

## Riscos à saúde em equipamentos médicos esterilizados com óxido de etileno.

### Health risks in medical devices sterilized using ethylene oxide.

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**Resumo:** O presente estudo analisou 275 medições de resíduos de óxido de etileno em equipamentos médicos esterilizados com óxido de etileno. A metodologia difere de outros estudos já realizados por não se tratar de uma simulação, mas sim de casos reais de equipamentos esterilizados, nos quais os resíduos foram medidos. A quantidade de resíduo mensurada foi comparada com os limites máximos estabelecidos por regulamentação. Observou-se uma grande compatibilidade das medições com os limites máximos estabelecidos pela regulamentação. No entanto problemas foram observados na grande quantidade de valores aberrantes, problemas estes que indicam possível tempo de aeração insuficiente dos equipamentos.

**Palavras-chave:** esterilização do óxido de etileno; resíduos de óxido de etileno; reuso de equipamentos médicos; riscos no reuso de equipamentos médicos.

**Abstract:** The present study analyzed 275 results for residues of ethylene oxide in medical devices sterilized using ethylene oxide. The methodology differs from other studies for not being a simulation, but rather real cases of sterilized devices in which the amount of residue was measured. The quantities of residues obtained were compared with the top levels established by regulations. There was a great adjustment of the results to the limits established by the regulation. However problems were found mainly in the large amount of outliers values, a problem that indicates possible issues during the airing stage of the devices.

**Keywords:** Ethylene Oxide Sterilization; Ethylene Oxide Residues; Reuse of Medical Devices; Risks in the Reuse of Medical Devices.

#### 1. INTRODUCTION

Reuse of medical devices became common practice due to pressure to reduce medical costs. In order to reuse medical devices, sterilization for disinfection and reduction of microbial load is

required. Several sterilizing methods[1] among which the ethylene oxide sterilization is one of the most used methods for sterilizing medical devices sensitive to heat. However, for being highly toxic, carcinogenic and teratogenic, ethylene oxide requires many exposure controls

for users of sterile medical devices and for the workers who handle them. For the control and analysis of ethylene oxide residues and by-products in medical devices after sterilization, laboratory tests are carried out by sampling, normally using gas chromatography. The results are compared the maximum acceptable limits of residues established in relevant legislation. The residue levels under the ones allowed primarily attest that the aeration process is suitable for the removal of residues [2].

The authors [3] have conducted simulated study contaminating intravenous catheters, tracheostomy tubes, and three-way taps, which after the contamination went through the cleaning process and subsequent sterilization using ethylene oxide. Studies were also made using an electronic microscope to check the degradation of devices after several cycles of cleaning and sterilization.

The penetrability of the ethylene oxide gas and its subsequent removal by aeration of the medical device will depend on several factors, such as material composition, type of packaging, gas concentration, exposure time, temperature used during the sterilization cycle and amount of moisture present in the medical devices [4].

## 2. OBJETIVES

From the studies described above it can be noticed that due to the diversity of physical conformations and raw materials of sterile medical devices, there are different minimum times required for aeration for the various medical devices. In sterilization companies, due to cost optimization, there are different medical devices in one sterilization cycle, hence the difficulty in establishing a period of proper aeration common to all devices.

This retrospective study sought to analyze and compare the presence of residues of ethylene oxide into five types of medical devices of 8<sup>th</sup> Brazilian Congress on Metrology, Bento Gonçalves/RS, 2015

different compositions, sub-mitted to the same parameters of sterilization and aeration. The relevance of the study is significant because it comprises a significant amount of samples submitted to actual conditions to sterilize and not from a simulated study, like previous studies, which often portray an unreal environment.

## 3. METHOD

The survey was conducted in a processing company that performs sterilization with ethylene oxide in medical devices. The methodology consisted in the retrospective analysis of quantification of residues of ethylene oxide (EO) in various types of medical devices sterilized during the period from 2010 to 2013. Residue measurements were made on a third-party laboratory and compared with the acceptable limits found in Interministerial Ordinance n° 482/1999 [5].

Ethylene oxide residues are measured by gas chromatography, using validated methods of extraction and measurement. In this study the extraction method used was the simulated use extraction, by allowing comparison to the limits. The choice of extraction method should be based on the intended use for the device [6]. The chromatographic analysis of residue samples are forwarded to the third-party laboratory service wrapped in ziplock-type polyethylene bag and polystyrene box, followed up by the annex form duly completed.

At the residue analysis laboratory, the medical devices to be analyzed are placed in the appropriate flasks fully covered with deionized water and kept by 60 minutes or 24 hours according to the usage type (instant or prolonged). After the extraction period, an part of the extract is transferred to a gas chromatograph flask and placed under analysis. The gas chromatograph is calibrated daily with a standard substance of EO in various concentrations and the respective

calibration curve is obtained before measurements.

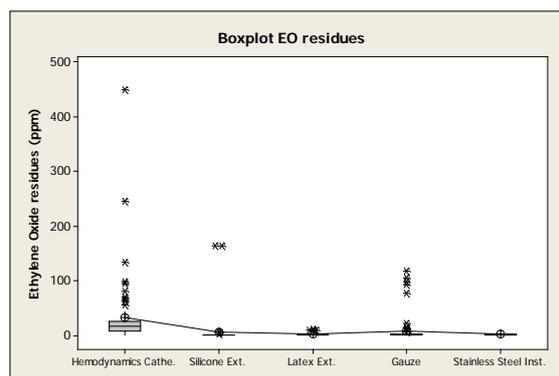
In order to facilitate interpretations, the devices have been classified according to their use (contact/exposure time), the predominant raw material type and acceptable limits of ethylene oxide (EO) residues, as recommended by Interministerial Ordinance nº 482. The devices were so classified: hemodynamics catheter with limited contact time and prevailing plastic as raw material; stainless steel instruments with limited contact time and stainless steel raw material; the gauze with prolonged contact time and cotton fabric raw material; the prolongation of silicone and latex extensions with prolonged contact time and silicon and latex raw materials, respectively.

The following limits are established for hemodynamics catheter, which is an item that comes into contact with blood, the maximum acceptable limit of EO is 25 ppm [6]. For the other devices considered related coming into contact with skin and mucous membranes, the maximum acceptable limits are 250 ppm of EO.

Statistical analysis software Minitab 16 Statistical Software [7] was used to analyze data and to obtain the respective graphics.

#### 4. RESULTS

The analysis of ethylene oxide residues in Hemodynamics catheter; Silicone extension; Latex extension; Gauze and Stainless steel instruments showed the presence of several outliers when examining through boxplots shown in Figure 1. The asterisks represent the outliers, much above the rest. Through the variance analysis shown in Table 1 it is observed that there are significant differences in the retention of ethylene oxide residues for the different devices analyzed.

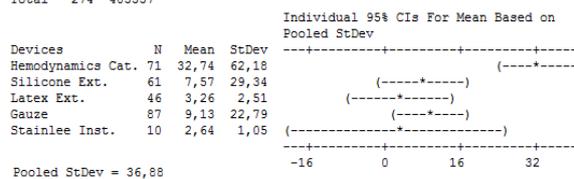


**Figure 1** - Boxplots of the EO residues for the different devices analyzed.

**Table 1** – Analysis of variance and 95% confidence intervals of ethylene oxide retentions for different medical devices all datas (ppm).

Curitiba, PR, Brazil, 2010 to 2013.

Source	DF	SS	MS	F	P
Factor	4	36097	9024	6,63	0,000
Error	270	367240	1360		
Total	274	403337			



#### 5. DISCUSSION

Despite the strong evidences it cannot be stated that the outliers originate in the sterilization process, since the residue measurement process is quite complex and involves a lot of care. An external audit of the process of measuring residues is strongly recommended where parameters such as: Selectivity; Specificity; Linearity; Working range; Sensibility; Limit of detection (L.D.); Limit of quantification (L.Q.); Accuracy and Trend; Precision; Robustness and Measurement Uncertainty are determined and monitored routinely.

In order to improve the process of sterilization is recommended: a) a good arrangement of devices in sterilization baskets in order to facilitate the air flow [8]; b) devices subject to sterilization are the most homogeneous as

possible and aeration times are appropriate to residue reduction to minimum values; c) that the sterilization process is described in all its details and possible sources of variability of the end result are studied.

## 6. CONCLUSIONS

Based on the confidence intervals of the averages of residues in medical devices analyzed and the thresholds established by the regulation, it can be concluded that: a) Only one situation was critical, the EO residues for the hemodynamics catheter when outliers were not deleted, since the maximum acceptable limit is 25 ppm [6] and 95% confidence interval is between (18.0 - 47.5) ppm. All other situations analyzed are within the limits established by the regulation for the ethylene oxide residues; b) Hemodynamics catheter is the most critical device as for ethylene oxide retention, possibly due to its physical conformation which makes aeration difficult; c) The sterilization process as long as it is placed under control, i.e. without outliers, does not produce devices with residue levels above those specified.

The large amount of deviant values in all measurements demonstrates a process out of control. Probably the problems should originate in the sterilization process, although it cannot rule out errors in the process of measuring residues. One of the problems of the process of sterilization can be insufficient aeration time caused mainly by the diversity of devices subject to the same cycle of sterilization.

It is observed that as actual medical usage devices were used, the comparison serves as a guideline for airing cycles. That is, devices with large concentrations of EO, such as hemodynamics catheter, must be subjected to a greater aeration process in order to decrease the concentration of residues.

## 7. REFERENCES

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