Air Quality in car parks: regulations

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ABSTRACT

This paper shows the results of a survey conducted among 10 AIVC members countries about air quality in garages and current requirements and regulations in this regard. Large differences were found among countries, not only in terms of the scope of the regulations, but also in relation to the parameters that are considered.
Natural ventilation is allowed under certain conditions. Mechanical ventilation rates are heterogeneous and when pollutants are monitored, CO stands out as the most commonly used, but it is not the only one taken into account. Reviews like this can show us where regulation is heading towards and what issues still need to be addressed to achieve the most adequate protection.

KEYWORDS

IAQ, air quality, parking, garage, Building code, regulation, CO, NO_2, survey.

1 INTRODUCTION

Air quality and ventilation of garages is an important issue that is addressed in most national regulations in order to protect users from the health and safety threat that pollutants generated by fuel vehicles pose. However, there is not a common set standard for air quality in garages and consequently many differences exist among the different national requirements and regulations.
In order to review the state of the art on regulations, information on requirements and regulations in different countries was collected and analysed, and general recommendations were extracted based on the findings.
Therefore, questionnaire was developed and sent in 2020 to the 17 national representatives of AIVC members. 10 members responded providing information: Australia, Belgium, England, Korea, Netherlands, New Zealand, Scotland, Spain, Sweden and USA.
This paper shows the results of the survey. Large differences were found among countries, not only in terms of the scope of the regulations, but also in relation to the parameters that are considered.

2 COMPARISON OF REQUERIMENTS AND REGULATIONS

2.1 Scope

The first question of the questionnaire was about the scope of the regulations. 60% of the countries regulate all car parks in all kind of buildings. The rest 40 %, just regulate enclosed car parks or garages: 10% in all kind of buildings, 10% in all non-residential buildings, 10% in parking lots buildings, and 10 % in offices. (See
Figure 1).

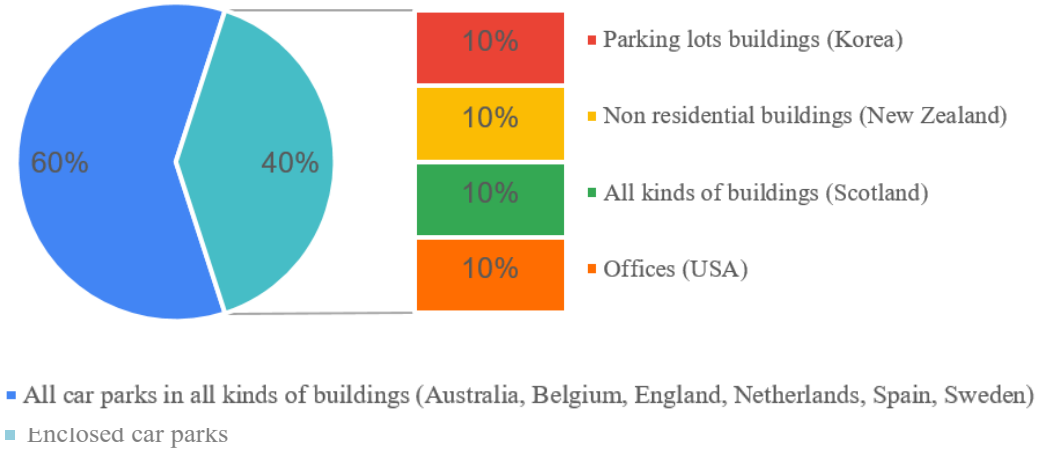

Figure 1. Scope of national regulations

In none of the national regulations, the fact that the garage is underground is used as a parameter for determining the scope.
40 % of national regulations only apply to car parks bigger than a minimum size, which varies from 30 to 50 m^2.

2.2 What are the main requirements?

The variety of requirements is small, although their quantification varies quite a bit. Establishing minimum ventilation rates or air changes per hour and limiting CO concentrations stand out as the most frequent requirements. Other requirements based on limiting other contaminants, such as NOx, or based on opening size are seldom used.

2.3 Ventilation requirements

90 % of national regulations establish some kind of minimum ventilation requirement during operation period. These requirements can be found at Table 1.

Table 1: Ventilation requirements

Country	Ventilation requirements	Comments
Australia	It varies given the geometry of building (1)	Calculation according to AS1668.2
Belgium	200 m^3/h (55.55 l/s) (2)	Brussels Region legislation
England	3 ach in basement carparks 10 ach in traffic concentration zones (3)	
Korea	27 m^3/h (7.5 l/s) per m^2 floor area	
Netherland	3 dm^3/s (3 l/s) per m^2 floor area	
New Zealand	It varies given the geometry of building	
Scotland	2 ach for floor area of at least 30 m^2 but not more than 60 m^2 6 ach and at least 10 ach in traffic concentration zones (3), for floor area more than 60 m^2	
Spain	120 l/s per parking place	
Sweden	No ventilation rates	
USA	3.7 l/s per m^2 exhaust	

(1) A minimum of 1 air change per 24 hours that can increase as a function of CO concentration up to a full ventilation rate according to AS1668.2.
(2) During 15 min when instantaneous detection of 50 ppm CO.
(3) Traffic concentration zones: zones where peaks of CO concentration are usual, like ramps and exits.

Ventilation rates are difficult to compare because they are expressed in different ways. In order to be able to compare them some assumptions have been made about car parks headroom, size of parking places and rate between common circulation areas to parking places, such as:

- car park headroom: 3 m;
- parking place size: 12.5 m^2;
- rate between common circulation areas and parking places: 12.5 m^2/parking place.

Taking into account the previous assumptions, ventilation rates in $l/s \cdot m^2$ are displayed in Figure 2.

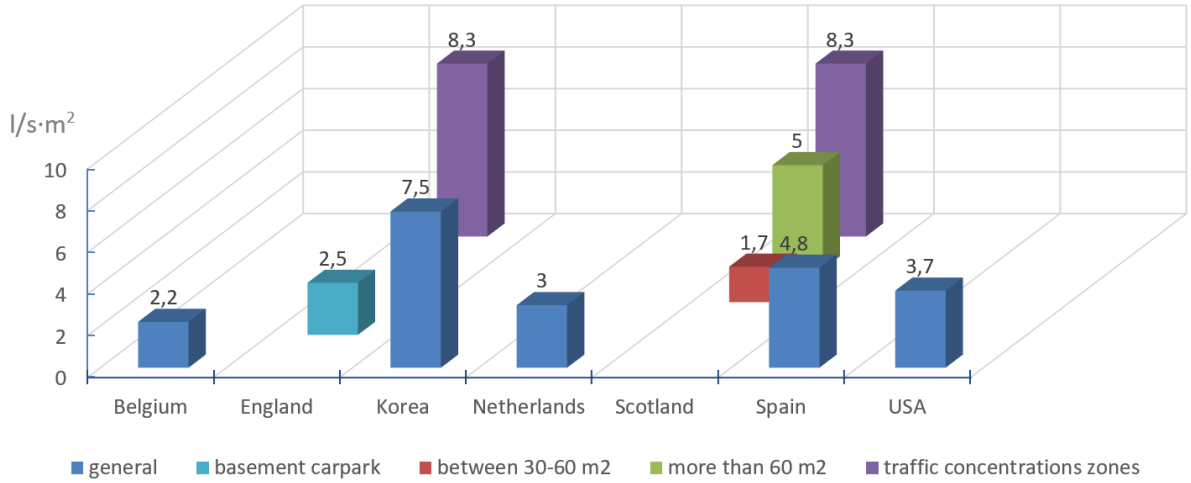

Figure 2 Minimum ventilation rates in l/s·m²

2.4 Contaminants control

70 % of national regulations set a contaminant control or limit. All of them control CO concentration, and 20 % include CO, NO_2 and other contaminants.
CO concentration threshold varies from an average of 25 ppm in Korea regulations to a maximum concentration of 100 ppm for non-staffed carparks in Spain regulations (see Table 2).

Table 2: CO concentration thresholds

Country	CO threshold	Time	Type	Comments
Australia	30 ppm for staffed carparks 60 ppm for non-staffed carparks	- -	Peak Peak	-
Belgium	90 ppm	15 min	Average	Large car parks with more than 50 parking places. When 50 ppm for 15 minutes, full ventilation rate is activated
England	30 ppm 90 ppm	8 h 15 min	Average Average	Traffic concentration zones (1)
Korea	25 ppm	Not specified	Average	Traffic concentration zones (1)
Netherland	No CO threshold	-	-	-
New Zealand	30 ppm for staffed carparks 60 ppm for non-staffed carparks	- -	Peak Peak	-
Scotland	30 ppm 90 ppm	8 h 15 min	Average Average	Traffic concentration zones (1)
Spain	50 ppm for staffed carparks 100 ppm for non-staffed carparks	- -	Peak Peak	Car parks with more than 5 parking places or bigger than100 m^2
Sweden	No CO threshold	-	-	-
USA	No CO threshold	-	-	-

(1) Traffic concentration zones: zones where peaks of CO concentration are usual, like ramps and exits.

Regulations of Australia, New Zealand and Spain opt for setting two thresholds depending on whether the car park is staffed or not, but the thresholds themselves are different.
Regulations of England and Scotland establish two thresholds as well but regarding time exposition.
Regulations of England, Korea and Scotland take into account traffic concentration zones with peak CO concentration, such as ramps and exits.

NO_2 is only included in two national regulations: Korea and New Zealand. Table 3 shows the data for NO_2.

Table 3: NO_2 concentration thresholds

Country	NO_2 threshold	Type of concentration	Scope
Korea	0.30 ppm	Average	Traffic concentration zones (1)
New Zealand	0.12 ppm	Peak	

(1) Traffic concentration zones: zones where peaks of CO concentration are usual, like ramps and exits.

Regulations of New Zealand control other contaminants in addition to CO and NO_2:
- photochemical oxidants (as ozone) < 0.10 ppm,
- SO_2 < 0.20 ppm,
- PM10 < 50 $\mu g/m^3$.

Regulations of Korea control the following contaminants in addition to CO and NO2:
- radon < 148 Bq/m^3,
- TVOC < 1000 $\mu g/m^3$,
- HCHO < 100 $\mu g/m^3$,
- PM10 < 200 $\mu g/m^3$.

The installation of a contaminant detection system is compulsory only under some conditions in 40% of national regulations. For example:
- In Australia, CO detection is required when air flow is variable.
- In Belgium, CO detection is required in large car parks of more than 50 parking places.
- In Spain, CO detection is required in car parks with more than 5 parking places or bigger than100 m^2.

2.5 Ventilation strategies

The use of both natural and mechanical ventilation systems is allowed in 90 % of national regulations. Only Korea regulations establishes that ventilation must be mechanical in any case.
Natural ventilation is regulated in terms of opening distribution and opening size.
Mechanical ventilation is based on mechanical extraction and supply in 50 % of national regulations, only mechanical extraction in 30 %, mechanical extraction or supply in 10 % and normally both mechanical extraction and supply with circumstances where each can be omitted in 10 %.
In 60 % of national regulations, mechanical ventilation for the car park must be independent from other areas of the building.
In 30 % of cases prevention of fan failure is regulated.
30 % of the national regulations include in their strategies the use of automatically operated jet fans, and 10 % manual ones.

3 CONCLUSIONS

Despite national regulations on air quality in car parks vary enormously some common trends can be extracted such as allowing:

- natural ventilation in small to medium size car parks as long as airing openings are big enough and are correctly placed;
- constant flow ventilation systems.

In most of the regulations, the compulsory requirement is a minimum ventilation rate, or a combination between ventilation rate and contaminants threshold.

Although 3 national regulations do not regulate contaminants, among the 7 regulations that do, CO stands out as the most commonly used contaminant, exclusively and setting two thresholds according to time exposition in some cases or to whether the car park is staffed, in other cases. Although nitrogen oxides (NOx) have been recognized as one of the main pollutants to be taken into account (Moncef, 2001), their health thresholds have not been included in national regulations according to the results of this survey. The reason behind this fact could be that when NOx health thresholds are reached, CO health threshold have already been reached and far beyond exceeded.

Several regulations specify particular provisions that take into account differences in pollutant exposition such as high pollutant concentration areas and staffed car parks. High pollutant concentration risk areas are areas in which traffic congestion may occur producing a high generation of pollutants. Staffed carparks hold security employers that may be exposed to long pollutants exposures. These regulations explicitly refer to the control of pollutants in the high pollutant concentration areas, or set reference concentration thresholds depending either on whether workers are present or on a length of time. This way, the threshold for long exposure varies from 30 to 50 ppm CO and the one for short exposure vary from 60 to 100 ppm CO.

EU promoted decarbonisation policies as well as the growing green awareness of people are leading towards the replacement of traditional fuel vehicles by electrical or hybrid ones as well as the anticipated withdrawal from service of the oldest or most pollutant vehicles. It is therefore foreseeable that ventilation systems based only on constant flow rates might become over-dimensioned. Oversizing ventilation systems is not desirable because of larger associated costs and energy demand Therefore, for the future, we believe that new regulations should take into account this trend:

- specifying ventilation rates or air changes related to number of fuel vehicles places instead of the total parking places or garage surface;
- set a base-line ventilation flow rate based on the surface area of the car park to remove other non-combustion related pollutants, such us particles, oil leaks or common indoor contaminants and
- including provisions on monitoring of contaminants that would accordingly activate ventilation, particularly in big to medium size and in staffed car parks.

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5 REFERENCES

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Regulatory documents for IAQ car parks regulations:

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Belgium	The compulsory ventilation of car parks and garages is included in the environmental permit: https://leefmilieu.brussels/de-milieuvergunning/algemene-en-specifieke-exploitatievoorwaarden-video/de-specifieke-28 https://navigator.emis.vito.be/mijn-navigator?woId=8967
England	Approved Document F of the Building Regulations of England: https://www.gov.uk/government/publications/ventilation-approved-document-f
Korea	http://www.law.go.kr/LSW/eng/engLsSc.do?menuId=2&section=lawNm&query=indoor+air&x=37&y=26#liBgcolor2
Netherlands	Dutch Building Regulations 2012 https://business.gov.nl/regulation/building-regulations/
New Zealand	https://www.building.govt.nz/building-code-compliance/g-services-and-facilities/g4-ventilation/
Scotland	Non Domestic Technical Handbook, Standard 3.14. https://www.gov.scot/publications/building-standards-technical-handbook-2019-non-domestic/3-environment/3-14-ventilation/
Spain	Spanish Building Code – HS3 Section https://www.codigotecnico.org/DocumentosCTE/Salubridad.html
Sweden	Boverket´s building regulations – mandatory provisions and general recommendations, BBR, Chapter 8.7. https://www.boverket.se/en/start/publications/publications/2019/boverkets-building-regulations--mandatory-provisions-and-general-recommendations-bbr/
USA	ASHRAE Standard 62.1 https://ashrae.iwrapper.com/ViewOnline/Standard_62.1-2019