

TUBE DIFFUSION OF AIR WITH HIGH INDUCTION NAD Tube



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SUMMARY

If the 21st century represents a new challenge for the control of technologies, the climate changes represent today a major stake as well with the regional scales as world. The high cost and the lack of energy encourage us to find alternatives to reduce in a considerable way consumption of this energy and consequently, to decrease the gas emissions with greenhouse effect which constitute the leading cause of the climate change and the deterioration of the quality of the air.

To control the quality of the air becomes an increasingly difficult spot for the conceptors of building, in particular industrial buildings, in order to ensure a comfortable work environment. The current systems of heating and air-conditioning of the buildings of great volumes often pose the problem of the homogeneity of the air.

In order to answer these requirements, NADKlima developed a new model of tube of air diffuser of the type **NAD Tube**.

With the **NAD Tube**, the problem of homogeneity of the air is controlled. Indeed, the multitudes of perforations and their positioning on the **NAD Tube** allow diffusing the fresh air of outside without heating it. The air jets obtained will enter in the mass of ambient air at very high speed by moving around them a great quantity of ambient air. That causes turbulences which favorise heat exchange between the two masses of air at different temperature. Heat exchange between supply air and ambient air is done then near the **NAD Tube** and the temperatures are quickly close to isotherm. That then makes it possible to move masses of isotherms air thus eliminating the risk of stratification.

The **NAD Tube** which is distinguished compared to the other tubes of dispersion of air, by the single positioning of the perforations, allows obtaining a better thermal comfort. Lightness and the resistance of the **NAD Tube**, offers the ideal solution and economic to any configuration of the buildings.

In this report, it is detailed operation, dimensions, the various modes of flow, characteristics and the fields of application of the **NAD Tube**. A comparative study with a standard ventilation system is carried out and which allow arising the performances of the **NAD Tube**, following of the economies generated by the **NAD Tube**.

Recently, the firm of engineering FORMATRIX 67 obtained the title **Lauréat 2008** of the contest **Énergia, 19th edition** for the use of the **NAD Tube** to ventilate the factory of Camoplast Richmond.

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INTRODUCTION

The comfort and the quality of air in the buildings of great volume or receiving from the public are two major objectives of the installations of treatment of air. The control of the processing atmospheres or the environments becomes a priority for a growing number of industrial sectors. Whatever the field of application, it is paramount correctly to distribute and diffuse the air in these buildings.

The experiment of NADKlima in ventilation with that of group DANCO, leader in the field of balancing and cleansing of the ventilation systems, allowed to develop a new model of air diffuser of the single type **NAD Tube** by the site of these perforations. **The NAD Tube directly uses the fresh air of outside without heating it** or with a weak heating. The performances of the **NAD Tube** allow a very effective ventilation of air diffusion which ensures comfort of the occupants, homogeneity of the temperatures in the room and without creating a feeling of draught even with conditions of temperature of outside air which can go until -15°C .



Figure 1: Tube of air diffuser **NAD Tube**

1. GENERAL DESCRIPTION

The **NAD Tube** is an air diffuser with high induction manufactured of polyester impregnated PVC (Polyvinyl Chloride) entirely impermeable. The mechanism resting on the principle of rail, extreme flexibility and lightness of material PVC allow an extreme speed of the installation of the **NAD Tube**. It is applicable in all the cases of the buildings. Also, it is easy to dismount, transport and especially it is easy to wash by a simple swiffer.

1.1 Operation of the NAD Tube

The **NAD Tube** was conceived of such kind to exceed all the technical limits of the traditional systems of diffusion of air. Its operation is based on the basic principle of the diffusion of air with high induction. Perforations of various diameters and their positioning on the **NAD Tube** and which is distinguished compared to the traditional diffusers make that the air leaves the holes at high speed thus making it possible to produce an entrainment effect by moving around them a great quantity of mass of ambient air (see figure 2). The heat exchange between supply air and ambient air is done then near the **NAD Tube** and the temperatures are quickly close to isotherm. So the risk of stratification is eliminated without creating draughts in occupied zone.

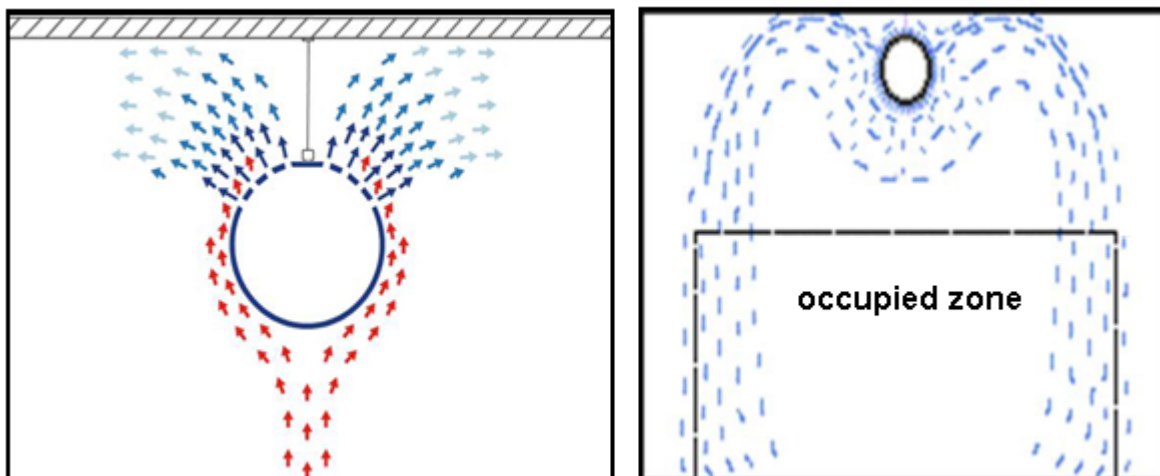


Figure 2: Representation of the effect of induction generated by the **NAD Tube**

1.2 Dimensions of the NAD Tube

Dimensions of the **NAD Tube** depend mainly on the type of application. Each application requires a boring and a positioning of the holes which make it possible to meet the needs specific for the room. The length and the diameter of the **NAD Tube** are selected according to the pulsated air flow. Application software of dimensioning was developed by NADKlima and allow to find a solution for each problem of ventilation and to response the requirements of each customer.

1.3 Assembly of the NAD Tube

The lightness of material PVC and the mechanism of support allow the faster installation of the **NAD Tube**. The installation consists of a rail which must be suspended with the ceiling using stems. These stems are threaded in order to make it possible to adjust the height of the rails according to dimensions of the room. Once the rail installed, the tube is then slipped into the rail. To note that the distance between two hanger rods is 10 feet (3.048 meters) as illustrated on figure 3.

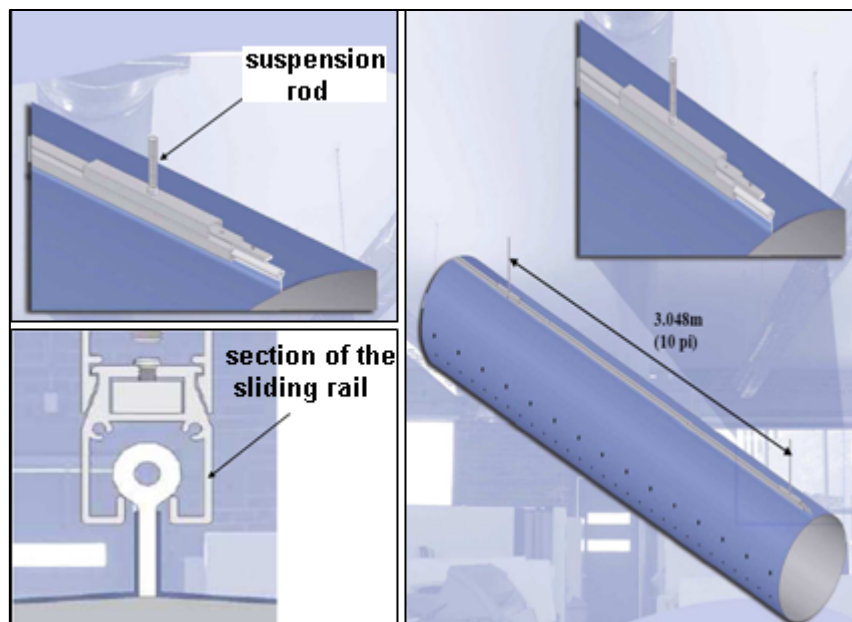


Figure 3: Stages of assembly of **NAD Tube**

1.4 Modes of flow

The capacity which the **NAD Tube** has to integrate all the techniques of diffusion and its facility to distribute and diffuse the air everywhere, in the most homogeneous possible way, fact that the thermal stresses or dimensions (height, surface, volume of the room) are solved and objectives of air treatment (comfort, absorption of the thermal loads, destratification for the heating of the buildings with great height) are reached.

The **NAD Tube** offers a multitude of mode of air diffusion owing to the positioning and to dimensions of the perforations. Each **NAD Tube** manufactured reached a very high performance levels adapted to the environment and the customer requirements. Using our software, a precise analysis is carried out compiling the data of the project (area to be treated, mode of climatic treatment, objectives of comfort or uniformity required) and which allows choosing a precise mode of air diffusion.

For example, in the case of a room with great volume with a high thermal contribution due to the process and requirements raised in terms of comfort and homogeneity, the **NAD Tube** comes with micro-perforations. This technique allow to create a very strong induction between the primary air (supply air) with the hot air of the room on a level of power and of effectiveness much larger than the traditional diffusers.

So, even the most complex needs for air-conditioning are treated with a remarkable and unequalled effectiveness (see figure 4).

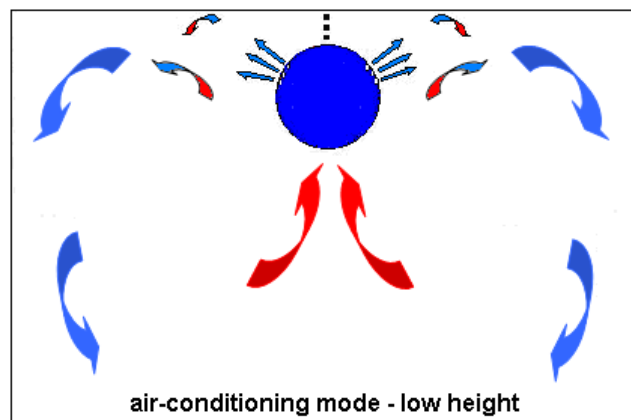


Figure 4: **NAD Tube** in air-conditioning mode. Case of a room with high thermal contributions

1.5 Characteristics of the NAD Tube

- 1.3 Very quiet whatever the pulsated air flow
- 1.4 Economic
- 1.5 Great range of diffusion
- 1.6 Function in heating mode and / or in air-conditioning (*cooling*)
- 1.7 Condense little
- 1.8 Esthetics by the variety of the colours
- 1.9 Hygienic, a healthier ambient air
- 1.10 Weak weight, easy to transport
- 1.11 Assembly very easily and in little time
- 1.12 Unequalled lifespan
- 1.13 Improve the work condition
- 1.14 100% recyclable

1.6 Ranges of application of the NAD Tube

The NAD Tube is conceived to measure and is adapted to each type of treatment of air and to the characteristics of the room (length, height, width, thermal contributions, occupations, etc). It is applicable in all the buildings of low, average and great volume whatever the type of process. Among the sectors concerned, we find:

- 1.7 Manufacturing Sector
- 1.8 Agro-alimentary Sector
- 1.9 Sector of drug company
- 1.10 Sector of manufacture of electronic products
- 1.11 Clean rooms: production zones or of conditioning of product
- 1.12 Shopping malls, Large surfaces
- 1.13 Areas of storage
- 1.14 Rooms of theatre, spectacles, ...
- 1.15 Sports Complexes: arenas, swimming pools, gaming rooms,...

2. PERFORMANCES OF THE NAD Tube

The requirements of thermal comfort in the industrial buildings depend directly on the ventilation and treatment of air. However, knowledge to control them rests primarily on the effectiveness of the ventilation system. Nevertheless, traditional systems of air diffusion used currently, often consisted of steel grids integrated in sheet conduits coated, are very limited in effectiveness of the diffusion and comfort of the occupants: draughts, noise levels raised, stratification, defective hygiene, are the recurring and less and less accepted complaints.

Other systems of air diffusion using the conduits in textiles called “textile sheaths” are used to diffuse air. This type of sheath is used in more of the Asian countries, precisely in China. Some companies engaged in manufacture and marketing to North America of this type of textile sheath. However, the quality of these sheaths and reflected them on the sedentary level, hygienic and performance of the product remain far from beings reached, and were not the subject of a thorough study.

For this purpose, NADKlima set up the **NAD Tube** which allows a better diffusion of air. In order to arise the performances of the **NAD Tube**, several points will be approached describing in details the advantages of the **NAD Tube** compared to the textile sheaths.

To conclude this part, a comparison was carried out to consider energy saving generated, following the replacement in our factory of the old system of air diffusion by the **NAD Tube**.

2.1 DURABILITY

The durability of a product generally depends on quality of its material. Other external factors such as the moisture ratio and the requests of use can influence the lifespan of the product largely. In the case of textile sheaths, the perforations (holes), all the same diameter, making it possible to diffuse the air, resists little the pressure of the air which practically limit are use.

Indeed, the pressure in the sheath often high are equivalent a speed of blowing air going to 2000 feet per minute (10 m/s), this pressure exerts a very important force on the contour of the holes. So, after a period of utilisation of these textile sheaths (often does not exceed a year), tearings are observed on the perimeter of the holes. Consequently, textile fibres are detached thus reducing the output from the sheath and supporting the formation of dust, and which becomes with time, a source vulnerable to inflammability as illustrated on figure 5.

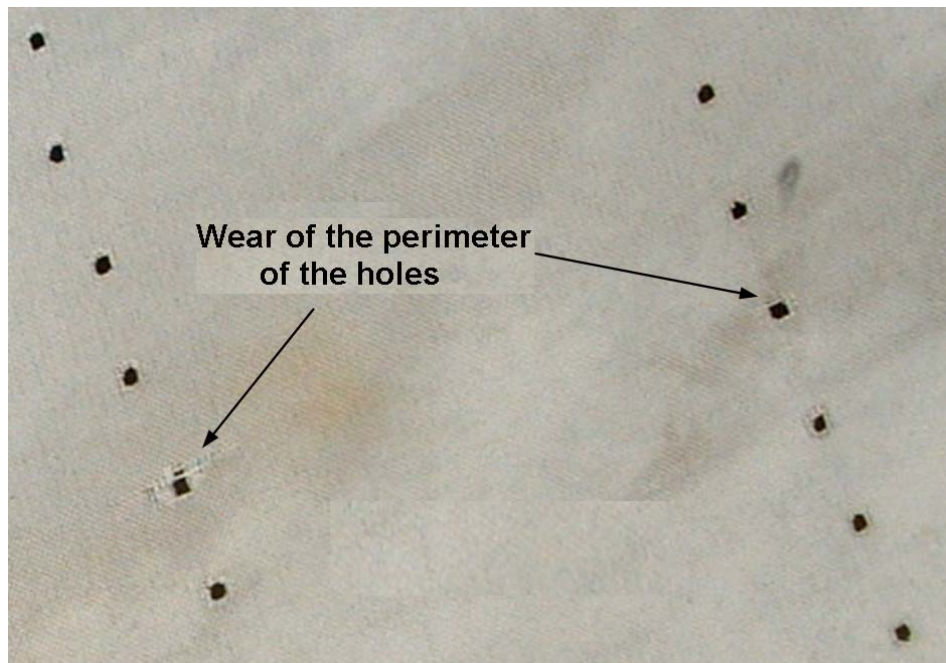


Figure 5: Wear of the perimeter of the holes of the textile sheaths

The characteristic of the **NAD Tube** consists of its material which is made of PVC. The PVC is an inert resin which combines excellent qualities of thermo isolation and acoustics. Its durability is almost unlimited, unlike other materials, PVC is remarkably stable, resists to the strong pressures and insensitive with the climatic aggressions (see figure 6).



Figure 6: Excellent resistance of the **NAD Tube**

2.2 DEGREE OF CLOGGING

Effective ventilation requires a continuous renewal of the air of the room by the primary air. In order to control this ventilation, the primary air must be filtered to eliminate all the impurities present in the air. In the case of textile sheaths, their porosity is used at the same time to filter the air, and to diffuse it through all the surface of fabric. However, this method is not very advantageous and which becomes after a short period of use, a very important source of contaminant.

The primary air, often made up of mixture of fresh air and air of return, is diffused through fabric. Thus, the particles of dust selected accumulate on all the internal surface of the sheath. Consequently, we obtain a very high clogging rate, supporting at the same time the obstruction of the bypass section of the air (reduction of the air flow) and the contamination of this one. Moreover, the textile sheaths does not offer any means to eliminate clogging formed inside and which requires frequent washings with sometimes a difficult access (Swimming pool, Theatre, factory, etc).

Also, the clogging of the textile tubes will be able to decrease the total volume of air and consequently made increase the static pressure in the sheath. If the porous textile tubes are not maintained in time, it results an insufficient quantity of air for the units of air-conditioning and heating.

Note: for a flow rate of less than 300 PCM/Tonne of air-conditioning, the units standards are strongly likely to make freeze the serpentines of evaporation and to avoid the evaporation of the liquids. Consequently, it generates breakings of the compressor knowing that a compressor is dimensioned to function with gas and non liquids.

The **NAD Tube** is the ideal solution with this kind of situation. It's made perfectly tight PVC fabric is the choice which offers a better diffusion of the air. Interior surface smoothes **NAD Tube** does not allow or little the accumulation of the particles of dust. So, a minimal filtration upstream will be enough to guarantee a hygienic air diffusion and stable throughout its use.

2.3 MAINTENANCE

Installations of the aeraulic system, in particular sheaths of diffusion of air, must designed beings, because of their operation uninterrupted, of such kind so that their maintenance is made as soon as possible and with the lower costs. These requirements depend primarily on the quality of material of these sheaths and on their degree of absorption of dust.

The various sources of dust generated in a room find refuge on any surface, in particular on that of the sheath of diffusion of air. The porosity of the textile sheath largely supports the accumulation of this dust on all its external surface. That results in a fast deterioration of the sheath, often very difficult to maintain, and thus requiring its replacement. Figure 7 shows the accumulation of dust on the external surface of the textile sheaths.



Figure 7: Accumulation of dust - textile sheaths

The **NAD Tube** is particularly adapted to diffuse the air. It's perfectly tight material is the best alternative, and which does not require practically any maintenance. The dust which accumulates in a workspace does not adhere on the **NAD Tube** owing to its external surface smoothes (PVC characteristic) as shown in the figure 8 below.



Figure 8: Clean external surface – **NAD Tube**

2.4 CLEANING

To carry out the regular cleaning of the ventilation system, it is to guarantee hygienic ventilation. However, time and the cost of cleaning depend on the quality of material of the ventilation system, more precisely, of that of the sheath of air diffusion.

In the case of textile sheaths, their cleaning requires their desinstallation. That results in an obligatory stopping of the ventilator. Consequently, to envisage as a preliminary a secondary ventilation system of replacement during the period of cleaning. Also, cleaning is done generally in quite precise places offering the service of washing of products of textile intended for the industrial sector. Lastly, it is necessary to add with all that, the labour necessary for the desinstallation and the installation, and the cost relied to transport.

This cycle of cleaning requires an important cost which increase the invoice of the budget intended for the system maintenance of air diffusion.

The performances of the **NAD Tube** made of fabric of PVC, allows reducing, even eliminating all the cleaning cycle which requires a textile sheath. Indeed, the smooth surface of the **NAD Tube** allows cleaning by a simple wet rag (swiffer), without stopping the ventilator, and within a very short time.

In what follows, we present applications of the **NAD Tube** for various situations of ventilation according to the configuration of the room.

2.5 APPLICATION IN HEATING AND AIR-CONDITIONING MODES

The heating of the space of a room represents nearly 70% of the expenditure according to ventilation. With the cost of the energy which increases, to find a solution to reduce the consumption of energy became a priority. Measurements making it possible to reduce this consumption were applied to the room, such as the effective insulation of the walls, the use of the furnaces which consume less gas... etc. However, these measurements remain insufficient and do not take into account the most important factor which is the diffusion of air (inadequate ventilation of space through the steel grids).

The characteristic of the **NAD Tube** consists in diffusing the air according to the configuration of the room. Indeed, for the buildings with high height ($H > 4$ meters), the **NAD Tube** is bored to diffused the air downwards according to an angle compared to the horizontal similar to a schedule of 3:20 and 9:40, and that for the two modes of ventilation, the heating and air-conditioning. Thus, in the case of the mode heating, the air is directed to the bottom in order to overcoming the forces of gravity related to the densities different from the supply hot air with the air of the room. So a great mass of air is involved allowing to have a soft and controlled circulation from the top to the bottom of the room for an optimal mixture on all the space occupied with very low variations of the temperature not exceeding 1°C as illustrated on figure 9.

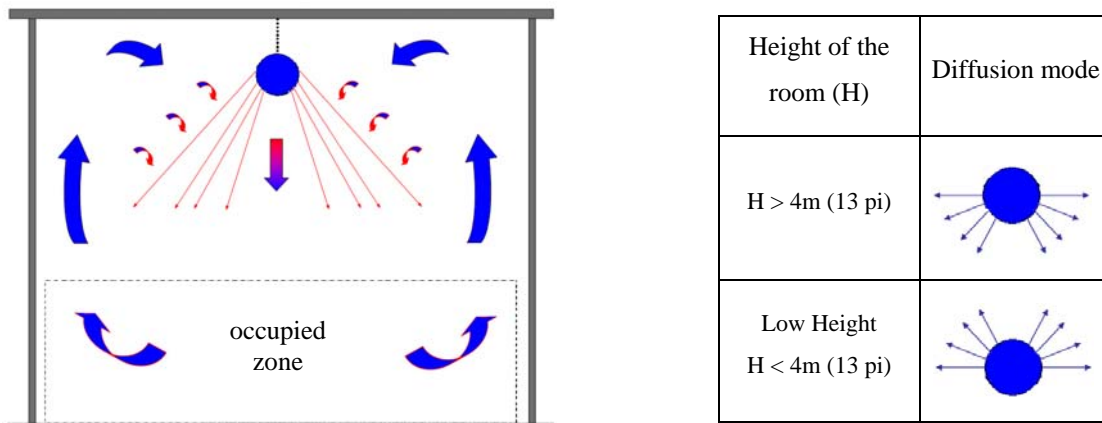


Figure 9: Diffusion of air in heating mode – **NAD Tube**

For the buildings with low height ($H < 4$ meters), the air is pulsed through the **NAD Tube** to the top similar to a schedule of 9:30 and 2:30 (see figure 10). Thus, for an air-conditioning mode, the multitude of the perforations with various diameters allows pulsed air at high-speed to the top which more quickly will mix with the hot air of the room often accumulated with the level of the roof. The mixture of fresh air obtained follows a circular course covering all the width of the room owing, to the high induction generated by the **NAD Tube**, and with the increase of the hot air due to the depression created under the **NAD Tube**.

The same phenomenon, contrary to the temperatures, is observed for the heating. The circulation of air obtained is perfectly controlled with a very homogeneous temperature and speeds in all the volume of the room. The performances of the **NAD Tube** with high induction allow to easily treating needs in air-conditioning or for heating by ventilation, and to provide an ideal comfort even with important variations in temperature between the primary air and that of the room. That results in a better productivity of the workers.

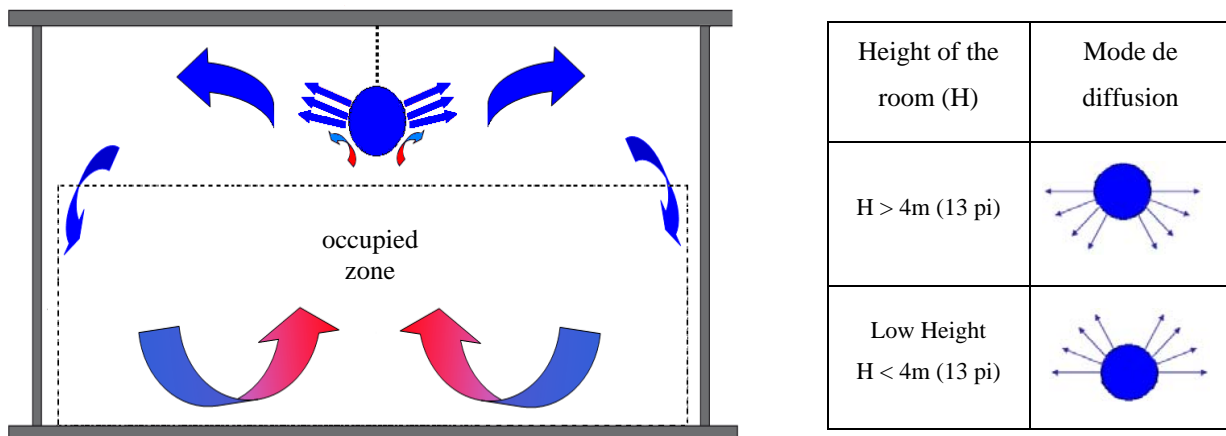


Figure 10: Diffusion of air in air-conditioning mode - **NAD Tube**

In order to arise the performances in term of energy efficiency of the **NAD Tube**, a comparison was carried out with a traditional system of air diffusion made up of coated steel grids integrated in sheet conduits.

3. ECONOMIES GENERATED BY THE **NAD Tube**

For reasons of availability of information, the comparison was carried out between the old system of air diffusion of the factory of company WESCO DISTRIBUTION CANADA Inc and its replacement by the **NAD Tube** during the resumption of this factory by NAD Klima dated September 1, 2008. This comparison relates to the savings in cost of installation and energy saving.

3.1 SAVING IN COST OF INSTALLATION

The quantity of material used, the time of installation allocated and the cost of the labour represents major expenditure in order to set up a system of diffuser of air. In the case of our factory, the old system of air diffusion consisted of steel grids integrated in conduits of sheet coated length of 30 feet (9 meters) with horizontal jet and two unit heaters with gas. The heating of the air was done via a power station (furnace) with natural gas of a power of 500.000 Btu/h with 4000 cfm (6796 m³) for a surface of 8800 square feet (820 square meters). The installation of this system including the labour cost approximately 6000\$.

During the resumption of the factory by NAD Klima, we kept the same power station with gas and process with the replacement of the system of diffusion of air by the installation of the **NAD Tube**. The facility of the installation (see the section assembly of the **NAD Tube**) and the low price of PVC cost only 1000\$ its installation. That represents economies of about 83% on the cost of installation.

Also, the installation of the **NAD Tube** which generates a high induction owing to the judicious positioning of the holes of various diameters allowed to eliminate all the ventilators from ceiling (six ventilators in total) and which were used for the circulation of air diffused through the grids.

3.2 ENERGY SAVING

The energy saving generated by the **NAD Tube** at the time of its installation in our factory is summarized in two parts: energy saving on the recovery of internal heat and energy saving on the destratification of the air.

3.2.1 ENERGY SAVING ON THE RECOVERY OF INTERNAL HEAT

Any space occupied requires a ventilation adequate and in conformity with the standards. This ventilation is possible if the ventilation system set up is effective. However, to introduce a fresh air in the room depends more precisely on the external conditions and the internal contributions of heat (heat released by the machines, lighting, by the personnel...).

During the occupation of the factory by former owner (WESCO), in winter season, the air was heated by the power station with natural gas. This air is then pulsated in the room by the system of air diffusion explained previously. Being given the resumption of the factory by NADKlima was done dated September 1, 2008 and that the year 2008-2009 is not completed yet, we limit in the present comparison at the period going of September 1, 2007 to April 15, 2008 corresponding to the consumption of gas of the old heating system.

Based on the Gas M tro invoice, the consumption of gas lasting this period was of approximately 16 232.38 m³. In order to determine in a more precise way needs for heating during this period, we use the method of the degree-days of heating (DJC) corresponding to the area of Sherbrooke. These data are available on internet site of Environment Canada. This method is often used by the firms of engineering and which consists in determining the relationship between the volume of consumed gas and the DJC during a defined period of the year.

According to the data of Environment Canada, the DJC for the area of Sherbrooke corresponding to the period of September 1, 2007 to April 15, 2008 are approximately 4327.2 DJC. Consequently, the natural gas consumption during this period rises with 3.75 m³/DJC.

For the same period of the following year: from September 1, 2008 to April 15, 2009, the natural gas consumption to heat the air of the factory and diffusing it through the NAD Tube is of $10\,925.48\text{ m}^3$. The DJC for this period are about 4461.6 DJC. A natural gas consumption of $2.44\text{ m}^3/\text{DJC}$ is thus obtained.

If we study closely this situation, we notices that even if currently there are any contribution of internal heat in the factory, with a colder winter climate this year compared to the previous year (according to the DJC), **the use of the NAD Tube allow energy saving of about 35%.**

In the case of its application in a room where the contributions of internal heat are raised, that will allow energy saving much more important. More the contributions of internal heat are higher, more the NAD Tube is powerful (see figure 11).

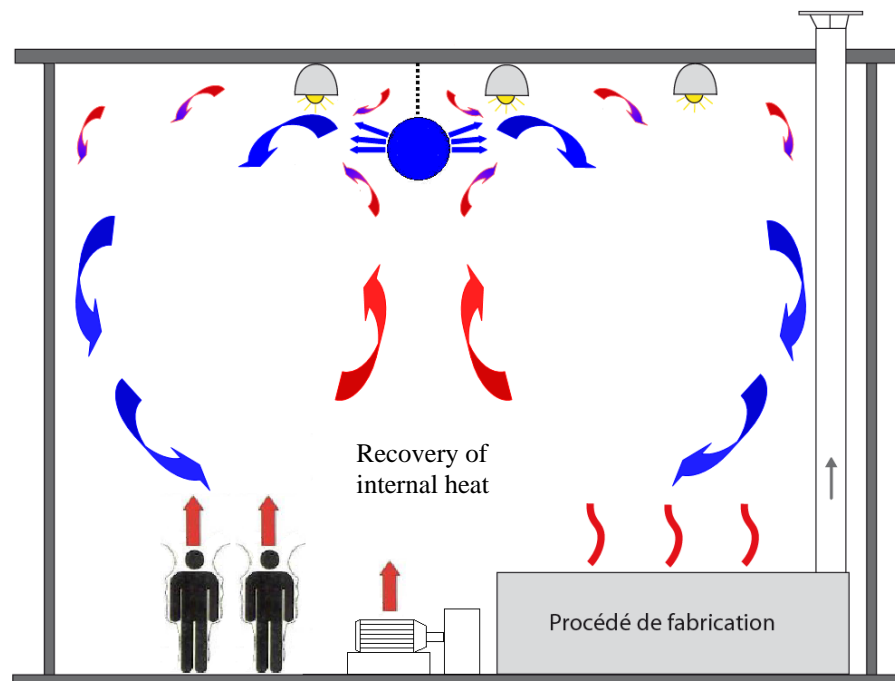


Figure 11: Representation of the recovery of internal heat by the **NAD Tube**

3.2.2 ENERGY SAVING ON THE DESTRATIFICATION OF THE AIR

The phenomenon of stratification of the air generally occurs in heating mode. The hot air pulsated in the room through the traditional system slightly reaches occupied space. Consequently, the influence of the forces of gravity related to the densities different from the hot air pulsated with the cold air of the room, create an important mass of hot air which remains stuck to the level of the roof. In the majority of the cases, the roof of the buildings with high height represents the greatest loss of heat. What supports losses increased through outside.

In the case of our factory, the low level of induction of the steel grids makes that most of the pulsated hot air remains stuck to the ceiling at a temperature of approximately 30°C. So the heat transfer with the outside air in winter average temperature of -10°C is done with a variation of 40°C as illustrated on figure 12.

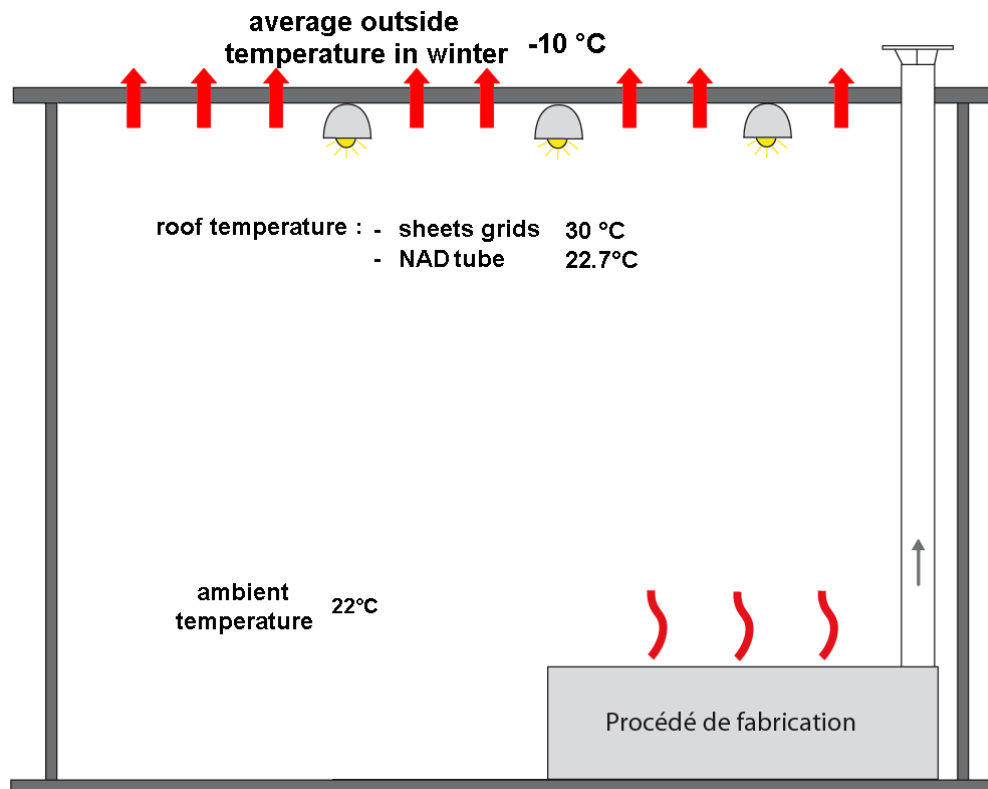


Figure 12: Representation of heat losses

After the replacement of the traditional system by the **NAD Tube**, the problem of stratification of the hot air was eliminated. The temperature of the air of 22.7°C on the level of the roof is practically the same that the room temperature. That results in energy saving of about 19%.

In term of cost (see appendix A for the details of calculation), for an operation of the 14 hour per day during all the wintry time estimated at 6 months, with an inadequate insulation of the roof of a thermal resistance of R8 and a surface of the roof of 8800 pi², we obtain, in the case of the use of the old system, expenditure about 5557\$/year at a cost of the natural gas energy of 9.5 cent\$/kWh.

The replacement of the old system by the **NAD Tube allowed, on only this parameter, economies of about 1015 \$/an**. The extension on the whole of the buildings through the province of Quebec will allow saving in enormous quantity of energy.

These performances rest on the technique of air diffusion with the **NAD Tube**. Precisely, the technique consists in diffusing a great quantity of micro-jets air, through the holes (perforations). Positioning and the various holes diameter of the **NAD Tube** which is distinguished compared to the traditional system, fact that each micro-jet air induced around him a quantity of ambient air by the principle of Venturi. The flow air induced increase with the speed of the jet and the total volume of air moved becomes even larger. This phenomenon is called **high induction**.

In other terms, induction is obtained according to perimeter of the air jets. More the outlet area of air is distributed by small holes, more there is induction around the air jet. The size and the distance between the holes largely influence velocities of air in the distance. Software must be used to calculate and in order to determine velocities of air.

TOTAL OF THE ECONOMIES GENERATED BY THE **NAD Tube**

The total of the economies generated by the **NAD Tube** is summarized in the form of the table presented below. To show the performances of the **NAD Tube**, we carried out a comparison of the old ventilation system used by WESCO compared to the DJC corresponding to the year 2008-2009. That will enable to determine the economies generated for the same DJC.

	Year of use ¹			Economies generated
	2007-2008	2008-2009	2008-2009	
	Degrees heating day (DJC)			
	3605.5	3878	3878	
	WESCO	WESCO	NAD Tube	
Gas consumption (in m ³)	16 232.38	16 736.55 ²	10 925.48	5 811
Total costs in dollars \$CND/year ³	9 790	11 414	7 161	4 253

¹ For the period of September 1 to April 15 of each year

² Consumption by WESCO if used during the year 2008-2009

³ Average rate of 59.96 cent/m³ for the year 2007-2008, Average rate of 68.2 cent/m³ for the year 2008-2009

GENERAL CONCLUSION

The ventilation of the buildings of great volume or receiving from the public always aroused the interest of the specialists in mechanics in building. The quality of the air and the comfort of the occupants are requirements major to which the choice of a system of air diffusion represents an important spot.

At the present time, the majority of the buildings of great volume, more precisely, the industrial buildings are equipped with traditional system of air diffusion made up of coated steel grids integrated in sheet conduits.

We showed in this report that the replacement of this system of air diffusion by the **NAD Tube** will allow economies at the same time on the cost of installation and the energy saving. The comparison to estimate these economies represents a minimum case, owing that no contribution of heat interns was considered.

The application of the **NAD Tube** in an occupied space generating of the contributions of internal heat will allow more important energy saving.

The comparison between the **NAD Tube** and the system of air diffusion of the type sheaths textile allowed arising all the advantages which the **NAD Tube** offers. The characteristic of polyester impregnated of PVC which is distinguished compared to the textile sheaths, emphasized the unequalled performances of the **NAD Tube** as regards durability, degree of clogging, maintenance and cleaning.

To conclude, the application of the **NAD Tube** in all the buildings of great volume through the province of Quebec will allow energy saving able to reach for the destratification of the air in commercial and industrial sectors of about 25% to 35%, and for the heating of the fresh air in industrial environment (where heat is released by the process) about 80% to 100% of economy.

We carried out several projects in Quebec, and which allowed all much appreciation for our product the **NAD Tube**. Energy saving to more than 50% was carried out with the **NAD Tube** in several places and improved largely the diffusion of air in occupied zone without creating of draught.

The effectiveness of the air diffusion by the **NAD Tube** allowed, with the support of confirmations of the persons in charge of these project management, to improve the performances of the employees and a significant drops of absenteeism.

To date, we believe that the **NAD Tube** is the most effective product in energy saving by taking account of the capital cost ratio versus saving energy ever caused, in addition to the largely improved parameters comfort in worn.

It becomes very advantageous to consider its installation in a maximum of trade and industry to achieve the objectives of savings in consumption of energy dependent on the warming of planet.

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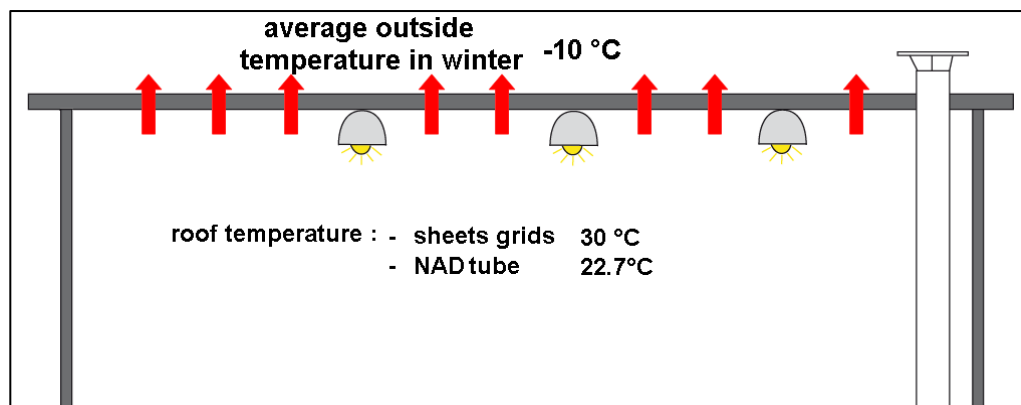
http://climate.weatheroffice.ec.gc.ca/climateData/dailydata_f.html

<http://www.xpair.com>

APPENDICES

APPENDICES A: DETAILS OF THE COSTS CALCULATION

The heat transfer with the outside air is represented in the following drawing:



In winter, the variation in temperature between the outside air and the room air in the level of the roof in the case of the traditional system of air diffusion is:

$$\Delta T = T_i - T_o = 30^{\circ}C - (-10^{\circ}C) = 40^{\circ}C$$

$$\Delta T = T_i - T_o = 86^{\circ}F - 14^{\circ}F = 72^{\circ}F$$

This variation is decreased in the case of the use of the **NAD Tube**:

$$\Delta T = 22.7^{\circ}C - (-10^{\circ}C) = 32.7^{\circ}C$$

$$\Delta T = 72.86^{\circ}F - 14^{\circ}F = 58.86^{\circ}F$$

We obtain a reduction of $\pm 19\%$ of the heat transfer.

To determine the economies in term of cost, the power (P) should be calculated corresponding to the heat losses by conduction. The relation to determine this power is: $P = U \cdot A \cdot \Delta T$

With: U: the total coefficient of heat transfer: $U = 1/R = 0.125 \text{ (hr-ft}^2\text{-F)/Btu}$

A: outside ceiling surface: 8800 pi^2 .

In the case of the traditional system: $P = 0.125 \cdot 8800 \cdot 72 = 79200 \text{ Btu} / h = 23211 \text{ Watts}$

In the case of the **NAD Tube**: $P = 0.125 \cdot 8800 \cdot 58.86 = 64746 \text{ Btu} / h = 18975 \text{ Watts}$

The difference of the powers gives:

$$\Delta P = 23211 - 18975 = 4236 \text{Watts}$$

In the majority of the buildings, more precisely factories, the system of air diffusion functions 24/24h. We limit in this comparison to the case of our factory with an operation of the system approximately 14 hours per days. The automatic control orders the stop of the system between 20:00 pm and 6:00 am.

By considering the period of the winter season of approximately 6 months, the operation per year will be thus:

$$(6\text{months/year}) \times (30\text{days/months}) \times (14\text{h/day}) = 2520 \text{ h/year}$$

So, the consumption in kWh per year will be:

$$4236\text{Watts} \times 2520\text{h/year} = 10675 \text{ kWh/year}$$

For an average costs of the thermal energy of 9.5 cent\$/KWh, we obtain economies of about **1015 \$/year** by the use of the **NAD Tube**.