TECHNICAL REPORT

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Solid fertilizers — Derivation of a sampling plan for the evaluation of a large delivery

Matières fertilisantes solides — Fondements théoriques du plan d'échantillonnage destiné à l'évaluation d'une grosse livraison

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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 5307, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 134, *Fertilizers and soil conditioners*.

This document is a type 3 Technical Report. It is not envisaged that it will be published as an International Standard. It gives the mathematical derivation of the sampling plan specified in ISO 8634.

Annexes A and B are for information only.

Introduction

Within the framework of its work on sampling, Technical Committee 134 "Fertilizers and Soil Conditioners" has, through its subcommittee 2, carried out statistical studies on various sampling plans which may be used to assess large deliveries of fertilizers. This work complements other standards for fertilizers, currently under preparation, and provides the theoretical background necessary to appreciate fully the requirements of those standards. This technical report (type 3), which is different from the international standards usually produced by ISO/TC 134/SC4, is intended to act as a complement to them, as a basis for the sampling of fertilizer deliveries.

Each country has its own regulations applicable to the fertilizer trade; an official department is responsible for carrying out checks regarding application of the regulations. If these regulations are violated, sanctions may be taken against those responsible for placing the fertilizer on the market in that country. In the case of an imported delivery, it is the representative of the manufacturing company in the country, or the importer who is considered by the relevant authorities to be responsible for the declared contents shown on labels or other documentation accompanying the fertilizers.

ISO 8634 concerns the case of an importer who resells, on his own responsibility, a large amount of fertilizer received from abroad. After unloading, this delivery is resold in smaller lots to traders (dealers or farmer cooperatives) who will themselves be direct suppliers to farmers. In the case in question, it is the importer whose name is associated with the fertilizer; and it is therefore he who will be considered by the retailers and users to be responsible for the declared contents.

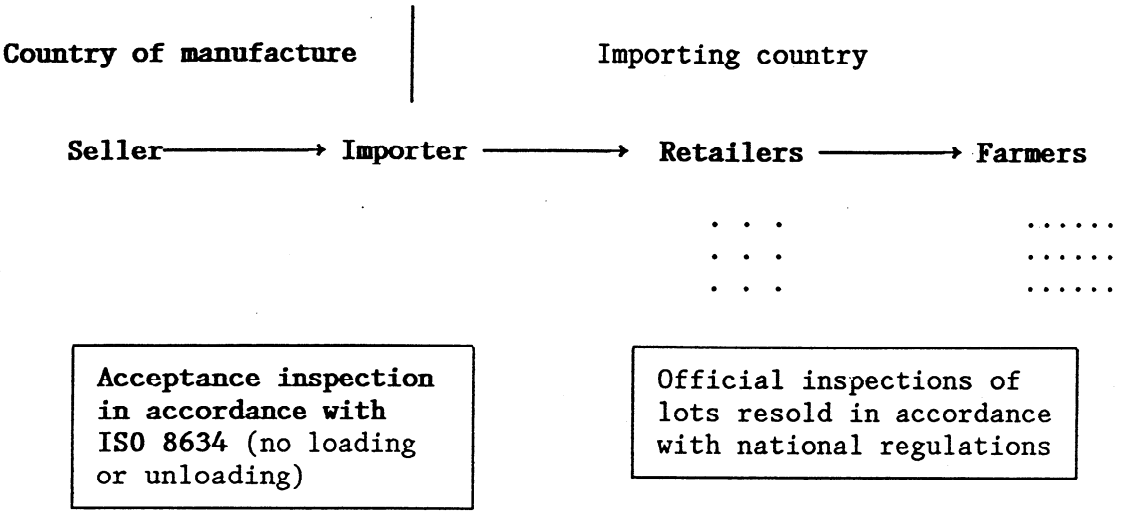
ISO 8634 is designed for **acceptance inspection**. It determines the rules for:

a) sampling (i.e. the sampling plan);

b) acceptance (the acceptance or rejection of the delivery);

and both apply to the bulk delivery imported.

The location of the acceptance inspection, as defined in ISO 8634, in the chain of transactions can be represented by the following diagram:



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Solid fertilizers — Derivation of a sampling plan for the evaluation of a large delivery

1 Scope

This Technical Report presents the sampling theory which has resulted in the definition of the sampling plan described in ISO 8634[1)].

The sampling plan is applicable to a large delivery of more than 250 t of fertilizer supplied to another party, for resale, on his own responsibility, in small lots, each of which would be subject to legislation.

By large amount is understood, for example, a full boat-load (5,000 t, 10,000 t or more) thus corresponding to a relatively long period of manufacture, but the theory applies to any delivery of 250 t or more.

2 References

ISO 8157:1984, *Fertilizers and soil conditioners - Vocabulary.*

ISO 8634:-[1)], *Solid fertilizers - Sampling plan for the evaluation of a large delivery.*

3 Notation and symbols

The following symbols appear in this Technical Report and have the meanings assigned to them below.

μ, $\underline{\sigma}$	Actual mean value and standard deviation between sampling units in the delivery.
μ_a, $\underline{\sigma}_a$	Mean value and standard deviation between sampling units in a delivery of just acceptable quality.

1) To be published.

μ_r, σ_r	Mean value and standard deviation between sampling units in a delivery of just unacceptable quality.
μ_e, σ_e, μ_f, σ_f	Mean and standard deviation, respectively, of two lots which can be considered by the importer to be of the same quality.
U	Number of sampling units in the delivery.
N	Number of sampling units to be selected during the sampling of the delivery. (Increments).
N'	Number of analyses to be carried out on the N increments during the inspection of the delivery.
N_R	Number of sampling units contained in the smallest lot presented for resale.
k	Number of increments to be combined into each aggregate sample for analysis.
n	Number of sampling units which will be mandatorily selected during the official sampling of a lot of N_R sampling units.
$\bar{x}$	Mean value found by analysis after the selection of n sampling units from a lot of sampling units.
s	Estimate of $\sigma/\sqrt{k}$ with the aid of the N' analyses, where σ is the standard deviation between the sampling units in the delivery.
X_i	Analytical result obtained on the sample of rank i.
$\bar{X}$	Estimate of the mean value of the delivery with the aid of the N' analyses.
D	Declared value e.g. of a plant nutrient in the fertilizer delivery.
L	Official inspection limit value which depends on the declared value(D). It may be equal to D or less than D by a prescribed tolerance which may depend on the size of the lot sold.

r_a — Probability that the mean value of n sampling units is lower than the official limit value (L), just acceptable by the importer.

r_r — Probability that the mean value of n sampling units is lower than the official limit value (L), just unacceptable by the importer.

$\underline{\alpha}$ — Probability of rejection of a delivery of just acceptable quality (seller's or producer's risk).

$\underline{\beta}$ — Probability of acceptance of a delivery of just unacceptable quality (importer's or consumer's risk).

u_{1-r_a} — Value of the standardized normal variable such that $Pr[u > u_{1-r_a}]$ equals r_a.

u_{1-r_r} — Value of the standardized normal variable such that $Pr[u > u_{1-r_r}]$ equals r_r.

$u_{1-\underline{\alpha}}$ — Value of the standardized normal variable such that $Pr[u > u_{1-\underline{\alpha}}]$ equals $\underline{\alpha}$.

$u_{1-\underline{\beta}}$ — Value of the standardized normal variable such that $Pr[u > u_{1-\underline{\beta}}]$ equals $\underline{\beta}$.

$\underline{\delta}$ — Non-centrality parameter.

K — Calculation coefficient which is dependent on n, the risk levels $\underline{\alpha}$ and $\underline{\beta}$ and the probability levels r_a and r_r.

a — Constant factor dependent on N' which represents the uncertainty associated with the estimate of the standard deviation.

t_0 — Value of the non-central Student ratio corresponding to the level of probability for a non-centrality parameter equal to

$$\frac{\sqrt{N}\ u_{1-r_a}}{\sqrt{n}}$$

B_0 — Limit value of the estimate calculated from t_0.

A, B	Calculation intermediates used during the estimation of the lot after analysis.
F	Calculation intermediate used to facilitate the calculation of k and N.

4 Preliminary hypotheses

The sampling plan has been drawn up on the assumption that there is no serial correlation between the successive units of the delivery.

The N units inspected are selected at random from the delivery, each unit having the same chance of being selected, and the N groups of k units made up at random from the N. It is also understood that the lots made up by the importer represent a random sample from among the U bags of the delivery and that the increments taken from a lot by the authorities responsible for the inspection are taken at random from the lot.

In the subsequent theory, it is assumed that a single plant nutrient is of interest or that, if this is not the case, each plant nutrient is considered separately. It is also assumed that the fertilizer is packaged. although similar arguments will also apply to products in bulk.

The analytical error is considered to be negligible in relation to the sampling error.

Finally, it is assumed once and for all, as has been shown by the studies of data from production and dispatch inspection carried out in various countries:

a) that the mean concentration of a certain component or value in the sampling units (e.g. bag) constituting a definite lot of fertilizer shall be considered as a random quantity which obeys a normal distribution;

b) that the distribution of this random quantity does not depend, at least for sufficiently large lots, on their size.

5 Principle of the sampling plan

5.1 General

The sampling plan described in ISO 8634 defines a pair of numbers, N and N', which depend on:

a) the legal requirements of the importing country (acceptable limit for the value and the size of the smallest lot which can be inspected);

b) the risks which the importer accepts.

NOTE - It should be remembered that it is intended for the inspection of the delivery received by the importer, and not for the lots resold by the same importer.

N is the number of increments which are to be taken from the delivery and N' the number of analyses to be carried out on these N increments.

The N increments are combined and mixed k by k (k is a whole number), thus resulting in N' aggregate samples ($N = kN'$) and an analysis is carried out on each of these N' aggregate samples.

This procedure is explained by the relatively long and costly nature for the analyses for determining the content of the various fertilizer nutrients.

The sampling plan adopted is based on the use of two non-central Student distributions.

As the standard deviation of the population is only known through N' analyses and the corresponding estimate s, the confidence intervals to be used should draw on Student's distribution and not Gaussian distribution. Moreover, in the present case, the two central values of the limit distributions which the buyer's and seller's risks should cover, will be defined on the basis of a fixed value (L) by a shift based on the standard deviation $\underline{\sigma}$ of the population. In this case, the reduced value of the interval between the value L and the confidence interval limits obeys a non-central Student distribution, which has been tabulated in particular by Neyman and Tokarska. It depends only on the shift of the central value (in relative value) in relation to the standard deviation $\underline{\sigma}$ of the population.

Given that in each non-central Student test (one linked to the seller's risk, and the other to the buyer's risk) the same standard deviation (i.e. $\underline{\sigma}_a$ or $\underline{\sigma}_r$) arose in the non-centrality parameter and in the dispersion of the mean of the N sample values, then the determination of N and N' is independent of the value of the actual standard deviation of the lot.

5.2 Information

This is of two types. The first type is derived from the national regulations of the importing country. That is:

n — The number of sampling units from which, in accordance with the regulations, partial samples are to be taken, in the case of the smallest lot that can be inspected.

L — The official inspection limit; if the declared value is D, it can be equal to D or less than D by a permitted tolerance which may or may not be a function of the number of lots inspected. ($L = D - T$, if T = tolerance).

The second type can be fixed by mutual agreement between the two contracting parties (the supplier and the importer), taking into account

the conditions of application of the regulations in the importing country (frequency and stringency of inspections, punitive sanctions, etc.):

That is:

r_a This is the fundamental parameter as **it defines the "level of quality" which shall be the minimum objective of the manufacturer in production, in order to give satisfaction to the importer** (see figure 1 and 7.1).

Production will normally be centred upon the declared value D; but it is not sufficient for it to fulfil this condition. What is required by the importer, and it should be noted that he is not the user, is to be able to resell small lots without being penalised by the official inspection service. He therefore wishes it to be impossible to draw from the overall delivery small lots which, after sampling, reveal average contents less than L, under official inspection conditions. The ideal would be for the production to contain no small lot likely to appear on inspection to have a value less than L; but this ideal is impossible to attain under practical manufacturing conditions and would only be verifiable by a full inspection, at a prohibitive cost. The importer therefore accepts a certain percentage of incorrect units (i.e. bags, if the bag is a sampling unit) defining the quality level of the overall delivery which he considers acceptable; this percentage is expressed by the parameter r_a which can be defined as "the probability, which is just acceptable to the importer, that the average value of n sampling units is less than the official limit L".

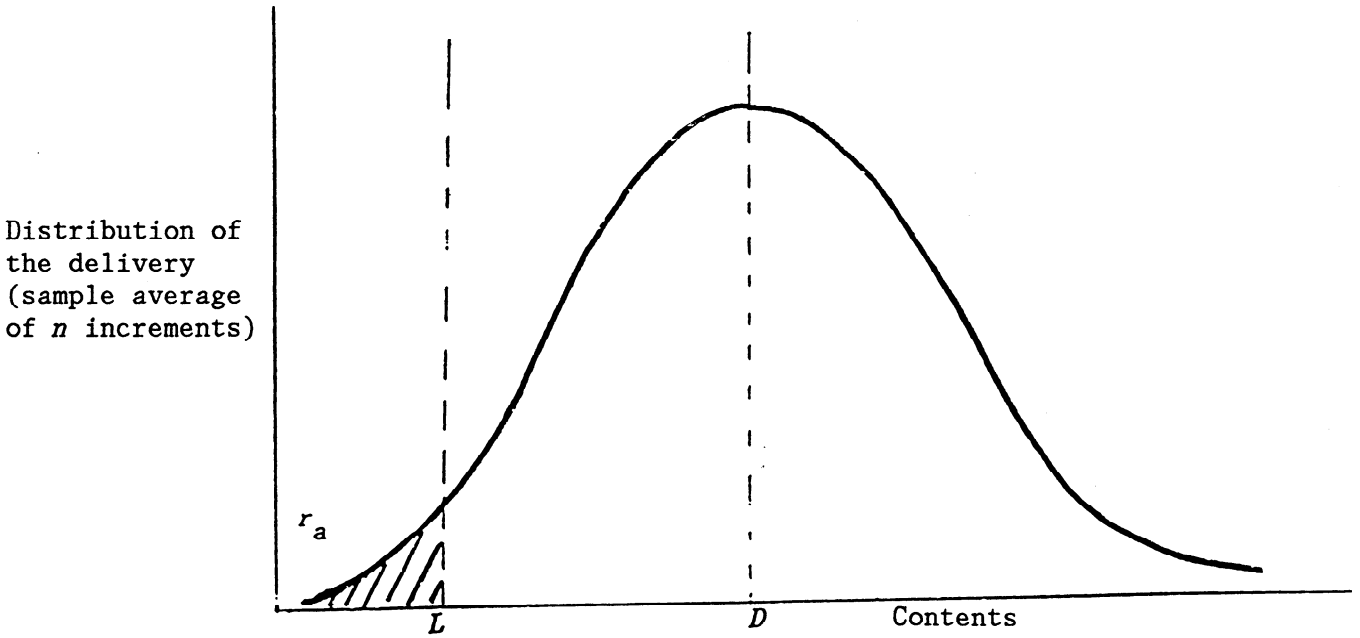

Figure 1 – The relationship between D, L and r_a