doi: 10.1255/tosf.55

A European standard for sampling of waste material: EN 14899

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Introduction

Management of waste streams requires knowledge of their intrinsic characteristics, especially with respect to evaluating their response to various treatments, and their potential impacts on the environment. Testing and characterization of wastes allows informed decisions to be made on the appropriate way in which they should be treated, (or not), recovered or disposed. In order to undertake valid tests, it is a requirement that this is based only on representative samples.

Wastes arise in a wide variety of types (e.g. pastes, liquids, granular materials, mixes of different materials) and sampling situations (e.g. during a waste production process, from stockpiles, tanks, drums). Because of the variability, instability, and their widely contrasting compositions, it is often difficult to make measurements directly at their production and the problem of sampling becomes particularly prominent. Moreover, there can be a variety of sampling objectives within each of the three broad categories, i.e. basic characterization, compliance testing and on-site verification.

In 2005, the European Committee for Standardization (CEN) and one year later AFNOR, the French Standardization Association, published the standard EN 14899[1] which deals with the general waste sampling problem. This European Standard, prepared by the Technical Committee CEN/TC 292 "*Characterization of Waste*", specifies the procedural steps to be taken in the preparation and application of appropriate sampling plans. It takes into account waste specific features resulting from:

- Strong heterogeneities;
- Occasional complex behaviours during the sampling and preparation stages, due to instability or other physicochemical characteristics;
- The result of a specific production process, which may be necessary to consider for a proper sampling strategy.

Thus, it provides a framework that can be used to produce standardised sampling plans for use under routine circumstances, with a view also to be able to incorporate specific sampling requirements demanded by European or national legislations, and finally to design and develop sampling plans for use on a case-by-case basis.

Presentation of standard EN 14899

To achieve the objectives of a waste testing program, appropriate sampling methods need to be selected or designed, that will ensure representative samples. For this purpose, the European Standard EN 14899 "Characterization of Waste – Sampling of waste materials: Framework for the preparation and application of a sampling plan", largely based on the concepts of the Theory of Sampling (TOS)[2-5] which represents the only comprehensive approach to representative sampling, provides a framework for how to prepare a sampling plan, in which the elements of the sampling process are defined. It is the first of the following seven program testing steps (see also Figure 1):

- Definition of sampling plan.
- Field sample extraction.
- Delivery to laboratory.
- Test sample preparation.
- Extraction.
- Analysis.
- Measurement report.

The standard EN 14899 aims to provide a list of issues which must be considered when establishing a waste sampling protocol; in particular, it is intended as a guide for writing standards applied to sampling of specific waste (daughter/derived standards).

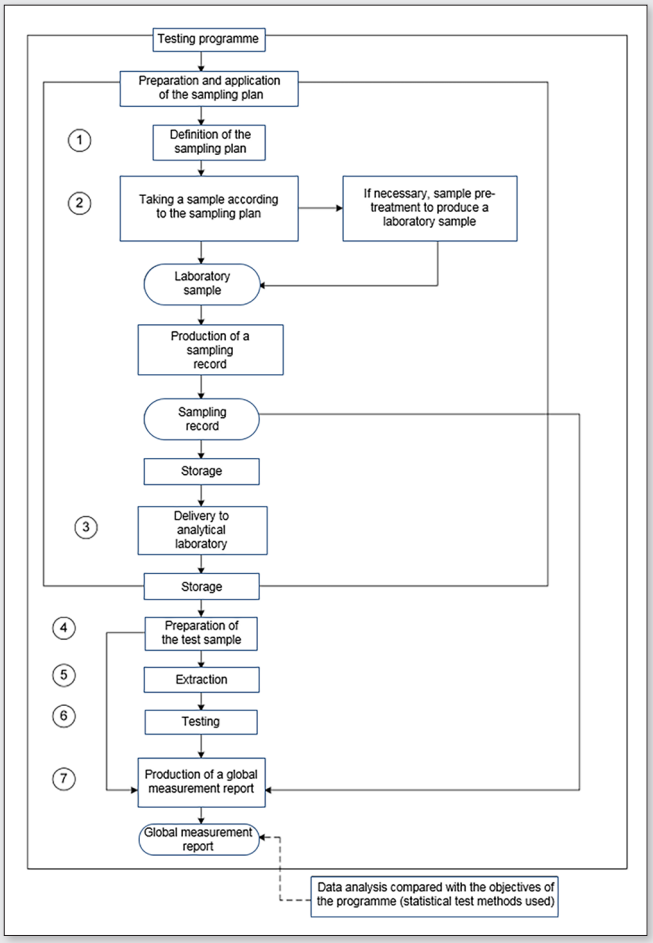

Figure 1. Links between the essential elements of a testing program following EN 14899. NOTE: Key Steps define the 7 overall steps that make-up a testing program.

To facilitate its implementation and enforcement, the standard EN 14899 is accompanied by the following five informative technical reports:

- CEN/TR 15310-1, Characterization of Waste – Sampling: Part 1 – Information on the selection and application of a basic statistical approach to sampling under various conditions[6].
- CEN/TR 15310-2, Characterization of Waste – Sampling: Part 2 – Information on sampling techniques[7].
- CEN/TR 15310-3, Characterization of Waste – Sampling: Part 3 – Information on procedures for subsampling in the field[8].
- CEN/TR 15310-4, Characterization of Waste – Sampling: Part 4 – Information on procedures for sample packaging, storage, preservation, transport and delivery[9].
- CEN/TR 15310-5, Characterization of Waste – Sampling: Part 5 – Information on the process of defining the sampling plan[10].

These technical reports contain procedural options that can be selected to match the sampling requirements of all testing program. By contrast, the five technical reports are not normative documents; rather they provide illustrative examples of potential approaches and tools allowing a project manager to design a customized sampling plan for a given test scenario.

The rest of the present contribution gives a brief overview of the main components of standard EN 14899. This cannot replace the official normative document, which remains the reference for any question of waste sampling plan definition.

Design of a sampling plan

The standard EN 16457:2014 "Characterization of waste – Framework for the preparation and application of a testing program – Objectives, planning and report"[11] describes requirements for a waste testing program regarding objectives, planning and reporting with the intent to ensure reliable and comparable results when using the reference methods that have been developed and/or adopted by CEN/TC 292. This defines the sampling plan as "all the information pertinent to a particular sampling activity" and specifies also that "Note 1: The sampling plan includes the taking of the sample, the production of a laboratory sample, and the transport (to the laboratory), and may include the storage of the laboratory sample" and "Note 2: In case the measurement can be done directly in the field, transport and storage might not be necessary and then will not be elaborated further in the sampling plan".

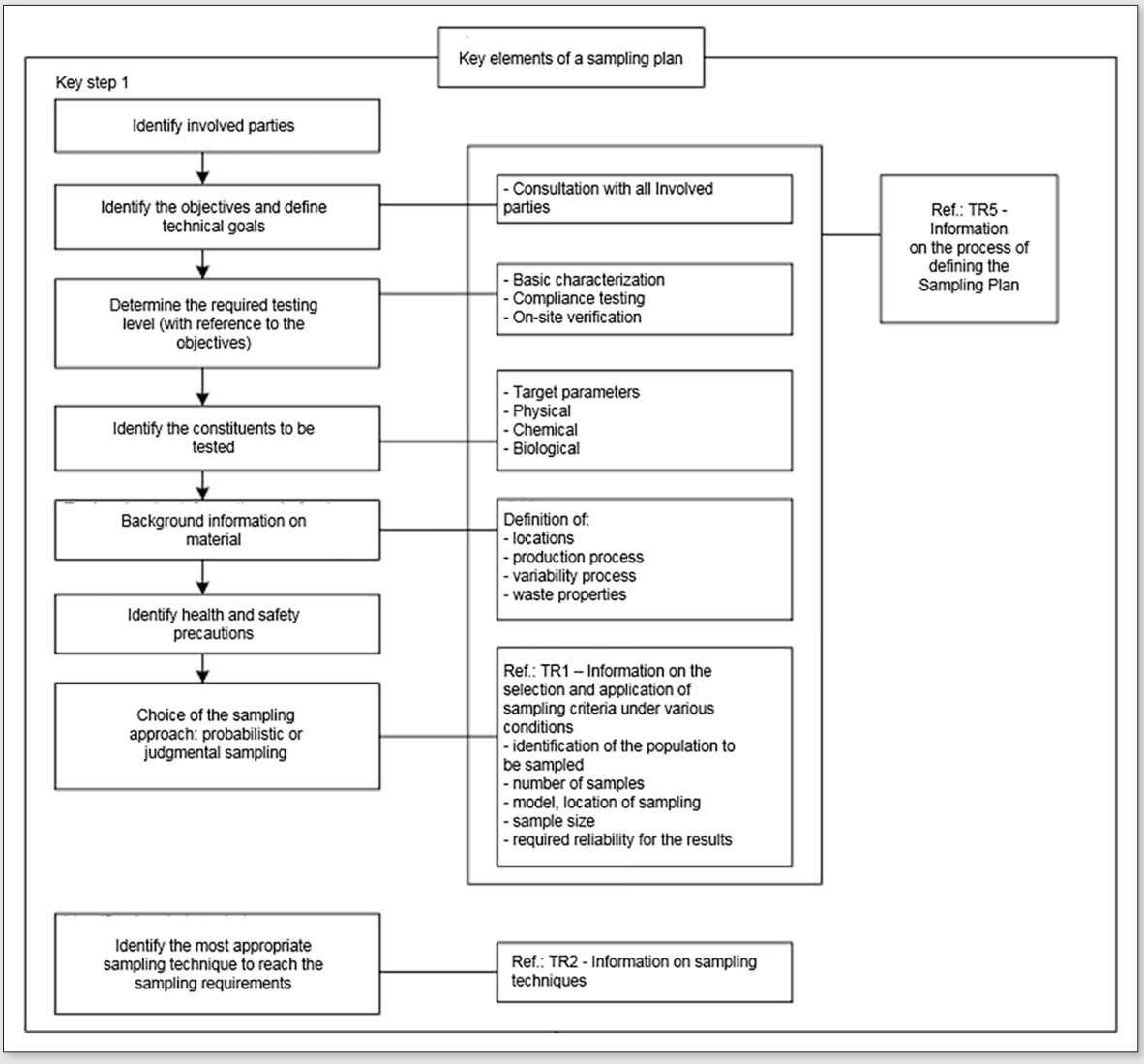

Figure 2. Key elements of a sampling plan following EN 14899.

In others words, a sampling plan shall be completed prior to undertaking any sampling and shall provide the sampler with detailed instructions on how sampling should be carried out. In the process of defining a sampling plan the key elements of the testing program, shown in Figure 2, shall be addressed.

When defining a sampling plan, the following points must be systematically addressed.

Identification of involved parties

The parties involved may as a minimum be the waste producer, but usually also the waste manager, the sampler, the laboratory analyst, etc. The process shall be guided by the need for all involved parties to participate fully, with the objective of improving the quality of the testing program.

Definition of the objectives of the testing program

The objectives of the testing program define what the involved parties want to achieve by the planned waste charaterisation project. Thus they determine the desired level of information (basic characterization, compliance testing or on-site verification) and the desired reliability of the sampling results. Examples of possible objectives of a testing program are:

- To compare the quality of the test material with quality levels defined in national or international legislation;
- To characterise the test material following a change in ownership;
- To determine the re-usability of the test material;
- To determine the leachability of the test material;
- To assess the human health and / or environmental risks posed by the test material.

In the majority of cases, the initial objective of the testing program is too general and non-specific for it to lead directly to the detailed instructions necessary for a proper sampling plan. It is therefore necessary to translate the objective into one or several practical and achievable technical goals. Since the technical specifications for the required samples and the quality level desired are not the same for different objectives, usually one sampling plan is needed for each objective. In some circumstances, it is possible to meet several objectives through a single sampling plan however.

Definition of the required testing level

The sampling plan shall identify the level of testing required to meet the technical goals of the testing program. These will dictate the different types and frequency of investigation to be performed. Examples of testing levels could include basic (or comprehensive) characterization, compliance testing or on-site verification.

Identification of constituents to be tested

The sampling plan shall identify the characteristics or components to investigate, taking into account all known information, such as:

- Origin of the material;
- Intended end-use of the material;
- Total volume of material (in the case of identical units: the population) to be assessed;
- Information from knowledge of process or material involved;

At this point, it is important to collect background information on the material, in order to identify details of the site location or to define the production process, the variability of the process and the waste properties (at least type and dimensions). The sampling plan shall list all known physical and chemical characteristics of the material, including all known potential hazards. In the absence of sufficient information, a 'preliminary investigation' should be instigated, a pilot study.

Selection of the most suitable sampling approach

The sampling plan shall take into account the variability within the lot, or the population and/or sub-population. In addition, the sampling plan shall identify when, where, by whom and how samples shall be taken and collected to ensure that the sample is appropriate to meet the sampling objectives.

At this stage, it is important:

- To define the lot/population to be sampled.
- The lot/population is defined as the total amount (volume or mass) of material about which information is required through sampling (see also technical report CEN/TR 15310-5:2006).
- To identify the scale that defines the volume or the mass of waste material that a sample shall represent. Depending on the nature and the objective of a testing program, scale can also be defined in terms of time. Because of heterogeneities of waste (following TOS, distributional heterogeneity and constitutional heterogeneity have to be considered), defining the scale is important, as heterogeneity is a scale dependent characteristic. As a consequence of the direct relation between scale and heterogeneity, sampling results will be only valid for the scale that is equal to the scale of sampling or higher scales (see also technical report CEN/TR 15310-5:2006).
- To choose the desired reliability of the sampling approach, mainly in terms of "confidence interval" and precision. This reliability strongly depends on the heterogeneities of the considered material, the chosen number of samples, the assumed statistical probability distribution followed by the population, etc. In most cases, it is suggested that the reliability should be as high as possible and representative samples are requested (according to the TOS, a sampling process is representative only when it is both accurate and precise)[12].

Depending on the sampling objective, the sampling plan shall specify either 'probabilistic' sampling, which ensure that each unit within the population being sampled has an equal chance of being sampled, or 'judgmental' sampling.

The sampling approach should at least include:

- The increment size, representing the amount of material (mass or volume) that is obtained through one single sampling action. An increment is not analysed as an individual unit, but is combined with other increments to form a composite sample.
- The sample size.
- The use of composite or individual samples (the latter is known as 'grab samples').
- The required number of samples.
- The sampling location.
- The sampling frequency.

Table 1 summarizes the main steps in defining a sampling plan for a testing program. This table summarizes one of the most important points to consider in establishing a sampling plan as consideration and appropriate choice of statistical criteria are of key importance in the production of a sampling plan.

All information relating to the choice of sampling approach, but also the determination of the size of the increment and of the

Table 1. Main steps in defining a sampling plan for a testing program.

Step	Subject
Specify the objectives of the testing program	
1	Specify the objectives of the testing program
Develop the Technical Goals from the objective	
2	Define the lot/population to be sampled
3	Assess variability
4	Select the sampling approach
5	Identify the scale
6	Choose the required statistical approach
7	Choose the desired reliability
Determine the practical instructions	
8	Choose the sampling pattern
9	Determine the increment/sample size
10	Determine the use of composite or individual samples
11	Determine required number of samples
Define the sampling plan	
12	Define the sampling plan

sample, as well as the number of samples associated with a specified level of uncertainty are given in the technical report CEN/TR 15310-1:2006.

Identify the most appropriate sampling technique

The sampling plan shall identify the technique(s) selected to collect the sample, and shall identify the consequences of deviation from the designated sampling technique or equipment.

Information on the type and use of sampling techniques are given in the technical report CEN/TR 15310-2:2006 and technical report CEN/TR 15310-3:2006 gives information on methods to reduce the sample size for presentation to the laboratory.

Conclusion

Wastes arising in a wide variety of types and sampling situations. Because sampling objectives may vary, a single standard cannot provide definitive instructions for each and every potential case. The European Standard 14899 prepared by the Technical Committee CEN/TC 292 is in fact an umbrella standard that defines minimum requirements on the program, objective, sampling plan and report for the execution of a testing program for waste characterization.

Since its release, it has been applied successfully many times in France, on different types of waste and for different objectives. Examples include:

- Sampling of municipal solid wastes during the last French national household waste characterization survey in 2007. The household waste of a representative sample of hundred municipalities randomly selected to represent the country as a whole was characterized and analysed in order to ascertain the composition of household waste on a national basis.
- Sampling of end-of-life tyres granulate. Aliapur, a Public Limited Company and the leader company in the field of recovering used tyres in France, implemented the standard to define sampling protocols with the objective of characterizing granulate. The resulting protocols have been transformed into standards which can be considered as daughter/derived norms of the EN 14899.

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8. CEN/TC292/WG1, TR 15310-3:2006, *Characterization of Waste – Sampling: Part 3 – Information on procedures for subsampling in the field* (2006).
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