TECHNICAL REPORT

# ISO/TR 8550-3

First edition
2007-06-01

# Guidance on the selection and usage of acceptance sampling systems for inspection of discrete items in lots —

## Part 3:
## Sampling by variables

*Lignes directrices pour la sélection d'un système, d'un programme ou d'un plan d'échantillonnage pour acceptation pour le contrôle d'unités discrètes en lots —*

*Partie 3: Échantillonnage par variables*



Reference number
ISO/TR 8550-3:2007(E)

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.



Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.



ISO/TR 8550-3 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.



This first edition of ISO/TR 8550-3, together with ISO/TR 8550-1 and ISO/TR 8550-2, cancels and replaces ISO/TR 8550:1994.

ISO/TR 8550 consists of the following parts, under the general title *Guidance on the selection and usage of acceptance sampling systems for inspection of discrete items in lots*:

— *Part 1: Acceptance sampling*

— *Part 3: Sampling by variables*

The following part is under preparation:

— *Part 2: Sampling by attributes*

## Introduction

This part of ISO/TR 8550 gives guidance on the selection of an acceptance sampling system for inspection by variables. It does this principally by reviewing the available systems specified by various standards and showing ways in which these can be compared in order to assess their suitability for an intended application. It is assumed that the choice has already been made to use sampling by variables in preference to sampling by attributes.

A corresponding guidance document on the selection of a generic acceptance sampling system, scheme or plan for inspection by attributes is given in ISO/TR 8550-2.

# Guidance on the selection and usage of acceptance sampling systems for inspection of discrete items in lots —

# Part 3: Sampling by variables

## 1 Scope

The guidance in this part of ISO/TR 8550 is confined to acceptance sampling of products that are supplied in lots and that can be classified as consisting of discrete items (i.e. discrete articles of product). Each item in a lot can be identified and segregated from the other items in the lot and has an equal chance of being included in the sample. Each item of product is countable and has specific characteristics that are measurable on a continuous scale. Each characteristic has, at least to a good approximation, a normal distribution or a distribution that can be transformed so that it closely resembles a normal distribution.

Standards on acceptance sampling by variables are applicable to a wide variety of inspection situations. These include, but are not limited to, the following:



a) end items, such as complete products or sub-assemblies;

b) components and raw materials;

c) services;

d) materials in process;

e) supplies in storage;

f) maintenance operations;

g) data or records;

h) administrative procedures.

Although this part of ISO/TR 8550 is written principally in terms of manufacture and production, it should be interpreted liberally as it is applicable to the selection of sampling systems, schemes and plans for all types of product and processes as defined in ISO 9000.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition listed applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

ISO/TR 8550-1:2007, *Guidance on the selection and usage of acceptance sampling systems for inspection of discrete items in lots — Part 1: Acceptance sampling*

# 3 Normality

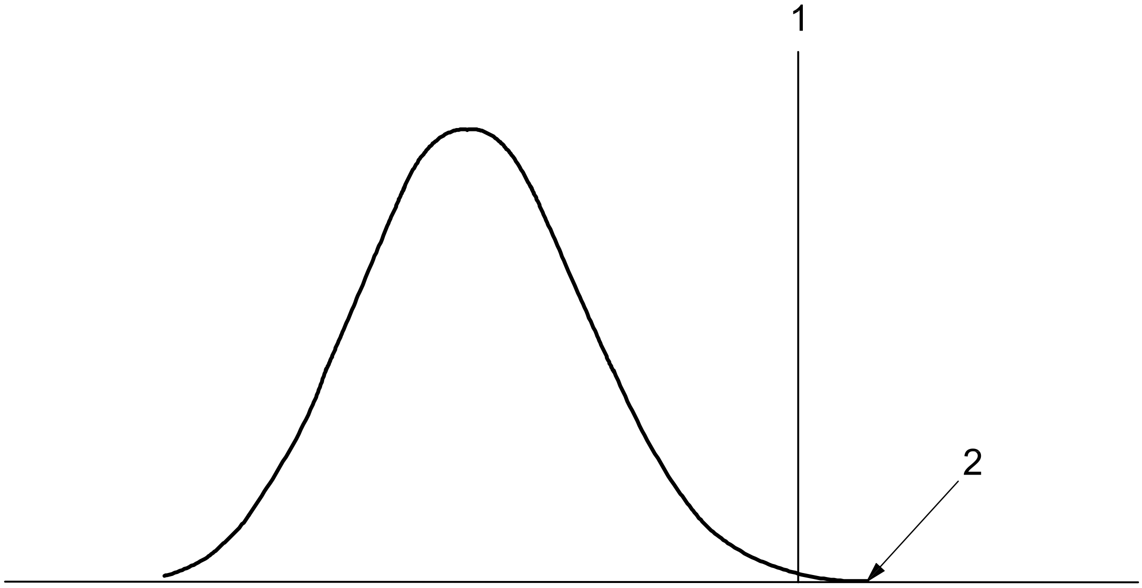
## 3.1 Relationship between form of distribution of quality characteristic and percent nonconforming

A key aspect of sampling by variables is the form of the distributions of the quality characteristics. Consider a single quality characteristic. If it is normally distributed and if an upper specification limit is located at the mean plus two standard deviations, the percent nonconforming is about 2,5 %. If the specification limit is located at the mean plus three standard deviations, the percent nonconforming is about 0,1 %. However, if the distribution of the quality characteristic is not normal and has a large positive skewness, i.e. a long tail to the right, an upper specification limit located at the mean plus three standard deviations could conceivably yield a percent nonconforming approaching 10 % instead of about 0,1 % (see Figures 1 and 2).

Therefore, whenever a sampling plan for inspection by variables for percent nonconforming is to be employed, it is highly desirable to check any assumptions about the shape of the distribution, especially in the tails of the distribution. If the AQL is very small, for example 0,1 %, a study of several thousand items should be made, including a test of distributional form.





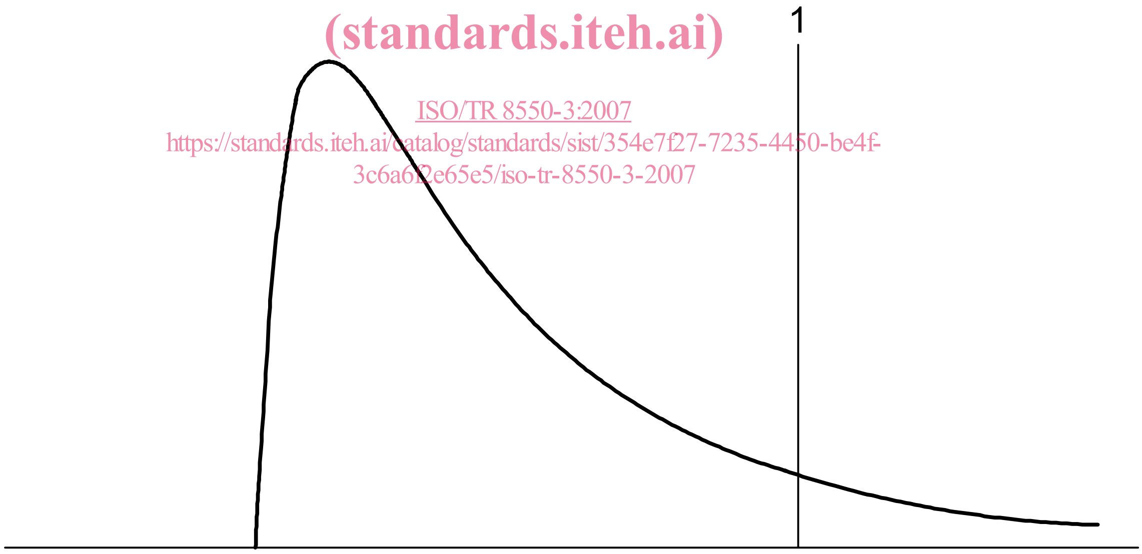

**Key**

1 upper specification limit

2 0,1 % above specification

**Figure 1 — Normal distribution**






**Key**

1 upper specification limit

**Figure 2 — Distribution with large positive skewness**

## 3.2 Identifying departure from normality

### 3.2.1 Subjective assessment

The degree to which a sample appears to have come from a normal distribution can be subjectively assessed by means of a normal probability plot. Such a plot is constructed in the following way. Once the random sample has been selected and the quality characteristic $x$ has been measured for each item, the values $x_1$, $x_2$, . . ., $x_n$ are arranged in ascending order $x_{[1]}$, $x_{[2]}$, . . ., $x_{[n]}$, such that $x_{[1]} \leqslant x_{[2]} \leqslant, . . . \leqslant x_{[n]}$. The points with coordinates $\left\{x_{[i]},\left(i-3/8\right)/\left(n+1/4\right)\right\}$ are then plotted on a sheet of normal probability paper for $i = 1, 2, \ldots, n$. To facilitate this process, an A4 sheet of normal probability paper that can be freely photocopied is provided in Annex A.

Figure 3 shows the normal probability plot of a random sample of size 100 from a normal distribution. The graph paper is specially designed so that data from a normal distribution tend to lie close to a straight line. A straight line has been drawn by eye through the data, showing in this case that there are only minor departures from linearity.

When data originate from a normal distribution, departures of the probability plot from linearity are due solely to sampling fluctuations. Conversely, data from other types of distribution will tend to show departures from linearity of a characteristic type, helping in the determination of the family of distributions to which the data belong. Knowledge of this family can indicate the appropriate transformation to make to the data to bring these closer to normality.

Figures 4 to 7 show the density functions and examples of normal probability plots based on a random sample of size 100 for, respectively, a lognormal, Cauchy, Laplace, and exponential distribution, respectively. On the normal probability plot for Figures 4 to 6, a straight line has been drawn through the data points to aid the eye in identifying the characteristic differences.

For the lognormal distribution, there is a pronounced downward concavity.

The Cauchy distribution is almost indistinguishable from the normal distribution towards its centre, but the extra thickness of its tails results in the plot being relatively high for low values of $x$ and relatively low for high values of $x$, the extremities of the plot being almost horizontal.



The Laplace distribution is similar, except that there is a shorter region in the normal probability plot where the distribution is indistinguishable from the normal distribution, and the extremities of the plot are far from horizontal.

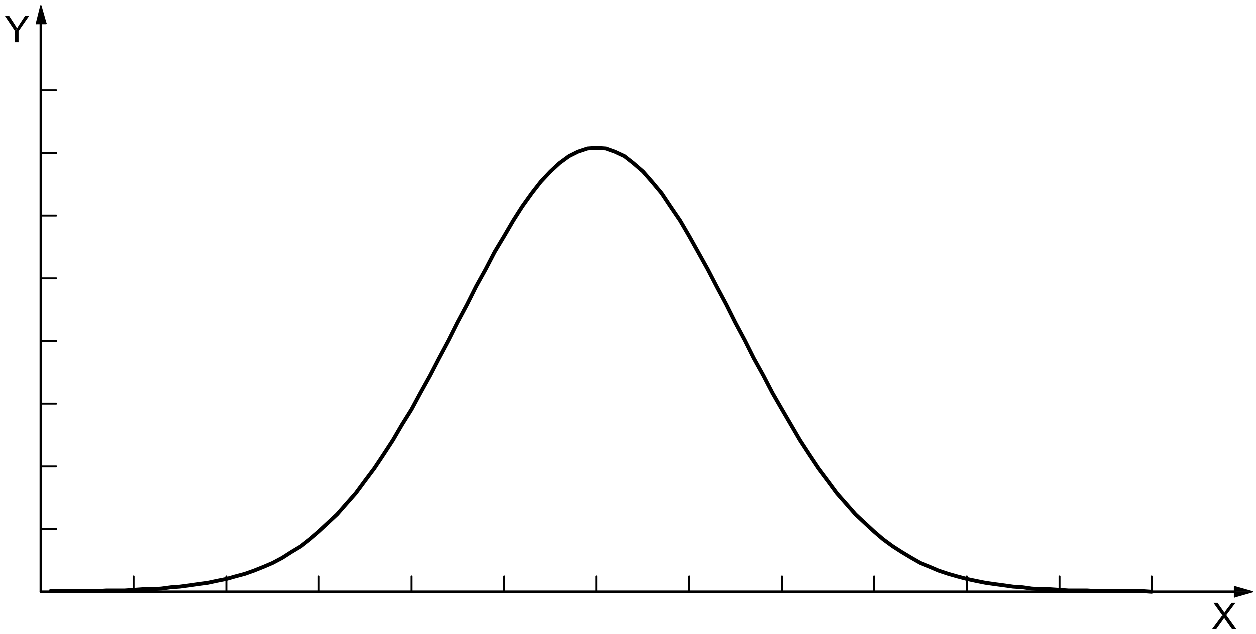


The normal probability plot for the exponential distribution has a very characteristic shape, rising very steeply at the left and becoming almost horizontal towards the right.

These are a small selection from the many possible distributions from which data might have arisen. In some cases, e.g. the lognormal distribution, the distribution can be transformed exactly to normality without knowing its parameters (see 3.3.2 and 3.3.3). In other cases, approximate normality may be achieved, e.g. by using the fourth root transformation on exponentially distributed variables, as shown by Kittlitz[20]. In other cases, acceptance sampling by variables might not be possible without a method tailored to that family of distributions. If such a method does not exist, acceptance sampling by attributes might have to be used instead, the loss in efficiency being more than compensated for by the increase in integrity of the acceptance sampling results.

Figures 4 to 7 show normal probability plots for samples of size 100. Often there is not the luxury of such large samples. With small samples, it is less clear whether the departures from linearity of the normal probability plot are due to non-normality or merely to sampling fluctuations. In case of doubt, subjective assessment of departure from normality should be replaced by objective statistical tests, such as those discussed in 3.2.2.

Further information on tests for departure from normality is given in ISO 5479 and ISO 2854:1976, Clause 2.



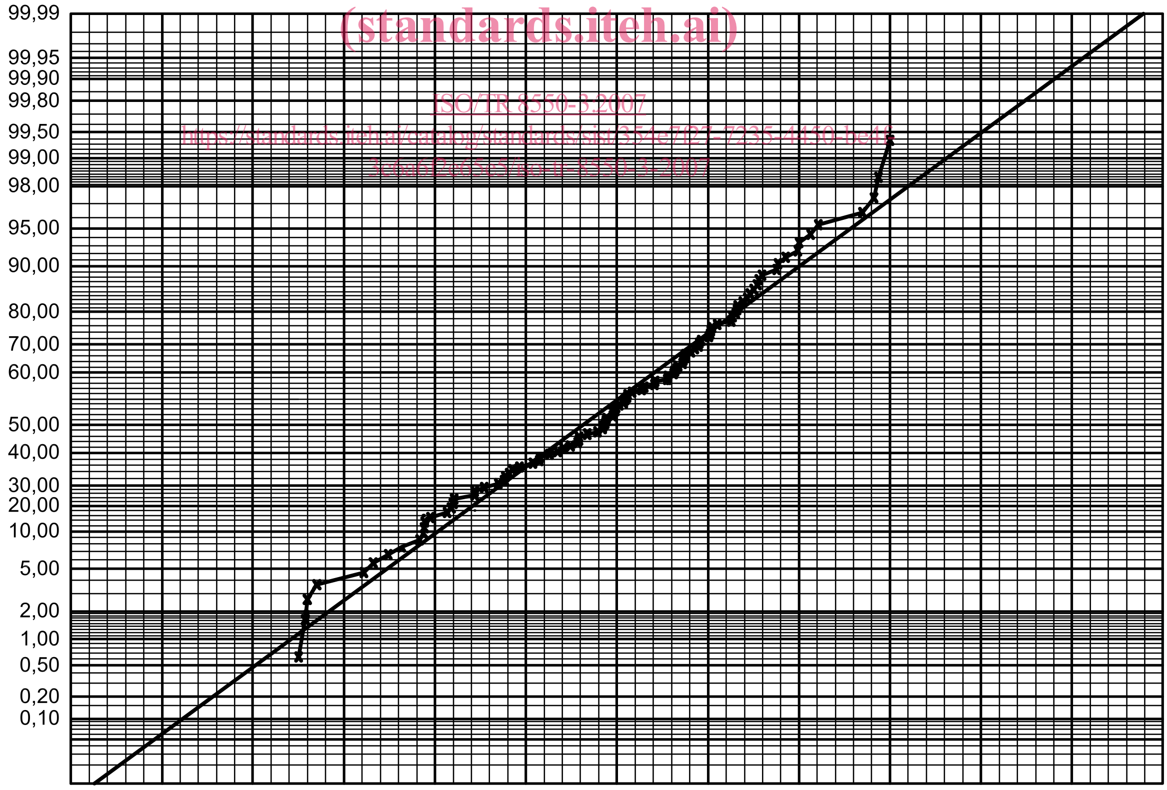

**Key**

X quality characteristic, *x*

Y probability density of *x*

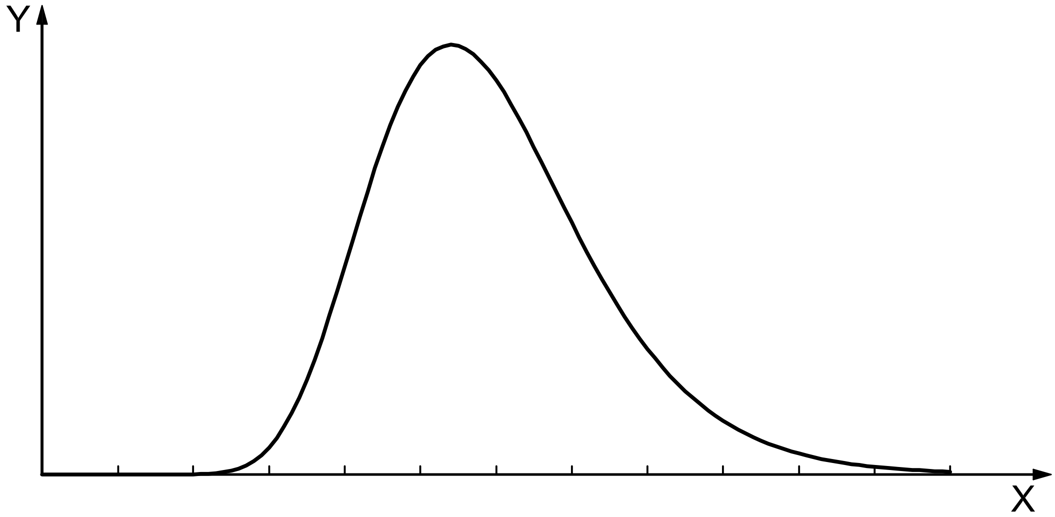
**a) Normal distribution**






**b) Normal probability plot of a random sample of size 100 from a normal distribution**

**Figure 3 — Normal distribution and normal probability plot**

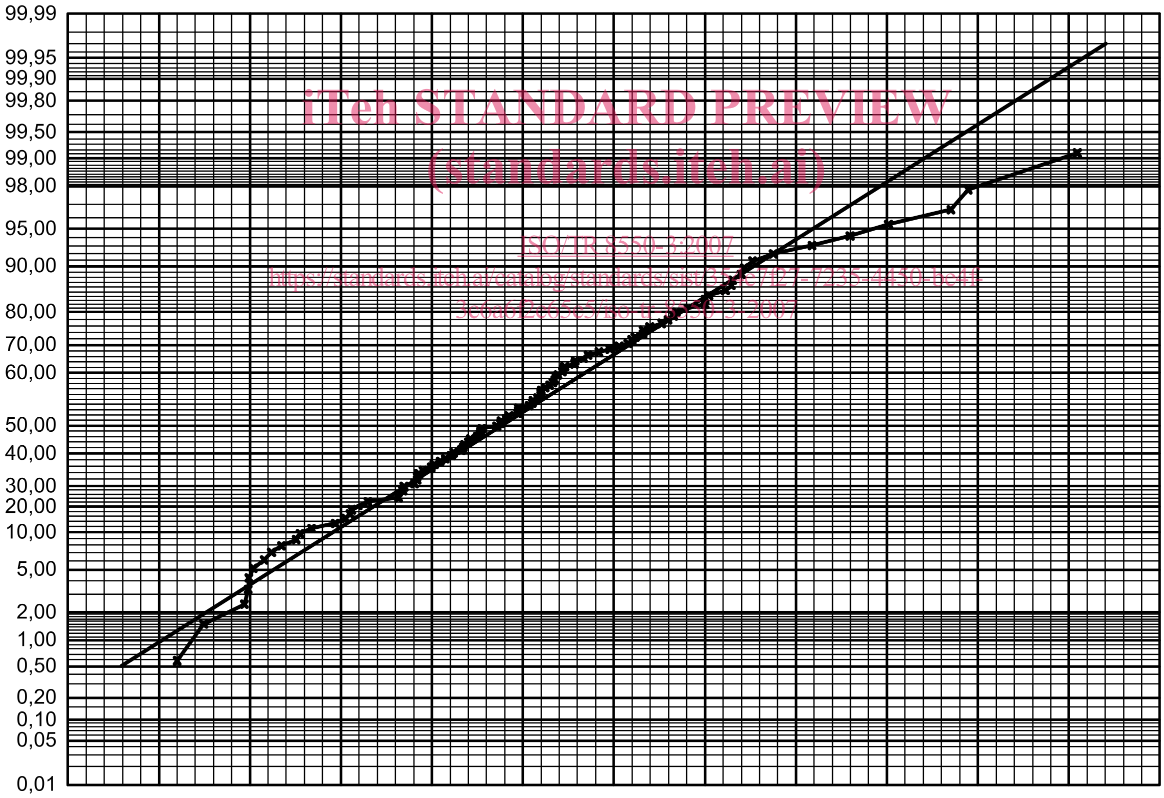



**Key**

X quality characteristic, $x$

Y probability density of $x$

**a) Lognormal distribution**

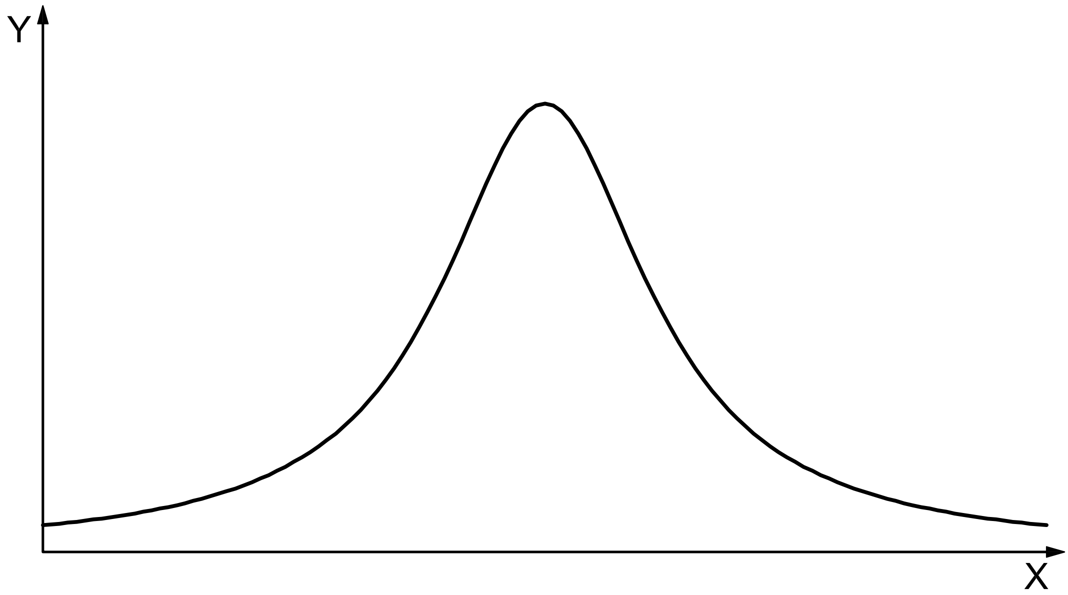





**b) Normal probability plot of a random sample of size 100 from a lognormal distribution**

**Figure 4 — Lognormal distribution and normal probability plot**




**Key**

X quality characteristic, $x$

Y probability density of $x$

**a) Cauchy distribution**




**b) Normal probability plot of a random sample of size 100 from a Cauchy distribution**

**Figure 5 — Cauchy distribution and normal probability plot**