IMPACT OF THE NEW RITE 2013 (REGULATION ON THERMAL INSTALLATION) ON INDOOR AIR QUALITY

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ABSTRACT

This paper presents a comparison of Indoor Air Quality in several buildings constructed prior to the implementation of the new Spanish regulation on thermal installations (RITE, 2007 modified on 2013) and some new ones that fully accomplish the requirements of this new regulation. The objective is to confirm whether new regulation had a positive impact on the indoor air quality.

The month of April 2014 marked a year since the publication of the amendment of RITE (RD 238/2013 of April 5, 2013 Spanish Regulation on Thermal Installations), among the changes that were included, we highlight two that had a great relevance in terms of Indoor Air Quality. Within the document in the section IT 3.3 describing maintenance programs to be implemented in facilities subject to RITE (> 70kW), two maintenance items where added:

38. Review of the ductwork and AHU hygiene according to the UNE 100012: t.
39. Revision of indoor environmental quality according to the UNE 171330: t.

This is accomplished by two types of reviews including several analysis and visual inspections, first ensure that HVAC systems are in good hygienic conditions (UNE 100012) and secondly that the quality of the air users breathe is satisfactory (UNE 171330).

On the other hand since 2007 RITE makes compulsory to install high quality filters according to outdoor air quality.

In order to estimate the positive impact of such measure we have analyzed Indoor Air Quality according to RITE requirements in 38 buildings half of them with low quality filtration (projects made before 2007) and the other half buildings projected and executed according to new RITE.

The summary of findings indicates an overall positive effect in all indicators related to pollution mainly found outdoor as particulates and fungi, but not so relevant in airborne bacteria since those are produced indoor by the occupants mainly.

Building projected, executed and maintained according to new RITE 2013 requirements offer in average 60% more reduction of pollution than old ones.

It must be taken into account that new buildings are also tighter than the old ones. Carbon dioxide have been used as and indicator of tightness being the Indoor-Outdoor relative CO_2

concentration higher in new buildings (indoor minus outdoor concentration of CO_2). That means new buildings have higher CO_2 readings but that does not mean worst Indoor Air Quality since filtration has been enhanced.

CONCLUSION:

New RITE buildings accomplish the goal of offering better indoor air quality enhancing at the same time energy efficiency.

KEYWORDS

Indoor Air Quality, Ventilation, Carbon dioxide, Indoor particles, Fungi, Bacteria.

1 INTRODUCTION

This paper presents a comparison of Indoor Air Quality in several buildings constructed prior to the implementation of the new Spanish regulation on thermal installations (RITE, 2007 modified on 2013) and some new ones that fully accomplish the requirements of this new regulation.

In order to estimate the positive impact of such measure we have analyzed Indoor Air Quality according to RITE requirements in 38 buildings half of them with low quality filtration (projects made before 2007) and the other half buildings projected and executed according to new RITE.

The summary of findings indicates an overall positive effect in all indicators related to pollution mainly found outdoor as particulates and fungi, but not so relevant in airborne bacteria since those are produced indoor by the occupants mainly.

The main overall conclusion of our study is that buildings constructed accomplishing RITE 2013 requirements offer 60% higher reduction of pollution and are tighter in terms of infiltration, meaning that enhanced IAQ and energy efficiency can be achieved together.

2 DESCRIPTION OF RITE (SPANISH REGULATION ON THERMAL INSTALLATIONS)

RITE is a regulation mainly intended originally to save energy in thermal installations of buildings. The aspects related to IAQ are applicable to all buildings holding a thermal capacity above 70 kW.

Some key questions of RITE we have used in our study are the following:

1.- Design requirements that affect IAQ:

1.1 The filtration must be designed taking into account outdoor level of pollution

1.2 There must be a minimum level of ventilation, that can be expressed in terms of ventilation rate (liters/second-person), but also as a maximum CO_2 level concentration.

2.- Periodic review of IAQ

2.1 In section IT 3.3 dealing with maintenance requirements RITE obligates to review and register IAQ and hygienic conditions of the building and the HVAC system respectively.

2.2 The standards applicable for the reviews are:

Ductwork and AHU hygiene according to the UNE 100012.

Indoor environmental quality according to the UNE 171330.

2.1 RITE: IAQ DESIGN REQUIREMENTS

Spanish HVAC regulation (RITE) establishes the quality of the filtration systems that must be installed in new or refurbished buildings according to the level of outdoor air pollution (ODA -Outdoor Air) existing in the area where the building is to be located range 1 to 3. The quality of the filters depends also on the type of activity which may require different levels of indoor air quality (IDA -Indoor Air range 1 to 4). The rationale has been taken from EN 13779 Standard see Table 1.

Table 1. Filtration requirements according to RITE

Outdoor Air Quality	Indoor Air Quality			
	IDA 1	IDA2	IDA 3	IDA 4
ODA 1	F9	F8	F7	F5
ODA 2	F7 + F9	F6 + F8	F5 + F7	F5 + F6
ODA 3	F7+GF+F9a	F7+GF+F9a	F5 + F7	F5 + F6

GF = Gas filter

The meaning of each aspect is shown on tables 2 and 3:

Table 2. Meaning of ODA

Category	Description
ODA 1	Pure air which may be only temporarily dusty e.g. pollen
ODA 2	Outdoor air with high concentrations of particulate matter and/or gaseous pollutants (within 1 to 1,5 times National Air Quality Standards)
ODA 3	Outdoor air with very high concentrations of particulate matter and/or gaseous pollutants. (above 1,5 times National Air Quality Standards)

Table 3. Meaning of IDA

Category	Description	Example of uses
IDA 1	High indoor air quality	Hospitals , clinics, laboratories and nurseries
IDA 2	Medium indoor air quality	offices, residences (common premises of hotels and similar (retirement and students houses), meeting and reading rooms, museums, courtrooms , classrooms and similar teaching areas and pools
IDA 3	Moderate indoor air quality	Commercial buildings , cinemas , theaters, auditoriums, hotel rooms and similar, restaurants, cafes, bars, clubs, gyms , rooms for sport (except swimming pools) and computer rooms .
IDA 4	Low indoor air quality	Not specified

Filtration systems are rated according to EN 779 see Table 4:

Table 4. Classification of filters

	Filter class	Average arrestance [%]	Average efficiency [%]	Minimum efficiency [%]
Coarse dust filters	G1	$50 \leq Am < 65$	-	-
	G2	$65 \leq Am < 80$	-	-
	G3	$80 \leq Am < 90$	-	-
	G4	$90 \leq Am$	-	-
Medium and Fine dust filters	M5	-	$40 \leq Em < 60$	-
	M6	-	$60 \leq Em < 80$	-
	F7	-	$80 \leq Em < 90$	35
	F8	-	$90 \leq Em < 95$	55
	F9	-	$95 \leq Em$	75

RITE also establishes the levels of mechanical ventilation that must be ensured in order to achieve an acceptable level of air renovation. The level depends on IDA as shown on table 5

Table 5. Level of ventilation

Category	Level of ventilation	
	Liters/second-person	Indoor - outdoor relationship* (ppm)
IDA 1	20	350
IDA 2	12,5	500
IDA 3	8	800
IDA 4	5	1200

* Calculated as absolute CO2 concentration outdoor minus absolute concentration indoor (in ppm)

2.2 RITE: PERIODIC IAQ INSPECTIONS.

The periodic inspection must be done according to standard UNE 171330 which establishes a minimum set of parameters that could be considered as general indicators of the Indoor Air Quality of any building, these are the following:

- Inspection of hygiene of HVAC system (including ductwork test: surface microorganisms, gravimetric analysis of settled dust)
- Carbon dioxide
- Temperature and relative humidity
- Carbon monoxide
- Particle concentration (PM10)
- Particle counting (size 0,5 microns)
- Airborne bacteria
- Airborne fungi

HVAC systems are the basic equipment involved in the control of IAQ, if the general maintenance, not only mechanical but also hygienic, does not meet a minimum standard the system could not only fail in enhancing IAQ, but even worse, could become a source of pollution (particles, fungi, bacteria, bad smell, etc)

Hygienic inspection of HVAC system

This is made according to UNE 100012 requirements and consist on visual inspection (ranging from 1 to 3 meaning 1 clean and 3 dirty), plus surface sampling for microorganisms and total settled dust.

Carbon dioxide

Readings of carbon dioxide indoors are referred to outdoor concentration. Relationship Indoor-Outdoor is the parameter to control. It is an excellent indicator of the quality of the ventilation.

Some critical aspects about carbon dioxide readings are the level of occupancy or timing, a typical building may need at least 1 hour to reach steady state, only at this moment readings are meaningful.

Temperature and relative humidity

Thermal comfort represents around 30% of typical complaints about indoor environments, however this is a parameters not directly related to IAQ therefore it was not included in the study.

Carbon monoxide

Carbon monoxide is rarely a problem, it could be a good indicator of car exhaust either from building parking areas or from general outdoor traffic. It has not been cosidered.

Particle concentration (PM10) and particle counting (size 0,5 microns)

Particle reading is a good indicator of the quality of the filtration system, concentration is a health concern.

Airborne bacteria and fungi

Humans are a source of airborne bacteria, so typically indoor airborne concentration is higher than outdoor, this is a good indicator of the general hygiene of the building and also a complementary indicator of the quality of the ventilation.

Fungi is mainly pulled in the building from outdoor and it is a good indicator of the hygiene of the HVAC and the quality of the filtration system.

All these parameters must be checked on a yearly basis according to Spanish law.

The inspection standard also establishes the number of sampling points to be taken as a result of the formula:

$$P = 0{,}15 \times \sqrt{A}$$

where

P= Nº sampling points

A: Area under study

The idea is that the number of sampling points do not have to increase linearly with the area under study.

3 DESCRIPTION OF THE BUILDINGS

Indoor air quality of 19 buildings designed and operated according to new RITE requirements (filter quality F7-F9 and enhanced hygiene maintenance, from now on Buildings F7/F9) were analyzed and the results have been compared with those in 19 old buildings (filter quality G4, from now on Buildings G4). We have analyzed data from 38 buildings. The inspection was made following UNE 171330 Standard.

The characteristics of the buildings investigated are the following:

BUILDINGS G4

Type of HVAC systems

ALL AIR CONSTANT VOLUME	35%
ALL AIR VARIABLE AIR VOLUME	30%
VRV (VARIABLE REFRIGERANT)	20%
AIR-WATER. PRIMARY AIR UNIT/FCU (FAN COIL UNITS)	15%

Quality of filters:

84%	G4
11%	G3
5%	F5

Cities: Madrid, Barcelona, Bilbao, Jerez and Badajoz.

Size of the buildings:

AVERAGE AREA	8.634 m2
MINIMUN AREA	1.111 m2
MAXIMUN AREA	30.044 m2

Outdoor air quality:

ODA 1	11%
ODA 2	53%
ODA 3	37%

BUILDINGS F7/F9

Type of HVAC systems

ALL AIR CONSTANT VOLUME	10%
ALL AIR VARIABLE AIR VOLUME	50%
VRV (VARIABLE REFRIGERANT)	20%
AIR-WATER. PRIMARY AIR UNIT/FCU (FAN COIL UNITS)	20%

Quality of filters:

F8	28%
F7	56%
F9	17%

Cities: Madrid, Barcelona, Sevilla and Albacete.

Size of the buildings:

AVERAGE AREA	21.294 m2
MINIMUN AREA	2.178 m2
MAXIMUN AREA	64.178 m2

Outdoor air quality:

ODA 1	11%
ODA 2	67%
ODA 3	22%

In both cases the inspections were made within September, 2013 and October, 2014

4 RESULTS OF THE STUDY

The results of the hygienic inspection of the air handling units was:

Table 6: Air Handling Units Hygiene

Air Handling Units	VISUAL INSPECTION	SURFACE BACTERIA	SURFACE FUNGI
	Range 1 to 3	<100 ufc/25cm^2	<100 ufc/25cm^2
BUILDINGS G4	1,7	39	41
BUILDINGS F7/F9	1,8	43	20

The level of dirt visually estimated is similar regardless the type of system, it depends basically on the quality of the maintenance.

About microorganisms bacteria differences are not relevant but fungi is almost 50% less in higher quality buildings.

Fungi are relatively big particles coming mainly from outdoor and therefore can be better controlled by filters. See table 6.

Table 7: Ducts Hygiene

DUCTS	VISUAL INSPECTION	SURFACE BACTERIA	SURFACE FUNGI	SETTLE DUST
	Range 1 to 3	<100 ufc/25cm^2	<100 ufc/25cm^2	mg/100cm^2
BUILDINGS G4	2,1	73	70	17
BUILDINGS F7/F9	2,2	51	47	11

Ductworks systems do not present differences in terms of level of dirt, it is interesting to point that ducts are dirtier than AHU´s, probably because of difficulties of access.

Bacteria, fungi and settle dust levels are significantly better in F7/F9 buildings. Better filtration protects ducts from excessive contamination.

See table 7.

Table 8: Airborne Particles (PM10)

AIRBORNE PARTICLES (PM10)	INDOOR AIRBORNE PARTICLES	OUTDOOR AIRBORNE PARTICLES
	micrograms/m^3	micrograms/m^3
BUILDINGS G4	13,3	19,9
BUILDINGS F7/F9	8,0	18,9
	% REDUCTION	
BUILDINGS G4	-50%	
BUILDINGS F7/F9	-138%	

Table 9: Airborne Particles (0,5 microns)

AIRBORNE PARTICLES (0,5 MICRONS) COUNTING	INDOOR 0,5 MICRONS PARTICLES	OUTDOOR 0,5 MICRONS PARTICLES
	particles/ft^3	particles/ft^3
BUILDINGS G4	2.699.391	3.688.003
BUILDINGS F7/F9	2.024.102	4.564.890
	% REDUCTION	
BUILDINGS G4	-37%	
BUILDINGS F7/F9	-126%	

Airborne particles (PM10) and 0,5 micros are much better retained by F7/F9 filtration systems. See tables 8 and 9.

Table 10: Airborne Fungi

AIRBORNE FUNGI	INDOOR AIRBORNE FUNGI	OUTDOOR AIRBORNE FUNGI
	cfu/m^3	cfu/m^3
BUILDINGS G4	122	371
BUILDINGS F7/F9	24	234
	% REDUCTION	
BUILDINGS G4	-204%	
BUILDINGS F7/F9	-855%	

Airborne fungi reduction in the buildings with filters F7F9 are up to 4 times better than in G4 buildings.

Some fungi species can promote allergic reactions on some people. Reducing the levels can enhance indoor air quality and can help on the durability of decoration materials.

Table 11: Airborne Bacteria

AIRBORNE BACTERIA	INDOOR AIRBORNE BACTERIA	OUTDOOR AIRBORNE BACTERIA
	cfu/m^3	cfu/m^3
BUILDINGS G4	246	268
BUILDINGS F7/F9	107	154
	% REDUCTION	
BUILDINGS G4	-9%	
BUILDINGS F7/F9	-44%	

Indoor airborne bacteria is heavily influenced by the presence of people, main source of those.

Control of bacteria by means of filters is not totally feasible, good ventilation can be more effective in this case. However buildings F7/F9 perform better than G4.

Table 12: Carbon Dioxide

CARBON DIOXIDE	INDOOR-OUTDOOR RELATIONSHIP
	Limit Value < 500 ppm
BUILDINGS G4	178
BUILDINGS F7/F9	237

Finally the results of carbon dioxide readings, show more ventilation in G4 buildings than F7/F9, however this is probably due to the fact that new buildings facades are tighter and then less infiltration is allowed, because mechanical ventilation must be higher according to new requirements.

In any case regardless the origin of the fresh air, excessive ventilation means energy waste, and according to our study this is useless since Buildings F7/F9 even though have less overall fresh air entrance perform better in terms of presence of particles and microorganisms.

Carbon dioxide itself is not a concern in terms of air quality, levels of 600 ppm to 700 ppm are perfectly normal. The air in humans lungs can reach up to 40.000 ppm CO2 concentration.

CONCLUSION

New RITE has been a major advance in terms of enhanced Indoor Air Quality in Spanish buildings built or refurbished according to this new requirements. In the near future the trend is that most buildings will be renovated to fulfill these requirements for the benefit of users.

This will have an impact not only in terms of enhanced quality of life but even from an economic point of view.

5 REFERENCES

Indoor Air Quality Handbook. Mc Graw Hill. John D. Spengler. 2000

Green Building and Productivity. Norm G. Miller. University of San Diego. 2009

DTIE 2.02: Calidad de aire interior Paulino Pastor Pérez. Atecyr 2006

DTIE 2.05 Calidad del Aire Exterior: Mapa de ODAs de las principales capitales de provincia de España Paulino Pastor Pérez. Atecyr 2013

UNE 171330 Indoor Air Quality

UNE 100012 Hygiene of HVAC systems.