# CRITICAL ELEMENTS FOR CORRECT CLIMATE CONTROL DESIGN FOR ELECTRICAL PANELS

## Electrical cabinet thermal balance

The "Moist air" and "Environmental conditions" WHITE PAPERS introduce the concepts necessary to understand what is meant by "electrical cabinet thermal balance". The designer's goal is to achieve the desired conditions inside the cabinet, in terms of relative humidity and above all of temperature.

In the case of stationary thermal balance, or in the absence of thermal inertia, the sum of all the powers involved is zero.

To guarantee the thermal balance, the following ratio is valid: $\Sigma \mathbf{Q}_i\mathbf{=0}$,

where $\mathbf{Q}_i$ indicates the n-th thermal power and $\Sigma \mathbf{Q}_i$ is the sum of all thermal powers that effect the electrical cabinet.

All possible situations are not considered in the design phase but only the most hostile to the electrical panel, namely:

- Maximum possible and maximum acceptable ambient temperature inside the electrical cabinet;
- Minimum verifiable and minimum acceptable ambient temperature in the electrical cabinet.

Through this distinction, as well as in the civil sphere, the design conditions are "**winter case**" and "**summer case**", for electrical panels the dimensioning is divided into thermal balance for "**heating**" and for "**cooling**". Furthermore, an additional differentiation must be made in designs for "**indoor**" and "**outdoor**" environments.

The calculation formulas to be used for the thermal balances are:

1. Heating: **Qdiss+Qrisc=0**

(Qdiss=dissipation through the wall; Qrisc=required heating power)

2. Cooling: **Qdiss+QJoule+Qsolar+Qraff=0**

(Qsolar = power due to solar irradiation, to be considered only for outdoor installations; Qraff = required cooling power)

*all **1** and **2** balance powers are measured in heat **[W]** .

Formulas 1 and 2 include many thermal power components, but at this stage, the objective of the WHITE PAPER is to provide guidance for the calculation of heat dissipated through the electrical cabinet walls: we only consider **Qdiss**.

## Electrical cabinet wall thermal transmittance

To determine the thermal power passing through the electrical cabinet it is necessary to calculate the transmittance of materials that constitute it, i.e. the heat transfer capacity of each wall.

The general formula of thermal transmittance is:

**$U=1/(1/\propto in + s1/\lambda 1 + s2/\lambda 2 + .... sn/\lambda n + 1/\propto out)$ [$W/m^2K$] 1**

- $\propto_{in}$ indicates the internal adduction exchange coefficient;

- **sn** is the n-th thickness of the considered wall;

- **$\lambda n$** is the thermal conductivity of the wall construction material;

- $\propto_{out}$ indicates the external adduction exchange coefficient;

In common practice, the calculation methods for thermal dimensioning do **not** take into account the possible variations of the adduction components. For completeness, it was decided to study the extent of the individual parameters that make up the transmittance U, adduction coefficients $\propto$ included, determined experimentally or from technical literature.

The **adduction coefficients** $\propto$ include thermal exchanges that take place both by convection and by radiation and are determined by the formula:

$\propto = \propto_{conv} + \propto_{irr}$

The **thermal conductivity** $\lambda_n$ are intrinsic to the cabinet construction material so they remain fixed and do not depend on the installation site.

**a - Electrical cabinet construction material thermal conductivity at room temperature [20°C]**

A. Mild steel (sheet metal): $\lambda_A$ =54[W/mK] ;

B. Plastic: $\lambda_B$=0.19[W/mK];

C. Stainless steel: $\lambda_C$ =16[W/mK];

D. Aluminium: $\lambda_D$=204[W/mK];

E. PE(polyethylene): $\lambda_E$=0.35[W/mK];

F. Paint on steel: $\lambda_F$ =0.265[W/mK] (cabinet interior and exterior).

Once the thickness of each layer is known, the respective thermal resistances are calculated with the formula **$Rn=sn/\lambda n[m^2K/W]$**.

The total resistance to heat conduction through the walls is given by the formula

$R_{tot}=\sum sn/\alpha n$ [m²K/W]    2

***In the case of "painted steel", the heat resistance of the steel layer and 2 paint layers, internal and external, are added. Because of the irrelevant thicknesses of the same, it is possible to neglect the resistive contribution to heat passage.**

b - Interna ($\alpha_i$) and external ($\alpha_e$) adduction coefficients

| Heat flow direction | ASCENDING | DESCENDING | HORIZONTAL |
|---|---|---|---|
| $\alpha_i$ | 10 | 7,7 | 5,88 |
| $\alpha_e$ | 25 | 25 | 25 |

*1 - internal adduction Coefficients ($\alpha_i$) and external ($\alpha_e$) for various geometric situations*

The coefficients indicated in **table 1** can be used, or for more precise dimensioning, calculate $h_r$ and $h_c$ according to **UNI EN ISO 6946**, standards as explained in the "Internal and external adduction coefficient calculation" WHITE PAPER.

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