**SECOND PART**

# INTRODUCTION

**Why and when does one sample**

# FACTORS AT STAKE IN SAMPLING

- **SAMPLING** is the first, the most risky, the most neglected and ignored link of …

**QUALITY CONTROL**

- **IN INDUSTRY and TRADE :**
  the factor at stake is especially the …

**ECONOMICAL FACTOR**

**QUALITY IS MONEY**

- IN BIOLOGY, MEDICINE, PHARMACEUTICAL RESEARCH and PRODUCTION,
- AGRICULTURE / FOOD PRODUCTION,
- CONTROL of the AIR we breathe,
- CONTROL of the WATER we drink,
- CONTROL of the ENVIRONMENT, etc.

the factor at stake is first of all …

**HUMAN HEALTH AND LIFE**

**TO SOME EXTENT, QUALITY IS LIFE**

**VERY OFTEN, SAMPLING IS QUALITY**

# SAMPLING IN THE LITERATURE

Some pertinent, some dubious and some rather surprising remarks …

**1930 : Grummel & Dunningham :**

« Those whose interest in sampling is recent will not easily understand how difficult it has been for the authors to have a new idea adopted » …

**This sad remark is still valid in 2000 !**

**1967 : Kaye (Illinois Inst. of Technology):**

« The accuracy of many analytical data reports is a mirage because unwitting negligence and false cost consciousness have ensured that a sample of powder taken with cursory swiftness has been examined with costly precision. »

**1968 : Dictionary of Mining, Mineral and Related Terms (U.S. Bureau of Mines)**

« Honest sampling requires good judgment and practical experience » … !

# 1981 : Kratochvil & Taylor : fireworks !

« Sampling is not simple … »

« Random sampling is difficult … »

« Obviously, a representative sample cannot be selected by a random process. »

« A good approach is to collect a small number of samples using experience and intuition as a guide to making them as repre-sentative of the population as possible»

**« SAMPLING THEORY CANNOT REPLACE EXPERIENCE AND COMMON SENSE … »**

**1990-2000 : Standards :**

« Analysis should be carried out on representative samples … »

… whose definition is not given anywhere !

**1995 : Laboratory of the Government Chemist :**

Definitions : …

« Representative Sample : this is a sample that is typical of the lot »

**But what is a typical sample ?**

**2000 : Catalog of a manufacturer :**

Section « Screening and sampling »

Sub-section 040G « Sampling »

« Sampling is a boring chore and all too often is relegated to cursory thought and disinterested personnel ».

**INDEED ! THAT IS THE QUESTION !**

Obviously, this manufacturer is unaware of the existence of a sampling theory …

# SAMPLING and MEASUREMENTS

Quality control involves measurements.

We must distinguish between three cases :

**1. MEASUREMENT CAN BE PERFORMED**

- **DIRECTLY** on the **ENTIRE** object …
- In a **SUFFICIENTLY ACCURATE** and **REPRODUCIBLE** way.

This is the only case where sampling is not required. A rare occurrence ...

# 2. MEASUREMENT CAN BE PERFORMED

- **DIRECTLY** on the **ENTIRE** object …
- But in an **INSUFFICIENTLY ACCURATE** and **REPRODUCIBLE** way.

Example : Measurement, nearly always biased, of mass or volume of flowing batches of particulate solids, liquids, pulps, etc. by means of belt or nuclear scales, volumeters or the like.

Proportional Sampling is an original bias-free method. Its use has been generalized in the South-African platinum mines.

# 3. MEASUREMENT CANNOT BE PERFOR-MED DIRECTLY ON THE ENTIRE OBJECT

**Chemical analysis**, very costly by unit mass is the most typical example of this case.

The measurement must therefore be carried out on a **FRACTION** of the object.

This fraction can be either …

- **A RELIABLE SAMPLE**, when it has been taken in certain conditions (see below) or …
- **AN UNRELIABLE SPECIMEN**, when these conditions are not fulfilled

# SAMPLING IS THEREFORE A MASS REDUCTION

- The object to be valued may weigh **tons or thousands of tons.** With modern methods, assay or test portions usually weigh between **one gram and a few mg.**

- Mass reduction by sampling is a step-wise progressive process. With particulate solids sampling steps alternate with crushing, grinding, pulverizing steps.

# QUALITY CONTROL = SAMPLING + ANALYSIS

**Quality control is a two-link chain.** Both links may generate errors. Both, therefore, should receive the same care and the same amount of investments. This is not the case.

In the year 2000, care and money still go to analysis, to the detriment of sampling that remains the poorest relation of the family …

# IS SAMPLING a SIMPLE HANDLING TECHNIQUE or a SCIENCE ?

Sampling is all too often regarded as a simple handling technique **on an equal footing with screening**. See catalog of an American manufacturer :

Section « Screening and sampling »
Sub-section 040G « Sampling »

**This point of view is very general !**

**Sampling is indeed a TECHNIQUE but this technique is submitted to the laws of a SCIENCE that is disdainfully ignored by interested parties :** this science should be known, **therefore taught**, and respected whenever solving a sampling problem.

A theory of sampling, founded on the Calculus of Probability has been developed since 1950. First publication in 1951. Presented in an International Congress in 1953 and published in 1954.

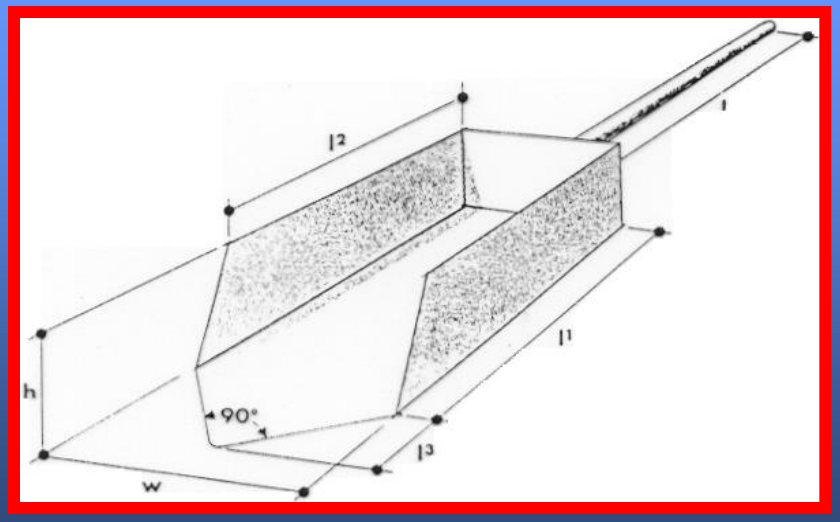
Since the 1951-53 papers, more than 200 articles have been published by the author in various languages. Nine books and numerous short courses in French and English. Latest books in English :

- **1992 : Heterogeneity, Sampling, Homo-genizion** (700 p.) , Elsevier , Amsterdam.
- **1998 : Sampling for analytical purposes** (150 p. version) , John Wiley , Chichester.
- **Books, articles and PhD theses** have been written by others on this theory.

# SAMPLING AND STANDARDS

**Standards are usually naïve and written by unqualified people without any regard to scientific considerations.**

Example of the sampling scoop (ISO) : the handle length alone is optional !



| Scoop Number | Top Size in mm | Volume in ml | Dimensions in mm | | | | | Thickness in mm |
|---|---|---|---|---|---|---|---|---|
| | | | $w$ | $h$ | $l_1$ | $l_2$ | $l_3$ | |
| 1 | 1 | 15 | 30 | 15 | 30 | 25 | 12 | 0.5 |
| 3 | 3 | 40 | 40 | 25 | 40 | 30 | 15 | 0.5 |
| 5 | 5 | 75 | 50 | 30 | 50 | 40 | 20 | 1 |
| 10 | 10 | 125 | 60 | 35 | 60 | 50 | 25 | 1 |
| 15 | 15 | 200 | 70 | 40 | 70 | 60 | 30 | 2 |
| 20 | 20 | 300 | 80 | 45 | 80 | 70 | 35 | 2 |
| 30 | 30 | 400 | 90 | 50 | 90 | 80 | 40 | 2 |
| 40 | 40 | 800 | 110 | 65 | 110 | 95 | 50 | 2 |
| 75 | 75 | 4,000 | 200 | 100 | 200 | 170 | 80 | 2 |
| 100 | 100 | 7,000 | 250 | 110 | 250 | 220 | 100 | 2 |
| 125 | 125 | 10,000 | 300 | 120 | 300 | 250 | 120 | 2 |
| 150 | 150 | 16,000 | 350 | 140 | 350 | 300 | 140 | 2 |

**Standards impose arbitrary rules to utilizers devoid of any critical formation !**

# REPRESENTATIVITY

All analytical standards state that assays must be carried out on …

**« REPRESENTATIVE SAMPLES »**

but these standards …

- **Fail to give any scientific definition of a « Representative sample »,**
- **Fail to say « what should or should not be done to obtain one ».**
- A scientific definition of a **Representative sample** is given in Part 3 **« Definitions ».**

# PHILOSOPHY OF STANDARDIZATION

- According to an ISO officer, the role of the technical committees, **ISO/TC**, should be **« to describe the practices on which trade has been based for a long time ».**
- No qualification required from TC members
- Decisions are taken after a vote !
- Practically **no standard on sampling is based on scientific considerations**. This dubious philosophy encourages **lobbying**.

Quotation of Jules Verne in « De la Terre à la Lune » (from Earth to Moon) :

« I ask you, Gentlemen, and I put the question to the vote of this Assembly **:** is life, as we know it on Earth, possible on the surface of Moon ? » … **YES … AY… HEAR ! HEAR !** (standing ovation ) !

This is the way decisions are taken in ISO/TCs re. Sampling. Example : ISO/TC 102 (iron ore) : maximum cutter speed 1.5 m/s instead of 0.6 m/s (scientific experiment).

# GENERALITY OF THIS THEORY

- This theory has been developed for particulate **SOLIDS of MINERAL origin** (ores and minerals, raw materials and products of the cement industry … )

- It has first been extended to **particulate SOLIDS of vegetable / animal / synthetic** origin (such as cereals, sugar beets, bovine bones, plastic materials … etc.) **and to all kinds of solids**.

- Thanks to a simple change of scale – from mm to Ångstrom – it is applicable to sampling of **LIQUIDS / GASES** (chemical, biological and pharmaceutical research and industry).
- To the sampling of **BODY FLUIDS** (such as blood, urine) or other biological materials,
- To **ENVIRONMENTAL CONTROL** of household refuses, industrial effluents, etc…
- To **CUSTOMS** control, **FRAUD** detection,
- Practical difficulties with **GASES / FUMES**.

# ROLE OF UNIVERSITY AND STANDARDS ORGANIZATIONS

- **This role should be major BUT in 2000 University and Standardization go on ignoring the mere existence of a theory which has NEVER been contested by anyone. Exceptions FINLAND and NORWAY**
- Equipment manufacturers follow standards that their clients are liable to know.
- **Lobbying** in ISO Technical Committees !

# HOW TO MASTER THE SAMPLING ERRORS

Sampling is a progressive mass reduction. At each sampling stage the total sampling error is sum of **SIX** components. Question …

Can one :

- **SUPPRESS** some of these ?
- **REDUCE** and **ESTIMATE** those one cannot suppress ?

The **QUALITATIVE** and **QUANTITATIVE** approaches try to answer these questions.

# INTERNATIONAL SAMPLING INSTITUTE ISI

**ISI has been created to fill up the gaps left by University and Standardization**

Its purposes are :

- to organize the teaching of the theory,
- to advise research and industry,
- to take an active part in the writing of new national, European and ISO standards,

- **To develop scientific sampling** in the following fields of activity :
  - Biology and medicine : research and cure
  - Agriculture : research and production,
  - Food industries : research and production
  - Chemistry : research and production,
  - Pharmacy : research and production,
  - Ecology : all kinds of control, etc.

- **To take part in the following controls :**
  - Control of human and cattle food,
  - Control of the water we drink,
  - Control of the air we breathe…
- **Protection of the environment, generally speaking, more specifically control of...**
  - Industrial effluents,
  - Household refuses and their processing,
  - Contaminated soils, etc.