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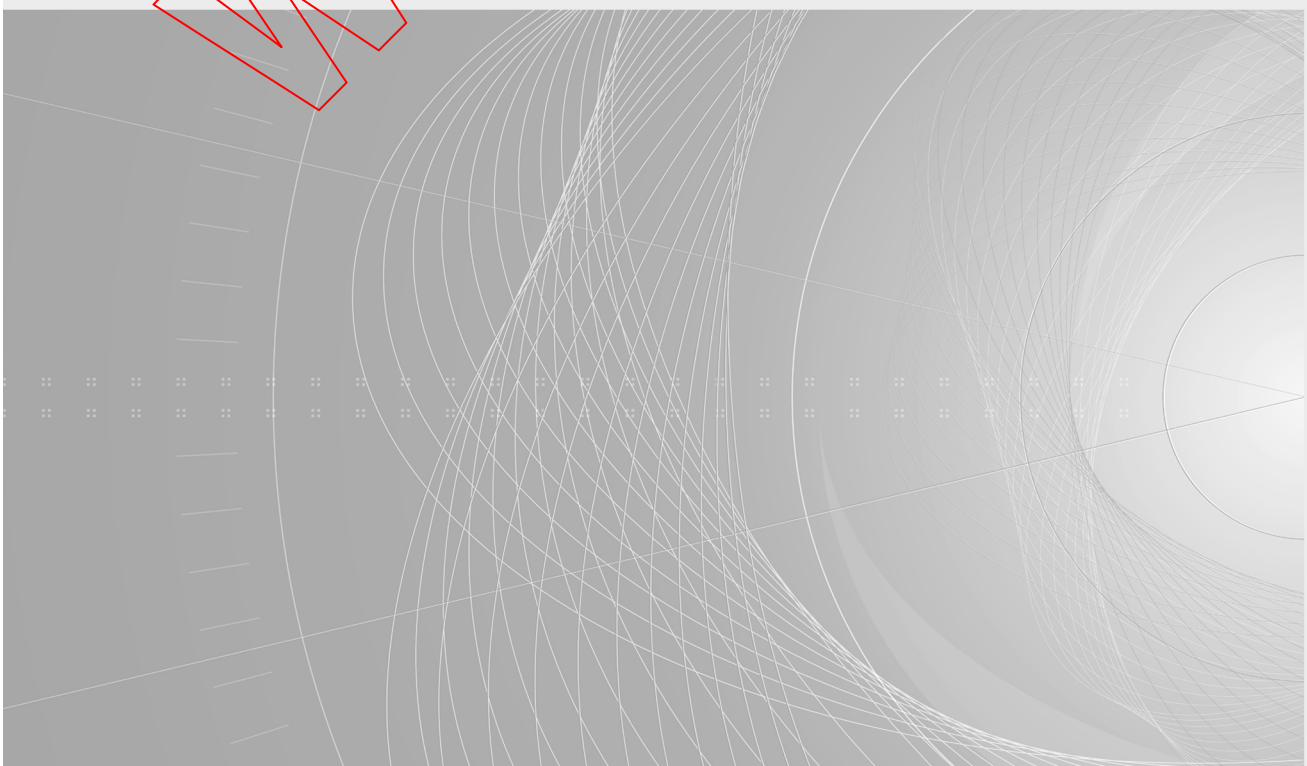
PRE-STANDARD

Electrotechnical products – Determination of restricted substances – Sampling procedure – Guidelines



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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROTECHNICAL PRODUCTS – DETERMINATION OF RESTRICTED SUBSTANCES – SAMPLING PROCEDURE – GUIDELINES

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IEC-PAS 62596 has been processed by IEC technical committee 111: Environmental standardization for electrotechnical products and systems.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
111/112/PAS	111/126/RVD

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INTRODUCTION

In the electrotechnical industry, much emphasis has been placed on minimizing the environmental burden of its products. Waste handling, recycling, chemicals and energy consumption are covered by regulations. Specifically, the use of materials containing lead (Pb), mercury (Hg), cadmium (Cd) and hexavalent chromium (Cr VI), as well as two types of brominated flame retardants (polybrominated biphenyls, PBBs, and polybrominated diphenyl ethers, PBDEs) in electrotechnical equipment is restricted in current and proposed regional legislation.

To demonstrate compliance with these requirements, it may be necessary to analyse electrotechnical products for a variety of reasons:

- to supplement supply chain material declarations (companies may choose to test products directly to determine compliance);
- companies may require their suppliers to perform analysis to support material declarations;
- companies may perform "spot checks" of their suppliers to assess compliance
- enforcement authorities may perform testing as part of their market surveillance activities.

IEC 62321 already provides test methods for the determination of six regulated substances in electrotechnical products. However, the preparatory steps before the analysis are critically important in obtaining accurate, reproducible results. Prior to this PAS, there was virtually no guidance or consensus as to how electrotechnical products should be sampled.

The purpose of this PAS is primarily to complement IEC 62321 by providing agreed guidelines on how electrotechnical products, assemblies and components should be sampled to determine the levels of restricted substances present.

Please note sampling and analytical testing is not the only way to obtain relevant information on the levels of substances in an electrotechnical product or component. Experience and knowledge of the materials used could remove the need for sampling and testing; for example, flame retardants are never used in metals. Furthermore, analytical test reports and material declarations received can be used to demonstrate that the levels of restricted substances are below the required limits.

ELECTROTECHNICAL PRODUCTS – DETERMINATION OF RESTRICTED SUBSTANCES – SAMPLING PROCEDURE – GUIDELINES

1 Scope

This PAS provides general sampling guidelines and strategies of sampling for electrotechnical products, electronic assemblies, electronic components. In order to obtain samples that can be used for analytical testing to determine the levels of restricted substances as described in the test methods of IEC 62321. Restrictions for substances will vary between geographic regions and from time to time. This PAS describes a generic process for the sampling of any substance which could be restricted.

This PAS does not provide:

- Full guidance on each and every product that could be classified as electrotechnical equipment. Since there is a huge variety of electrotechnical components, with various structures and processes, along with the continuous innovations in the industry, it is unrealistic to attempt to provide procedures for the disjointment of every type of component.
- Analysis procedures to measure the levels of restricted substances. This is covered by other standards (for example the future IEC 62321), which are referred to as the "test standard" in this PAS.
- Guidelines for assessment of compliance.
- Guidance regarding other routes to gather additional information on restricted substances in a product, although the information collected has relevance to the sampling strategies in this PAS.
- Sampling procedures for packaging and packaging materials.
- Safe disassembly and mechanical disjointment instructions related to electrotechnical products (e.g. Hg containing switches) and the recycling industry (e.g. how to handle CRTs or the safe removal of batteries).

2 Normative references

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

IEC 62321, *Electrotechnical products – Determination of levels of six restricted substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers)*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

NOTE As this PAS is closely related to IEC 62321, terms and definitions from that standard have not been duplicated here.

3.1.1
electronic assembly
group of components, at least one of which is an electronic device, but in which individual parts may be replaced without damage to the assembly

[Definition H.2.5.9, IEC 60730-1:1999]

EXAMPLE Group of components mounted on a printed wiring board.

3.1.2
electronic components
electrical or electronic devices that are not subject to disassembly without destruction or impairment of design use. They are sometimes called electronic parts, or piece parts

[Definition 3.1.5, IEC 62239:2008]

EXAMPLE Resistors, capacitors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays.

3.1.3
composite testing
testing two or more materials as a single sample that could be mechanically disjointed if necessary

3.1.3
electronics
electronic assembly and/or electronic component and/or field replaceable unit

3.1.4
field replaceable unit
FRU
part, component or subassembly that is easily removed (mechanically disjointed) using ordinary tools

NOTE "Easily removed" consists of using ordinary tools to perform such functions as screwing or disconnecting, and only without irreversibly destroying the unit.

[Definition 3.7, IEC Guide 114:2005]

3.1.5
disassembly
process of taking apart an electrotechnical product; possibly using simple hand tools such as a screwdriver, pliers and wrenches

NOTE A disassembled unit can, in theory, be re-assembled and be made operational.

3.1.6
disjointment
process of, in principle, separating the materials by mechanical actions such as: unscrewing, cutting, grinding, scratching and abrasive processes

NOTE A disjointed part or assembly cannot be re-assembled into an operational unit.

3.1.7
homogeneous material
material that cannot be mechanically disjoined into different materials

NOTE 1 The term "homogeneous" means "of uniform composition throughout". Examples of "homogeneous materials" are individual types of: plastics, ceramics, glass, metals, alloys, paper, board, resins and coatings.

NOTE 2 The term "mechanically disjointed" means that the materials can, in principle, be separated by mechanical actions such as: unscrewing, cutting, crushing, grinding and abrasive processes

3.1.8
infinite thickness
critical thickness
thickness of the specimen which, if increased, yields no increase in intensity of X-rays measured from the sample due to their absorption by the sample matrix. This thickness varies with the energy of X-rays

3.1.9
sampling
process of selecting a representative part or section of a product (any electrotechnical device) for the purpose of determining by means of analysis the concentrations of restricted substances present. Sampling can be carried out by selecting a section on an object or by disassembly and disjointment

NOTE Representative part or section could be the lead-frame of an integrated circuit or the plastic jacket of an electrical wire.

3.1.10
screening
analytical procedure to determine the presence or absence of substances or compounds in the representative part or section of a product, relative to the value or values accepted as the criterion for this decision

NOTE If the screening method produces values that are not conclusive, then additional analysis or other follow-up actions may be necessary to make a final presence/absence decision

3.2 Abbreviations

AAS	Atomic absorption spectroscopy
ABS	Acrylonitrile butadiene styrene
AFS	Atomic fluorescence spectroscopy
ASTM	American Society for Testing and Materials
BGA	Ball grid array (electronic component)
CV-AAS	Cold vapour atomic absorption spectrometry
CRT	Cathode ray rube (television)
DIP	Dual-in-line package (electronic component)
DVD	Digital versatile disc
ED XRF	Energy dispersive X-ray fluorescence
EDX	Energy dispersive X-ray spectroscopy
FRU	Field replaceable unit
GC-MS	Gas chromatography – mass spectrometry
GLP	Good laboratory practice
HPLC-UV	High-performance liquid chromatography – Ultraviolet
IC	Integrated circuit
ICP-OES	Inductively coupled plasma optical emission spectrometry
ICP-MS	Inductively coupled plasma mass spectrometry
MDL	Minimum detection level
LCD	Liquid crystal display
MQCA	Minimal quantity for chemical analysis
OEM	Original equipment manufacturer
PAS	Publicly Available Specification
PBB	Polybrominated biphenyl

PBDE	Polybrominated diphenyl ether
PC	Polycarbonate
PDA	Personal digital assistant
PE-HD	High-density polyethylene
PS-HI	High-impact polystyrene
PVC	Polyvinyl chloride
PWB	Printed wiring board
QA	Quality assurance
SEM-EDX	Scanning electron microscopy – energy dispersive XRF
SMD	Surface mounted device
TFT	Thin film transistor
TV	Television
WD XRF	Wavelength dispersive X-ray fluorescence
XRF	X-ray fluorescence

4 Introduction to sampling

4.1 Introductory remark

Obtaining a sample (i.e. sampling) is the first step in analyzing electrotechnical products for the presence of restricted substances. The strategy and process of sampling is often as important as the analytical measurement itself. Hence an effective sampling strategy requires a clear understanding of the electrotechnical product, reasons for the analysis, and the requirements that are to be met.

Sampling and testing for restricted substances is performed for many reasons including:

- business-to-business for commercial release (e.g. contractual agreement between the OEM and component manufacturer).
- compliance with regulatory limits.
- forensic/impact assessment (why the product does not satisfy contractual or legal requirements, when did this happen, and how many products are affected?).

4.2 Requirements and concerns for restricted substances

While many governments, industry partners and other stakeholders have their own requirements, it is not the intention of this PAS to discuss fully all of these differences. However, awareness of different limits for regulated substances is an important step in preparing the sampling strategy. This clause highlights the main areas of concern regarding the requirements for restricted substances.

1. Restricted substances: Not all geographic regions or industrial partners restrict the same substances. For example, some regions have chosen to restrict the use of only a few specific PBDE compounds, while others have a broader restriction regarding this class of flame-retardants. When sampling a product, component etc. it is critical to keep in mind what are the applicable legal requirements.
2. Allowable limits for restricted substances: Generally speaking, the allowable levels of most restricted substances are below 1 000 mg/kg. Some geographic regions and industrial partners have limits below 1 000 mg/kg. For some product types, limits for restricted substance are above 1 000 mg/kg, e.g. lead in copper and aluminum alloys.
3. Application of the allowable level: The manner in which the allowable level of a restricted substance is applied to an electrotechnical product determines the sampling strategy and how the test results are interpreted. Many geographic regions apply their allowable limits

to "homogeneous materials". In this PAS an “homogeneous material” (3.1.8) is defined as a material that cannot be mechanically disjointed into different materials. However, the interpretation of "homogeneous material" is not consistent across the different regions. Some regions have defined the smallest possible amount of material to be homogeneous (e.g. bonding wires in semiconductor chips only several microns thick), while other regions try to apply a more pragmatic approach.

4. Applicable exemptions: Some types of electrotechnical products are exempt from restricted substances requirements. These exemptions may be based on different rationales including the scope of the restrictions (e.g. for military purposes), the application of the material (e.g high melting temperature solder), size of the sample, or the electrical properties of the product.

4.3 Complexity of electrotechnical products and related challenges

The complex characteristics of electrotechnical products are another important consideration when preparing a sampling strategy. These characteristics have a bearing on the practical execution of sampling and analysis. The following elements are identified as relevant to analysis and sampling:

1. Miniaturization: Miniaturization is one of the key trends in the electrotechnical industry. This implies that more functionality is provided within a smaller volume. More and more components and materials are used per cm² of printed wiring board (PWB) every year. Taking samples for measurement from these small amounts of material is difficult. For example, the size of surface mounted devices (SMDs) is too small for regular tools to further disjoint or separate and the quantity of the remaining sample is often too small after disjointment to satisfy the requirements of adequate analysis.

2. Number of homogeneous materials: Many components have complex structures and are constructed of multiple layers of different materials. In a typical case, one single component has more than 10 to 20 material layers, whereas many electrotechnical products or assemblies contain hundreds or thousands of components. This means one electrotechnical product can have more than 1 000 to more than 10 000 homogeneous materials. Often homogeneous materials adhere too tightly together for a clean separation in a practical manner (see Figure 15). Experience has shown that the composition often changes due to molecular diffusion between materials (e.g. the composition of a plating is affected by a base material containing Pb). Similarly, current electrotechnical products are made of many components and parts. A typical TV or laptop computer for example, contains thousands of parts/components. Hence the design database for an OEM may include several tens of thousands of components. In Clause 5 this point is further illustrated in the disassembly of a mobile phone.

3. "Invisible" substances: Another complicating factor in sampling and analysis is that generally restricted substances are not visibly apparent. A component containing a restricted substance looks and performs in an identical manner to one that is "clean". The presence or absence of restricted substances can vary from lot to lot in the manufacturing process without any readily observable clues. While there are some visible indications (e.g. a yellow coating on steel products suggests the presence of hexavalent chromium) as to the presence of restricted substances, visual detection is not practical.

4. Batch–to-batch variations: Most product assembly manufacturers use commodity components from several suppliers simultaneously, e.g. cables, resistors and capacitors. Commodity components are mixed during production, because technically they are fully interchangeable as long as they fit the umbrella specification. However in most cases they are not chemically identical. Furthermore experience has shown that base materials can be changed by commodity manufacturers (e.g. in times of shortage) which leads to a change in the chemical composition as well. Notifications of these changes do not always occur if the component still meets its technical specification.

5. Depth of the supply chain: Producing electronic components/parts involves a complex supply chain. Relatively simple products such as an external cable, can utilize supply chains at least seven tiers deep. The supply chain for a more complex component like an LCD screen or IC is considerably deeper.

These characteristics of the electrotechnical industry show that the management of restricted substances, along with sampling and analysis, is not straightforward. The size and number of components, and complexity of the supply chain make it challenging to fully grasp the locations of restricted substances in an electrotechnical product. The prospect of implementing homogeneous material level sampling and testing at the upper regions of the supply chain (towards finished products) is not practical for complex products.

4.4 Strategies for sampling

While different sampling approaches may be utilized as appropriate for the broad range of electrotechnical products, it is possible to describe a generic procedure that will be applicable in the majority of cases. This is shown in Figure 1.

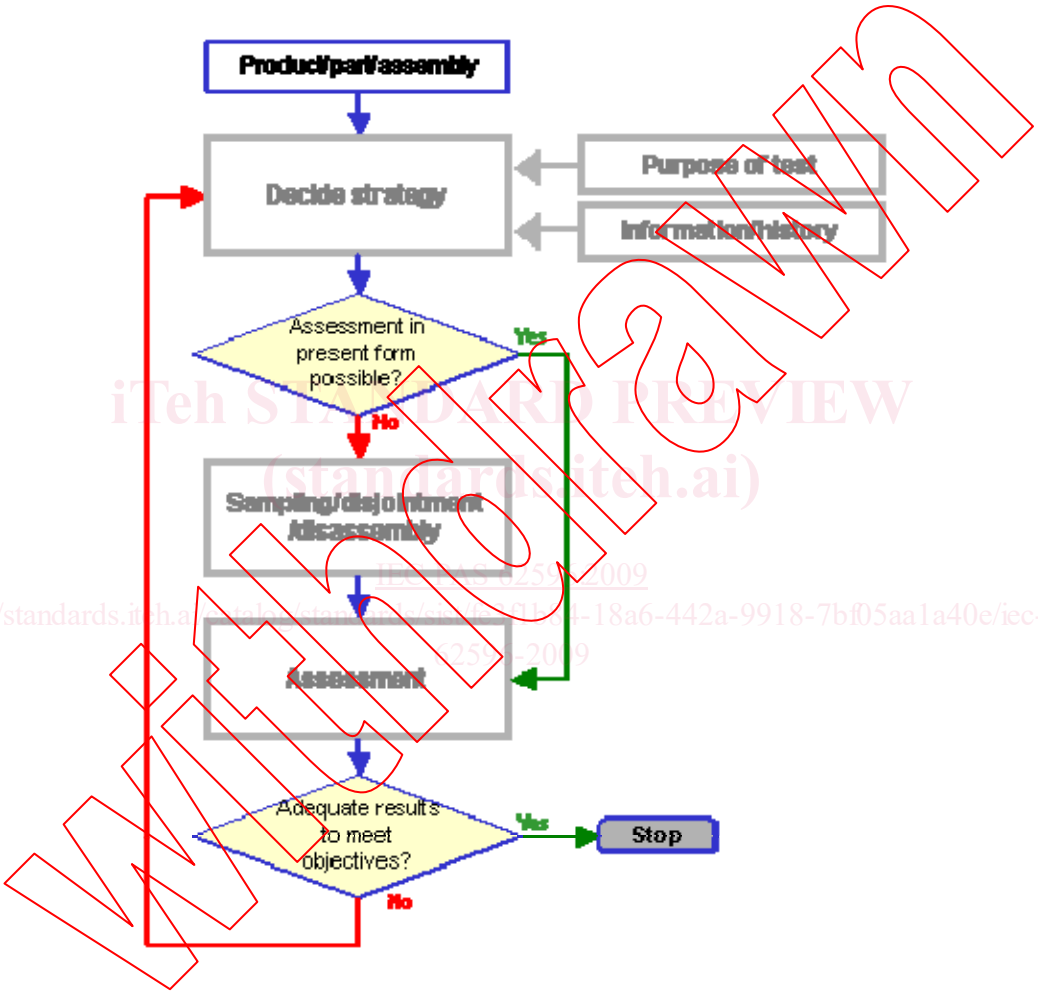

Figure 1 – Generic iterative procedure for sampling

The process depicted in Figure 1 can have several iterative loops including:

- 1st iteration: partial disassembly (see 5.2)
- 2nd iteration: complete disassembly (see 5.3)
- 3rd iteration: partial disjointment (see 5.4).
- 4th – nth iteration: complete disjointment (see 5.5)

These iterative steps are described further in Clause 5.

Development of the sampling strategy for a particular electrotechnical product/part/assembly begins with an information gathering stage. Some basic questions to be considered include:

- What is the complexity of the product/part/assembly and is it practical to consider sampling and testing at the homogeneous material level?

- Which substances are restricted?
- What are the allowable limits for these restricted substances?
- Are there appropriate exemptions for the restricted substance?
- Is a bill of materials available for the components/assemblies/materials in the product?
- Are specifications/drawings of the components available?
- What is the depth of the supply chain for the components and materials in this product?
- Are material declarations for this product available?
- Is there any previous experience evaluating this product or similar products that could be helpful?
- Are there any published probability of presence matrices for the materials or parts used in this product?
- Was any screening (e.g. XRF) previously performed on this product or similar products that could be helpful?
- Is there any information regarding the manufacturing process of materials/components (metal making or IC production) used in this product or similar products that could be helpful?
- Are there any perceived process controls present at the component or material suppliers (e.g. level of trust in the manufacturer)
- Is there any history of concern with the component or material supplier?

The answers to these questions and other characteristics will influence the sampling strategy. The organization's position in the supply chain will determine what extent of sampling is appropriate. Release for production of products/components etc. requires a more in-depth sampling strategy than an occasional verification check on specifications. In order to optimize costs and efficiency the desired outcome of the testing needs to be understood. As previously stated, it is often impractical to sample and test all components/materials. An organization is left to determine the optimum balance of effort/costs against effectiveness of the sampling strategy. Some considerations to minimize sampling/testing efforts and costs are listed below:

- homogeneous materials with a low probability of containing restricted substances (see Annex B);
- applicable exemptions for restricted substances;
- material declarations;
- historical test data;
- composite sampling and testing (see 5.6 and Annex C);
- minimum sample size necessary to run analytical tests and the number of samples necessary to determine whether or not it's practical to test.

The sampling strategy will depend very much on the ultimate objective of analysis. One strategy (perhaps used by enforcement authorities) could be an analysis to verify if the product contains at least one restricted substance at the level exceeding the allowable limit. This approach involves gradual, selective sampling, targeting deliberately those parts of the product that are either known to, or are likely to, contain restricted substances. Each sampling phase could be followed by analysis. If the results show no restricted substances above the allowable limit, a further stage of sampling and analysis could be performed. Once the test results exceed the allowable limit for at least one restricted substance in any part of the product, it is deemed non-compliant and no further sampling and analysis is necessary. Annex B provides a list of components where there is currently a probability of the presence of one or more of six restricted substances.

Another strategy may be to prove total compliance of the product, as far as possible down to the homogeneous material level. This approach would be typical of the product or component manufacturer. Samples would be prepared from each individual material or component. As the

objective is to cover all components and materials in a product/assembly, other routes may be used to gather information on a product level. In the downstream supply chain process documentation and/or analysis reports may exist that would reduce the effort required in sampling and analysis.

Once the objective of the analysis has been defined, an assessment is performed as to the feasibility of testing (e.g. is the sample mass/size/volume sufficient?). Further sampling and disjointment may be necessary, in which a choice can be made to either completely disjoint or only select materials with a high probability of containing restricted substances. Table B.1 can be used to assist in the identification of these components and materials.

If testing is appropriate, the relevant testing procedure should be followed. Where restricted substances are present in the product/part there may be an applicable exemption (some examples are given in Table B.1).

Following the flowchart in Figure 1 is an iterative process, retrieving samples at an ever deeper level. How far this process is pursued will be dependent on the objective of the sampling strategy. After the screening steps further analytical testing may be undertaken.

5 Sampling

5.1 Introductory remark

This PAS only provides general sampling guidelines, which are intended to form the basis of the sampling strategy appropriate to the electrotechnical product.

Whenever possible, sampling should be performed by stages of minimal disassembly and disjointment. Each stage is followed by an assessment of its effectiveness (see the flowchart in Figure 1), typically by screening analysis. Depending on the results of the assessment and objectives of the analysis, further disassembly and sampling may be required, especially for verification analysis of the product's components/materials. This approach to sampling and assessment offers the least expensive, fastest and the most efficient means of analysis, especially when undertaken on the finished product.

The enormous number of types and diversity of electrotechnical products make it impractical to provide detailed sampling strategies for each product. Instead, sampling procedures covering four levels of disjointment and sampling are described for two products:

- cell phone;
- printed wiring board (PWB).

The cell phone is a compact and complex product containing large number of small components. Therefore, sampling procedure of such product should be a good example of how sampling strategies can be developed for virtually any other electrotechnical product.

Annex A provides generic sampling flowcharts based on Figure 1 for some characteristic electrotechnical products: DVD player, CRT tube, LCD TV Set, PDA/phone and a desk fan, along with two components, a thick film resistor and SMD potentiometer. Annex D lists some commonly used disassembly and disjointment tools, and Annex E describes the use of XRF screening techniques in sampling.

NOTE During disjointment, several tools are used. In restricted substances assessment is highly recommended to ensure that the tools are free of the restricted substances to avoid possible contamination.

5.2 Partial disassembly

Sampling of the complete product is the first step in the iterative sampling strategy. It infers that representative parts of the product can be analysed without disassembly or disjointment;