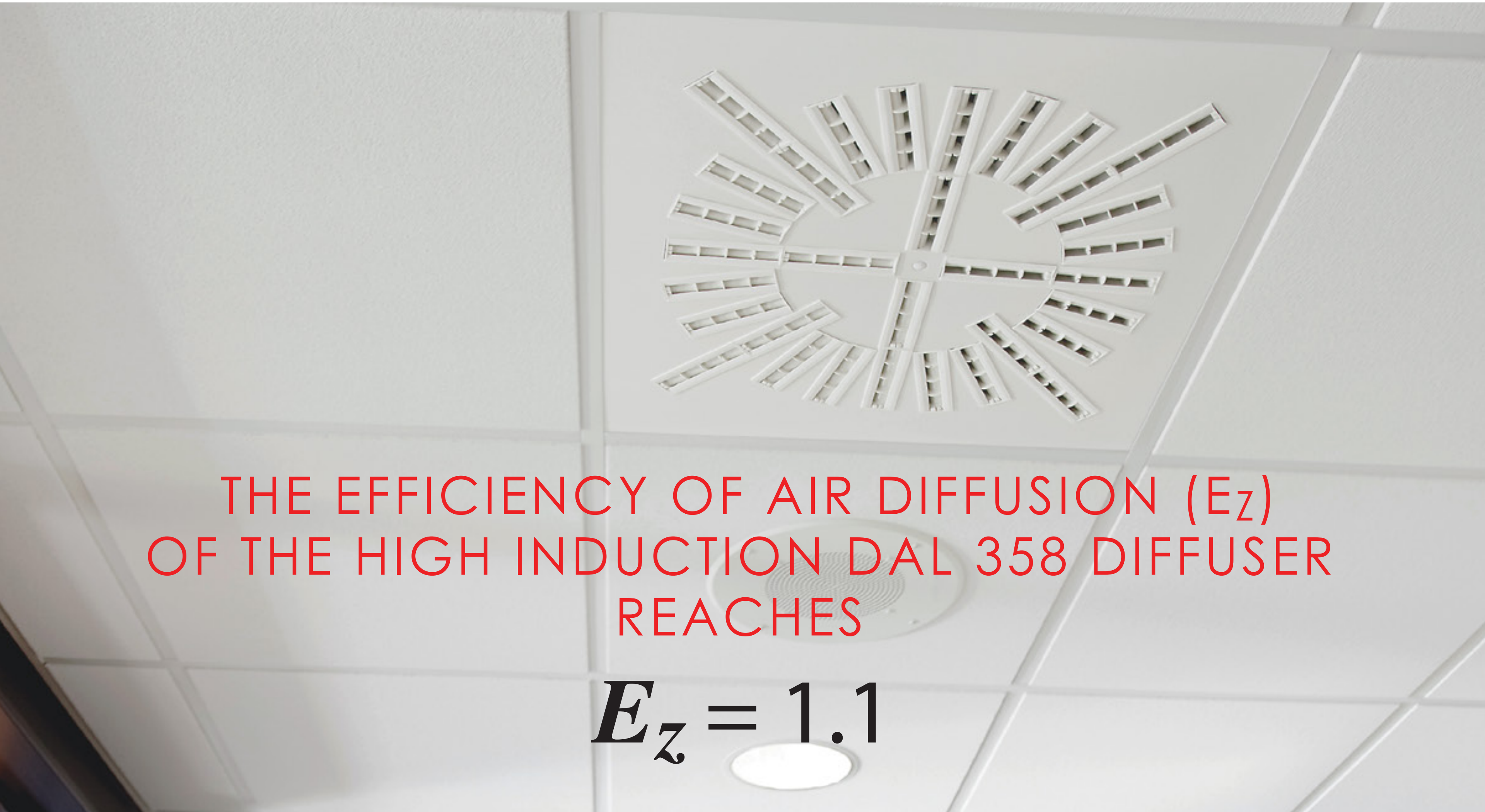

THE EFFICIENCY OF AIR DIFFUSION (E_Z) OF THE HIGH INDUCTION DAL 358 DIFFUSER REACHES

$$E_z = 1.1$$

National Building Code Requirements - Canada 2010 (NBC)

Section 6.2.2.1. Required Ventilation

2) Except in *storage garages* and *repair garages* covered by Article 6.2.2.3., the rates at which outdoor air is supplied in *buildings* by ventilation systems shall be not less than the rates required by ANSI/ASHRAE 62.1, "Ventilation for Acceptable Indoor Air Quality".

ASHRAE 62.1 – outdoor airflow calculations

Standard ANSI/ASHRAE 62.1-2016 recommends a quantity of outdoor airflow calculated based on the number of occupants and the surface area using the values in table **6.2.2.1.**

In order to determine the total outdoor airflow, you must :

1. Calculate the quantity of outdoor airflow as follows :

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$$

where

Rp : outdoor airflow rate per person

Pz : zone population

Ra : outdoor airflow rate per unit area

Az : zone floor area

2. Select the zone air distribution effectiveness *Ez*, Table 6.2.2.2 **or according to ASHRAE 129 test** (*Measuring Air-Change Effectiveness*)

3. Calculate the total outdoor airflow: $V_{oz} = V_{bz} / E_z$

ASHRAE 62.1 – Calculate outdoor airflow

TABLE 6.2.2.2 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level (See Note 6)	1.0
Floor supply of cool air and ceiling return, provided that the vertical throw is greater than 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) or more above the floor	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is less than or equal to 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust, return, or both.	0.8
Makeup supply drawn in near to the exhaust, return, or both locations.	0.5

NOTES:
1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling supply" includes any point above the breathing zone.
4. "Floor supply" includes any point below the breathing zone.
5. As an alternative to using the above values, E_z may be regarded as equal to air-change effectiveness determined in accordance with ASHRAE Standard 129 [16] for air distribution configurations except unidirectional flow.

DAL 358 and DAL 359 diffuser tests with ASHRAE 129

An Evaluation of Air Distribution Effectiveness for the NAD Klima Ceiling High Induction Diffusers

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National Research Council Canada
Conseil national de recherches Canada

Canada

Testing Conditions
Typical Configuration

2.1 Indoor Environment Research facility (IERF)

This state-of-the-art research facility was designed to allow full-scale testing and physical modeling of office space lighting, thermal comfort, indoor air quality, airflow, contaminant-flow patterns, ventilation, acoustical characteristics, and occupants' reactions to these parameters. A plan of the facility is shown in Figure 1 and Figure 2, and the dimensions in Table 1.

Figure 1: IERF office environment, with a window on the exterior wall.

Testing Conditions : layout zone

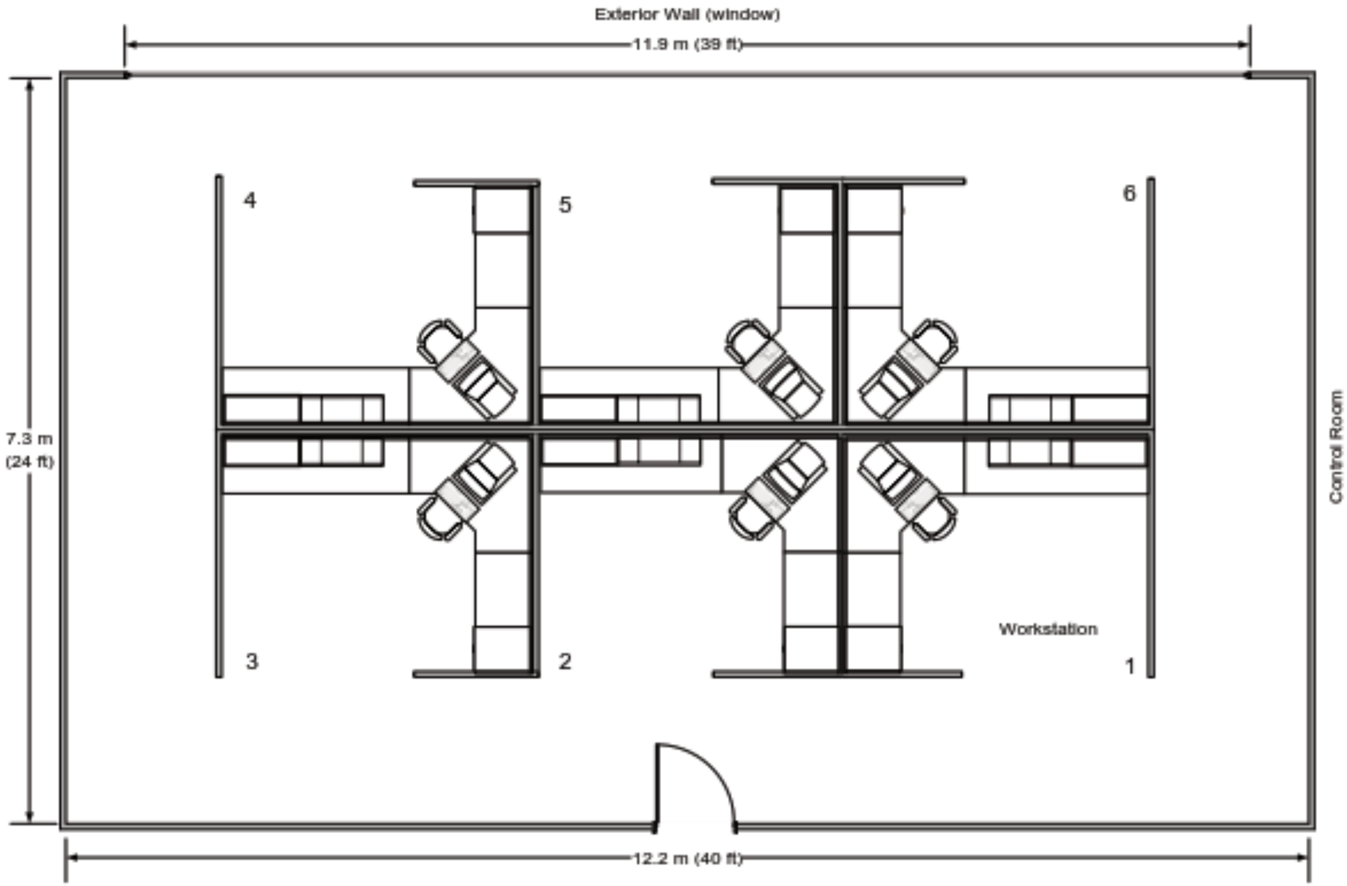
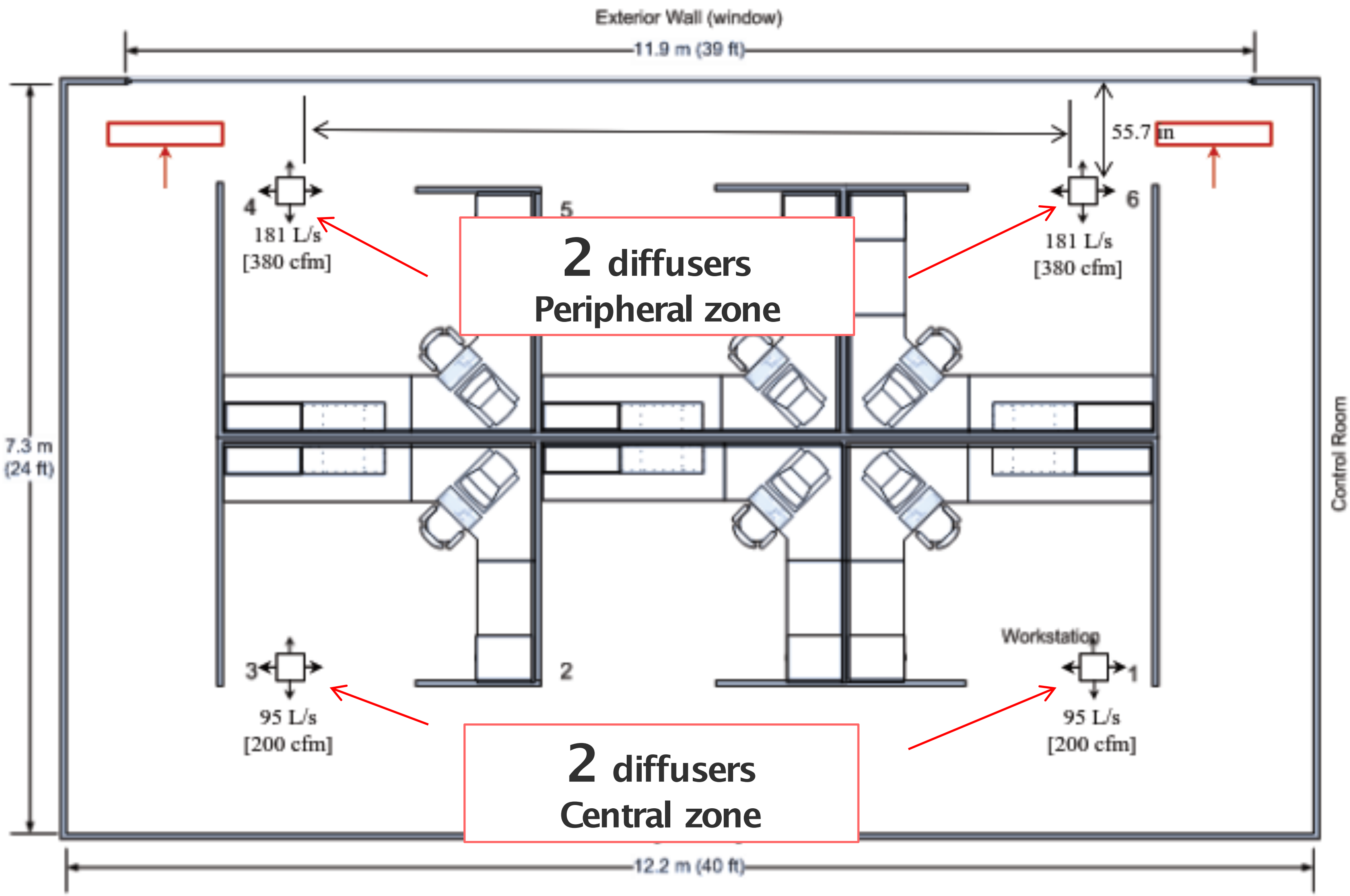


Figure 2: Plan view of the IERF test area.

Testing Conditions : diffusers location



Testing Conditions HVAC System

The facility has a dedicated air handling unit (AHU). The system is zoned (into the five zones) and has supply and return ducts in both the floor and ceiling plenums allowing air delivery/return from either high or low level. Each zone is equipped with re-heat. The system can be operated in variable air volume (VAV) or constant air volume (CAV) mode.

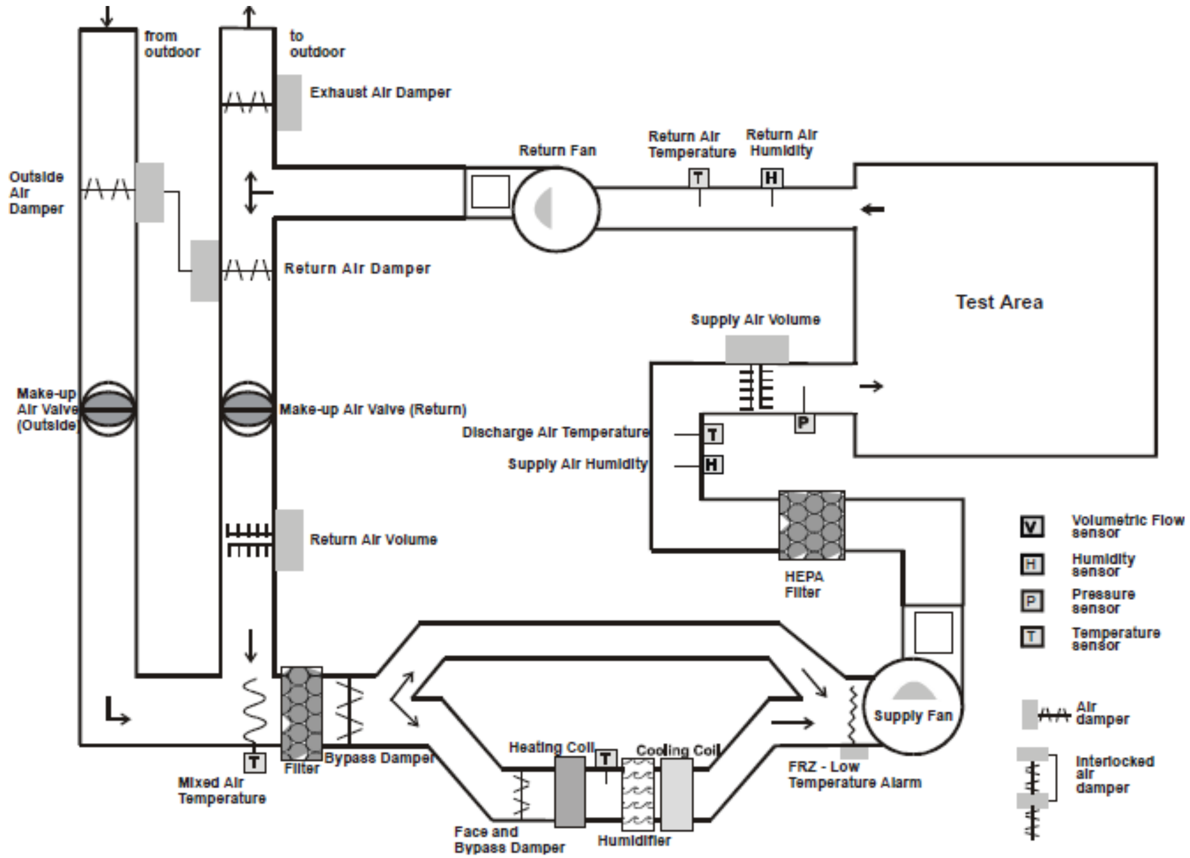


Figure 3: IERF HVAC system.

Testing Conditions : Automated tracer gas system

The NRC is **the only laboratory in Canada** that is equiped with a tracer gas system

Testing Conditions : data instruments

The measurements of air velocity, air temperature, relative humidity and SF_6 concentration were conducted in cubicles 1, 3, 4 and 6. Instruments were supported by poles with sensors attached to a sensor holder (cluster) as shown in Figure 14 and sensor holder was located on the pole at different heights above the floor.

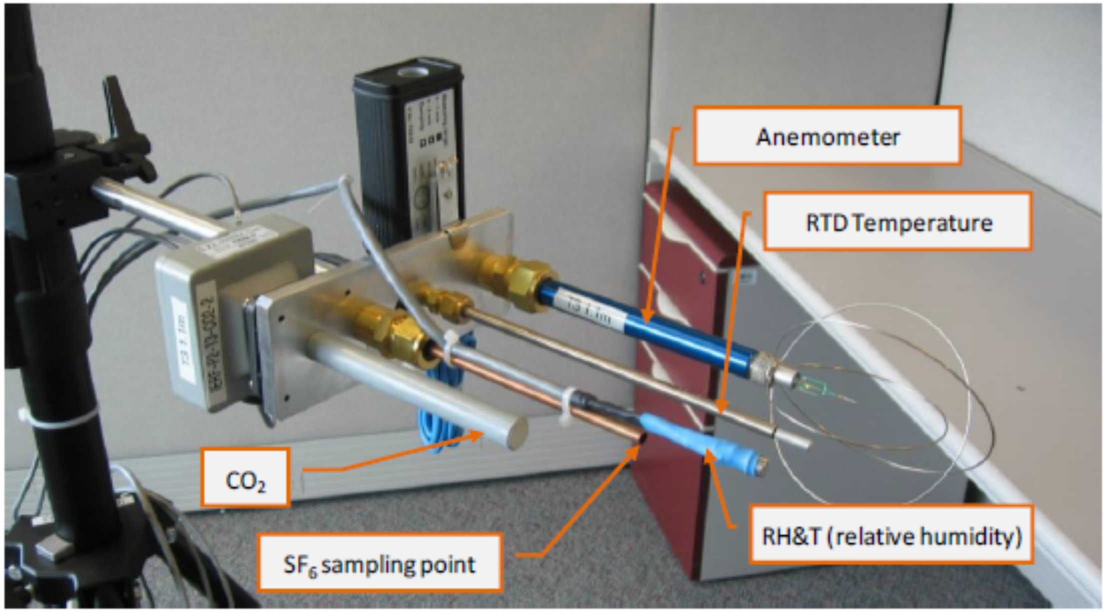


Figure 14: Sensor holder with sensors attached. A PVC pipe was attached to the back end of the copper pipe for SF_6 sampling.

Testing Conditions : location of instruments

Measurement poles were placed in selected workstations. The instruments were held vertically by a pole 0.6 m from the desk (measurement normal to the desk). Each pole supports anemometers, RTDs, RH sensors, anemometers and tracer gas sampling tubes. Measurement poles have been placed in workstations number 1, 3, 4 and 6 and close to exterior wall/window (cubicle 4 and 6 locations) as shown in Figure 12.

Figure 12: Measurement poles installed in a workstation (left) and at the exterior wall (window)

Testing diffusers

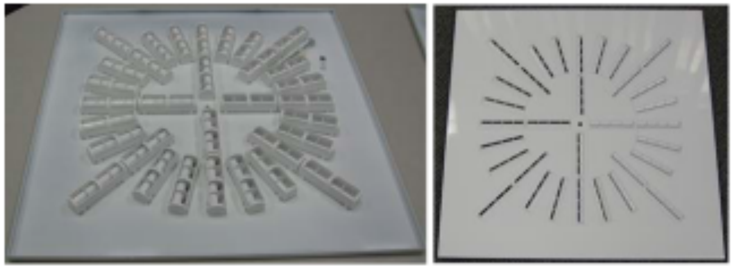


Figure 7: Diffuser DAL 358 DN500

Figure 8: Diffuser DAL 358 DN600

Figure 9: Diffuser DAL 359 DN500

Figure 10: Diffuser DAL 359 DN600

Figure 11: Conventional 6" square diffuser

Example of testing results

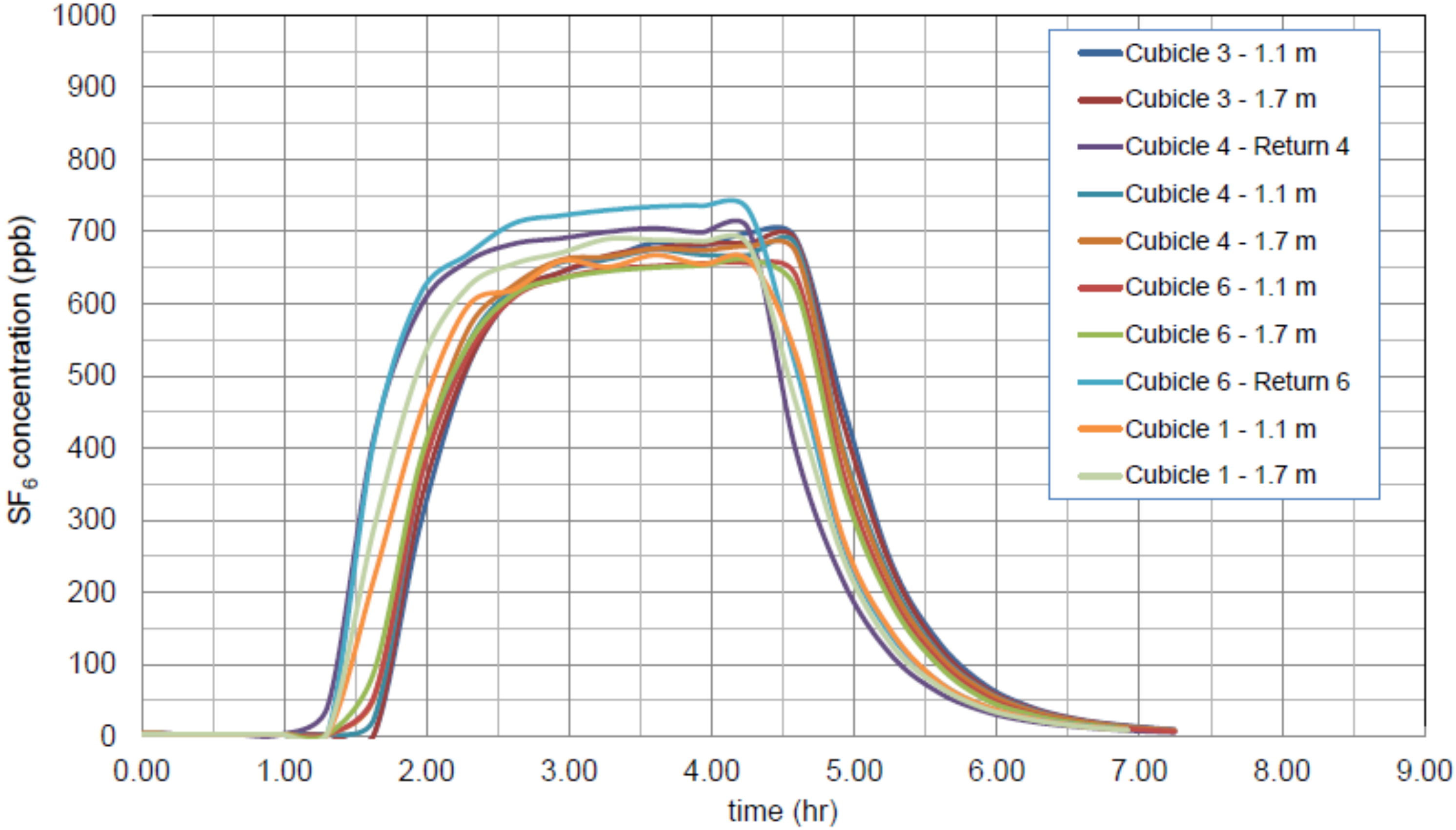
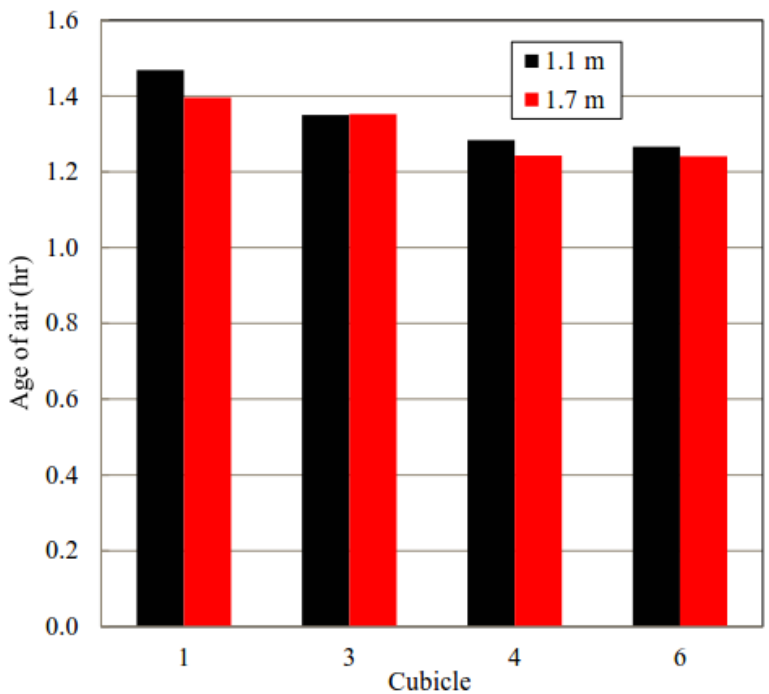


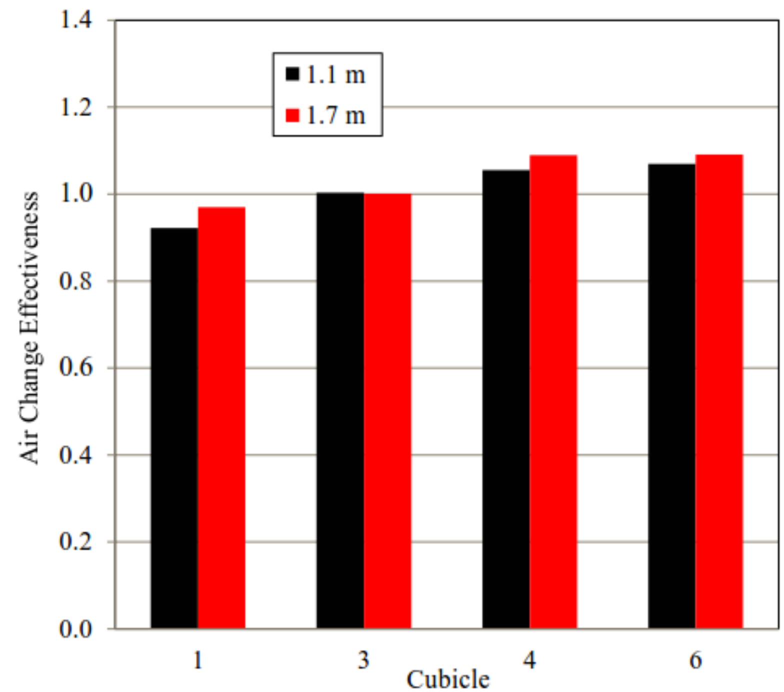
Figure 24: Example of tracer gas test results

Test results

NRC·CNRC

Age of Air & Air Change Effectiveness – DAL 358 March 29 (Night Time)





Final results

Table 12: Summary of measured ACE in the simulated office space

Case	**1**	**2**	**3**	**4**	**5**	**6**
Diffuser	DAL 359	DAL 359	DAL 359	DAL 358	Square Conv.	DAL 358
Number (type)	2 (DN600)	2 (DN500)	2 (DN500) 2 (DN 600)	2 (DN500) 2 (DN600)	4	2 (DN600)
Workstation	4 & 6	1 & 3	1 & 3 / 4 & 6	1 & 3 / 4 & 6	1 & 3 / 4 & 6	4 & 6
Minimum	0.92	0.88	0.91	0.92	0.68	0.97
Maximum	1.11	1.12	1.16	1.18	0.87	1.16
Mean	1.01	0.96	1.03	1.10	0.77	1.06
STDV	0.05	0.06	0.07	0.05	0.04	0.06

Conclusion

Executive Summary

This report details the experiments that were undertaken as part of the project A1-008251 on the air distribution effectiveness of overhead systems using high induction diffusers compared to a system using conventional square diffusers.

NAD Klima manufactures a new model of swirl diffuser DAL359 and DAL 358 equipped with off-centre drums (rollers). This technology is able at the same time, to diffuse air with high flow rate and with a low acoustic power, to produce any form of flow of air even after assembly, to vary the outlet velocity of the air and especially allows a better mixture between the primary air and the air of the room realized by a high induction immediately at exit of the slits.

Experiments were undertaken at the NRC Construction Indoor Environment Research Facility (IERF). The study investigated the ventilation effectiveness of overhead distributions systems using two types of high induction diffusers as indicated by the air distribution effectiveness. The assessment of the ventilation effectiveness required the use of tracer gas techniques.

This investigation evaluated the performance of two overhead systems using two swirl high induction diffusers; DAL 358 Swirl diffusers which is a high induction swirl airflow diffuser with square front plate and eccentric ABS cylinders and profiles controlling air stream, and DAL 359 which is a highly inductive swirl diffuser with a square front plate and fitted air control blades of ABS. The performance of the swirl diffusers was also compared to the air distribution performance of conventional square diffusers.

The study measured several aspects of the performance of overhead systems with the focus on the air change effectiveness. The measured air change effectiveness for the baseline (conventional square ceiling diffusers) was an average value of 0.77 (nominalized to 0.8), value reported in ASHRAE 62.1-2016 for overhead system in heating mode with ceiling supply of warm air (8°C or more above space temperature) and ceiling return. The measured ACE for overhead system using high induction diffusers DAL 359 was an average value of 1.03 (nominalized to 1.0), showing no need to increase of 25% the required rate of outdoor air supply. The measured ACE for overhead system with high induction diffusers DAL 358 was higher with an average value of 1.1 (nominalized to 1.1) showing not only that the increase of rate of outdoor air supply by 25% is not required but could be reduced by 9%. This means that when using DAL 358 diffusers, the rate of outdoor air supply could be reduced by 27%. Results obtained in this study provide evidence of improved air distribution effectiveness of overhead ventilation systems using swirl high induction diffusers.

The predicted thermal comfort, in terms of vertical air temperature difference and limit to air speed obtained for overhead systems using high induction diffusers under test conditions (in heating mode) were not different from those obtained for an overhead system using conventional square diffusers and were within the limit set by ASHRA 55-2013.

Example of application
1 Place Ville-Marie, Montreal

Number of levels
43

Area per level
36 000 ft. Ca.

Total area
1 548 000 ft. Ca.

Zone population
12 600

$$Vbz = Rp \cdot Pz + Ra \cdot Az$$

$$= 5 \text{ cfm /pers x } 12\,600 \text{ pers.} + 0{,}06 \text{ cfm/ft}^2 \text{ x } 1\,548\,000 \text{ ft}^2$$

$$= 155\,880 \text{ cfm}$$

Example of application
1 Place Ville-Marie, Montreal

Vbz = 155 880 cfm

$V_{oz} = V_{bz} / E_z$	Conventional diffusers	High induction diffuser DAL358
E_z (Air distribution effectiveness)	0,8	1,1
V_{oz} (Zone outdoor airflow)	192 150 cfm	139 745 cfm
Heating / Cooling costs	$2,8 / cfm	$2,8 / cfm
Humidifying costs	$2,4 / cfm	$2,4 / cfm
Dehumidifying costs	$0,8 / cfm	$0,8 / cfm
Annual cost (6$ x V_{oz})	$1 152 900	$838 470
Energy savings (%)	-	**27%**
Savings ($) / year	-	**$314 430**
Savings ($) / 5 years	-	**$1 572 150**

Annual savings with the DAL 358 according to ASHRAE 62.1

Simulation

Occupyrcy Category	Size (≈120 ft² /pers)	cfm/pers.	cfm/ft²	Standard diffuser E_z=0.8 Costs ≈ 30$	Diffuser DAL 358 E_z=1.1 Costs ≈ DN 600 : 219$ DN 500 : 164$	Savings generated/year/diffuser	Payback NAD
Office (2 persons)	15x16 240 ft²	5 cfm/pers= 10 cfm	0.06 240x0.06= 14.4 cfm	24.4 cfm ÷ 0.8 = 30.5 cfm O/A	24.4 cfm ÷ 1.1 = 22.2 cfm O/A	8.3 cfm x *6$ = Savings of 50$/diffuseur	219$ ÷ 50$ = **4.4 years**
Pharmacy (20 persons)	100 x 100 10 000 ft²	5 cfm/pers= 100 cfm	0.18 10000x0.18= 1 800 cfm	1 900 cfm ÷ 0.8 = 2 375 cfm O/A	1 900 cfm ÷ 1.1 = 1 727 cfm O/A	648.6 cfm x *6$ = Savings of 3 888$/yr DAL358 DN 600=400 cfm 10 000ft²÷400 cfm= 25 3 888 $/yr÷25 diffusers= 155.52$ / diffusers	219$ ÷ 155.5$ = **1.4 years**
Librairy Université Sherbrooke Faculté de Droit (88 persons)	34 000 ft²	1 pers/400 ft² = 88 pers. 5 cfm/pers= 440 cfm	0.12 34000x0.12= 4 080 cfm	4 520 cfm ÷ 0.8 = 5 650 cfm O/A	4 520 cfm ÷ 1.1 = 4 109 cfm O/A	1 541 cfm x *6$ = Savings of 9 246$/yr DAL358 DN 500=280 cfm 34 000 ft²÷280 cfm= 121 9 246$/yr÷121 diffusers= 76 $ / diffusers	164$ ÷ 76$ = **2.2 years**
Store Ex : Bouclair (20 persons)	6 000 ft²	7.5 cfm/pers= 150 cfm	0.12 6 000x0.12= 720 cfm	870 cfm ÷ 0.8 = 1 087.5 cfm O/A	870 cfm ÷ 1.1 = 790.9 cfm O/A	296.6 cfm x *6$ = Savings of 1 779.6$/yr DAL358 DN 600=400 cfm 6 000 ft²÷400 cfm= 15 1779.6$/yr÷15 diffusers= 118.6 $ / diffusers	219$ ÷ 118.6$ = **1.8 years**
Nail salon (10 persons)	2 000 ft²	20 cfm/pers= 200 cfm	0.12 2 000x0.12= 240 cfm	440 cfm ÷ 0.8 = 550 cfm O/A	440 cfm ÷ 1.1 = 400 cfm O/A	150 cfm x *6$ = Savings of 900$/yr DAL358 DN 500=280 cfm 2 000 ft²÷280 cfm= 7 900$/yr÷7 diffusers= 128.6 $ / diffusers	164$ ÷ 128.6$ **=1.3 years**
Pet shop (10 persons)	5 000 ft²	7.5 cfm/pers= 75 cfm	0.18 5 000x0.12= 600 cfm	675 cfm ÷ 0.8 = 843.7 cfm O/A	675 cfm ÷ 1.1 = 613.7 cfm O/A	230 cfm x *6$ = Savings of 1 380$/yr DAL358 DN 500=280 cfm 5 000 ft²÷280 cfm= 18 1 380$/yr÷18 diffusers= 76.7 $ / diffusers	164$ ÷ 76.7$ = **2.1 years**
Gym Ex : Complexe Thibault (40'x100') (20 persons)	4 000 ft²	20 cfm/pers = 400 cfm	0.06 4 000x0.06= 240 cfm	640 cfm ÷ 0.8 = 800 cfm O/A	640 cfm ÷ 1.1 = 582 cfm O/A	218 cfm x *6$ = Savings of 1 308$/yr DAL358 DN 600=400 cfm	219$ ÷ 131$ = **1.8 years**