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AURA CO2



## ICONE index - How to assess air containment?

by eLichens

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This report refers to the **ICONE index** which is **only available in France** at that time. *The ICONE index (also called “containment index”) reflects the quality of indoor air renewal during the occupation of the room. It is originally made for classrooms, and it tells you whether or not the room needs to be ventilated.*



## Introduction

### 1. How to prevent unhealthy air quality in a public building?

The Covid-19 crisis has brought to light the existing indoor air quality malfunctions, particularly in classrooms of schools, colleges, high schools, university lecture halls and all establishments open to the public such as retirement homes, restaurants, ...

The spread of SARS-CoV-2 virus responsible for the Covid crisis is mainly airborne. Its circulation is increased in indoor environments that are poorly ventilated and/or crowded and occupied for long periods of time.

In a confined space, without a suitable ventilation system, the gases and particles in suspension, such as the aerosol vectors of SARS-CoV-2, remain still. This lack of ventilation aggravates and promotes the contamination risk and the spread of the virus. The gases and particles that remain in suspension create an unhealthy environment with adverse effects on the well-being of the occupants.

A way must then be found to assess the containment level of the room. To this end, an "indoor air containment index" has been defined: the "ICONE index". It is based on the concentration of carbon dioxide present in the room.

Thanks to the ICONE index, it is possible to assess the quality of indoor air, thus allowing the implementation of a more suitable and efficient aeration/ventilation system.

This paper aims to introduce and describe the following concepts:

- The indoor air containment level
- The ICONE index
- Strategies for applying and deploying the ICONE index





## The ICONE index

### 1. Definition

In France, the "ICONE" index (Indoor Air Containment Index in Schools) is an index to assess the air containment of a room by assigning it a score from 0 to 5, mostly for schools. The government has generalized the use of the ICONE index nationwide. This generalization shows the importance of the ICONE index in monitoring the containment level and CO2 level in an enclosed space. This index thus makes it possible to assess the quality and efficiency of ventilation and air renewal systems in a closed and occupied space.

The containment index reflects the quality of air renewal during the occupation of the room. Developed by the CSTB (The Scientific and Technical Center for Building), the ICONE index is based on carbon dioxide (CO2) measurements taken continuously over a school week by steps of 10 min and is calculated exclusively on the periods while the premises are occupied (Ribéron et al., 2016).

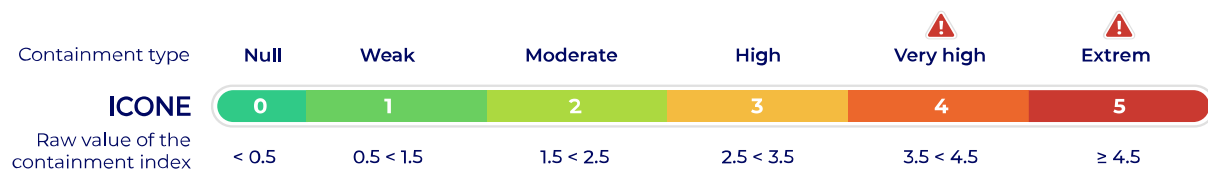


Figure 1: Illustration of the ICONE index on a scale of 0 to 5

Figure 1 illustrates the scale of the ICONE index. The air containment index is calculated for each room equipped with a CO2 sensor and expressed with a precision equal to 1 (i.e., rounded to 0 decimal places) on a scale of 0 to 5.

A score of 0 corresponds to zero air containment (CO2 concentrations are always below 1000 ppm) and constitutes the most favorable case for healthy air quality in an enclosed space. A score of 5 corresponds to extremely confined air. Median scores 1, 2 and 3 correspond to Low, Medium and High levels.

The ICONE 4 and 5 indexes, corresponding respectively to a Very High and Extreme level of containment, automatically lead to the implementation of the following air quality monitoring strategies: (Source: CSTB, May 2012)

#### ICONE 4: Very High Containment

- Ensure that room usage is not exceeding the recommended occupancy rate.
- Have the ventilation system inspected if existing, otherwise open the windows more often during the occupancy period.

#### ICONE 5: Extreme Containment

- Conduct additional investigations and inform the local authorities within fifteen days of receipt of all the analysis results
- Ensure that room usage is not exceeding the recommended occupancy rate.
- Have the ventilation system inspected if existing, otherwise open the windows more often during the occupancy period.



## 2. Details of the method of calculation

The ICONE index is based on the frequency and intensity of CO<sub>2</sub> concentrations, with two defined thresholds: 1000 and 1700 ppm and considering only the student's period of attendance i.e., from Monday morning to Friday evening.

It is based on a logarithmic function between the intensity of a sensation and the value of the stimulus (Fechner model).

It results from the average of the CO<sub>2</sub> concentrations measured weekly, rounded to the nearest integer and corresponds to one of the six air containment categories.

It is calculated according to the following formula:

$$ICONE = \left( \frac{2,5}{\log_{10}(2)} \right) \log_{10}(1 + f_1 + 3f_2)$$

**f**<sub>1</sub>: proportion of values between 1000 ppm and 1700 ppm  $\left( f_1 = \frac{n_1}{n_0 + n_1 + n_2} \right)$

**f**<sub>2</sub>: proportion of values above 1700 ppm  $\left( f_2 = \frac{n_2}{n_0 + n_1 + n_2} \right)$

**f**<sub>1</sub>: proportion of values between 1000 ppm and 1700 ppm

**n**<sub>0</sub>: number of values below or equal to 1000 ppm

**f**<sub>2</sub>: proportion of values above 1700 ppm

**n**<sub>1</sub>: number of values between 1000 and 1700 ppm

**n**<sub>2</sub>: number of values above 1700 ppm

## 3. What are the regulations in France ?

HCSP (The High Council for Public Health in France) recommendations relating aeration and ventilation of public establishments have been updated in the context of the Covid-19 pandemic.

The air containment index is part of a national decree correlated to the monitoring of indoor air quality in public buildings (Decree n°2012-14 of January 5, 2012, modified by decree n° 2015-1926 of December 30, 2015, by the Ministry of Ecology, Sustainable Development and Energy).

This decree supports the obligation to set up an ICONE containment index calculation.

It's now used in the compulsory control of air quality in schools and kindergartens, thus allowing building managers to improve the ventilation conditions of occupied spaces.



## Strategy and application for better indoor air quality?

### 1. Link between CO2 levels and unhealthy air

The CO2 level in a room is calculated in ppm (parts per million); it shows the amount of CO2 present in the air, CO2 being a harmful gas if prolonged exposure to an abnormal dose.

Unhealthy air here corresponds to significant air containment (>1700ppm), characterized by pollution linked to occupancy parameters:

- The occupants' metabolic CO2 production
- The ventilation conditions for air renewal in the room (presence or not of a ventilation system, purification, filtration, air permeability of the room, opening of windows and doors).

The HCSP considers that the rise in CO2 concentrations generates: <sup>1</sup>

- A decrease in people's cognitive performance
- An increase in the concentration of airborne infectious agents (in the presence of source individuals).

If the indoor atmosphere is not ventilated, where the exposure is chronic or extended, then an elevated level of carbon dioxide can lead to an increase in asthma attacks for asthmatic children<sup>2</sup>, a drop in cognitive and psychomotor performance<sup>3</sup> as on the decision making, problem solving from 1000ppm.<sup>4</sup>

At higher concentrations, CO2 can have other effects such as a change in heart and breathing rate<sup>5</sup>, drowsiness, headaches<sup>6</sup> and even at very high doses respiratory acidosis (lower blood pH) when 10,000 ppm are reached<sup>7</sup>.

In confined space, the rise of CO2 level in the air has a significant negative impact on well-being and comfort of people who are permanently exposed.

Therefore, it's important to control the indoor air quality, to improve the well-being of individuals and prevent damage to their health. It is therefore imperative to have a frequent renewal of the air in the buildings.

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<sup>1</sup> HCSP report, January 21, 2022, <https://www.hcsp.fr>

<sup>2</sup> Simoni & al., 2010

<sup>3</sup> Satish & al, 2012 ; Kajtar & al., 2003

<sup>4</sup> Berkeley Lab scientists, Mark Mendell & William Fisk, 2012

<sup>5</sup> INRS, 2005

<sup>6</sup> Marquardt & Schäfer, 1994 ; Jiang & al, 2005 ; cited in Guais & al, 2011

<sup>7</sup> Anses, Collective expert report, 2013



## 2. Strategy of measures, and mechanisms to be implemented

In the context of a pandemic and with the aim of maximizing the supply of healthy air in places open to the public, several measures had to be implemented such as individual barriers (wearing a mask, distancing, hand hygiene), the management of the accessibility of public buildings, the establishment of means of aeration/ventilation and the establishment of information systems on the indoor air quality. There was therefore a need to create an indicator like the ICONE index for better management of aeration/ventilation.

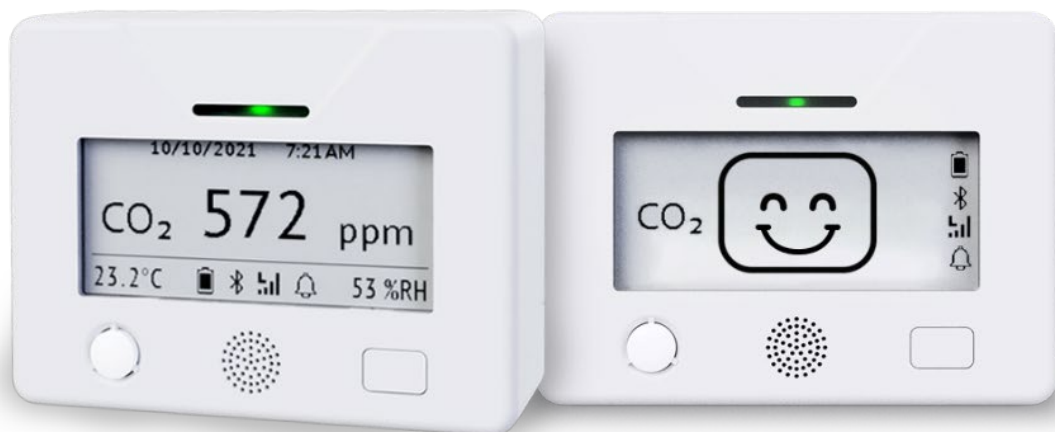
This evaluation of the means of ventilation has become mandatory as well as the implementation, at your choice:

- A prevention action plan based on a review of practices and specific measurements of air pollutants

or

- An in-depth indoor air quality measurement campaign

## 3. ICONE index application using the Aura-CO2 monitor



**Aura-CO2** developed by **eLichens** is the latest innovation in autonomous indoor CO2 detection.

It is an easy-to-deploy, self-contained, turnkey solution with a 5-year battery life and over 20-year sensor lifespan. The monitor is connected, labeled Made in France and monitors in real time the concentration of carbon dioxide, the temperature, the relative humidity and the atmospheric pressure of an indoor area with relevant and reliable information.

It adapts perfectly to the current regulations and needs of local authorities to equip classrooms, or to measure the indoor air quality in buildings, restaurants, malls, and any other public establishments.

Connected station information is available via an online dashboard as well as a dedicated iOS and Android mobile app to complete user experience, for viewing data and connecting to the station via Bluetooth Low Energy to configure Aura-CO2 wherever you are.



- The ICONE index measurement is already available on the Aura-CO2 app; it directly shows the air containment level of the room and thus allows proper measures to be taken. (eLichens offers a CO2 measurement and the ICONE index of your confined space according to the protocol defined by the CSTB).
- Equipped with a "school mode" allowing the sensor to measure only the time range necessary for the ICONE index to be calculated during busy class.
- Aura-CO2 display can switch to "Smiley Mode", easier to read using 3 faces, 😊 😐 😞 which each display corresponds to a certain CO2 level and switches from one to the other when it exceeds a certain threshold (configurable by the user). You can switch between Advanced and Smiley mode by simply pressing the user button 3 times.

**Indoor Air Containment Index (ICONE)**

Ranging from 0 (null containment) to 5 (extrem containment)

Weak

0 1 2 3 4 5

For more information on Aura-CO2, visit [elichens.com](http://elichens.com)

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