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IAQ in workplace in Belgium: alternatives to CO_2 requirement

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In March 2016 a new IAQ requirement came into force for workplaces in Belgium with a maximum absolute CO_2 concentration of 800 ppm, leading to a very substantial increase in the required ventilation flowrates.

The proposed alternatives for IAQ requirements take also into account the emissions from materials in order to maximise the final IAQ improvement while assuring an effective implementation in practice.

Keywords: IAQ requirement, working environment, material emission, CO_2 concentration, compliance framework.

Indoor air quality in workplaces is important for comfort, productivity and health of the workers. Requirements are necessary and CO_2 is a common proxy for ventilation in presence of people.

The new requirement, expressed as a maximum **absolute** CO_2 concentration of 800 ppm [1], raises the question of the responsibility of the different involved persons, such as the designer, contractor and owner of the building, the employer but also the employee as end user of the building. Moreover, the stricter requirement remains an economical and technical challenge, especially for existing building without a complete ventilation system. Finally, this higher flow rate is maybe not necessary in all cases, especially if the sources of pollutants from materials have been limited and the persons are the main pollutant source.

For example, the results of the Healthvent project [3] [4] recommends a minimum flow rate, for health, of 4 l/s.pers if the non-human pollutants are limited; and FprEN16798-1:2016 [2] recommends flow rates from 10 l/s.pers to 4 l/s.pers depending on the targeted perceived IAQ.

Our work aimed to identify alternative approaches for the expression of IAQ requirements for working environments in order to maximise the final IAQ improvement for the workers while assuring an effective implementation in practice thanks to a robust compliance framework. Note that the current regulation in Belgium is still based on the requirement of 800 ppm CO_2 and that there is up to now no decision to implement the proposed alternative approaches in the regulation.

Possible approaches

Approach 1 (current regulation in Belgium)

The advantages of the CO_2 requirement are that it is performance based and easily measurable on site. However, the CO_2 requirement focuses only on the persons as source of pollutants and does not consider the possibility to control the other sources of pollutants, such as emissions from materials, by limiting them at the source (for example choosing low emitting materials).

The alternative approaches could then consider the emissions from the material to determine the flow rate required in the working spaces. The draft standard FprEN16798-1:2016 has been used as a basis to identify alternative approaches.

Approach 2

A second (alternative) approach could be two different CO_2 requirements (or flow rate requirements) depending on the level of emission of the materials. In case no attention has been paid to limit emissions from materials, the higher flow rate is required, e.g. minimum 14 l/s.pers or maximum 400 ppm of CO_2 concentration above outdoor (= 800 ppm if outdoor concentration is 400 ppm). On the other hand, if it can be proved that the emissions from the materials are limited by choosing (very) low emitting materials, a less strict requirement applies, e.g. minimum 7 l/s.pers or maximum 800 ppm of CO_2 concentration above outdoor (= 1200 ppm if outdoor concentration is 400 ppm).

Approach 3

A third (alternative) approach is to consider the flow-rate needed for the persons and that needed for material emissions separately in accordance with method 2 described in the standard FprEN16798-1:2016. A first flow rate is calculated for the persons, e.g. 7 l/s.pers (according to class II for the perceived IAQ in the standard). A second flow rate is calculated for the pollutant emissions from the materials, based on different flow rates per m² depending on the level of emission of the building, e.g. 0.35 l/s.m² for very low emissions, 0.7 l/s.m² for low emissions and 1.4 l/s.m² for non-low emissions. Both of these flow rates are calculated for each space and the highest of them is the flow rate to consider as requirement.

Figure 1. Example of a meeting room in a working environment.

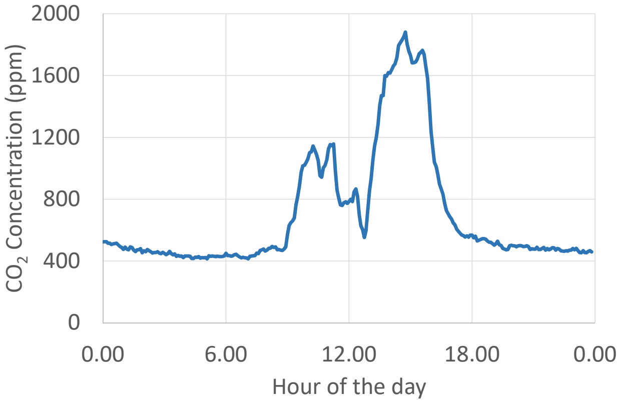

Figure 2. Example of CO_2 measured in an office environment during an occupied day.

For these two alternative approaches, a framework is necessary to classify the type of emissions in a building between very low emissions, low emissions and non-low emissions. For example, this framework could be based on existing framework to classify the emissions from the building materials used for the floor covering, paint and materials for the ceiling and walls, etc. Such a framework exists for example in France [5], with an emission label (with several classes from A+ to C); and in Belgium [6], for floor materials only, with a pass/fail approach.

Table 1. Application of the 3 approaches on 3 typical building spaces and for three levels of emissions from materials. The results are expressed as flow rate per surface area, flow rate per person and CO_2 concentration.

Type of space / building			**Flowrate or [CO_2]**			
	Area per person (m^2/pers)	**Building emission level**		**Approach 1**	**Approach 2**	**Approach 3**
Office	15	Very low	l/s.m^2	0.9	0.5	0.5
			l/s.pers	14	7	7
			ppm	800	1200	1200
		Low	l/s.m^2	0.9	-	0.7
			l/s.pers	14	-	10.5
			ppm	800	-	933
		High/ unknown	l/s.m^2	0.9	0.9	1.4
			l/s.pers	14	14	21
			ppm	800	800	667
Inter-mediate	10	Very low	l/s.m^2	1.4	0.7	0.7
			l/s.pers	14	7	7
			ppm	800	1200	1200
		Low	l/s.m^2	1.4	-	0.7
			l/s.pers	14	-	7
			ppm	800	-	1200
		High/ unknown	l/s.m^2	1.4	1.4	1.4
			l/s.pers	14	14	14
			ppm	800	800	800
Meeting room / school	3.5	Very low	l/s.m^2	4.0	2.0	2.0
			l/s.pers	14	7	7
			ppm	800	1200	1200
		Low	l/s.m^2	4.0	-	2.0
			l/s.pers	14	-	7
			ppm	800	-	1200
		High/ unknow	l/s.m^2	4.0	4.0	2.0
			l/s.pers	14	14	7
			ppm	800	800	1200

Application of the approaches to typical buildings

Methodology

The three approaches described above have been applied to three types of building spaces with different occupation rates: an office with 15 m²/pers, a meeting room with 3.5 m²/pers, and an intermediate space with 10 m²/pers. For each type of space, three different levels of material emissions have been considered: very low emitting, low emitting, non-low emitting.

In these nine configurations, the required flowrates have been calculated according to the three approaches described above and the results are presented in Table 1 in the form of: flow rate per surface area (l/s.m²), flow rate per person (l/s.pers) and absolute CO_2 concentrations (for outdoor concentration of 400 ppm).

Overview of the results

For the first approach (maximum 800 ppm of CO_2), the flow rate per person are the same for all types of spaces and all emission levels. However, because the occupation is different, the flow rate per surface area is lower for the office and higher for the meeting room.

For the second approach (maximum 1200 or 800 ppm of CO_2 depending on emission level), the design flow rate per person depends on the emission level of the building.

For the third approach (flowrate for persons and flowrate for emissions), the final design flow rate of the space depends on the nominal capacity (number of persons) of the space and on the surface area of the space and level of emission of the building.

Comparison of the approaches

With the third approach, based on the standard FprEN16798-1:2016, the design flow rate of a space is determined based on the most limiting pollutant source of this specific room. If the occupation rate of the space is low and the emission level of the building is high, then the limiting factor is the emission. In contrast, if the occupation rate of the space is high and the emission level of the building is low, then the limiting factor is the presence of the persons (bio effluents) and the design flow rate depends only on the number of persons in the room. The design flow rate is thus adapted, case by case, according to the most limiting factor for IAQ.

In contrast to this third approach, the first one requires the same flow rate per person whatever the occupation rate and the emissions from material. For example, in the meeting room, the design flow rate is higher than in the third approach. When low emission materials are used, these higher flow rates are probably unnecessary, causing also unnecessary energy consumption.

For the second approach, the design flow rate of the spaces depends partly on the emission level of the building. In case low emitting material are used, the flow rate per person can be lower while assuring equivalent IAQ and decreasing energy consumption. This is the main advantage of the second approach compared to the first one. However, in case of non-low emitting buildings, the same problems occur for the meeting room: higher design flow rate compared to the third approach based on the standard FprEN16798-1:2016 (method 2).

Discussion of pros and cons of the approaches

Some pros and cons of the different approaches have been identified and listed in Table 2, and a few of them are discussed below.

The approaches can be compared based on the expected impact on the real IAQ in the working environment and their incentives for a better ventilation system on one hand and a better source control on the other hand.

Because the first approach focuses only on a CO_2 requirement and not at all on the source control of material emissions, this approach has absolutely no incentives, for the employers and building designers and contractors, to limit the sources of pollutants by choosing (very) low emission materials. The high level of requirement in this first approach (800 ppm absolute CO_2 concentration) could in theory lead to high IAQ for bio-effluents as well as "indirectly" for other pollutant sources. However, because this higher flow rate has a huge economic impact for the employers as well as for the building owners (larger ductworks and technical rooms, higher energy consumption and operational costs), the true applicability of this first approach in practice is expected to be very poor.

On the other hand, the two alternative approaches allow an effective incentive to control the pollutant emissions at the source, by choosing (very) low emitting materials, and at the same time to adapt the required flow rate for ventilation accordingly. The ambition level of IAQ can then be similar to the first approach but adding two main advantages compared to the first approach: (1) a better incentive for source control, and

Table 2. Comparison of the three approaches in terms of pros and cons.

Comparison Criteria	Approach 1	Approach 2	Approach 3
Expected impact on real IAQ	In theory high but difficult applicability in practice	High and better applicability expected	High and better applicability expected
Incentives for better source control	No	Yes, roughly	Yes, case to case
Incentives for better ventilation system	Yes but high flow rate	Yes, flow rate depends on emissions, but sometimes high flow rate (meeting room)	Yes, flow rate depends on emissions
Ease of conformity control	Easy: CO_2 measurement	Easy for CO_2 measurement + need framework for emissions	Flowrate measurement possible but more difficult + need framework for emissions
Ease of design and installation	Easy to calculate	Easy to calculate flow rates + need framework for emissions	Easy to calculate flow rates + need framework for emissions
Economic impact (for new building)	Very high (higher flow rates)	Choice between effort on materials or flow rates	Choice between effort on materials or flow rates
Applicability for existing buildings	Difficult (higher flow rates)	Ok if low emission	Ok, flow rate depends on emissions

(2) a better expected applicability of the requirement in practice because the flow rate can be lower in case of low emission.

Compared to the second approach, the third one presents an additional advantage: the design flow rate of a space can be fine-tuned in function of the design number of persons in the room and the amount (surface area) and the type of emitting materials in the room. In such way, the third approach is probably more appropriate for some specific cases such as meeting rooms where the occupation rate is high and consequently the flow rate per person can be the limiting factor even if the emission level of the material is high or unknown. This is an important point for this type of space (meeting room, etc.) where the impact of higher flow rate can have high economic consequences.

However, the two alternative approaches also require a framework in order to classify the emission level of a building (or a space) at the design stage as well as for the conformity check. Such an effective framework remains a challenge. One possible approach would be to use existing regulation and framework for material emission, such as the current Belgian regulation on pollutant emission for floor covering materials. ■

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