COBEM-2017-1898
THERMAL COMFORT CONDITIONS IN A CLASSROOM CONDITIONED BY A SPLIT-TYPE SYSTEM

Anastácio Silva Jr.
Instituto Federal de Santa Catarina, Department of Refrigeration and Air Conditioning, São José, Brazil
Pontifícia Universidade Católica do Paraná, Mechanical Engineering Graduate Program, Curitiba, Brazil
anastac@ifsc.edu.br

Rogério Vilain
vilain@ifsc.edu.br

Marcelo Luiz Pereira
Instituto Federal de Santa Catarina, Department of Refrigeration and Air Conditioning, São José, Brazil
Marcelo.pereira@ifsc.edu.br

Nathan Mendes
Pontifícia Universidade Católica do Paraná, Mechanical Engineering Graduate Program, Curitiba, Brazil
nathan.mendes@pucpr.br

Katia Cordeiro
L'Ècole D'Ingénieurs CESI - Campus La Rochelle, Lagord, France.
kcordeiro@cesi.fr

Abstract. Environments conditioned by split-type systems present comfort conditions that may vary substantially according to the position of the equipment. In this work, the comfort conditions in a classroom were evaluated experimentally based on the PMV index, according to ISO 7730 Standard that defines the thermal satisfaction in occupied environments. Two split-type equipment were installed in two different positions of the room. For each position, three different supply airflows were tested. The results showed that there is a considerable variation in the air velocity field in the room as well as in the PMV values in the two situations for three different supply airflows, consequently there are a considerable variation in the thermal comfort indices. Therefore, it is possible to establish a control of the classroom thermal comfort only by varying the supply airflow.

Keywords: Thermal comfort, classroom, split-type systems, air velocity, air temperature.

1. INTRODUCTION

Many air-conditioned schools in Brazil use split-type systems for air conditioning. This type of equipment has also been largely used in in residential and commercial buildings, being currently the most used equipment in these environments (ABRAVA, 2016). The air velocity field in air-conditioned classrooms with this type of system presents a great variation, which causes a great difficult to obtain uniform thermal comfort conditions (Pereira 2012). In this work, the comfort conditions in a classroom were evaluated experimentally based on PMV index, using two split-type equipment installed in two different positions. Figure 1 shows the geometry and layout of the classroom studied and the position of the split-type systems.
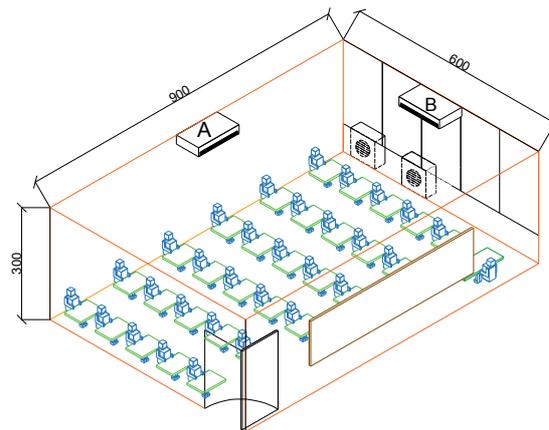
Figure 1: Geometry and layout of the classroom studied and the position of the split-type systems (A and B) – dimensions in cm (900x600x300).

2. EXPERIMENTAL PROCEDURE

For the field test, two floor-ceiling models of split-type system (equipment A and B) were both instrumented in a classroom. All the parameters for both cases were measured and evaluated at 1.10m height, that is the breathing height for a sitting person. The equipment A is located on the wall with the wider size (Figure 2 a), while the Split B was installed at the position most appropriate to the geometry of this environment, i.e., on the small wall. For both positions, the personal comfort parameters were measured and monitored to obtain the PMV, following the method described in ISO 7730-2005 and ASHRAE 55-2010. That is, comfort parameters (air velocity, air temperature, mean radiant temperature and relative humidity) were measured with the three original flows (high, medium and low) for each equipment at 8 measurement points distributed throughout the room, as shown in Figure 2b. With these data, the PMV indices were calculated for each point and for each configuration, using a thermal 23°C set point for all tests, which corresponds to a thermal comfort temperature, according to ISO 7730 - 2005.
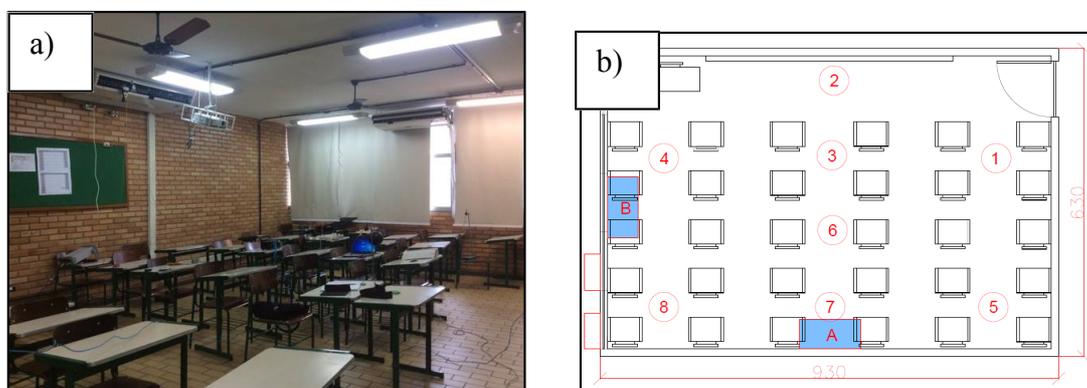

Figure 2: (a) Classroom with the instrumentation; (b) Lay-out and measuring points.

3. RESULTS AND DISCUSSION

The average of air velocity obtained at each point for systems A and B are shown in Figures 3 and 4 for the three airflow rates (high, medium and low). It is observed that the highest values of PMV were measured at regions with higher air velocities (points 2 and 6 for both configurations). These points are located in front of the equipment, being directly reached by the air jet.

high			medium			low		
	0.80			0.73			0.71	
0.21	0.11	0.18	0.15	0.19	0.16	0.11	0.31	0.14
	0.46			0.34			0.32	
0.11	0.10	0.11	0.04	0.08	0.05	0.02	0.07	0.05

Figure 3: Average air velocity (m/s) in each measurement point for the three flows (high, medium and low) for the Split A.

high			medium			low		
	0.63			0.46			0.55	
0.04	0.07	0.27	0.07	0.05	0.25	0.05	0.08	0.27
	0.83			0.33			0.50	
0.03	0.15	0.24	0.14	0.30	0.23	0.16	0.28	0.21

Figure 4: Average air velocity (m/s) in each measurement point and for three flows (high, medium and low) for the Split B.

The mean air temperature at each point is presented in Figures 5 and 6, where it is observed that for the two configurations there was no large variations along the room, which did not produce great effects on the variation of the PMV

high			medium			low		
	20.6			19.8			19.9	
21.2	21.4	21.5	20.9	21.2	21.4	20.6	20.7	21.2
	21.4			20.8			21.0	
21.1	21.2	21.6	20.8	21.1	21.3	20.8	21.0	21.2

Figure 5: Average temperature in each point and for three flows (high, medium and low) for Split A.

high			medium			low		
	21.7			21.5			21.2	
20.7	21.5	20.9	20.7	21.3	21.5	20.7	20.9	21.1
	21.2			21.0			20.8	
20.4	20.8	21.0	20.6	20.5	20.7	20.7	20.5	20.8

Figure 6: Average temperature in each point and for three flows (high, medium and low) for Split B.

Figures 7 and 8 presented the values of PMV obtained for each measurement point, according to the equipment position and the three airflow rates. Figure 7 shows that the PMV with the high air supply airflow varies from   -0.9 to -2.6, and, in Figure 8, it is observed that the PMV varies from -0.9 to -2.1.

high			medium			low		
	21.7			21.5			21.2	
20.7	21.5	20.9	20.7	21.3	21.5	20.7	20.9	21.1
	21.2			21.0			20.8	
20.4	20.8	21.0	20.6	20.5	20.7	20.7	20.5	20.8

Figure 7: PMV distribuition for Split A.

high			medium			low		
	-1.9			-1.7			-2.0	
-1.0	-0.9	-1.5	-1.1	-0.9	-1.4	-1.1	-1.1	-1.5
	-2.1			-1.7			-2.0	
-1.2	-1.5	-1.5	-1.2	-1.7	-1.5	-1.3	-1.7	-1.4

Figure 8: PMV distribuition for Split B.

4. CONCLUSIONS

The comfort conditions in a classroom were experimentally evaluated based on PMV index, using two split-type equipment installed in two different positions. For the configuration A, the most critical point for the thermal comfort index (Figure 7) is located in front of the blackboard, point 2, for the three supply airflows, which was -2.4, -2.6 and -2.6.

It also shows a proportional variation of the thermal comfort index with the supply airflow rate, that is, the higher the air velocity more uncomfortable is the environment, i.e., more distant from 0 PMV. This situation can be used as a representative point to control the thermal comfort of the room. For the configuration B, the most representative points for the control of thermal comfort (Figure 8) through the variation of the supply air flow of the equipment are located where the incidence of the cold supply jet is located, points 2 and 6, which the PMV values were -2.1, -1.7 and -2.9 respectively for point 6.

The initial objective of this work was to establish a relationship between the thermal comfort indices and the supply airflows rates of a split-type equipment. It was observed that in fact there are points in the room that can be used to characterize the index of thermal comfort , that is, improving the comfort conditions in these points will result in a better distribution of comfort for the whole room. It has also been shown that with the change in the equipment position, as expected, the distribution of comfort within the room also changes. Finally, it is concluded that it is possible to improve the thermal comfort conditions by varying the supply airflow rate of the machine and establishing a single measuring point to characterize the comfort conditions in the room (in this case, point 2 for configuration A and point 6 for configuration B , which correspond to the points of incidence of the cold jet of the split type system).

5. ACKNOWLEDGEMENTS

6. REFERENCES

ABRAVA - Associação Brasileira de Refrigeração, Ar Condicionado, Ventilação e Aquecimento.
   <http://www.abrava.com.br, acesso em 24/05/2016.>
ASHRAE 2010 - Standard 55. "Thermal Environmental Conditions for Human Occupancy". American Society of Heating Refrigeration and Air-Conditioning Engineers, Atlanta,.
Pereira, M. L., Vilain R., Tribes, A., "Thermal Comfort Conditions In A Room Ventilated With Split System – Numerical And Experimental Analysis". In *14th Brazilian Congress of Thermal Sciences and Engineering*, Rio de Janeiro, RJ, Brazil, 2012.

ISO, 2005. "Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria", ISO 7730:2005. Geneva, Switzerland: International Organization for Standardization.

7. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.