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TASKS IN PLANNING OF QUALITY INSPECTION

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Abstract: *Quality inspection is a necessary element of the quality management systems. The analysis of quality conditions is impossible without inspection. Therefore, parallel to the elaboration of methods for fast planning of production processes, methods for optimum planning of the quality inspection must be ensured. A precondition for increasing the quality and determining costs for quality are the inspection plans and the manufacturing plans. Because of the imperfection of inspection plans, fit products may fall into unfit and vice versa, which leads to major losses. Unfounded ,the reasons for high costs for inspections are – the lack of regulations, that solves problems with the inspection, insufficient qualification of the personnel, responsible for quality inspection, incorrect selection of inspection instruments, insufficient applying of progressive methods and means for inspection and lack of unified terminology. The purpose of this paper is to make parallel between the manufacturing plans and the inspection plans and to create algorithm for inspection planning, which include assessment of the necessity of inspection, inspection type, defining the AQL (acceptable quality level) and determining the inspection scope (batch size). In the paper are presented current problems with the planning of quality inspection, such as selection of inspection characteristics and defining the scope of inspection, selection of inspection instruments, inspection points and stages, time for inspection and processing of results obtained for each inspection characteristic and the issues for future studies are identified.*

Key words: *quality, inspection, planning, inspection instruments, inspection plan, manufacturing plan, inspection characteristics.*

1. INTRODUCTION

The system of production quality inspection is a set of interconnected inspection objects and subjects, methods and tools for assessing the quality of products for all life-cycle of production. Effective system for inspection allows timely and targeted influence of product quality.

During the last decades, the methods for quick planning of production processes have been incorporated in the serial production. However, the quality inspection still runs chaotic, without the necessary coordination with the theory of quality assurance. The inspection should be preliminary planned, to be in relation with the quality requirements. The inspection plan is result of the quality inspection planning. Figure 1 shows the components used to create the quality inspection plan. To create quality inspection plan it is necessary the following components to be included – the safety regulations, which defines the criteria for safety regulations, the order documents – contracts, order details, drawings as a part of the technical documentation, the plan for the manufacturing process, the standards and normative documents and the specification of the test equipment. The inspection planning should be considered not just as a part of the manufacturing planning, but also as a part of quality management system. The correct planning of the quality inspection, leads to efficient and effective performance of the tests, hence to detection of discrepancies in time, and to improvement of the products quality [8, 11].

Since quality inspection is performed according to inspection characteristics, the inspection planning aims identification of specific quality requirements at the inspection plans. The technical documentation of the tests includes instructions for the production and inspection, as well as inspection instruments guides for the workplaces and quality inspection zones. Figure 2 presents the parallelism of the tasks at the production and inspection planning. The inspection plan and the manufacturing plan are in narrow link, so they can be united in a common technology.

One of the primary tasks at the planning of inspection is the selection of inspection characteristics.

For each inspection characteristic it is necessary to define the scope of measurements, the test method, the data processing and the elaboration of inspection plans. At the planning of the inspection, decisions are taken on the necessity of inspection, test methods, scope of measuring, selection of inspection instruments and processing of the data obtained.

2. SEQUENCE OF INSPECTION PLANNING

For planning of quality inspection an information from different departments from the enterprises, is required – constructive, production and distribution de-

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partment. The trueness of this information and the documents used to transfer it is a precondition for a properly planning of quality inspection.

With reference to activities about the planning of quality inspection, the type of the technical inspection is defined. It is recommended to group the criteria by the classification principles shown in Fig. 3 [12].

The sequence for the planning of quality inspection given at the developed algorithm in Fig. 4. The algorithm in left contains the input data. In the centre is shown the data processing, and on the right – the output data or accepted decisions.

Fig. 1. Components for creation the quality inspection plan.

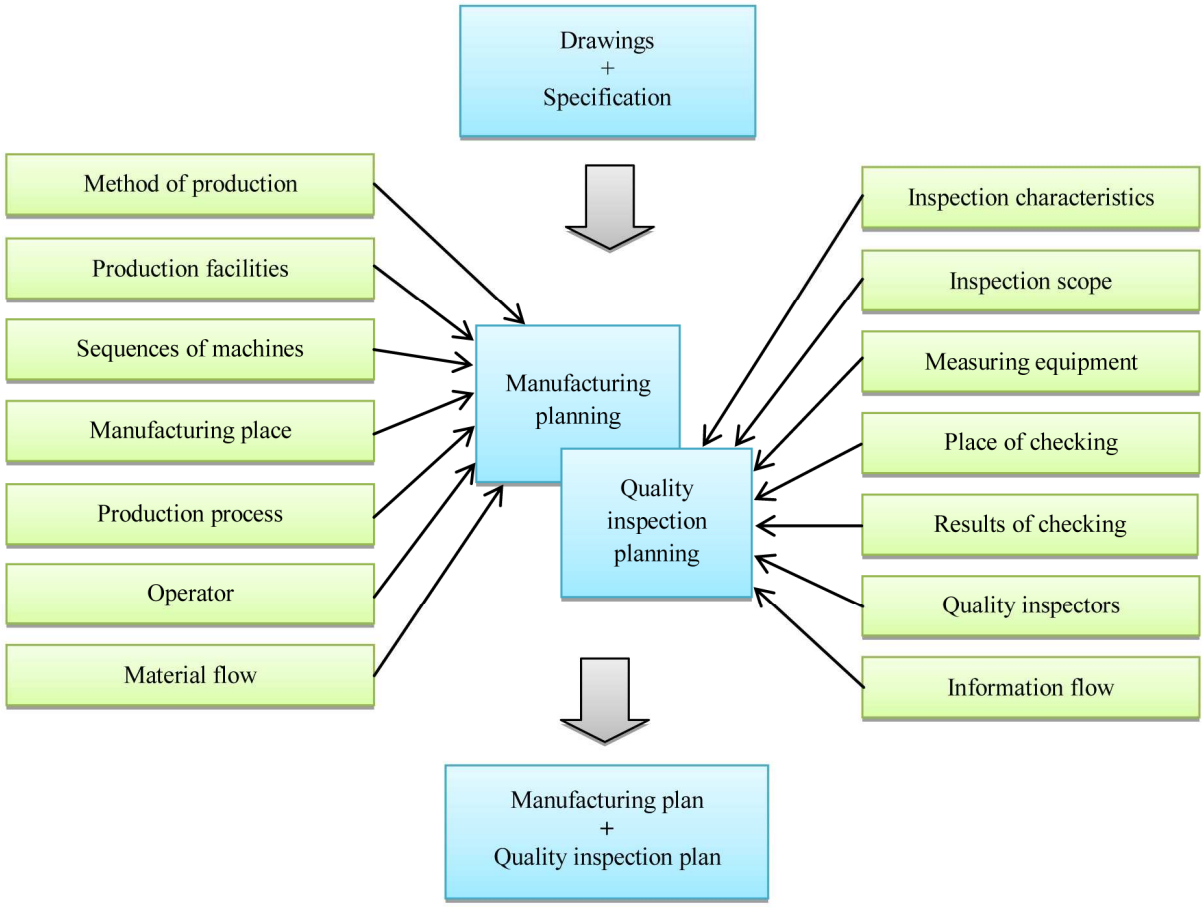

Fig. 2. Parallel planning of manufacturing and quality inspection.

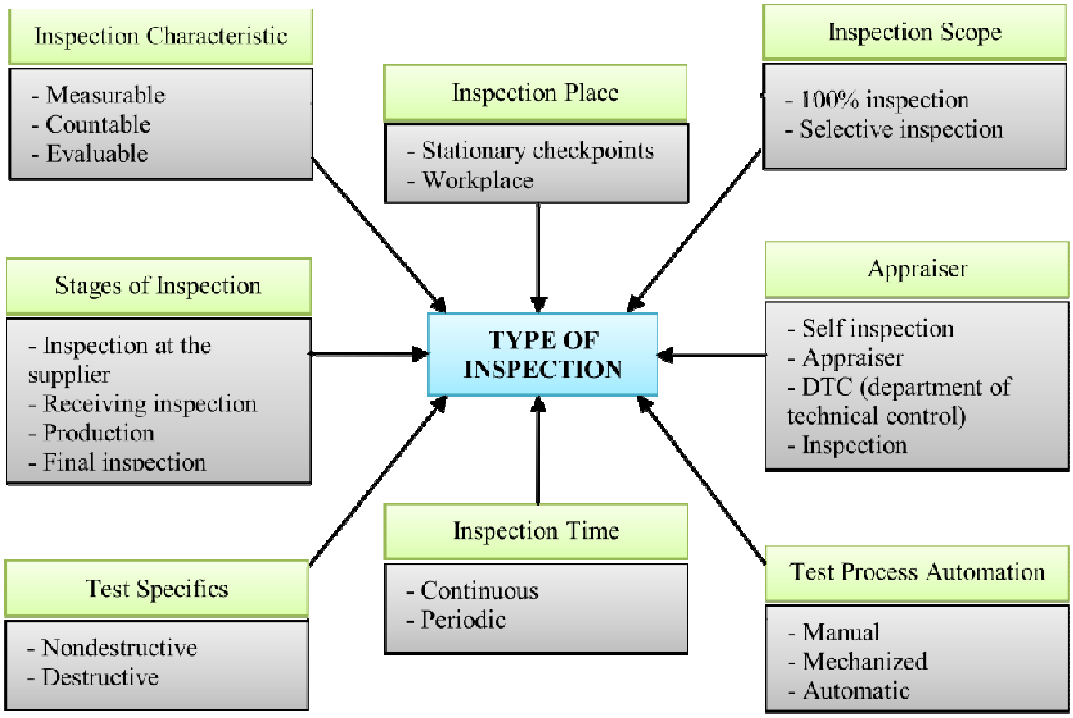

Fig. 3. Classification of quality inspection.

Determining the type of the inspection and the algorithm created for planning of quality inspection includes the following types of inspection operations:

2.1. Selection of inspection characteristics

The inspection characteristics can be measurable, countable and evaluable. The most frequent and with greatest importance in the mechanical production are the geometric parameters.

Irrespective of the variety of forms and dimensions, they are systematized [1]. Specifying a tolerance of a certain parameter does not mean it have to be measurable, and vice versa, not all dimensions with unspecified tolerance are unmeasurable. Each test is related to expenses and leads to breaks in the production process, so it has to be well motivated. A test may be required due to legal provisions or security / reliability reasons. In other cases, the necessity of testing is determined by calculation of the expenses [1]. The expenses for the inspection are compared to the accidental losses in case the inspection is rejected. The losses are expressed by the expenses, resulting from hidden defect, called "damage risk" (R).

$$R = W.K\,, \tag{1}$$

where: W – probability of appearance of defects, K – expenses originating from defects.

The risk of damages incurred (R) is compared to the expenses for inspection K_p.

If R > K_p – inspection is obligatory;

If R > K_p – inspection is not obligatory.

There are no convenient practicable methods for selection of the inspection characteristics.

2.2. Inspection scope

- 100% Inspection - this type will involve careful inspection in detail of quality at each strategic point or stage of manufacture where the test involved is non-destructive and every piece is separately inspected [4]. It requires more number of inspectors and hence it is a costly method. There is no sampling error. This is subjected to inspection error arising out of fatigue, negligence, difficulty of supervision etc. Hence complete accuracy of influence is seldom attained. It is suitable only when a small number of pieces are there or a very high degree of quality is required.
- Sampling Inspection – the inspection is made only on samples of the production. Usually it is used in the following cases - large number of identical parts, high degree of stability of the technological process, and after minor operations. In this method randomly selected samples are inspected. Samples taken from different batches of products are representatives. Sampling inspection is cheaper and quicker. It requires less number of inspectors. It is subjected to sampling errors but the magnitude of sampling error can be estimated. In the case of destructive test, random or sampling inspection is desirable. This type of inspection governs wide currency due to the introduction of automatic machines or equipment which are less susceptible to chance variable and hence require less inspection, suitable for inspection of products which have less precision importance and are less costly.

Having established a necessity of inspection does not mean it is necessary a 100% inspection. If 100% checking is not specified by legal regulations, sampling inspection may be used. The scope of inspection depends on the size of the batch. Considering the stability of production and importance of the inspection characteristics to the operation of product, the possibility to replace a 100% inspection with sampling inspection may be checked. The inspection scope is determined by the plan for sampling inspection, where the acceptable quality level

(AQL) is used to determine the inspection method [6, 7] for batches of a certain size. In the end, the inspection method is a decisive factor for the inspection expenses, and parallel to the production expenses for a given product.

2.3. Inspection point

The inspection point is not randomly chosen. In number of cases it is related to the production process. In such cases coordination of the inspection plan and production technology is obtained. The inspection during the production process is used, beside for quality evaluation, also for observation of the production process itself. The direction of changes in the specified values, characterizes the trend, which has to be corrected by adjusting or replacing the measuring tool [2, 10].

The interval between two measurements depends on the size of tolerance of the inspection characteristics and the accuracy of the machine.

2.4. Measuring instruments

The selecting of the most appropriate measuring instruments is a complex task. At the selection of measuring equipment the following factors are taken into account:

- available measuring equipment, in consideration of the part geometry and weight;
- time for inspection;
- acceptable error of measurement, depending on the tolerance of the measured value and specified error of the measuring instrument;
- inspection costs;
- processing of the measuring results, depending on measuring instruments;
- limitation of the diversity of measuring instruments at the enterprise.

Each measuring instrument is characterized with metrological indices – measuring interval, field of application, error of measurement, inspection point and measurement expenses. Part of listed metrological indices of measuring instruments are given in their passports:

- value of one interval;
- measuring interval;
- limit error of measurement.

Available measurement instruments in the enterprise are coded with numbers. The measurement instruments are registered in inspection plans by the numbers or codes.

2.5. Stages of inspection

Product quality is important as it is well known, and 80% **of** all costs and problems of quality are created in early product development stages, including product planning, product design and process planning phases. The product features and failure rates are largely determined during quality planning. For great importance of inspection stages is that the quality inspection planning is the activity of establishing quality goals in production operations and developing procedure and processes required to meet the goals.

In the inspection plans, instructions for the inspection places are given. The inspection is implemented on various places, within or outside the enterprise. There are four stages of doing inspection [4, 5, and 9]:

- Inspection at the supplier (acceptation inspection) - this inspection type is used for large-size equipment, such as tool machines, etc. The parameters, stated in the contract for delivery are being checked, supplemented by evaluation of the working accuracy of machine, based on its details. It is also called receiving inspection. It consists of inspecting and checking of all the purchased raw materials and parts that are supplied before they are taken on to stock or used in actual manufacturing. Inspection may take place either at supplier's end or at manufacturer's gate. If the incoming materials are large in quantity and involve huge transportation cost it is economical to inspect them at the place of vendor or supplier.
- Receiving inspection (incoming inspection) – it has a "filtering" function. The unfit purchased parts have to be detected and not to be allowed for subsequent processing or mounting. The incoming inspection allows improvement of the quality though a feedback information from the supplier for the quality data, in the sense of quality management [4].

  The parameters of the supplied details which have to be monitored are given in the technical documentation and in the technical requirements. The planning of inspection has to be effected during the design stage, no later than the date of signing the contract for delivery.

  In the contract for delivery have to state, beside in the inspection characteristics and the respective AQL values, also the steps and measures which have to be taken in case an order is being rejected. The selected inspection characteristics and AQL values in the contract of delivery must be accepted observing the efficiency of the inspection plan.
- Inspection in production process – the work of inspection is done while the production process is simultaneously going on. Inspection is done at various work centres of men and machines and at the critical production points. This had the advantage of preventing wastage of time and money on defective units and preventing delays in assembly. The test of the geometric values during the mechanical processing comes to the fore. The place, where these parameters have to be inspected, depends on the production process, the sequence and the scope of the operations, the necessary and available personnel, measuring and transport means and the measuring conditions. The place for measuring may be in the workshop or in a special laboratory.
- Inspection at the dispatch (final inspection) – this is the last stage when finished goods are inspected and carried out before marketing to see that poor quality product may be either rejected or sold at reduced price. With the final inspection the inspector gets convinced whether the actual condition of the product is within the allowable limit tolerances. The final inspection serves for evaluation of the production quality, which is characterized with the level of matching the prescribed with the manufactured parameters.

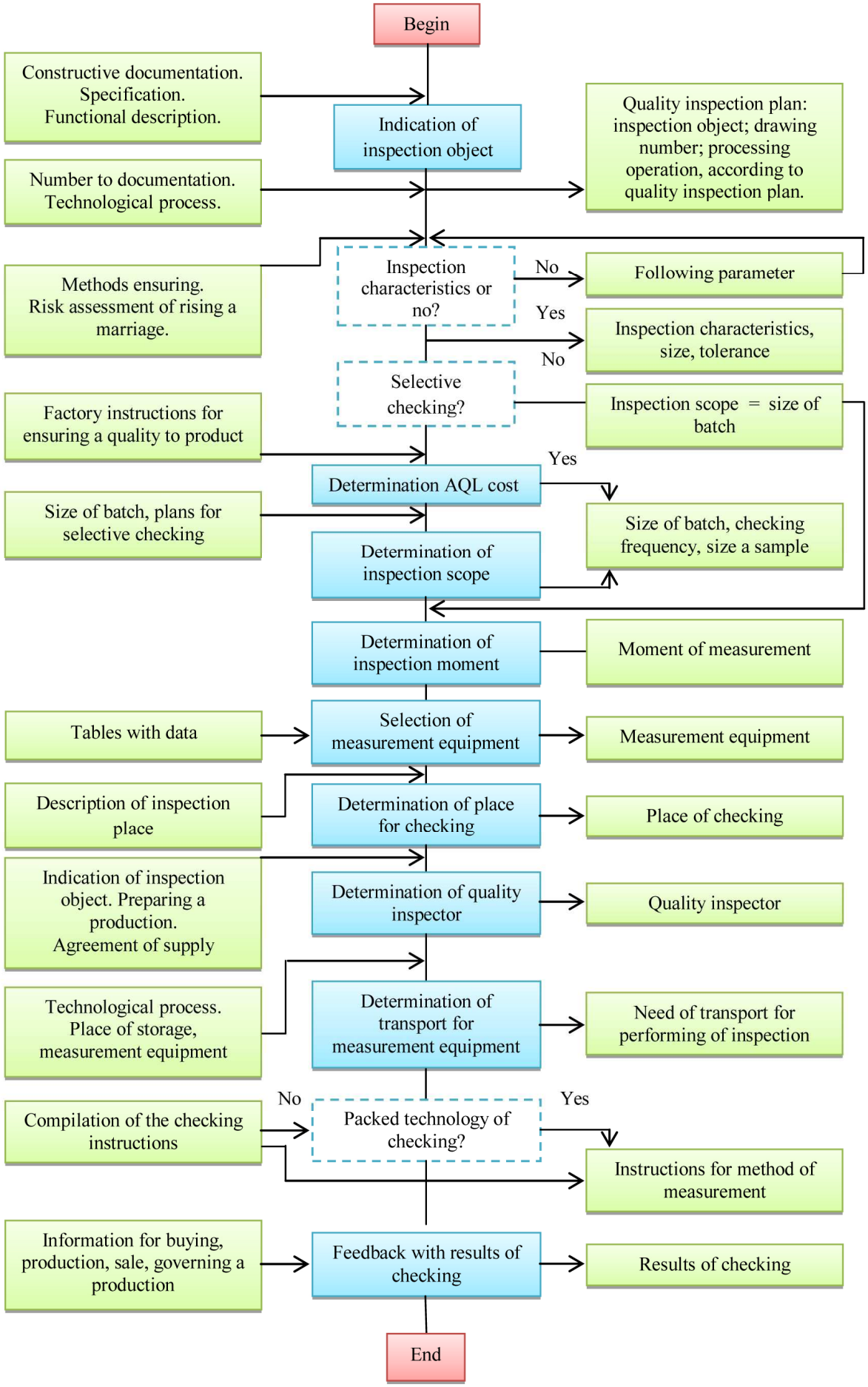

Fig. 4. Algorithm for inspection planning.

2.6. Time for inspection

The time for inspection is an important value for the co-ordination of the inspection plan with the production technology, as well as for the monitoring and planning of the production capacity [5]. The time for inspection is dependency:

$$T = \frac{T_r}{N} + T_g + T_v, \quad (2)$$

where:

T_r – preparation and conclusive time;
T_g – basic time used;
T_v – auxiliary time;
N – number of the measured details.

The preparation and conclusive time (T_p) includes the time, required for the preparation of the system for the performance of the task, and the time necessary to restore the equipment to its initial state;

The basic time (T_g) comprises of the total sum of all compulsory times of the stages in the performance of a certain process, required for each unit at the performance of the operation, according to the used production technology.

The auxiliary time (T_v) depends on personal and objectives breaks of the manufacturing process, and consists of the total sum of all times, necessary for the correct running of a certain process, which are not included in the basic time.

2.7. Inspection results

The results obtained from the inspection show the fitness of a shipment (delivery) or the reliability of supplier, the safety of the production process and the measurement. Any measurements that do not lead to specific results, are unnecessary. The measured data are entered into protocols, whereby the measuring results may be presented in various forms, e.g. [3, 13]:

- measured value of the parameter of a single detail;
- average value of the inspection characteristics of a group of details.

The type of the necessary processing of the measured data and the persons, who have to receive information on the inspection results, may be shown in the quality inspection plan.

3. CONCLUSION

In this paper is made a parallel of the manufacturing plans and the inspection plans. An algorithm is created for making of the inspection plans, which are the result of planning of quality inspection.

The future purposes of this paper are associated with the development of:

- easy to practice methods for selecting the inspection characteristics, based on the applying of FMEA;
- practical methods for determining the value of the acceptable quality level (AQL), from which depends the scope of the measurement;
- methods for determining the time interval, during which selective inspection is needed.

The advantages of a strategically well effected planning of the quality inspection depend on the specificity and the size of the enterprise, the type of production, range of produce and qualification of the personnel. However, for all enterprises the systematic planning leads to conflict between the each production units and between the enterprise and the suppliers, as well as to decreasing the ratio of the inspection expenses to the total expenses incurred for quality assurance. Planning of the quality is a guarantee for stable production and compliance of the article with the requirements, state in the contracts.

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