is in operation, on the other hand, it allows the team that will maintain the system maintenance to identify the modalities more effective troubleshooting.

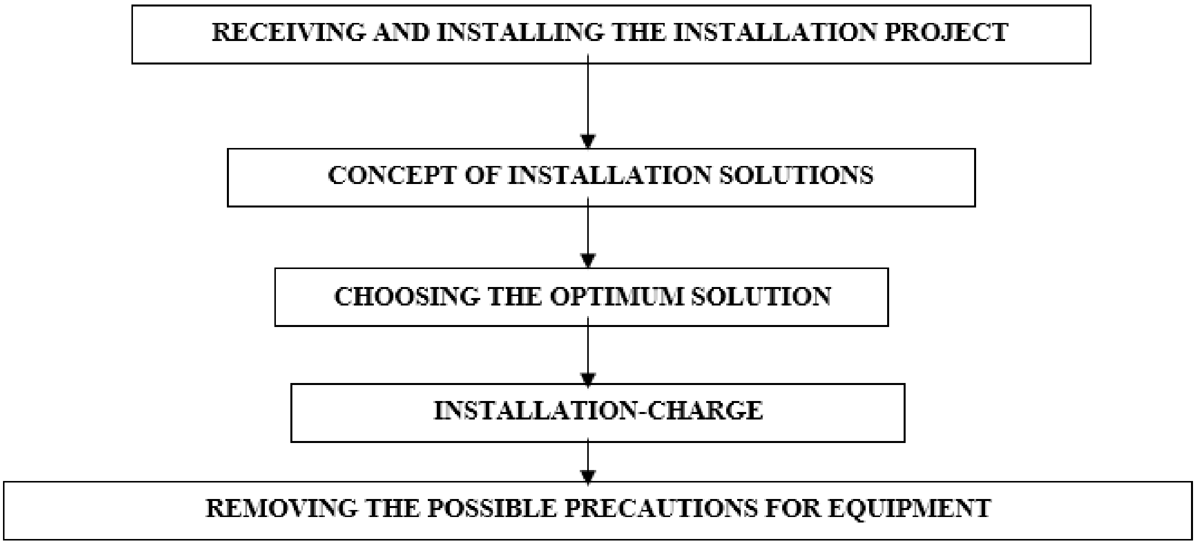

Fig. 6.5. Progressive control during device installation

B. Optimization of maintenance policy

A consistent maintenance policy allows a significant reduction in the number of equipment failures and their consequences. It is the objective of preventive maintenance and is achieved by:

- **Systematic maintenance** - Preventive maintenance performed with respect to the intervening and repair times.

- **Conditional maintenance** - maintenance performed as a result of unplanned actions of self-diagnosis of the operating state of the equipment, or based on information received from the user.

C. Improving the performance of existing equipment

It is one of the objectives of total productive maintenance. Optimizing and implementing the results obtained by applying a value-of-cost analysis method generally leads to improved performance. In Japan, the generalization of this method and its application together with total productive maintenance have led to the development of high performance equipment tailored to the needs of the company. In fact, a repair rule says: **"If you break up the machine 100 times and then re-assemble it, you're likely to discover 100 significant improvements."**

Starting from these realities, we have developed an own methodology for finding the opportunities for improving the performances of precision machines and apparatus, presented in Fig. 6.6.

The implementation of this methodology in industrial enterprises would not imply special financial funds, but could lead to a reconsideration of the maintenance, repair and re-engineering of precision machinery and machines.

D. Reducing human errors that occur in exploitation, maintenance and repair activities

These errors are very varied, some of which have common causes, others occur by chance. However, irrespective of the causes that cause them, they sometimes increase considerably the operating costs of machines, appliances and equipment.

A grouping of these errors according to the moment of occurrence would be:

Human errors during operation:

- misconduct, misinterpretations of some of the information in the machine's usage books,
- negligent machine signals or misinterpretations by the operator,
- distorted communications between operators of operating instructions,
- inappropriate or incomplete use of the machine.

Human errors introduced during periodic revisions of machines and appliances:

- failure to perform the periodic review or erroneous performance,
- calibration or adjustment errors,

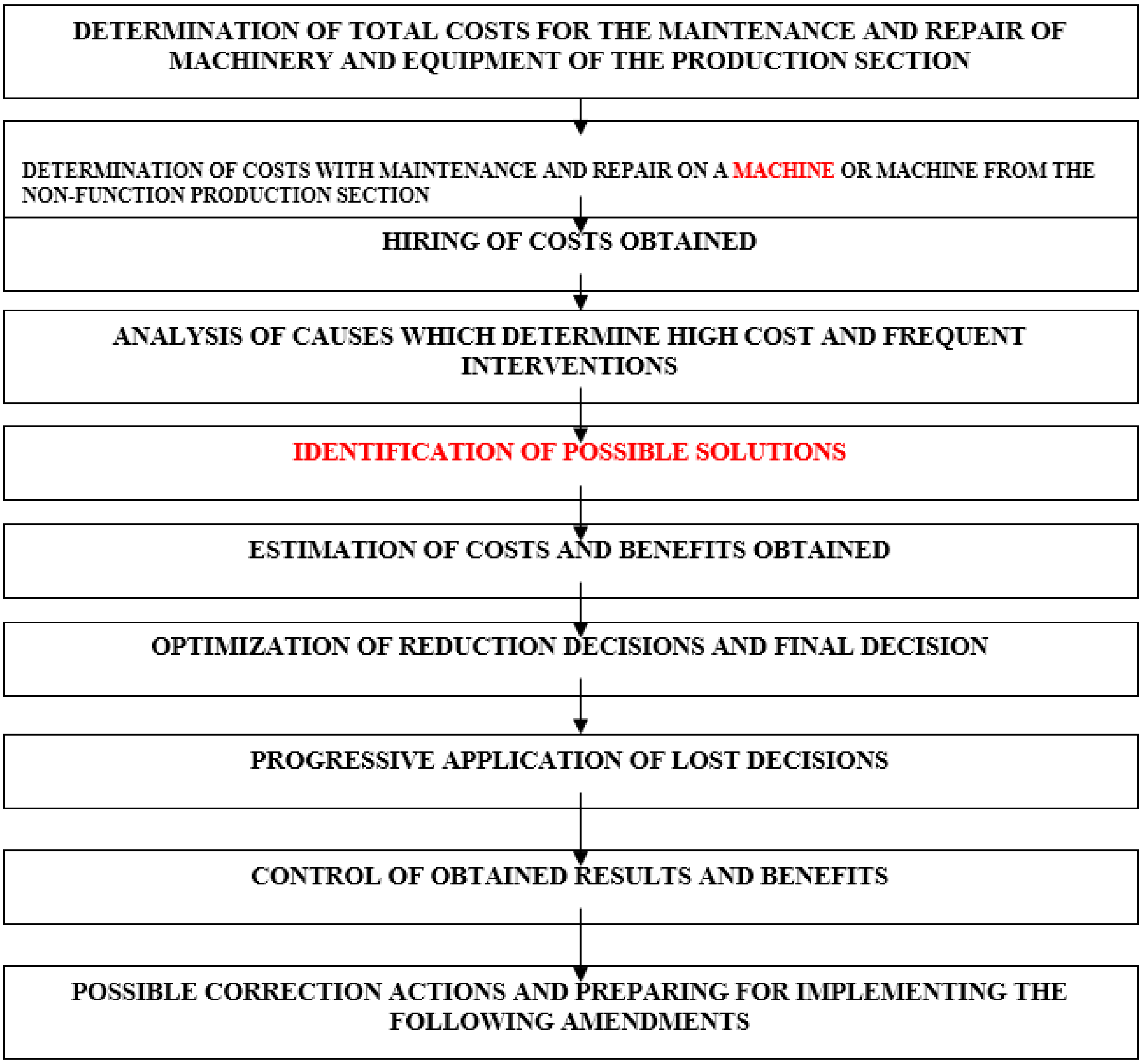

Fig. 6.6. Improving the performance of precision machines and devices through improvement actions

- the use of obsolete or incomplete periodic review procedures,
- negligence or omission of the system restoration in the initial state of operation after the revision.

Human errors occurring during the maintenance and repair of the machine:

- machine maintenance procedures have not been followed,
- use of obsolete or incomplete maintenance and repair procedures,
- negligence or failure to restore the system to its original state of operation after repair.

The main resources available to minimize the frequency of human errors are as follows:

- assessment of the possible behaviour of the operator at the design stage of the equipment;
- Providing clear and precise instructions on how to regulate and maintain the equipment that will not allow for further interpretations;
- control of the quality of the operation: control of the operating procedures, revision or repair, proper application of these procedures, etc.;
- initial training, continuous information and subsequent recycling of users and employees of the repair and maintenance department.

REVIEW QUESTIONS

1. What are the quality quantification indicators? 44
2. How is quality optimized? 45
3. What is measurement fidelity in quality assessment? 51
4. What are the methodological norms for the calculation of quality indicators? 53
5. How can you describe the principles and methods in quality optimization? 54

7 THE ACTUAL STAGE OF RESEARCH ON QUALITY ASSURANCE OF PRODUCTS AND PRODUCTION (Part 1)

7.1 Aspects specific to the development of production systems

Production machinery and equipment are essential components of any industrial enterprise. In the last decades, the outstanding development of these equipment, their complexity and quality reflected directly in very high productivity but also in the purchase price, have led to growing concerns about their maintenance and repair, cost savings and the duration of these activities.

For a device to meet the requirements of a user, it must meet three conditions: hold the required quality; to have a lower price; to be delivered on time.

In order to meet these three requirements, the management of an industrial enterprise has to correlate and control a large number of factors which contribute to the fulfilment of the above conditions, namely:

1. Technical capability and design of products.
2. The level of achievement of the production / marketing processes used to produce the respective products / services.
3. The level of training and involvement of the personnel contributing to the respective products / services.
4. Market requirements related to products / services made within the enterprise.
5. Cost and price of the product / service concerned.
6. The company's ability to provide technical assistance, service, spare parts, customer to the customer of the product / service.

Due to this multitude of factors, it is very difficult to control and verify the quality characteristics of each component of the product, thus defending the need for a new way of dealing with quality issues, which has been called quality assurance. This involves taking steps to prevent defects by systematically and planning all quality related activities, completing non-compliant identification activities, correcting them (the specifics of the product / service's technical compliance check with the specifications in the technical documentation and the execution).

A distinction must be made between quality, which refers to a product / service and which, for the customer, is the satisfaction of existing requirements at a given time, and the quality assurance of the producer itself, representing the winning of the customer's confidence in the achievements of the enterprise, to the conquest of that market.

Ensuring consumer satisfaction can be achieved through quality, service and value. Satisfaction or un-satisfaction upon purchase depends on the ratio of the performance of the offer to its expectations. The factors presented above have determined the need for competitiveness for products, services, and projects within a company.

This competitive relationship - satisfaction of customer needs has also emerged, thanks to the demand / offer ratio. In human society there have been periods of involution (now third world countries), transition (a crisis for former communist and developing countries) and development (the current developed countries), distinct or simultaneously (present) in the market world.

After 1950, the evolution of the free market economy in the US, Japan and Western European countries were determined, depending on the evolution of the supply / demand ratio, the emergence and development of five types of market economy presented in **Table 4.1.**

Analysing the data in the table, it can be noticed that the conditions / hypostases of the evolution of the free market economy are determined by the relations between:

- competitiveness;
- consumers' ability to pay;

- market conjuncture;
- the hierarchy of human needs specified in Maslow's pyramid. [D.09].

Table 7.1. THE EVOLUTION OF THE FREE MARKET ECONOMY

DECADE	REPORT (C / O) REQUEST / OFFER	TYPE OF NATIONAL ECONOMY	DOMINANT ACTIVITIES IN ORGANIZATION
Al-VI	O < C	OF PRODUCTION	- supply - production
Al –VII	O ≅ C	DISTRIBUTION	- supply - production - the sale
Al –VIII	O > C	OF THE MARKET	- the sale - supply - production - the management
Al –IX	O >> C	ADAPTING TO THE ENVIRONMENT	- the sale - the management - the quality - supply - production - adaptation to the environment
After 2000	O >>>> C	OF THE CONSUMER	- the sale - the management - the quality - flexible predictive adaptation - supply - production

Thus, around 1950, after the war, the need for products was rigorous, the user's ability to pay was low, market competition was inexistent, material and human resources seemingly sufficient but not appropriately valued. Dominant functions were supply and production that largely satisfied the fundamental physiological and security needs of the vast majority of consumers.

Along with industrial development, with increased consumer spending capacity, striking a balance between supply and demand and competition, dominant functions for the Decade VII organizations are supply, production and sales. For many consumers, buying a company product can determine membership of a particular group.

The Decade VIII also brings fundamental changes in the market context (from the point of view of the internal environment, the external environment of the organization, the time factor and the market itself). The supply of products exceeds demand and therefore survives only those organizations that adopt a high-performance management that offers quality products on time, at a price that is acceptable from a quality / price point of view. Some of the products marketed must give the user some prestige.

In the next decade competition on the market becomes fierce. In developed economies there are slight crisis trends. Most businesses are gaining more and more of a niche in the market. They survive those organizations that adapt to the increasingly stringent menu conditions. Consuming or using non-polluting or natural products becomes a constant concern of most consumers. Because of this, the adaptive function is of particular importance.

After 2000, the consumer will probably become the absolute master of the market. By buying a particular product you will want to satisfy certain personal fulfilment. He will dictate the shape, the colour, the size and the functions that the product will fulfil, because the ability to pay is no longer a problem for him, and the achievement of maximum satisfaction is the primordial element. All this will lead to an important increase in the role of predictive flexible management, quality and correlation between them.

Michael Porter, a professor at Harvard University, proposed as a tool to identify ways to create higher consumer satisfaction and implicitly increase product competitiveness by developing a "value chain" as shown in Fig. 7.1.

The value chain highlights the existence of nine activities of strategic importance, activities that underpin the process of creating customer satisfaction and generating the costs of a company, grouped into:

a) Primary activities;

b) Support activities.

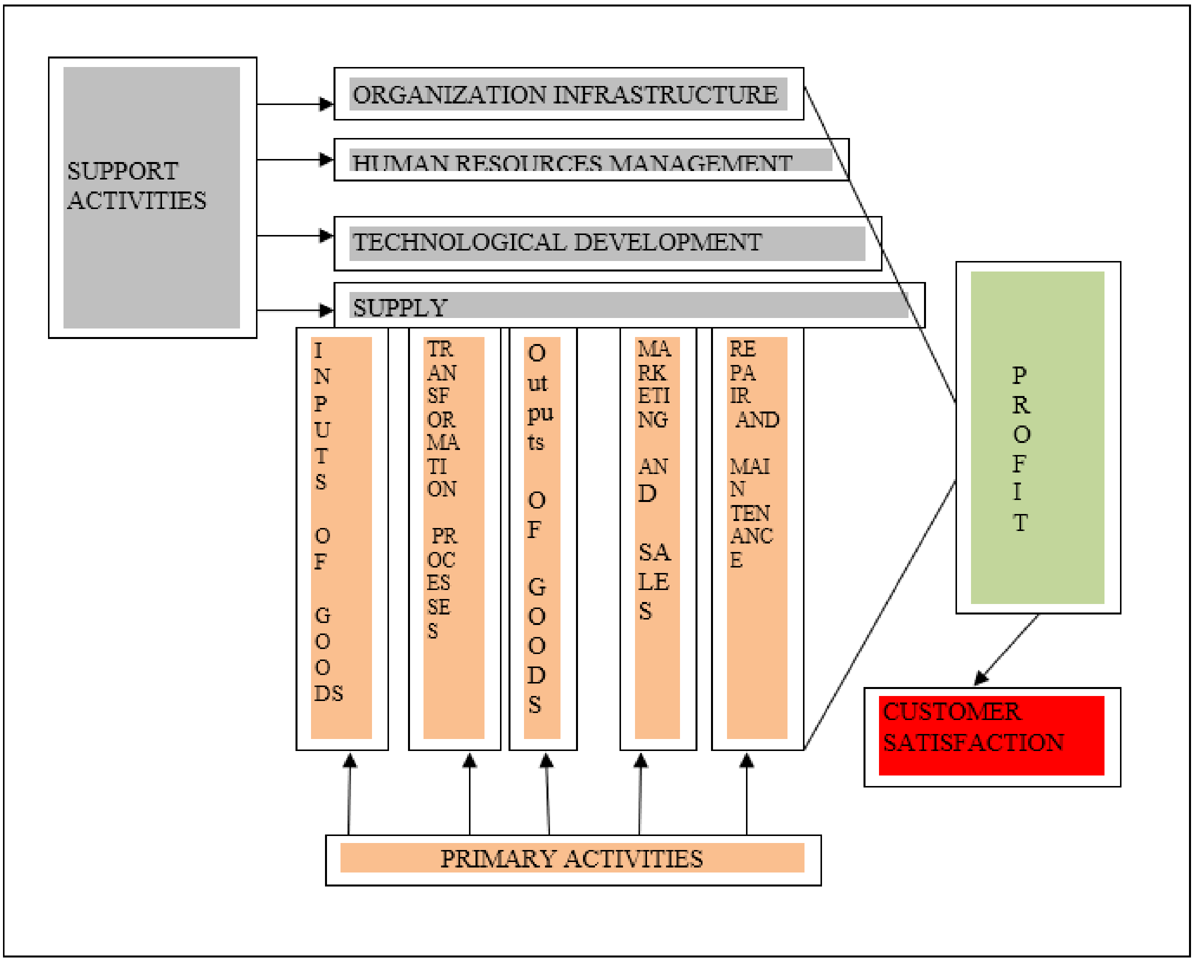

Fig. 7.1. Value chain, profit and customer satisfaction [P.03]

A careful analysis of these issues has prompted me to propose the introduction of a new concept, the general quality concept of the economic chain - a broad concept of use for products as well as for services, works or projects, which defines the necessity to observe certain conditions quality and environment from the nature supplier of raw materials, water, fuel, energy, etc. until the product returns in kind.

This new concept would lead to a true development of the flexible adaptive work of organizations, protection of the natural environment, consumers, producers, and a change in the overall concept of quality. It would cause important changes in the concepts of supply, production, disposal, revaluation of waste, maintenance and repair of machinery and others.

Market competition involves several aspects: price, quality, deadlines, service activity, and more. As a factor of competitiveness, quality implies the following:

- Designing a new product to provide customers with a host of new features related to functionality, appearance, price, presentation, lifetime, environmental protection, etc.;
- Clear knowledge of the service conditions granted to the beneficiaries;
- Knowing the costs that partners ought to bear because of operating interruptions or product use;
- Knowing the quality level of competition products and adapting (redesigning and recalculating the price) of their own products;
- Guaranteeing the quality of the product or service to the user;
- Achieving and maintaining a positive reputation for quality by promptly delivering products consistent with market requirements and avoiding any failures that could seriously damage the company's reputation;
- Advertising the performance listed above through advertising, information, work-shops, open-homes, fairs or other domestic and international events.

All this leads to the conclusion that having a potentially competitive quality is the fundamental issue. Quality can be studied from the point of view of: **the quality of the production system, quality assurance and total quality.**

In the development of different types of market economy several stages were manifested:

- **Stage 1**: Cost-effectiveness of production processes
- **Stage 2**: profitability + quality, based on the economy of financial, technical, technological, human resources to ensure the quality of production and products
- **Stage 3:** Profitability + Quality + Flexibility + Productivity

The last step has led to the development of concepts on reliability, maintainability, availability of products and products. Quality has become a necessity, with new meanings, being more and more a viable solution to meet new user expectations.

7.2 Availability of production systems and equipment

The availability of a product or service is expressed qualitatively as the ability of a product to perform its specified global function at a given time or within a given time frame.

The availability of the production system is determined by the availability of each piece of equipment, machine or machine in its composition. If these components have high availability and the availability of the production system is high. The factors influencing the availability of productive equipment are shown in Fig. 7.2.

It can be seen from the figure that availability is conditioned by many factors, whose optimization, although difficult to achieve, is absolutely necessary:

- optimization criteria, which may be: execution costs, operating costs, unavailability, gauge, and weight;
- logistics expressed by: strategies and practical means;
- maintainability with its components: accessibility, availability and service;
- reliability determined by: mission to accomplish, element connections, cost of falls and lifetimes.

For equipment, plant or machinery, **predictive availability** can be estimated and **operational availability** analysed with its two components, shown in Fig. 7.3.:

- manufacturer availability;
- availability to the user (beneficiary).

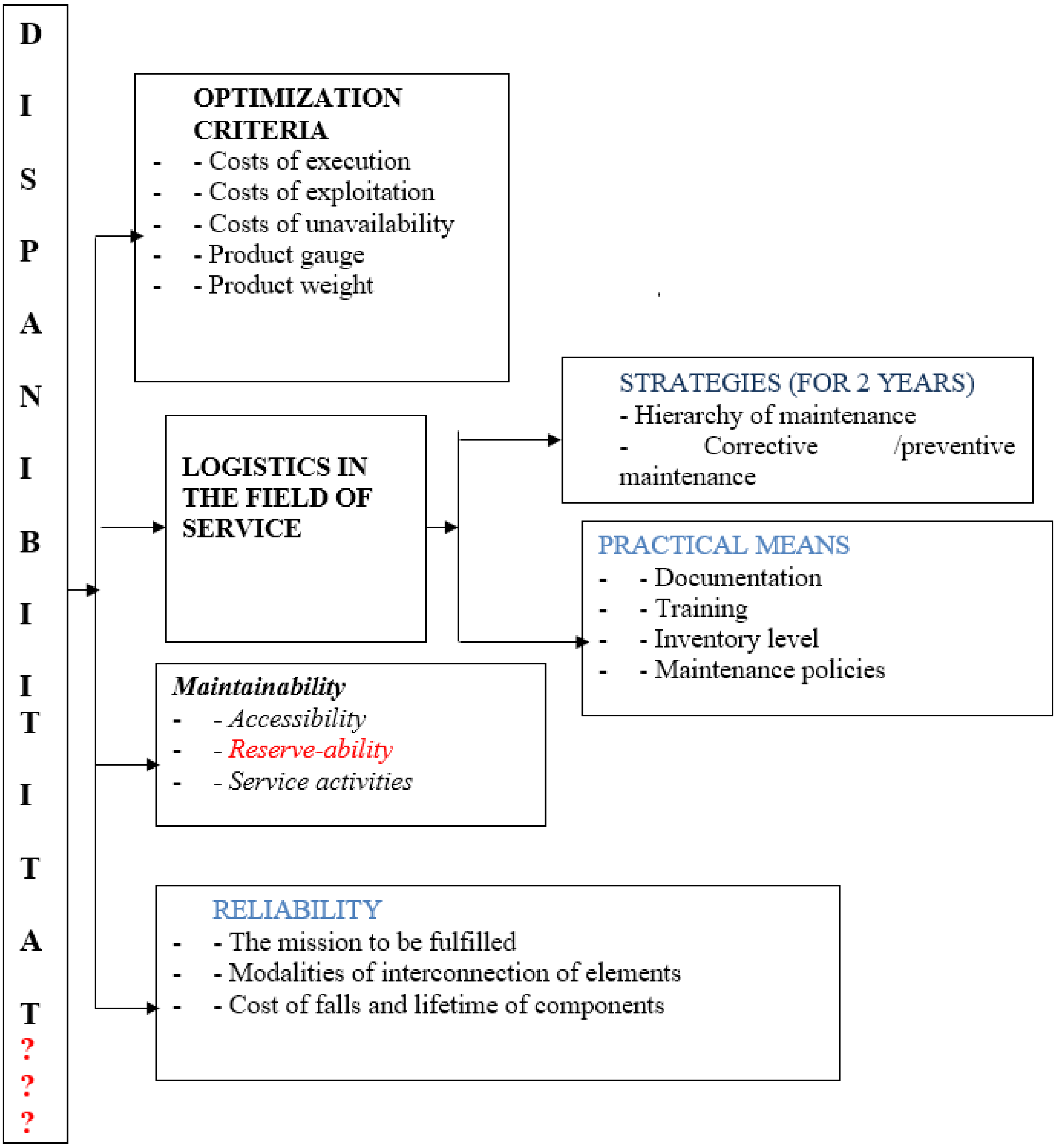

Fig. 7.2. Factors of availability influence

7.3 Evolution of opinions on quality assurance

Worldwide, much of the issues of quality, reliability, maintainability and availability have found both a theoretical and a practical solution. The key issue at world level, whose applicability now requires laborious work, is the implementation of a new concept of total quality management and total productive maintenance in companies, starting from the hypothesis that the human factor is the most important resource of a company.

It also tries to implement a total quality, maintenance and reliability management that is no longer based on obtaining results at any price, but satisfying customer needs (basically exceeding their product value expectations) internal or external to the organization.

Undoubtedly, the foundations of modern quality have been put in the US. In the twenties, with the development of serial production, there was a need for new methods of controlling the quality of products and production. The problem was partly solved by Fischer and Shewart, and then deepened by Juran and Deming.

After December 7, 1941, after Pearl Harbor, Deming, who was an occasional advisor to the American War Department, Stanford University helped organize seminars on **quality control**. More than 30,000 people have benefited from these courses, then acting effectively in the field of quality, especially in military production. In parallel, the Pentagon has called on statisticians to establish some common industrial quality standards that have been set up in military standards.

After the Second World War, the **Standardized Military Norms** were also studied and implemented in the civilian field, at first in the aeronautics and nuclear industry, but the application was not easy, and the qualified staff made important mistakes for an ever-expanding industry. To eliminate these issues, Americans have introduced and developed the concept of **quality assurance**.

Parallel to this, the American Feigenbaum formulated and explained in the fifties the following concepts of quality:

- **Total quality control,** the current basis for **total quality**;
- **"Ghost Factories",** which included the entire industrial activity of an enterprise dedicated to the production of non-marketable products;
- **Costs needed for quality;**
- **Costs related to quality prevention activities;**
- **Quality assessment costs;**
- **Costs of falling products in the manufacturing process;**
- **Costs related to product drops that occur to the user.**

In recent years, the concept of "**Acceptable Quality Level**" has emerged and developed, which lists the risks of customers (purchasing batches of defective products) and those of suppliers.

In the 1980s, due to the pressure exerted by Japanese competition, a humanistic conception of **total quality** developed within American society. All Japanese solutions on total quality crossed the Pacific and applied to the American economy were **Total Quality Management**, the most advanced conception of Kaoru Ishikawa and Genichi Taguchi through the eight points mentioned above.

In the area of system use, maintenance and repair, the concept of **Total Productive Maintenance (MTP)** is gaining momentum, seen as a technical initiative to achieve effective employee involvement in increasing the service life of the equipment, equipment and machinery.

The natural conditions, the material resources of Japan, forced the local specialists in the field to conceive otherwise the concept of quality. The Industrial Revolution, which began in 1867 under the Menji Dynasty, did not change the quality of products and production until around the 1950s.

In July 1950, E. Deming was invited by the Japanese Union of Sciences and Engineers to lay the foundations for a new concept of quality developed by J.M. Juran and K. Ishikawa through a series of seminars and conferences. The concept of "Deming Price" has been created to enhance quality improvement.

It is also Edward Deming who first promotes the basic principles of **participatory management** of an organization's human resources, which frequently include quality issues and assurance:

1. Creating an established attitude among employees of an organization to continually improve the quality of products and services;

2. Adopt a new philosophy in the field of quality;
3. Stopping the dependence of the reliability of the results obtained by the quality control, by the total production control;
4. Stopping the practice of assessing product quality based on the reputation of the manufacturer;
5. Constant and continuous improvement of production and service systems by increasing quality, productivity and constant cost reduction;
6. Establish consistently the principle of achieving better results through employee training;
7. Implementing leadership;
8. Reduced image promotion outside the organization leads to additional effective work inside the enterprise;
9. Breaking existing barriers between various departments of the organization;
10. Eliminating zero-defect slogans and setting concrete, measurable, realistic, time-based, objective-oriented objectives that will lead to a new tangible level of productivity;
11. Removing existing barriers and disagreements between top management and employees and developing the true meaning of the word of teamwork;
12. Remove rigid labour standards and rules for lower levels of the organization to determine their true involvement;
13. Design and implement a constant program of continuous training and improvement of their own performance;
14. Involve all employees in the processes of developing creativity and in organizational changes.

In April 1962, in the first issue of the magazine "**The Workshop and the Quality Circles**", it is proposed for the first time the formation of quality circles.

In 1967, the Japanese Institute for Maintenance Studies attacked for the first time the issue of quality in maintenance, laying the foundations of a **totally productive maintenance** concept.

After 1980, the Japanese, aware of the fragility of their success, **generalized the cost-cutting operations of quality**. The main resources of total quality control are employees, which must be co-ordinated within quality circles.

At the same time, a Japanese statistician, G. Taguchi, has developed a new philosophy of quality, aimed at optimizing its economic dimensions. One of the practical applications in terms of industrial experience of this concept is presented in the Japanese automotive industry, which has practically won the competition with American and Western European competitions.

Faced with the same problems as the American industry, it was normal for the Western European industry to have taken similar steps in the field of quality. American and Japanese theories, adapted and implemented in industrial enterprises, were taken over.

After 1985, the Western European notion of "Total Quality Control" became synonymous with the Japanese-American "Total Quality Management", with small non-essential differences.

Practically Total Quality Control was invented by Americans, copied and adapted by the Japanese and reintroduced into the U.S. in the form of Total Quality Management. In France and Germany the fundamental dynamics in total quality is **continuous progress** based on the principles of KAIZEN:

1. Develop supplier-client relationships;
2. The use of process management for lasting improvement of results and implementation of total productive maintenance;
3. Increasing responsibility and accountability of staff;

4. Employing people in implementing total quality management determines product value increases and cost savings.

In Romania quality issues have existed and exist both before and after 1989. In the last period it becomes necessary to adapt, take over and implement new concepts regarding quality, availability, reliability, maintainability, total quality management, quality assurance, total productive maintenance, etc.

The low financial possibilities of most Romanian organizations will cause particular problems regarding the necessary changes in the organizational culture regarding the maintenance of the maintenance, the introduction of the new ISO 9000 - 9004 standardization system and the implementation of the totally productive maintenance.

However, the introduction and adoption of the new ISO 9000 - 9004 standardization system is an essential condition for Romania's integration into the world economy.

Some of the problems that are partially or unresolved in the field of product quality and production in Romania, in our opinion are:

- Introducing the new proposed concept, that of the **general quality**;
- Quality - cost correlation - delivery term - permanent adjustment to market requirements;
- Quality management for lasting improvement of the results obtained in the field of product quality and / or production;
- Quality cost optimization through: actions on the costs of production quality at the producer, maximizing the net income, minimizing the consumption of resources, minimizing the quality costs from the design phase;
- Control of in-service behaviour of products;
- Correlation Needs - Research - Production - Control - Consumption;
- Continuous reduction of production costs at the same quality level of products;
- Reduced maintenance, repair and after-sales service costs;
- Minimizing quality costs;
- Implementation of total quality management;
- Introducing the concept of total productive maintenance.

Through the implementation of the total productive maintenance it is possible to: increase the value of the product and increase the service life of the product; maximize equipment efficiency; technical analysis of the equipment's diagnosis during the operation; increasing the life cycle of the product; involving all departments within the organization; involvement of all employees; creating interdepartmental groups; etc.

Total productive maintenance is an effective solution for any productive organization. It combines the involvement of the most important resource of an organization, the human resource, with the rational and efficient use of the other resources of the enterprise.

REVIEW QUESTIONS

1. What had impact on the development of production systems? 62
2. How can you define the availability of production systems and equipment? 65
3. How can you describe the evolution of opinions on quality assurance? 66

8 THE ACTUAL STAGE OF RESEARCH ON QUALITY ASSURANCE OF PRODUCTS AND PRODUCTION (Part 2)

8.1 Quality assurance in industrial enterprises

8.1.1 Total Quality Management

Quality assurance in industrial enterprises involves running the managerial cycle: **prognosis and analysis - organization - decision - control - regulation.**

The forecasting and analysis is carried out starting with the diagnosis analysis of the considered system and it continues with the determination of the variants of the objectives to be achieved, the need of material, human, financial resources, the elaboration of the variants of the system's functioning programs over time and is reflected in operational forecasts, plans and programs.

The organization presupposes the design of the variants of the system-specific structures, the informational connections necessary for its operation over time.

The decision determines how the system works best, materialized in the goals, resource requirements, organizational programs and structures over time.

The control determines how the system takes the decisions made, identifying the corrections necessary to remove the deviations from the objectives originally set.

The adjustment ensures the optimal operation of the quality assurance system conceived by means of some necessary corrections with its practical implementation.

This cycle is repeated for each new product or service multiple times, the final conclusions of an old system being part of the new elements of the new one.

The keys to success for the quality assurance cycle in an enterprise are:

- firm involvement of the company's management in the implementation of the quality assurance cycle;
- the participation of the specialized personnel of the company in the design and application of the quality assurance cycle for the products and services of the company (it has an average contribution of up to 80 % in the activities of the company's employees);
- the participation of all staff in concrete implementation through activities carried out within quality circles, working groups or individual activities (the difference is up to 100% complete);
- use of a clear methodology based on the modern means of quality assurance within the firm;
- permanent intervention through regulation, improvement and refinement;
- implementing **total productive maintenance**.

In the current economic situation, competition is stronger than ever. For small and medium-sized Romanian enterprises to continue to survive and develop, and maintaining an acceptable level of quality of products and **services becomes** the most important objective. Customer satisfaction can be achieved if a total quality management (T.Q.M.) tailored to the size of the enterprise is really applied within the organization.

Worldwide there is a real revolution in quality - a period of profound change that affects any business, enterprise, organization or individual. In general, organizations are targeting three final results: optimal quality, competitive price and efficient distribution.

Total Quality Management (T.Q.M.) contributes decisively to improving the efficiency, flexibility and competitiveness of a business. It is a cost and loss reduction method involving all employees and implementing the concept of continuous improvement.

The principles of total quality management are based on the development of the following:

- leadership; employment; total customer satisfaction; continuous improvement;
- total involvement; training and education; ownership;
- reward and recognition; preventing errors; cooperation and teamwork.

Following the consistent application of these points, the results presented in Fig. 8.1. are possible.

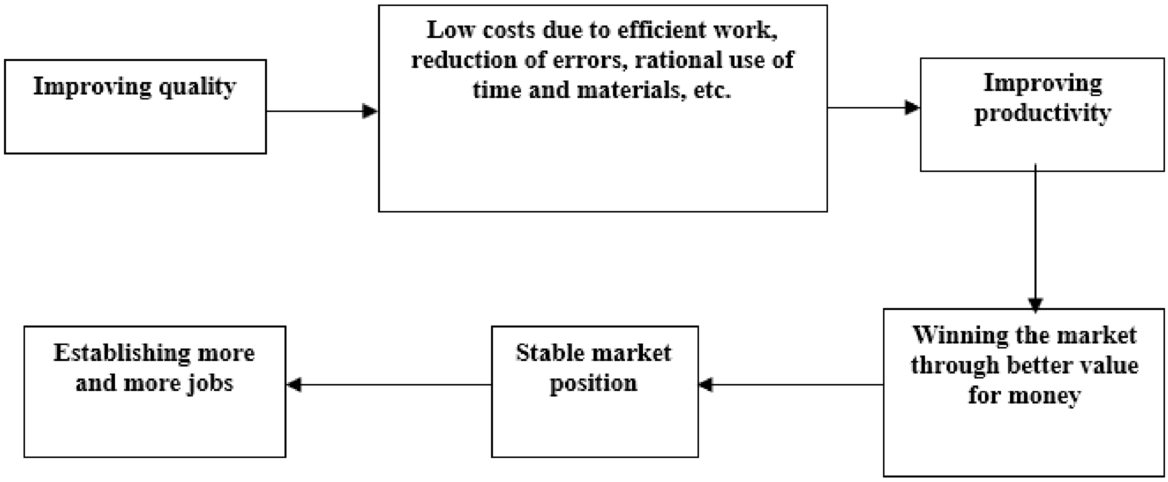

Fig. 8.1. The predictable results from the implementation of a total quality management program

To succeed, implementing a quality management program requires a drastic change in the way the organization is running. This does not imply a shallow change in company policy and no overlapping over the existing structures of this program, but the consistent design and **implementation of the following components of T.Q.M.**:

1. A strong base. The T.Q.M. must be supported through sound knowledge of the principles and experiences gained through application to similar organizations. Further knowledge and efficiency in the T.Q.M. from managers and employees do not come by themselves. Initial support from external consultants should not be avoided.

2. Focusing on customer needs. Customer focus is considered essential in T.Q.M. and takes into account both internal and external customers. Internal customers are the next beneficiaries in the productive flow. Continuous improvement actions, preferably through teamwork and based on analytical methods, should be geared to customer needs. The goal is to exceed its expectations at the lowest possible cost. Customers, whether internal or external, cannot be satisfied if their expectations are not met.

3. Clear objectives and involvement of managers. Managers should first understand T.Q.M.'s problem, then believe in it, and then only demonstrate their acquired skills and commitment through daily practice. Top managers need to get involved in helping their employees meet their goals. Through each decision on organization policy, allocation of resources and interaction with any of its subordinates, managers must convey total confidence in the T.Q.M. implementation program.

4. Delegations of responsibilities regarding T.Q.M. employees. Each employee has a certain freedom of action that manifests in his decision to engage or refrain from implementing the T.Q.M. The ultimate goal of delegating employee responsibilities is to make it contribute to the maximum through its freedom action to continual improvement of our own work and collaborators.

5. Partnership with suppliers. This partnership includes both internal and external suppliers. The internal provider is complementary to the internal customer. As a customer, the company needs to meet its requirements, a goal that can be achieved through close collaboration with suppliers to ensure that they understand and accept the needs and priorities of the organization. Fulfilling this relationship requires a proactive effort on the part of the organization in its client position.

6. Implementation of T.Q.M. Policies In the framework of overall quality management, strategy, philosophy, values and general objectives must be passed on to employees, from hierarchical level to systematically, to capture the attention, communicate the clarity of the vision and determine their involvement. Implementing T.Q.M. is the process through which the goal is achieved and the action plans are realized, through which the company's mission, strategic directions and goals are achieved by all levels of the organization.

7. Process management. Deming said: "Focus on the quality of the process and the quality of the product will take care of itself." Continuous improvement of the T.Q.M. is the key to success on the final results.

8. Decisions based on facts. The main tools used to make decisions about T.Q.M. are: process modelling through logic schemes, brainstorming, network diagrams, Pareto analysis, decision tree, cause-effect diagram, correlation diagram, control diagrams, error matrix, Gantt and Pert charts, force field analysis, etc.

9. Continuous improvement. It is not just about improving the results, but more importantly, improving the capacity to produce better results in the future. The five main areas of focus on capacity enhancement are: demand generation, supply generation, ownership technology, internal organization and potential of employees. Continuous improvement focuses primarily on preventive actions, because mistakes can be made by employees, but most of them are caused or at least determined by systems or processes that produce errors.

10. Employee training, education and training. Organizations that implement T.Q.M. develop certain special skills of employees that are not provided by traditional training. In addition to developing traditional managerial capabilities: providing, communicating, organizing, deciding, and controlling, employees are trained in areas such as ethics, quality, customer orientation, global vision, teamwork, cultural differences, interpersonal relationships. Finally, the employees have a complex training, being able to convey from these knowledge and attitudes to the other employees.

11. Understanding necessity and accepting change. Change is generally a harder process accepted by many employees. Resistance to change is sometimes particularly strong and has been manifested since the start of the T.Q.M. program implementation. Until this resistance is removed, the program has minimal chances of success.

12. Developing your personal skills. To implement any T.Q.M. to succeed is essential for managers and employees to develop their personal skills, a special place in communication skills. If these are improved, sensitivity to the concerns of internal and external clients and teamwork and organization cooperation are increasing.

13. Creating opportunities for future organization development. One of the major issues of introducing new quality concepts is the impetus for top managers to get immediate results. The T.Q.M. it takes a lot of time, energy and patience to change certain work habits and organizational cultures. If the company expects to get high results in the near future, employees will probably be disappointed. It is unrealistic to expect employees to abandon old values and behaviours just because managers ask for it.

14. Leaders and employees working in a team. Through their support for the implementation of the program, employees contribute to the justification or not of the chosen solution. Very often in the case of T.Q.M. implementation, the employees are the clients of the leaders, and they must see the organization with the eyes of the subordinates. Ideally, in the end, the two groups, managers and employees will develop a common understanding of the operational impacts of the program.

15. T.Q.M. it's not just a passing illusion. Some sceptical specialists have claimed that T.Q.M. is just a whim, a concept that will be replaced in a few years. This attitude has to be avoided because it can decisively influence the final results of the program.

In conclusion, total quality management focuses on the total satisfaction of internal and external customers, by emphasizing the role of quality in design and defect prevention. The overall goal is to reduce costs, eliminate losses, and develop relationships with and between employees and customers.

8.1.2 Standardization in quality assurance

The issue of normalization in quality assurance can be divided into two aspects: the existing provisions in STAS, normative, ISO norms, etc. and normalization of control activity itself.

From the point of view of the first aspect, based on the adherence of the Romanian Institute for Standardization to the European Committee for Electro-technical Standardization, as well as to the International Terminology Network, in our country were adopted the norms of the series ISO 9000 series EN 29000 and EN 4500 series, including them in the Romanian Standards Nomenclature. An example of adapting Romanian standards to ISO 9000 - 9004 is presented in Fig. 8.2.

As can be seen from the figure, the provisions of ISO 9003 refer to general issues regarding the quality of production: quality system adopted, production control, traceability, quality control of products, handling, storage, packing, delivery, control of equipment, calibration and calibration of measuring and control devices, quality records, statistical processing of measured data, training of personnel involved in this field, all under the name of **final inspection;**

ISO 9002 focuses on control and corrective actions required for marketing, supply, production, internal audits under generic control;

ISO 9001 specifies actions for **quality assurance** of design and post-sale activities entitled quality assurance;

All the **quality management** provisions are covered by ISO 9004.

The implementation of **ISO 9000** in Romanian organizations has the following advantages: increasing customer satisfaction, increasing efficiency of work, employee involvement is a motivating action for them, a more efficient and prompt internal organization, a stable position in the domestic market and the possibility of penetrate the European community market, higher profits, etc.

However, **ISO 9000** certification involves four cost categories that the organization has to bear: financial costs, commitment costs, cultural costs, and time-related costs.

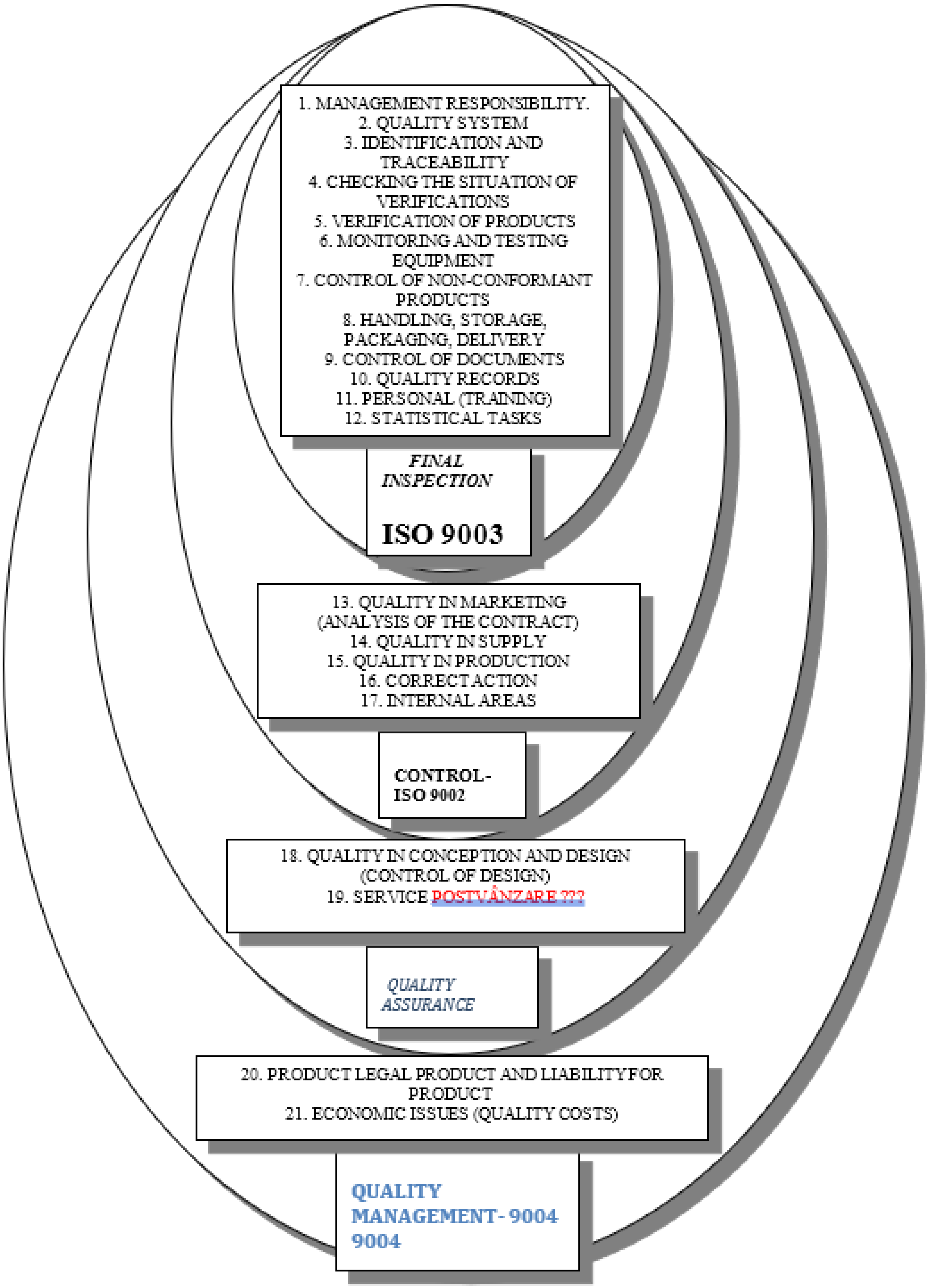

Fig. 8.2. ISO 9000 quality system requirements

Financial costs include: enrolment and evaluation fees to the certification body, annual certification and supervision fees of the certification body, costs of various evaluations and audits, additional staff costs and internal and external consultants, production costs initially reimbursed, costs with the purchase and maintenance of various equipment and materials, etc.

The cost of the commitment includes the costs of allocating human, financial, time, effort and training resources, the cost of delays and potential contractual disagreements, and after obtaining the certification.

Cultural costs are due to the necessary cultural changes in most organizations seeking the adoption of the ISO 9000 system. Often these involve restructuring the entire organization, abandoning all the old methods and adopting some completely new ones. Practically, this cost is manifested in the form of irreversible change in the identity and culture of a firm, and therefore a pertinent analysis of the opportunity / inopportunity to achieve this goal is necessary.

Time related costs are due to the fact that even for small businesses with a relatively simple quality system, it takes a few months to get the certification. Large companies sometimes need a few years to choose the operational profile and depreciate the amount of resources allocated to the project. One aspect is that all company personnel will be involved in one way or the other and most employees will have to spend a great deal of their time on this project.

However, **ISO 9000** certification becomes an essential condition for organizations that want to have a significant share in the domestic and / or international market.

From the second point of view: normalization of the work of control activities, we distinguish two major components:

A. Normalization of activities concerning the design and implementation of the quality assurance system;

B. The actual normalization of control activities in the manufacturing process;

In the first case, it is an activity of conception that includes: the study of the market for the new product or service, their feasibility study, the elaboration of the constructive solutions for the new product / service, the design of the manufacturing and control technology, the design regarding the production system management and the quality assurance system, their implementation, control and regulation within the enterprise, can be used to determine the relation of work volume - [Popa H., Dumitrescu C., Sabău C., ş.a. - 1993].

$$\mathbf{M} = \mathbf{E} + \mathbf{N_i} \times \mathbf{K_i} \times \mathbf{K_f} \times \mathbf{K_S} \times \mathbf{K_e} \text{ (average convention hours)} \quad (8.1)$$

in which:

- **E** - workmanship for the preparation of the conception works;
- $\mathbf{N_i}$ - the basic physical work standard, determined according to the degree of complexity of the product / service;
- $\mathbf{K_i}$ - correction factor taking into account the purpose of the activity (taking into account the complexity of the conception activity, the complexity of the calculations made, the constructive variants);
- $\mathbf{K_f}$ - correction factor depending on the nature of the activity and the design phase;
- $\mathbf{K_S}$ - correction coefficient for special design conditions;
- $\mathbf{K_e}$ - correction coefficient that takes into account the destination of the paper.

Once the work consumption calculations have been completed for each stage of the technical, technological and organizational design process, the programming of the activities takes place over time.

In the second case, you can apply any of the following methods:

- **The timing of the control activity**, consisting in analytically and systematically critical measurement of the duration of the elements of a production process, which is repeated identically at each controlled product unit. It can be continuous, repeated, selective or selective grouping.
- **Taking control of the control activity** is the method of measuring and analysing the duration of non-productive elements of the control process. It can be individual when pursuing the activity of an individual controller or group (collective) when the control operation involves teamwork.
- **The timer control activity** is the timing and method that combines photography, used to analyse the usability of the working time of the controller components and

establishing targeting works with high degree of repeatability. The results of the observations are transferred to **a timer of working time.**

- **Instantaneous observation** is the method of measuring and analysing time by recording at certain intervals the time activity of one or more performers in order to determine the weight or duration of control elements.
- **Filming** is a method that highlights both the duration and the way in which the control activity is carried out.
- **The Motion Time Norms System (MTM)** is a normative system (most advisable to apply to control activities) that decomposes any control or basic movement work required to execute, giving each movement a normative time predetermined.

There are three distinct MTM1, MTM2 and MTM3 variants depending on the number of base movements 24, 9 or 3 for the head, body, upper or lower limbs. Normative aspects of the quality assurance system must, in order to be effective, correlate with production, design and manufacturing activities. It is necessary to establish a unitary system of standardization at the company level.

In the case of specific normative control of different control activities, normative groups can also be used. There are several sets of norms that can be used to develop the rules for control activities:

1. Combinations of the MTM system with normatives for general purposes:

- the USD system and the universal normative system;
- the MSD system, ie. the system of fundamental norms;
- the MTM - GPD system, ie. the MTM normative system for general purposes, developed by the MTM Association for Norms and Research;

2. Groups of norms on elements of two different types, ie. normative on elements established on the basis of time studies by timing on individual control activities, combined with normative groups that serve to elaborate the norms for other similar activities;

3. Normative by elements covering common parts of a number of categories of control activities;

4. The norms on works or various theoretical formulas for setting the time norms can be deduced from the previous cases, leading to norms with values close to the timed or filmed ones. Formulas are deduced by combining norms into elements so that time rules are developed to execute a specific part of a control activity that is not a full operation or a full norm;

5. Normative for control operations performed at the bank.

However, it is particularly difficult to standardize rules and norms on control activities. They differ according to the specific nature of the enterprise, even if from the outset the data are set to be of a universal nature and not specific to or limited to a certain work, the time on the elements determined on their basis must be determined with care; they must be based on thorough and obvious analyses, specifying their application and their limitation, so that these norms can be successfully applied in other enterprises as well.

8.1.3 Methods of product and production quality analysis

Quality analysis is a particularly important activity within the framework of an enterprise's quality assurance cycle. Quality analysis activity involves analysing an inappropriate current state in identifying ways to intervene to reach an acceptable future state. Solving both problems involves going through a universal cycle: elementary information (symptoms) - analysis - diagnosis - developing several solutions - choosing the optimal solution - applying in practice - final adjustment actions.

In the above approach, two errors can be avoided: the wrong formulation of the problem and the rapid application of a proven solution that is not optimal over time. In order to avoid them, the methods of product and production quality analysis are used, which are divided into: *general methods of quality analysis; specific methods of quality analysis.*

A. The main general methods of quality analysis

There are many general methods of quality analysis, but the most commonly used and applicable in quality circles are:

a) The method of confrontation (brainstorming)

It is a group practice that consists in recording ideas in an appropriate way and evaluating them after the meeting. It is used to identify the possible causes of a problem and find solutions to eliminate or improve existing situations. A few basic rules must be observed:

- an idea can only be considered wrong after being analysed in a group;
- an idea is not criticized immediately;
- an idea is not immediately argued;
- the group leader encourages the delivery of as many ideas as possible, which are then selected in order to establish optimal solutions through deepening, association, development or improvement;
- the more unusual the ideas are, the better it is.

Finally, solutions can be found to solve problems or improve an existing state.

b) The method of the cause-effect diagram

It is also known as the Ishikawa diagram or fish-form diagram. It allows the precise identification of the causes of the deficiencies with the help of the existing relationships between the qualitative characteristics and the respective causes and their classification by families (the 5M): working hand, method, means, material and raw material.

When constructing the cause and effect diagram, a distinction will be made between the factors obtained by the measurements and those determined by the calculations:

- *Factors obtained through measurements*: temperature, current voltage, lengths, fluidity, time, etc.
- *Factors determined by calculations* and classified on machines, teams of workers, exchanges, raw materials and materials, lots of products, etc.

What is important to analyse is not the cause of deficiencies, but how to eliminate them. For the construction of the cause-effect diagram a working session should be organized in which all the involved staff participates, creating a favourable environment for the exchange of ideas and information.

c) Quality circle method

This method is especially used in the Japanese industry to identify an optimal solution when the problem data are qualitative. Ideas are based on responses in circles with different selection criteria. At the common intersection of all these circles can be found, the solution to the problem originally stated.

d) Matrix methods

Several variants may appear, of which the most important are: the Discovery Matrix Method and the Simple Matrix Method. The first consists of a combination of two factors and is used to look for new solutions, products, product quality or service enhancements.

The matrix is in the form of a double-entry array in which different variables are combined horizontally and vertically. It is possible to construct the matrices of technical discoveries **(Table 4.2.**) or technical-economic through which we analyse a large number of variants to solve the problem:

Table 8.1. TECHNICAL DESCRIPTION MATRIX

LIST A / LIST B	LATHE	HORIZONTAL FREQUENCY	EXTERIOR RECTIFIER MACHINE
LATHE	STRUNG MULTIAX	PROCESSING CENTER	PROCESSING CENTER
VERTICAL FREQUENCY	PROCESSING CENTER	UNIVERSAL FREQUENCY	PROCESSING CENTER
INTERNAL RECTIFIED MACHINE	PROCESSING CENTER	PROCESSING CENTER	UNIVERSAL FREQUENCY

Simple matrix is a method similar to the previous one. An array is constructed in which all variants of a factor or parameter of a system, an object and a product are correlated with variants of another factor of the same system. Once the matrix has been finalized and the preferred combinations have been retained, they may be correlated with other variants of another factor in a new matrix, the process being repeated until a valuable solution is obtained.

e) Multi-voting method

It consists in organizing a seminar to find solutions to improve the quality of products or services involving all persons involved in the design, production, delivery, operation, maintenance and repair of the system.

All the elements that can influence the behaviour of the system are listed, trying to determine a causal relationship between them. Then, for each major cause, solutions are issued, which are noted without being commented. From the solution groups, by awarding a score, a solution is chosen to solve a cause.

The chosen solutions are then discussed, and pertinent additions can be made that determine the optimization of the chosen partial solutions. The final results then apply in practice. The method is particularly effective in improving reliability and maintainability.

f) Pareto Diagram Method - ABC Method

The ABC method consists in analysing a curve that graphically illustrates Pareto's law and is called the ABC curve because it has three distinct domains determined by inflections of the curve, as seen in Fig. 8.3. where the theoretical diagram of the total loss due to qualitative deficiencies of production equipment over a certain period (Tpc) according to the percentage of failures by classes (a, ..., j).

The steps of applying this method are:

- defining the phenomenon and its specific parameter, in our case the failures of productive equipment and their causes;
- establishing the values of the specific parameter;
- classification of components of the phenomenon investigated by an ABC logic, in descending order of the specific parameter;
- determining the cumulative value of the specific parameter;
- determination of the three groups of ABC significance;
- graphical representation of the phenomenon using the ABC curve.

It has been noticed that most equipment has several fault categories, of which usually two or three categories A, B, C comprise about 80 - 98% of the total defects. Three areas are distinguished:

- field A, which contains a small number of causes of failure, but whose frequency is high (80,5%);
- field B, which contains a number of causes causing relatively average failures, the frequency of which is 14%;
- field C, which contains a large number of failure causes, the frequency of which is relatively low (5.5%).

It is thus demonstrated that the hypothesis that the causes of any failure are unlimited is false, noting that only two or three of the possible causes exert a decisive influence on the final quality of the equipment. Once the causes of high-defects have been identified, by eliminating them, the overall percentage of quality defects decreases, costs are reduced, and in-service behaviour and equipment performance increases their productivity.

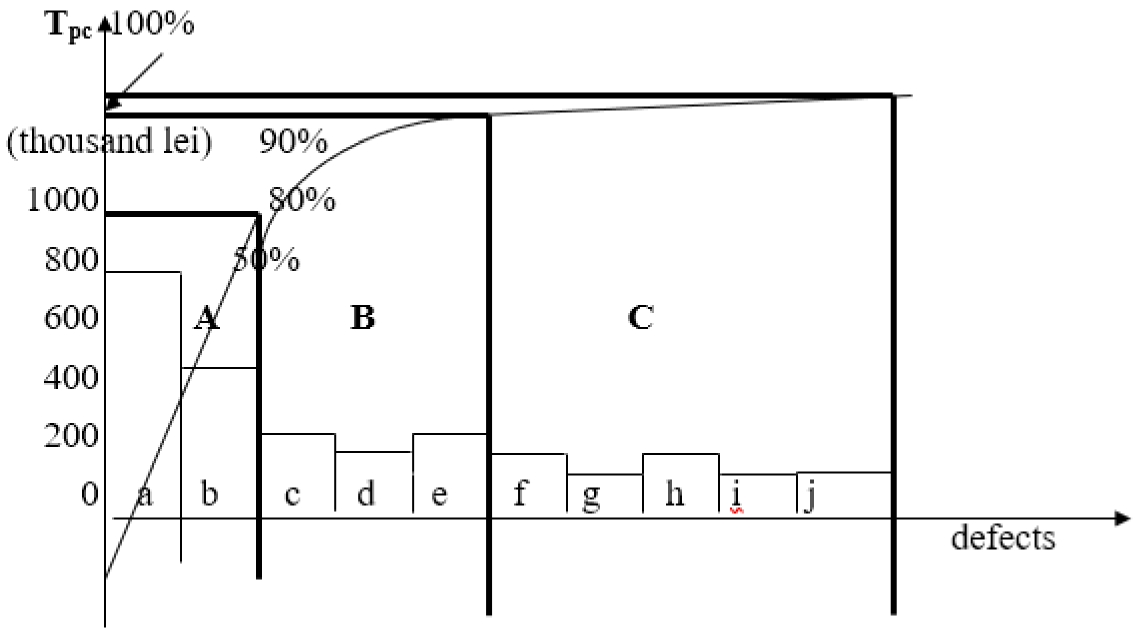

Fig. 8.3. ABC chart

B. The main specific methods of quality analysis

The main specific methods used to analyse the quality of products and production are presented in **Table 4.3.**

Table 8.2. SPECIFIC METHODS OF ANALYSIS

NAME OF THE METHOD	THE MAIN OBJECTIVES OF THE METHOD
Method of Statistical Process Control	Increased reliability of products and processes
Method of maintainability analysis	Increase equipment reliability and maintenance
The method of series changes of all factors of quality influence	Reduce adjustment times to series changes
The method of analysing weaknesses and their effects until the critical state of the system is reached	Reducing the risk of falls
Taguchi methods	Simplification of experiments

a) Method of Statistical Process Control

It is the method of analysis based on the statistical interpretation of the data. It allows, based on a small number of measured values, to diagnose the overall behaviour of the systems and to identify possibilities for improving their performance. The use of this method presupposes for the characteristics studied a variation according to a normal law (Gauss's law) allowing the appreciation if:

- the system is capable of producing according to the specifications in the technical and execution documentation;
- process management during manufacture is possible.

Based on these, it can be concluded whether the system meets the initial control list.

b) The maintenance review method

Topo Maintenance is particularly prevalent in the Japanese steel industry. This systemic method tends to bring a plant to maximum efficiency throughout its lifetime through the joint work of all individual services or workers within an enterprise (preventative maintenance activity).

Is based on:

- the responsibility of the users for the proper functioning of the equipment, equipment, installation;
- overall yield.

c) The method of series changes of all factors of quality influence

This is the method to reduce the time due to series changes, based on simple observation and group work of operators. It changes one of the system's influence factors one after the other, keeping the others steady and measuring the different results that appear. The measured values are analysed and steps are taken to improve the process.

d) The method of analysing weaknesses and their effects until the critical state of the system is reached

It is a prevention method that allows you to estimate the falls that may occur and how to avoid them. Each potential fall is characterized by:

- probability of occurrence "A";
- probability of "N" un-detectability;
- gravity estimated by users "G".

The product of the three coefficients is the **criticality index** "C". When it exceeds a predetermined limit, corrective actions are expensive and delayed.

Everything involves a group activity of people trained in the field who know the system and can provide relevant information analysis.

e) Taguchi methods

For 25 years, Genichi Taguchi has developed these methods based on the creation and implementation of **quality plans**. Taguchi's philosophy is formulated from two main ideas:

- **all processes or products in which a characteristic deviates from the optimum value implies a loss for the company itself, even if this characteristic remains within acceptable limits (**the company being broadly considered as the supplier + manufacturer + customer);
- **all processes or products are subject to factors that, if unchecked, become disruptive. These disturbances are all that is likely to cause a quality indicator to cause a fall. An insensitive product to disturbance is a robust product.**

Taguchi proposes to improve total quality management (T.Q.M.):

- value optimization of the process or product operation factors;
- choosing a minimum cost for less important factors;
- designing insensitive processes or products to ultimately achieve them (robust).

8.1.4 New methods for analysing the quality of products and production and possibilities for application within the Romanian companies

These methods have been taken over from Japanese school and have been widely used in Europe since 1990 and are generally based on **teamwork** and **consensus on addressing** quality improvement issues. They are presented together with the areas of application in **Table 4.4.:**

Table 8.3. NEW METHODS IN ANALYSIS OF EQUIPMENT QUALITY

NAME OF THE METHOD	AREAS OF APPLICATION OF THE METHOD
Method Meta plan	Increased reliability of products and processes by identifying optimal solutions both in the design and production phase and in the exploitation phase
Relationship Diagram Method	Especially in the design and redesign phase of equipment, machinery and equipment
The matrix diagram method	Establishing the optimal order of events
The Tree of Possibilities Method	Improving the performance of various productive equipment especially during the exploitation phase
Decision Diagram Method	Programming quality decision-making processes
Pert Chart Method	Optimization of real-time planning of maintenance and repairs of equipment
Method of Factorial Analysis of Falls	Determining the main variables that influence quality and developing a plan of measures to increase the quality, reliability, maintainability and availability of equipment

a) Affinity Diagram Method

It is also known as the Meta plan method. Particularly important is the role of the moderator who has to coordinate the team's work towards achieving the original goal. This method is more sophisticated than the cause-effect method in addressing important business issues, and should be applied to issues that improve the maintainability, reliability, or availability of the system.

Its originality lies in the technique of communication and the stages involved:

- a clear and concise presentation of the problem to be solved and the formation of a team willing to work to solve it (a representative of the designer, suppliers, manufacturer, traders, users, staff who arrange the system's adjustment and repair, an economist, a psychologist, etc.);
- choosing the venue, date of the seminar and moderator;
- starting from the problem solved, the participants issue ideas on cardboard pieces;
- the ideas are collected, read by the moderator and then grouped according to the "similar ideas" criterion on families;
- giving a name to each family and marking these preliminary results;
- identifying possible links (relationships) between them;
- each participant gives 3 points the most important idea, 2 points of the second place and 1 point of the 3rd place;
- the ranking of the importance of these families after multiple voting;
- for the most important families, teams formed of 3 to 5 members;
- identifying within these teams the current situation of the family of analysed issues, the future evolution, the restrictions that block this evolution and the issuance of concrete solutions for their elimination;
- presenting these solutions to the group, discussing and analysing them jointly;
- choosing the optimal solutions to be implemented immediately;
- applying solutions, tracking the results obtained, corrective actions.

b) The Relationship Diagram Method

It resembles the causal tree method, a method commonly used in value analysis and engineering.

It consists in asking several times the question "Why?" and accepting that the answers to these questions are the causes of the observed phenomena. Each case is again asked the previous question and identifies other particular causes that produce the phenomenon – Fig. 8.4. The method continues until the elementary causes of the phenomenon are identified.

Basically, every general problem is divided into derivative issues then detailed in specific problems determined by specific causes. Solving all the specific causes leads to solving the derived problems, and then finding the optimal solution to the general problem.

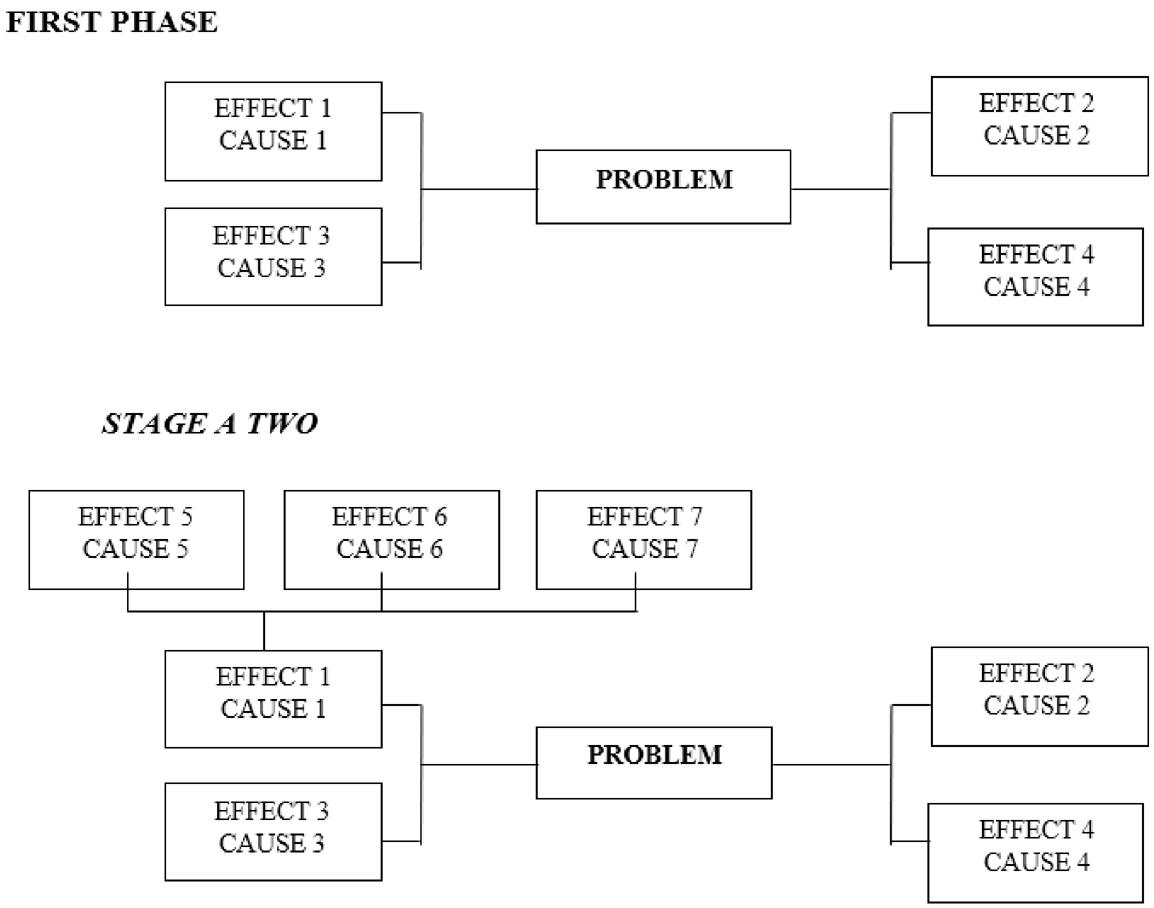

Fig 8.4. Relationship diagram

c) The matrix diagram method

This method allows you to visualize and analyse existing relationships between the events that occur in the process to identify all of their features. It differs from the simple matrix method by comparing events with criteria, established and evaluated initially, two by two.

Initially weightings are established for the established criteria. Then a coefficient (3 = strong, 2 = medium, 1 = weak) is given for each event in relation to each criterion, multiplied by the originally established weight. Summarize partial products and get a score for each event. Based on these scores, an event hierarchy is finally obtained, as shown in **Table 4.5.:**

Table 8.4. MATRIX DIAGRAM

MATRIX DIAGRAM							
	CRITERIA						
WEIGHT	**1**	**2**	**3**	**4**	**5**	**TOTAL**	**PRIORITIES**
	1	**1**	**1**	**2**	**3**		
EVENT 1	@ (3x1=3)	& (2x1=2)	& (2x1=2)	& (2x2=4)	@ (3x3=9)	20	2
EVENT 2	& (2x1=2)	& (2x1=2)	# (1x1=1)	# (1x2=2)	# (1x3=3)	10	3
EVENT 3	@ (3x1=3)	@ (3x1=3)	@ (3x1=3)	@ (3x2=6)	@ (3x3=9)	24	1
SIGNIFICANCE AND VALUE OF SYMBOLS: @ POWERFUL, VALUE 3 & MIDDLE, VALUE 2 # WEAK, VALUE 1							

After processing the results, the order of events is: Event 3, Event 1 and Event 2.

d) The Tree of Possibilities Method

The method is based on centralizing, analysing and optimizing answers to the questions: How do we improve? It is a method of analysing the ways to achieve objectives, used especially in the areas of total quality and total productive maintenance, considering that for each problem to be solved there are several sub-problems which, arborescent, can be broken down successively and for which there are possibilities of improvement.

On the tree, each action at a certain level becomes a goal to be achieved at the lower level. This makes it easier to identify the possibilities for improvement and can effectively set up an action plan.

e) Decision Diagram Method

It is also known as the programming of decision-making processes and is based on a schematic diagram of a process, starting from a situation to solve a future situation.

At each intermediate stage, the problems that arise must be provided and solved. This allows time to run the forecasting process, identifying possible solutions that have already been applied.

f) Arrow diagram or Pert method

It resembles the previous method, analysing a process between a past and future situation and identifying what actions are actually to be carried out in the intermediate stages.

The factor that can be optimized is the time factor, particularly important in complex crisis situations. This method allows you to optimize a real-time planning activity and quickly detect delays that may occur.

g) The method of facial analysis of falls

It is a particularly complex method that requires the possession of solid knowledge of mathematical statistics and computer use. In short, it consists in determining several variables that influence the quality of the system, and based on them, a plan of measures can be developed to increase quality, reliability, maintainability and availability.

Any of these methods can be used in the analysis of production and product quality, total productivity maintenance, or improved reliability. Art is to choose the method that ensures maximum efficiency in solving the problem.

The study of these methods identified important areas where these methods, proposed in **Table 4.6.**, can be applied with very good results:

Table 8.5. THE MAIN FIELDS OF APPLICATION OF METHODS IN EQUIPMENT QUALITY ANALYSIS

NAME OF THE METHOD	AREAS OF APPLICATION OF THE METHOD
Brainstorming	In solving any problem that has arisen in the design, manufacturing or operation phases of the equipment
The cause - effect method	When identifying ways to remove the various causes that cause equipment failures that may occur in the design, manufacturing, or operating phases
Quality circle method	At any stage to solve a qualitative problem of productive equipment
Matrix methods	Especially in the design phase, but also when looking for various new solutions in solving some damages resulting from the exploitation of productive equipment
Multi-Criteria Analysis Method	Identifying the optimal solution needed to solve a qualitative problem of productive equipment
Multi-voting method	At any stage to solve a qualitative problem of productive equipment
ABC method	Analysis of defects in the functioning of the equipment, its causes and identification of the main actions required, with immediate significant economic effects
Method of Statistical Process Control	Exploiting equipment by increasing reliability, maintainability and availability
Method of maintainability analysis	During the exploitation phase it increases the reliability and maintenance of the equipment
The method of series changes of all factors of quality influence	Particularly in the operating phase, reducing the time to adapt to series changes
The method of analysing weaknesses and their effects until the critical state of the system is reached	Both in the design and manufacturing phases and in the exploitation phase, reducing the risk of falls
Taguchi methods	In the design and manufacturing phase by simplifying the experiments
Method Meta plan	In the design and production phase and in the exploitation phase by identifying optimal solutions that increase the reliability of products and processes
Relationship Diagram Method	Especially in the design and redesign phase of equipment, machinery and equipment
The matrix diagram method	Establishing the optimal order of events
The Tree of Possibilities Method	Improving the performance of various productive equipment especially during the exploitation phase
Decision Diagram Method	Programming quality decision-making processes
Pert Chart Method	Optimization of real-time planning of maintenance and repairs of equipment
Method of Factorial Analysis of Falls	Determining the main variables that influence quality and developing a plan of measures to increase the quality, reliability, maintainability and availability of equipment

8.2 Particularities in the prognosis, organization, decision and control of product and production quality assurance

Prognosis and diagnosis of product or production quality are particularly important activities, which are based on the determination of costs with the ineffectiveness of the equipment used. The overall yield of a productive unit can be expressed as the ratio between the actual output produced and the theoretical output that can be achieved.
A careful analysis is based for a determined period on:

- **existing relative statistics on:**
  - serious damage and their causes, which determines the unavailability of the system;

- long-term falls, frequency and cost;
- other sources of unavailability of equipment, time required for preventive maintenance, possibilities for improvement, etc.;

➢ **loss of yield due to minor falls and lower overall system function level,** which are not always known and must be identified;

➢ **the cost of equipment** ineffectiveness previously recorded;

➢ **existing equipment in the reserve**, which may replace those defective or **existing buffer stocks.**

The quality of the forecast is also determined by the way this diagnostic analysis is performed, the team that performs it, the methods that use them, and last but not least the possibilities available to them.

The forecast also attempts to define the key information on the production sold and the level of costs. It is important to determine the influence of different equipment or equipment falls on the qualitative and quantitative level of production, the level of non-quality costs.
The essential elements needed to achieve the product and production quality forecast and their influence on reliability, maintenance, quality and production in general are outlined in Fig. 8.5.:

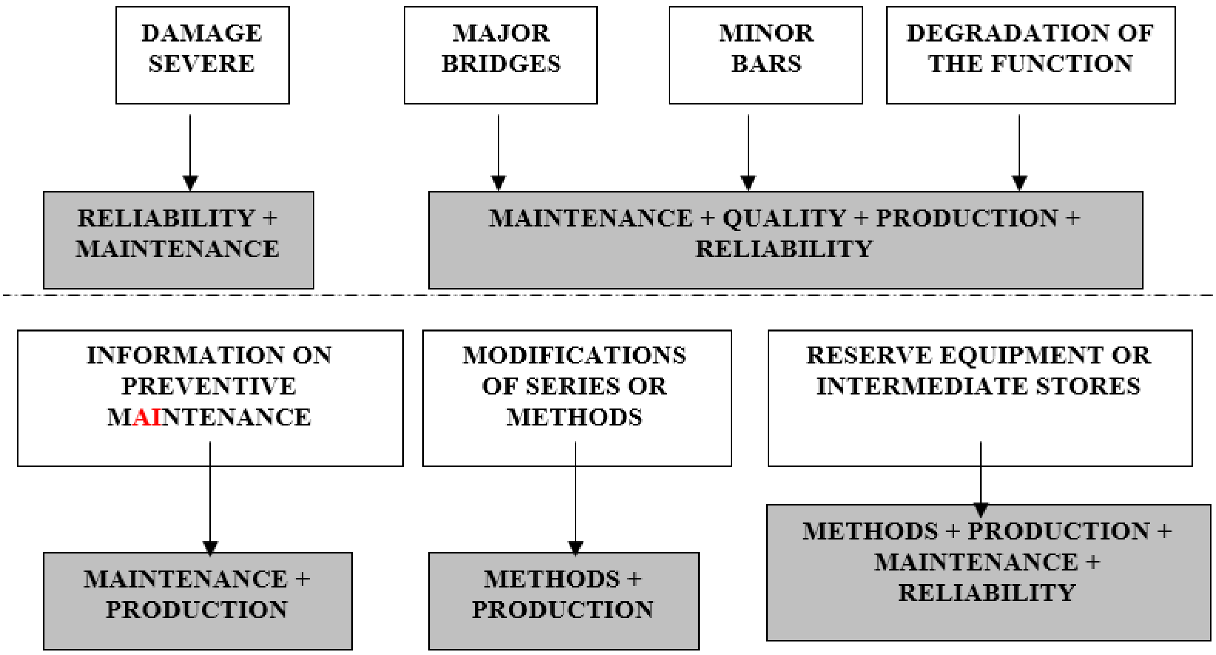

Fig. 8.5. The technical elements of the diagnosis

Determining the cost of equipment inefficiency can serve both for maintenance and for studying the various functions of the enterprise.

Serious breakdowns of various products may have catastrophic consequences (nuclear, air, maritime, rail, petrochemical or chemical accidents) and may result in total or partial destruction of the systems. Because of this, we cannot always study the reasons that have determined them. In these cases, costs for quality and reliability, or for identifying the best solutions, are much higher to avoid the risk of catastrophe.

The activity of forecasting both costs and quality indicators is particularly laborious. Interruptions in the long-term operation of equipment, machinery, or equipment are generally recorded and can serve a thorough diagnostic analysis. Partial falls also have micro-defects that are manifested by:

➢ momentary stops, with easy operation (auto-off in case of overload, qualitative abnormality, correction adjustment);

- idle;
- micro-drops.

Considered to be normal, the causes of these falls are generally unknown, but they cause decreases in plant returns. Estimation of the operation of these equipment can be done on the basis of a systematic observation and measurement. These measurements are useful in order to specify the variation of the quality indicators. They can be done either by instantaneous observation, by timing, or by automatic recording.

Part of the cost of non-quality is due to the poor functionality of the equipment. It is especially important to detect and estimate the underlying causes that determine them. These costs have as main components:

- costs due to internal malfunctions (refurbishments, scrap, repairs);
- costs due to external malfunctions (user complaints, warranty costs, recommissioning or returns);
- detection costs, related to the verification of conformity of products with precision and high importance with the technical documentation;
- costs due to prevention activities, to avoid or reduce the occurrence of other malfunctions.

Effective application of the results of diagnostic analysis and forecasting activities depends on the managerial team. It can appeal to the decision-making that is required in some particular instances of the unavailability forecast:

a) Continuous production lines with series-mounted equipment with no intermediate stocks – Fig. 8.6. - the total cost of unavailability being the sum of the costs due to the unavailability of the equipment (the costs of ensuring the reliability and maintenance of the equipment at the manufacturer during the experimentation and the user in run time + costs resulting from actual user equipment usage conditions + costs due to actions to ensure user maintenance).

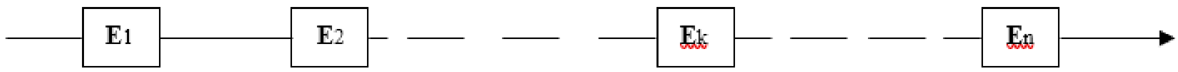

Fig. 8.6. Continuous flow production line with series-fitted equipment without intermediate stocks

They can thus forecast:

- costs of unavailability of each equipment and total unavailability;
- consequences of total unavailability: loss of production, additional costs for identifying and removing the causes that led to the occurrence of unavailability, contractual penalties.

b) Continuous production lines with series-mounted equipment with small intermediate stocks (S), but consuming a feeding time – Fig. 8.7. - The overall cost of unavailability is lower, but one of its components is the cost of storage.

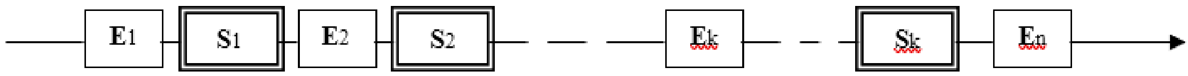

Fig. 8.7. Continuous flow line with serial equipment with small intermediate stocks

In this case, you can forecast:

- different times of the unavailability of various equipment;
- times due to total system unavailability;
- production losses;
- additional costs due to intermediate stocks.

By means of the Pert diagram, a critical path or the maximum delay that can occur in the real arrangement of the mixed equipment can be determined - Fig 8.8. -, marked with line):

And in this case we can forecast:

- time and costs of total unavailability;
- production losses;
- additional costs for identifying and removing the causes that led to the occurrence of unavailability;
- contractual penalties.

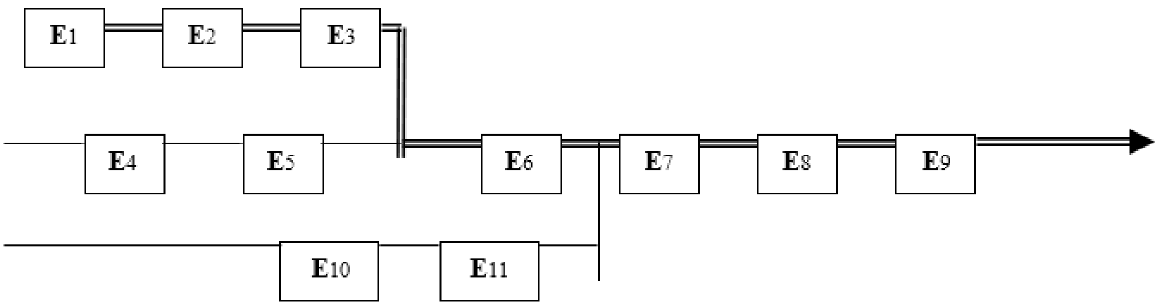

Fig. 8.8. Identifying the critical path in the real-world location of the equipment

Costs of unavailability may be diminished if there are other machines and equipment already purchased, although with different maintenance costs.

A particularly important issue is how the quality assurance department is organized within an enterprise. The official document drawn up by the quality assurance department of the quality management function of a company, which refers to the quality policy adopted within the firm, being closely related to the quality system, is called the **quality manual.**

Through the Quality Manual, the coordination and correlation of all internal factors involved in assuring the quality of the company's products or services is achieved.

In describing the organization of society, the hierarchical and functional organization chart, the informational and decision flow, the departments, the workshops, the offices, etc., are listed, each of them assigning the attributions and responsibilities related to the quality assurance.

Figure 8.9. shows a solution for organizing the quality department within an enterprise. Information flows from bottom to top, while decisions are passed from the department head to services or offices. Between these services and offices there must be a permanent exchange of information on the quality and production process.

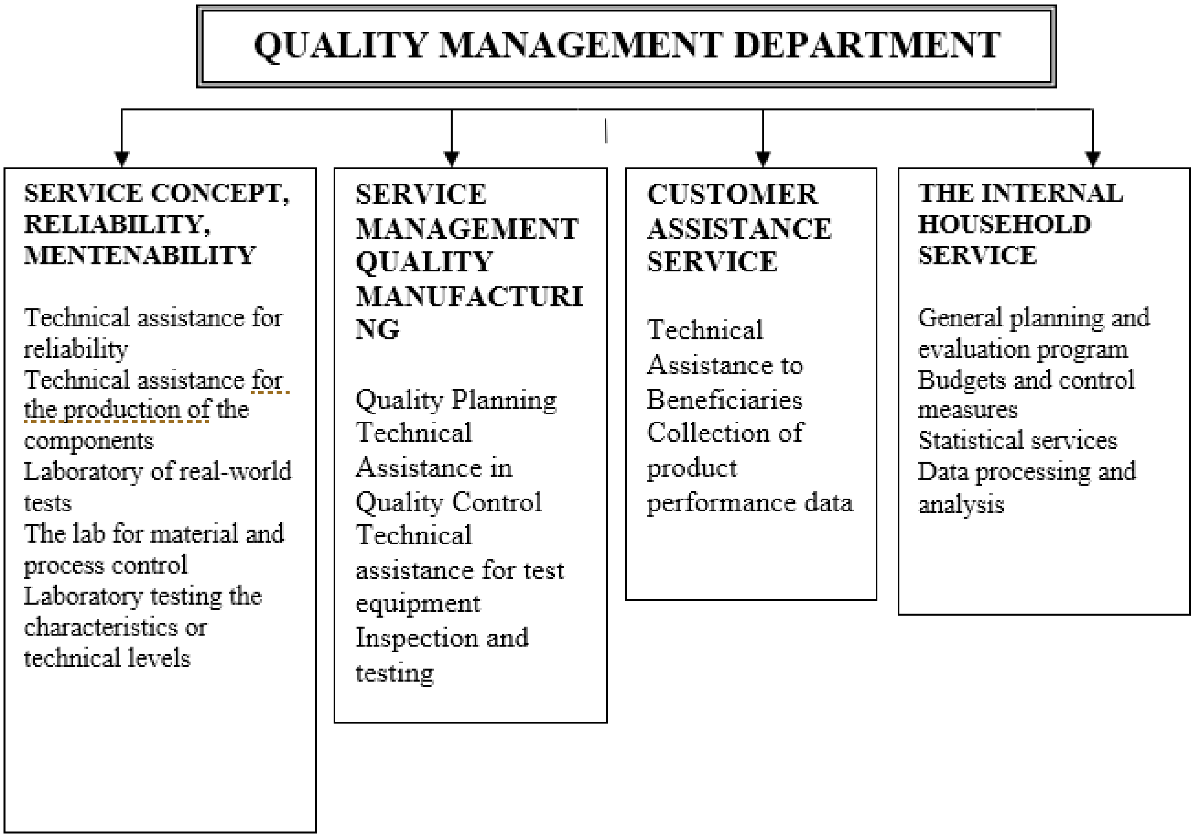

Fig. 8.9. Organization of the quality assurance department

Another variation of the organization chart for the quality department is shown in Fig. 8.10. Every member of the team must participate in each department or department in the preparation and implementation of decisions. The decision will generally be taken by applying multi-criteria methods, taking into account all the factors that can influence the process.

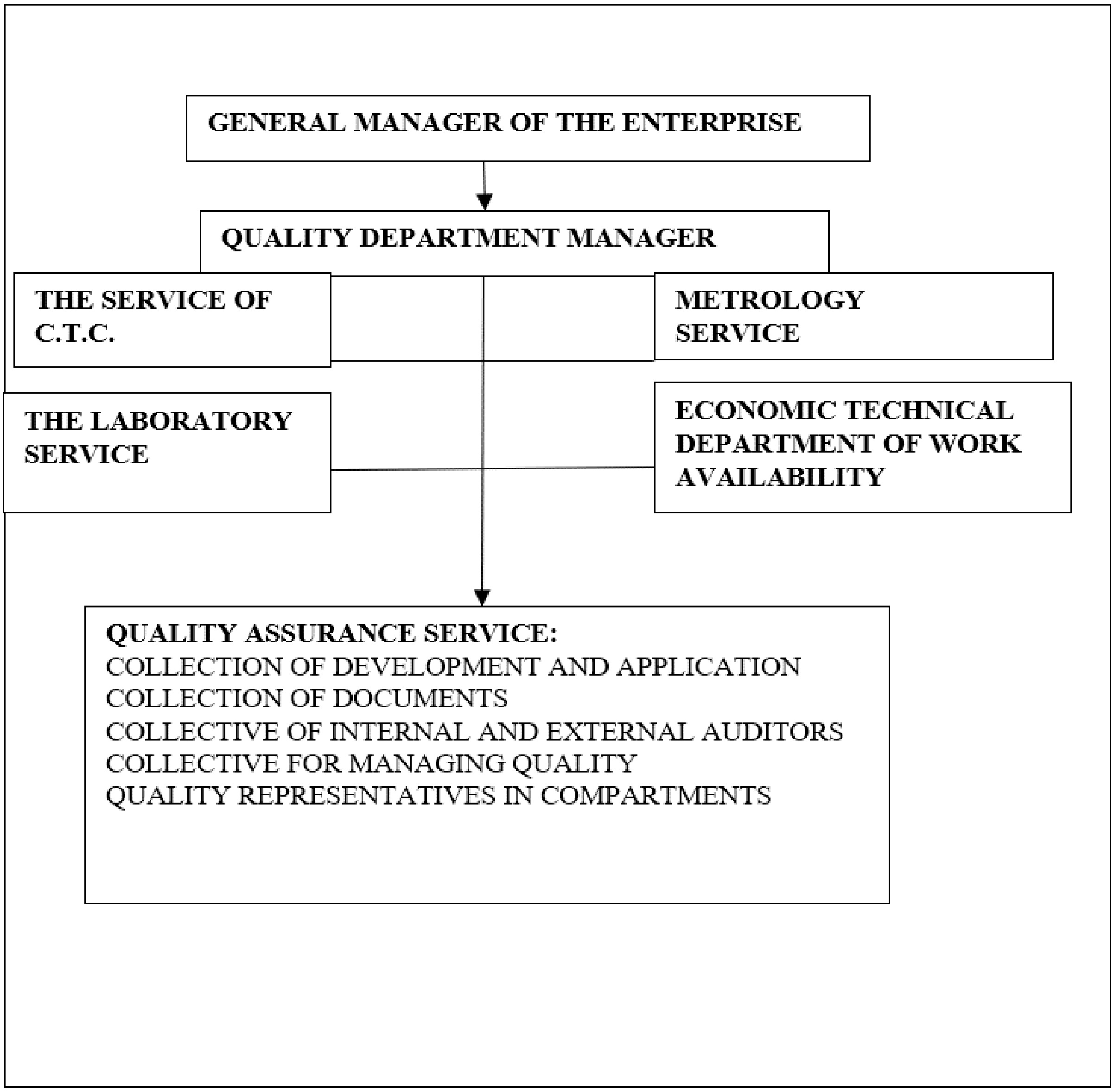

Fig. 8.10. Organization chart of quality assurance in enterprises

Without going into detail, it should be noted that the organized and consistent way of quality assurance and control of products and services within an enterprise is reflected in **quality plans / quality control, testing and testing plans (PC / PCCVI).**

Based on the behaviour of the products in operation, the observations received from the production compartment, the modifications imposed by the beneficiaries' requests, the last component of a managerial cycle, **the function of the system regulation, is made**.

The realization of this function is based on the methods of quality analysis combined with engineering methods and value analysis, with multi-criteria optimization criteria and, last but not least, according to the possibilities of the enterprise.

Quality assurance in an enterprise must provide products and production with **certainty, formal guarantee and total trust.** It is a set of prior and systematic actions needed to make sure the product or service delivered meets the quality requirements. This is achieved on the basis of planning, implementing, achieving and maintaining the quality level required by the consumer.

In a business, the quality assurance management cycle is translated into:

- **a quality assurance plan for the synthesis of problems**, the maintenance and progress of the quality management system;
- **relevant and applicable procedures and instructions**, which imply competence, rigor and intellectual honesty;
- **an adequate information system** to provide information and decision making in optimal timing;
- **a permanent client-to-door customer or external contact between all departments**, offices, workshops of the enterprise, identifying all aspects of non-compliance with clear requirements, in order to ensure the necessary progress and corrective actions;
- **concerted audits in enterprises** to achieve optimization of the quality system at the required level.

I.S.O. 9000 provides for optimal methods of quality assurance within industrial enterprises, but it must be adapted to the specificity of Romanian enterprises and markets, developed in a turbulent environment. The design of the quality assurance system should be based on identifying customer needs in order to ensure the beneficiaries' loyalty to the products or services of the enterprise and, obviously, the sale of these assortments.

REVIEW QUESTIONS

1. What is Total Quality Management? 70
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9 QUALITY MANAGEMENT SYSTEM (QMS)

9.1 QMS - Definition, Features, Principles

THE QUALITY MANAGEMENT SYSTEM (QMS) consists of: **THE ORGANIZATIONAL STRUCTURE, RESPONSIBILITIES, PROCEDURES, PROCESSES AND RESOURCES REQUIRED TO IMPLEMENT QUALITY MANAGEMENT** at the level of an enterprise or production structure.

The implementation of QMS is a "long-lasting" activity in the sense that it is based on a structure with a detailed planning of the activities necessary to ensure the ultimate success. At the same time, **it should be noted that the working team will include the specialists in planning the activities necessary for the establishment and implementation of the QMS, which will collaborate with the managerial team of the enterprise in order to develop the best solutions.**

In order to understand better the usefulness of implementing a QMS, some relevant aspects have to be considered:

- *QMS MUST BE SUFFICIENT AS YOU NEED TO SATISFY OBJECTIVES WHICH ARE QUALITY.*
- *QMS IMPLEMENTATION OF AN ORGANIZATION IS DESIGNED FIRST TO SATISFY THE INTERNAL MANAGERIAL NEEDS OF THE ORGANIZATION.*
- *QMS IMPLEMENTED MUST BE BETWEEN THE REQUIREMENTS OF A NECESSARY CLIENT. THIS IS TO EVALUATE ONLY QMS'S POSITIVE, REMEDIAL (INTEREST) INTERESTS. THE EFFECTS OF THE IMPLEMENTATION IN THE ENTERTAINMENT RADIATION, AS A PICTURE, STRICTLY OUTSIDE THEM.*
- *FOR CONTRACTUAL OBJECTIVES OR OBLIGATIONS IN CUSTOMER RELATIONS WITH REGARD TO QUALITY ASSESSMENT, YOU MAY BE REQUESTED TO DEMONSTRATE THE IMPLEMENTATION OF QMS IDENTIFICATION ELEMENTS.*

For the correct implementation in an enterprise, the team must be aware of the following information with reference to the QMS, and its position vis-à-vis the user:

- One of the QMS's core objectives is **continuous improvement of the quality of the company**.
- QMS MUST BE PERIODICALLY SUPPORTED TO MANAGEMENTIAL **ANALYSIS** AT THE HIGHER LEVEL AND INTERNAL **AUDIT**.
- **REGISTERS** OF THESE **ANALYSES AND AUDITS** MUST BE (ARCHIVED).
- QMS MUST BE **DEFINED AND DOCUMENTED.**
- It is **normal** to work out a plan and **to control** the processes in order **to obtain the results desired**, at **a time** and with **a minimal cost**.
- THE CAPABILITY TO **PROVIDE OBJECTIVES** OF QUALITY OBJECTIVES IN **A PLANNED, CONTROLLED** MODE MUST BE EXCLUSIVED.
- THE CAPACITY OF **DEMONSTRATING** THE EFFECTIVENESS OF **CORRECTIVE ACTIONS** MUST BE EXTENDED.

In the design and implementation of a QMS, SEPI will observe basic principles:

1. **PHILOSOPHY** OF QMS ACHIEVEMENT IS: PREVENTION AND NO CONCLUSION.
2. **TREATMENT** OF PROBLEMS VISITS **ALL MANAGERIAL LEVELS**, INCLUDING AT LEAST MANAGEMENT.
3. **THE RESPONSIBILITY** OF THE QMS CONCEPTION / IMPLEMENTATION RETURNS ALL THE EMPLOYEES OF THE ENTERPRISE, THAT ALL ARE RESPONSIBLE FOR QUALITY.

4. **THE EFFICIENCY** OF THE EVALUATION IS ASSURED BY ANALYSIS OF QUALITY COSTS COVERED BY QMS DESIGN / IMPLEMENTATION REPORTED IN THE ANNUAL IMPLEMENTATION ECONOMIES.

5. **THE STANDARD** TO WHICH THE QMS IMPOSES IT, MAINTAINS:
ANY ACTIVITY IS REALIZED, INDEPENDENTLY OF DESTINATION, STRUCTURE, CONSUMPTION OR COST, IT MUST BE FIRST OF THE FIRST TIME.

6. **QMS APPLICATION** SCOPE WELCOMES THE ORGANIZATION.

7. **THE FOLLOWING OBJECTIVE** IS A CONTINUOUS IMPROVEMENT OF ACTIVITIES AT THE LEVEL OF THE ORGANIZATION
TO FULFILL THESE PRINCIPLES, THE AVAILABLE HUMAN RESOURCES MUST BE CONSIDERED BY THE LINE:

- INSURANCE OF A GOOD COMMUNICATION,
- ACCEPTING THE WORK IN THE TEAM, AND AWARENESS OF THE NEED FOR CONTINUOUS TRAINING.

Following the QMS implementation, users count on the occurrence of favourable effects, generated by the diminution of certain disturbing factors in the process, along with the development, strengthening of positive stimulating factors, as outlined in Table 5.1.

Table 9.1.Favourable outcomes expected from the QMS

AIM	***DIMINISHES***	***ZOOM IN***
CUSTOMERS	COMPLAINTS	FIDELITY
COMPANIES	COSTS OF NON-CALCITY	VALUE ADDED
CONTRIBUTORS	REMEDIES	LABOR SATISFACTION
MANAGEMENT	DISORGANIZATION	PREVENTION
MARKET	REF. NEGATIVE	NOTORIETY

9.2 Efficiency of QMS implementation

The studies carried out in the field of QMS implementation have highlighted everything "The industry of the world", the fact that an essential component of the success of companies is due to the correct and effective implementation / implementation of QMS. The question is:
WHY SUCCESS COMPANIES SHOULD A SIGNIFICANT IMPORTANCE SMOKE?
The answer has two essential components:

- The first part of the answer derives from the observations synthesized below:

1. THE CUSTOMER EXPECTATIONS IN CEE REGARDS THE QUALITY OF
CRESCENT
PERMANENT

2. CLIENTS WHERE TO MORE OF SUPPLIERS AN OFFICIAL CERTIFICATION OF QUALITY SYSTEMS USED.

3. COMPETITORS ON THE SAME MARKET STRENGTHEN THEIR QUALITY COMMITMENT.

4. THERE ARE THAT THE SUCCESSFUL GROWTH OF MARKET ACTIONS WILL MEET THE CONFORMITY OF THE REQUIREMENTS RELATING TO QUALITY.

5. COST REDUCTIONS ARE IN THE MAJORITY OF CASES IN THE QUALITY ASSUMPTION.

6. IT HAS MORE FREQUENTLY IMPROVED THE PRINCIPLE THAT MANUFACTURING A PRODUCT OR REALIZING A WELL-FIRST DAY

SERVICE IS LOGIC AND REASONABLE AND GIVES ONLY THE SUPPLIER'S BENEFITS.

7. QUALITY DISTANCE PROMOTES A BETTER AND STRONGER PATH FOR SATISFYING CLIENTS 'SPECIFIC REQUIREMENTS AND EXPECTATIONS.

- The second part of the answer refers to the fact that: QMS APPROACH IS BASED ON THE PROCESS, IN ORDER TO ENSURE CLIENTS SATISFACTION, as shown in Fig. 9.1.

Within a successful organization, management ensures

- Leading and correlating a package of interrelated processes to ensure the ultimate goal;
- An activity using resources and driven to enable the input elements to be transformed into output elements can be considered a process;
- Identify and coordinate a set of individual processes, or interact (intertwine) in time and space, can be considered a "process-based approach".

THE ADVANTAGES OF a "process-based approach" are:

- understanding and meeting the requirements of the process;
- the need to consider processes by value added;
- achievement of results in terms of performance and effectiveness of the process;
- continuous improvement of processes based on objective measurements.

All processes can be applied to the methodology**:**

PLANIFIC - EFFECT - VERIFY - ACTION (PDCA → PLAN - DO - CHECK - ACT)

The two components target short-term, possibly medium-term objectives.

The desire for customer satisfaction is socializing with the producer; it measures, analyses the client's request on a multi-criteria basis and at the optimal time (technical, economic, social, financial) assumes management's responsibility for: purchasing the resources from the suppliers; for the formation of the necessary resources for the process, for the qualitative organization of the production processes, including for participation in the design / implementation of a QMS, according to the requirements of the manufacturing process and the agreed delivery terms. The performance of value-generating activities is supported by the related information flows, they are modelled according to the basic processes.

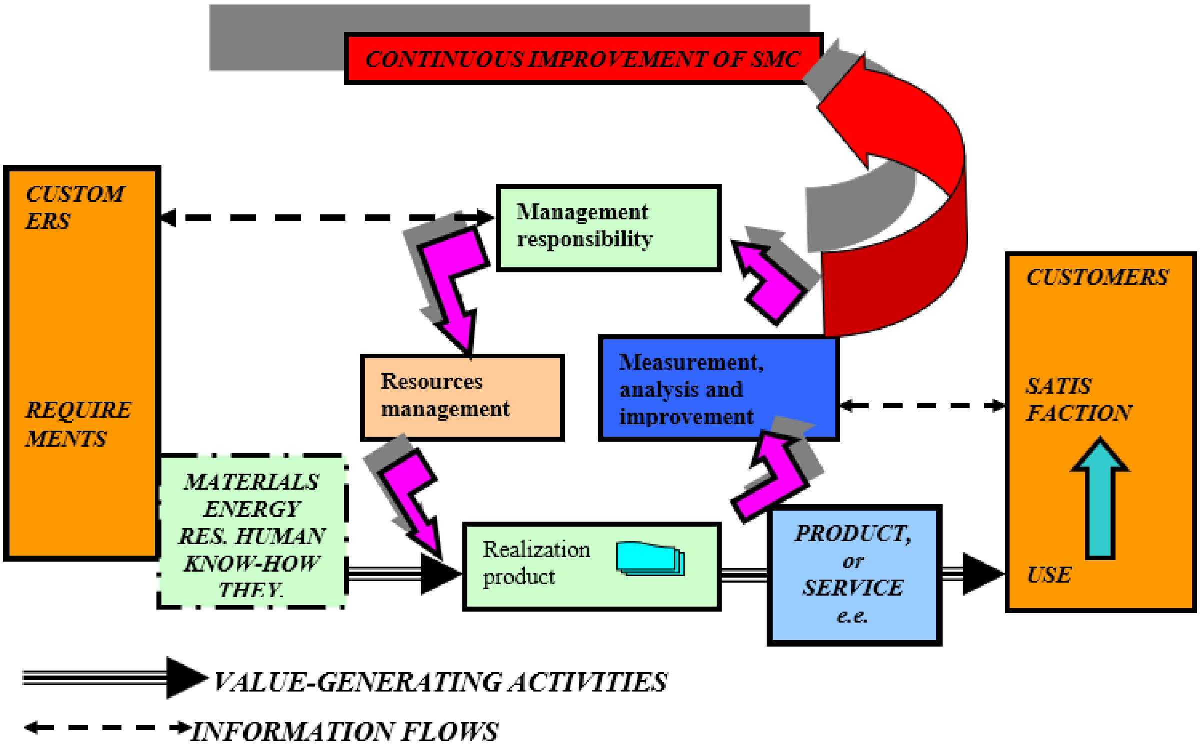


Fig. 9.1. The Quality Management System uses a "process-based approach"

A long-term approach takes into account that quality assurance through the use of properly designed QMS, the correct implemented and especially stimulated with the necessary responsibility of the top managers and the human resource available to be exploited is actually a generator profits at the company level. The possible sources of profit are shown in Fig. 9.2.

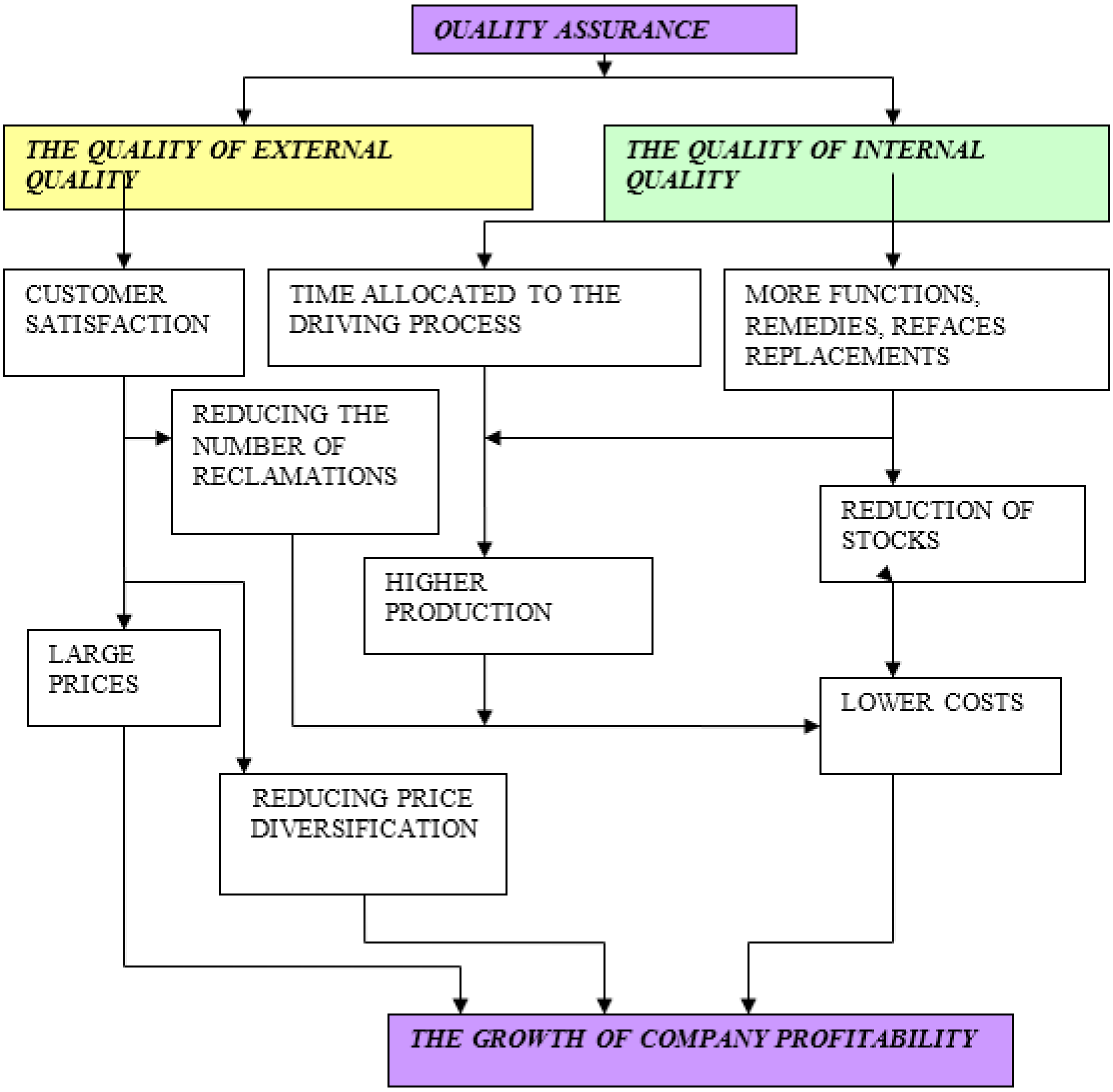


Fig. 9.2. Sources of profit due to QMS implementation

9.3 ISO 9000/2000 standards for QMS training / implementation

In 2000, a family of 4 standards was designed to design and implement a QMS. Standards are used individually to solve specific punctual problems, but their effects can be matched to achieve a QMS implementable in a production system.

The four standards are:

- **EN ISO 9001**: 2000 QUALITY MANAGEMENT SYSTEMS. REQUIREMENTS
- EN ISO 9000: 2000 QUALITY MANAGEMENT SYSTEMS. FUNDAMENTAL PRINCIPLES AND EXPRESSIONS
- **EN ISO 9004:** 2000 QUALITY MANAGEMENT SYSTEMS. GUIDELINES FOR IMPROVING PERFORMANCE
- **EN ISO 19011:** 2000 LINE DIRECTORS FOR THE AUDIT OF QUALITY AND ENVIRONMENTAL MANAGEMENT SYSTEMS

The way in which standards are corroborated, as well as the issues that each one addresses, is presented in Fig 9.3.

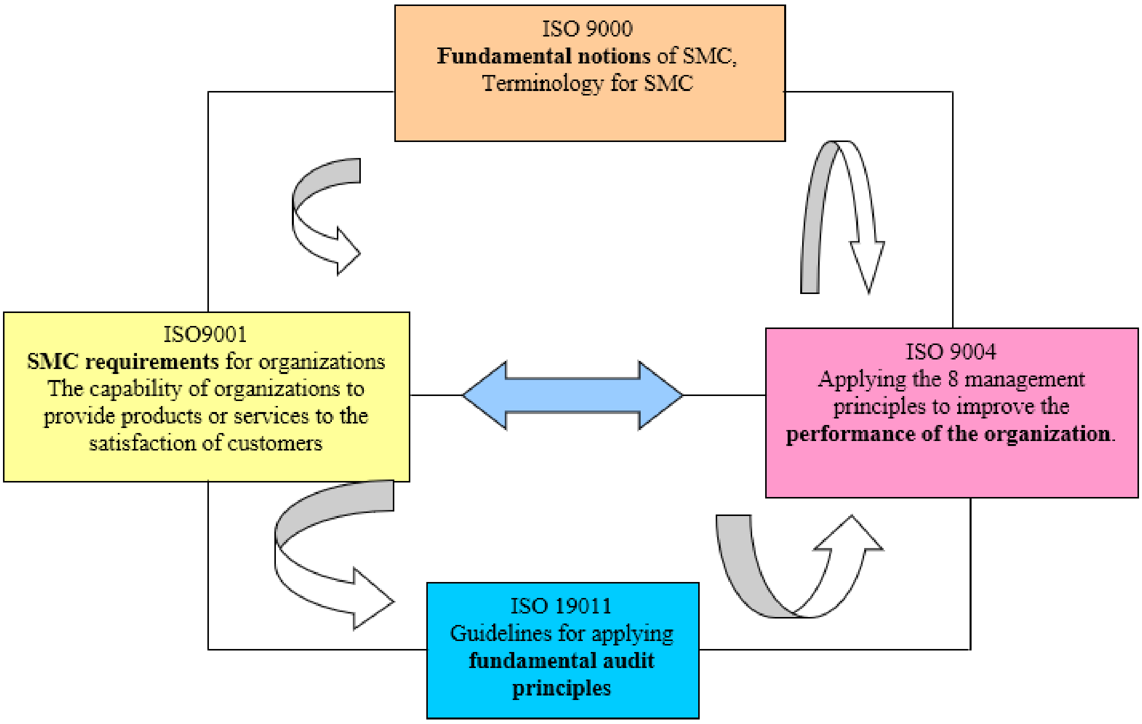


Fig. 9.3. The connection of standards in the ISO family

9.4 Structure of the SR EN ISO 9001 standard

SR EN ISO 9001 sets the requirements for QMS if:

- **An organization is faced with the need to demonstrate its ability to consistently provide products and / or services to meet customer requirements and applicable regulations.**
- **Wants to achieve increased customer satisfaction through effective QMS implementation, including ensuring on-going QMS improvement processes.**

The main chapters of the standard are as follows:

INTRODUCTION

1. ADOPTION OF A QMS IS A STRATEGIC DECISION OF THE EASTERN MANAGEMENT TEAM.

2 THE PURPOSE OF THIS INTERNATIONAL STANDARD IS NOT TO IMPROVE UNIFORMITY IN THE QMS STRUCTURE OR IN THE DOCUMENTATION OF THE DOCUMENTATION.

RELATIONSHIP ISO9001 - ISO9004

- **ARE COMPLEMENTARY**
- **CAN BE USED INDEPENDENTLY OR IN TANDEM**

ISO9001 USED FOR
- *application in the organization for internal purposes,*
- *for contractual purposes*
- *for certification activities*

ISO9004 USED FOR
- *guidelines for enhancing the performance of org.*
- *guidelines for increasing the efficiency of ec. global.*
- *to improve the performance of the guide*

1. FIELD OF APPLICATION

- An organization is faced with the need to demonstrate its ability to consistently provide products and / or services to meet customer requirements and applicable regulations.
- Wants to gain customer satisfaction through an effective QMS implementation, including ensuring on-going QMS improvement processes.
- All standard requirements are generic and are intended for use by all organizations, regardless of size, type of production or type of product or service provided. If a standard requirement (product quality requirements in an organization) cannot be entered into the QMS documentation, it can be ruled out under certain conditions. Exclusions can only be made if unfulfilled requirements are confirmed by an organization before accepting the requirement in the documentation.

2. NORMAL REFERENCES

- This standard is a normative document; it contains the most recent provisions in the field of QMS standardization, according to the latest provisions of the international standards in the field.
- Parties that enter into agreements based on this standard ARE INVITED to examine the possibility of applying the most recent edition.

3. TERMS AND DEFINITIONS

- The terms and definitions defined in ISO 9000 apply.
- In order to explain the supply chain, within ISO 9001, the notions: vendor → organization → client.

The term "ORGANIZATION" replaces the term "SUPPLIER" used in
ISO 9001/1994, and refers to the unit that applies this International Standard.
The term "SUPPLIER" replaces the term "SUB-CONTRACTOR".

4. QUALITY MANAGEMENT SYSTEM

4.1 GENERAL REQUIREMENTS:

QMS
- **STABILIZED, DEFINED**
- **DOCUMENT**
- **IMPLEMENT**
- **REMAINED**
- **IMPROVING CONTINUING EFFICIENCY**

ACTIVITIES AT THE ORGANIZATION

- IDENTIFICATION OF PROCESSES NECESSARY QMS;
- APPLICATION OF PROCEDURES FOR IDENTIFICATION OF PROCESSES AT ORGANIZATION;
- DETERMINING THE SUCCESS AND INTERACTION OF THESE PROCESSES;
- ESTABLISHING CRITERIA AND METHODS TO ENSURE THAT THE OPERATION AND CONTROL OF PROCESSS ARE EFFECTIVE;
- TO ENSURE THE AVAILABILITY OF RESOURCES (INFORMATION) FOR THE STOPPING AND MONITORING OF PROCESSES;
- MONITORING, MEASURING PROCESSES;
- GET UP ACTIONS FOR CONTINUOUS IMPROVEMENT OF PROCESSES.

4.2 DOCUMENTATION REQUIREMENTS

4.2.1. Overview

QMS Documentation:

a) Proven statements of quality policy and quality objectives;

b) Quality Manual;

c) Documented procedures required by this International Standard;

d) Documents attesting the efficient planning, operation and control of the processes;

e) Quality records required by this International Standard that will be archived according to specific procedures.

N1. DOCUMENT PROCEDURE is established, documented, implemented and maintained.

N2. The extent of the documentation depends on:

Size of organization and type of activities, Complexity and process interaction,
The competence of the staff.

N3. The documentation can be presented in any form or on any medium.

4.2.2. Manual of Quality.

a) QMS domain, including details and justifications for exclusions.

b) Documented procedures established for QMS (refer to procedures).

c) A description of the interaction between QMS processes.

4.2.3. Control of documents.

A documented procedure shall be established defining the controls in order to:

a) approving the documents (their adequacy before issuing)

b) analysis / update / re-approval (when applicable)

c) identification of changes, (status of current / up-to-date revisions of the documents)

d) ensuring the use of the most relevant documents at the intended work points

e) ensuring readability / easy identification of documents

f) ensuring that documents of extreme origin are identified and have a controlled distribution

g) preventing unauthorized use of obsolete documents

h) establishing the obsolete archiving circuit.

4.2.4. Control of quality records.

Records of the quality of the processes / their interaction must remain legible, easily identifiable / recoverable (procedure for identifying, storing, protecting, retrieving, storing, removing records).

5. RESPONSIBILITY OF MANAGEMENT

5.1 MANAGEMENT ASSISTANCE

Top management will provide evidence of commitment to implementing / continuously improving its effectiveness through

a) communication within the organization, at all levels, legal requirements, regulated requirements customer requirements (way of meeting them),

b) establishing quality objectives,

c) establishing policy in the field of quality,

d) conducting management analyses,

e) ensuring availability.

5.2. ORIENTATION TO THE CLIENT. The top management must ensure that the client's requirements are correctly identified / fulfilled in order to increase its satisfaction.

5.3 QUALITY POLICY (PC)

a) is appropriate to the purpose of the organization

b) includes the commitment to continuously improve the efficacy of QMS

c) provide a framework for setting / analysing quality objectives

d) communicated and understood in the organization

e) is analysed for its continued suitability.

5.4. PLANNING

5.4.1. The quality objectives of the processes as well as the objectives of the product requirements will be detailed on the main management functions, at different levels of management; they must be measurable and in line with quality policy.

5.4.2. QMS planning covers two aspects:

a) to ensure the requirements stipulated in the subchapter: 4.1.

b) integrity of QMS (changes in QMS are planned and implemented)

5.5 RESPONSIBILITY, AUTHORITY / COMMUNICATION.

5.5.1 Responsibility / authority

Top management responsibilities, their authorities / inter-correlation are secured (defined and communicated) at all levels!

5.5.2. Management Representative

Top management will appoint a team member who will handle responsibility / authority for:

a) Ensure that QMS processes are stable, implemented, maintained;

b) Report to top management that the QMS is operating in accordance with program / improvements are needed;

c) Ensure that awareness of the requirements is promoted in the organization customers.

5.5.3. Internal communication

Top management must make sure that the most appropriate communication channels within the organization are in place to ensure the QMS effectiveness.

5.6. MANAGEMENT IMPLEMENTATION

QMS will be periodically analysed by top management (level of suitability over time / EMS effectiveness), according to Fig. 9.4.

Management analyses should be maintained over time according to archiving procedures.

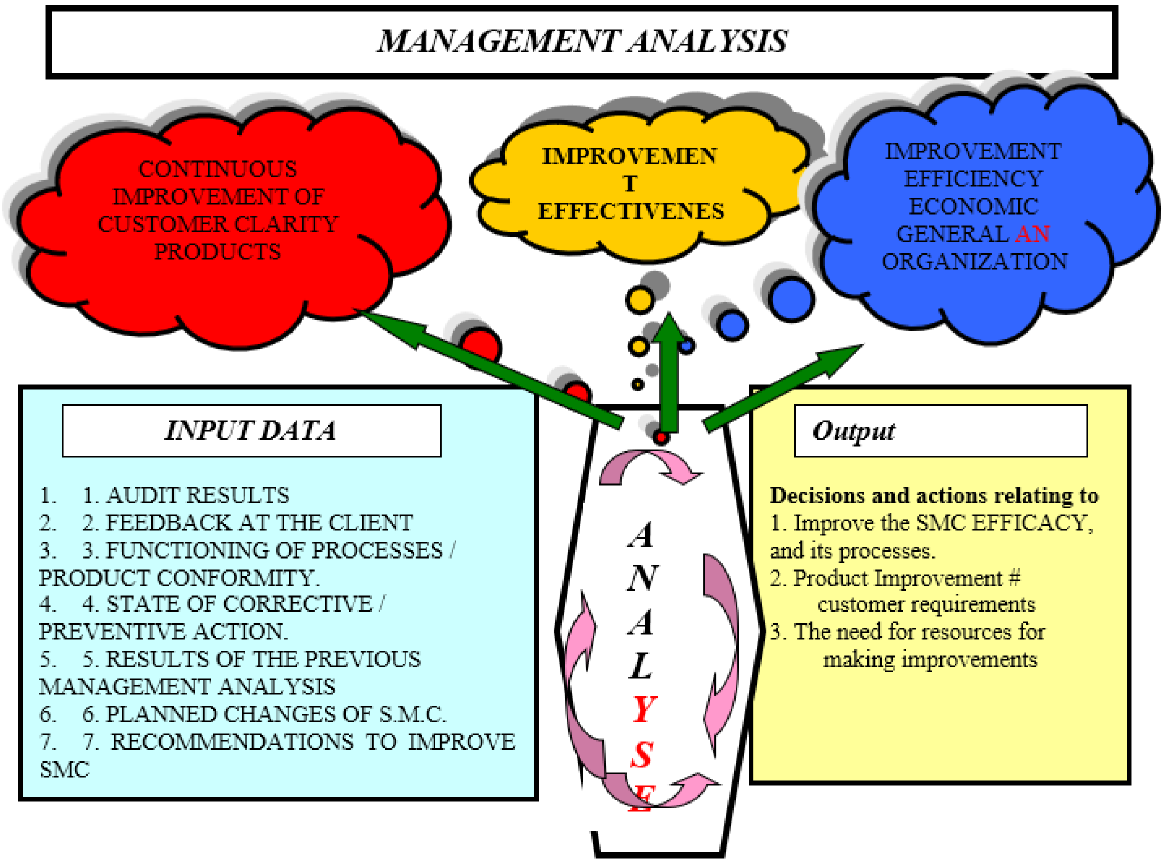


Fig. 9.4. Management analysis

6. MANAGEMENT OF HUMAN RESOURCES

6.1. PROVIDED RESOURCES ASSURANCE: (PURPOSE)

• for QMS implementation / retention

• to increase customer satisfaction.

6.2 HUMAN RESOURCES (asig. QMS)

PERSONNEL COMPETENT: STUDIES, TRAINING, ABILITY, EXPERIENCE

Obligations of the organization: identification of the necessary competence

- Assessing the effectiveness of the actions undertaken,
- Providing the necessary training,
- Staff awareness of their actions,
- Maintaining appropriate records on studies,
- Training, skills, and their cyclical reassessment, according to a predefined program.

INFRASTRUCTURE NECESSARY TO COMPLY WITH THE DOCUMENTATION REQUIREMENTS:

• buildings, workspaces, associated utilities

• process, hardware, software

• associated support services (internal transport, logistics, information system, communication systems, saddle)

THE WORKING ENVIRONMENT of the organization will ensure compliance with product requirements.

7. PRODUCT REALIZATION

7.1. PLANNING PRODUCT REALIZATION

The organization will plan and develop the processes necessary to achieve the product. (quality objectives and product requirements, process setting and resource allocation, monitoring, validation, inspection, product testing and product acceptance criteria, making records to provide evidence of product quality)

The planning activity will be correlated with the other processes in the QMS structure

For complex products QUALITY PLAN QMS processes

7.2 PROJECTS RELATING TO CLIENT RELATIONSHIP

- Customer requirements related to delivery / post-delivery.
- Customer requirements related to contract, order and other issued documents.
- Requirements not specified by the customer, but necessary for the specified performance, for known and intentional use.
- Requirements related to product-related regulations.
- Any other additional requirements identified at the organization level.

Processes are subject to continuous analysis for the organization to respond to the customer in good time.

The organization will always communicate with the customer (product information, treatment of offers, or even order changes, customer feedback, including its claim).

7.3. PRODUCTION AND DEVELOPMENT

IT IS A PLANNED AND CONTROLLED PROCESS AT THE ORGANIZATION.

Planning of design and development:

• Designing stages of development

• Analysis, verification and validation of processes

Responsibilities and authority to design and develop the product.

P / D INPUT DATA	OUTPUTS OF P / D
Performance and performance requirements	To meet the requirements of the P / D input data
Applicable legal / regulatory requirements	To provide inf.ref.la supply, production, service
When the process is applicable to provide inf. derived from pr. Similar.	Contain or refer to product acceptance criteria
Other requirements for design / dex.	Any other additional requirements identified

7.4. SUPPLY

Supply information:

- Target the product's lighters to be supplied.
- Requirements for product approval, procedures, processes and equipment (agreements with partners).
- Requirements for staff qualification.
- Requirements for QMS.
- Checking the supplied product.

7.5. PRODUCTION AND SUPPLY OF SERVICES

CONTROL of production refers to:

- the availability of information describing product characteristics,
- the availability of working instructions,
- using appropriate equipment,
- the availability and use of measuring and control devices,
- implementation of monitoring and measurement of processes,
- implementation of release, delivery, and post-delivery activities.

In order to VALID the processes, you need:

- defining the criteria for process analysis and approval

- approval of measurement equipment and staff qualification
- the use of specific methods and procedures
- record requirements
- revalidate the processes as often as needed.

IDENTIFICATION AND TRACEABILITY

The organization's ability to identify the product in relation to measurement and monitoring requirements:

- CUSTOMER'S PROPERTY
- STORING THE PRODUCT

7.6. CONTROL OF MEASURING AND MONITORING DEVICES

See ISO 10012-1 and 10012-2.

8. MEASUREMENT, ANALYSIS AND IMPROVEMENT.

The purpose of implementing monitoring, measurement, analysis and improvement processes:

- To demonstrate product compliance
- To ensure QMS compliance
- To continuously improve QMS efficacy
- Ensuring customer satisfaction

To maintain QMS at effective performance levels, an audit program and a group of auditors will be set up in the organization to act on audit areas (objectivity, impartiality, professionalism).

ISO 10011-1 and ISO 10011-2 to guide the audit work.

Monitoring and measurement refers to the following objectives:

- Monitoring and measuring processes in the organization.
- Product monitoring and measurement.
- Monitoring and measuring non-compliant products.
- Data analysis.
- Continuously improve the effectiveness of QMS through corrective and preventive actions.

The monitoring and measurement processes have the following algorithm:

a) detailed analysis of the process
b) determining the causes that generated them
c) assessing the need for action to prevent further occurrence of the case
d) records of the results of the action taken.

REVIEW QUESTIONS

1. What is QMS and what are its features and principles? 91
2. What defines the efficiency of QMS implementation? 92
3. What is the relationship between QMS and ISO 9000/200? 95
4. How can you describe the structure of the SR EN ISO 9001 standard? 96

10 THE SEVEN QUALITY CONTROL (7 QC) TOOLS: AN OVERVIEW

Today, quality became a really important topic in economic and social life. So organisations, such as business organisations have to managing for quality. But what is the meaning of the word: quality. According to Juran & Godfrey (1998) **quality has two crucial meanings**, one is the **features of products** which meet customer needs and thereby provide customer satisfaction, and the other is **freedom from deficiencies**, freedom from errors that require doing work over again (rework) or that result in field failures, customer dissatisfaction, customer claims, and so on.

Improving the quality means, on the one hand, **increasing customer satisfaction** and, on the other hand, **reducing customer dissatisfaction and waste**. Both are needed, since competitive pressure on businesses is growing year on year, thus continuing improvement, in relation with intensifying competition in quality is vital. In order to stay in competition, businesses have to response adequately to the challenges, which requires high rate of quality improvement. Better quality, which is a form of beneficial change is the end result of quality improvement to increase customer satisfaction and to reduce deficiencies. **Improvement can be understand as the organized creation of beneficial change or otherwise, the attainment of unprecedented levels of performance**. It is important to stress that there is no such thing as improvement in general, because all improvement takes place project by project and in no other way (Juran & Godfrey, 1998).

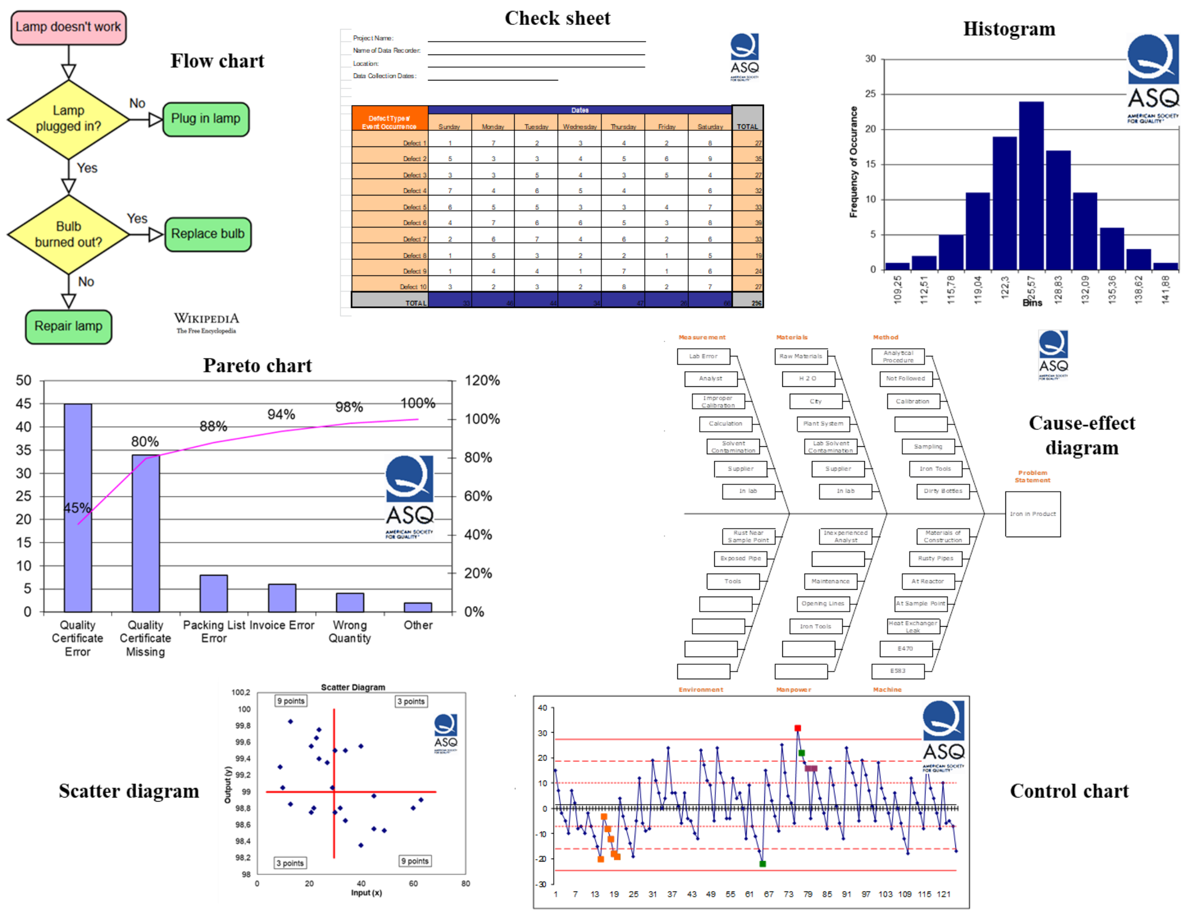
As quality has become the most important factor for success, **quality management has become the competitive issue for many organizations**. As Juran stated: „Just as the twentieth century was the century of productivity, the twenty-first century will be the quality century" (Juran & Godfrey, 1998). As a consequence of the foregoing, one of the fundamental concepts or requirement of quality management is continuous improvement, so the primary goal of any businesses is quality improvement.

The purpose of this chapter is to present and briefly describe the seven quality tools, that are integrated elements of the quality improvement process. **These tools facilitate problem recognition, help define and remedy the problems**. In this way **the tools serve the continuous quality improvement process**.

10.1 Introduction to 7 QC (quality control) tools

The aforementioned „organized creation of beneficial change" can be understood as a **creative problem solving process**, wich is a continuous activity that affects all functions and departments of the organisation in which every employee is involved.

The 7 QC tools ("The Old Seven", "The First Seven" "The Basic Seven") are considered quite powerful and helpful in solving quality problems and hence have gained a prominent role in quality management. **These tools are commonly used across all types of industries** because of the simplicity and ease of use; these tools can be learned and widely applied to practical situations. **The legendary quality guru Kaoru Ishikawa has stated that 95% of the quality problems can be solved by using "7 QC tools"** and this should indicate the power and importance of these tools in solving the problems (Jagadeesh, 2015). **The 7 QC tools are as follows** (see Figure 10.1): 1.) Flow chart, 2.) Check sheet (Data sheet), 3.) Histogram, 4.) Pareto chart (Pareto analysis), 5.) Cause-Effect Diagram (Ishikawa diagram, Fishbone diagram), 6.) Scatter Diagram (Correlation diagram), 7.) Control Chart. **A detailed description of the tools will be presented below**.

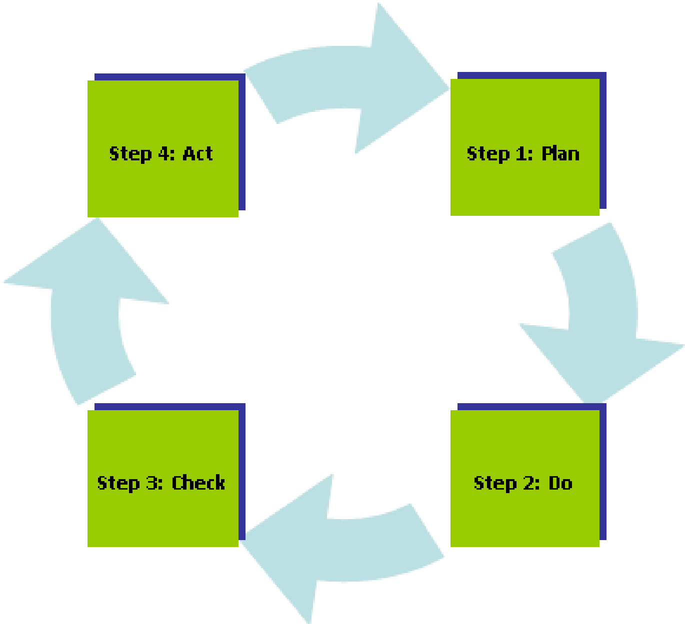


Source: Own compilation based on ASQ and Wikipedia

Figure 10.1. The 7 QC tools in pictures

10.2 Problem solving in PDCA cycle and the 7 QC tools

The feedback loop is a universal and it is fundamental to any problem in quality control. It applies to all types of operations, whether in service industries or manufacturing industries, whether for profit or not. There are many ways of dividing the feedback loop into elements and steps, but a popular example is the so-called **PDCA cycle (also known as Deming wheel)** as shown in Figure 10.2 (Juran & Godfrey, 1998).



Source: Deming, 1986 in Juran & Godfrey, 1998

Figure 10.2. The PDCA cycle

In this example the feedback loop is divided into four steps labeled (1)Plan, (2)Do, (3)Check, and (4)Act. **The steps should be continued** as Step 5 refers to „Repeat step 1", with knowledge accumulated, Step 6. stand for „Repeat step 2", and onward. **So it becomes a cycle of learning, which is a basement of continous improvement**.

By integrating problem solving into the PDCA cycle, it can be seen that **each step of problem-solving process can be assigned to one of the steps of PDCA cycle**. Step 1 (Plan) involves identifying the problem or problems, selecting the most important problem(s). To do this, the current processes must be assessed, data collection, data analysis and cause and effect analysis must be carried out. Step 2 (Do) includes designing and implementing solution(s). Step 3 (Check) involves all activities that are aimed to observe, investigate and evaluate the effects of the changes made at step 2. Step 4 (Act) is about taking corrective actions in order to eliminate, reduce or prevent problems. **Continuous process improvement is based on application of PDCA cycle, which is a dynamic model, and its effectiveness is based on continuity**. That means **a process can always be further improved, thus can be raised to a higher quality level**. The cycle should be continued by repeating the steps of the cycle one after another. **In line with the PDCA principle, problem-solving process does not end, and improvement continues at a higher level over and over again**.

If we take a closer look at PDCA cycle and problem-solving process, we can see that the **seven quality tools can be well integrated into the** steps discussed above. The application of the seven basic quality tools in connection with **four steps of PDCA cycle** is shown in Table 10.1.

Table 10.1. The relationship between PDCA cycle and 7 QC tools

7 QC tools	**The steps of PDCA cycle**			
	Plan	**Do**	**Check**	**Act**
Flow chart	+	-	-	-
Check sheet	+	-	+	-
Histogram	+	-	+	-
Pareto chart	+	-	+	-
Cause-Effect Diagram	+	-	-	-
Scatter Diagram	+	-	+	-
Control Chart	+	-	+	-

Source: Farkas & Tóth (2018), Juran & Godfrey (1998), Paliska et al. (2007), Pavletić et al., (2008), Soković et al. (2009)

As can be clearly seen from the table, **the tools are used for data collection, detection and analysis, to gather data, to analyze the situation and to find solution to help the problem-solving process**.

10.3 The 7 QC tools for quality improvement

There are many ways to improve processes. **To support, develop and advance a process of continuous improvement it is necessary for an organisation to use a selection of tools and techniques** (Dale, 2003). **The success of any process improvement** project lies in right identification of root causes, identifying relationship between variables, identifying patterns within data and standardization. **The use of 7 QC tools is the first step towards successful process improvements** (AIGPE, n.d.).
Quality tools and techniques have different roles to play in continuous improvement process and if applied correctly give repeatable and reliable results.
Their roles include (Dale, 2003):

- Summarizing data and organizing its presentation
- Data-collection and structuring ideas
- Identifying relationships
- Discovering and understanding a problem
- Implementing actions
- Finding and removing the causes of the problem
- Selecting problems for improvement and assisting with the setting of priorities
- Monitoring and maintaining control
- Planning
- Performance measurement and capability assessment

Table 10.2 provides a **short description of the 7 QC tools** and shows **how they are integrated with a structured quality improvement process** according to their role in problem solving.

Table 10.2. The seven QC tools and their roles in quality improvement

7 QC tools	What role to play
Flow chart (Flow diagram, Process chart) – Representation of the process	A graphic representation of the sequence of steps needed to produce some output
Check sheet (Data sheet) – Data collection, Data recording	The gathering of the objective data needed to shed light on the problem at hand, and in a form appropriate for the tool selected for the analysis of the data.
Histogram – Graphic summary of variation in a set of data	Summarize quantitative data in pictorial representations, it gives a descriptive presentation of data collected
Pareto chart (Pareto analysis) – Helps focusing on the most important problems	Employed for prioritizing problems of any type; to establish priorities, dividing contributing effects into the "vital few" and "useful many"
Cause-Effect Diagram (Ishikawa diagram, Fishbone diagram) – Helps clarifying the potential causes of a problem	Organize and visualize the interrelationships of various ideas of root cause of a problem
Scatter Diagram (Correlation diagram) – Determine correlation between two variables	Charting the relationship between two variables
Control Chart – Monitoring the progress of the process over time	For monitoring processes and for distinguishing between controlled (common cause variation) and uncontrolled (special cause variation) variation; help indicate any process changes over time

Source: Own compilation based on ASQ (n.d.), Dale (2003), Juran & Godfrey (1998), Farkas & Tóth (2018), Singh & Singh (2015)

There are two important things to be kept in mind, one is that **none of the tools in itself can be effective**; the other is that **none of the tools is more important than the others**, each has its own role and significance. To apply any of the tools or technics in quality improvement process some **important issues need to be considered** (Dale, 2003):

- What is the fundamental purpose of the technique?
- What will it achieve?
- Will it produce benefits if applied on its own?
- Is the technique right for the company's product, processes, people and culture?
- How will the technique facilitate improvement?
- How will it fit in with, complement or support other techniques, methods and quality management systems already in place, and any that might be introduced in the future?
- What organizational changes, if any, are necessary to make the most effective use of the technique?
- What is the best method of introducing and then using the technique?
- What are the resources, skills, information training, etc. required to introduce the technique successfully?
- Has the company the management skills and resources and the commitment to make the technique work successfully?
- What are the potential difficulties in using the technique?
- What are the limitations, if any, of the technique?

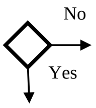
I fully agree with Dale's advice (Dale, 2003), that **organisation should start quality improvement with** the simpler techniques, such as checklists, flowcharts and the other **7 QC tools**. These tools can be just as effective as the more complex ones. The combined and integrated use of the **seven quality control tools can significantly facilitates problem resolution and process improvements**.
False belief in applying more sophisticated and more complex tools and technics, together with ignoring simple tools and using tools in isolation, will not lead to the desired result. Just as a reminder to readers, Ishikawa, who contributed to the simplification and widespread use of the seven basic quality control tools, stated that **95% of the quality problems can be solved with the seven quality control tools**. Thus, the idea that complicated quality problems can only be addressed by high-level statistical methods such as analysis of variance, regression analysis, or design of experiments, does not stand up to scrutiny.
The tools are briefly described and illustrated in the following. The focus is on presenting the tools and their use.

10.4 Flow chart

Flow chart (flow diagram, process chart) **is a prerequisite to gain an in-depth understanding of a process, before the application of quality management tools and techniques**. A flow chart is employed to provide a diagrammatic picture, by means of a set of established symbols (see Figure 10.3), showing all the steps or stages in a process. **It is a considerable assistance in documenting and describing a process to better understand the context of the examination and improvement** (Dale, 2003).
According to the ISO 9000:2015 International Standard a **process** can be defined as a „**set of interrelated or interacting activities that use inputs to deliver an intended result**". The output of a process may be a physical product, a service, information, or a combination of the three. Figure 10.3 lists **the most typical flow chart symbols** and gives a short explanation of where and how the symbols are used.

The following are **the main steps in constructing a flowchart** (Dale, 2003):

- Define the process and its boundaries, including start- and end-points.
- Decide the type and method of charting and the symbols to be used, and do not deviate from the convention chosen.
- Decide the detail with which the process is to be mapped.
- Describe the stages, in sequence, in the process using the agreed methodology.
- Assess if these stages are in the correct sequence.
- Ask people involved with the process to check its veracity.

Symbol	**Name**	**Description**
	Activity	The activity symbol (process step or action step) is a rectangle, that indicates a single step in the process. A brief description of the activity is shown inside the rectangle.
	Decision	It is a dimond shape symbol that designates decision or branch point in the process. The description of the decision or branch is written inside the symbol, usually in the form of a question. The answer to the question determines the path that will be taken out of the decision symbol. Each path is labeled to correspond to an answer (Yes/No, No/No-Go, Pass/Fail etc.).
	Terminal	Terminal symbol (terminal point, terminator) is a rounded rectangle that identifies the beginning or the end of a process. „Start” or „End” is shown inside the symbol.
	Flow line	The flow line (arrow, connector) represents the progression of steps in the sequene. The arrowhead on the flow line idicates the direction of the process flow.
	Document	The document symbol represents written information (document) relevant to the process. Indicates the document to be used or made during the action step. The title or description of the document is shown inside the symbol.
	Data base	The most universally recognizable symbol for a data storage location Data base symbol represents electronicall stored information relevant to the process. The title or description of the data base is shown inside the symbol.
	Connector	Connector symbol is a circle used to indicate a continuation of the flow diagram. A letter or number is shown inside the circle (A, B, C, or 1, 2, 3 etc.). This same letter or number is used in a connector symbol on the continued flow diagram to indicate how the processes are connected.

Source: Farkas & Tóth (2018), Hebb (n.d.), Juran & Godfrey (1998)

Figure 10.3. The basic flow chart symbols and their meanings

10.5 Check sheet (Data sheet)

The purpose of data collection is to have objective data for the right assesment, decision and action. ISO 9000:2015, 3.8.3, provides a definition of objective evidence as data supporting the existence or verity of something, where data are facts about an object.

The checksheet is a simple and convenient recording method for collecting and determining the occurrence of events. **The events relate to non-conformities** (nonconforming items, breakdowns of machinery and/or associated equipment, nonvalue-adding activity or, indeed, anything unexpected and inappropriate which may occur within a process (Dale, 2003). **Check sheet is one of the most simple tool that provides the factual basis for subsequent analysis and corrective action**. **It can be adapted** for a wide variety of purposes, **and used** in any process. Types of data collection include check sheets (providing data and trends), data sheets (simple tabular or columnar format), and checklists (simple listing of steps to be taken) (Juran & Godfrey, 1998). Figure 10.4 presents an example of check sheet.

Defect Types/ Event Occurrence	Dates							TOTAL
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Defect 1	IIIII							5
Defect 2	II							2
Defect 3	III							3
Defect 4	IIIIIII							7
Defect 5	II							2
Defect 6	III							3
Defect 7	IIIIIIIIII							10
Defect 8	IIII							4
Defect 9	I							1
Defect 10	IIIIII							6
TOTAL	43							43

Source: Based on ASQ Check Sheet Template

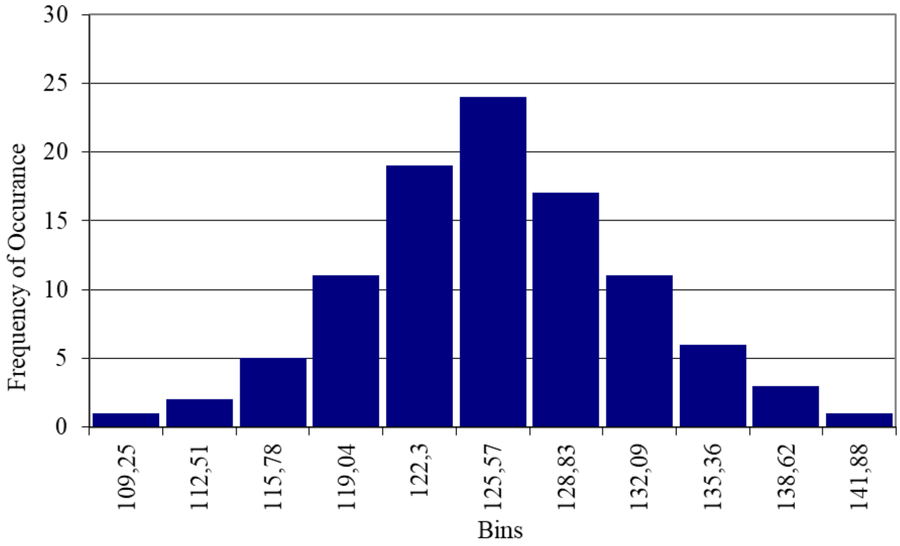
Figure 10.4. An example for check sheet

According to Dale (2003) **the main steps in constructing a check sheet** are the following:

- Decide the type of data to be illustrated. The data can relate to: number of defectives, percentage of total defectives, cost of defectives, type of defective, process, equipment, shift, business unit, operator, etc.
- Decide which features/characteristics and items are to be checked.
- Determine the type of check sheet to use (i.e. tabular form or defect position chart).
- Design the sheet; ideally it should be flexible enough to allow the data to be arranged in a variety of ways. Data should always be arranged in the most meaningful way to make best use of them.
- Specify the format, instructions and sampling method for recording the data, including the use of appropriate symbols.
- Decide the time period over which data are to be collected.

10.6 Histogram

A histogram is the most commonly used graph to show frequency distributions. **A frequency distribution shows how often each different value in a set of data occurs** (ASQ, n.d). **The histogram helps to visualize the distribution of data and in this way reveals the amount of variation within a process**, and/or other factors such as edited data and poor sampling techniques. **It can be used to assess performance to a given standard, specification or tolerance** (Dale, 2003). Histogram analysis consists of identifying and classifying the pattern of variation displayed by the histogram, then relating what is known about the characteristic pattern to the physical conditions under which the data were created to explain what in those conditions might have given rise to the pattern (Juran & Godfrey, 1998).
Figure 10.5 illustrates a histogram that represents the frequency distribution of a data set.



Source: Based on ASQ Histogram Template

Figure 10.5. An example for check sheet

Dale (2003) gives the following **guidelines for the treatment** of continuous data of sufficient quantity that grouping is required:

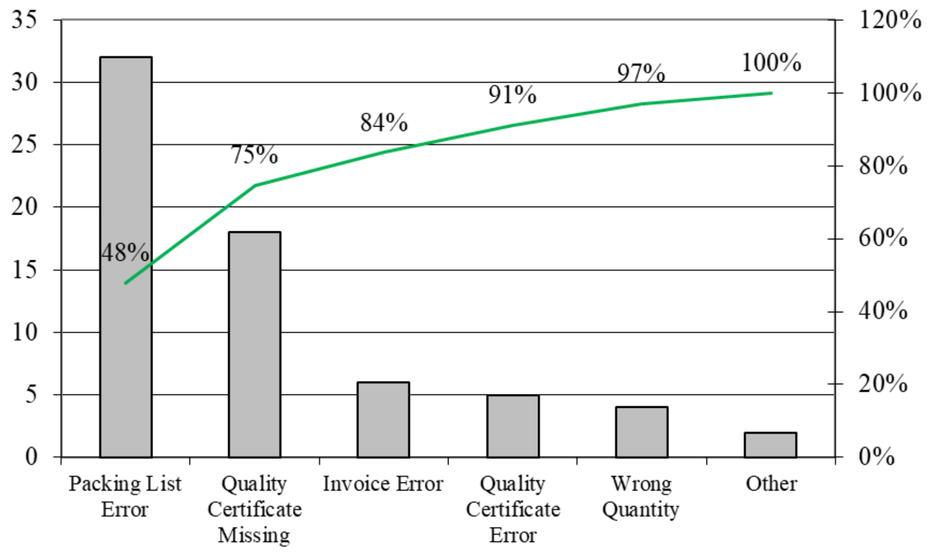
- Subtract the smallest individual value from the largest.
- Divide this range by 8 or 9 to give that many classes or groups.
- The resultant value indicates the width or interval of the group. This should be rounded for convenience, e.g. 4.3 could be regarded as either 4 or 5 depending upon the data collected.
- These minor calculations are undertaken to give approximately eight or nine group class intervals of a rational width.
- Each individual measurement now goes into its respective group or class.
- Construct the histogram with measurements on the horizontal scale and frequency (or number of measurements) on the vertical scale.
- The „blocks” of the histogram should adjoin each other, i.e. there should be no gaps unless there is a recorded zero frequency.
- Clearly label the histogram and state the source of the data.

10.7 Pareto chart

This is a tool used for prioritizing problems, dividing contributing effects into categories like Juran's (1998) „vital few” and „useful many”. **Pareto analisys** based on the observation that a large proportion of quality problems were attributable to a small number of causes according to the **Pareto principle or 80/20 rule**. **The analysis highlights the fact that most problems come from a few causes, and it indicates what problems to solve and in what order**. In this way improvement efforts and resources are directed where they will have the greatest impact (Dale, 2003).

A Pareto diagram includes three basic elements: (1) the contributors to the total effect, ranked by the magnitude of contribution; (2) the magnitude of the contribution of each expressed numerically; and (3) the cumulative-percent-of-total effect of the ranked contributors (Juran, 1998).

Figure 10.6 shows a **Pareto diagram that illustrates errors in order of occurrence** (bar chart), **and their contribution to the total effect** (cumulative percentage curve).



Source: Based on ASQ Pareto Chart Template

Figure 10.6. An example for Pareto chart

Pareto analysis, despite of its construction, is extremely powerful in presenting data by focusing attention on the major contributor(s) to a quality problem in order to generate attention, efforts, ideas and suggestions to hopefully gain a significant overall reduction in these problems. The following are the **basic steps in constructing a Pareto diagram** (Dale, 2003):

- Agree the problem which is to be analysed.
- Decide the time period over which data are to be collected.
- Identify the main causes or categories of the problem.
- Decide how the data will be measured.
- Collect the data using, for example, a check sheet.
- Tabulate the frequency of each category and list in descending order of frequency (if there are too many categories it is permissible to group some into a miscellaneous category, for the purpose of analysis and presentation).
- Arrange the data as a bar chart.
- Construct the Pareto diagram with the columns arranged in order of descending frequency.
- Determine cumulative totals and percentages and construct the cumulative percentage curve, superimposing it on the bar chart.
- Interpret the data portrayed on the diagram.

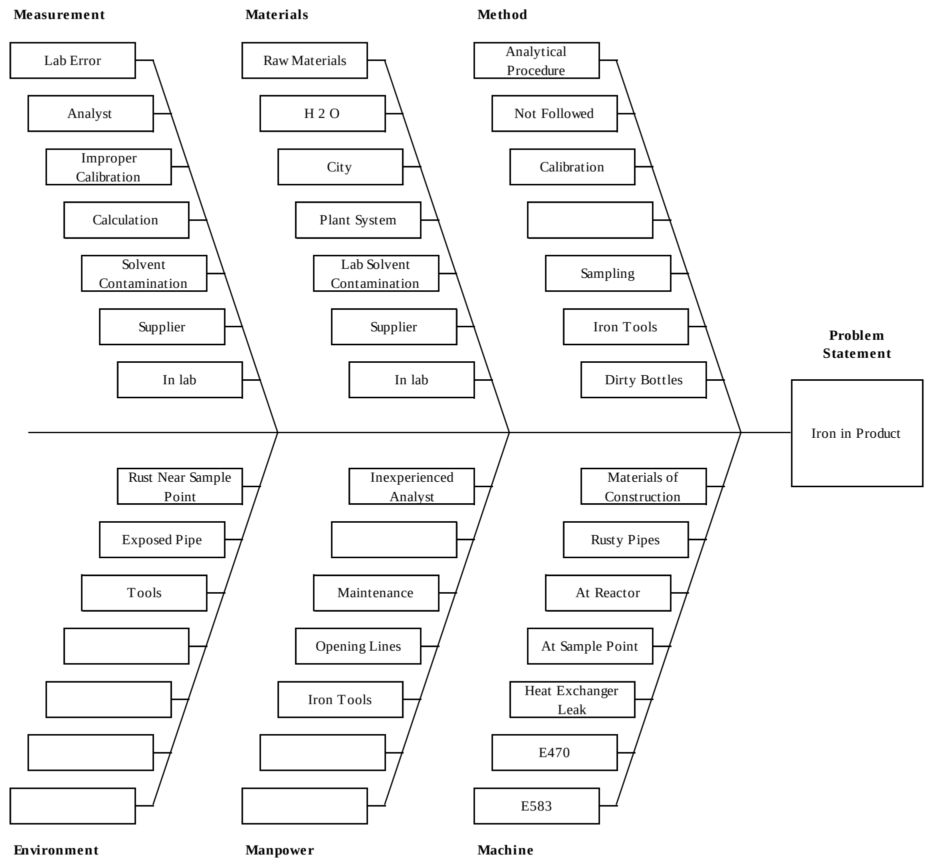
10.8 Cause-Effect diagram

This type of diagram was developed by Kaoru Ishikawa, and this tool is often called Ishikawa diagram, and sometimes fishbone diagram because it resembles the skeleton of a fish. Its purpose is to organize and display the interrelationships of various theories of root cause of a problem. By focusing attention on the possible causes of a specific problem in a structured, systematic way, **the diagram enables a problem-solving team to clarify its thinking about those potential causes, and enables the team to work more productively** toward discovering the true root cause(s) (Juran & Godfrey, 1998).

Cause–effect diagrams are usually produced via a team approach and involve the following basic steps (Dale, 2003):

– Define with clarity and write in a box to the right the key symptom or effect of the problem and draw a horizontal line from the left of the box.
– Ensure that every team member understands the problem and develop a clear problem statement.
– Decide the major groupings or categories for the causes of the effect; these form the main branches of the diagram.
– In a brainstorming session, the group members speculate on causes of the effect and these are added to the branches or sub-branches of the diagram.
– In a following session the causes are discussed and analysed to determine those which are most likely to have caused the effect.
– The most likely, or major causes of the problems are ranked, by the group, in order of importance. This can be done by Pareto voting: 80 per cent of the votes should be cast for 20 per cent of the causes. (If, for example, there are 35 causes, using the figure of 20 per cent gives each member seven votes to allocate to what they believe are the causes of the effect.)
– Additional data are sometimes gathered to confirm the key causes.
– Improvement plans, actions, tests and experiments are decided upon to both verify and address the key causes.

Figure 10.7 shows an example of a cause-and-effect diagram.

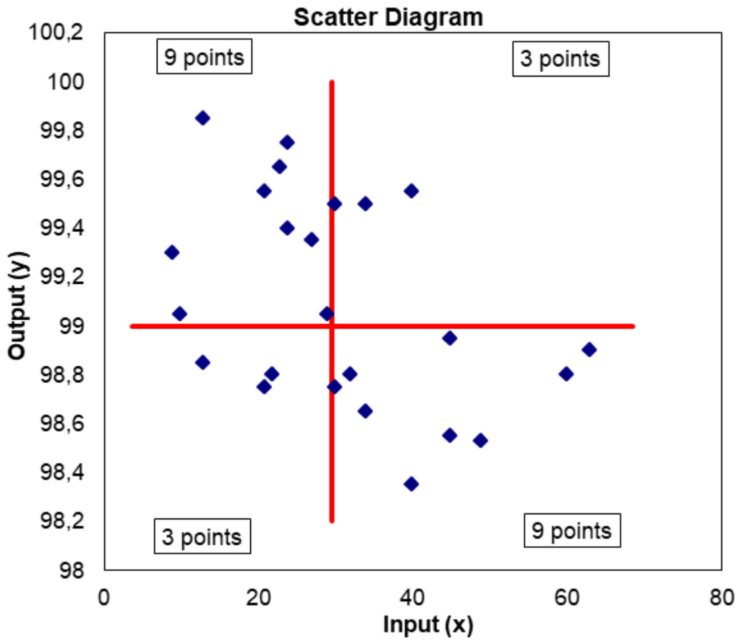


Source: Based on ASQ Cause-and-Effect Diagram Template

Figure 10.7. An example for cause-effect diagram

10.9 Scatter diagram

This is a tool for charting the relationship between two variables to determine whether there is a correlation between the two which might indicate a cause-effect relationship or indicate that no cause-effect relationship exists (Juran & Godfrey, 1998).
Scatter plot illustrates the degree of correlation between two variables (also called correlation diagram). The independent variable is plotted on horizontal (x) axis and the dependent variable on the vertical (y) axis. **The results, when plotted on a graph, will give what is called a scatter graph, scatter plot or scatter diagram** (Dale, 2003).
An example of a scatter diagram is given in Figure 10.8.

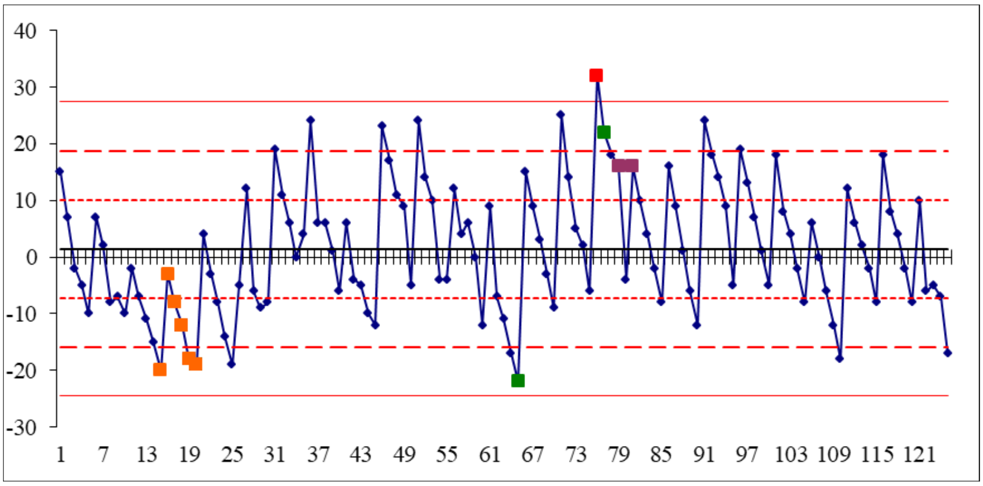


Source: Based on ASQ Scatter Diagram Template
Figure 10.8. An example for scatter diagram

10.10 Control chart

The control charts are based on statistical data and are used to record and monitor the progress of the process over time. Its significance lies in the fact that we can intervene in a timely manner and keep the process in the right path by constantly monitoring the process. Control charts are graphical tools to monitor the activity of a process. **The control charts only record the presence of a problem**. It is not possible to expect quality improvement or process stability from the control chart itself. This requires feedback, appropriate intervention to the process.
The first step in the use of SPC (Statistical Process Control) is to collect data to a plan and plot the gathered data on a graph called a control chart (see Figure 10.9). **The control chart is a picture of what is happening in the process at a particular time**: it is a line graph (Dale, 2003).
A control chart, then, is a graphic representation of the variation in the computed statistics being produced by the process. It has a decided advantage over presentation of the data in the form of a histogram in that it shows the sequence in which the data were produced. It reveals the amount and nature of variation by time, indicates statistical control or lack of it, and enables pattern interpretation and detection of changes in the process (Juran & Godfrey, 1998).

A control chart always has a **central line** for the average, an upper line for the **upper control limit** and a lower line for the **lower control limit**. These lines are determined from historical data. **By comparing current data to these lines, we can draw conclusions about whether the process variation is consistent** (in control) **or is unpredictable** (out of control, affected by special causes of variation) (ASQ, n.d).



Source: Based on ASQ Control Chart Template

Figure 10.9. An example for control chart

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