Subject: Methods of quality control. Types of control

Objective: to consider the issues related to control; maintaining cooperation with suppliers, and assessing the effectiveness of their work.

The purpose of the control is to ensure that the customer receives the product of the required quality.

1. Generalities

There are three variants of control:

1) 100% control (expensive, time-consuming, not always feasible);

2) sample control based on the mathematical theory of probability (the most appropriate method for the customer, particularly if an independent manufacturer takes responsibility for the products to meet the requirements);

3) random sampling with no mathematical proof (not a good solution as it comes with high risk of mistakes and inability to perform calculations).

It should be noted that the costs for testing materials or components are to be minimized.

1.1 Classification of defects and forms of control for product acceptance

The types of defects are as follows:

1) **Critical defect** is the defect that can cause danger or threat to safety of people using, maintaining or relying on the product, or complete incapacitation.

2) **Big defect** is the defect which leads either to failure or substantial reduction of production efficiency;

3) **Small defect** is the defect that does not impact functioning of the product.

A completely defective product is the product with one or more critical defects.

A highly defective product is the product with one or more big (but not critical) defects.

A slightly defective product is the product with one or more small defects.

There are a number of basic types of control carried out prior to product acceptance:

1) periodic monitoring the effectiveness of the quality assurance system of the manufacturer and analyzing daily performance;

2) requirement to supply the products with the control process protocols;

3) requirement to the supplier to carry out 100% inspection and testing;

4) acceptance sampling of the lot;

5) formal system of quality assurance defined by the consumer and used by the supplier (e.g. ISO 9000 (2000));

6) verification, inspection or testing of products by the consumer at the supplier or subcontractor;

7) inspection or testing and certification which implies involvement of the third party at some stage prior to acceptance of the products by the consumer.

100% input control is not always acceptable. Sample based on Limiting

Quality or Lot Tolerance Percent Defective programs is used for serial, large-scale and mass production when the quality of individual lots is to be inspected.

1.2.2 One-phase sample by attributes

In this type of control one sample is inspected for conformity to technical documentation. In case the number of defective units (units with one or more defects not permitted by technical documentation) in sample does not exceed the acceptance number, the lot is accepted. If the number of defective units per sample exceeds the acceptance number, the lot is rejected and, as a rule, returned to the manufacturer without the right for subsequent inspection. This type of control is referred to as nonrectifying sampling inspection.

To use quality units from rejected lots defect inspection can be performed. In this case, the rejected units are subjected to ongoing control of the lot. As a result, all quality units are accepted and defective ones are replaced.

The lot tolerance percent defective ranges from 0.5 to 10 %, and the consumer's risk (probability of acceptance of a lot with the lot tolerance percent defective) varies from 5 to 10 %.

The universal formula proposed for calculating control plans with the acceptance number of zero by Academician A.N. Kolmogorov is:

$$n = N\left(1 - \left(\frac{\beta}{100}\right)^{\frac{100}{qN}}\right)$$

where β is the average percent of accepted lots;
q is the fraction defective , %;
n is the number of units per sample;
N is the number of units per lot.

The expected percentage of accepted lots in this sample number is determined as a function of the fraction defective per lot and is referred to as the operating characteristic of the control plan:

$$\beta(q) = 100\left(1 - \frac{n}{N}\right)^{\frac{qN}{100}}$$

The operational characteristics of the control plan can be illustrated in the form of a diagram (Fig. 1), which the manufacturer can use to determine the quality level of the most of lots to be accepted by the consumer and to take appropriate measures to ensure the production of the desired average input quality level by the formula:

$$q = \frac{100\lg\beta - 2}{N\lg\left(1 - \frac{n}{N}\right)}$$

To choose a control plan standards with tables of control plans are worked out.

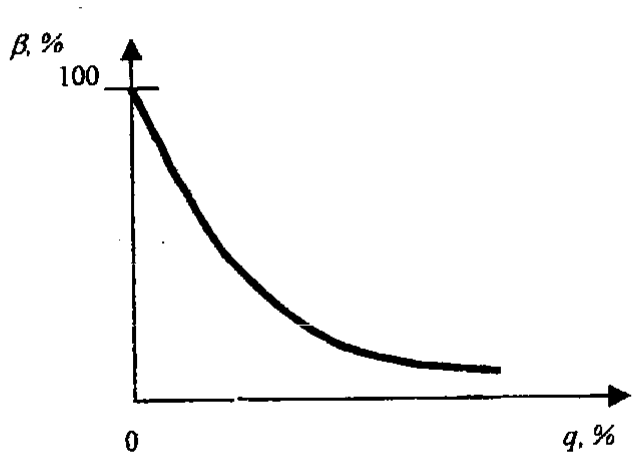

Fig. 1. Operational characteristics of the control plan

To determine the sample number for a given volume of the lot and the limit of the average output quality level with the acceptance number *c=0*
A. Kolmogorov suggested the formula:

$$n = N\left(1 - e^{\frac{100}{cq^{*}n}}\right)$$

where *e* is the base of natural logarithms;
q^{*} is the limit of the average output quality,%.

Procedure

Test assignment №1

1) Draw a diagram (Fig. 1) of the operational characteristic of the control plan using the data in Table 2.1

2) Determine the average the fraction defective in the lots (q % of the units under inspection to ensure acceptance β % of the lots under the control plan (Table 2.1)

3) Determine the control plan that ensures that the average fraction defective in the accepted lots does not exceed q and the volume of each lot is equal to N (Table 2.2.).

Table 2.1

№	N,	*n*,	C	β
1	10	21	0	90
2	12	25	0	92
3	14	29	0	90
4	15	32	0	92
5	16	34	0	90
6	18	38	0	92
7	20	42	0	90
8	22	46	0	92
9	24	50	0	90
10	26	55	0	92

Table 2.2

Variant №	Average fraction defective, unit	Lot number, N, unit	Acceptance number, c
1	1%	100	0
2	2%	110	0
3	3%	110	0
4	4%	120	0
5	5%	130	0
6	1%	140	0
7	2%	150	0
8	3%	160	0
9	4%	170	0
10	5%	180	0

1.2.3. A two-phase sample by attributes

This type of control is used to reduce the amount of inspection, and it is performed as follows:

1) the first sample of n units is taken from the lot under control;

2) all the units of the first sample are tested, and if the number of defective units does not exceed the acceptance number c, the first lot is accepted;

3) if the number of defective units in the first sample exceeds the second acceptance number ($c_2 > c_1$), the lot is rejected. In case of rejection, the lot, in the same way as in the one-phase control, can be returned to the manufacturer or subjected to ongoing inspection to accept only quality units;

4) if the number of defective units in the first sample is greater than the first acceptance number, but less than the second acceptance number, the second sample of n_2 is taken from the lot;

5) all the units of the second sample are tested. If the total number of defective units in the first and second samples is less than the second acceptance number, the lot is accepted;

6) if the total number of defective items in both samples is greater than the second acceptance number, the lot is rejected.

Test assignment № 2

The lot of N units is inspected without further rectifying inspection, and n_1, n_2, c_1, c_2, x_1, x_2 are known (Table 2.3). Answer the questions:

1) Is the lot accepted if the defective units are not found in the first sample?

2) Is the lot accepted if x_1 defective units are found in the first sample?

3) One defective unit is found in the first sample. The second sample n_2 is performed with the untested units. In the second sample x_2 defective units are found. Is the lot accepted?

Table 2.3

№	N, unit	n_1	n_2	c_1	$c_{2,}$	x_1, *unit*	x_2, *unit*
1	1000	20	20	0	2	1	3
2	1200	25	25	0	2	1	1
3	1400	30	30	0	3	1	5
4	1500	35	35	0	2	1	1
5	1600	35	35	0	3	1	2
6	1800	40	40	0	3	1	8
7	2000	45	45	0	4	1	4
8	2200	50	50	0	3	1	2
9	2400	55	55	0	4	1	3
10	2600	55	55	0	2	1	1

1.3. Assessment of suppliers

After approving a supplier his products must be inspected for conformity to various established criteria. This inspection depends on the complexity of the product, its operating parameters, significance etc.

Inspection begins with the series of samples offered, which are then subjected to physical, functional, durability and operational suitability test.

After positive assessment of samples the supplier is permitted to prepare the production for manufacturing these products.

After completion of this work the supplier manufactures several small lots of products, testing the manufactured unit, changing the tooling and manufacturing process until the desired product quality is achieved. In this case, the customer must be aware of the mode of equipment operation and promptly informed about deviations from the established requirements.

The results of equipment testing and the units manufactured with the equipment under testing should be sent to the customer. This enables to solve the problem of inspection adequacy.

To assess the work of the supplier information from several departments must be collected and analyzed:

- *Supply Department:* delivery dates, comments about delays, required quantity, return of materials, etc.;
- *Quality Assurance Department*: the results of the input control, abort analysis, etc.;
- *Production Department*: internal and other production losses and failure;
- *Maintenance and Sales Department:* incapacitation during operation, return under the guarantee, etc.

It should be noted that responsibility for the analysis of the supplier work rests with the Sales Department or the Quality Assurance Department.

Consider the indexing method (from Quality Control Handbook by Zhuran and Grain), which implies several sources of information and sets the penalty points given in Table 3.1.

Table 3.1

Table with points

Factors	Points
Rejection of lot	20 points
Failure is found later	10 points
Limiting acceptance	5 points
Dealer complaint	10 points
Guarantee request	10 points

Table 3.2 shows the example of assessment of the supplier and combined assessment of quality index, price and services adopted by US National Association of Purchasing Managers.

Table 3.2

What is done with the lot	Lot number (from 50)	% of lots	Weight number	Weig ht % x
Is used	2	2/50=4	1	4
Sorted/remanufactured	1	1/50=2	5	10
Resected /returned	1	1/50=2	2	4
Supplier rating: 100-18 = 82%			**TOTAL:**18	

Table 3.3

Factor	**Measurement units**	**Weight, %**
Quality	Percent of decisions	40
Price	Low price/ net price	35
Service	Percent of fulfilled promises	25

The customer and the supplier are required to keep exchanging information on the product quality, i.e. to provide feedback loop. In case the supplier is not finally approved and needs to confirm ability to achieve the acceptable level (B), Table 3.4 is to be used. Decrease of the supplier level to satisfactory (C) means that they work worse than they are able to, however they are given a chance to take measures until the next rating is issued (e.g. within four months). In reassessments, if suppliers cannot achieve level B, they are excluded from the list.

Table 3.4

Level	**Grade**	**Status**	**Action**
A	95–100	Preferably	Cannot be the only source
B	80–95	Acceptable	Cannot be the only source
C	70–80	Satisfactory	Requires improvement up to B
D	Less than 70	Unacceptable	Exclude from the list

Test assignment No 3

Typically, the earlier diagnosed the cause of the fault, the cheaper its elimination. Apply this principle to cases in Tables 3.1 and 3.2, comment on the procedure for determining weight number for both of the cases.

Make a report on the work performed.