SLOVENSKI STANDARD
SIST CR 13695-1:2001

01-februar-2001

Embalaža - Zahteve za merjenje in overjanje štirih težkih kovin in drugih nevarnih snovi v embalaži ter njihov izpust v okolje - 1. del: Zahteve za merjenje in overjanje štirih težkih kovin in drugih nevarnih snovi v embalaži

Packaging - Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging and their release into the environment - Part 1: Requirements for measuring and verifying the four heavy metals present in packaging

Ta slovenski standard je istoveten z: **CR 13695-1:2000**

ICS:

13.020.40	Onesnaževanje, nadzor nad onesnaževanjem in ohranjanje	Pollution, pollution control and conservation
55.020	Pakiranje in distribucija blaga na splošno	Packaging and distribution of goods in general

SIST CR 13695-1:2001 **en**

CEN REPORT

RAPPORT CEN

CEN BERICHT

CR 13695-1

March 2000

ICS

English version

Packaging - Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging and their release into the environment - Part 1: Requirements for measuring and verifying the four heavy metals present in packaging

Emballage - Exigences pour la mesure et la vérification des quatre métaux lourds et autres substances dangereuses présents dans l'emballage et leur cession dans l'environnement - Partie 1: Exigences pour la mesure et la vérification des quatre métaux lourds présents dans l'emballage

Verpackung - Anforderungen zur Messung und Feststellung der vier Schwermetalle und andere gefährlichen Substanzen in Verpackungen und deren Freisetzung in die Umwelt - Teil 1: Anforderungen zur Messung und Feststellung der vier Schwermetalle in Verpackungen

This CEN Report was approved by CEN on 16 June 1999. It has been drawn up by the Technical Committee CEN/TC 261.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. CR 13695-1:2000 E

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Foreword

This document has been prepared by CEN /TC 261, "Packaging".

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

This document has to be implemented at national level, either by publication of an identical text or by endorsement, by **month year**, and conflicting national standards have to be withdrawn by **month year**.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this document: Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This document is a CEN Report for "the measurement and verifying of heavy metals present in packaging and their release to the environment".

The European Commission gave a mandate to CEN for promoting the preparation of European Standards and CEN reports in order to support the application of the Directive 94/62/EC of 20 December 1994, in particular "the requirements for measuring and verifying heavy metals and other dangerous substances, present in packaging, and their release into the environment".

The Ad-Hoc Group, in charge of the task by a resolution of CEN TC 261 SC4, has set as a priority in the first part of the report the four heavy metals mentioned in Article 11 of the Directive : Lead, Cadmium, Chromium (VI), Mercury, for two reasons :

- To release as early as possible, guidelines for assessing compliance with the Directive for these four metals (cf. Chapter 8).

- Other dangerous substances as mentioned in the mandate are the subject of the part two of the CEN Report.

Have been considered for the development of this work :

→ the existing European or national legislation (Directives)

→ the CONEG legislation as a source of information

→ the CEN standardisation on waste CEN/TC 292.

→ the OECD environment monograph series.

To better identify and control the main sources of contamination by heavy metals, an extensive enquiry involved the European industry operating on this market and their associations, from raw materials and constituents to finished products (chapter 7). It results in the proposal of an efficient tool for the industry to assume compliance, i.e. a procedure limiting the need for individual packaging testing in favour of an "up-stream" assessment more in line with the quality assurance system. It is developed in chapter 8 and covers both packaging and its components; the provided guideline includes minimisation according to art. 9 and annex II, the relevant test methods for measuring being expressed in chapters 9 and 10.

The main conclusions of the report (chapter 11), are the identification of only a few needs for intentional use of heavy metal's compounds in packaging, a preferable "up-stream" approach for assuming compliance, including minimisation, and a need for developing standardised methods.

1 Scope

This part 1 of the report is related to the four heavy metals specified in Art. 11 of the Directive : lead, cadmium, chromium (VI) and mercury. A second part of this CEN-report is related to the need to assess other dangerous substances present in packaging.

2 Normative references

This CEN Report incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this CEN Report only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 45001 : (1989), *General criteria for the operation of testing laboratories.*

EN ISO 8402 : (1995), *Quality management and quality assurance – Vocabulary.*

ISO 3534.1 : (1993), *Statistics - vocabulary and symbols part 1 : probability and general statistical terms.*

ISO Guide 30 : (1992) *Terms and definitions used in connection with reference materials.*

ISO 10012-1 : (1992), *Quality assurance requirements for measuring equipment - Part 1 : metrological confirmation system for measuring equipment.*

ASTM D 4057 : (1995), *Standard practice for manual sampling of petroleum and petroleum products.*

3 Terms and definitions

For the purposes of this CEN Report, the following definitions apply:

3.1
packaging component
any part of packaging that can be separated by hand or by using simple physical means

3.2
packaging constituent
the smallest part from which packaging or its components are made and which cannot be separated by hand or by using simple physical means

NOTE The comprehensive application of the definitions with examples is given in 8.1.2.

4 The European packaging market at present

According to statistics, recently published by PIRA, the value of packaging materials used in Western Europe is estimated at USD 95.8 billion (1994). The estimated amount by weight is 64.8 million tonnes (Annex B, Tables 2.4 and 2.5).

The proportion, by value, of consumer packaging (and probably of the whole market) that goes to the food and beverage market is about 70 %. The quality requirements for the majority of materials used in this part of the market has for many years been in accordance with the Food Contact legislation. This legislation specifies limits for the migration of constituents in packaging materials into packaged food products and a large number of standardised test methods are developed in support of this legislation.

5 The packaging and packaging waste directive

One of the objectives of the Directive is to prevent or to reduce the impact on the environment of Packaging and Packaging Waste (cf. Art. 1).

The recoverable including recyclable nature of Packaging Waste is an essential requirement (cf. Annex II).

In order to reduce the toxicity of Packaging Waste it is essential to prevent the addition of noxious heavy metals to packaging and/or ensure that such substances are not released to the environment (cf. Preamble and Annex II).

In the Directive there are specific requirements related to Heavy Metals in two Articles : Article 9/Annex II and Article 11.

Article 9 requires that all packaging that is placed on the market after 1st January 1998 shall conform to the Directive including the essential requirements defined in Annex II.

Annex II, part 1, third indent contains the following requirement : "Packaging shall be so manufactured that the presence of noxious and other hazardous substances and materials as constituents of the packaging material and any of the packaging components is minimised with regard to their presence in emissions, ash or leachate when packaging or residues from management operations or packaging waste are incinerated or landfilled."

Article 11 specifies three levels for the sum of concentrations in ppm of lead, cadmium, mercury and hexavalent chromium [Cr (VI)], which are not to be exceeded after three different points of time.

The requirements in Article11 for concentration limits come into force in :

- July 1998 (600 ppm)
- July 1999 (250 ppm) and
- July 2001 (100 ppm).

In Article 11 an exemption is included for packaging made entirely of lead crystal glass.

Further exemptions are provided for recycled materials and product loops which are in closed and controlled chain and types of packaging according to the Committee procedure described in Art. 21.

6 Consideration of factors that influence the presence of Heavy Metals in Packaging and in emissions from Packaging Waste management

This chapter contains a review of published or otherwise generally available information relevant to:

- the general presence of Heavy Metals in the environment,
- the eventual presence of Heavy Metals in certain kinds of packaging and,
- the presence of Heavy metals in emissions when household waste containing used packaging is incinerated or landfilled.

a) The general awareness about the risks associated with heavy metal emissions into the environment is the subject of the section **6.1: "Heavy Metals in the environment and risk reduction".**

b) The presence of Heavy Metals in packaging is influenced by the previously existing "Food-contact-legislation" restricting the use of heavy metals in packaging for food. This is the subject of the section: **6.2 : "Packaging intended to come into contact with Foodstuffs".**

c) There is a recognised need for technology intended for control of the emission of heavy metals from plants for incineration of waste, including household waste. The development in this area of technology is the subject of the section: **6.3: "Emission Control at Incineration of Household Waste.**

d) A considerable amount of published research exists on leakage from landfills. A review of findings related to the leakage of heavy metals is the subject of the section: **6.4: "Leachate from Landfills"**.

6.1 Heavy metals in the environment and risk reduction

Heavy metals in the environment arise from many different sources : engines exhaust gases, ferrous or non-ferrous metallurgical activities, combustion (wood, peat, coal, fuel, refuse, sewage sludge, ...), agricultural/mining/other industrial activities, post-user waste of various types, ...

A great progress has nevertheless been made since the mid-eighties to decrease the emissions of the most critical ones into the environment:

- Between 1980 and 1995 the non-ferrous metal industry in Flanders/Belgium reduced its lead, cadmium, mercury ... emissions by a factor 10 (ICME/International Council on Metals and the Environment).

- Lead emissions into the atmosphere have decreased by 30 % between 1983 and 1992, the mobile sources being by far the most important contributor ; the lead level in urban waste is decreasing in some countries ; lead emissions from incineration units can be kept under control thanks to appropriate technologies, the efficiency of which may exceed 99 % ; hygienic problems associated with landfills can be kept under control, as evidenced by studies, provided that the landfills are properly managed ; and since 1992 leaded gasoline use has still decreased.

- The selective collection of specific wastes, such as batteries for instance (European Ecolabel batteries is continuously improving the map).

Two important OECD environment monographs - n°1 on lead (1993) and n°5 on cadmium (1995) - are related to the background and national experience with reducing risk. Here are summarised only part of the conclusions, based on the aim of this report.

- **Concerning lead**, a continuous decline in levels in environmental media is observed as a consequence of restrictions and reductions in dispersive uses but also due to "the development of technology for safe management of wastes destined for final disposal in landfills or incinerators." Current activities and national measures such as in Denmark, Finland, France, Germany, etc. are reviewed, but from the different tables showing a continuous drastic decrease in the concentration of lead in air and in human blood with years, at least two tables are illustrating the relatively low contribution of packaging : figure 43 (from Switzerland) shows that as early as 1970, household source is negligible compared to traffic and industry ; figure 55 covering the estimated discards of lead in MSW in the US for the period 1970-1986 reveals a continuous decrease for the concerned packaging materials (becoming therefore an insignificant contributor).

- **Concerning cadmium**, the major products containing this heavy metal are reviewed, including some constituents such as coatings, pigments or stabilisers, but one of the main conclusion is that a well-managed waste treatment should be safe : for municipal waste, "99.8 to 99.9 per cent of cadmium introduced to the incinerator of municipal waste was caught in the boiler and the air pollution control equipment" (1993) and "the cadmium concentration in leachates from controlled, state-of-the-art industrial or municipal landfills is often below the limit of detection". "In a study on one uncontrolled municipal landfill in Denmark, ... the cadmium concentration in twelve samples was below the limit of detection, 0.2 µg/l ". (1991).

6.2 Packaging Intended to come into Contact with Foodstuffs

For more than 20 years the European food packaging market has been dependent on the Food Contact Legislation (see Bibliography), with the objective to restrict the migration of toxic substances from packaging materials into packaged food products. Since the existence of this legislation might influence the implementation of some of the requirements of Packaging and Packaging Waste Directive, it is relevant to review the basis for this legislation.

The Food Contact legislation is based on toxicological evaluation of effects on humans under certain assumptions regarding their daily or weekly consumption of packaged food, and published by WHO (World Health Organisation) and SCF (Scientific Committee for Food). For cadmium and lead the provisional tolerable weekly intake (PTWI) for lead is 25 micrograms per kg bodyweight and for cadmium 7 micrograms per kg bodyweight. (see Annex C). In a similar way toxicological data have been published for other heavy metal compounds e.g. methylated mercury.

Based on these toxicological data two kinds of requirements have been defined for materials used in articles, including packaging, intended to come into contact with foodstuffs.

There are National, European or inventory lists of constituents approved for use in materials in contact with food. Generally such positive lists do not include compounds of the heavy metals listed in Art 11.

The use of recycled organic materials for Food Contact applications is subject to some controversy, mainly because of the difficulty to verify, in a reasonable way, the amounts of different constituents that may be present in such materials due to other sources than packaging materials.

Glass Packaging complies with all food contact legislation, regardless of heavy metal contents, including crystal glass.

In the case of ceramic materials -however not including glass- test methods and migration limits are specified in Directive 84/500 of Oct. 15, 1984. Normally such migration limits are defined using very large safety margins in relation to the toxicological data referred to above.

6.3 Emission control at incineration of mixed municipal solid waste

An extensive review of the literature by the CEN working group on Energy Recovery is covered in its reports "Packaging-Energy Recovery from used Packaging CEN-CR 1460 - 1994" and "Optimisation of Energy Recovery from Packaging Waste - CEN-CR 13686".

Hg, Cd, Pb and Cr^{6+} from packaging waste do not lead to significant emissions from incineration for the following technical reasons:

- their relatively low content in most packaging waste compared to MSW.

- their trapping through the incineration process. Pb and Cr^{6+} are mainly retained in the bottom ash and slag. Most of the volatilised Cd compounds in the flue gas are condensed on fly ash. Hg is not condensed but it is not present in packaging. Furthermore "the EC Directive of 8 June 1989 on the prevention of air pollution from municipal waste incinerators" (89/369/EEC) sets the emission limits for new plants and the Council Directive of 21 June 1989 (89/429/EEC) sets out to regulate air pollution from existing MSW incinerator plants.

6.4 Leachate from Landfills.

In the scientific literature results of extensive measurements of the presence of Heavy Metal ions in leak water from landfills have been published (including OECD Cadmium monograph mentioned above). In a recently published paper (Attenuation of Landfill Leachate Pollutants in Aquifers, T.H. Christensen, P. Kjeldsen, H-J. Albrechtsen, G. Heron, P.H. Nielsen, P.L. Bjerg and P.E. Holm, Critical Reviews in Environmental Science and Technology, 24(2) : pp 119-202, 1994), the experience of the research into heavy metals in landfills is summarised as follows :

" Conclusions : Heavy Metals.

The behaviour of heavy metals in a landfill leachate plume is simultaneously controlled by sorption, perhaps precipitation and complexation, and proper evaluations of metal attenuation must account for this complex system. Generally, heavy metals do not constitute a groundwater pollution problem at landfills because landfill leachates usually contain only modest heavy-metal concentrations and the metals are subject to strong attenuation by sorption and precipitation. Especially sulphide-producing conditions result in extremely low solubilities of heavy metals, although the effect of increased solubility due to the complexation of heavy metals in both inorganic and organic substances should not be ignored. Also, the long-term effect of changes in the landfill leachate need future attention because of the possible effect of these changes toward increased mobility of heavy metals."

The logical consequence of this research is that testing of individual packaging materials or components for leachate of heavy metals cannot reflect the real conditions in landfills and is hence of minor relevance. Especially the available test do not take into account the "bonding" of heavy metals in landfills which is enhanced by chemical reactions between heavy metal ions and a multitude of other components of landfills.

7 Summary of the present situation in relevant industrial sectors

In order on the one hand to reach an objective view of the existing levels of Heavy Metals and -on the other hand- to better understand what should be known for an optimal control by the industry, the Ad-hoc-Group organised a review in the different relevant sectors.

7.1 Possible sources of heavy metals present in packaging

7.1.1 Natural sources

The Heavy Metals specified in Art. 11 occur naturally with the exception of Cr^{6+}. Ionic Cr^{6+} is the highest oxidation state of chromium. Cr^{6+} ions are very unstable especially after release in the environment, since they are readily reduced by organic and inorganic matter.

Most of the national standards for quality compost accept a higher level than 100 ppm for the total of the four Heavy Metals than Article 11.1. In the voluntary European ecolabel for soil improvers (European Commission, decision of 07/04/98) the four heavy metals reach a total of 101 ppm.

A study by U. Hamm (Institut of Darmstadt - April 1989 - see Annex B Bibliography : Schwermetalle in der Umwelt) presents some concentrations in the environment including living organisms and plants; their emission and their biological availability, depending on their chemical structure and the surrounding matrix, are discussed. Nevertheless their concentrations are very low and that is one reason why, when present in virgin raw materials or some major components due to natural sources, they have to be considered as impurities with low effect (such as kaolin in paper).

7.1.2 Recycling

The levels of impurities in many cases increase with extended use of recycled materials. The exception is for some industrial processes which separate heavy metals. The most significant sources for heavy metals in recycled material do not come from recycling of packaging, but from other products introduced into the same loop as packaging materials.

This can be perceived when considering the concentrations of Heavy Metals in waste. Indeed, data from study by the French Agency on Energy and Environment (ADEME) on the origin of Heavy Metals in municipal waste, show that materials issued from other applications than packaging present different compositions or high foreign contamination ; this is not contradictory to some overviews (e.g. APME).

→ In some cases, closed-loop recycling of some long-life products has the effect of keeping on the market old materials with initial high Heavy Metals content (DTI's survey and LNE's report). This has been confirmed by the industrial enquiry.

7.1.3 Functional use

The survey has identified very few examples for intentional introduction of heavy metal compositions. Examples are given below in chapter 7.2 under each material section and for packaging generally.

7.1.4 Cr(VI) in metallic materials

Cr(VI) does not occur in metallic materials and would not be stable on the surface in those cases where surface treatments using chromium salts were applied.

No routine method is available for demonstrating the absence of Cr(VI) in metallic materials but basic chemical principles dictate against the presence of Cr(VI) in metals.

7.2 The situation in individual material sectors

The following table provides the summary of the survey by material. It reflects the current European practice in packaging production. The answers collected are made under the responsibility of the reporting sectors. The complete responses are given in Annexes D1 to D8.

Table

Main material or component	Natural sources	Functional use	Recycling	Comments
Aluminium		Chromium as alloying element or Cr(III) surface treatment but Cr(VI) is not detected	Pb between 10 and 80 ppm depending on the origin of raw and recycled materials	Cd and Hg < 10 ppm No Cr(VI) ; therefore Pb + Cr^{6+} + Hg + Cd < 100 ppm
Glass : - undecorated			3 main possible sources of Pb, contribution in decline : - wine bottle capsules - lead-containing glasses - ceramic glazes	Cd, Hg, Cr(VI) not found or at very low levels At low recycling rate (30 %) Pb-concentration under 100 ppm, but at high rates 100 to 250 ppm and sometimes more are likely Exemption needed according to article 11.3
- decorated by enamels		Enamel with heavy metals, PbO as basic component provide high chemical resistance in the case of reuse: no appropriate substitute available. Cd for red and yellow bright colours in much smaller quantities. No use of Cr(VI) or Hg	Minor effect on recycling (cf. Annex D2, chapter 2)	Migration resulting from leaching is undetectable. Emission resulting from incineration is very low. Wide range of concentrations on individual decorated glass containers. Temporary specific measures needed to develop appropriate substitutes.

Main material or component	Natural sources	Intentionally added	Recycling	Comments
- Lead Crystal Glass		PbO is the essential constituent of lead Crystal (> 24 %) or full lead Crystal (> 30 %) imparting the specific properties of these materials : density, optical properties, workability, polishability	- Cullet resulting from manufacturing is reintroduced keeping the reference batch composition (internal recycling) for the main part (~ 95 %) or recovered (recovering of metallic lead use by craftsmen) - Lead crystal is used as luxury packaging and kept by consumer. None of these cullet sources contributes to container glass recycling loop.	The concentration levels will not apply to packaging entirely made of lead Crystal glass as defined in Directive 69/493 EEC
Paper Board	Contamination of natural white pigments (kaolin, clay, calcium carbonate) used as fillers and/or surface coatings : -Cr(III) <10ppm -Pb < 15 ppm		Minor increases in all heavy metals	Cr(VI) Cr(III) Maximum total Cr = 10 ppm [mostly as Cr(III)] Pb 15 ppm to 50 ppm Pb + Cr(VI) + Hg + Cd < 100 ppm

Main materialor component	Natural sources	Functional use	Recycling	Comments
Plastics 1. Food contact grade	Contamination by fillers/additives ($CaCO_3$, SiO_2,...) below the 94/62 levels	No 94/62 heavy metal intentionally added		Regulations for food-contact grade material apply
2. Industrial packaging : Reusable boxes, pallets and crates	idem as above	Colorants were used containing cadmium for crates and pallets manufactured before 1994 -Pb, Cr(VI), Hg under 10ppm each)	Crates and pallets are long life returnable packaging and recycled plastic recyclable several times for the same application.	Crates and pallets are long life returnable and recycled ; Cd (colorant pigment, therefore white and light blue not concerned) above the 94/62 limits for those manufactured before 1994. Lixiviation tests under the detection limit. Packaging after 1996 is heavy metals free.