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D04667

United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.133/28
17 January 1973
ORIGINAL: English

Seminar on Furniture and Joinery Industries
Lahti, Finland, August 1972
6 21

QUALITY CONTROL [1]

by

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id.73-419

1. Introduction

Quality determines the usefulness of a product. A certain grade of quality corresponds to different uses. The quality of a product has generally no constant value. That is why we can only talk about average quality. Pieces are not equal because their qualities are always different from each other. Variation is usually due to many factors that are connected with raw material and semi-manufactured articles, machines, tools and workers' ability. Variation is quite natural and it cannot be avoided even in the most careful production. Quality is a stochastic (accidental) quantity.

Variable qualities of a product in wood industry are, for instance:

measures - length, thickness, breadth
condition of wood - moisture content, number and size of knots, specific gravity etc.
quality of work - evenness of surface, durability of glued joints, several clearances etc.

Compared to many other branches of industry there are very many sources of variation in the wood industry. That is why the arrangement of quality control in the wood industry is complicated and difficult. As the productive process in the furniture and joinery industry is divided into many secondary stages, it is always possible that faults multiply themselves.

That is why it is not enough to sort out finished products, but it is necessary to do quality control in all stages of production. It can be said that it is most important to control production in the beginning of the process. Thanks to this, economic losses can be avoided because faults do not multiply themselves.

One example: faulty measurement of length in precutting. The piece is dried, edged, surfaced and thickness planed. If the piece is noticed to be too short in edge planing it is rejected, moved into another part of the product or stored for future uses. This may result in unnecessary work, increase of raw material waste, need of more stores, difficulties in arrangement of work or repairs of products which usually means the same as decline of quality.

As a summary it can be said that an uncontrolled quality causes many difficulties, among which are:

- marketing (selling) becomes more difficult,
- reclamations arise,
- customers are not pleased,
- profitability of production becomes smaller,
- feeling among the workers gets worse.

2. The aims of quality control

The purposes of quality control are:

- to distinguish variation due to abnormal factors from the normal dispersion of the process and to find out and eliminate its cause,
- to find out how by examining measurements the variation can be made as small as possible and kept within certain limits,
- to choose a method by which the process can be followed in different stages in such a way that unfavourable factors cannot suddenly affect the process,
- to make quality control proportional to other expenses of the factory.

3. The methods of quality control

The nature of the production usually forms the basis of this choice. In separate production there are no big series but many different articles which are produced in variable successions and are often made to order. In this case production (and the factory unit) is often relatively small. The costs of quality control cannot be very high.

Control by sample tests and measurements, normally by a foreman, is suitable for this kind of production.

Control must be absolutely regular inspite of its accidental nature. It must also be repeated to cover all tho stages of the work. Simple visual examination as a general procedure belongs to this type of control. In addition, measurements must be carried out using several instruments:

- linear measure: length, crossmeasures (rectanqular form), breadth, height;
- sliding gauge: thickness, breadth;
- clearance measure and ruler: clearances of doors and boxes, the smoothness of the surface (a powerful source of light is necessary);
- hygrometer: the moisture content of wood (electrical meter or weighing method), humidity of air (a pair of thermometers and equilibrium-curves).

The time of checking may change but control must take place every day. If foremen are responsible for the quality control, each of them must have a special limited field of his own.

The best results in quality control are achieved if a special inspector can perform this task.

In any case the results of measurements must be written down. The best way of doing this is to have a special time-table for this purpose which makes it easy to control the situation. The notes also make it possible to examine the circumstances of manufacture afterwards. This possibility is important expecially if disagreement about performance arises later. The time-table of quality control can be compared with reports that factories give on the cost calculation. Thus it also serves the body of managers of a factory.

In serial production a relatively limited amount of articles is manufactured in big series. The place of production is usually bigger than in the previous case and in addition is more automatic.

As the unit costs of a factory can be kept rather low, more money can be invested in quality control in serial production. Because these factories are to some degree automated, have many phase workers and in some cases the whole process gets on without even a controlling eye, the meaning of quality control becomes very great.

In uncontrolled serial production a great danger lurks in the fact that the amount of faulty products may grow very big before it is noticed.

Serial production can be controlled by using sample tests as mentioned above, but statistical (mathematical) quality control must in this case be considered as the proper method of control.

Almost always only a craftsman (an expert) can perform the task. The objects and the means of control are the same as in the previous alternative.

The difference lies in the fact that the time-table of specimen or sample measurements is regular, their number is rather large and the treatment of measurent results is mathematical (in the main by counting some testfigures).

It is not possible to introduce statistical quality control as a whole in this lecture. We have to examine only its general outlines and principles. Within this field you can easily find much appropriate literature.

Statistical quality control is based on the concept of probability. Suppose an event can happen in h ways out of a total of n possible equally likely ways. The probability of occurence of the event is denoted by

$$p = \frac{h}{n}$$

Raw data are collected data which have not been organized numerically.

An array is an arrangement of raw numerical data in ascending or descending order of magnitude. The difference between the largest and smallest numbers is called the range of the data.

It is often useful to distribute the data into classes and to determine the number of individuals belonging to each class, called the class-frequency. The number of class intervals is usually taken between 5 and 20, depending on the data.

Histograms and frequency-polygons are two graphical representations of frequency distributions (fig. 1).

Frequency curves arising in practice take on certain characteristic shapes (fig. 2).

An important example is the normal curve, called the symmetrical or bell-shaped or GAUSS-frequency curve. It is characterized by the fact that observations equidistant from the mean have the same frequency.

We can draw many conclusions from the shape and type of the frequency-distribution (fig. 1). In this connection I take up only the normal curve, because it is the most frequent distribution used in quality control in the mechanical wood industry.

When the regularity of the GAUSS-curve begins to take shape we approach at the same time the suitable number of measurement results. In favourable cases it can be very small (10...30), but sometimes more measurements are needed.

The degree to which numerical data tend to spread about an average value is called the variation or dispersion of the data. Various testing-measures of variation are available, the most common being the range, mean deviation and the standard deviation. The standard deviation of a set of N numbers $x_1, x_2 \ldots x_N$ is denoted by S and is defined by

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{N}}$$

where $\bar{x}$ represents the mean.

Thus S is the root mean square of the deviations from the mean (root mean square deviation).

Sometimes, especially if $N < 30$, the standard deviation for the data of a sample is defined with (N - 1) replacing N because the resulting value represents a better estimate of the standard deviation of a population from which the sample is taken.

The variance of a set of data is defined as the square of the standard deviation and is thus given by S^2.

For normal distributions it turns out that:

1. 68.27 % of the cases are included between $\bar{x} - S$ and $\bar{x} + S$
2. 95.45 % of the cases are included between $\bar{x} - 2\,S$ and $\bar{x} + 2\,S$
3. 99.73 % of the cases are included between $\bar{x} - 3\,S$ and $\bar{x} + 3\,S$

   (i.e. 1...3 standard deviations on either side of the mean) (fig. 3)

The actual variation or dispersion as determined from the standard deviation or other measure of dispersion is called <u>the absolute dispersion</u>. However, a variation of 10 inches in measuring a distance of 1000 feet is quite different in effect from the same variation of 10 inches in a distance of 20 feet. A measure of this effect is supplied by the <u>relative dispersion</u> defined by

$$\text{Rel. dispersion} = \frac{\text{Abs. dispersion}}{\text{Average}}$$

The relative dispersion is called <u>the coefficient of variation</u> given by

$$V = \frac{S}{\bar{x}}$$

It is generally expressed as a percentage. The coefficient of variation is independent of units used. For this reason it is useful in comparing distributions where units may be different.

Tables based on the normal distribution have been calculated. With the help of these tables, problems concerning the process may be solved when the mean value and the average dispersion of the process are known from sampling.

An example:

How big must the average thickness of 25 mm sawed timber be as dry so that undersized pieces would be at most 1 %, when the average dispersion of dry thickness counted on the basis of specimen is 0.52 mm ?

According to the table of the normal distribution the value λ = 2.325 corresponds with 49 % probability. On the other hand the distance between the mean and the limit of undersize (25 mm) must be $\lambda \cdot S$ (fig. 4)

$$\bar{x} = 25 + 2.325 \cdot 0.52 = 26.21 \text{ mm}$$

Control cards based on the normal distribution

Single value (x-) card

A control card is made similar to fig. 3 by turning it through 90° and drawing horizontal lines from the mean value and from the distance of the average dispersions on both sides of the mean (fig. 5). The last mentioned lines are called control-limits. When the card is used every measured value is written down on the control card (a point). The horizontal axis is a time-axis so that values are written down in the order of measurement. Now it is known that only 0.3 % of values can accidentally come outside the control-limits, if the process remains unchanged.

Thus we can say with confidence whether the rosult of measurement is included in the natural dispersion of the process or whether it is caused by some exeptional disturbing factor.

Mean value ($\bar{x}$ R) card

This control card is in common use. Through it the mean values of small samples (5...15) are examined instead of single values. The advantage of this card is a clearly smaller number of false alarms than a single value card gives concerning the same population. If a change really takes place in the process, the mean value card shows it much easier.

The main knowledge about mean value and dispersion comes from 20 samples or specimens which have been taken as successive time units. The length of a time unit depends on how sensitive the process is to change and how big would be the economic loss caused by the change.

Although the mean value might remain unchanged this is no guarantee that the process remain unchanged, as well. The dispersion must also be controlled.

The range of variation of the results can easily be used for this purpose.

The mean value card ($\bar{x}$-) and the dispersion card (R-) used in this connection are drawn up as follows:

- the mean values and the ranges of dispersion are counted from specimens taken as 20 successive time units;
- the mean value of specimen mean values and the mean value of ranges of variation are counted (centre lines of the cards);
- the control-limits are counted in the following way:

$$\bar{x} - \text{card} \begin{cases} \bar{x} + A2\ \bar{R} \\ \bar{x} - A2\ \bar{R} \end{cases}$$

$$R - \text{card} \begin{cases} D4\ \bar{R} \\ D3\ R \end{cases}$$

$$\bar{R}/S = d2$$

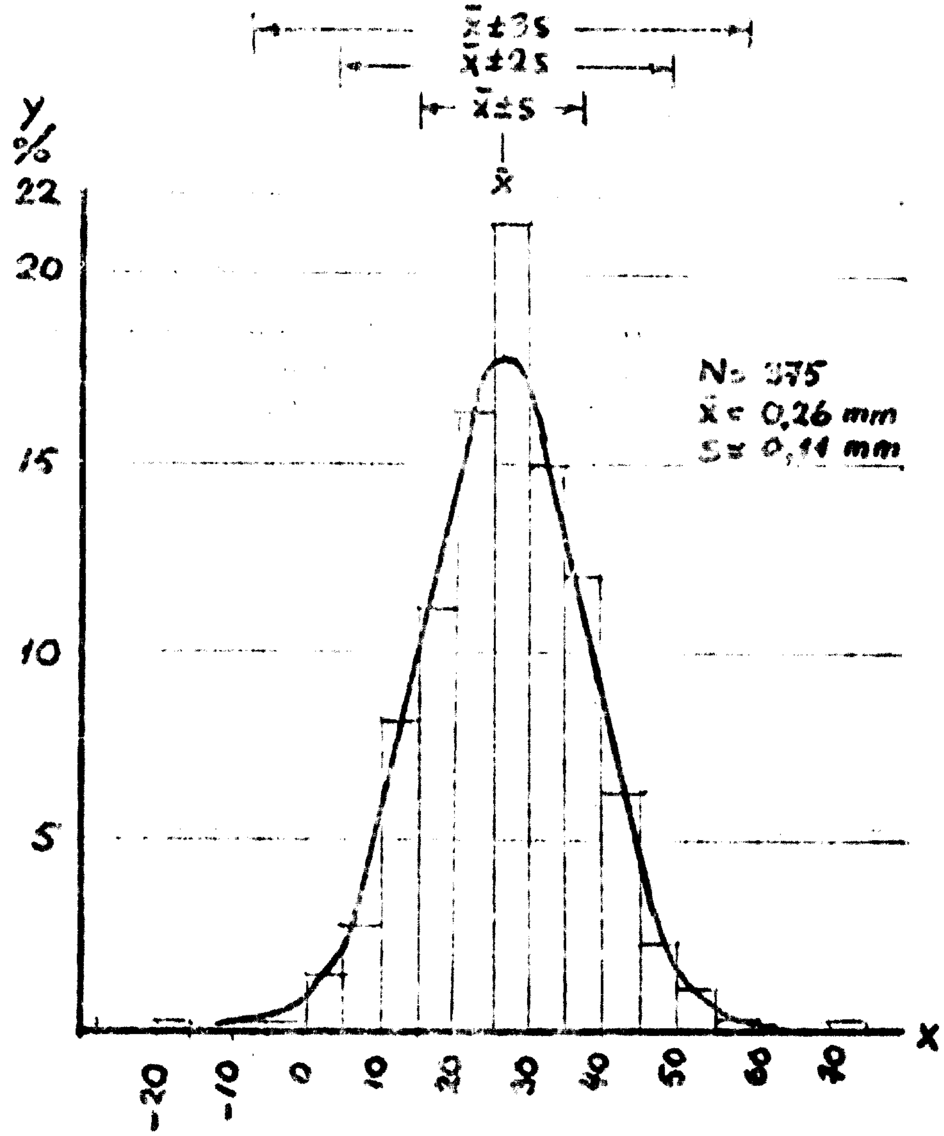
Constants A2, D4, D3 and d2 may be found in tables. They have been determined so that control-limits are on the distance of 3 standard deviations from the centreline on both cards.

Thus again only 0.3 % of the values can accidentally come outside the control-limits.

To statistical quality control belongs many methods, of which only one important example has been presented. The basis of everything is, however, probability calculation, the extensive mastery of which is needed, if this method is to put into practice in factories.

The quality control of a product is an essential element in marketing. A good and above all even quality makes selling easy. It can be said that it is one of the best trump cards in price competition. Thus questions about quality deserve the notice of a responsible body of managers in every production unit.

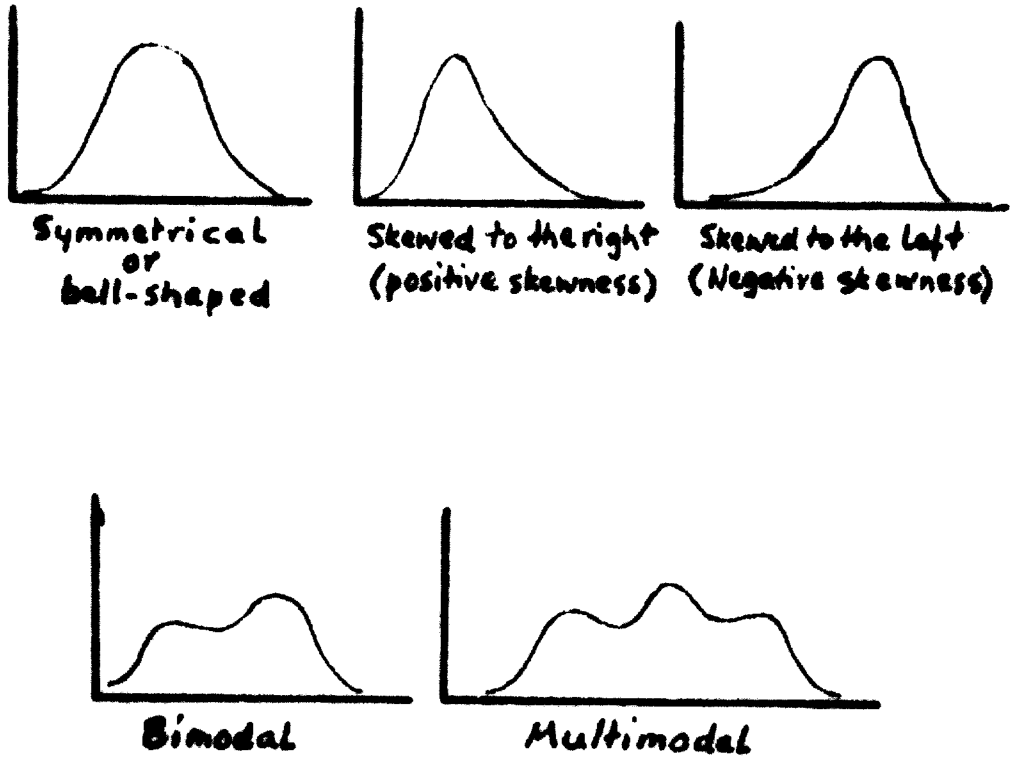
QUALITY CONTROL FIG. 4



DEVIATION OF NOMINAL THICKNESS 0.01 mm

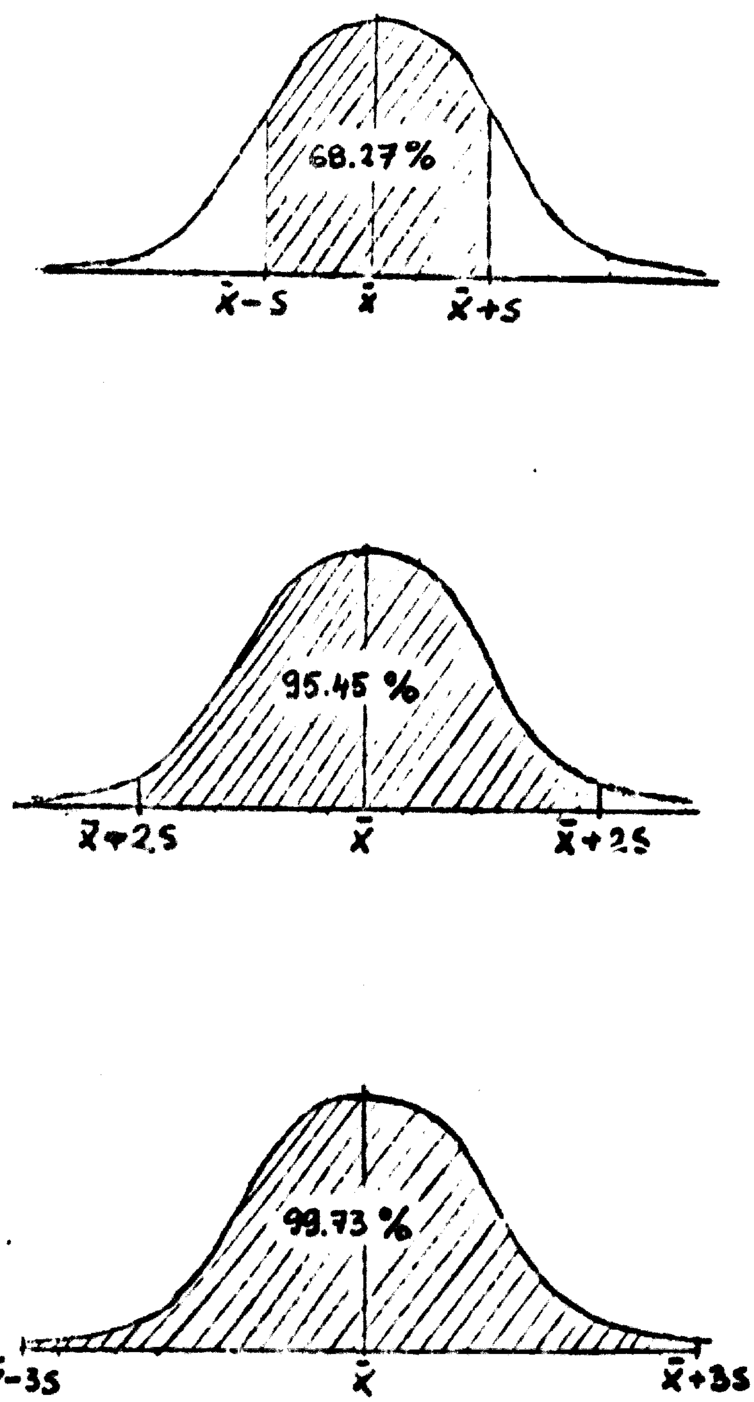
HISTOGRAM AND FREQUENCY POLYGON

QUALITY CONTROL FIG. 2



SOME TYPES OF FREQUENCY CURVES

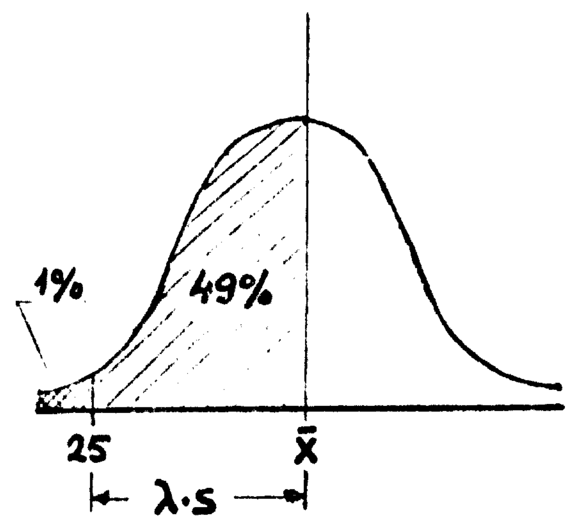
QUALITY CONTROL FIG. 3



PROPERTIES OF THE STANDARD DEVIATION

NORMAL CURVES

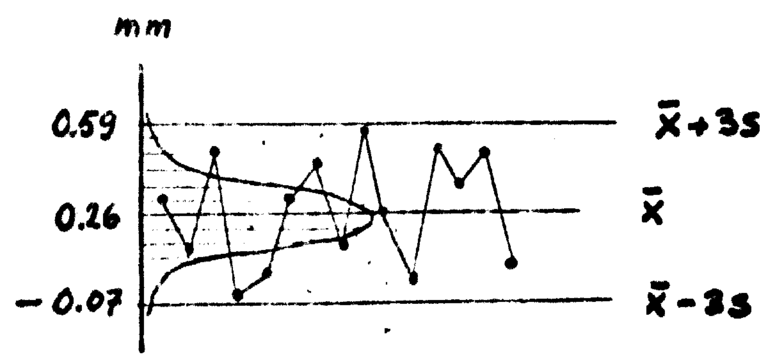
QUALITY CONTROL FIG.4



SEEKING OF THE MEAN

Standard deviation is known and the loss is 1 percent

QUALITY CONTROL FIG.5



SINGLE VALUE (X–) CARD

The same data as in figure 1.

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