verelec

Plasma Technology Radiators

technology under license CNRS centres national of scientific research

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VERELEC DOCUMENTATION

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RADIATOR

FIRST PLASMA TECHNOLOGY RADIATOR

This pitch is aimed at briefly going back over the specifications and advantages of plasma radiators, high-tech products under C.N.R.S. licence, by way of five criteria.

Energy saving

Plasma technology radiators require 60 to 90 watts of electricity per m2 compared to 80 to 120 watts per m2 for convection radiators.
The homogeneity of the temperature means the difference between the temperature desired and the temperature at the ceiling can be greatly reduced and in doing so, make substantial savings in energy.

I.E. : 20 % ENERGY SAVING

Before electrical heating was the least expensive heating system to install but the most expensive to run.
With its new long infrared radiation technology, the verelec radiator becomes one of the most cost-effective modes of heating amongst conventional heating.

- The convection is very low compared to other products on the market, only 45 %.
- Energy saving :
- Verelec requires 60 to 90 W/m² against 100 to 120 w/m² for our namesakes.
- For homogeneous heat in a room at 20°
  Namesakes: 17 to 18°C on the floor and 24°C at the ceiling
  Verelec: 17°C on the floor and 21°C at the ceiling
  The degrees at the ceiling are no good to anyone and are expensive. EDF's official website provides the following information:
  -1°C=7 % in real economy.
  Our 21°C at the ceiling (against 24°C) i.e. 3°C less (7 x 3 = 21°C) therefore represents savings of 21 %.
- The hike in fossil energy prices (fuel oil, gas) as well as the increase in the price of electricity can but acceler ate this difference in price in the future to the benefit of Verelec radiators.

Quality of heat & User comfort

The quality of heat emitted by plasma radiator is second-to-none.
Plasma radiators transmit 55 % of their electrical power by radiation whereas the most efficient of its namesakes on the market cap at 25 % radiation.
This long range radiation principle comes directly from heating people, objects, walls and the floor without having to heat the air. In physical terms, convection heats the air in a room whereas, like the sun, radiation emits infrared rays directly heating bodies and objects which subsequently become emitters themselves.

The surfaces thus heated re-emit radiation and contribute to the homogeneity of temperature. The air in the room is evenly heated and the thermal comfort is optimum.

This long wave infrared radiation principle is identical to that of the sun or those used by our body, it is therefore beneficial to it and provides a feeling of well-being in the form of gentle heat, greatly appreciated by all users.

- Natural heat identical to that emitted by the sun's rays
- Eliminates overheated ambient effects

As opposed to other technologies, the heating system is efficiently based on radiation

- No agitation of air, no dust, less allergies. Recommended for those suffering from asthma or allergies
- Cleanliness of product : requires the same maintenance as a conventional mirror
- No more black stains on walls
- Hygiene: no more mould from salpetre. Long wave infrared action of a range of 8 metres cleans out walls, ceilings and floors (expels humidity)
- No more unpleasant smells of damp in the bathroom and other damp rooms
- No variation in the moisture content

Eye-catching

Its sober lines making it eye-catching and also its compact size (4.5 cm thick) mean the plasma radiator can blend in perfectly with interiors.

By definition, a mirror reflects what surrounds it and can but be a tasteful addition to your home.

Verelec radiators can be mounted horizontally or vertically on your walls or even ceiling mounted.

Classed as IPX4, the most stringent level in terms of tightness to water and dust meaning they can be easily installed close to a source of water or in places prone to damp.

Finally, the highly appreciated absence of mist on the bathroom wall mirror means you can shave or put on make-up without any problems.

- Optimisation of space: heating and high end quality finish mirror all in one
- Compact: extra flat (4.5 cm thick)
- Modular and adaptable to all accessories on the market : thermo stat, programmer, switch, etc
- Easy to install: 2 hooks fixed to multi supports
- Modern, varied design suitable to all types of interiors.
- Personalisation of product.

Healthy

The long wave infrared action cleans out walls and ceilings (expels dampness). It therefore reduces the appearance of mould, germs, salpetre.

As opposed to the principle of typical radiators heating the air and therefore increasing the impurity of the ambient air by agitation, radiation reduces this making it recommended for those suffering from asthma or allergies.

- Hygiene : no more damp from saltpetre. The long wave infrared action of a range of 8 metres cleans out walls, ceilings and floors (expels humidity).

- No more unpleasant damp smells in the bathroom or other damp rooms.

Environment

In addition to the substantial energy savings provided by plasma radiators, a small quantity of raw materials is required to make them and they are easily 98 % recyclable.

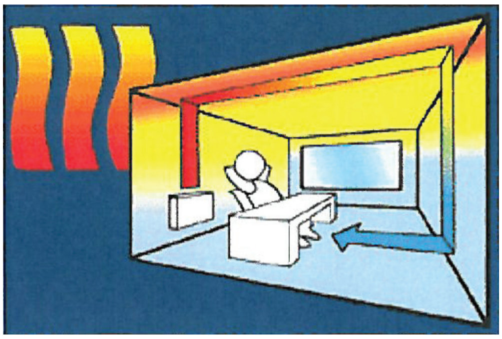
Of all electric radiators, plasma radiators are those that are the most environmental friendly.

- No toxic or polluting emissions
- Significant energy savings
- No CO_2 emissions, protects the ozone layer
- 98 % recyclable with very little raw materials con sumed.

RADIATION

MAJOR HEATING MODES

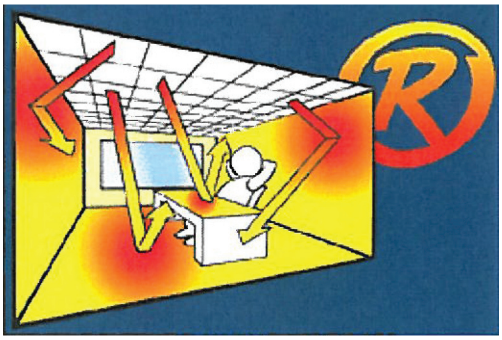
Convection



Transfer of thermal energy using moving air as transfer fluid between the heating system and the persons to be heated. The air temperature is always greater than the temperature of the walls of the room heated.

Air T° > wall T°

Radiation



Transfer of thermal energy using infrared waves as a transfer vector between the heating system and the rooms and/ or persons to be heated.
The air temperature is always lower than the temperature of the walls of the room heated. This process can be used in the residential, tertiary and industrial sectors indifferently.

RADIATION

Exchange parameters

The thermal exchanges by radiation are related to :

- the power of the source
- the exchange surface
- the distance between the emitter and the receiver

Basic principle

Two bodies exchange energy by radiation if and only if there is a difference in temperature between them.

The energy exchanged depends on the following variables :

- the difference in temperature between the two bodies
- the emission power of the hottest body
- the surfaces of the bodies opposite one another
- the distance between the two bodies
- the total absorption coefficient of the coldest body
- the transparency of the environment separating the two bodies

In the case of radiation, there is no thermal fluid passing the energy from one body to another, i.e. from the emitter to the receiver.

Radiation : how it works. Thermal radiation exchanges

If you take the case of the sun which has a temperature of over 5,000°C and a snowman at 0°C, there is a distance of 150 million kilometres between them. Yet when the sun comes out, the snowman melts. If you put a screen in between them, the snowman would take longer to melt by the sun.

Radiation exchanges are related to :

- the difference in temperature
- the distance
- the transparency of the environment.

In the case of a fire in a chimney, a person will get warm differently depending on the intensity of the fire, the position in front of the fireplace and the colour of the clothes worn (light or dark).

Radiation exchanges are related to :

- the emission power of the hottest body
- the surfaces of the bodies opposite one another
- the total absorption of the coldest body.

Note :

The notion of distance and exchange surface opposite one another is called the form factor, i.e. how the receiver is seen by the emitter.

The form factor between any two surfaces is given by reference to two infinite parallel planes whose theoretical form factor is 1.

The form factor is always less than the unit unless in the case of geometric elements of the same concentric shape (eg: a cylinder in a cylinder). It is used to calculate the flow from the emitter received by the receiver. The sum of the form factors of an emitter to its environment is equal to 1.

Flux levels

As a reminder, the irradiance values can be summed up as follows:

- 20 W/m² corresponds to the threshold of perception of a person
- 40 to 50 W/m² corresponds to irradiance immediately felt by persons
- 20 to 150 W/m² : this is the field of very low temperature ceilings felt by persons
- 50 to 80 W/m² : field of radiant panels
- 80 to 50 W/m² : irradiance encountered in industrial premises reputed for being difficult to heat especially in the work areas.

Irradiance

For radiant heating systems, the overall thermal comfort is ensured (as the nuisance of draughts or dampness usually does not exist). Alternatively, three local nuisances can occur:

- nuisance due to "cold radiation" from a big glazed sur face which can be made worse by hot radiation coming from the ceiling
- nuisance due to the air temperature gradient be tween the head and the feet
- nuisance due to asymmetric vertical radiation.

The first of these nuisances only occurs in the case of very big windows. In any case, this type of configuration calls for a special study.

The other two nuisances go hand in hand and usually the nuisance due to asymmetric vertical radiation is the first one felt. This asymmetric vertical radiation is commonly assessed based on a difference between the temperature directed to the ceiling and the temperatures directed to the floor measured at the individual.

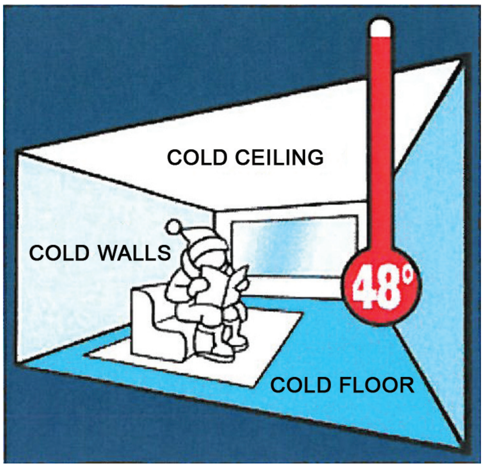
If this difference in temperature is :

- less than 8°C, the atmosphere is considered as comfortable
- between 8 and 12°C, the atmosphere is qualified as slightly un comfortable
- greater than 12°C, the atmosphere is considered as uncomfortable.

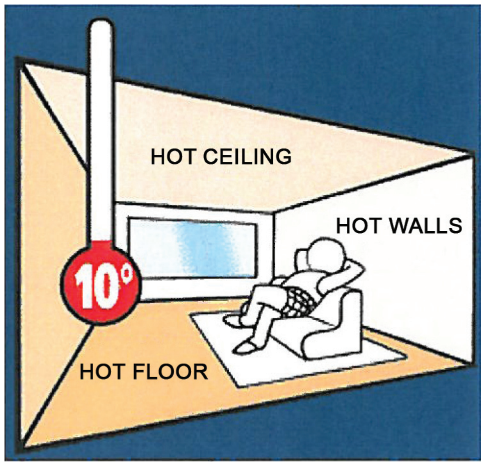
Principle

With heating, there are two major modes of heat transfer: convection which heats the air (convectors) and radiation, that of the sun for instance, which directly transmits its heat to walls, objects and our body.
All bodies emit infrared radiation. This is radiation which heats. Two objects at different temperatures radiate towards one another, the one that is the hottest exchanges heat with the other.

A valuable experiment was conducted at the M.I.T. (Massachusetts Institute of Technology) using an experimental chamber the walls of which could be cooled and in which hot air was introduced.
The air temperature was brought to 48°C whereas the walls remained cold the occupants felt cold.



The opposite experiment was then performed where by the walls were heated and the air temperature lowered to 10°C. This time the occupants were too hot.



In actual fact, cooling the air is not enough to compensate for the intake of heat from the radiation from the walls to the bodies of the occupants. This experiment proves the instrumental role of the temperature of the walls in the feeling of comfort.

Comfort

Humans permanently exchange heat with their environment. Too sudden a loss of heat causes a feeling of being cold.
The body maintains its thermal equilibrium by bringing unpleasant additional controlling mechanisms into play such as the shivers.

It is therefore necessary for a thermal neutrality point coinciding with the unperceivable loss of heat to the body to be obtained without causing an imbalance or discomfort which corresponds to a comfort temperature. The latter is defined by the air temperature, the temperature of the walls, the air velocity and moisture content.

This is why radiation heating is fully suited to human comfort requirements.

Rules

One can say that the comfort temperature is defined by the following rule :
Comfort temperature (Tr) : (referred to as resultant temperature).

To provide optimum comfort, the resultant temperature must be obtained from two parameters (temperature of the walls and air temperature) closest to one another.
Example of a room heated by a radiant ceiling system:
In this case, the occupant's body moderately diffuses its heat to the tempered walls and thus naturally finds its thermal equilibrium (maximum comfort).

WHY CHOOSE RADIATION TO CREATE PERSONAL COMFORT ?

Thermal equilibrium : why ?

The human body produces energy by its metabolic activity and must physiologically or artificially maintain its internal temperature at 37°C.

Thermal equilibrium : how it works

The human body has heat losses :

- by radiation (body temperature > absolute zero) i.e. approx. 32 %
- by evaporation (transpiration and breathing) i.e. approx. 32 %
- by convection i.e. approx. 26 %
- by conduction (if you are in your bare feet).

In all cases the human body is a perfect machine, it is always trying to find an equilibrium to a given situation, i.e. :

- when the losses are greater than the metabolic production: **feeling of cold.**
  To balance the exchanges : increased clothing, limiting the thermal conditions of the environment by a heating system.

- when the losses are lower than the metabolic production, it is difficult to eliminate the energy stored in the body : **feeling of heat.**
  To balance the exchanges: less clothing, limiting the thermal conditions of the environment by a cooling system.

Technical requirements dictating the exchange

1- the air's dry temperature is around the person
2- the radiation temperature, temperature of the surrounding bodies enhancing radiation exchanges
3- the greater the air's velocity and its mode of diffusion, the greater the losses by convection of the person
4- the relative humidity in the air increasing losses by sweating.

Advantage of infrared radiation

To reduce the environmental thermal restrictions, all or part of the above parameters must be looked at. However in certain contexts it is not technically possible or economically viable to control these parameters.

This is the case of work stations and areas dispersed in tertiary and industrial premises where infrared radiation can provide the sufficient amount of energy to achieve the thermal equilibrium for people.

1- the thermal equilibrium can be obtained by increasing the radiation temperature of the environment
2- for these applications, a flux of 10 W/m² absorbed by the human body would compensate for the lack of a degree of dry air temperature.

UCRES (uniformity, draughts, radiation asymmetry, deviation, floor) profile (CSTB)

It characterises the uniformity of comfort in the area studied.

Thermal comfort depends on 5 criteria :

- Horizontal uniformity of temperatures
- Draughts
- Radiation asymmetry
- Deviation in air temperature between head and feet
- Hot or cold floor

The consideration of one single overall comfort level as per the PMV (predicted mean vote) and PPD (predicted percentage dissatisfied) indexes is not enough to perform a heterogeneous ambient thermal diagnosis. This is why the CSTB (French scientific and technical construction centre) has developed the UCRES profile designed to characterise the thermal atmosphere of an area of occupation at different points. This method determining the quality of a thermal atmosphere is an additional method to the previous one: as the PMV and PPD indexes are designed to assess the comfort in the middle of the room and the UCRES profile, the uniformity of the area studied.

Due to this complementary aspect, the fields of application of the PMV/PPD indexes and the UCRES profile are the same. In other words they have been established for steady values of the different variables characterising the thermal atmosphere and included in the same intervals. This profile is determined based on five measured criteria. Three categories have been defined from physiological data for each of these criteria.

Category :

0 corresponds to comfort
1 corresponds to “slightly uncomfortable”
2 corresponds to “very uncomfortable”

a) Five types of thermal nuisances

The five criteria defined in the UCRES comfort profile are in fact five types of nuisances leading to local discomfort :

- Lack of horizontal uniformity of temperatures
- Draughts
- Radiation asymmetry
- Deviation in air temperature between the feet and the head
- A hot or cold floor

b) Example of UCRES comfort profile

Previously, for the five nuisance criteria, three comfort categories were defined (category 1, 0 and 2). If we want the atmosphere studied to be considered as "comfortable", all the points must be within category 0 or adhere to the following two requirements:

- No score must be greater than 2
- The total score must be less than 5

ASYMMETRIC HORIZONTAL AND VERTICAL RADIATION

Flexibility

- Low inertia of emitters with respect to hot water emitters
- Quick rise in temperature of premises
- Direct heating – good incorporation of free thermal intake
- Possibility of creating different programmable areas

Efficiency

- No air in movement, agitation, dust, smells
- Homogeneous air temperature
- convection and stratification of air practically eliminated

Simplicity

- easy design and installation
- easy control and programming
- easy maintenance

Comfort

- No air in movement, therefore less dust, allergic effects reduced
- Constant, homogeneous heat
- Noiseless operation
- Optimum thermal comfort, no stratification therefore reduced difference in temperature between the head and the feet of occupants, floor at room temperature
- The air is neither overheated nor dehydrated.

Intelligence

System easy to manage, good adaptation to the Building Management Systems (BMS)

Practical aspect

- frees up floor space
- invisible

Cleanliness

No stains on walls as there is no carbonisation of dust.

Safety

No risk of getting burnt (reflex heat).

Cost-effective

- maintenance costs are practically nil
- operating cost without surprises thanks to the BMS

Eye-catching

Wide range of products making for endless creation solutions for architects.

ELECTROMAGNETIC WAVES AND VERELEC TECHNOLOGY

WAVES AND HOW THEY ARE APPLIED TO HEATING

Electromagnetic spectrum

Two key notions for the electromagnetic wave spectrum

- radiation forms part of the electromagnetic wave field, known as thermal waves in the optical field
- The thermal waves used to heat premises come within the electromagnetic spectrum in a band between 0.72 and 10 µm which includes the majority of electrical radiation emitters with a temperature ranging between 35 and 2,400°C.

Electromagnetic spectrum table

WAVELENGTH
TYPE CLASSIFICATION

0.01 µm

0.1 µm

1 µm

10 µm

100 µm

1 mm

X rays
UV rays
IONISING

T

H

E

R

M

A

Visible (0.4 to 0.8 µm)

OPTICAL

Short IR (0.8 to 2 µm)
Mid IR (2 to 4 µm)
Long IR (4 to 10 µm)

Let us study radiation in more depth

Where is thermal radiation ? What is it ?

Radiation forms part of the electromagnetic wave field known as thermal waves in the optical field.

Electromagnetic waves are characterised by their spectral wavelength expressed in metres.

For a radiating source at a temperature T, the expression of the calculation of the characteristic maximum wavelength of this source is given by Wien's law :

$$\max \lambda = 2\,896 / T$$

Details of the composition of the other fields of the spectrum

From 0.01 to 0.1 µm: X rays of the ionising radiation field emitted by natural or artificial (fission) radioactive sources. They are classed into three categories depending on the wavelength :

- alpha rays (a)
- beta rays (b)
- gamma rays (g)

They are mainly used in medical applications (radiography, radiotherapy, scan and nuclear magnetic resonance imaging) or even in the food industry to prolong product preservation times.

From 0.1 to 0.4 µm: UltraViolet (UV) rays of the ionising radiation field emitted by natural (sun) or artificial (lamps) sources. They are classed into two categories depending on the wavelength :

- UVA rays
- UVB rays

They are mainly used for skin applications (medical or tanning) or even in industrial processes (varnish polymerising).

From 0.4 to 0.8 µm : visible rays of the optical radiation field emitted by natural (sun, lightning) or artificial (lamps, electric arcs) sources. They are mainly used for lighting, plant physiological activation, photochemical or photoelectric reactions.

From 10 to 100 µm : thermal waves of the optical radiation field, the thermal radiation of sources is not used to heat premises.

max $\lambda > 10\ \mu m \Leftrightarrow T < 16°C$

Above 100 µm : radio wave field emitted by natural (noise) or artificial (electronic frequency generators) sources. They are mainly used for molecular energizing (HF and UHF microwaves) and telecommunication (sound, images, signals) applications.

Radiation emission law

Reminder : the density of flux radiated by an infrared source is proportional to the 4th power of its temperature.

Henceforth, the work conducted by the European Commission has led to the flux radiated to a person being limited to 150 W/m².

These provisions thus limit the physical risks related to sensitivity of radiation to eyes.

Additional information

ε : emission coefficient

The emission coefficient of any body is given by referring to the emissivity of a theoretical perfect body:

the black body $\varepsilon = 1$

The emissivity of real bodies (grey bodies) is always less than the unit. It varies according to the temperature, the type and state of the surface of the real bodies (selective emission).

TECHNICAL DATA

FILM RESISTANCE DEPSOIT ON GLASS/BRIEF DESCRIPTION

The VERELEC radiant panel is made up of a thin metal layer of a special alloy deposited by a plasma process by atoms on the rear side of a plate of tempered glass.

This metal layer plays the role of an electric resistance. An electric current goes through it and heats the whole mass of glass. This emits in particular an infrared flux to the front of the panel.

1. Substrate

The substrate is made up of a volume of tempered glass the surface quality of which is controlled according to strict procedures following traditional washing with no rejects into the environment.

2. Surface preparation

The surface of the glass taking the layer of metal is subjected to argon atomic vacuum blasting to ensure atomic stripping and optimum adhesion of the coat of metal.

3. Resistance deposit

Combined vacuum deposit of a film resistance made up of a Ni-Cr type alloy of approximately 2000Å thick and copper current tracks.
The visible parts of the copper tracks are themselves protected by a Ni-Cr type alloy layer.
Depending on the specifications required, a complete resistive surface or resistive tracks can be performed according to a specific configuration as per the surface treated and the power required.
Differentiated areas of power within the same surface can be performed by either adjusting the thickness of the layer or the width of the resistive track.
The thickness of the layers is controlled to approximately ±3 %.
This specification guaranties optimum heat emission homogeneity and performance reproducibility.

4. Track deposit

Deposit of tin alloy tracks on the copper tracks for the connection to the network, soldering of current intake wires. This phase is performed in a conventional atmosphere.

5. Industrial process

The glass is treated in a tunnel type vacuum machine ensuring vacuum continuity between the different stripping and deposit phases. This process ensures optimum adhesion of the resistive layer and the copper tracks.

6. Track deposit

Approximately 10,000 domestic heating products have been in operation for the past ten years with a very low down time rate.

7. Heat emission specification

The Ni-Cr type resistive layer has a low emission coefficient whereas the glass has a high emission coefficient (practical black body). The combination of a low emission layer on a very emissive substrate leads to a product with optimum heat emission on one side. When the product is used on only one side of the surface, this combination is energy-effective and ensures thermal insulation.

8. Environmental aspect

The process uses very little extreme resources whereby approximately one gram of resistive alloy material is used per m^2. The vacuum process does not furthermore entail any rejects into the atmosphere.