



## **Leaching of Cathode Ray Tubes as a justification for recycling Erich Lopes Braitback de Oliveira<sup>1</sup>, Guilherme Feron<sup>1</sup>, Hugo M. Veit<sup>2</sup>**

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### **Resumo**

A Política Nacional de Resíduos Sólidos (lei 12305) aprovada em 2010 prevê a disposição adequada de resíduos eletroeletrônicos. Dentre os diversos tipos de resíduos encontram-se os tubos de raios catódicos (CRT) utilizados em monitores. A comercialização de novas tecnologias, como monitores LCD e LED fez com que grandes volumes de monitores CRT fossem gerados. Os monitores CRT apresentam em sua composição chumbo, que é um agente tóxico. A disposição desse resíduo em aterros surge como uma alternativa a reciclagem visto que o chumbo, a princípio, está imobilizado na matriz de sílica. Entretanto, existe a dúvida se esse tipo de gerenciamento pode ter algum impacto ambiental. Nesse trabalho foram realizados os ensaios de lixiviação de tubos de raios catódicos com o objetivo de averiguar a toxicidade desse resíduo a fim de justificar sua reciclagem. As normas NBR 10004 e 10005 foram usadas para caracterizar o resíduo sólido. Os resultados indicam que concentrações de chumbo lixiviado ultrapassam os limites da norma, sendo, desta forma, classificados como classe I - resíduos perigosos.

Palavras-chave: Lixiviação. Monitores CRT. Resíduo eletrônico.

Área Temática: *Tema 1 – Resíduos Sólidos.*

### **Abstract**

The National Policy on Solid Waste (Law No. 12305) approved in 2010 provides for the proper disposal of waste electrical and electronic equipment (WEEE). Among the various types of waste are the cathode ray tube (CRT) used in monitors. The commercialization of new technologies such as LED and LCD monitors caused the generation of large volumes of CRT waste. CRT monitors have lead in their composition which is a toxic agent. The disposal in landfills is an alternative to recycling because the lead is, in principal, immobilized in the silica matrix. However, there is a doubt if this type of management may have some environmental impact. This work presents the leaching tests of cathode ray tubes in order to determine the toxicity of this waste to justify the recycling of this residue. The NBR 10004 and 10005 standards were used to characterize the solid residue. The results indicate that concentrations of leached lead exceed the limits of the standard and were classified as class I.

*Key words: Cathode ray tubes. WEEE. Leaching.*

*Theme Area: Theme 1 – Solid Waste.*



## 1 Introduction

The new National Policy on Solid Waste (PNRS) provides for the proper disposal of waste electrical and electronic equipment. Cathode ray tubes are equipments used in many applications such as televisions and monitors for computers. They have been losing sales with the arrival of new technologies like liquid crystal displays (LCD) and light emission diodes (LED) (ABINEE, 2011).

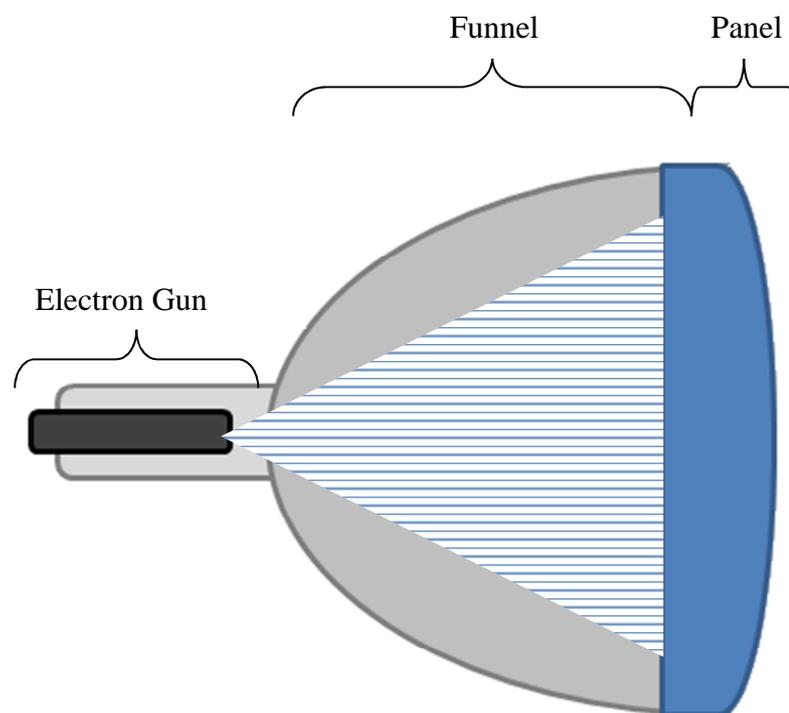
Data on the generation of WEEE are difficult to obtain in Brazil, because of the informal and illegal market (ARAÚJO, 2012). It is estimate that 130 thousand tons of televisions are generated in Brazil every year (UNEP, 2009; ROCHA et al, 2009).

The cathode ray tubes are made in different parts, each with a different glass composition. The figure 1 shows the three different parts of the tube. The mean difference is in the chemical composition of the glass, as each part has a specific function in the tube. The CRT monitor emits X rays radiation from the process of image creation. In order to avoid exposing the user to this kind of lethal radiation, it is added lead to the glass of the tube. Lead has physical-chemical proprieties that inhibit the radiation from hitting the users.

The electron gun and funnel are the most exposed to radiation, so they have a higher concentration of lead. The panel does not have lead in his composition, since the action of radiation in the glass turns him brown, so barium oxide is added. The addition of barium oxide instead of lead is restricted only to the part of the panel due to cost.

The chemical composition of three types of glass varies greatly depending on the type of monitor, if it's black and white or color, and year of manufacture.

Figure 1 – CRT parts.



The presence of lead in the composition of the glass serves as a warning to the disposal of such waste. The controlled landfilling of CRT may be inappropriate if the leaching



tests indicate that the concentrations of substances like lead have values higher than allowed by law. The toxicity of lead is well known, particularly in the development of children. According to EPA (1989), lead from monitors and televisions corresponds to 29.8% of lead found in municipal landfills.

The objective of this study is to analyze the leaching capacity of CRT glass using the NBR 10004:2004 standard.

## 2 Materials and methods

The samples of CRT monitors from different manufacturers with different years of manufacture were collected and manually disassembled to be used in the analysis.

Initially, the monitors were weighted, dismantled and disassembled in parts (polymeric frames, printed circuit boards, cables and cathode ray tubes). The separation of the different glass parts of the tubes was performed with a diamond saw in specially designed chamber.

The analysis of fluorescence spectroscopy was performed to characterize parts of the CRT monitor, and to determine the lead concentrations in three types of CRT glass.

Each part of the tubes were milled in a hammer mill, sieved in a 60 mesh sieve and dried in an oven at 80 °C for 2 hours.

The NBR 10007:2004 standard was used for sampling of the solid waste. The three types of glass CRT monitors were analyzed separately. A sample containing a mixture of the proportions by weight of each part of the monitor (A1), was also analyzed. This analysis was intended to represent actual conditions in which the monitors are disposed in the landfill.

The NBR 10005:2004 standard was used in the leaching tests.

According to the NBR 10005, the leaching tests follow these procedures:

- Screening in sieves of 9.5 mm;
- Determination of the extraction solution;
- Leaching HDPE bottles;
- Analysis of leachates in atomic absorption spectrometers.

The atomic absorption analysis were performed in an atomic absorption spectrometer model Varian 240FS in duplicate.

## 3 Results e discussion

Table 1 shows the chemical composition of the three types of glass present in CRT monitors. It is possible to identify lead in the three parts of the CRT monitor, especially in a Electron gun and Funnel.



Table 1 – Chemical composition of the glass in CRT monitors.

Óxide	Electron Gun	Funnel	Panel
Na <sub>2</sub> O	5,78	5,55	7,38
MgO	1,95	1,83	0,35
Al <sub>2</sub> O <sub>3</sub>	1,77	1,79	1,79
SiO <sub>2</sub>	59,3	56,2	66,5
P <sub>2</sub> O <sub>5</sub>	0,03	0,28	0,02
SO <sub>3</sub>	nd	0,08	0,1
K <sub>2</sub> O	6,98	6,69	6,65
CaO	3,4	3,28	1,57
TiO <sub>2</sub>	0,03	0,15	0,42
Cr <sub>2</sub> O <sub>3</sub>	0,08	0,06	nd
MnO	0,01	0,03	nd
Fe <sub>2</sub> O <sub>3</sub>	0,83	1,39	0,38
Co <sub>3</sub> O <sub>4</sub>	nd	0,02	0,01
NiO	0,02	0,02	0,03
CuO	nd	nd	0,01
ZnO	0,02	0,02	0,01
Rb <sub>2</sub> O	0,04	0,03	0,01
SrO	0,06	0,08	6,79
ZrO <sub>2</sub>	0,03	0,02	1,49
Nb <sub>2</sub> O <sub>5</sub>	nd	0,05	nd
Sb <sub>2</sub> O <sub>3</sub>	0,12	0,13	0,2
BaO	nd	0,17	6,25
La <sub>2</sub> O <sub>3</sub>	nd	0,13	nd
HfO <sub>2</sub>	nd	nd	0,04
PbO	19,6	22,1	0,03

\* nd – Not Detected

According to the NBR 10004, the maximum leaching for lead is 1.0 mg/L. If this limit is exceeded the residue is classified as Class I – dangerous residue, but if it's not, the residue is Class II and follows to the solubility test. This test has a limit of 0.01 mg/L of lead. If this limit is exceeded the residue is classified as Class IIA – not inert residue, if not, the residue is Class IIB – inert residue.

Table 2 presents the concentrations of lead found in the analysis of leachates for the three parts of the CRT monitor and the sample A1, that represent the mixture of the CRT parts.

Table 2 – Concentrations of leachates

Sample	Concentration of Lead (mg/L)
Panel	18,9 ± 20,9
Funnel	108,6 ± 0,5
Electron Gun	22,3 ± 2,1
A1	58,5 ± 2,1

It is clear that the values found in the test exceed the values of the NBR standard, so the cathode ray tubes are considered a solid waste Class I. Therefore, the disposal of CRTs in landfills is discouraged.



## 4 Conclusion

Through this work it was possible to identify three types of glass present in the cathode ray tubes and check the large concentrations of lead in two types (electron gun and the funnel).

The conclusion of this work is that the leaching tests of all the leachate extracts from the CRT monitor have reached the values of a Class I – dangerous residue according with the NBR standard.

The recycling of CRT monitors arises as an option to landfilling. Technologies for the separation of lead from the silica matrix are under development (XHANG, 2011). Alternatives such as the immobilization of a lead in glass ceramic materials were also presented in recent studies (MEAR, 2006). However, the complete removal of lead from the silica matrix is the best way to ensure no environmental impact and economically viable process.

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