GUIDELINES FOR THE MEASUREMENT OF AIR FLOW AND MERCURY IN CELLROOM VENTILATION

Env. Prot. 5

3rd Edition

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Euro Chlor

Euro Chlor is the European federation which represents the producers of chlorine and its primary derivatives.

Euro Chlor is working to:

- improve awareness and understanding of the contribution that chlorine chemistry has made to the thousands of products, which have improved our health, nutrition, standard of living and quality of life;
- maintain open and timely dialogue with regulators, politicians, scientists, the media and other interested stakeholders in the debate on chlorine;
- ensure our industry contributes actively to any public, regulatory or scientific debate and provides balanced and objective science-based information to help answer questions about chlorine and its derivatives;
- promote the best safety, health and environmental practices in the manufacture, handling and use of chlor-alkali products in order to assist our members in achieving continuous improvements (*Responsible Care).*

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Prior to 1990, Euro Chlor's technical activities took place under the name BITC (Bureau International Technique du Chlore). References to BITC documents may be assumed to be to Euro Chlor documents.

RESPONSIBLE CARE IN ACTION

Chlorine is essential in the chemical industry and consequently there is a need for chlorine to be produced, stored, transported and used. The chlorine industry has co-operated over many years to ensure the well-being of its employees, local communities and the wider environment. This document is one in a series which the European producers, acting through Euro Chlor, have drawn up to promote continuous improvement in the general standards of health, safety and the environment associated with chlorine manufacture in the spirit of *Responsible Care.*

The voluntary recommendations, techniques and standards presented in these documents are based on the experiences and best practices adopted by member companies of Euro Chlor at their date of issue. They can be taken into account in full or partly, whenever companies decide it individually, in the operation of existing processes and in the design of new installations. They are in no way intended as a substitute for the relevant national or international regulations which should be fully complied with.

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This edition of the document has been drawn up by the Environmental Protection Working Group to whom all suggestions concerning possible revision should be addressed through the offices of Euro Chlor.

Summary of the Main Modifications in this version

Section	Nature
Summary	Removed and brought in the introduction
All	Some old stuff was removed
2.2.6 and Annex	Heat balance method reviewed on the base of several sites experience (plus alternative method added)
3.	Reference added to the updated Analytical 6 - Determination of mercury in gasses (and old text removed)

TABLE OF CONTENTS

1. INTRODUCTION

In the frame of the mercury balance that is required to all European producers a least yearly (***Env Prot 12 – Guideline for Making a Mercury Balance in a Chlorine Plant***), this paper presents a summary and evaluation of the present Euro Chlor knowledge on the measurement of mercury emissions in cell room ventilation air.

Both direct and indirect techniques for air flow measurement are available. When practical, direct measurement of air flow using anemometers is preferred.

Techniques for the sampling and analysis of air to evaluate mercury content are also presented (see chapter 3).

Comparisons are made between different types of cell room regarding the number of measurements required and the accuracy that can be expected in the mercury emission results.

The chlorine industry in Europe puts a great deal of effort into minimising the mercury emissions from the amalgam process (***Env Prot 12R – Reduction of Mercury Emissions from West European Chlor Alkali Plants***), and for the last three decades European chlorine producers have been successful in reducing their overall mercury emissions via products, waste water, process exhausts and cell room ventilation.

The mercury losses by cell room ventilation air remain the highest figures in the average European Emission Data of amalgam plants and to be successful, it is necessary to know all sources or means by which mercury can enter the cell room atmosphere. While modelling the cell room ventilation has helped in defining how to measure, continuous monitoring has helped in a quicker detection of leaks and that has led to a reduction of mercury concentration in cell room atmospheres, mainly for closed cell rooms.

However it is more difficult to obtain accurate emission data for cell room ventilation air than for any of the other types of emission.

The basic principle of all techniques is to measure the mercury concentration of the cell room outlet air and simultaneously the air flow rate to obtain the mercury emission rate.

This paper summarises and evaluates the measurement techniques which are known at present.

2. AIR FLOW MEASUREMENT

The volumetric flow rate of air (i.e. m^3/h) leaving the building can only be measured directly for enclosed cell rooms with a limited number of air inlets and outlets.

In open-air cell rooms or those without sidewalls, the air flow pattern is not sufficiently defined to allow accurate measurements. The local atmospheric and climatic conditions can affect both ventilation rates and mercury concentrations.

2.1. Factors Affecting Ventilation Rate

Cell rooms with forced ventilation (by fans) are generally regarded as having a fairly constant air throughput. However the ventilation rate is not totally dependent upon the capacity of the fans, it can be increased dramatically by wind, especially if windows are open. Forced ventilation can also be assisted by natural convection within the building.

Many cell rooms rely totally upon natural convection and some of the important influences on the ventilation rates are:

- geometry of the building in particular the number, type, size and position of air inlet and outlets
- electrical current loading on the cells and resultant heat evolution (effect on internal air temperature)
- general climatic conditions e.g. wind velocity and direction, humidity, outside temperature and atmospheric pressure
- orientation of the building with respect to the prevailing wind and whether the building is free-standing or surrounded by other constructions.

Many of the above variables also apply to cell rooms with forced ventilation.

2.2. Ventilation Rate Measurement Techniques for Enclosed Cell rooms

Direct methods of ventilation rate measurements are available which are based upon the measurement of air velocity. Indirect methods of measurement are mainly based upon the dilution rate of a component blown or injected directly into the cell room atmosphere.

The accuracy of such methods is unlikely to be better than ± 10%.

A more theoretical approach is to calculate the heat balance for the cell room air based on the temperature difference between incoming and exit air.

2.2.1. Hot Wire Anemometer

The measurement principle used in hot wire anemometers is the cooling effect of air flowing past an electrically heated wire. The wire has a known temperature dependent resistance and the resistance change due to cooling corresponds to the flow velocity of air. The wire must be oriented at right angles to the flow direction. The equipment available usually has scales ranging from 0.05 to 15 m/sec.

In order to evaluate the amount of air leaving the ventilation outlets of a cell room building, air flow profiles must be measured, i.e. at each outlet a number of point velocities over the outlet area must be measured. If there are doubts about the direction of air flow, smoke candles could be used. In the case of low flow rates through large outlet areas, from the top to the bottom of the window or lamellas, a flow reversal can often be observed.

Numerical integration of the measured point velocities gives the average air velocity for the outlet. The average velocity when multiplied by the outlet area gives the volumetric flow rate of air (m^3/h). The total volumetric flow through the building is then the sum of the individual outlet flows.

Hot wire anemometer scales are calibrated in dry air at 20° C. It has been found that air of up to 50 % relative humidity gives a deviation of ± 3 % of the scale range at 20 to 40° C and a flow of 0.1 to 1 m/sec. With higher temperatures and humidity the deviation increases but this seems unimportant for real cell room conditions. Correction charts are supplied with the instruments.

2.2.2. Vane Anemometer

Vane anemometers detect the flow velocity of air directly and usually give a direct reading in m/sec. An advantage of vane anemometers is the fact that the direction of air flow can be seen. Vane anemometers are also subject to the effects of air temperature and humidity.

Again the vanes must be oriented exactly at right angles to the air flow to avoid incorrect measurement.

The measurement procedure and subsequent handling of the data is the same as for hot wire anemometers.

2.2.3. Pitot-tubes, Nozzles, Orifice Plates ...

Pitot-tubes, nozzles or orifice plates are the classical physical equipment which have been used for many decades in the measurement of liquid and gas flow in pipelines. They are all based upon the measurement of pressure drops produced by fluid flow.

At lower velocities these instruments have poorer sensitivity than anemometers and are less practical in their application.

2.2.4. Smoke Method

In cell rooms using natural convection the flow rate of ventilation air can be measured in a more direct way by the smoke method. The technique is based upon the rate of dilution of an artificially produced smoke cloud. Results give the air change rate for the cell room (e.g. number of air changes per hour).

The powder is divided into equal portions and placed on small plates. The plates are distributed evenly through the cell room on the cell covers. Each portion of powder must be ignited at the same instant. A film camera is focused through the smoke onto a black wall and the intensity of the light being dispersed by the smoke cloud is recorded on film.

A calibration test is required using the same film and light. A 20-litre sample of air containing the same concentration of smoke, as used in the cell room test, is diluted by an equivalent volume of clean air. The drop in dispersed light intensity is photometrically measured on the film. Thus the change in intensity corresponds to one air change.

A comparison is made between the calibration film and the test film. The point on the test film which corresponds to a 50 % drop in dispersed light intensity gives the time in minutes corresponding to one air change in the cell room. It is then a simple calculation to obtain the number of air changes per hour and the total volumetric flow rate is given by the product of the air change rate and the volume of the test area.

Alternative methods of continuous smoke generation now exist based on vegetable oils in aerosol form passed over heater elements. Suitable compact generators are manufactured by Concept Engineering.

2.2.5. Sulphur Hexafluoride Method

Different tracers can be used to determine the air change rate of buildings. Sulphur hexafluoride has been applied in different mercury cell plants to determine the mercury losses.

New scientific evidence has come to light concerning the severe global warming potential of sulphur hexafluoride. Following the December 1997 Kyoto Protocol, Euro Chlor has reviewed the use of this chemical as a tracer gas. The advantages of SF6 are its inertness, harmlessness to health, ease of detection (at ppt levels) and similarity in molecular weight to mercury. The disadvantage of global warming impact is offset by the insignificant quantities used in testing. Overall the conclusion is that, since calibration with SF6 is only required for the initial determination or when a re-evaluation is necessary, the environmental impact is very limited. In any case the method is only recommended in special circumstances (see Section 2.3).

The technique is based upon a physical model of the actual mercury emission sources using the following principles, which can be verified by a preliminary control.

a. When a small known quantity of tracer gas is continuously injected into a cell room atmosphere at or close to a point of known mercury emission the tracer will diffuse and be diluted in a similar manner to the mercury. At steady state conditions (i.e. ventilation rate, mercury concentration and tracer injection rate all constant), the ratio of mercury concentration to tracer concentration in the atmosphere will be the same as the ratio of mercury emission rate to the tracer injection rate