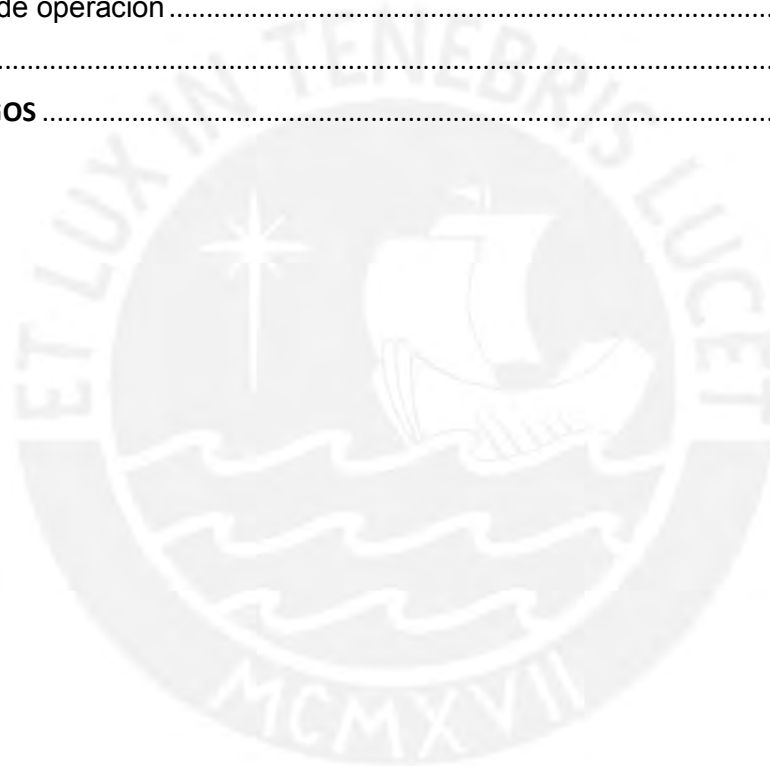


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## A. DATOS Y TABLAS

### A.1. Condiciones ambientales de la ciudad de pisco (Fuente: ASHRAE CLIMATIC DESIGN CONDITIONS)

2013 ASHRAE Handbook - Fundamentals (SI)

 PISCO, PERU (WMO: 846910)

| Lat:13.73S  |                        | Long:76.22E     |                               | Elev:7            |       | StdP: 101.24 |                    | Time zone:-5.00                           |                       | Period:86-10 |            |                            |                       |      |            |     |
|---|------------------------|-----------------|-------------------------------|-------------------|-------|--------------|--------------------|---|-----------------------|--------------|------------|----------------------------|-----------------------|------|------------|-----|
| <b>Annual Heating and Humidification Design Conditions</b>              |                        |                 |                               |                   |       |              |                    |   |                       |              |            |                            |                       |      |            |     |
| Coldest Month   | Heating DB             |                 | Humidification DP/MCDB and HR |                   |       |              |                    |   | Coldest month WS/MCDB |              |            |                            | MCWS/PCWD to 99.6% DB |      |            |     |
|   | 99.6%                  | 99%             | 99.6%                         |                   | 99%   |              | 99%                |   | 0.4%                  |              | 1%         |                            | MCWS                  | PCWD |            |     |
|   |                        |                 | DP                            | HR                | MCDB  | DP           | HR                 | MCDB                                      | WS                    | MCDB         | WS         | MCDB                       |                       |      |            |     |
| 8   | 11.9                   | 12.8            | 9.8                           | 7.6               | 12.3  | 10.6         | 7.9                | 13.0                                      | 11.1                  | 20.2         | 9.6        | 19.0                       | 0.9                   | 80   |            |     |
| <b>Annual Cooling, Dehumidification, and Enthalpy Design Conditions</b> |                        |                 |                               |                   |       |              |                    |   |                       |              |            |                            |                       |      |            |     |
| Hottest Month   | Hottest Month DB Range | Cooling DB/MCWB |                               |                   |       |              |                    | Evaporation WB/MCDB                       |                       |              |            | MCWS/PCWD to 0.4% DB       |                       |      |            |     |
|   |                        | 0.4%            |                               | 1%                |       | 2%           |                    | 0.4%                                      |                       | 1%           |            | 2%                         |                       | MCWS | PCWD       |     |
|   |                        | DB              | MCWB                          | DB                | MCWB  | DB           | MCWB               | WB  | MCDB                  | WB           | MCDB       | WB                         | MCDB                  |      |            |     |
| 2   | 7.0                    | 29.0            | 23.4                          | 28.0              | 22.7  | 27.1         | 22.2               | 23.7                                      | 28.3                  | 23.0         | 27.4       | 22.4                       | 26.6                  | 6.2  | 180        |     |
| <b>Dehumidification DP/MCDB and HR</b>                                  |                        |                 |                               |                   |       |              |                    |   |                       |              |            |                            |                       |      |            |     |
| 0.4%  |                        | 1%              |                               | 2%                |       | 0.4%         |                    | 1%  |                       | 2%           |            | Hours 8 to 4 and 12.8/20.6 |                       |      |            |     |
| DP  | HR                     | MCDB            | DP                            | HR                | MCDB  | DP           | HR                 | MCDB                                      | Enth                  | MCDB         | Enth       | MCDB                       | Enth                  | MCDB |            |     |
| 22.0  | 16.7                   | 27.7            | 21.2                          | 15.8              | 26.5  | 20.8         | 15.5               | 26.1                                      | 71.1                  | 28.3         | 68.1       | 27.7                       | 65.9                  | 26.8 | 1365       |     |
| <b>Extreme Annual Design Conditions</b>                                 |                        |                 |                               |                   |       |              |                    |   |                       |              |            |                            |                       |      |            |     |
| Extreme Annual WS   |                        |                 | Extreme Max WB                | Extreme Annual DB |       |              |                    | n-Year Return Period Values of Extreme DB |                       |              |            |                            |                       |      |            |     |
| 1%  |                        | 2.5%            |                               | 5%                | Mean  |              | Standard deviation |   | n=5 years             |              | n=10 years |                            | n=20 years            |      | n=50 years |     |
| Min   | Max                    | Min             |                               | Max               | Min   | Max          | Min                | Max                                       | Min                   | Max          | Min        | Max                        | Min                   | Max  | Min        | Max |
| 10.5  | 9.3                    | 8.3             | 29.2                          | 10.1              | 30.5  | 0.7          | 1.1                | 9.6                                       | 31.3                  | 9.1          | 31.9       | 8.7                        | 32.5                  | 8.2  | 33.3       |     |
| <b>Monthly Climatic Design Conditions</b>                               |                        |                 |                               |                   |       |              |                    |   |                       |              |            |                            |                       |      |            |     |
| Temperatures, Degree-Days and Degree-Hours                              | Tavg                   | 20.1            | 23.4                          | 24.2              | 23.7  | 21.8         | 19.3               | 17.6                                      | 17.1                  | 17.0         | 17.7       | 18.5                       | 19.6                  | 21.5 |            |     |
|   | Sd                     | 1.35            | 1.28                          | 1.28              | 1.40  | 1.55         | 1.48               | 1.48                                      | 1.33                  | 1.20         | 1.10       | 1.18                       | 1.18                  | 1.35 |            |     |
|   | HDD10.0                | 0               | 0                             | 0                 | 0     | 0            | 0                  | 0   | 0                     | 0            | 0          | 0                          | 0                     | 0    |            |     |
|   | HDD18.3                | 172             | 0                             | 0                 | 0     | 0            | 8                  | 32  | 46                    | 26           | 12         | 3                          | 0                     | 0    |            |     |
|   | CDD10.0                | 3681            | 415                           | 398               | 426   | 355          | 288                | 227                                       | 219                   | 217          | 231        | 263                        | 287                   | 356  |            |     |
|   | CDD18.3                | 812             | 157                           | 165               | 168   | 105          | 38                 | 9   | 6                     | 4            | 7          | 16                         | 39                    | 98   |            |     |
|   | CDH23.3                | 2659            | 579                           | 766               | 711   | 286          | 48                 | 13  | 6                     | 3            | 4          | 5                          | 32                    | 206  |            |     |
|   | CDH26.7                | 293             | 63                            | 114               | 91    | 16           | 1                  | 0   | 0                     | 0            | 0          | 0                          | 0                     | 9    |            |     |
| Precipitation   | PrecAvg                | 0               | 0                             | 0                 | 0     | 0            | 0                  | 0   | 0                     | 0            | 0          | 0                          | 0                     | 0    |            |     |
|   | PrecMax                | N/A             | N/A                           | N/A               | N/A   | N/A          | N/A                | N/A                                       | N/A                   | N/A          | N/A        | N/A                        | N/A                   | N/A  |            |     |
|   | PrecMin                | N/A             | N/A                           | N/A               | N/A   | N/A          | N/A                | N/A                                       | N/A                   | N/A          | N/A        | N/A                        | N/A                   | N/A  |            |     |
|   | PrecSD                 | N/A             | N/A                           | N/A               | N/A   | N/A          | N/A                | N/A                                       | N/A                   | N/A          | N/A        | N/A                        | N/A                   | N/A  |            |     |
| Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures       | 0.4%                   | DB              | 29.9                          | 30.2              | 29.9  | 28.2         | 26.0               | 25.0                                      | 24.1                  | 23.7         | 24.0       | 24.0                       | 25.2                  | 27.9 |            |     |
|   |                        | MCWB            | 24.2                          | 24.4              | 24.1  | 22.9         | 21.3               | 20.9                                      | 20.6                  | 20.1         | 20.4       | 19.8                       | 20.6                  | 22.6 |            |     |
|   | 2%                     | DB              | 28.1                          | 29.1              | 28.8  | 27.0         | 24.8               | 22.9                                      | 22.0                  | 21.6         | 22.2       | 23.0                       | 24.2                  | 26.2 |            |     |
|   |                        | MCWB            | 22.8                          | 23.4              | 23.2  | 22.1         | 20.7               | 19.3                                      | 18.5                  | 18.2         | 18.4       | 19.0                       | 19.9                  | 21.4 |            |     |
|   | 5%                     | DB              | 27.1                          | 28.1              | 27.8  | 26.0         | 23.7               | 21.5                                      | 20.9                  | 20.5         | 21.2       | 22.1                       | 23.2                  | 25.2 |            |     |
|   |                        | MCWB            | 22.2                          | 22.7              | 22.6  | 21.5         | 20.1               | 18.4                                      | 17.6                  | 17.3         | 17.7       | 18.4                       | 19.3                  | 20.7 |            |     |
|   | 10%                    | DB              | 26.1                          | 27.1              | 26.9  | 25.0         | 22.8               | 20.6                                      | 20.0                  | 19.9         | 20.3       | 21.2                       | 22.6                  | 24.3 |            |     |
|   |                        | MCWB            | 21.6                          | 22.2              | 22.1  | 21.0         | 19.5               | 17.7                                      | 17.1                  | 16.9         | 17.2       | 17.9                       | 18.9                  | 20.3 |            |     |
| Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures       | 0.4%                   | WB              | 24.4                          | 24.9              | 24.5  | 23.3         | 21.6               | 20.9                                      | 20.7                  | 20.1         | 20.5       | 20.1                       | 21.1                  | 22.8 |            |     |
|   |                        | MCDB            | 29.3                          | 29.9              | 29.3  | 27.7         | 25.2               | 24.6                                      | 23.9                  | 23.3         | 23.7       | 23.5                       | 24.9                  | 27.3 |            |     |
|   | 2%                     | WB              | 23.1                          | 23.8              | 23.5  | 22.2         | 20.7               | 19.5                                      | 18.7                  | 18.5         | 18.7       | 19.2                       | 20.1                  | 21.7 |            |     |
|   |                        | MCDB            | 27.6                          | 28.4              | 28.1  | 26.4         | 24.2               | 22.6                                      | 21.5                  | 21.2         | 21.6       | 22.5                       | 23.7                  | 25.9 |            |     |
|   | 5%                     | WB              | 22.3                          | 23.0              | 22.7  | 21.7         | 20.2               | 18.5                                      | 17.8                  | 17.5         | 17.9       | 18.5                       | 19.5                  | 21.0 |            |     |
|   |                        | MCDB            | 26.5                          | 27.4              | 27.1  | 25.6         | 23.4               | 21.3                                      | 20.4                  | 20.2         | 21.0       | 21.8                       | 23.0                  | 24.8 |            |     |
|   | 10%                    | WB              | 21.9                          | 22.4              | 22.1  | 21.0         | 19.5               | 17.8                                      | 17.2                  | 16.9         | 17.4       | 17.9                       | 18.9                  | 20.4 |            |     |
|   |                        | MCDB            | 25.8                          | 26.6              | 26.3  | 24.7         | 22.5               | 20.3                                      | 19.7                  | 19.5         | 20.2       | 21.2                       | 22.3                  | 24.1 |            |     |
| Mean Daily Temperature Range  | 5% DB                  | MDBR            | 6.8                           | 7.0               | 7.1   | 7.1          | 6.7                | 6.3                                       | 6.0                   | 6.1          | 6.5        | 6.7                        | 7.0                   | 6.9  |            |     |
|   |                        | MCDBR           | 7.4                           | 7.6               | 7.7   | 7.9          | 7.9                | 7.7                                       | 7.4                   | 7.1          | 7.3        | 7.3                        | 7.5                   | 7.5  |            |     |
|   | 5% WB                  | MCWBR           | 4.3                           | 4.4               | 4.4   | 4.8          | 5.3                | 5.7                                       | 5.3                   | 5.0          | 5.0        | 5.0                        | 5.0                   | 4.6  |            |     |
|   |                        | MCWBR           | 7.2                           | 7.4               | 7.4   | 7.7          | 7.6                | 7.5                                       | 7.0                   | 6.9          | 7.1        | 7.1                        | 7.3                   | 7.3  |            |     |
| Clear Sky Solar Irradiance  | taub                   | 0.567           | 0.540                         | 0.526             | 0.526 | 0.451        | 0.418              | 0.434                                     | 0.542                 | 0.653        | 0.544      | 0.566                      | 0.574                 |      |            |     |
|   | taud                   | 2.095           | 2.151                         | 2.134             | 2.040 | 2.181        | 2.203              | 2.125                                     | 1.836                 | 1.652        | 2.008      | 2.010                      | 2.053                 |      |            |     |
|   | Ebn,noon               | 798             | 814                           | 806               | 770   | 797          | 809                | 805                                       | 744                   | 696          | 801        | 793                        | 790                   |      |            |     |
|   | Edn,noon               | 173             | 163                           | 161               | 167   | 136          | 129                | 143                                       | 202                   | 257          | 185        | 187                        | 180                   |      |            |     |





### A.3. Correlaciones para transferencia de calor por convección natural (Extraído de la guía del curso de Transferencia de Calor de Juan Cruz)

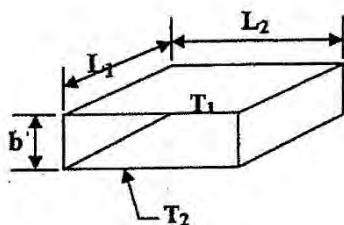
#### IV.2.0.- CONVECCIÓN LIBRE EN SUPERFICIES INTERIORES

|    |                      |   |
|----|----------------------|---|
| 46 | $Nu = 0.55 Ra^{1/4}$ | Espacios cilíndricos cerrados con: $3/4 < L/D < 2$ ; Tf<br>Horizontales: $L_c = D$<br>Verticales: $L_c = L$ |
| 47 | $Nu = 0.59 Ra^{1/4}$ | Cavidades esféricas: $10^4 \leq Ra < 10^9$ ; Tf<br>$L_c = D$  |
| 48 | $Nu = 0.13 Ra^{1/3}$ | Cavidades esféricas: $10^9 \leq Ra \leq 10^{12}$ ; Tf<br>$L_c = D$  |

#### IV.3.0.- CONVECCIÓN LIBRE EN CAVIDADES RECTANGULARES

La convección libre entre superficies planas próximas que forman espacios cerrados, horizontales o verticales, requieren del uso de correlaciones especiales.

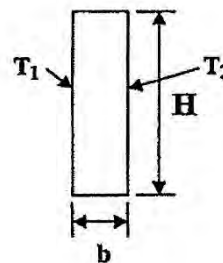
Horizontales:



$$3 \leq L/b \leq 42$$

$$L_c = \frac{1}{2}(L_1 + L_2)$$

Verticales:



$$3 \leq H/b \leq 42$$

|  |   |
|--|---|
| $Nu = 0.069 Ra^{1/3} Pr^{0.074}$<br>(Correlación de Globe y Dropkin) | $L_c = b$ ; Propiedades del aire a<br>$T_b = \frac{1}{2}(T_1 + T_2)$<br>$3 \times 10^5 < Ra < 7 \times 10^9$<br>Ra y q se hallan con:<br>$\Delta T = T_1 - T_2$ |
|--|---|

### III.2.3.- SERPENTINES

|    |                           |  |
|----|---------------------------|--|
| 42 | $Nu_s = Nu (1 + 3.5 D/d)$ | <p>Nu : Número de Nusselt obtenido mediante las correlaciones 35 ó 36</p> <p>D: Diámetro interior del tubo.</p> <p>d: Diámetro medio del cuerpo del serpentín.</p> |
|----|---------------------------|--|

### III.2.4.- TUBOS DE SECCIÓN RECTA NO CIRCULAR Y TUBOS CONCÉNTRICOS

Para el cálculo del número de Nusselt referente a estos casos, en flujo interno, se utilizarán las mismas correlaciones dadas para tubos de sección recta circular, pero utilizando el diámetro hidráulico:

$$D_h = 4 A_c / P$$

Donde:  $A_c$  : Área de la sección recta del tubo.  
 P: Perímetro de la sección en contacto con el fluido (perímetro mojado).

## IV.- CORRELACIÓN DE VARIABLES EN CONVECCIÓN LIBRE

Fórmula general:

$$Nu = C Ra^n$$

### IV.1.0.- CONVECCIÓN LIBRE EN SUPERFICIES EXTERNAS

|    |   |  |
|----|---|--|
| 43 | $Nu = \left[ 0.825 + \frac{0.387 Ra^{1/6}}{\left[ 1 + \left[ \frac{0.492}{Pr} \right]^{9/16} \right]^{8/27}} \right]^2$ | <p>Placas verticales.<br/>         Cilindros verticales con:<br/> <math>D/L \geq (35/Gr^{1/4})</math><br/> <math>L_c = L</math> ; Tf</p> |
| 44 | $Nu = C Ra^n$   | <p>Hallar constantes en la Tabla A.5 ; Tf</p>  |
| 45 | $Nu = \left[ 0.60 + \frac{0.387 Ra^{1/6}}{\left[ 1 + \left[ \frac{0.559}{Pr} \right]^{9/16} \right]^{8/27}} \right]^2$  | <p>Cilindros horizontales con:<br/> <math>10^{-5} &lt; Ra &lt; 10^{12}</math><br/> <math>L_c = D</math> ; Tf</p>                         |

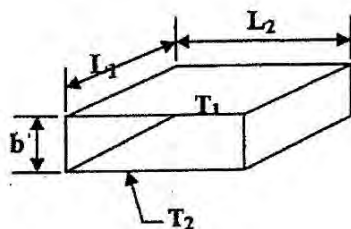
#### IV.2.0.- CONVECCIÓN LIBRE EN SUPERFICIES INTERIORES

|    |                      |  |
|----|----------------------|--|
| 46 | $Nu = 0.55 Ra^{1/4}$ | Espacios cilíndricos cerrados<br>con: $3/4 < L/D < 2$ ; Tf<br>Horizontales: $L_c = D$<br>Verticales: $L_c = L$ |
| 47 | $Nu = 0.59 Ra^{1/4}$ | Cavidades esféricas:<br>$10^4 \leq Ra < 10^9$ ; Tf<br>$L_c = D$  |
| 48 | $Nu = 0.13 Ra^{1/3}$ | Cavidades esféricas:<br>$10^9 \leq Ra \leq 10^{12}$ ; Tf<br>$L_c = D$  |

#### IV.3.0.- CONVECCIÓN LIBRE EN CAVIDADES RECTANGULARES

La convección libre entre superficies planas próximas que forman espacios cerrados, horizontales o verticales, requieren del uso de correlaciones especiales.

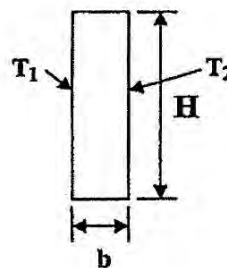
Horizontales:



$$3 \leq L/b \leq 42$$

$$L_c = \frac{1}{2}(L_1 + L_2)$$

Verticales:



$$3 \leq H/b \leq 42$$

|  |   |
|--|---|
| $Nu = 0.069 Ra^{1/3} Pr^{0.074}$<br>(Correlación de Globe y Dropkin) | $L_c = b$ ; Propiedades del aire a<br>$T_b = \frac{1}{2}(T_1 + T_2)$<br>$3 \times 10^5 < Ra < 7 \times 10^9$<br><br>Ra y q se hallan con:<br>$\Delta T = T_1 - T_2$ |
|--|---|

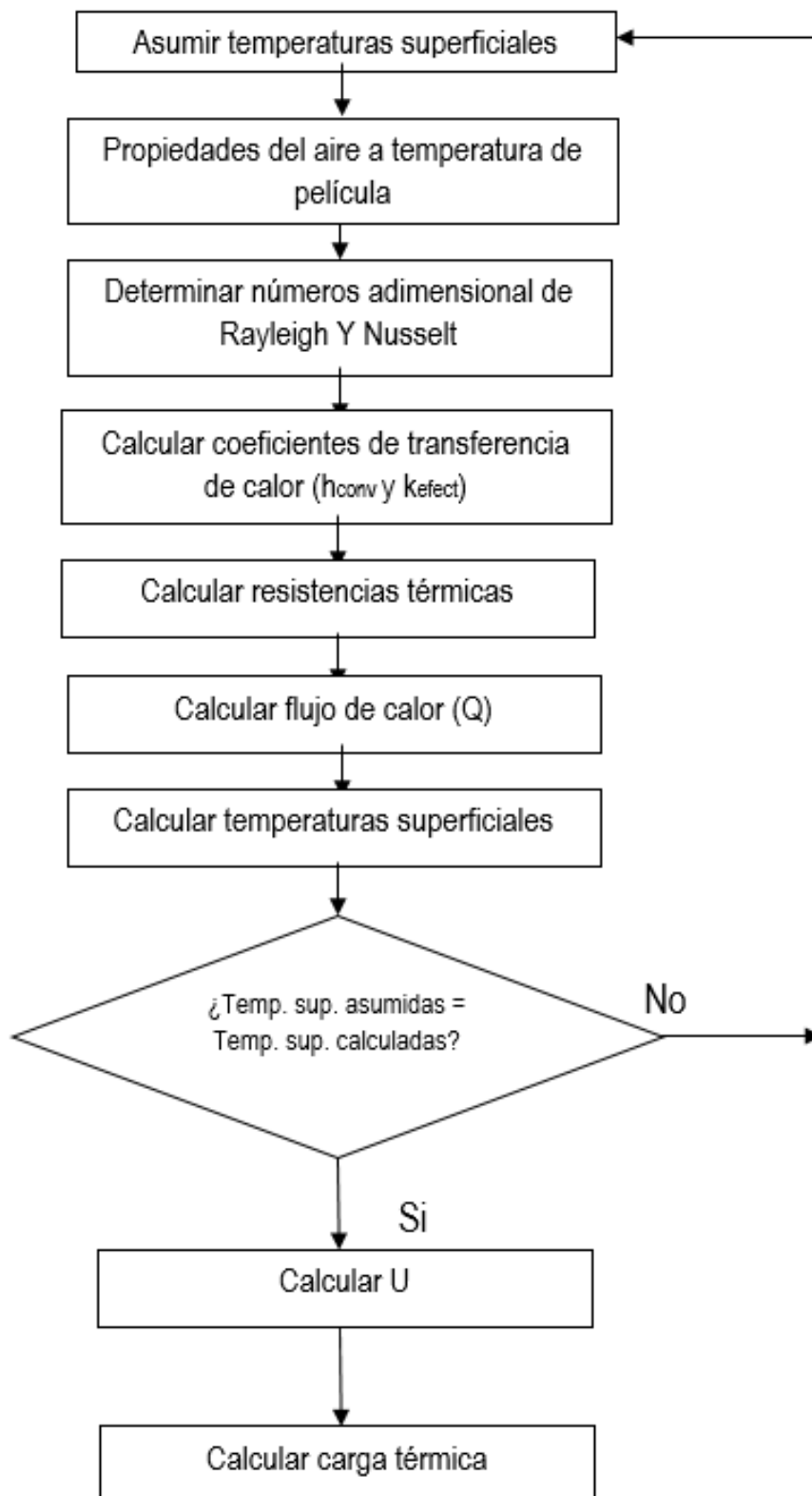


**TABLA A.5.-** Constantes y variables para convección libre, para casos de contacto con fluido en campo abierto.

| CONFIGURACIÓN   | REGIMEN                     | Ra   | Lc  | C                       | N     |
|---|-----------------------------|--|---|-------------------------|-------|
| Paredes verticales y cilindros verticales de gran diámetro                      | Laminar                     | $10^4 - 10^9$  | $L_v$   | 0.59                    | 1/4   |
|   | Turbulento                  | $10^9 - 10^{12}$   | $L_v$   | 0.13                    | 1/3   |
| Placas verticales y cilindros grandes   | Laminar                     | $10^{-1} - 10^4$   | $L_v$   | Ver Fig. N° 2 (pág. 68) |       |
| Cilindros verticales de pequeño diámetro (alambres)                             | Laminar                     | $10^{-14} - 10^{-1}$   | $L_v$   | Ver Fig. N° 1 (pág. 68) |       |
| Paredes horizontales<br>( $L_1$ y $L_2$ : Lados de la superficie horizontal)    | Laminar (Tipo $\alpha$ )    | $10^5 - 2 \times 10^7$   | $(L_1 + L_2) / 2$                             | 0.54                    | 1/4   |
|   | Turbulento (Tipo $\alpha$ ) | $2 \times 10^7 - 3 \times 10^{10}$   | $(L_1 + L_2) / 2$                             | 0.15                    | 1/3   |
|   | Laminar (Tipo $\beta$ )     | $3 \times 10^5 - 3 \times 10^{10}$   | $(L_1 + L_2) / 2$                             | 0.27                    | 1/4   |
| Cilindros horizontales. (alambres)<br>( $0.5 \text{ mm} < D < 305 \text{ mm}$ ) | Laminar                     | $10^{-10} - 10^{-2}$<br>$10^{-2} - 10^2$<br>$10^2 - 10^4$<br>$10^4 - 10^9$ | D   | 0.675                   | 0.058 |
|   | Turbulento                  | $10^9 - 10^{12}$   |   | 0.130                   | 1/3   |
| Cilindros horizontales de pequeño diámetro ( $D < 0.5 \text{ mm}$ )             | Laminar                     | -----  | D   | 0.40                    | 0     |
| Formas sólidas Diversas (esferas, bloques, cilindros cortos, etc.)              | Laminar                     | $10^4 - 10^9$  | $\frac{1}{L} = \frac{1}{L_v} + \frac{1}{L_h}$ | 0.60                    | 1/4   |
| Formas sólidas diversas   | Laminar                     | $10^{-4} - 10^4$   | $\frac{1}{L} = \frac{1}{L_v} + \frac{1}{L_h}$ | Ver Fig. N° 3 (pág. 68) |       |



#### A.4. Método de iteración para cálculo de coeficiente global de transferencia de calor.



### A.5. Coeficientes ventilación e infiltración (ASHRAE 2009:16.23)

**Table 4 Basic Model Stack Coefficient  $C_s$**

|                   | House Height (Stories) |           |           |
|-------------------|------------------------|-----------|-----------|
|                   | One                    | Two       | Three     |
| Stack coefficient | 0.000 145              | 0.000 290 | 0.000 435 |

**Table 5 Local Shelter Classes**

| Shelter Class | Description   |
|---------------|---|
| 1             | No obstructions or local shielding  |
| 2             | Typical shelter for an isolated rural house   |
| 3             | Typical shelter caused by other buildings across street from building under study   |
| 4             | Typical shelter for urban buildings on larger lots where sheltering obstacles are more than one building height away  |
| 5             | Typical shelter produced by buildings or other structures immediately adjacent (closer than one house height): e.g., neighboring houses on same side of street, trees, bushes, etc. |

**Table 6 Basic Model Wind Coefficient  $C_w$**

| Shelter Class | House Height (Stories) |           |           |
|---------------|------------------------|-----------|-----------|
|               | One                    | Two       | Three     |
| 1             | 0.000 319              | 0.000 420 | 0.000 494 |
| 2             | 0.000 246              | 0.000 325 | 0.000 382 |
| 3             | 0.000 174              | 0.000 231 | 0.000 271 |
| 4             | 0.000 104              | 0.000 137 | 0.000 161 |
| 5             | 0.000 032              | 0.000 042 | 0.000 049 |

- Terrain used for converting meteorological to local wind speeds is that of a rural area with scattered obstacles
- $R = 0.5$  (half the building leakage in the walls)
- $X = 0$  (equal amounts of leakage in the floor and ceiling)
- Heights of one-, two-, and three-story buildings = 2.5, 5.0, and 7.5 m, respectively

El domo será tomado como una casa de 1 piso y no cuenta con obstrucciones en los alrededores por tanto, el coeficiente de estancamiento será  $0.000145 \text{ L}^2/\text{s}^2\text{cm}^4\text{K}$  y el coeficiente del aire será  $0.000319 \text{ L}^2/\text{cm}^4\text{m}^2$

## A.6. Ratios de requerimientos mínimos para ventilación mecánica (Pita: 147)

**TABLE 6.17 MINIMUM MECHANICAL VENTILATION REQUIREMENT RATES**

Outdoor air shall be provided at a rate no less than the greater of either  
 A. 15 CFM per person, times the expected occupancy rate.  
 B. The applicable ventilation rate from the following list, times the conditioned floor area of the space.

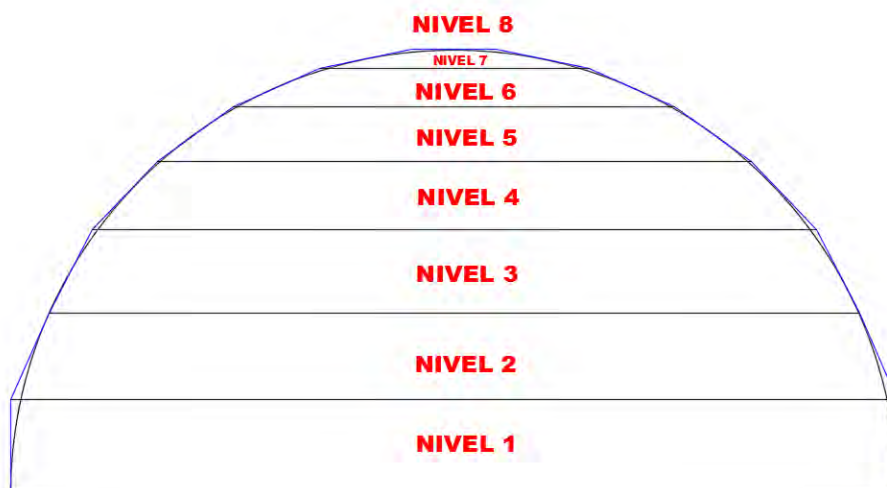
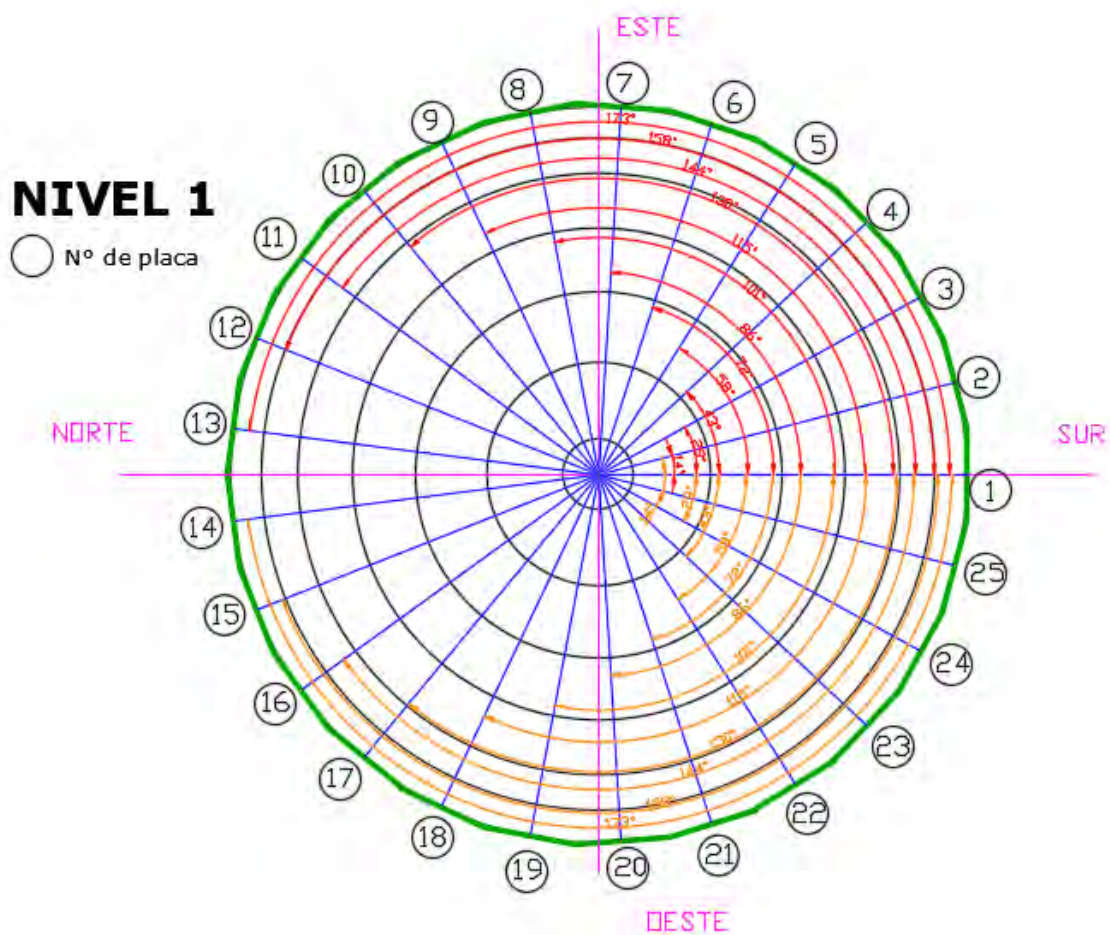
| Type of Use                              | CFM per Square Foot of Conditioned Floor Area |
|--|---|
| Auto repair workshops                    | 1.50  |
| Barber shops                             | 0.40  |
| Bars, cocktail lounges, and casinos      | 1.50  |
| Beauty shops                             | 0.40  |
| Coin-operated dry cleaning               | 0.30  |
| Commercial dry cleaning                  | 0.45  |
| Hotel guest rooms (less than 500 sq ft)  | 30 CFM/Guest Room                             |
| Hotel guest rooms (500 sq ft or greater) | 0.15  |
| Retail stores                            | 0.20  |
| Smoking lounges                          | 1.50  |
| All others                               | 0.15  |

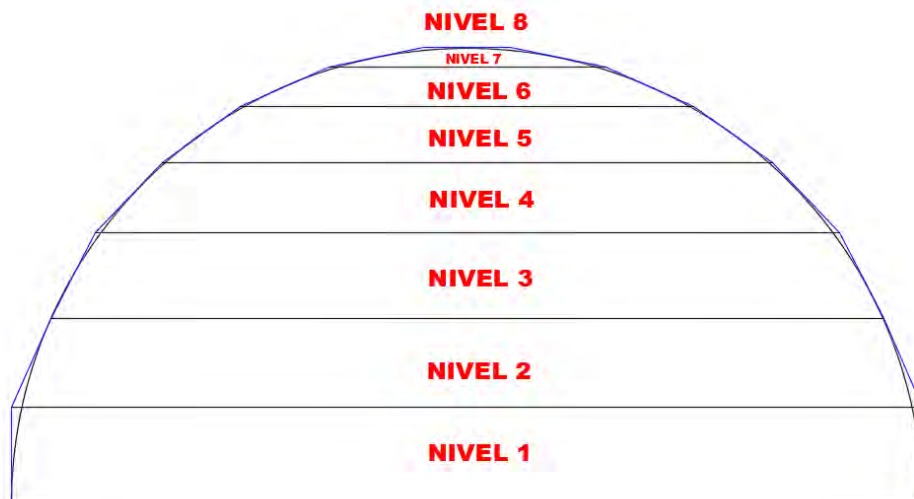
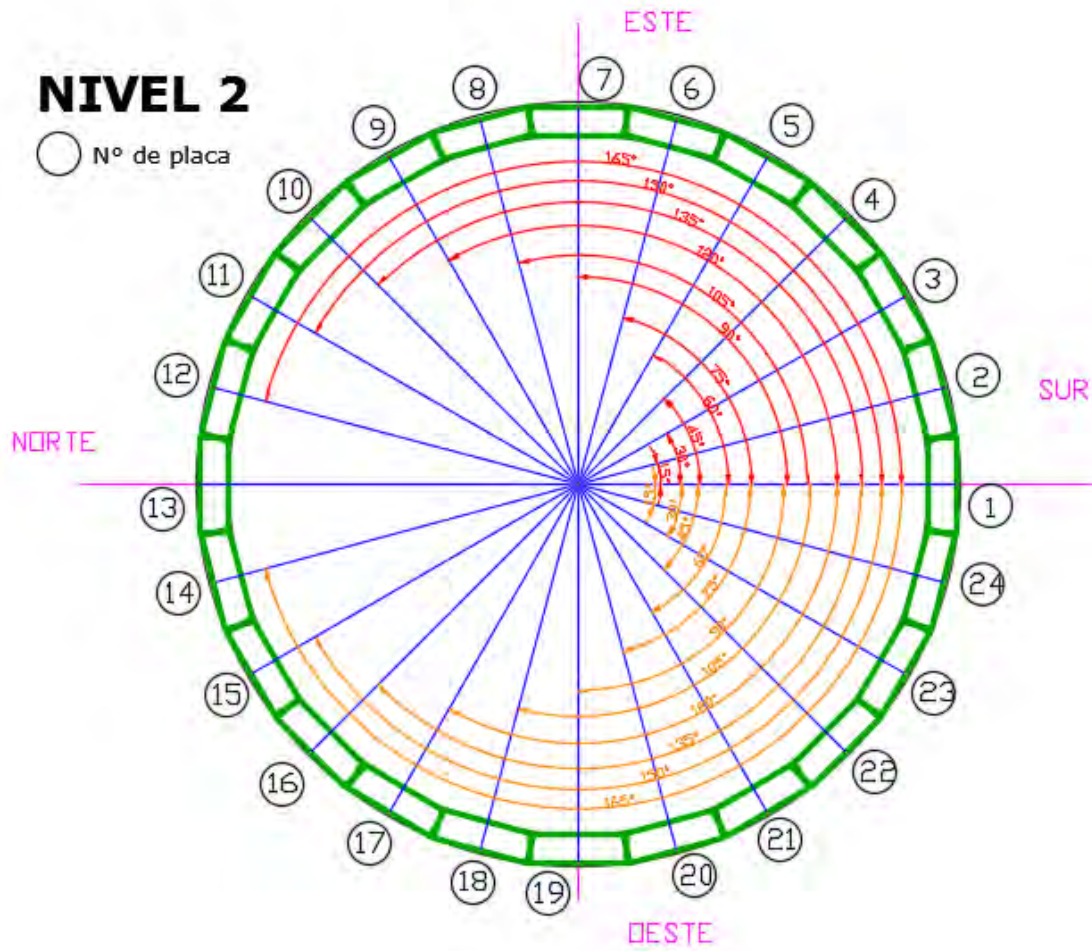
Abridged from *Energy Efficiency Standards*, California Energy Commission, 1999.

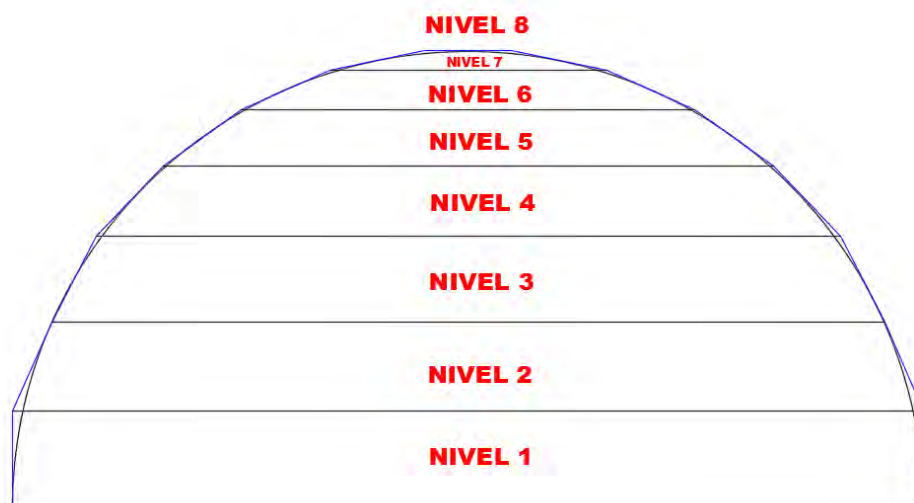
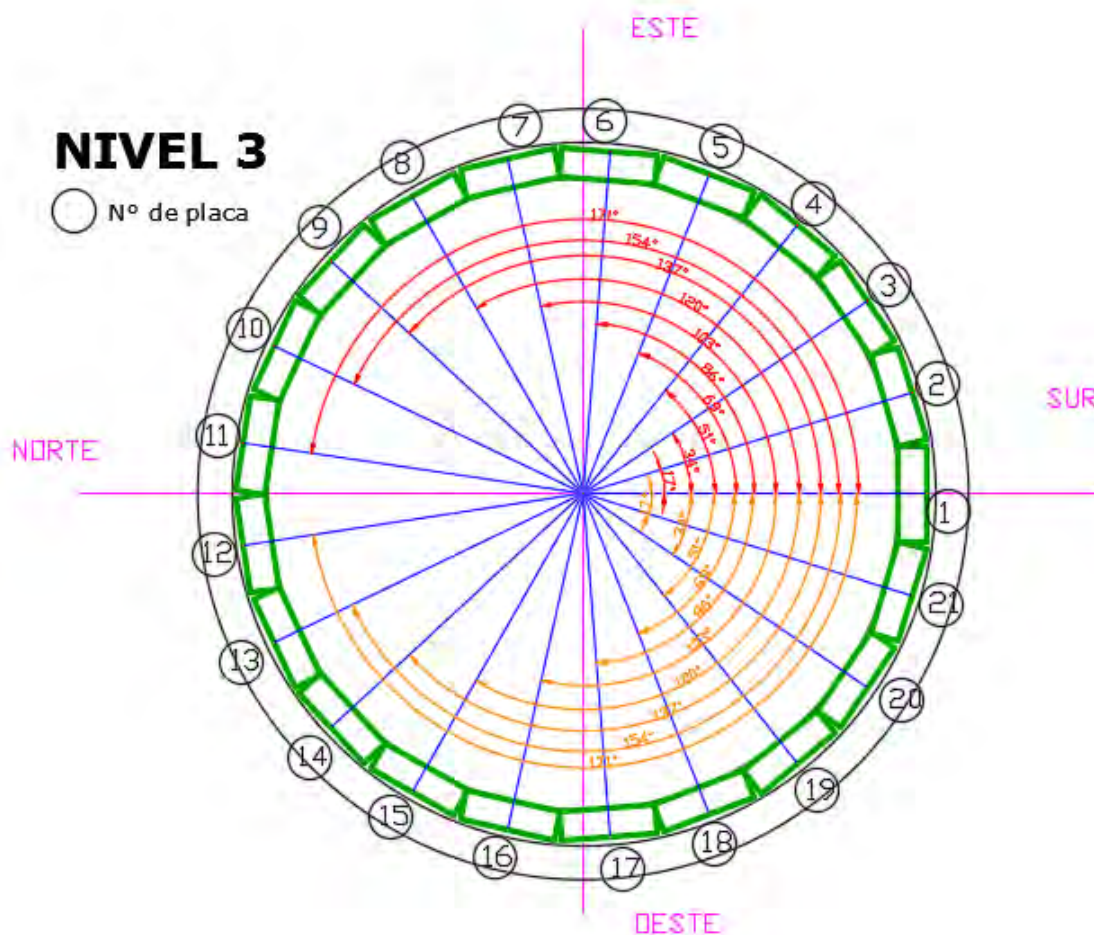
Por un lado, para 4 personas se necesita 60 CFM de aire limpio, por otro lado, el tipo de uso del domo se considera como sala de visitas en hoteles, entonces se toma 0.15 CFM/ft<sup>2</sup>. Se tiene un área de piso de 540 ft<sup>2</sup> (50.27 m<sup>2</sup>) por lo que se requeriría 81 CFM de aire. Finalmente, para satisfacer ambas necesidades se toma el valor de 81 CFM como caudal mínimo de aire de ventilación.



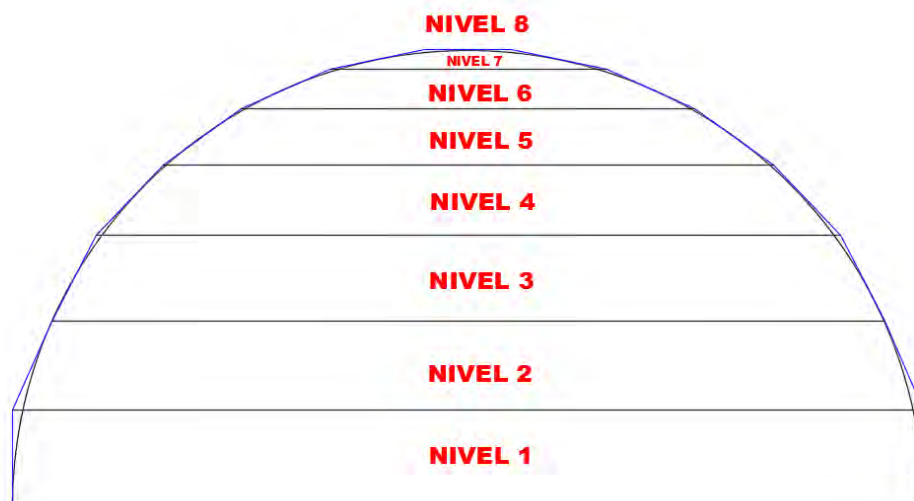
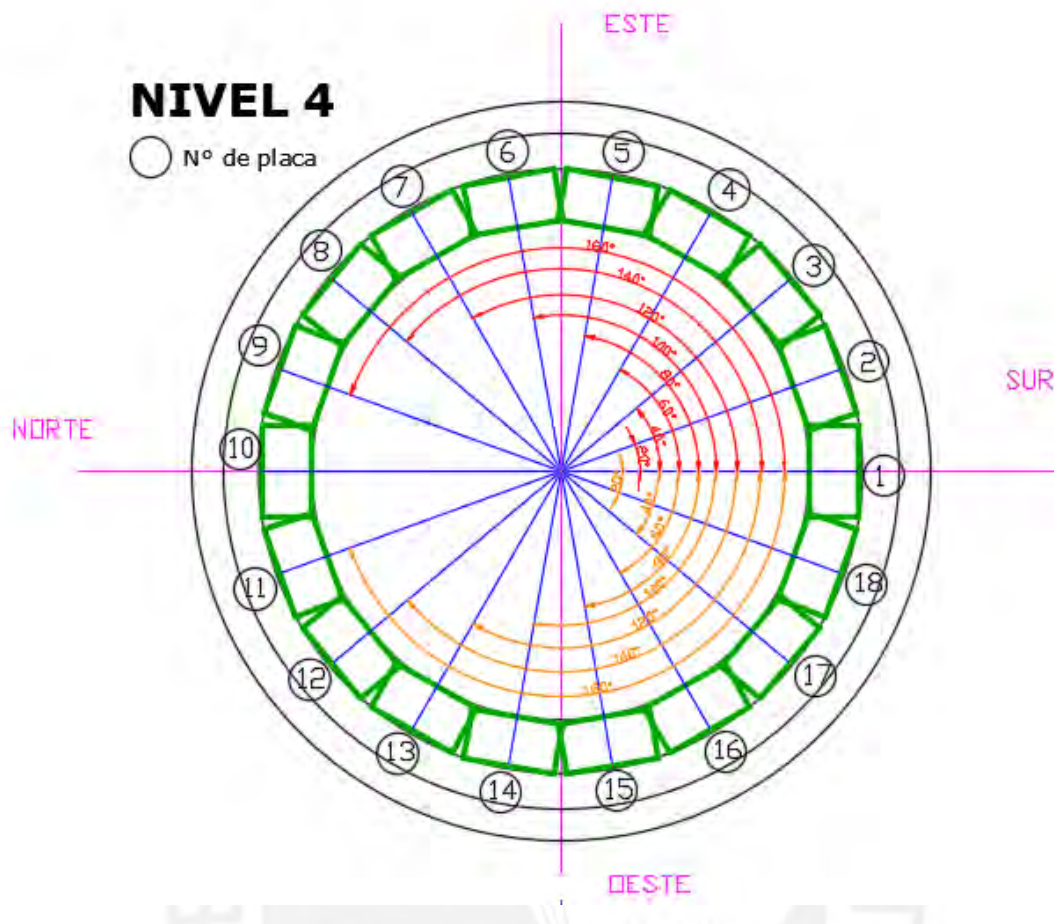
## A.7. Distribución de placas por niveles

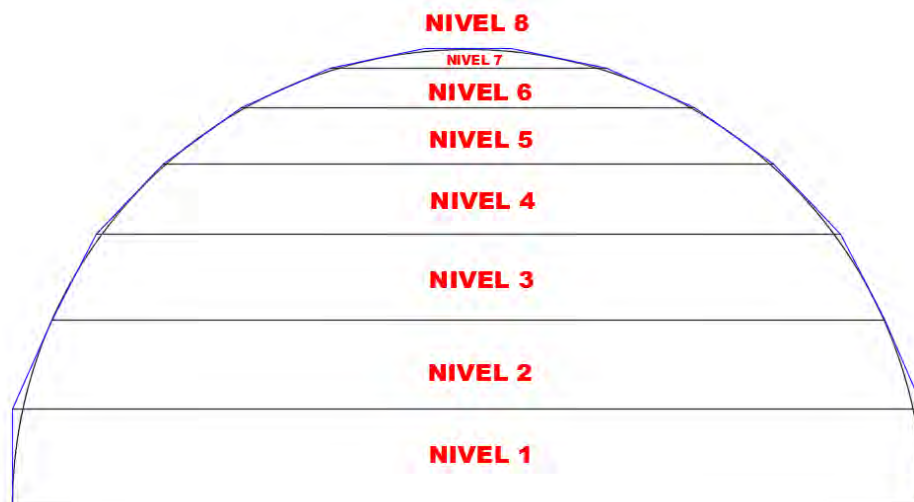
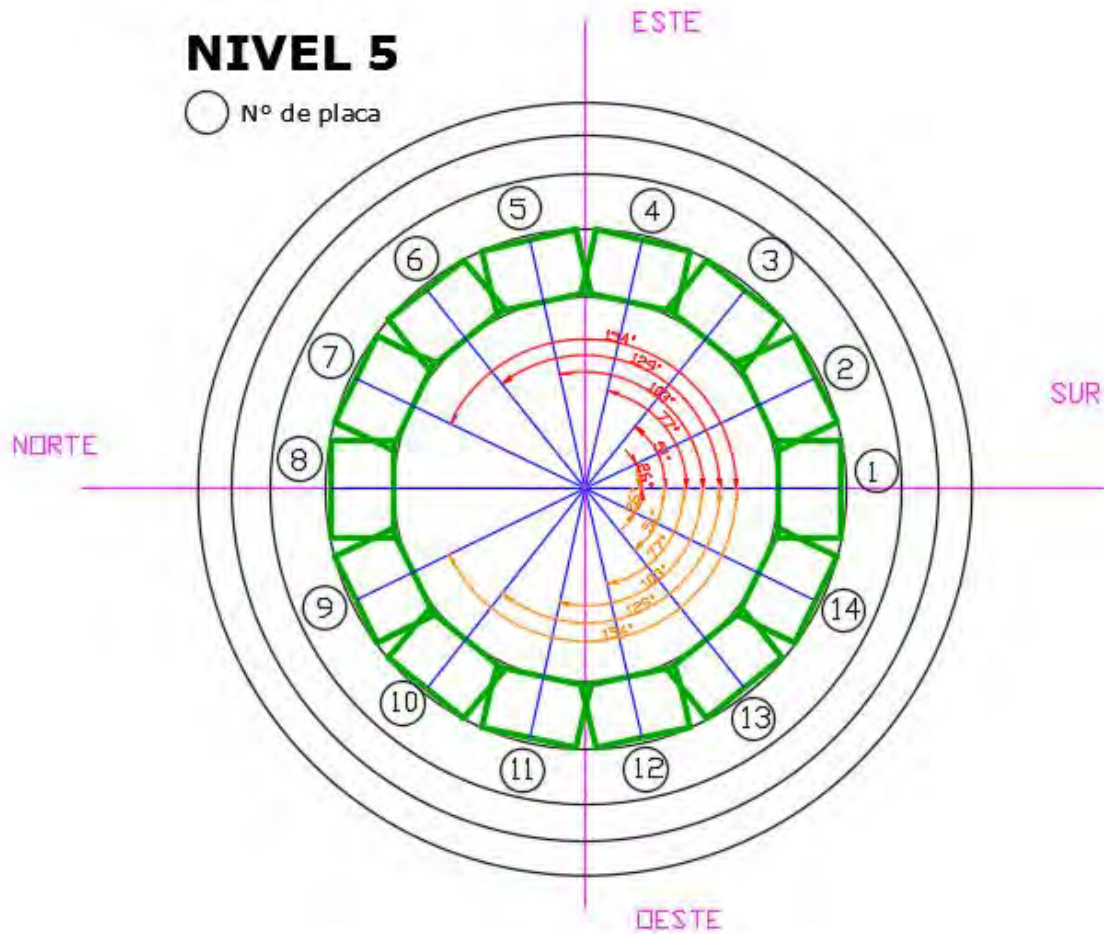


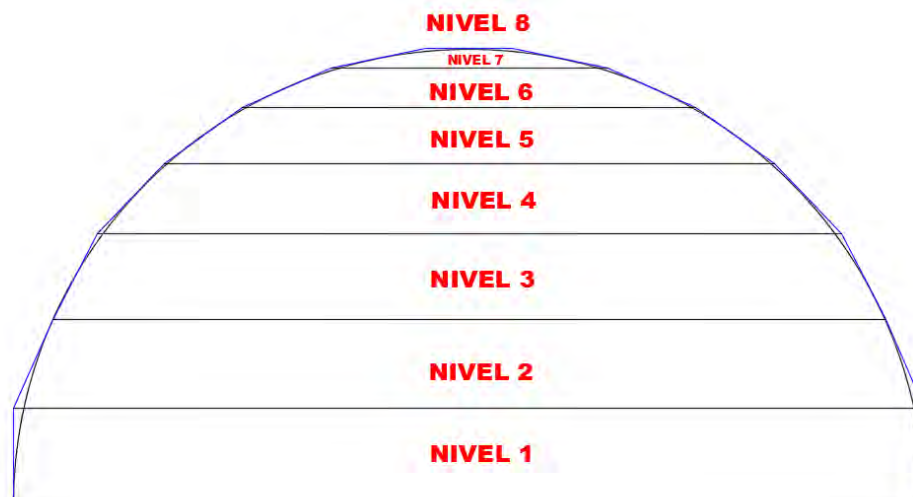
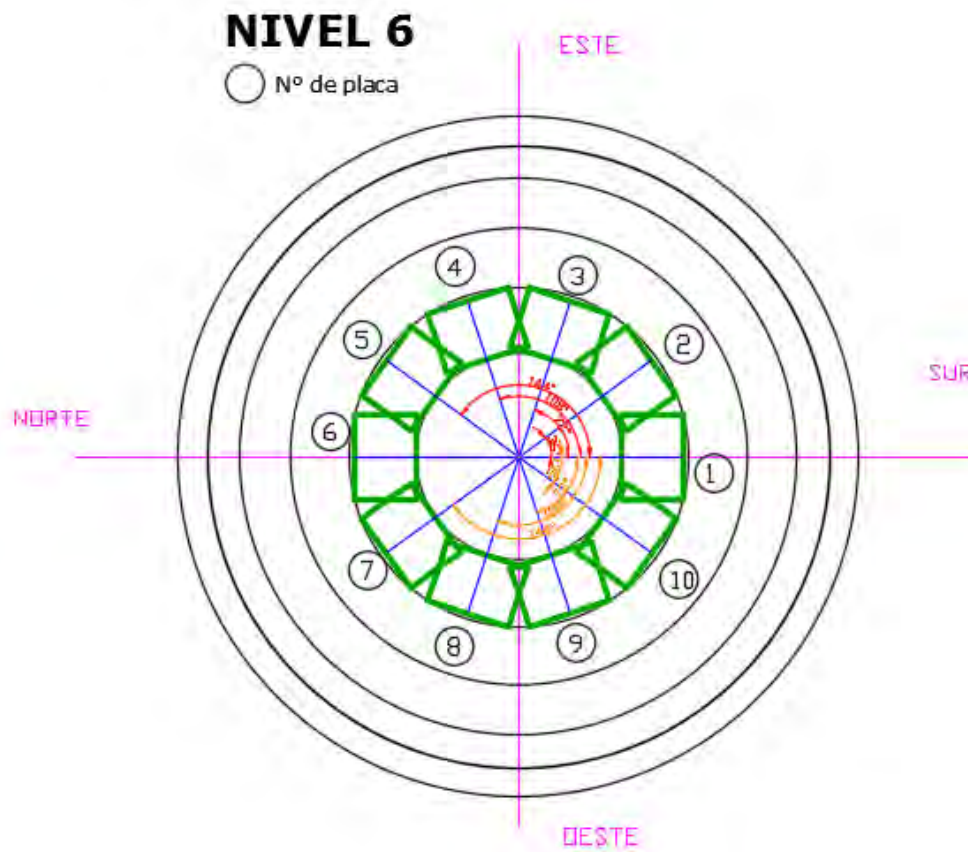




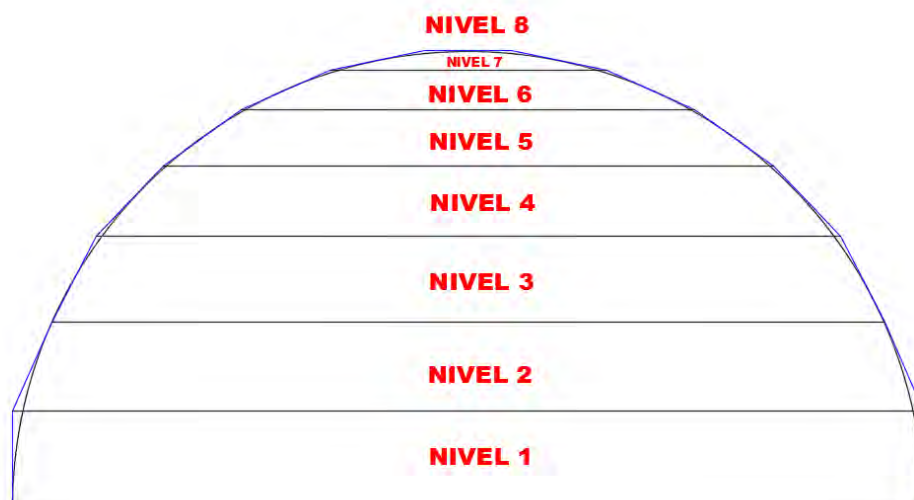
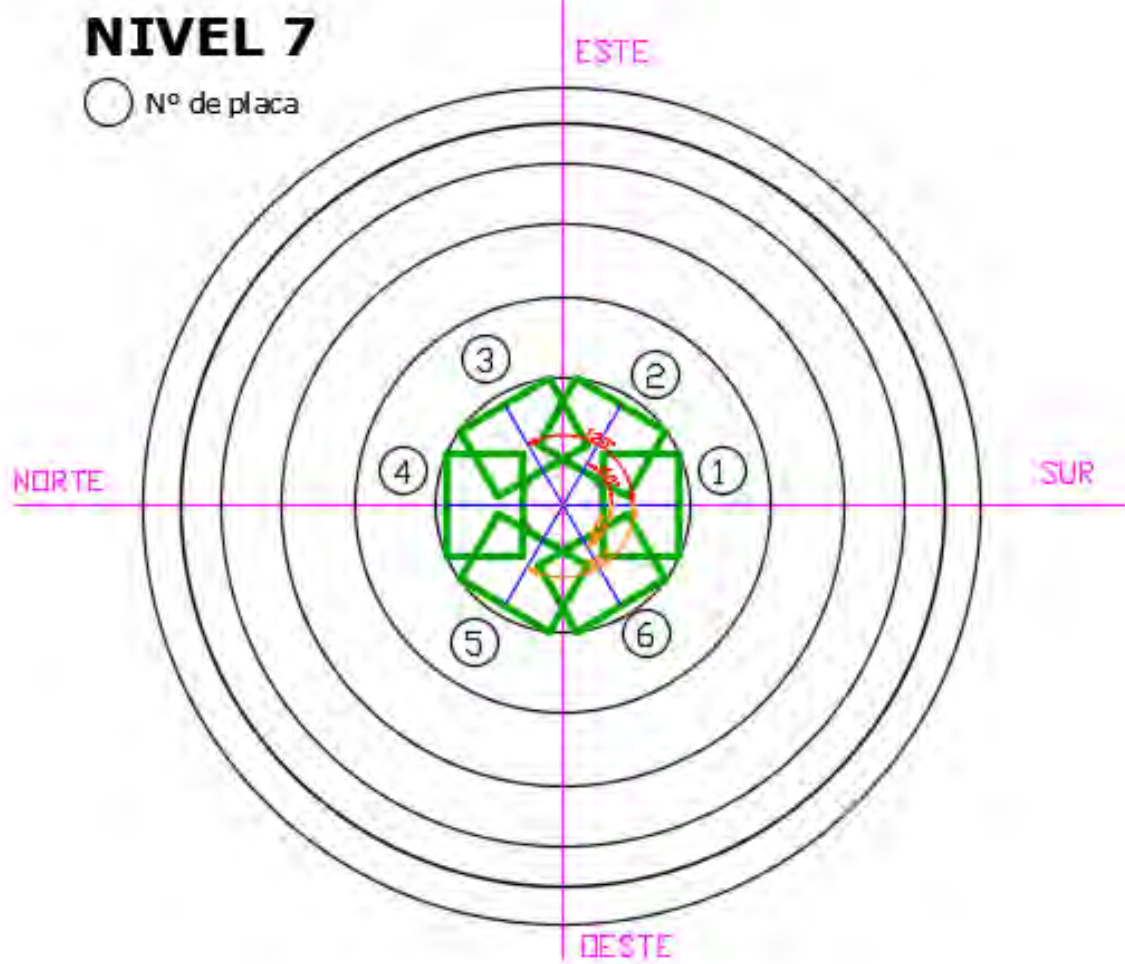












## A.8. Calor sensible y latente emitido por personas en diferentes situaciones (ASHRAE 2009:18.4)

**Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity**

| Degree of Activity                   |                                | Total Heat, W     |                            | Sensible Heat, W | Latent Heat, W | % Sensible Heat that is Radiant <sup>b</sup> |               |
|--------------------------------------|--------------------------------|-------------------|----------------------------|------------------|----------------|--|---------------|
|                                      |                                | Adult Male        | Adjusted, M/F <sup>a</sup> |                  |                | Low <i>V</i>                                 | High <i>V</i> |
|                                      |                                | Seated at theater | Theater, matinee           | 115              | 95             | 65   | 30            |
| Seated at theater, night             | Theater, night                 | 115               | 105                        | 70               | 35             | 60   | 27            |
| Seated, very light work              | Offices, hotels, apartments    | 130               | 115                        | 70               | 45             |  |               |
| Moderately active office work        | Offices, hotels, apartments    | 140               | 130                        | 75               | 55             |  |               |
| Standing, light work; walking        | Department store; retail store | 160               | 130                        | 75               | 55             | 58   | 38            |
| Walking, standing                    | Drug store, bank               | 160               | 145                        | 75               | 70             |  |               |
| Sedentary work                       | Restaurant <sup>c</sup>        | 145               | 160                        | 80               | 80             |  |               |
| Light bench work                     | Factory                        | 235               | 220                        | 80               | 140            |  |               |
| Moderate dancing                     | Dance hall                     | 265               | 250                        | 90               | 160            | 49   | 35            |
| Walking 4.8 km/h; light machine work | Factory                        | 295               | 295                        | 110              | 185            |  |               |
| Bowling <sup>d</sup>                 | Bowling alley                  | 440               | 425                        | 170              | 255            |  |               |
| Heavy work                           | Factory                        | 440               | 425                        | 170              | 255            | 54   | 19            |
| Heavy machine work; lifting          | Factory                        | 470               | 470                        | 185              | 285            |  |               |
| Athletics                            | Gymnasium                      | 585               | 525                        | 210              | 315            |  |               |

**Notes:**

1. Tabulated values are based on 24°C room dry-bulb temperature. For 27°C room dry bulb, total heat remains the same, but sensible heat values should be decreased by approximately 20%, and latent heat values increased accordingly.
2. Also see Table 4, Chapter 9, for additional rates of metabolic heat generation.
3. All values are rounded to nearest 5 W.
- <sup>a</sup>Adjusted heat gain is based on normal percentage of men, women, and children for the application listed, and assumes that gain from an adult female is

- 85% of that for an adult male, and gain from a child is 75% of that for an adult male.
- <sup>b</sup>Values approximated from data in Table 6, Chapter 9, where *V* is air velocity with limits shown in that table.
- <sup>c</sup>Adjusted heat gain includes 18 W for food per individual (9 W sensible and 9 W latent).
- <sup>d</sup>Figure one person per alley actually bowling, and all others as sitting (117 W) or standing or walking slowly (231 W).

Se considera que las personas que habitarán el domo se encuentran sentadas y/o que desarrollan actividades de esfuerzo ligero y además, el lugar que más se asemeja al domo es un departamento por lo que se toman el valor de 70 W como calor sensible y 45 W como calor latente por persona.

### A.9. Densidad de potencia de iluminación (ASHRAE 2009:18.5)

Table 2 Lighting Power Densities Using Space-by-Space Method

| Common Space Types*  | LPD, W/m <sup>2</sup> | Building-Specific Space Types   | LPD, W/m <sup>2</sup> |
|--|-----------------------|---|-----------------------|
| Office—enclosed  | 12                    | Gymnasium/exercise center   |                       |
| Office—open plan   | 12                    | Playing Area  | 15                    |
| Conference/meeting/multipurpose  | 14                    | Exercise Area   | 10                    |
| Classroom/lecture/training   | 15                    | Courthouse/police station/penitentiary  |                       |
| For penitentiary   | 14                    | Courtroom   | 20                    |
| Lobby  | 14                    | Confinement cells   | 10                    |
| For hotel  | 12                    | Judges' chambers  | 14                    |
| For performing arts theater  | 36                    | Fire Stations   |                       |
| For motion picture theater   | 12                    | Engine room   | 9                     |
| Audience/seating Area  | 10                    | Sleeping quarters   | 3                     |
| For gymnasium  | 4                     | Post office—sorting area  | 13                    |
| For exercise center  | 3                     | Convention center—exhibit space   | 14                    |
| For convention center  | 8                     | Library   |                       |
| For penitentiary   | 8                     | Card file and cataloging  | 12                    |
| For religious buildings  | 18                    | Stacks  | 18                    |
| For sports arena   | 4                     | Reading area  | 13                    |
| For performing arts theater  | 28                    | Hospital  |                       |
| For motion picture theater   | 13                    | Emergency   | 29                    |
| For transportation   | 5                     | Recovery  | 9                     |
| Atrium—first three floors  | 6                     | Nurses' station   | 11                    |
| Atrium—each additional floor   | 2                     | Exam/treatment  | 16                    |
| Lounge/recreation  | 13                    | Pharmacy  | 13                    |
| For hospital   | 9                     | Patient room  | 8                     |
| Dining Area  | 10                    | Operating room  | 24                    |
| For penitentiary   | 14                    | Nursery   | 6                     |
| For hotel  | 14                    | Medical supply  | 15                    |
| For motel  | 13                    | Physical therapy  | 10                    |
| For bar lounge/leisure dining  | 15                    | Radiology   | 4                     |
| For family dining  | 23                    | Laundry—washing   | 6                     |
| Food preparation   | 13                    | Automotive—service/repair   | 8                     |
| Laboratory   | 15                    | Manufacturing   |                       |
| Restrooms  | 10                    | Low bay (<7.6 m floor to ceiling height)                                      | 13                    |
| Dressing/locker/fitting room   | 6                     | High bay (≥7.6 m floor to ceiling height)                                     | 18                    |
| Corridor/transition  | 5                     | Detailed manufacturing  | 23                    |
| For hospital   | 11                    | Equipment room  | 13                    |
| For manufacturing facility   | 5                     | Control room  | 5                     |
| Stairs—active  | 6                     | Hotel/motel guest rooms   | 12                    |
| Active storage   | 9                     | Dormitory—living quarters   | 12                    |
| For hospital   | 10                    | Museum  |                       |
| Inactive storage   | 3                     | General exhibition  | 11                    |
| For museum   | 9                     | Restoration   | 18                    |
| Electrical/mechanical  | 16                    | Bank/office—banking activity area   | 16                    |
| Workshop   | 20                    | Religious buildings   |                       |
| Sales area [for accent lighting, see Section 9.6.2(B) of ASHRAE Standard 90.1] | 18                    | Worship pulpit, choir   | 26                    |
|  |                       | Fellowship hall   | 10                    |
|  |                       | Retail  |                       |
|  |                       | Sales area for accent lighting, see Section 9.6.3(C) of ASHRAE Standard 90.1] | 18                    |
|  |                       | Mall concourse  | 18                    |
|  |                       | Sports arena  |                       |
|  |                       | Ring sports area  | 29                    |
|  |                       | Court sports area   | 25                    |
|  |                       | Indoor playing field area   | 15                    |
|  |                       | Warehouse   |                       |
|  |                       | Fine material storage   | 15                    |
|  |                       | Medium/bulky material storage   | 10                    |
|  |                       | Parking garage—garage area  | 2                     |
|  |                       | Transportation  |                       |
|  |                       | Airport—concourse   | 6                     |
|  |                       | Air/train/bus—baggage area  | 11                    |
|  |                       | Terminal—ticket counter   | 16                    |

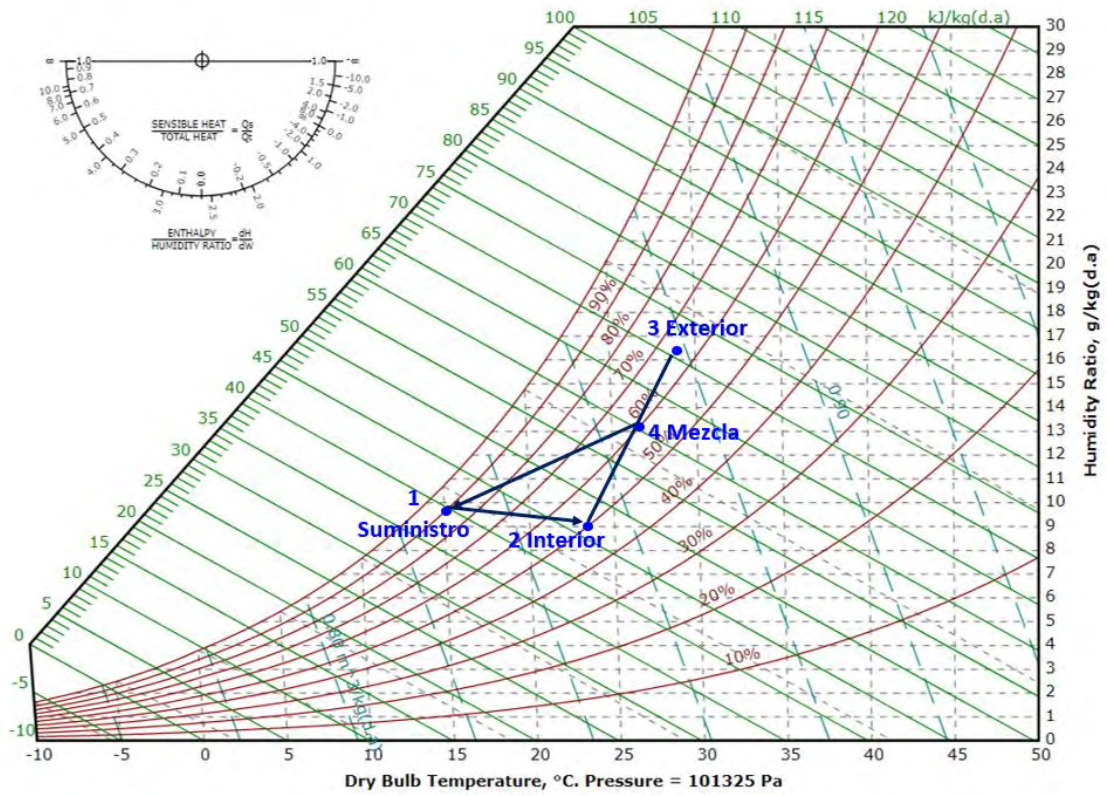
Source: ASHRAE Standard 90.1-2007.

\*In cases where both a common space type and a building-specific type are listed, the building-specific space type applies.

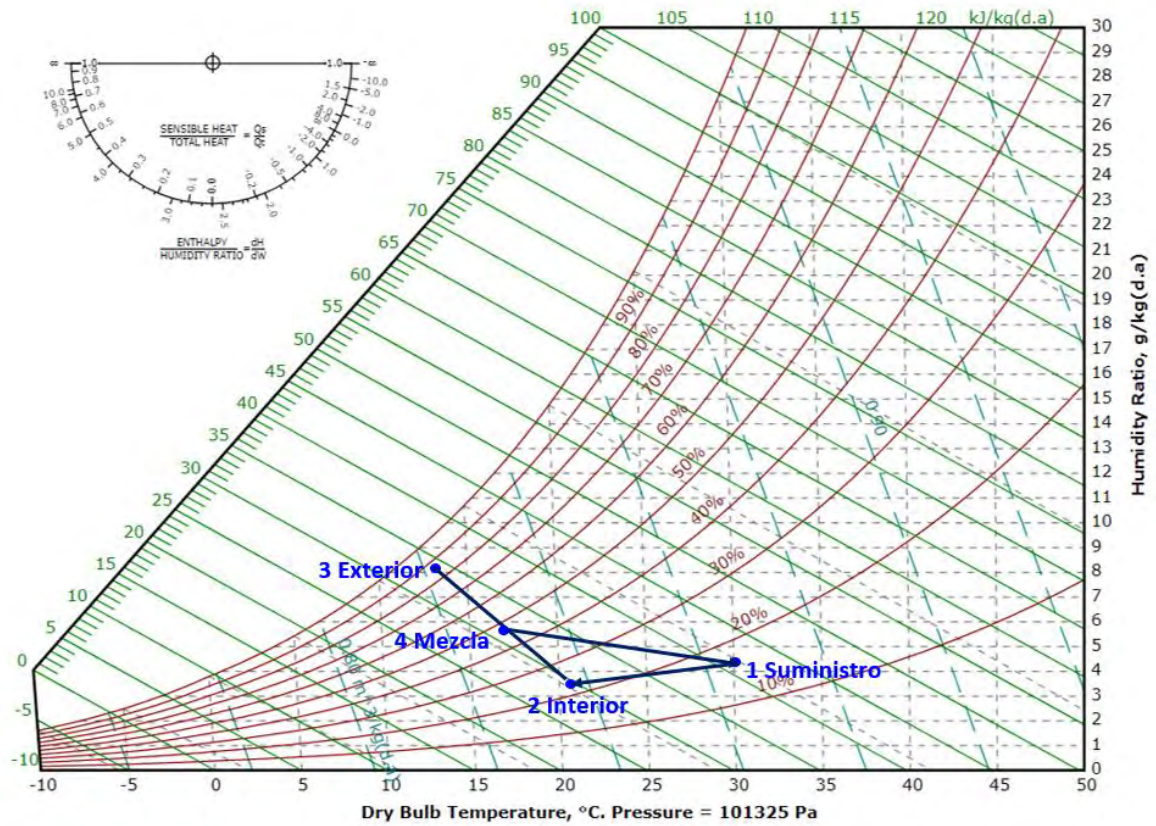
El domo será tomado como una habitación de huéspedes para un hotel, por lo que la densidad de potencia de iluminación es de 12 W/m<sup>2</sup>.



### A.10. Carta psicrométrica para la época de verano.



### A.11. Carta psicrométrica para la época de invierno.



### A.12. Velocidades recomendadas de retorno. (ASHRAE 2005:33.15)

**Table 5 Recommended Return Inlet Face Velocities**

| Inlet Location                       | Velocity Across Gross Area, m/s |
|--------------------------------------|---------------------------------|
| Above occupied zone                  | >4                              |
| Within occupied zone, not near seats | 3 to 4                          |
| Within occupied zone, near seats     | 2 to 3                          |
| Door or wall louvers                 | 1 to 1.5                        |
| Through undercut area of doors       | 1 to 1.5                        |

**Table 5 Recommended Return Inlet Face Velocities**

| Inlet Location                       | Velocity Across Gross Area, fpm |
|--------------------------------------|---------------------------------|
| Above occupied zone                  | >800                            |
| Within occupied zone, not near seats | 600 to 800                      |
| Within occupied zone, near seats     | 400 to 600                      |
| Door or wall louvers                 | 200 to 300                      |
| Through undercut area of doors       | 200 to 300                      |

Para el caso descrito, se tomará el valor de 3m/s (600fpm) ya que las rejillas de retorno si bien estarán sobre una zona ocupada, velocidades muy altas generan mucho ruido.



**A.13. Velocidades máximas recomendadas para salidas de aire y retornos que satisfagan el criterio de diseño acústico detallado. (ASHRAE 2003:47.10)**

Unidades del Sistema Internacional (SI)

**Table 4 Maximum Recommended “Free” Supply Outlet and Return Air Opening Velocities Needed to Achieve Specified Acoustic Design Criteria**

| Type of Opening    | Design RC(N) | “Free” Opening Airflow Velocity, m/s |
|--------------------|--------------|--------------------------------------|
| Supply air outlet  | 45           | 3.2                                  |
|                    | 40           | 2.8                                  |
|                    | 35           | 2.5                                  |
|                    | 30           | 2.2                                  |
|                    | 25           | 1.8                                  |
| Return air opening | 45           | 3.8                                  |
|                    | 40           | 3.4                                  |
|                    | 35           | 3.0                                  |
|                    | 30           | 2.5                                  |
|                    | 25           | 2.2                                  |

*Note:* The presence of diffusers or grilles can increase sound levels by varying amounts, depending on how many diffusers or grilles are installed and on their design, construction, and installation. Thus, allowable outlet or opening airflow velocities should be reduced accordingly.

Unidades del Sistema Imperial

**Table 4 Maximum Recommended “Free” Supply Outlet and Return Air Opening Velocities Needed to Achieve Specified Acoustic Design Criteria**

| Type of Opening    | Design RC(N) | “Free” Opening Airflow Velocity, fpm |
|--------------------|--------------|--------------------------------------|
| Supply air outlet  | 45           | 625                                  |
|                    | 40           | 560                                  |
|                    | 35           | 500                                  |
|                    | 30           | 425                                  |
|                    | 25           | 350                                  |
| Return air opening | 45           | 750                                  |
|                    | 40           | 675                                  |
|                    | 35           | 600                                  |
|                    | 30           | 500                                  |
|                    | 25           | 425                                  |

*Note:* The presence of diffusers or grilles can increase sound levels by varying amounts, depending on how many diffusers or grilles are installed and on their design, construction, and installation. Thus, allowable outlet or opening airflow velocities should be reduced accordingly.



#### A.14. Velocidad de aire máxima recomendada para ductos (CARRIER 2009:II-36)

**TABLA 6 - Velocidades máximas recomendadas para sistemas de baja velocidad (m/s)**

| APLICACIÓN  | FACTOR DE CONTROL DEL NIVEL DE RUIDO<br>(conductos principales) | FACTOR DE CONTROL ROZAMIENTO EN CONDUCTO |         |                     |         |
|---|---|--|---------|---------------------|---------|
|   |   | Conductos principales                    |         | Conductos derivados |         |
|   |   | Suministro                               | Retorno | Suministro          | Retorno |
| Residencias   | 3   | 5  | 4       | 3                   | 3       |
| Apartamentos; Dormitorios de hotel; Dormitorios de hospital | 5   | 7,5                                      | 6,5     | 6                   | 5       |
| Oficinas particulares; Despachos de directores; Bibliotecas | 6   | 10                                       | 7,5     | 8                   | 6       |
| Salas de cine y teatro Auditorios                           | 4   | 6,5                                      | 5,5     | 5                   | 4       |
| Oficinas públicas; Restaurantes de primera categoría        | 7,5   | 10                                       | 7,5     | 8                   | 6       |
| Comercios de primera categoría; Bancos                      |   |  |         |                     |         |
| Comercios de categoría media; Cafeterías                    | 9   | 10                                       | 7,5     | 8                   | 6       |
| Locales industriales  | 12,5  | 15                                       | 9       | 11                  | 7,5     |

El domo será de uso familiar por lo que se considera una residencia, entonces de acuerdo a la tabla mostrada, la velocidad máxima recomendada para el conducto principal será de 3 m/s.



**A.15. Dimensiones equivalentes de ductos rectangulares (fragmento).  
(CARRIER 2009: II-37)**

**TABLA 7a - DIÁMETROS EQUIVALENTES DE CONDUCTOS RECTANGULARES**

| Medidas del conducto | 100 | 150 | 200 | 250 | 300 | 350 | 400  | 450  | 500  | 550  | 600  | 650  | 700  | 750  | 800  | 900  | 1000 |
|----------------------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|
| 100                  | 109 | --- | --- | --- | --- | --- | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 150                  | 133 | 164 | --- | --- | --- | --- | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 200                  | 152 | 189 | 219 | --- | --- | --- | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 250                  | 169 | 210 | 244 | 273 | --- | --- | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 300                  | 183 | 229 | 266 | 299 | 328 | --- | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 350                  | 195 | 245 | 286 | 322 | 354 | 383 | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 400                  | 207 | 260 | 305 | 343 | 378 | 409 | 437  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 450                  | 217 | 274 | 321 | 363 | 400 | 433 | 464  | 492  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 500                  | 227 | 287 | 337 | 381 | 420 | 455 | 488  | 518  | 547  | ---  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 550                  | 236 | 299 | 352 | 398 | 439 | 477 | 511  | 543  | 573  | 601  | ---  | ---  | ---  | ---  | ---  | ---  | ---  |
| 600                  | 245 | 310 | 365 | 414 | 457 | 496 | 533  | 567  | 598  | 628  | 656  | ---  | ---  | ---  | ---  | ---  | ---  |
| 650                  | 253 | 321 | 378 | 429 | 474 | 515 | 553  | 589  | 622  | 653  | 683  | 711  | ---  | ---  | ---  | ---  | ---  |
| 700                  | 261 | 331 | 391 | 443 | 490 | 533 | 573  | 610  | 644  | 677  | 708  | 737  | 765  | ---  | ---  | ---  | ---  |
| 750                  | 268 | 341 | 402 | 457 | 506 | 550 | 592  | 630  | 666  | 700  | 732  | 763  | 792  | 820  | ---  | ---  | ---  |
| 800                  | 275 | 350 | 414 | 470 | 520 | 567 | 609  | 649  | 687  | 722  | 755  | 787  | 818  | 847  | 875  | ---  | ---  |
| 900                  | --- | 367 | 435 | 494 | 548 | 597 | 643  | 686  | 726  | 763  | 799  | 833  | 866  | 897  | 927  | 984  | ---  |
| 1000                 | --- | 384 | 454 | 517 | 574 | 626 | 674  | 719  | 762  | 802  | 840  | 876  | 911  | 944  | 976  | 1037 | 1093 |
| 1100                 | --- | 399 | 473 | 538 | 598 | 652 | 703  | 751  | 795  | 838  | 878  | 916  | 953  | 988  | 1022 | 1086 | 1146 |
| 1200                 | --- | 413 | 490 | 558 | 620 | 677 | 731  | 780  | 827  | 872  | 914  | 954  | 993  | 1030 | 1066 | 1133 | 1196 |
| 1300                 | --- | --- | 506 | 577 | 642 | 701 | 757  | 808  | 857  | 904  | 945  | 990  | 1031 | 1069 | 1107 | 1177 | 1244 |
| 1400                 | --- | --- | 522 | 595 | 662 | 724 | 781  | 835  | 886  | 934  | 980  | 1024 | 1066 | 1107 | 1146 | 1220 | 1289 |
| 1500                 | --- | --- | 536 | 612 | 681 | 745 | 805  | 860  | 913  | 963  | 1011 | 1057 | 1100 | 1143 | 1183 | 1260 | 1332 |
| 1600                 | --- | --- | 551 | 629 | 700 | 766 | 827  | 885  | 939  | 991  | 1041 | 1088 | 1133 | 1177 | 1219 | 1298 | 1373 |
| 1700                 | --- | --- | --- | 644 | 718 | 785 | 849  | 908  | 964  | 1018 | 1069 | 1118 | 1164 | 1209 | 1253 | 1335 | 1413 |
| 1800                 | --- | --- | --- | 660 | 735 | 804 | 869  | 930  | 988  | 1043 | 1096 | 1146 | 1195 | 1241 | 1286 | 1371 | 1451 |
| 1900                 | --- | --- | --- | 674 | 751 | 823 | 889  | 952  | 1012 | 1068 | 1122 | 1174 | 1224 | 1271 | 1318 | 1405 | 1488 |
| 2000                 | --- | --- | --- | 688 | 767 | 840 | 908  | 973  | 1034 | 1092 | 1147 | 1200 | 1252 | 1301 | 1348 | 1438 | 1523 |
| 2100                 | --- | --- | --- | --- | 782 | 857 | 927  | 993  | 1055 | 1115 | 1172 | 1226 | 1279 | 1329 | 1378 | 1470 | 1558 |
| 2200                 | --- | --- | --- | --- | 797 | 874 | 945  | 1013 | 1076 | 1137 | 1195 | 1251 | 1305 | 1356 | 1406 | 1501 | 1591 |
| 2300                 | --- | --- | --- | --- | 812 | 890 | 963  | 1031 | 1097 | 1159 | 1218 | 1275 | 1330 | 1383 | 1434 | 1532 | 1623 |
| 2400                 | --- | --- | --- | --- | 826 | 905 | 980  | 1050 | 1116 | 1180 | 1241 | 1299 | 1355 | 1409 | 1461 | 1561 | 1655 |
| 2500                 | --- | --- | --- | --- | --- | 920 | 996  | 1068 | 1136 | 1200 | 1262 | 1322 | 1379 | 1434 | 1488 | 1589 | 1685 |
| 2600                 | --- | --- | --- | --- | --- | 935 | 1012 | 1085 | 1154 | 1220 | 1283 | 1344 | 1402 | 1459 | 1513 | 1617 | 1715 |
| 2700                 | --- | --- | --- | --- | --- | 950 | 1028 | 1102 | 1173 | 1240 | 1304 | 1366 | 1425 | 1483 | 1538 | 1644 | 1744 |
| 2800                 | --- | --- | --- | --- | --- | 964 | 1043 | 1119 | 1190 | 1259 | 1324 | 1387 | 1447 | 1506 | 1562 | 1670 | 1772 |
| 2900                 | --- | --- | --- | --- | --- | --- | 1058 | 1135 | 1208 | 1277 | 1344 | 1408 | 1469 | 1529 | 1586 | 1696 | 1800 |
| 3000                 | --- | --- | --- | --- | --- | --- | 1076 | 1154 | 1228 | 1299 | 1366 | 1431 | 1494 | 1555 | 1613 | 1725 | 831  |

En esta tabla de diámetros equivalentes las dimensiones están expresadas en mm y se han obtenido utilizando la ecuación (2) de este capítulo:

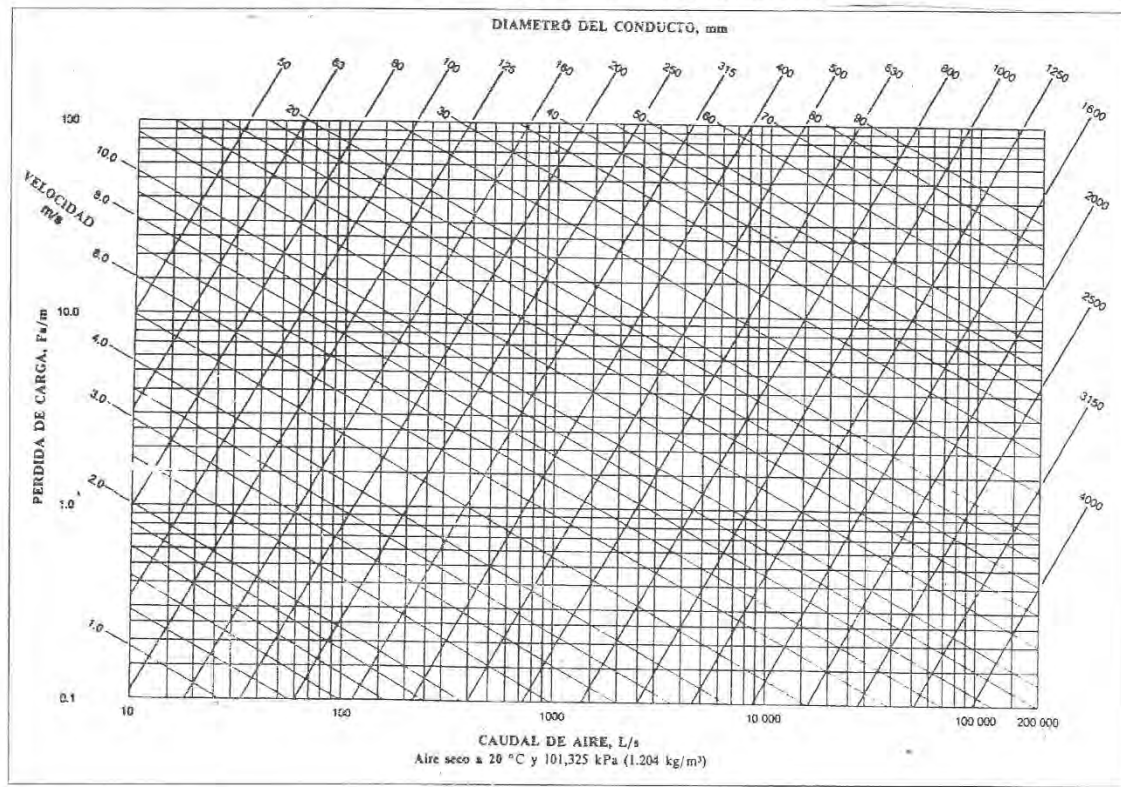
$$D_{eq} = 1,55 S^{0,625} / P^{0,25}$$

Siendo S = Área de paso de la sección recta;

P = Perímetro interior de la sección recta.

**A.16. Pérdida por rozamiento en conducto redondo (Aire seco a 20 °C y 101,325 kPa). (CARRIER 2009: II-39)**

GRÁFICO 2. PÉRDIDA POR ROZAMIENTO EN CONDUCTO REDONDO

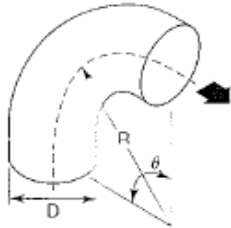


## A.17. Coeficientes de pérdida de los accesorios (ASHRAE 2005:35.52-35.66)

**TABLE 8.4 LOSS COEFFICIENTS, ELBOWS**

Use the velocity pressure ( $H_v$ ) of the upstream section. Fitting loss ( $H_f$ ) =  $C \times H_v$

### A. Elbow, Smooth Radius (Die Stamped), Round



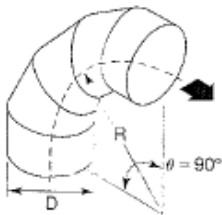
Coefficients for 90° Elbows: (See Note)

| R/D | 0.5  | 0.75 | 1.0  | 1.5  | 2.0  | 2.5  |
|-----|------|------|------|------|------|------|
| C   | 0.71 | 0.33 | 0.22 | 0.15 | 0.13 | 0.12 |

Note: For angles other than 90° multiply by the following factor:

| $\theta$ | 0° | 20°  | 30°  | 45°  | 60°  | 75°  | 90°  | 110° | 130° | 150° | 180° |
|----------|----|------|------|------|------|------|------|------|------|------|------|
| K        | 0  | 0.31 | 0.45 | 0.60 | 0.78 | 0.90 | 1.00 | 1.13 | 1.20 | 1.28 | 1.40 |

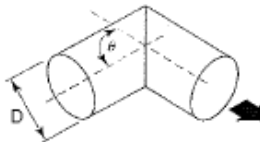
### B. Elbow, Round, 3 to 5 pc — 90°



Coefficient C

| No. of Pieces | R/D  |      |      |      |      |
|---------------|------|------|------|------|------|
|               | 0.5  | 0.75 | 1.0  | 1.5  | 2.0  |
| 5             | —    | 0.46 | 0.33 | 0.24 | 0.19 |
| 4             | —    | 0.50 | 0.37 | 0.27 | 0.24 |
| 3             | 0.98 | 0.54 | 0.42 | 0.34 | 0.33 |

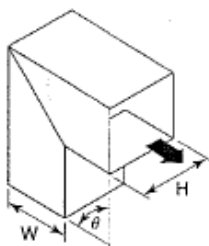
### C. Elbow, Round, Mitered



Coefficient C

| $\theta$ | 20°  | 30°  | 45°  | 60°  | 75°  | 90° |
|----------|------|------|------|------|------|-----|
| C        | 0.08 | 0.16 | 0.34 | 0.55 | 0.81 | 1.2 |

### D. Elbow, Rectangular, Mitered

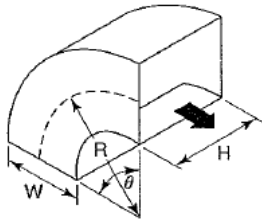


Coefficient C

| $\theta$ | H/W  |      |      |      |      |      |      |      |      |      |      |
|----------|------|------|------|------|------|------|------|------|------|------|------|
|          | 0.25 | 0.5  | 0.75 | 1.0  | 1.5  | 2.0  | 3.0  | 4.0  | 5.0  | 6.0  | 8.0  |
| 20°      | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 |
| 30°      | 0.18 | 0.17 | 0.17 | 0.16 | 0.15 | 0.15 | 0.13 | 0.13 | 0.12 | 0.12 | 0.11 |
| 45°      | 0.38 | 0.37 | 0.36 | 0.34 | 0.33 | 0.31 | 0.28 | 0.27 | 0.26 | 0.25 | 0.24 |
| 60°      | 0.60 | 0.59 | 0.57 | 0.55 | 0.52 | 0.49 | 0.46 | 0.43 | 0.41 | 0.39 | 0.38 |
| 75°      | 0.89 | 0.87 | 0.84 | 0.81 | 0.77 | 0.73 | 0.67 | 0.63 | 0.61 | 0.58 | 0.57 |
| 90°      | 1.3  | 1.3  | 1.2  | 1.2  | 1.1  | 1.1  | 0.98 | 0.92 | 0.89 | 0.85 | 0.83 |



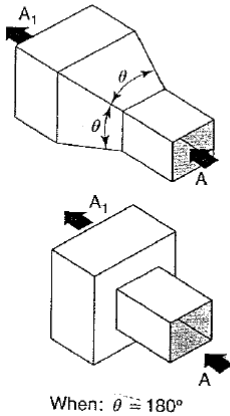
**E. Elbow, Rectangular, Smooth Radius without Vanes**



Coefficients for 90° elbows: (See Note)

| R/W  | H/W  |      |      |      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|------|------|------|------|
|      | 0.25 | 0.5  | 0.75 | 1.0  | 1.5  | 2.0  | 3.0  | 4.0  | 5.0  | 6.0  | 8.0  |
| 0.5  | 1.5  | 1.4  | 1.3  | 1.2  | 1.1  | 1.0  | 1.0  | 1.1  | 1.1  | 1.2  | 1.2  |
| 0.75 | 0.57 | 0.52 | 0.48 | 0.44 | 0.40 | 0.39 | 0.39 | 0.40 | 0.42 | 0.43 | 0.44 |
| 1.0  | 0.27 | 0.25 | 0.23 | 0.21 | 0.19 | 0.18 | 0.18 | 0.19 | 0.20 | 0.21 | 0.21 |
| 1.5  | 0.22 | 0.20 | 0.19 | 0.17 | 0.15 | 0.14 | 0.14 | 0.15 | 0.16 | 0.17 | 0.17 |
| 2.0  | 0.20 | 0.18 | 0.16 | 0.15 | 0.14 | 0.13 | 0.13 | 0.14 | 0.14 | 0.15 | 0.15 |

**B. Transition, Rectangular, Pyramidal**



Coefficient C (See Note 1)

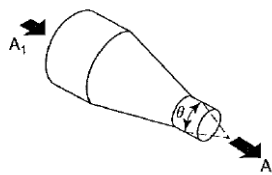
| A <sub>1</sub> /A | θ    |      |      |      |      |      |      |      |
|-------------------|------|------|------|------|------|------|------|------|
|                   | 16°  | 20°  | 30°  | 45°  | 60°  | 90°  | 120° | 180° |
| 2                 | 0.18 | 0.22 | 0.25 | 0.29 | 0.31 | 0.32 | 0.33 | 0.30 |
| 4                 | 0.36 | 0.43 | 0.50 | 0.56 | 0.61 | 0.63 | 0.63 | 0.63 |
| 6                 | 0.42 | 0.47 | 0.58 | 0.68 | 0.72 | 0.76 | 0.76 | 0.75 |
| ≥10               | 0.42 | 0.49 | 0.59 | 0.70 | 0.80 | 0.87 | 0.85 | 0.86 |

Note: A = Area (Entering airstream), A<sub>1</sub> = Area (Leaving airstream)

**TABLE 8.6 LOSS COEFFICIENTS, TRANSITIONS (CONVERGING FLOW)**

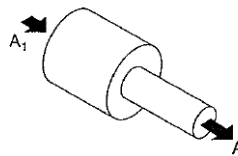
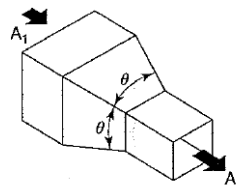
Use the velocity pressure ( $H_v$ ) of the downstream section. Fitting loss ( $H_f$ ) =  $C \times H_v$

**A. Contraction, Round and Rectangular, Gradual to Abrupt**



Coefficient C (See Note)

| A <sub>1</sub> /A | θ    |         |         |      |      |      |      |
|-------------------|------|---------|---------|------|------|------|------|
|                   | 10°  | 15°-40° | 50°-60° | 90°  | 120° | 150° | 180° |
| 2                 | 0.05 | 0.05    | 0.06    | 0.12 | 0.18 | 0.24 | 0.26 |
| 4                 | 0.05 | 0.04    | 0.07    | 0.17 | 0.27 | 0.35 | 0.41 |
| 6                 | 0.05 | 0.04    | 0.07    | 0.18 | 0.28 | 0.36 | 0.42 |
| 10                | 0.05 | 0.05    | 0.08    | 0.19 | 0.29 | 0.37 | 0.43 |



When:  $\theta = 180^\circ$

Note: A = Area (Entering airstream), A<sub>1</sub> = Area (Leaving airstream)

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## B. RESULTADOS

### B.1 Cálculo de coeficientes globales de transmisión de calor

#### Cálculo del coeficiente global para placa vertical

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area superficial      | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.6 °C                      |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.00 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coefficiente de expansión v  | β         | 0.00334448 1/K               |
| Conductividad térmica  | k         | 0.02558 °W/m.K               |
| Viscosidad cinemática  | v         | 0.00001571 m <sup>2</sup> /s |
| Número adimensional de Pr  | Pr        | 0.72938                      |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 38774.72444                  |
| Número de Nusselt  | Nu        | 2.51                         |
| Kefec  | kefec     | 0.06421 °W/m.K               |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | 27.8 °C                      | 24.3 °C                      |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 °W/m.K               | 0.02544 °W/m.K               |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 23090221.51                  | 30676777.95                  |
| Número de Nusselt  | Nu      | 39.8                         | 43.3                         |
| Coefficiente convectivo                                  | hconv   | 1.205 W/m <sup>2</sup> K     | 1.295 W/m <sup>2</sup> K     |
| Coefficiente radiactivo                                  | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |

| Cálculo de resistencias                                |           |              |
|--|-----------|--------------|
| Resistencia convección y radiación en el interior      | Rcomb.int | 0.147848 K/W |
| Resistencia conducción en capa interna                 | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de aire | Rcap aire | 0.778743 K/W |
| Resistencia conducción en capa externa                 | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior      | Rcomb.ext | 0.145019 K/W |
| Resistencia total                                      | Rtotal    | 1.075457 K/W |
| Flujo de calor   | Q         | 4.091 W      |

|   | Asumida  | Calculada                  |
|---|----------|----------------------------|
| Temperatura superficial exterior              | 27.80 °C | 27.607 °C                  |
| Temperatura aire exterior                     | 27.60 °C | 27.599 °C                  |
| Temperatura aire interior                     | 24.40 °C | 24.413 °C                  |
| Temperatura superficial interior              | 24.30 °C | 24.405 °C                  |
| Coefficiente global de transferencia de calor | U        | 0.9298 W/m <sup>2</sup> .K |

### Cálculo del coeficiente global para placa inclinada 66°

|                       |            |                    |
|-----------------------|------------|--------------------|
| Temperatura exterior  | Text       | 28.2 °C            |
| Temperatura interior  | Tint       | 23.8 °C            |
| Largo                 | H          | 0.850 m            |
| Ancho                 | W          | 1.000 m            |
| Area superficial      | As = L x W | 1.00m <sup>2</sup> |
| Espesor 1             | e1         | 0.001 m            |
| Espesor capa de aire  | eaire      | 0.05 m             |
| Espesor 2             | e2         | 0.001 m            |
| Material              |            | Poliuretano        |
| Emisividad            | ε          | 0.92               |
| Emisividad efectiva   | εefectiva  | 0.852              |
| Conductividad térmica | k          | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ          | 66                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | ν       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 21093966.98                  | 28024631.15                  |
| Número de Nusselt  | Nu      | 38.8                         | 42.1                         |
| Coefficiente convectivo                                  | hconv   | 1.174 W/m <sup>2</sup> K     | 1.261 W/m <sup>2</sup> K     |
| Coefficiente radiactivo                                  | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 6.865 W/m <sup>2</sup> K     | 6.730 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | <b>27.6 °C</b>               |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.00 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coefficiente de expansión volumétrica                              | β         | 0.00334448 1/K               |
| Conductividad térmica  | k         | 0.02558 W/m.K                |
| Viscosidad cinemática  | ν         | 0.00001571 m <sup>2</sup> /s |
| Número adimensional de Prandtl                                     | Pr        | 0.72938                      |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 38774.72444                  |
| Número de Nusselt  | Nu        | 2.56                         |
| Kefec  | kefec     | 0.06561 W/m.K                |

| Cálculo de resistencias                           |           |              |
|---|-----------|--------------|
| Resistencia convección y radiación en el interior | Rcomb.int | 0.148587 K/W |
| Resistencia conducción en capa interna            | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de | Rcap.aire | 0.762025 K/W |
| Resistencia conducción en capa externa            | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior | Rcomb.ext | 0.145677 K/W |
| Resistencia total                                 | Rotal     | 1.060135 K/W |
| Flujo de calor                                    | Q         | 4.150 W      |

|   | Asumida  | Calculada                  |
|---|----------|----------------------------|
| Temperatura superficial exterior            | 27.80 °C | 27.595 °C                  |
| Temperatura aire exterior                   | 27.60 °C | 27.587 °C                  |
| Temperatura aire interior                   | 24.40 °C | 24.425 °C                  |
| Temperatura superficial interior            | 24.30 °C | 24.417 °C                  |
| Coficiente global de transferencia de calor | U        | 0.9433 W/m <sup>2</sup> .K |





### Cálculo del coeficiente global para placa inclinada 63°

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area supeficial       | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ           | 63                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coeficiente de expansión volumétrica                     | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 20573538.01                  | 27333209.29                  |
| Número de Nusselt  | Nu      | 38.5                         | 41.8                         |
| Coeficiente convectivo                                   | hconv   | 1.166 W/m <sup>2</sup> K     | 1.252 W/m <sup>2</sup> K     |
| Coeficiente radioactivo                                  | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coeficiente combinado                                    | hcomb   | 6.856 W/m <sup>2</sup> K     | 6.721 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | <b>27.6 °C</b>               |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.00 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coefficiente de expansión volumétrica                              | $\beta$   | 0.00334448 1/K               |
| Conductividad térmica  | k         | 0.02558 W/m.K                |
| Viscosidad cinemática  | $\nu$     | 0.00001571 m <sup>2</sup> /s |
| Número adimensional de Prandtl                                     | Pr        | 0.72938                      |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 38774.72444                  |
| Número de Nusselt  | Nu        | 2.64                         |
| Kefec  | kefec     | 0.06743 W/m.K                |

| <b>Cálculo de resistencias</b>                         |           |              |
|--|-----------|--------------|
| Resistencia convección y radiación en el interior      | Rcomb.int | 0.148789 K/W |
| Resistencia conducción en capa interna                 | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de aire | Rcap.aire | 0.741547 K/W |
| Resistencia conducción en capa externa                 | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior      | Rcomb.ext | 0.145856 K/W |
| Resistencia total                                      | Rotal     | 1.040038 K/W |
| Flujo de calor   | Q         | 4.231 W      |

|   | Asumida  | Calculada                  |
|---|----------|----------------------------|
| Temperatura superficial exterior              | 27.80 °C | 27.583 °C                  |
| Temperatura aire exterior                     | 27.60 °C | 27.575 °C                  |
| Temperatura aire interior                     | 24.40 °C | 24.438 °C                  |
| Temperatura superficial interior              | 24.30 °C | 24.429 °C                  |
| Coefficiente global de transferencia de calor | U        | 0.9615 W/m <sup>2</sup> .K |

### Cálculo del coeficiente global para placa inclinada 46°

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area superficial      | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ           | 46                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 16609715.33                  | 22067027.32                  |
| Número de Nusselt  | Nu      | 36.2                         | 39.3                         |
| Coefficiente convectivo                                  | hconv   | 1.096 W/m <sup>2</sup> K     | 1.176 W/m <sup>2</sup> K     |
| Coefficiente radiactivo                                  | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 6.786 W/m <sup>2</sup> K     | 6.646 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.6 °C                      |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.00 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coeficiente de expansión $\nu\beta$                                |           | 0.00334448 1/K               |
| Conductividad térmica  | k         | 0.02558 W/m.K                |
| Viscosidad cinemática  | $\nu$     | 0.00001571 m <sup>2</sup> /s |
| Número adimensional de Pr  | Pr        | 0.72938                      |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 38774.72444                  |
| Número de Nusselt  | Nu        | 2.93                         |
| Kefec  | kefec     | 0.07495 W/m.K                |

| <b>Cálculo de resistencias</b>                         |           |              |
|--|-----------|--------------|
| Resistencia convección y radiación en el interior      | Rcomb.int | 0.150477 K/W |
| Resistencia conducción en capa interna                 | Rcap.int  | 0.001923 K/W |
| Resistencia por conveccion y radiacion en capa de aire | Rcap.aire | 0.667110 K/W |
| Resistencia conducción en capa externa                 | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior      | Rcomb.ext | 0.147356 K/W |
| Resistencia total                                      | Rtotal    | 0.968788 K/W |
| Flujo de calor   | Q         | 4.542 W      |

|  | Asumida  | Calculada                  |
|--|----------|----------------------------|
| Temperatura superficial exterior             | 27.80 °C | 27.531 °C                  |
| Temperatura aire exterior                    | 27.60 °C | 27.522 °C                  |
| Temperatura aire interior                    | 24.40 °C | 24.492 °C                  |
| Temperatura superficial interior             | 24.30 °C | 24.483 °C                  |
| Coeficiente global de transferencia de calor | U        | 1.0322 W/m <sup>2</sup> .K |



### Cálculo del coeficiente global para placa inclinada 36°

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area supeficial       | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ           | 36                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 13572091.68                  | 18031357.67                  |
| Número de Nusselt  | Nu      | 34.2                         | 37.1                         |
| Coefficiente convectivo                                  | hconv   | 1.034 W/m <sup>2</sup> K     | 1.110 W/m <sup>2</sup> K     |
| Coefficiente radioactivo                                 | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 6.725 W/m <sup>2</sup> K     | 6.579 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.7 °C                      |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.05 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coeficiente de expansión vol                                       | $\beta$   | 0.00334392 1/K               |
| Conductividad térmica  | k         | 0.02559 W/m.K                |
| Viscosidad cinemática  | $\nu$     | 0.00001572 m <sup>2</sup> /s |
| Número adimensional de Pr  | Pr        | 0.729369                     |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 39955.74695                  |
| Número de Nusselt  | Nu        | 3.07                         |
| Kefec  | kefec     | 0.07861 W/m.K                |

| <b>Cálculo de resistencias</b>                    |           |              |
|---|-----------|--------------|
| Resistencia convección y radiación en el interior | Rcomb.int | 0.152001 K/W |
| Resistencia conducción en capa interna            | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de | Rcap.aire | 0.636041 K/W |
| Resistencia conducción en capa externa            | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior | Rcomb.ext | 0.148708 K/W |
| Resistencia total                                 | Rotal     | 0.940597 K/W |
| Flujo de calor                                    | Q         | 4.678 W      |

|  | Asumida  | Calculada                  |
|--|----------|----------------------------|
| Temperatura superficial exterior             | 27.80 °C | 27.504 °C                  |
| Temperatura aire exterior                    | 27.70 °C | 27.495 °C                  |
| Temperatura aire interior                    | 24.40 °C | 24.520 °C                  |
| Temperatura superficial interior             | 24.30 °C | 24.511 °C                  |
| Coeficiente global de transferencia de calor | U        | 1.0632 W/m <sup>2</sup> .K |

### Cálculo del coeficiente global para placa inclinada 24°

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area superficial      | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ           | 24                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 23090221.51                  | 30676777.95                  |
| Número de Rayleigh inclinado                             | Raθ     | 9391639.18                   | 1.25E+07                     |
| Número de Rayleigh crítico                               | Rac     | 1258925.41                   | -                            |
| Número de Nusselt  | Nu      | 43.3                         | 33.3                         |
| Coefficiente convectivo                                  | hconv   | 1.310 W/m <sup>2</sup> K     | 0.996 W/m <sup>2</sup> K     |
| Coefficiente radioactivo                                 | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 7.000 W/m <sup>2</sup> K     | 6.465 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.7 °C                      |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.05 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coeficiente de expansión volumétrica                               | $\beta$   | 0.00334392 1/K               |
| Conductividad térmica  | k         | 0.02559 W/m.K                |
| Viscosidad cinemática  | $\nu$     | 0.00001572 m <sup>2</sup> /s |
| Número adimensional de Prandtl                                     | Pr        | 0.729369                     |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 39955.74695                  |
| Número de Nusselt  | Nu        | 3.18                         |
| Kefec  | kefec     | 0.08138 W/m.K                |

| <b>Cálculo de resistencias</b>                    |           |              |
|---|-----------|--------------|
| Resistencia convección y radiación en el interior | Rcomb.int | 0.154673 K/W |
| Resistencia conducción en capa interna            | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de | Rcap.aire | 0.614394 K/W |
| Resistencia conducción en capa externa            | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior | Rcomb.ext | 0.142857 K/W |
| Resistencia total                                 | Rotal     | 0.915770 K/W |
| Flujo de calor                                    | Q         | 4.805 W      |

|  | Asumida  | Calculada                  |
|--|----------|----------------------------|
| Temperatura superficial exterior             | 27.80 °C | 27.514 °C                  |
| Temperatura aire exterior                    | 27.70 °C | 27.504 °C                  |
| Temperatura aire interior                    | 24.40 °C | 24.552 °C                  |
| Temperatura superficial interior             | 24.30 °C | 24.543 °C                  |
| Coeficiente global de transferencia de calor | U        | 1.0920 W/m <sup>2</sup> .K |



### Cálculo del coeficiente global para placa inclinada 12°

|                       |             |                    |
|-----------------------|-------------|--------------------|
| Temperatura exterior  | Text        | 28.2 °C            |
| Temperatura interior  | Tint        | 23.8 °C            |
| Largo                 | H           | 0.850 m            |
| Ancho                 | W           | 1.000 m            |
| Area superficial      | As = L x W  | 1.00m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m            |
| Espesor capa de aire  | eaire       | 0.05 m             |
| Espesor 2             | e2          | 0.001 m            |
| Material              | Polietileno |                    |
| Emisividad            | ε           | 0.92               |
| Emisividad efectiva   | εefectiva   | 0.852              |
| Conductividad térmica | k           | 0.52000 °W/m.K     |
| Ángulo de inclinación | θ           | 12                 |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      |
| Temperatura superficial asumida                          | Ts'     | <b>27.8 °C</b>               | <b>24.3 °C</b>               |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               |
| Conductividad térmica                                    | k       | 0.02573 W/m.K                | 0.02544 W/m.K                |
| Viscosidad cinemática                                    | ν       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 0.85 m                       | 0.85 m                       |
| Número de Rayleigh                                       | Ra      | 23090221.51                  | 30676777.95                  |
| Número de Rayleigh inclinado                             | Raθ     | 4800727.00                   | 6.38E+06                     |
| Número de Rayleigh crítico                               | Rac     | 100000                       | -                            |
| Número de Nusselt  | Nu      | 44.9                         | 28.1                         |
| Coefficiente convectivo                                  | hconv   | 1.358 W/m <sup>2</sup> K     | 0.842 W/m <sup>2</sup> K     |
| Coefficiente radiactivo                                  | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 7.048 W/m <sup>2</sup> K     | 6.311 W/m <sup>2</sup> K     |

| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.7 °C                      |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película  | Tf        | 26.05 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coefficiente de expansión volumétrica                              | $\beta$   | 0.00334392 1/K               |
| Conductividad térmica  | k         | 0.02559 W/m.K                |
| Viscosidad cinemática  | $\nu$     | 0.00001572 m <sup>2</sup> /s |
| Número adimensional de Prandtl                                     | Pr        | 0.729369                     |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh   | Ra        | 39955.74695                  |
| Número de Nusselt  | Nu        | 3.25                         |
| Kefec  | kefec     | 0.08317 W/m.K                |

| <b>Cálculo de resistencias</b>                    |           |              |
|---|-----------|--------------|
| Resistencia convección y radiación en el interior | Rcomb.int | 0.158443 K/W |
| Resistencia conducción en capa interna            | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de | Rcap.aire | 0.601206 K/W |
| Resistencia conducción en capa externa            | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior | Rcomb.ext | 0.141879 K/W |
| Resistencia total                                 | Rotal     | 0.905374 K/W |
| Flujo de calor                                    | Q         | 4.860 W      |

|   | Asumida  | Calculada                  |
|---|----------|----------------------------|
| Temperatura superficial exterior              | 27.80 °C | 27.510 °C                  |
| Temperatura aire exterior                     | 27.70 °C | 27.501 °C                  |
| Temperatura aire interior                     | 24.40 °C | 24.579 °C                  |
| Temperatura superficial interior              | 24.30 °C | 24.570 °C                  |
| Coefficiente global de transferencia de calor | U        | 1.1045 W/m <sup>2</sup> .K |

## Cálculo del coeficiente global para placa horizontal

|                       |            |                    |
|-----------------------|------------|--------------------|
| Temperatura exterior  | Text       | 28.2 °C            |
| Temperatura interior  | Tint       | 23.8 °C            |
| Largo                 | H          | 0.850 m            |
| Ancho                 | W          | 1.000 m            |
| Area superficial      | As = L x W | 1.00m <sup>2</sup> |
| Espesor 1             | e1         | 0.001 m            |
| Espesor capa de aire  | eaire      | 0.05 m             |
| Espesor 2             | e2         | 0.001 m            |
| Material              |            | Polietileno        |
| Emisividad            | ε          | 0.92               |
| Emisividad efectiva   | εefectiva  | 0.852              |
| Conductividad térmica | k          | 0.52000 °W/m.K     |

| Item   | Símbolo | Superficie                   |                              | Item   | Símbolo   | Exterior                     |
|--|---------|------------------------------|------------------------------|--|-----------|------------------------------|
|  |         | Exterior                     | Interior                     |  |           |                              |
| <b>Temperaturas</b>                                      |         |                              |                              |  |           |                              |
| Temperatura  | T       | 28.2 °C                      | 23.8 °C                      | Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | 27.6 °C                      |
| Temperatura superficial asumida                          | Ts'     | 27.8 °C                      | 24.3 °C                      | Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | 24.4 °C                      |
| Temperatura de película                                  | Tf      | 28.00 °C                     | 24.1 °C                      | Temperatura de película  | Tf        | 26.00 °C                     |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |  |           |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00332226 1/K               | 0.00336644 1/K               | Coefficiente de expansión v  | β         | 0.00334448 1/K               |
| Conductividad térmica                                    | k       | 0.02573 °W/m.K               | 0.02544 °W/m.K               | Conductividad térmica  | k         | 0.02558 °W/m.K               |
| Viscosidad cinemática                                    | v       | 0.00001590 m <sup>2</sup> /s | 0.00001553 m <sup>2</sup> /s | Viscosidad cinemática  | v         | 0.00001571 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7288                       | 0.7298                       | Número adimensional de FPr   | FPr       | 0.72938                      |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |  |           |                              |
| Longitud Característica                                  | Lc      | 0.23 m                       | 0.23 m                       | Longitud Característica  | Lc        | 0.05 m                       |
| Número de Rayleigh                                       | Ra      | 4.57E+05                     | 607766.1018                  | Número de Rayleigh   | Ra        | 38774.72444                  |
| Número de Nusselt  | Nu      | 7.0                          | 7.5                          | Número de Nusselt  | Nu        | 1.00                         |
| Coefficiente convectivo                                  | hconv   | 0.786 W/m <sup>2</sup> K     | 0.834 W/m <sup>2</sup> K     | Kefec  | kefec     | 0.02558 °W/m.K               |
| Coefficiente radioactivo                                 | hrad    | 5.690 W/m <sup>2</sup> K     | 5.469 W/m <sup>2</sup> K     |  |           |                              |
| Coefficiente combinado                                   | hcomb   | 6.476 W/m <sup>2</sup> K     | 6.303 W/m <sup>2</sup> K     |  |           |                              |

| Cálculo de resistencias                                |           |              |
|--|-----------|--------------|
| Resistencia convección y radiación en el interior      | Rcomb.int | 0.158655 K/W |
| Resistencia conducción en capa interna                 | Rcap.int  | 0.001923 K/W |
| Resistencia por convección y radiación en capa de aire | Rcap.aire | 1.954346 K/W |
| Resistencia conducción en capa externa                 | Rcap.ext  | 0.001923 K/W |
| Resistencia convección y radiación en el exterior      | Rcomb.ext | 0.154420 K/W |
| Resistencia total                                      | Rotal     | 2.271268 K/W |
| Flujo de calor   | Q         | 1.937 W      |

|   | Asumida  | Calculada                  |
|---|----------|----------------------------|
| Temperatura superficial exterior              | 27.80 °C | 27.901 °C                  |
| Temperatura aire exterior                     | 27.60 °C | 27.897 °C                  |
| Temperatura aire interior                     | 24.40 °C | 24.111 °C                  |
| Temperatura superficial interior              | 24.30 °C | 24.107 °C                  |
| Coefficiente global de transferencia de calor | U        | 0.4403 W/m <sup>2</sup> .K |

### Cálculo del coeficiente global para domo en invierno

|                       |             |                       |
|-----------------------|-------------|-----------------------|
| Temperatura exterior  | Text        | 12.8 °C               |
| Temperatura interior  | Tint        | 21.0 °C               |
| Largo                 | H           | 0.850 m               |
| Ancho                 | W           | 1.000 m               |
| Area superficial      | As = L x W  | 20 6.34m <sup>2</sup> |
| Espesor 1             | e1          | 0.001 m               |
| Espesor capa de aire  | eaire       | 0.05 m                |
| Espesor 2             | e2          | 0.001 m               |
| Material              | Polietileno |                       |
| Emisividad            | ε           | 0.92                  |
| Emisividad efectiva   | εefectiva   | 0.852                 |
| Conductividad térmica | k           | 0.52000 °W/m.K        |

| Item   | Símbolo | Superficie                   |                              |
|--|---------|------------------------------|------------------------------|
|  |         | Exterior                     | Interior                     |
| <b>Temperaturas</b>                                      |         |                              |                              |
| Temperatura  | T       | 12.8 °C                      | 21.0 °C                      |
| Temperatura superficial asumida                          | Ts'     | 13.2 °C                      | 20.8 °C                      |
| Temperatura de película                                  | Tf      | 13.00 °C                     | 20.9 °C                      |
| <b>Propiedades del aire @Tf</b>                          |         |                              |                              |
| Coefficiente de expansión volumétrica                    | β       | 0.00349650 1/K               | 0.00340252 1/K               |
| Conductividad térmica                                    | k       | 0.02461 °W/m.K               | 0.02521 °W/m.K               |
| Viscosidad cinemática                                    | v       | 0.00001452 m <sup>2</sup> /s | 0.00001524 m <sup>2</sup> /s |
| Número adimensional de Prandtl                           | Pr      | 0.7328                       | 0.7307                       |
| <b>Cálculos de números adimensionales y coeficientes</b> |         |                              |                              |
| Longitud Característica                                  | Lc      | 8.104 m                      | 8.00 m                       |
| Número de Rayleigh                                       | Ra      | 2.54E+10                     | 1.07E+10                     |
| Número de Nusselt  | Nu      | 184.0                        | 286.9                        |
| Coefficiente convectivo                                  | hconv   | 0.559 W/m <sup>2</sup> K     | 0.904 W/m <sup>2</sup> K     |
| Coefficiente radioactivo                                 | hrad    | 4.881 W/m <sup>2</sup> K     | 5.297 W/m <sup>2</sup> K     |
| Coefficiente combinado                                   | hcomb   | 5.440 W/m <sup>2</sup> K     | 6.201 W/m <sup>2</sup> K     |



| Item   | Símbolo   | Exterior                     |
|--|-----------|------------------------------|
| <b>Temperaturas</b>  |           |                              |
| Temperatura superficial de la capa de aire asumida (lado exterior) | Taire.ext | <b>13.0 °C</b>               |
| Temperatura superficial de la capa de aire asumida (lado interior) | Taire.int | <b>20.6 °C</b>               |
| Temperatura de película  | Tf        | 16.80 °C                     |
| <b>Propiedades del aire @Tf</b>                                    |           |                              |
| Coeficiente de expansión volumétrica                               | $\beta$   | 0.00345066 1/K               |
| Conductividad térmica  | k         | 0.02490 °W/m.K               |
| Viscosidad cinemática  | $\nu$     | 0.00001485 m <sup>2</sup> /s |
| Número adimensional de Prandtl                                     | Pr        | 0.731796                     |
| <b>Cálculos de números adimensionales y coeficientes</b>           |           |                              |
| Longitud Característica  | Lc bien   | 0.05 m                       |
| Número de Rayleigh   | Ra bien   | 1.07E+05                     |
| Factor geométrico  | Fesf      | <b>0.000194000</b>           |
| Kefec  | kefec     | 0.03236 °W/m.K               |

| <b>Cálculo de resistencias</b>                                |           |               |
|---|-----------|---------------|
| <b>Resistencia convección y radiación en el interior</b>      | Rcomb.int | 0.000802 K/W  |
| <b>Resistencia conducción en capa interna</b>                 | Rcap.int  | 0.0000096 K/W |
| <b>Resistencia por convección y radiación en capa de aire</b> | Rcap.aire | 0.007587 K/W  |
| <b>Resistencia conducción en capa externa</b>                 | Rcap.ext  | 0.0000093 K/W |
| <b>Resistencia convección y radiación en el exterior</b>      | Rcomb.ext | 0.000891 K/W  |
| <b>Resistencia total</b>                                      | Rotal     | 0.009299 K/W  |
| <b>Flujo de calor</b>   | Q         | 881.804 W     |

|  | Asumida  | Calculada                  |
|--|----------|----------------------------|
| Temperatura superficial exterior             | 13.20 °C | 13.6 °C                    |
| Temperatura aire exterior                    | 13.00 °C | 13.6 °C                    |
| Temperatura superficial interior             | 20.80 °C | 20.3 °C                    |
| Coeficiente global de transferencia de calor | U        | 0.5212 W/m <sup>2</sup> .K |

## B.2 Cálculo de irradiación sobre superficie

Cálculo de la hora donde se produce la mayor irradiación

| Ítem   | Símbolo  | Magnitud    | Unidad           |
|--|----------|-------------|------------------|
| Lugar  |          | Lima        |                  |
| Latitud local                                | L        | 13.73       | °S               |
| Longitud del sitio                           | LON      | -76.22      | E                |
| Time zone (zona horaria)                     | TZ       | -5          |                  |
| Longitud del tiempo meridiano estándar local | LSM      | -75         | °                |
| Profundidad óptica directa                   | $\tau_b$ | 0.556       |                  |
| Profundidad óptica difusa                    | $\tau_d$ | 1.801       |                  |
| Exponentes de masa de aire directa           | ab       | 0.766624476 |                  |
| Exponentes de masa de aire difusa            | ad       | 0.28664236  |                  |
| Día del año                                  | n        | 47          |                  |
| Declinación solar                            | $\delta$ | -12.95      | °                |
| Constante para ecuación de tiempo            | $\rho$   | 45.37       | °                |
| Ecuación del tiempo                          | ET       | -14.1       | min              |
| Irradiación normal extraterrestre            | $E_o$    | 1400        | W/m <sup>2</sup> |

| Hora       | Local Standard Time | Apparent Solar time (horas) | Hora angular | Angulo de altitud solar | Masa de aire | Irradiación directa       | Irradiación difusa        | Irradiación total |
|------------|---------------------|-----------------------------|--------------|-------------------------|--------------|---------------------------|---------------------------|-------------------|
|            | LST (horas)         | AST (horas)                 | H (horas)    | $\beta$ (°)             | m            | $E_b$ (W/m <sup>2</sup> ) | $E_d$ (W/m <sup>2</sup> ) | Esuma             |
| 08:00 a.m. | 8                   | 7.68                        | -64.74       | 20.53                   | 2.83         | 407.11                    | 123.58                    | 530.69            |
| 09:00 a.m. | 9                   | 8.68                        | -49.74       | 33.96                   | 1.79         | 587.94                    | 166.87                    | 754.80            |
| 10:00 a.m. | 10                  | 9.68                        | -34.74       | 46.45                   | 1.38         | 687.45                    | 194.33                    | 881.78            |
| 11:00 a.m. | 11                  | 10.68                       | -19.74       | 56.91                   | 1.19         | 740.73                    | 210.56                    | 951.29            |
| 12:00 p.m. | 12                  | 11.68                       | -4.74        | 62.90                   | 1.12         | 762.42                    | 217.53                    | 979.95            |
| 01:00 p.m. | 13                  | 12.68                       | 10.26        | 61.44                   | 1.14         | 757.65                    | 215.98                    | 973.62            |
| 02:00 p.m. | 14                  | 13.68                       | 25.26        | 53.42                   | 1.24         | 725.32                    | 205.73                    | 931.05            |
| 03:00 p.m. | 15                  | 14.68                       | 40.26        | 42.01                   | 1.49         | 657.46                    | 185.70                    | 843.16            |
| 04:00 p.m. | 16                  | 15.68                       | 55.26        | 29.10                   | 2.05         | 533.81                    | 153.18                    | 686.99            |
| 05:00 p.m. | 17                  | 16.68                       | 70.26        | 15.46                   | 3.71         | 306.91                    | 101.75                    | 408.66            |

## Cálculo de la irradiación sobre placas

| Item  | Símbolo | Magnitud                |
|---|---------|-------------------------|
| Temperatura exterior                                | Text    | 28.2 °C                 |
| Temperatura interior                                | Tint    | 23.8 °C                 |
| Coefficiente de transferencia de calor              | ho      | 17 W/m <sup>2</sup> K   |
| Área superficial                                    | As      | 0.85m <sup>2</sup>      |
| Coefficiente de reflexión de la superficie          | ρ       | 0.2                     |
| Absortividad  | α       | 0.4                     |
| <b>Irradiación y posición del sol a las 12 p.m.</b> |         |                         |
| Irradiación directa normal                          | Eb      | 762.42 W/m <sup>2</sup> |
| Irradiación horizontal difusa                       | Ed      | 217.53 W/m <sup>2</sup> |
| Ángulo de altitud solar                             | β       | 62.9°                   |
| Ángulo azimuth                                      | φ       | 10.19°                  |

## Nivel 1: Placas verticales

| Nº de placa | Solar azimuth φ | Surface azimuth ψ | Surface-solar azimuth γ | Tilt angle Σ | Angle of incidence θ | cosθ         | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |
|-------------|-----------------|-------------------|-------------------------|--------------|----------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|--------|
| 1           | 10.187          | 0                 | 10.187                  | 90           | 63.36614221          | 0.448287392  | 341.785 | 0.45                             | 0.8088026 | 175.93961 | 89.628006 | 607.3524103            | 42.49         | 14.77  |
| 2           | 10.187          | -14               | 24.187                  | 90           | 65.45027711          | 0.415482776  | 316.774 | 0.45                             | 0.7855979 | 170.89187 | 89.628006 | 577.2936683            | 41.78         | 14.21  |
| 3           | 10.187          | -29               | 39.187                  | 90           | 69.32748578          | 0.353026054  | 269.155 | 0.45                             | 0.7432808 | 161.68659 | 89.628006 | 520.4699156            | 40.45         | 13.16  |
| 4           | 10.187          | -43               | 53.187                  | 90           | 74.16209695          | 0.272916726  | 208.078 | 0.45                             | 0.692578  | 150.65716 | 89.628006 | 448.3632598            | 38.75         | 11.82  |
| 5           | 10.187          | -58               | 68.187                  | 90           | 80.25638365          | 0.169239696  | 129.032 | 0.45                             | 0.6329227 | 137.68029 | 89.628006 | 356.3406043            | 36.58         | 10.10  |
| 6           | 10.187          | -72               | 82.187                  | 90           | 86.45032348          | 0.061913918  | 47.2046 | 0.45                             | 0.5782562 | 125.78864 | 89.628006 | 262.6212631            | 34.38         | 8.36   |
| 7           | 10.187          | -86               | 96.187                  | 90           | 92.81378507          | -0.049090076 | 0       | 0.45                             | 0.5293019 | 115.13956 | 89.628006 | 204.7675669            | 33.02         | 7.29   |
| 8           | 10.187          | -101              | 111.187                 | 90           | 99.47483843          | -0.16461446  | 0       | 0.45                             | 0.4865451 | 105.83864 | 89.628006 | 195.4666418            | 32.80         | 7.11   |
| 9           | 10.187          | -115              | 125.187                 | 90           | 105.216324           | -0.262464108 | 0       | 0.45                             | 0.4568649 | 99.382276 | 89.628006 | 189.0102819            | 32.65         | 6.99   |
| 10          | 10.187          | -130              | 140.187                 | 90           | 110.4789982          | -0.34986402  | 0       | 0.45                             | 0.4354221 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 11          | 10.187          | -144              | 154.187                 | 90           | 114.2062474          | -0.410022486 | 0       | 0.45                             | 0.4234412 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 12          | 10.187          | -158              | 168.187                 | 90           | 116.4759492          | -0.445822112 | 0       | 0.45                             | 0.4173868 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 13          | 10.187          | -173              | 183.187                 | 90           | 117.0497111          | -0.454763386 | 0       | 0.45                             | 0.4159998 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 14          | 10.187          | 173               | -162.813                | 90           | 115.7934686          | -0.435128466 | 0       | 0.45                             | 0.4191113 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 15          | 10.187          | 158               | -147.813                | 90           | 112.6727696          | -0.385467553 | 0       | 0.45                             | 0.4280579 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 16          | 10.187          | 144               | -133.813                | 90           | 108.3802387          | -0.315321751 | 0       | 0.45                             | 0.4433253 | 97.888938 | 89.628006 | 187.5169441            | 32.61         | 6.96   |
| 17          | 10.187          | 130               | -119.813                | 90           | 103.0877546          | -0.226443142 | 0       | 0.45                             | 0.4670939 | 101.60739 | 89.628006 | 191.2353947            | 32.70         | 7.03   |
| 18          | 10.187          | 115               | -104.813                | 90           | 96.6896412           | -0.16444769  | 0       | 0.45                             | 0.5033577 | 109.4959  | 89.628006 | 199.1239016            | 32.89         | 7.18   |
| 19          | 10.187          | 101               | -90.813                 | 90           | 90.37013752          | -0.006460073 | 0       | 0.45                             | 0.54719   | 119.03078 | 89.628006 | 208.6587816            | 33.11         | 7.36   |
| 20          | 10.187          | 86                | -75.813                 | 90           | 83.59059987          | 0.116631971  | 85.1108 | 0.45                             | 0.6026837 | 131.10237 | 89.628006 | 305.8412006            | 35.40         | 9.17   |
| 21          | 10.187          | 72                | -61.813                 | 90           | 77.57608736          | 0.215142927  | 164.03  | 0.45                             | 0.6585051 | 143.24526 | 89.628006 | 396.9032676            | 37.54         | 10.86  |
| 22          | 10.187          | 58                | -47.813                 | 90           | 72.18933349          | 0.305872554  | 233.204 | 0.45                             | 0.71295   | 155.0887  | 89.628006 | 477.9210963            | 39.45         | 12.37  |
| 23          | 10.187          | 43                | -32.813                 | 90           | 67.49298399          | 0.382796561  | 291.853 | 0.45                             | 0.763147  | 166.00811 | 89.628006 | 547.4891667            | 41.08         | 13.66  |
| 24          | 10.187          | 29                | -18.813                 | 90           | 64.46032985          | 0.431135921  | 328.708 | 0.45                             | 0.7965863 | 173.28219 | 89.628006 | 591.6183041            | 42.12         | 14.48  |
| 25          | 10.187          | 14                | -3.813                  | 90           | 62.96981104          | 0.454459905  | 346.491 | 0.45                             | 0.8132441 | 176.90577 | 89.628006 | 613.0246408            | 42.62         | 14.88  |
|             |                 |                   |                         |              |                      |              |         |                                  |           |           |           |                        | TOTAL         | 239.55 |

## Nivel 2: Placas inclinadas 66°

| Nº de placa | Solar azimuth φ | Surface azimuth ψ | Surface-solar azimuth γ | Tilt angle Σ | Angle of incidence θ | cosθ         | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |
|-------------|-----------------|-------------------|-------------------------|--------------|----------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|--------|
| 1           | 10.187          | 0                 | 10.187                  | 66           | 39.49959373          | 0.771629094  | 588.308 | 0.45                             | 1.0735657 | 301.82155 | 53.173012 | 943.3026361            | 46.40         | 17.86  |
| 2           | 10.187          | -15               | 25.187                  | 66           | 42.38537207          | 0.73862747   | 563.147 | 0.45                             | 1.0435438 | 295.85546 | 53.173012 | 912.1753375            | 45.66         | 17.28  |
| 3           | 10.187          | -30               | 40.187                  | 66           | 47.15901401          | 0.679965997  | 518.422 | 0.45                             | 0.9918619 | 285.585   | 53.173012 | 857.179999             | 44.37         | 16.26  |
| 4           | 10.187          | -45               | 55.187                  | 66           | 53.15571227          | 0.599642358  | 457.181 | 0.45                             | 0.9245894 | 272.21633 | 53.173012 | 782.570699             | 42.61         | 14.87  |
| 5           | 10.187          | -60               | 70.187                  | 66           | 59.79267233          | 0.503130476  | 383.598 | 0.45                             | 0.8491009 | 257.21492 | 53.173012 | 693.986374             | 40.53         | 13.22  |
| 6           | 10.187          | -75               | 85.187                  | 66           | 66.60876581          | 0.397007477  | 302.688 | 0.45                             | 0.7728257 | 242.05718 | 53.173012 | 597.9179743            | 38.27         | 11.44  |
| 7           | 10.187          | -90               | 100.187                 | 66           | 73.23149838          | 0.288505466  | 219.963 | 0.45                             | 0.7021296 | 228.00812 | 53.173012 | 501.1444468            | 35.99         | 9.64   |
| 8           | 10.187          | -105              | 115.187                 | 66           | 79.3377862           | 0.185018678  | 141.063 | 0.45                             | 0.6415678 | 215.97301 | 53.173012 | 410.2085853            | 33.85         | 7.94   |
| 9           | 10.187          | -120              | 130.187                 | 66           | 84.62927834          | 0.093599566  | 71.3625 | 0.45                             | 0.5936452 | 206.44962 | 53.173012 | 330.9851266            | 31.99         | 6.47   |
| 10          | 10.187          | -135              | 145.187                 | 66           | 88.82660413          | 0.02047819   | 15.6131 | 0.45                             | 0.5590802 | 199.58072 | 53.173012 | 268.3667817            | 30.51         | 5.31   |
| 11          | 10.187          | -150              | 160.187                 | 66           | 91.68258043          | -0.029362348 | 0       | 0.45                             | 0.5374385 | 195.27998 | 53.173012 | 248.4529919            | 30.05         | 4.94   |
| 12          | 10.187          | -165              | 175.187                 | 66           | 93.01087485          | -0.052525497 | 0       | 0.45                             | 0.5279099 | 193.38641 | 53.173012 | 246.5594254            | 30.00         | 4.90   |
| 13          | 10.187          | -180              | 190.187                 | 66           | 92.71871523          | -0.047432728 | 0       | 0.45                             | 0.5299761 | 193.79702 | 53.173012 | 246.9700305            | 30.01         | 4.91   |
| 14          | 10.187          | 165               | -154.813                | 66           | 90.82687006          | -0.014431104 | 0       | 0.45                             | 0.5437588 | 196.53598 | 53.173012 | 249.7089871            | 30.08         | 4.96   |
| 15          | 10.187          | 150               | -139.813                | 66           | 87.46495953          | 0.044203069  | 33.7223 | 0.45                             | 0.569941  | 201.73902 | 53.173012 | 288.6342994            | 30.99         | 5.68   |
| 16          | 10.187          | 135               | -124.813                | 66           | 82.84499899          | 0.124554007  | 94.9629 | 0.45                             | 0.6092859 | 209.55781 | 53.173012 | 357.6937114            | 32.62         | 6.97   |
| 17          | 10.187          | 120               | -109.813                | 66           | 77.22835449          | 0.221065889  | 168.546 | 0.45                             | 0.6619021 | 220.01395 | 53.173012 | 441.7327633            | 34.59         | 8.53   |
| 18          | 10.187          | 105               | -94.813                 | 66           | 70.90175898          | 0.327188889  | 249.456 | 0.45                             | 0.726489  | 232.84893 | 53.173012 | 535.4784066            | 36.80         | 10.27  |
| 19          | 10.187          | 90                | -79.813                 | 66           | 64.17073498          | 0.4355690899 | 332.181 | 0.45                             | 0.7998126 | 247.42013 | 53.173012 | 632.7740757            | 39.09         | 12.08  |
| 20          | 10.187          | 75                | -64.813                 | 66           | 57.373222            | 0.539177687  | 411.082 | 0.45                             | 0.8766137 | 262.68238 | 53.173012 | 726.9370691            | 41.30         | 13.83  |
| 21          | 10.187          | 60                | -49.813                 | 66           | 50.9058329           | 0.6305968    | 480.782 | 0.45                             | 0.950036  | 277.27318 | 53.173012 | 811.2279426            | 43.29         | 15.40  |
| 22          | 10.187          | 45                | -34.813                 | 66           | 45.27391978          | 0.703718176  | 536.531 | 0.45                             | 1.0125285 | 289.69196 | 53.173012 | 879.3961756            | 44.89         | 16.67  |
| 23          | 10.187          | 30                | -19.813                 | 66           | 41.10040781          | 0.753558713  | 574.531 | 0.45                             | 1.0570424 | 298.53798 | 53.173012 | 926.2417795            | 45.99         | 17.54  |
| 24          | 10.187          | 15                | -4.813                  | 66           | 39.03859554          | 0.776721863  | 592.191 | 0.45                             | 1.0782594 | 302.7543  | 53.173012 | 948.1182291            | 46.51         | 17.95  |
|             |                 |                   |                         |              |                      |              |         |                                  |           |           |           |                        | TOTAL         | 264.92 |

## Nivel 3: Placas inclinadas 63°

| Nº de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |  |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|--------|--|
| 1           | 10.187               | 0                      | 10.187                         | 63                  | 36.52540634                 | 0.803593023  | 612.678 | 0.45                             | 1.1032936 | 312.59903 | 48.937743 | 974.2148916            | 47.12         | 18.43  |  |
| 2           | 10.187               | -17                    | 27.187                         | 63                  | 40.07927109                 | 0.765154387  | 583.372 | 0.45                             | 1.0676218 | 305.68508 | 48.937743 | 937.9944249            | 46.27         | 17.76  |  |
| 3           | 10.187               | -34                    | 44.187                         | 63                  | 45.95932989                 | 0.695168802  | 530.013 | 0.45                             | 1.005049  | 293.55712 | 48.937743 | 872.5078246            | 44.73         | 16.54  |  |
| 4           | 10.187               | -51                    | 61.187                         | 63                  | 53.14783736                 | 0.599752344  | 457.265 | 0.45                             | 0.9246788 | 277.97964 | 48.937743 | 784.1825973            | 42.65         | 14.90  |  |
| 5           | 10.187               | -69                    | 79.187                         | 63                  | 61.29511881                 | 0.480298222  | 366.191 | 0.45                             | 0.8320952 | 260.03494 | 48.937743 | 675.1632844            | 40.09         | 12.87  |  |
| 6           | 10.187               | -86                    | 96.187                         | 63                  | 68.87361169                 | 0.360426454  | 274.798 | 0.45                             | 0.7481673 | 243.76792 | 48.937743 | 567.503223             | 37.55         | 10.87  |  |
| 7           | 10.187               | -103                   | 113.187                        | 63                  | 75.85497425                 | 0.244377108  | 186.319 | 0.45                             | 0.6754852 | 229.68056 | 48.937743 | 464.9371298            | 35.14         | 8.96   |  |
| 8           | 10.187               | -120                   | 130.187                        | 63                  | 81.8195157                  | 0.142291795  | 108.487 | 0.45                             | 0.6185188 | 218.63925 | 48.937743 | 376.0635849            | 33.05         | 7.31   |  |
| 9           | 10.187               | -137                   | 147.187                        | 63                  | 86.38270369                 | 0.063091798  | 48.1027 | 0.45                             | 0.578817  | 210.94419 | 48.937743 | 307.9845969            | 31.45         | 6.04   |  |
| 10          | 10.187               | -154                   | 164.187                        | 63                  | 89.21511231                 | 0.013698446  | 10.444  | 0.45                             | 0.556045  | 206.53047 | 48.937743 | 265.9122302            | 30.46         | 5.26   |  |
| 11          | 10.187               | -171                   | 181.187                        | 63                  | 90.09005488                 | -0.001571753 | 0       | 0.45                             | 0.5493139 | 205.22585 | 48.937743 | 254.1635946            | 30.18         | 5.04   |  |
| 12          | 10.187               | 171                    | -160.813                       | 63                  | 88.80328761                 | 0.020885053  | 15.9233 | 0.45                             | 0.5592633 | 207.15426 | 48.937743 | 272.0125207            | 30.60         | 5.37   |  |
| 13          | 10.187               | 154                    | -143.813                       | 63                  | 85.60520712                 | 0.076628414  | 58.4233 | 0.45                             | 0.5853245 | 212.20548 | 48.937743 | 319.566521             | 31.72         | 6.26   |  |
| 14          | 10.187               | 137                    | -126.813                       | 63                  | 80.73531971                 | 0.160995448  | 122.747 | 0.45                             | 0.6284678 | 220.56758 | 48.937743 | 392.2520207            | 33.43         | 7.61   |  |
| 15          | 10.187               | 120                    | -109.813                       | 63                  | 74.53716392                 | 0.266613278  | 230.272 | 0.45                             | 0.6887589 | 232.25328 | 48.937743 | 484.4632263            | 35.60         | 9.33   |  |
| 16          | 10.187               | 103                    | -92.813                        | 63                  | 67.40269425                 | 0.38425191   | 292.963 | 0.45                             | 0.7641324 | 246.86229 | 48.937743 | 588.7626811            | 38.05         | 11.27  |  |
| 17          | 10.187               | 86                     | -75.813                        | 63                  | 59.75949299                 | 0.503630947  | 383.98  | 0.45                             | 0.8494773 | 263.40397 | 48.937743 | 696.321648             | 40.58         | 13.27  |  |
| 18          | 10.187               | 69                     | -58.813                        | 63                  | 52.09765431                 | 0.614317505  | 468.37  | 0.45                             | 0.9365786 | 280.28607 | 48.937743 | 797.5938526            | 42.97         | 15.15  |  |
| 19          | 10.187               | 51                     | -40.813                        | 63                  | 44.65800637                 | 0.71131482   | 542.323 | 0.45                             | 1.0192128 | 296.30237 | 48.937743 | 887.5631677            | 45.08         | 16.82  |  |
| 20          | 10.187               | 34                     | -23.813                        | 63                  | 39.15476563                 | 0.75443227   | 591.216 | 0.45                             | 1.0770794 | 307.51816 | 48.937743 | 947.6719589            | 46.50         | 17.94  |  |
| 21          | 10.187               | 17                     | -6.813                         | 63                  | 36.18396797                 | 0.807125539  | 615.371 | 0.45                             | 1.1066182 | 313.24342 | 48.937743 | 977.5525623            | 47.20         | 18.50  |  |
|             |                      |                        |                                |                     |                             |              |         |                                  |           |           |           |                        | TOTAL         | 245.50 |  |

## Nivel 4: Placas inclinadas 46°

| Nº de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |  |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|--------|--|
| 1           | 10.187               | 0                      | 10.187                         | 46                  | 19.79808482                 | 0.940892091  | 717.358 | 0.45                             | 1.2382618 | 344.8713  | 27.367161 | 1089.5966              | 49.84         | 20.58  |  |
| 2           | 10.187               | -20                    | 30.187                         | 46                  | 25.62746306                 | 0.901625315  | 687.42  | 0.45                             | 1.1984568 | 338.64266 | 27.367161 | 1053.43005             | 48.99         | 19.91  |  |
| 3           | 10.187               | -40                    | 50.187                         | 46                  | 34.08573065                 | 0.828199334  | 631.439 | 0.45                             | 1.1266148 | 327.40092 | 27.367161 | 986.2070829            | 47.40         | 18.66  |  |
| 4           | 10.187               | -60                    | 70.187                         | 46                  | 43.1578406                  | 0.729472134  | 556.167 | 0.45                             | 1.0353359 | 313.11771 | 27.367161 | 896.6514922            | 45.30         | 16.99  |  |
| 5           | 10.187               | -80                    | 90.187                         | 46                  | 51.87712954                 | 0.617349943  | 470.682 | 0.45                             | 0.9390728 | 298.05459 | 27.367161 | 796.1037871            | 42.93         | 15.12  |  |
| 6           | 10.187               | -100                   | 110.187                        | 46                  | 59.64494946                 | 0.506356953  | 385.296 | 0.45                             | 0.8507767 | 284.23813 | 27.367161 | 696.9012558            | 40.60         | 13.28  |  |
| 7           | 10.187               | -120                   | 130.187                        | 46                  | 65.98340828                 | 0.407001171  | 310.307 | 0.45                             | 0.7797079 | 273.11739 | 27.367161 | 610.7917621            | 38.57         | 11.67  |  |
| 8           | 10.187               | -140                   | 150.187                        | 46                  | 70.47939983                 | 0.334145756  | 254.761 | 0.45                             | 0.7309692 | 265.49081 | 27.367161 | 547.6185152            | 37.09         | 10.50  |  |
| 9           | 10.187               | -160                   | 170.187                        | 46                  | 72.80779122                 | 0.295578146  | 225.356 | 0.45                             | 0.7065133 | 261.66399 | 27.367161 | 514.3868467            | 36.30         | 9.88   |  |
| 10          | 10.187               | -180                   | 190.187                        | 46                  | 72.78547784                 | 0.295950165  | 225.639 | 0.45                             | 0.7067448 | 261.70021 | 27.367161 | 514.7066996            | 36.31         | 9.89   |  |
| 11          | 10.187               | 160                    | -149.813                       | 46                  | 70.41426945                 | 0.335216941  | 255.577 | 0.45                             | 0.7316617 | 265.59918 | 27.367161 | 548.5435785            | 37.11         | 10.52  |  |
| 12          | 10.187               | 140                    | -129.813                       | 46                  | 65.88042394                 | 0.408642322  | 311.558 | 0.45                             | 0.7808441 | 273.29517 | 27.367161 | 612.2207993            | 38.61         | 11.70  |  |
| 13          | 10.187               | 120                    | -109.813                       | 46                  | 59.51118686                 | 0.507370122  | 386.831 | 0.45                             | 0.8522946 | 284.47565 | 27.367161 | 698.673662             | 40.64         | 13.31  |  |
| 14          | 10.187               | 100                    | -89.813                        | 46                  | 51.72093003                 | 0.619492313  | 472.315 | 0.45                             | 0.9408384 | 298.33087 | 27.367161 | 798.0134585            | 42.98         | 15.16  |  |
| 15          | 10.187               | 80                     | -69.813                        | 46                  | 42.98894277                 | 0.731485303  | 557.702 | 0.45                             | 1.0371362 | 313.39943 | 27.367161 | 898.4680942            | 45.34         | 17.02  |  |
| 16          | 10.187               | 60                     | -49.813                        | 46                  | 33.9175829                  | 0.829641085  | 632.69  | 0.45                             | 1.1281837 | 327.64641 | 27.367161 | 987.703832             | 47.44         | 18.68  |  |
| 17          | 10.187               | 40                     | -29.813                        | 46                  | 25.48519449                 | 0.9026965    | 688.237 | 0.45                             | 1.1995299 | 338.81057 | 27.367161 | 1054.414658            | 49.01         | 19.92  |  |
| 18          | 10.187               | 20                     | -9.813                         | 46                  | 19.7350576                  | 0.94126411   | 717.642 | 0.45                             | 1.2386436 | 344.93103 | 27.367161 | 1089.939969            | 49.85         | 20.59  |  |
|             |                      |                        |                                |                     |                             |              |         |                                  |           |           |           |                        | TOTAL         | 273.38 |  |

## Nivel 5: Placas inclinadas 36°

| Nº de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |  |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|--------|--|
| 1           | 10.187               | 0                      | 10.187                         | 36                  | 10.350883                   | 0.98372586   | 750.016 | 0.45                             | 1.2827835 | 340.00487 | 17.117426 | 1107.137907            | 50.25         | 20.91  |  |
| 2           | 10.187               | -26                    | 36.187                         | 36                  | 20.56057933                 | 0.936301388  | 713.858 | 0.45                             | 1.2335584 | 333.71088 | 17.117426 | 1064.686384            | 49.25         | 20.12  |  |
| 3           | 10.187               | -51                    | 61.187                         | 36                  | 31.86928468                 | 0.849254853  | 647.492 | 0.45                             | 1.1468706 | 322.62684 | 17.117426 | 987.2360334            | 47.43         | 18.68  |  |
| 4           | 10.187               | -77                    | 87.187                         | 36                  | 42.83065599                 | 0.733366222  | 559.136 | 0.45                             | 1.0388206 | 308.81141 | 17.117426 | 885.0644028            | 45.03         | 16.78  |  |
| 5           | 10.187               | -103                   | 113.187                        | 36                  | 52.06126687                 | 0.614818497  | 468.752 | 0.45                             | 0.9369902 | 295.79123 | 17.117426 | 781.606607             | 42.59         | 14.85  |  |
| 6           | 10.187               | -129                   | 139.187                        | 36                  | 58.82812054                 | 0.517607138  | 394.636 | 0.45                             | 0.8600524 | 285.95384 | 17.117426 | 697.707057             | 40.62         | 13.29  |  |
| 7           | 10.187               | -157                   | 167.187                        | 36                  | 62.66593021                 | 0.459177872  | 350.988 | 0.45                             | 0.8166655 | 280.40499 | 17.117426 | 647.6103633            | 39.44         | 12.36  |  |
| 8           | 10.187               | -180                   | 190.187                        | 36                  | 62.82354303                 | 0.456732424  | 348.223 | 0.45                             | 0.8148853 | 280.17871 | 17.117426 | 645.5196176            | 39.39         | 12.32  |  |
| 9           | 10.187               | 154                    | -143.813                       | 36                  | 59.72459878                 | 0.504156896  | 384.381 | 0.45                             | 0.8498731 | 284.6523  | 17.117426 | 686.1507368            | 40.34         | 13.08  |  |
| 10          | 10.187               | 129                    | -118.813                       | 36                  | 53.75754605                 | 0.591203432  | 450.747 | 0.45                             | 0.9177561 | 293.33193 | 17.117426 | 610.1966801            | 42.11         | 14.47  |  |
| 11          | 10.187               | 103                    | -92.813                        | 36                  | 45.00119294                 | 0.707092059  | 539.104 | 0.45                             | 1.0154927 | 305.82867 | 17.117426 | 862.0496263            | 44.48         | 16.35  |  |
| 12          | 10.187               | 77                     | -66.813                        | 36                  | 34.34659034                 | 0.825639788  | 629.487 | 0.45                             | 1.1241708 | 319.72441 | 17.117426 | 966.3289258            | 46.94         | 18.29  |  |
| 13          | 10.187               | 51                     | -40.813                        | 36                  | 22.65347497                 | 0.922851147  | 703.603 | 0.45                             | 1.2198537 | 331.95858 | 17.117426 | 1052.679308            | 48.97         | 19.89  |  |
| 14          | 10.187               | 26                     | -15.813                        | 36                  | 12.09118958                 | 0.977815458  | 745.509 | 0.45                             | 1.2765719 | 339.21065 | 17.117426 | 1101.837452            | 50.13         | 20.81  |  |
|             |                      |                        |                                |                     |                             |              |         |                                  |           |           |           |                        | TOTAL         | 232.18 |  |

## Nivel 6: Placas inclinadas 24°

| Nº de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d      | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W) |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|-----------|-----------|-----------|------------------------|---------------|-------|
| 1           | 10.187               | 0                      | 10.187                         | 24                  | 5.36409482                  | 0.995620743  | 759.085 | 0.45                             | 1.2953509 | 313.33425 | 7.7487482 | 1080.167543            | 49.62         | 20.40 |
| 2           | 10.187               | -36                    | 46.187                         | 24                  | 19.68840483                 | 0.941538745  | 717.851 | 0.45                             | 1.2389254 | 308.34185 | 7.7487482 | 1033.941764            | 48.53         | 19.54 |
| 3           | 10.187               | -72                    | 82.187                         | 24                  | 33.02125206                 | 0.838468494  | 639.268 | 0.45                             | 1.1364589 | 299.27584 | 7.7487482 | 946.2925818            | 46.47         | 17.91 |
| 4           | 10.187               | -108                   | 118.187                        | 24                  | 43.46628306                 | 0.725779322  | 553.351 | 0.45                             | 1.0320401 | 290.03709 | 7.7487482 | 851.1369684            | 44.23         | 16.14 |
| 5           | 10.187               | -144                   | 154.187                        | 24                  | 49.72066496                 | 0.646514665  | 492.918 | 0.45                             | 0.963355  | 283.95998 | 7.7487482 | 784.6266359            | 42.66         | 14.91 |
| 6           | 10.187               | -180                   | 190.187                        | 24                  | 50.87968502                 | 0.630950925  | 481.052 | 0.45                             | 0.9503306 | 282.80761 | 7.7487482 | 771.6081008            | 42.36         | 14.67 |
| 7           | 10.187               | 144                    | -133.813                       | 24                  | 46.76180352                 | 0.685032924  | 522.285 | 0.45                             | 0.9962409 | 286.86966 | 7.7487482 | 816.9035308            | 43.42         | 15.51 |
| 8           | 10.187               | 108                    | -97.813                        | 24                  | 37.99139808                 | 0.788103175  | 600.868 | 0.45                             | 1.0888075 | 295.05974 | 7.7487482 | 903.6767858            | 45.46         | 17.12 |
| 9           | 10.187               | 72                     | -61.813                        | 24                  | 25.73758615                 | 0.900792346  | 686.785 | 0.45                             | 1.1976229 | 304.68749 | 7.7487482 | 999.2213962            | 47.71         | 18.90 |
| 10          | 10.187               | 36                     | -25.813                        | 24                  | 11.46191664                 | 0.980057004  | 747.    |                                  |           |           |           |                        |               |       |



## Nivel 7: Placas inclinadas 12°

| N° de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |           | Et,d      | Et,d     | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W)  |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|-----------|-----------|----------|------------------------|---------------|--------|
| 1           | 10.187               | 0                      | 10.187                         | 12                  | 15.42009185                 | 0.964002223  | 734.978 | 0.45                             | 1.26214   | 269.8605  | 1.958587 | 1006.79693             | 47.89         | 19.04  |
| 2           | 10.187               | -60                    | 70.187                         | 12                  | 25.45871677                 | 0.902896245  | 688.388 | 0.45                             | 1.199729  | 267.03782 | 1.958587 | 957.3848669            | 46.73         | 18.12  |
| 3           | 10.187               | -120                   | 130.187                        | 12                  | 35.93424229                 | 0.809691056  | 617.327 | 0.45                             | 1.1090377 | 262.9361  | 1.958587 | 882.2220932            | 44.96         | 16.72  |
| 4           | 10.187               | -180                   | 190.187                        | 12                  | 38.95920515                 | 0.777593843  | 592.856 | 0.45                             | 1.0790646 | 261.58051 | 1.958587 | 856.3948307            | 44.35         | 16.24  |
| 5           | 10.187               | 60                     | -49.813                        | 12                  | 21.26625447                 | 0.93190501   | 710.506 | 0.45                             | 1.2290664 | 268.36467 | 1.958587 | 980.8294378            | 47.28         | 18.56  |
| 6           | 10.187               | 120                    | -109.813                       | 12                  | 32.9968173                  | 0.838700821  | 639.445 | 0.45                             | 1.1366824 | 264.1864  | 1.958587 | 905.5901125            | 45.51         | 17.16  |
|             |                      |                        |                                |                     |                             |              |         |                                  |           |           |          |                        | TOTAL         | 105.84 |

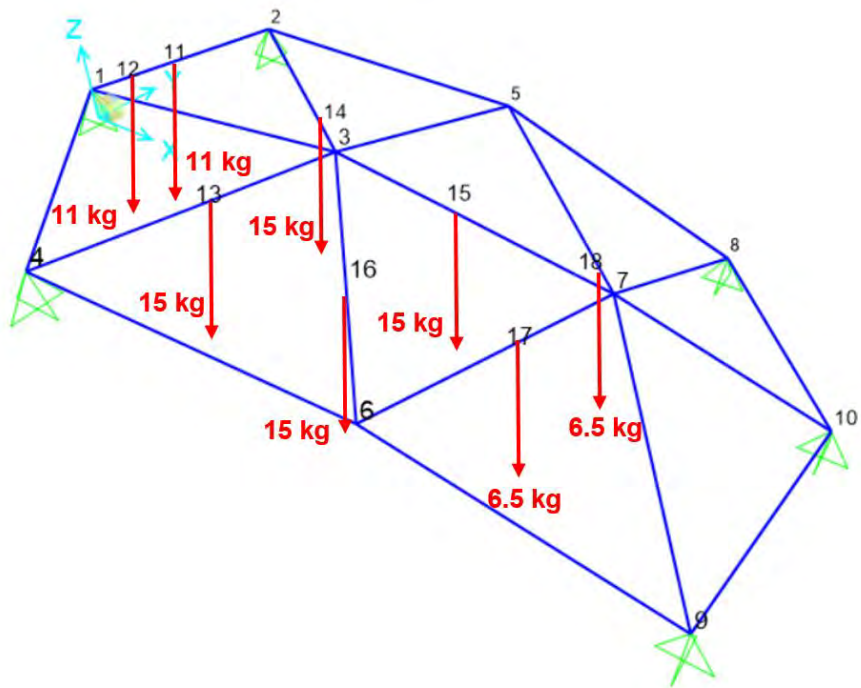
## Nivel 8: Placa horizontal

| N° de placa | Solar azimuth $\phi$ | Surface azimuth $\psi$ | Surface-solar azimuth $\gamma$ | Tilt angle $\Sigma$ | Angle of incidence $\theta$ | $\cos\theta$ | Et,b    | Factores para irradiación difusa |          | Et,d      | Et,d | Et (W/m <sup>2</sup> ) | Tsol-air (°C) | Q (W) |
|-------------|----------------------|------------------------|--------------------------------|---------------------|-----------------------------|--------------|---------|----------------------------------|----------|-----------|------|------------------------|---------------|-------|
| 1           | 10.187               | 0                      | 10.187                         | 0                   | 27.09504729                 | 0.890252179  | 678.749 | 0.45                             | 1.187108 | 217.53097 | 0    | 896.2900605            | 45.29         | 9.19  |
|             |                      |                        |                                |                     |                             |              |         |                                  |          |           |      |                        | TOTAL         | 9.19  |

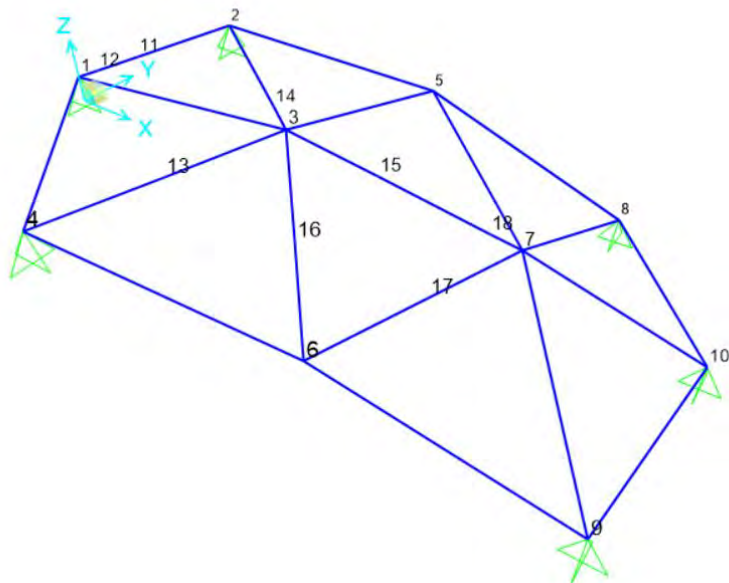


### B.3 Cálculo estructural

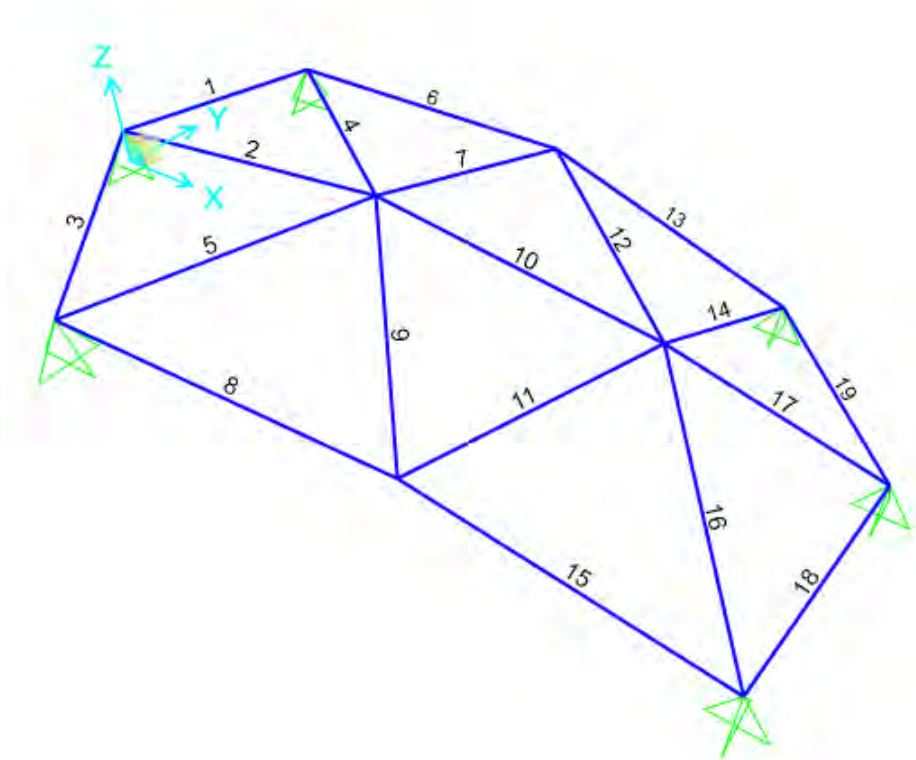
Modelo 3D



Numeración de nudos



## Numeración de barras



## Propiedades y dimensiones del material de las barras del domo

|                            |                   |                           |
|----------------------------|-------------------|---------------------------|
| <b>Material</b>            | 6060-T66 Aluminum |                           |
| <b>Diámetro exterior</b>   | dext              | 32 mm                     |
| <b>Diámetro interior</b>   | dint              | 28 mm                     |
| <b>Sección Transversal</b> | Sbar              | 188.5 mm <sup>2</sup>     |
| <b>Inercia</b>             | I                 | 21300.048 mm <sup>4</sup> |
| <b>Fluencia</b>            | $\sigma_f$        | 170 Mpa                   |

## FUERZAS, ESFUERZOS Y VERIFICACIÓN DE BARRAS

Tabla: Verificación en barras

| Barra | Posición | F <sub>n</sub> (N) | F <sub>yz</sub> (N) | F <sub>xz</sub> (N) | F <sub>comb</sub> (N) | M <sub>xy</sub> (N-mm) | M <sub>xz</sub> (N-mm) | M <sub>comb</sub> (N-mm) | m <sub>n</sub> (Mpa) | σ <sub>f</sub> (Mpa) | τ <sub>c</sub> (Mpa) | σ <sub>req</sub> (Mpa) | FS     |
|-------|----------|--------------------|---------------------|---------------------|-----------------------|------------------------|------------------------|--------------------------|----------------------|----------------------|----------------------|------------------------|--------|
| 1     | 628.97   | 391.59             | -22.92              | -1.02               | 22.94                 | 1247.00                | 20146.00               | 20184.56                 | 2.08                 | 15.16                | 0.12                 | 17.24                  | 9.86   |
| 1     | 650.47   | 390.59             | -22.92              | -1.02               | 22.94                 | 1567.00                | 19641.00               | 19703.41                 | 2.07                 | 14.80                | 0.12                 | 16.87                  | 10.07  |
| 1     | 680.47   | 382.62             | 35.87               | -1.02               | 35.88                 | 2416.00                | 18468.00               | 18625.36                 | 2.03                 | 13.99                | 0.19                 | 16.00                  | 10.61  |
| 1     | 1257.94  | 381.62             | 41.85               | -1.02               | 41.86                 | 2458.00                | -9764.74               | 10069.35                 | 2.02                 | 7.56                 | 0.22                 | 9.60                   | 17.72  |
| 1     | 0        | 391.59             | -28.90              | -1.02               | 28.91                 | -320.54                | -2989.20               | 3006.34                  | 2.08                 | 2.26                 | 0.15                 | 4.34                   | 39.14  |
| 2     | 0        | -420.48            | -11.96              | -3.80               | 12.55                 | -3188.49               | -6376.97               | 7129.67                  | -2.23                | 5.36                 | 0.07                 | 3.13                   | 54.37  |
| 2     | 629.26   | -423.47            | -6.48               | -3.80               | 7.51                  | -754.18                | -597.44                | 962.14                   | -2.25                | 0.72                 | 0.04                 | 1.53                   | 111.45 |
| 2     | 1258.53  | -425.46            | -1.03               | -3.80               | 3.94                  | 1594.24                | 1793.52                | 2399.65                  | -2.26                | 1.80                 | 0.02                 | 0.46                   | 372.79 |
| 3     | 0        | -727.37            | -84.69              | 3.40                | 84.76                 | 1594.24                | -22020.48              | 22078.11                 | -3.86                | 16.58                | 0.45                 | 12.75                  | 13.33  |
| 3     | 597.81   | -727.37            | -79.71              | 3.40                | 79.78                 | -406.93                | 17589.00               | 17593.71                 | -3.86                | 13.22                | 0.42                 | 9.39                   | 18.11  |
| 3     | 597.81   | -727.37            | 69.75               | 3.40                | 69.83                 | -406.93                | 16843.00               | 16847.92                 | -3.86                | 12.66                | 0.37                 | 8.82                   | 19.27  |
| 3     | 1187.05  | -727.37            | 75.73               | 3.40                | 75.80                 | -2391.36               | -15643.51              | 15625.23                 | -3.86                | 11.89                | 0.40                 | 8.06                   | 21.10  |
| 3     | 298.91   | -727.37            | -82.70              | 3.40                | 82.77                 | 610.10                 | 2989.20                | 3050.83                  | -3.86                | 2.29                 | 0.44                 | 1.74                   | 97.59  |
| 3     | 892.43   | -727.37            | 72.74               | 3.40                | 72.82                 | -1394.96               | 6177.69                | 6333.23                  | -3.86                | 4.76                 | 0.39                 | 1.12                   | 151.75 |
| 4     | 1188.07  | -692.50            | 184.33              | -5.20               | 184.41                | 1394.96                | -30062.54              | 30094.89                 | -3.67                | 22.61                | 0.98                 | 19.01                  | 8.94   |
| 4     | 592.38   | -375.64            | -5.68               | -2.53               | 6.22                  | 429.35                 | 996.40                 | 1084.97                  | -1.99                | 0.81                 | 0.03                 | 1.18                   | 144.16 |
| 4     | 0        | -374.65            | -10.96              | -2.53               | 11.25                 | -1096.04               | -3985.61               | 4133.57                  | -1.99                | 3.10                 | 0.06                 | 1.12                   | 151.49 |
| 4     | 1184.76  | -376.64            | -0.25               | -2.53               | 2.55                  | 1893.16                | 2789.92                | 3371.61                  | -2.00                | 2.53                 | 0.01                 | 0.54                   | 317.74 |
| 5     | 0        | 0.61               | -104.62             | -6.12               | 104.80                | -3636.69               | -69224.72              | 69322.82                 | 0.00                 | 52.07                | 0.56                 | 52.08                  | 3.26   |
| 5     | 1018.44  | -0.61              | -94.66              | -6.12               | 94.86                 | 2491.00                | 55607.52               | 55663.29                 | 0.00                 | 41.81                | 0.50                 | 41.82                  | 4.07   |
| 5     | 509.22   | 0.00               | -99.64              | -6.12               | 99.83                 | -586.78                | -44112.92              | 44116.82                 | 0.00                 | 33.14                | 0.53                 | 33.15                  | 5.13   |
| 6     | 0        | 254.08             | -30.89              | 9.96                | 32.46                 | 9067.25                | -11253.00              | 14451.47                 | 1.35                 | 10.86                | 0.17                 | 12.21                  | 13.93  |
| 6     | 592.27   | 253.09             | -25.91              | 9.96                | 27.76                 | 3188.49                | -6775.53               | 7488.27                  | 1.34                 | 5.62                 | 0.15                 | 6.97                   | 24.38  |
| 6     | 1184.53  | 252.09             | -19.93              | 9.96                | 22.28                 | -2789.92               | 6875.17                | 7419.68                  | 1.34                 | 5.57                 | 0.12                 | 6.91                   | 24.59  |
| 7     | 0        | -692.50            | 23.91               | -5.20               | 24.47                 | -4782.73               | 25746.00               | 26186.47                 | -3.67                | 19.67                | 0.13                 | 16.00                  | 10.63  |
| 7     | 481.04   | -692.50            | 28.90               | -5.20               | 29.36                 | -2192.08               | 15478.00               | 15632.46                 | -3.67                | 11.74                | 0.16                 | 8.07                   | 21.06  |
| 7     | 962.08   | -692.50            | 182.34              | -5.20               | 182.42                | 267.23                 | 3387.77                | 3398.29                  | -3.67                | 2.55                 | 0.97                 | 2.02                   | 84.30  |
| 7     | 962.08   | -692.50            | 32.88               | -5.20               | 33.29                 | 267.23                 | 3387.77                | 3398.29                  | -3.67                | 2.55                 | 0.18                 | 1.16                   | 146.29 |
| 8     | 0        | -201.27            | 17.94               | 1.71                | 18.02                 | 2192.08                | 21721.55               | 21831.88                 | -1.07                | 16.40                | 0.10                 | 15.33                  | 11.09  |
| 8     | 592.38   | -203.27            | 22.92               | 1.71                | 22.98                 | 1195.68                | 9665.10                | 9738.77                  | -1.08                | 7.32                 | 0.12                 | 6.24                   | 27.24  |
| 8     | 1184.77  | -204.26            | 28.90               | 1.71                | 28.95                 | -5480.21               | -5480.21               | 5482.47                  | -1.08                | 4.12                 | 0.15                 | 3.05                   | 55.81  |
| 9     | 1184.24  | -335.79            | 91.67               | 5.72                | 91.85                 | -3487.41               | -29692.77              | 29896.86                 | -1.78                | 22.46                | 0.49                 | 20.69                  | 8.22   |
| 9     | 550.15   | -337.78            | 86.69               | 5.72                | 86.88                 | 161.82                 | 26803.20               | 26803.69                 | -1.79                | 20.13                | 0.46                 | 18.36                  | 9.26   |
| 9     | 550.15   | -374.65            | -58.79              | 5.72                | 59.06                 | 161.42                 | 26803.20               | 26803.69                 | -1.99                | 20.13                | 0.31                 | 18.15                  | 9.36   |
| 9     | 592.12   | -337.78            | 86.69               | 5.72                | 86.88                 | -78.26                 | 23116.52               | 23116.65                 | -1.79                | 17.36                | 0.46                 | 15.59                  | 10.90  |
| 9     | 0        | -376.64            | -63.77              | 5.70                | 64.02                 | 3288.13                | -6775.53               | 7531.24                  | -2.00                | 5.66                 | 0.34                 | 3.71                   | 45.87  |
| 10    | 0        | -1076.11           | -116.58             | 2.34                | 116.60                | 1494.60                | -34973.70              | 35005.62                 | -5.71                | 26.29                | 0.62                 | 20.61                  | 8.25   |
| 10    | 461.2    | -1078.11           | -112.59             | 2.34                | 112.62                | 457.75                 | 17735.95               | 17741.85                 | -5.72                | 13.33                | 0.60                 | 7.68                   | 22.14  |
| 10    | 461.2    | -1136.89           | 24.91               | 2.32                | 25.02                 | 457.85                 | 17735.95               | 17741.86                 | -6.03                | 13.33                | 0.13                 | 7.30                   | 23.29  |
| 10    | 1037.03  | -1162.80           | 84.69               | 2.33                | 84.73                 | -879.42                | 1793.52                | 1997.53                  | -6.17                | 1.50                 | 0.45                 | 4.73                   | 35.92  |
| 10    | 600.54   | -1136.89           | 25.91               | 2.32                | 26.01                 | 134.22                 | 14148.90               | 14149.54                 | -6.03                | 10.63                | 0.14                 | 4.60                   | 36.93  |



| Tabla: Verificación en barras |          |          |          |         |           |            |            |              |          |          |          |           |        |
|-------------------------------|----------|----------|----------|---------|-----------|------------|------------|--------------|----------|----------|----------|-----------|--------|
| Barra                         | Posición | Fn (N)   | Fyz (N)  | Fxz (N) | Fcomb (N) | Mxy (N-mm) | Mxz (N-mm) | Mcomb (N-mm) | on (Mpa) | of (Mpa) | tc (Mpa) | oeg (Mpa) | FS     |
| 10                            | 1037.03  | -1138.89 | 29.89    | 2.32    | 29.98     | -879.42    | 1793.52    | 1997.53      | -6.04    | 1.50     | 0.16     | 4.55      | 37.36  |
| 10                            | 1201.08  | -1162.80 | 86.69    | 2.33    | 86.72     | -1295.32   | -12255.74  | 12324.00     | -6.17    | 9.26     | 0.46     | 3.19      | 53.30  |
| 11                            | 0        | 146.47   | -500.00  | 3.95    | 500.02    | 5878.77    | -69739.80  | 69987.14     | 0.78     | 52.57    | 2.65     | 53.55     | 3.17   |
| 11                            | 509.22   | -42.85   | 283.97   | 3.95    | 284.00    | 3786.33    | 69839.44   | 69942.00     | -0.23    | 52.54    | 1.51     | 52.38     | 3.25   |
| 11                            | 358.68   | 51.81    | -458.34  | 3.95    | 458.36    | 4384.17    | 68502.00   | 68642.15     | 0.27     | 51.56    | 2.43     | 52.01     | 3.27   |
| 11                            | 358.68   | -42.85   | 282.98   | 3.95    | 283.01    | 4384.17    | 67825.00   | 67966.55     | -0.23    | 51.05    | 1.50     | 50.89     | 3.34   |
| 11                            | 103.95   | 51.81    | -461.33  | 3.95    | 461.35    | 5480.21    | 55308.60   | 55579.44     | 0.27     | 41.75    | 2.45     | 42.24     | 4.02   |
| 11                            | 1018.45  | -43.84   | 288.96   | 3.95    | 288.98    | 1793.52    | -45934.11  | 45969.11     | -0.23    | 34.53    | 1.53     | 34.40     | 4.94   |
| 11                            | 103.95   | 146.47   | -1202.66 | 3.95    | 1202.66   | 5480.21    | 25308.60   | 25895.13     | 0.78     | 19.45    | 6.38     | 23.05     | 7.38   |
| 12                            | 509.17   | -503.18  | 55.80    | -7.35   | 56.28     | -1893.16   | 44946.02   | 44985.88     | -2.67    | 33.79    | 0.30     | 31.13     | 5.46   |
| 12                            | 1018.34  | -504.18  | 59.78    | -7.35   | 60.23     | 1893.16    | -44447.82  | 44488.12     | -2.67    | 33.42    | 0.32     | 30.75     | 5.53   |
| 12                            | 0        | -502.19  | 50.82    | -7.35   | 51.34     | -5579.85   | 41948.51   | 42317.99     | -2.66    | 31.79    | 0.27     | 29.13     | 5.84   |
| 13                            | 0        | -128.54  | -2.30    | 1.48    | 2.74      | 968.30     | 2391.36    | 2579.97      | -0.68    | 1.94     | 0.01     | 1.26      | 135.32 |
| 13                            | 653.5    | -132.52  | 2.96     | 1.48    | 3.31      | -1.50      | 2192.08    | 2192.08      | -0.70    | 1.65     | 0.02     | 0.94      | 180.07 |
| 13                            | 1307     | -135.51  | 8.22     | 1.48    | 8.35      | -971.29    | -1494.60   | 1782.48      | -0.72    | 1.34     | 0.04     | 0.62      | 272.10 |
| 14                            | 1258.61  | 387.60   | 0.25     | -2.79   | 2.80      | 2989.20    | 5280.93    | 6068.24      | 2.06     | 4.56     | 0.01     | 6.61      | 25.70  |
| 14                            | 629.3    | 386.60   | -5.65    | -2.79   | 6.30      | 1295.32    | 3587.05    | 3813.76      | 2.05     | 2.86     | 0.03     | 4.92      | 34.58  |
| 14                            | 0        | 385.61   | -11.96   | -2.79   | 12.28     | -502.19    | -1793.52   | 1862.50      | 2.05     | 1.40     | 0.07     | 3.45      | 49.32  |
| 15                            | 0        | -620.76  | -9.96    | -6.97   | 12.16     | -6177.69   | -5978.41   | 8596.82      | -3.29    | 6.46     | 0.06     | 3.17      | 53.69  |
| 15                            | 653.5    | -623.75  | -4.89    | -6.97   | 8.51      | -1594.24   | -996.40    | 1880.01      | -3.31    | 1.41     | 0.05     | 1.90      | 89.55  |
| 15                            | 1307     | -627.73  | 0.38     | -6.97   | 6.98      | 2889.56    | 441.90     | 2923.16      | -3.33    | 2.20     | 0.04     | 1.14      | 149.62 |
| 16                            | 0        | -429.45  | -3.47    | 4.76    | 5.89      | 2291.72    | 6874.00    | 7245.96      | -2.28    | 5.44     | 0.03     | 3.17      | 53.71  |
| 16                            | 629.02   | -426.46  | 1.97     | 4.76    | 5.15      | -704.66    | 387.50     | 804.17       | -2.26    | 0.60     | 0.03     | 1.66      | 102.47 |
| 16                            | 1258.04  | -424.47  | 7.42     | 4.76    | 8.81      | -3686.69   | -2590.64   | 4505.90      | -2.25    | 3.38     | 0.05     | 1.14      | 149.69 |
| 17                            | 0        | -349.74  | -15.94   | 1.10    | 15.98     | 891.08     | -9864.38   | 9904.54      | -1.86    | 7.44     | 0.08     | 5.59      | 30.43  |
| 17                            | 1048.9   | -354.72  | -7.14    | 1.10    | 7.22      | -259.36    | 5685.00    | 5690.91      | -1.88    | 4.27     | 0.04     | 2.39      | 71.01  |
| 17                            | 524.45   | -351.73  | -11.96   | 1.10    | 12.01     | 315.86     | -2690.28   | 2708.76      | -1.87    | 2.03     | 0.06     | 0.20      | 843.14 |
| 18                            | 1153.93  | 0.00     | 6.96     | 0.76    | 7.00      | 14.66      | -1594.24   | 1594.31      | 0.00     | 1.20     | 0.04     | 1.20      | 141.75 |
| 18                            | 384.64   | 0.00     | -0.32    | 0.76    | 0.82      | 597.84     | 953.16     | 1125.13      | 0.00     | 0.85     | 0.00     | 0.85      | 201.14 |
| 18                            | 0        | 0.00     | -3.96    | 0.76    | 4.04      | 889.49     | 128.83     | 898.77       | 0.00     | 0.68     | 0.02     | 0.68      | 251.43 |
| 18                            | 769.29   | 0.00     | 3.32     | 0.76    | 3.40      | 306.29     | 377.04     | 485.77       | 0.00     | 0.36     | 0.02     | 0.37      | 464.19 |
| 19                            | 0        | 0.00     | -5.98    | -0.09   | 5.98      | -338.58    | -1793.52   | 1825.20      | 0.00     | 1.37     | 0.03     | 1.37      | 123.90 |
| 19                            | 1154.62  | 0.00     | 4.95     | -0.09   | 4.95      | -238.74    | -1195.68   | 1219.28      | 0.00     | 0.92     | 0.03     | 0.92      | 185.39 |
| 19                            | 384.87   | 0.00     | -2.33    | -0.09   | 2.34      | -305.30    | -207.55    | 369.17       | 0.00     | 0.28     | 0.01     | 0.28      | 611.22 |
| 19                            | 769.75   | 0.00     | 1.31     | -0.09   | 1.31      | -272.02    | -10.06     | 272.20       | 0.00     | 0.20     | 0.01     | 0.20      | 829.99 |

## DESPLAZAMIENTOS EN NUDOS

| Tabla Desplazamientos de Nodos |        |        |        |           |           |           |
|--------------------------------|--------|--------|--------|-----------|-----------|-----------|
| Nodo                           | X      | Y      | Z      | R1        | R2        | R3        |
| Texto                          | mm     | mm     | mm     | Radianes  | Radianes  | Radianes  |
| 1                              | 0.000  | 0.000  | -0.003 | -1.17E-02 | 1.64E-03  | 7.16E-04  |
| 2                              | 0.000  | 0.000  | -0.001 | 8.19E-03  | 2.51E-04  | -6.80E-04 |
| 3                              | -0.054 | -0.019 | -0.186 | 3.54E-04  | -6.84E-04 | 1.06E-04  |
| 4                              | 0.000  | 0.000  | -0.002 | -5.67E-04 | 3.35E-03  | 2.94E-04  |
| 5                              | 0.000  | 0.034  | -0.005 | 7.04E-04  | 8.56E-04  | -5.08E-04 |
| 6                              | -0.039 | -0.034 | -0.075 | -1.63E-03 | -1.39E-03 | 2.65E-04  |
| 7                              | -0.023 | -0.008 | -0.140 | 6.12E-04  | -1.01E-03 | -2.60E-05 |
| 8                              | 0.000  | 0.000  | -0.001 | 8.80E-05  | -2.23E-04 | 6.30E-05  |
| 9                              | 0.000  | 0.000  | -0.003 | -1.42E-04 | -1.40E-05 | 1.39E-04  |
| 10                             | 0.000  | 0.000  | -0.002 | 2.20E-05  | 1.69E-04  | -7.10E-05 |
| 11                             | -0.190 | -0.298 | -0.324 | -4.69E-03 | 1.13E-03  | 3.80E-05  |
| 12                             | -0.083 | -0.173 | -0.265 | -1.33E-02 | 1.48E-03  | 4.98E-04  |
| 13                             | -0.054 | -0.001 | -1.513 | 2.50E-04  | 1.23E-03  | -4.00E-05 |
| 14                             | -0.070 | -0.051 | -1.568 | 3.29E-04  | -2.60E-03 | 1.84E-04  |
| 15                             | -0.226 | -0.057 | -1.862 | -1.44E-04 | 8.10E-04  | -9.10E-05 |
| 16                             | -0.183 | 0.130  | -1.811 | 2.46E-04  | -1.01E-04 | -1.96E-04 |
| 17                             | -0.076 | -0.095 | -0.456 | -4.40E-05 | -1.29E-03 | 1.95E-04  |
| 18                             | -0.101 | -0.041 | -0.292 | 6.71E-04  | -1.36E-03 | -8.10E-05 |

## C. COTIZACIONES

### C.1 Costos de equipos, accesorios y materiales.

| ITEM | DESCRIPCIÓN   | CANT. | UN. | COSTO US\$ |          |
|------|---|-------|-----|------------|----------|
|      |   |       |     | UNITARIO   | TOTAL    |
| 1    | Suministro de equipo de aire acondicionado tipo "split" para operar con ductos, refrigerante R140A, con unidad condensadora enfriada por aire. Capacidad: 8.8 kW (30000 BTU/h) modo enfriamiento y 4.8 kW (16500 BTU/h) modo calefacción<br>Suministro eléctrico: 220V, 60Hz, 1ph.<br>Incluye:<br>- Unidad Exterior Split Ducto 14HPX-036 MERIT Series.<br>- Unidad Interior Split Ducto CBX25UH MERIT Series | 1     | UN  | 1,734.00   | 1,734.00 |
| 2    | Suministro de calentador eléctrico para ducto modelo SL10A marca WARREM de 3.6 kW de capacidad.<br>Suministro eléctrico: 220 V, 1ph.  | 1     | UN  | 575.00     | 575.00   |
| 3    | Suministro de termostato / humidistato digital marca CAREL para sistemas de climatización.<br>Suministro eléctrico: 24 Vac/dc, 60 Hz, 3W.   | 1     | UN  | 310.00     | 310.00   |
| 4    | Suministro de extractor helicoidal para pared serie HV-STYLVENT modelo HV-300 M de capacidad 1100 m³/h. Suministro eléctrico: 220 V, 60 Hz, 1ph   | 1     | UN  | 192.00     | 192.00   |
| 5    | Suministro de louver de marco y paletas de aluminio extruido. Dimensiones: 500 x 380 x 76 (alto x ancho x espesor). Medidas en mm.  | 1     | UN  | 32.00      | 32.00    |
| 6    | Suministro de filtro metálico lavable de aluminio eficiencia MERV 7. Dimensiones: 500 x 380 x 25 (alto x ancho x espesor). Medidas en mm.   | 1     | UN  | 45.00      | 45.00    |

|    |  |    |                |        |        |
|----|--|----|----------------|--------|--------|
| 7  | Suministro de difusor de techo de conos variables construido en aluminio serie ARCV. Tamaño 250 para caudales de 1100 m <sup>3</sup> /h  | 1  | UN             | 105.00 | 105.00 |
| 8  | Suministro de rejilla de retorno series At para caudales hasta 900 m <sup>3</sup> /h con dimensiones 500 x 350 mmm.  | 1  | UN             | 27.00  | 27.00  |
| 9  | Suministro de paquete de 6 m de tubería de cobre de 7/8" de diámetro para línea de vapor para equipo split ducto de 8.8 kW (30000 BTU/h) modo enfriamiento y 4.8 kW (16500 BTU/h) modo calefacción. Incluye accesorios.                                | 1  | UN             | 80.00  | 80.00  |
| 10 | Suministro de paquete de 6 m tubería de cobre de 3/8" de diámetro para línea de líquido, con aislamiento térmico de 7/8" para equipo split ducto de 8.8 kW (30000 BTU/h) modo enfriamiento y 4.8 kW (16500 BTU/h) modo calefacción. Incluye accesorios | 1  | UN             | 55.00  | 55.00  |
| 11 | Suministro de tubería flexible de pvc de 1/4" de diámetro para línea de drenaje de equipo split ducto  | 6  | m              | 2.60   | 15.60  |
| 12 | Fabricación y suministro de ductos de plancha galvanizada de 3 mm según medidas en plano, bajo norma SMACNA.   | 30 | kg             | 5.00   | 150.00 |
| 13 | Suministro de aislamiento térmico de lana de vidrio con cubierta exterior de foil de aluminio. El forrado del aislamiento es exteriormente 3 cm.   | 10 | m <sup>2</sup> | 6.50   | 65.00  |



|    |  |   |    |       |       |
|----|--|---|----|-------|-------|
| 14 | <p>Suministro de material para soporte de ductos y unidad interior de split ducto. La cantidad y tipo de material para la instalación de los ductos y equipo de aire acondicionado se detalla a continuación:</p> <ul style="list-style-type: none"> <li>- 4 Perfiles C 150 x 102 x 10 mm</li> <li>- 8 Varillas galvanizadas roscadas de 24mm</li> <li>- 8 Tuercas hexagonal M24</li> <li>- 12 Arandelas de neopreno M24</li> <li>- 4 Arandelas M24</li> <li>- 8 Contratuerca hexagonales M24</li> <li>- 8 Abrazaderas normales de 32mm</li> <li>- 16 Pernos hexagonales M6X20</li> <li>- 16 Arandelas planas de M6</li> <li>- 16 Tuercas hexagonales M6</li> </ul>  | 1 | UN | 48.00 | 48.00 |
| 15 | <p>Suministro de material para soporte de tuberías de Cu de diámetro 3/8" y 7/8" y tubería flexible de PVC 1/4" La cantidad y tipo de material para la instalación de las tuberías se detalla a continuación:</p> <ul style="list-style-type: none"> <li>- 2 Ángulos de 60x80x10 mm</li> <li>- 4 Varillas galvanizadas roscadas M12</li> <li>- 4 Tuercas hexagonal M12</li> <li>- 8 Arandelas M12</li> <li>- 4 Contratuerca hexagonales M12</li> <li>- 4 Abrazaderas de 32 mm</li> <li>- 8 Pernos hexagonales M6</li> <li>- 8 Arandelas planas M6</li> <li>- 8 Tuercas hexagonales M6</li> <li>- 2 U-Bolt de 6MM</li> <li>- 2 Arandelas planas de <math>\Phi 7</math> mm</li> <li>- 4 Tuercas hexagonales de <math>\Phi 7</math> mm</li> <li>- 2 U-Bolt de 8mm</li> <li>- 2 Arandelas planas de <math>\Phi 10</math> mm</li> <li>- 4 Tuercas hexagonales de <math>\Phi 10</math> mm</li> <li>- 2 Abrazadera de PVC de 18cm</li> <li>- 2 Pernos PAN M6</li> <li>- 2 Arandelas M6</li> </ul> | 1 | UN | 35.00 | 35.00 |
| 16 | <p>Suministro de material para soporte de extractor helicoidal de pared. La cantidad y tipo de material para la instalación del extracto se detalla a continuación:</p> <ul style="list-style-type: none"> <li>- 1 Plancha galvanizada 3mm</li> <li>- 4 U-Bolt de 32mm</li> <li>- 4 Arandelas de <math>\Phi 8</math> mm</li> <li>- 8 Tuercas de <math>\Phi 8</math> mm</li> </ul>  | 1 | UN | 12.00 | 12.00 |

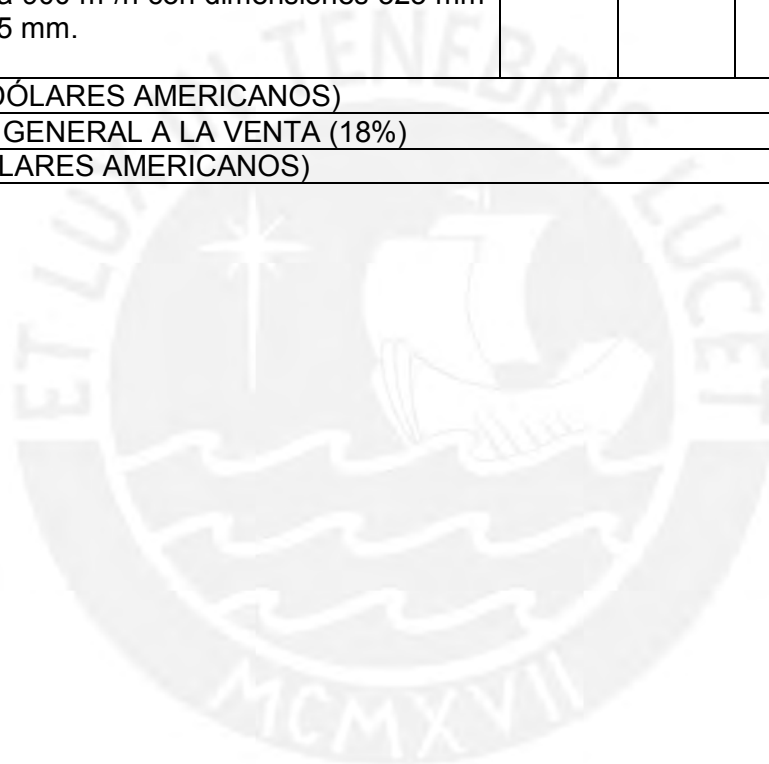
|  |   |   |    |        |          |
|--|---|---|----|--------|----------|
| 17   | Suministro de material para soporte de unidad exterior split ducto. La cantidad y tipo de material que se incluye para la instalación de los soportes se detalla a continuación:<br>- 4 Perfiles en L 76 x 76 x 13 mm   | 1 | UN | 15.00  | 15.00    |
| 18   | Suministro material para instalación eléctrica de un equipo de aire acondicionado tipo split ducto, un extractor helicoidal de pared, un calentador eléctrico y un termostato - humidistato digital. La cantidad y tipo de material para la instalación eléctrica se detalla a continuación:<br>- 2 Relés térmicos EASY 1-1.6A Schneider<br>- 1 Relé térmico EASY 1.6-2.5A Schneider<br>- 3 Fusibles 2A 5mm de diámetro y 20 mm de largo, 250Vca.<br>- 3 Portafusible de presión AMPF-1<br>- 3 Interruptores automáticos lc60n tensión de empleo 110/220VAC<br>- Contactor LC1L06013M7 6A Schneider<br>- 15 m Conductor libre de halógeno 4mm <sup>2</sup><br>- 15 m Conductor libre de halógeno 1.5 mm <sup>2</sup><br>- 4 Pulsadores telemecanique 2mm tipo hongo<br>- 1 Tubo de pvc 3m 1/2" Pavco<br>- 10 Canaletas PVC Blanca con adhesivo 20 x 12 x 200 mm | 1 | UN | 325.00 | 325.00   |
| <b>Sub Total (Dólares americanos)</b>      |   |   |    |        | 3,820.60 |
| <b>IMPUESTO GENERAL A LAS VENTAS (18%)</b> |   |   |    |        | 687.71   |
| <b>TOTAL (Dólares americanos)</b>          |   |   |    |        | 4508.31  |

## C.2 Costo de instalación

| ITEM | DESCRIPCIÓN  | CANT. | UNID. | COSTO (US\$) |         |
|------|--|-------|-------|--------------|---------|
|      |  |       |       | UNITARIO     | TOTAL   |
| 1    | <p>Servicio de instalación de equipo de aire acondicionado tipo split ducto marca LENNOX Serie MERIT de 8.8 kW (30000 BTU/h) modo enfriamiento y 4.8 kW (16500 BTU/h) modo calefacción en domo geodésico de 50 m<sup>2</sup>.</p> <p>Detalle del servicio:</p> <ul style="list-style-type: none"> <li>- Acarreo, izaje e instalación de unidad interior en domo a 3 m de altura acoplado al ducto de suministro de aire.</li> <li>- Acarreo, izaje e instalación de unidad exterior afuera del domo (aproximadamente 7 m alejado de la unidad evaporadora) soportado en plataforma metálica.</li> <li>- Instalación de tuberías de cobre de 3/8" y 7/8" para el sistema de refrigeración a 2.8 m de altura realizando un recorrido de aproximadamente 6 metros. Las tuberías van soportadas en canales que se soportan a su vez de la estructura del domo.</li> <li>- Instalación de accesorios para el sistema de refrigeración.</li> <li>- Instalación de aislamiento térmico del sistema de refrigeración con manguera aislante de 3/4" de espesor.</li> <li>- Instalación de tubería flexible de pvc de 1/4" desde unidad interior de split ducto hasta exterior de domo.</li> <li>- Instalación de conductores eléctricos, conexión eléctrica a puntos de suministro previsto por el cliente, incluye circuito de control y fuerza.</li> <li>- Recarga de gas refrigerante.</li> <li>- Pruebas finales.</li> <li>- Puesta en servicio.</li> </ul> | 1     | SERV. | 1853.87      | 1853.87 |
| 2    | Servicio de instalación de calentador eléctrico para ducto modelo SL10A marca WARREM de 3.6 kW de capacidad con suministro eléctrico: 220 V, 60 Hz y 1ph.  | 1     | SERV. | 464.09       | 464.09  |

|   |  |   |       |        |        |
|---|--|---|-------|--------|--------|
|   | <p>Detalle del servicio:</p> <ul style="list-style-type: none"> <li>- Acarreo, izaje e instalación calentador eléctrico en domo a 3 m de altura acoplado al ducto de suministro de aire.</li> <li>- Instalación de conductores eléctricos, conexión eléctrica a puntos de suministro previsto por el cliente, incluye circuito de control y fuerza.</li> <li>- Pruebas finales.</li> <li>- Puesta en servicio.</li> </ul>  |   |       |        |        |
| 3 | <p>Servicio de instalación de termostato/humidistato digital marca CAREL para sistema de climatización en domo geodésico de 50 m<sup>2</sup>.</p> <p>Detalle del servicio:</p> <ul style="list-style-type: none"> <li>- Instalación de termostato/humidistato en domo a 1.6 m de altura acoplado a tubo de domo.</li> <li>- Instalación de conductores eléctricos, conexión eléctrica a puntos de suministro previsto por el cliente, incluye circuito de control.</li> <li>- Prueba de funcionamiento.</li> <li>- Puesta en servicio.</li> </ul>  | 1 | SERV. | 201.24 | 201.24 |
| 4 | <p>Servicio de instalación de extractor helicoidal para pared serie HV-STYLVENT modelo HV-300 M de capacidad 1100 m<sup>3</sup>/h en domo geodésico de 50 m<sup>2</sup>.</p> <p>Detalle del servicio:</p> <ul style="list-style-type: none"> <li>- Instalación de extractor helicoidal en domo a 0.2 m de altura soportado a la estructura del domo mediante una plancha galvanizada de 3 mm y cuatro abrazadera U.</li> <li>- Instalación de conductores eléctricos, conexión eléctrica a puntos de suministro previsto por el cliente, incluye circuito de control y fuerza.</li> <li>- Pruebas finales.</li> <li>- Puesta en servicio.</li> </ul> | 1 | SERV. | 123.84 | 123.84 |
| 5 | <p>Servicio de instalación de ductos de plancha galvanizada bajo norma</p>   | 1 | SERV. | 887.62 | 887.62 |

|                                   |   |  |  |  |         |
|-----------------------------------|---|--|--|--|---------|
|                                   | <p>SMACNA aislado térmicamente con lana de vidrio y cubierta exterior de foil de aluminio. El ducto irá soportado a la estructura del domo mediante cuatro varillas roscadas galvanizadas. El servicio incluye la instalación de los siguientes accesorios para ducto:</p> <ul style="list-style-type: none"> <li>- Louver de marco y paletas de aluminio extruido. Dimensiones: 20" x 15" x 3" (alto x ancho x espesor).</li> <li>- Difusor de techo de conos variables construido en aluminio serie ARCV para caudales de 1080 m<sup>3</sup>/h.</li> <li>-Rejilla de retorno Serie AT para caudales hasta 900 m<sup>3</sup>/h con dimensiones 325 mm x 425 mm.</li> </ul> |  |  |  |         |
| Sub Total (DÓLARES AMERICANOS)    |   |  |  |  | 3530.65 |
| IMPUESTO GENERAL A LA VENTA (18%) |   |  |  |  | 635.52  |
| TOTAL (DÓLARES AMERICANOS)        |   |  |  |  | 4166.17 |





### C.3 Costo de mantenimiento

| ITEM | DESCRIPCIÓN   | CANT. | UNID. | COSTO US\$ |        |
|------|---|-------|-------|------------|--------|
|      |   |       |       | UNITARIO   | TOTAL  |
| 1    | <p>Servicio de mantenimiento preventivo de calentador eléctrico para ducto.</p> <p>El servicio incluye:</p> <ul style="list-style-type: none"> <li>- Limpieza general externa del equipo.</li> <li>- Registrar los Parámetros del equipo.</li> <li>- Verificar calentamiento anormal de resistencias.</li> <li>- Revisar el estado de cableado eléctrico de fuerza y control, cambiar si es necesario.</li> </ul>   | 3     | SERV. | 111.15     | 333.44 |
| 2    | <p>Servicio de mantenimiento preventivo de ductos de plancha galvanizada, aislamiento de lana de vidrio y accesorios de ducto como: louver, difusor de techo de conos variables, filtro metálico MERV 7 y rejilla de retorno.</p> <p>El servicio incluye:</p> <ul style="list-style-type: none"> <li>- Limpieza general externa e interna de ducto metálico.</li> <li>- Limpieza general de accesorios de ducto: louver, difusor y rejilla.</li> <li>- Extracción de residuos y/o elementos contaminantes.</li> </ul>   | 3     | SERV. | 61.61      | 184.83 |
| 3    | <p>Servicio de mantenimiento preventivo de equipo de aire acondicionado tipo split ducto (unidad interior y exterior) que incluye sistemas de tubería de Cu de 3/8" y 7/8" y tubería flexible de pvc de 1/4"</p> <p>El servicio incluye:</p> <ul style="list-style-type: none"> <li>- Limpieza general externa de unidad interior y exterior</li> <li>- Registrar los parámetros del equipo</li> <li>- Registrar ruidos y vibraciones anormales</li> <li>- Ajustar bornes de los conductores de control y fuerza del sistema eléctrico.</li> <li>- Verificar calentamiento anormal y motor-ventilador y demás partes móviles con pirómetro.</li> <li>- Revisar temperatura y presiones de succión y descarga del compresor</li> </ul> | 3     | SERV. | 135.91     | 407.74 |

|   |   |   |       |       |        |
|---|---|---|-------|-------|--------|
|   | <ul style="list-style-type: none"> <li>- Revisar el funcionamiento de la válvula solenoide según temperatura requerida.</li> <li>- Revisar el correcto funcionamiento de accesorios en líneas de cobre.</li> <li>- Inspeccionar el visor de líquido, y filtro secador.</li> <li>- Revisar fugas de aceite y/o refrigerante en el sistema.</li> <li>- Limpiar serpentines y aletas.</li> <li>- Limpieza de los ventiladores, ajuste de pernos y tornillos.</li> <li>- Revisar el estado de aislante de tubería. Reemplazar si es necesario.</li> <li>- Revisar funcionamiento de las Válvulas de cuatro Vías.</li> <li>- Mantenimiento de pintura</li> <li>- Limpiar los filtros de aire de la unidad interior, (malla de aluminio, filtro de eficiencia, soplear.</li> <li>- Revisar la tubería de drenaje y limpieza de la trampa.</li> <li>- Realizar lavado químico exteriormente a los serpentines del evaporador y bandeja de Condensado.</li> <li>- Cambio de filtros de aire.</li> </ul> |   |       |       |        |
| 4 | <p>Servicio de mantenimiento preventivo de extractor helicoidal para pared serie HV-STYLVENT modelo HV-300 M de capacidad 1100 m<sup>3</sup>/h en domo geodésico de 50 m<sup>2</sup>.</p> <p>El servicio incluye:</p> <ul style="list-style-type: none"> <li>- Limpieza general externa del equipo.</li> <li>- Registrar los Parámetros de Operación.</li> <li>- Ajustar bornes de los conductores de control y fuerza del sistema eléctrico.</li> <li>- Verificar estado de componentes eléctricos. Limpiar y/o cambiar los terminales Deteriorado.</li> <li>- Mantenimiento y Limpieza general al gabinete interior y exterior.</li> <li>- Mantenimiento y limpieza de las rejillas y difusores pertenecientes al equipo.</li> <li>- Verificar/registran ruidos y vibración anormales en el equipo.</li> </ul>  | 3 | SERV. | 77.09 | 231.27 |

|                                   |   |  |  |  |         |
|-----------------------------------|---|--|--|--|---------|
|                                   | <ul style="list-style-type: none"> <li>- Aplicar Lubricantes y engrasado de las partes móviles, rodamientos y chumaceras del conjunto motor ventilador.</li> <li>- Limpiar y ajustar tornillería de soporte perteneciente al equipo.</li> <li>- Revisar motor de extractor, realizar mediciones de resistencia de bobinas, prueba de aislamiento entre bobinas y carcasa.</li> <li>- Mantenimiento de pintura del Extractor.</li> </ul> |  |  |  |         |
| Sub Total (DÓLARES AMERICANOS)    |   |  |  |  | 1157.28 |
| IMPUESTO GENERAL A LA VENTA (18%) |   |  |  |  | 208.31  |
| TOTAL (DÓLARES AMERICANOS)        |   |  |  |  | 1365.59 |



## C.4 Costo de operación

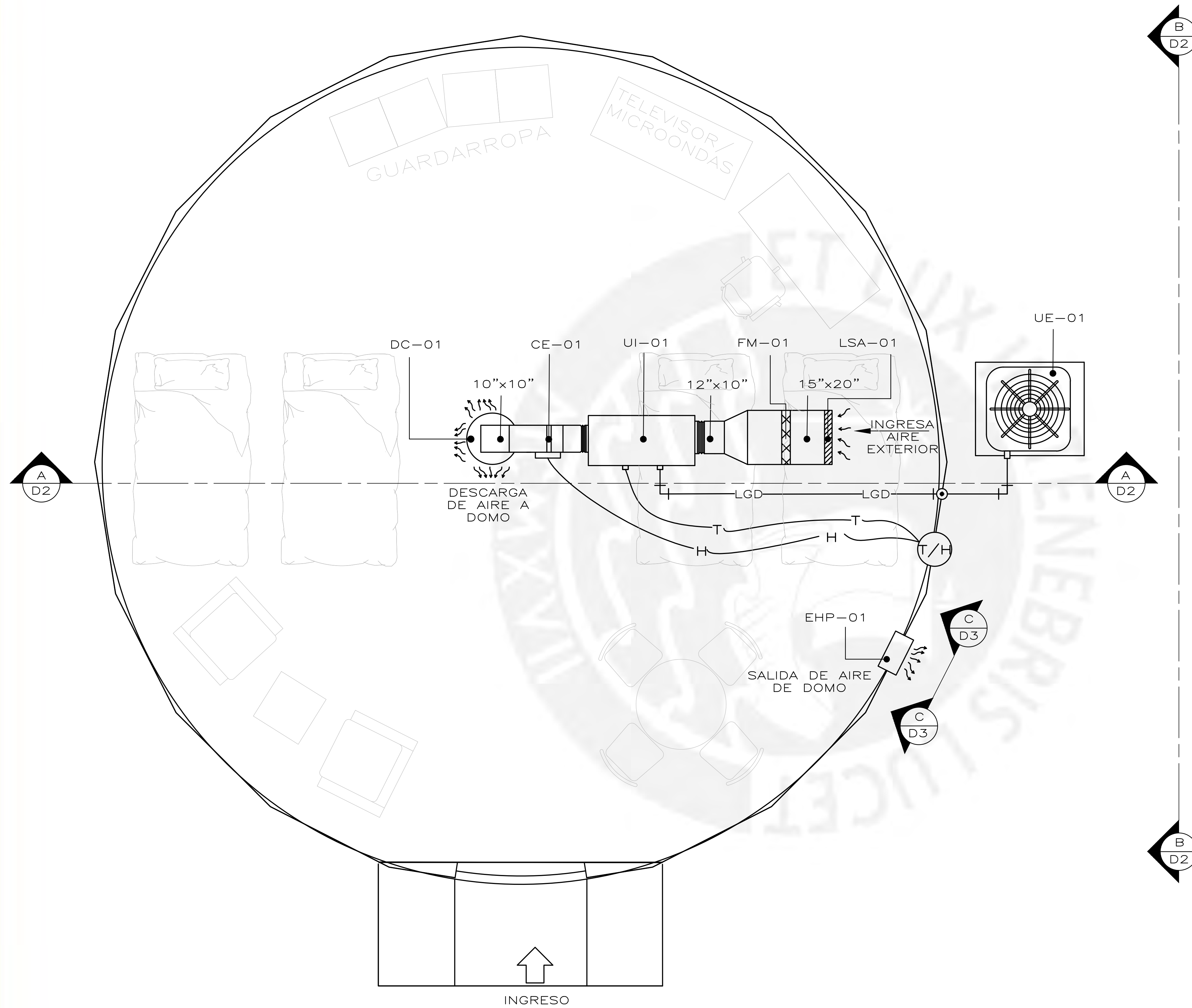
| Época                    | Equipo   | Carga empleada (W) | Horas de funcionamiento estimadas por día | Consumo (kW-h) | Precio de energía eléctrica en Pisco (soles/kW-h) | Costo de operación diario | Costo de operación mensual | Costo de operación trimestral |
|--------------------------|--|--------------------|---|----------------|---|---------------------------|----------------------------|-------------------------------|
| Verano (Dic-Ene-Feb)     | Equipo de aire acondicionado split ducto. Capacidad: Refrigeración 36,000 BTU/h (SEER 15.50) y Calefacción 20,400 BTU/h (SEER 15.50) | 1700               | 7   | 12             | 2.047   | S/. 24.36                 | S/. 730.78                 | S/. 2,192.34                  |
|                          | Calentador eléctrico   | 3100               | 7   | 22             | 2.047   | S/. 44.42                 | S/. 1,332.60               | S/. 3,997.79                  |
|                          | Extractor de aire  | 68                 | 7   | 0.48           | 2.047   | S/. 0.97                  | S/. 29.23                  | S/. 87.69                     |
|                          | <b>Sub - Total</b>   |                    |   |                |   | S/. 69.75                 | S/. 2,092.61               | S/. 6,277.82                  |
| Otoño (Mar-Abr-May)      | Equipo de aire acondicionado split ducto. Capacidad: Refrigeración 36,000 BTU/h (SEER 15.50) y Calefacción 20,400 BTU/h (SEER 15.50) | 1700               | 7   | 12             | 2.047   | S/. 24.36                 | S/. 730.78                 | S/. 2,192.34                  |
|                          | Calentador eléctrico   | 3100               | 7   | 22             | 2.047   | S/. 44.42                 | S/. 1,332.60               | S/. 3,997.79                  |
|                          | Extractor de aire  | 68                 | 7   | 0.48           | 2.047   | S/. 0.97                  | S/. 29.23                  | S/. 87.69                     |
|                          | <b>Sub - Total</b>   |                    |   |                |   | S/. 69.75                 | S/. 2,092.61               | S/. 6,277.82                  |
| Invierno (Jun-Jul-Ago)   | Equipo de aire acondicionado split ducto. Capacidad: Refrigeración 36,000 BTU/h (SEER 15.50) y Calefacción 20,400 BTU/h (SEER 15.50) | 225                | 7   | 1.575          | 2.047   | S/. 3.22                  | S/. 96.72                  | S/. 290.16                    |
|                          | Calentador eléctrico   | 400                | 7   | 2.8            | 2.047   | S/. 5.73                  | S/. 171.95                 | S/. 515.84                    |
|                          | Extractor de aire  | 25                 | 7   | 0.175          | 2.047   | S/. 0.36                  | S/. 10.75                  | S/. 32.24                     |
|                          | <b>Sub - Total</b>   |                    |   |                |   | S/. 9.31                  | S/. 279.42                 | S/. 838.25                    |
| Primavera (Sep-Oct-Nov)  | Equipo de aire acondicionado split ducto. Capacidad: Refrigeración 36,000 BTU/h (SEER 15.50) y Calefacción 20,400 BTU/h (SEER 15.50) | 1700               | 7   | 12             | 2.047   | S/. 24.36                 | S/. 730.78                 | S/. 2,192.34                  |
|                          | Calentador eléctrico   | 3100               | 7   | 22             | 2.047   | S/. 44.42                 | S/. 1,332.60               | S/. 3,997.79                  |
|                          | Extractor de aire  | 68                 | 7   | 0              | 2.047   | S/. 0.97                  | S/. 29.23                  | S/. 87.69                     |
|                          | <b>Sub - Total</b>   |                    |   |                |   | S/. 69.75                 | S/. 2,092.61               | S/. 6,277.82                  |
| <b>Sub - Total anual</b> |  |                    |   |                |   |                           |                            | S/. 19,671.71                 |
| <b>IGV</b>               |  |                    |   |                |   |                           |                            | S/. 3,540.91                  |
| <b>Total</b>             |  |                    |   |                |   |                           |                            | S/. 23,212.62                 |
|                          |  |                    |   |                |   |                           |                            | US\$ 7098                     |

**D. PLANOS**

**E. CATÁLOGOS**

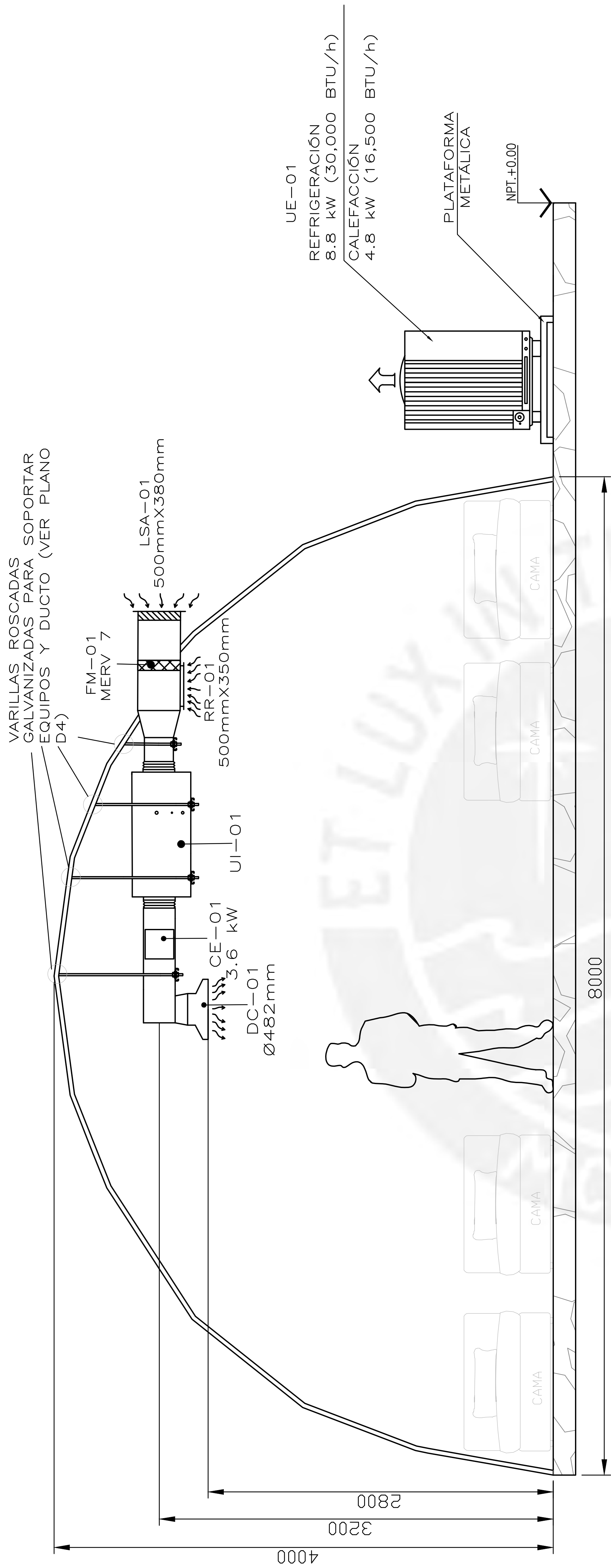






| LEYENDA |                                     |
|---------|-------------------------------------|
|         | DUCTO DE PLANCHA GALVANIZADA        |
|         | UNIÓN FLEXIBLE PARA DUCTO           |
|         | REJILLA DE RETORNO (RR)             |
|         | DIFUSOR CÓNICO (DC)                 |
|         | FILTRO METÁLICO (FM)                |
|         | LOUVER DE SUMINISTRO DE AIRE (LSA)  |
|         | SENSOR DE TEMPERATURA (T)           |
|         | SENSOR DE HUMEDAD RELATIVA (H)      |
|         | UNIDAD EXTERIOR DE SPLIT DUCTO (UE) |
|         | UNIDAD INTERIOR DE SPLIT DUCTO (UI) |
|         | CALENTADOR ELÉCTRICO (CE)           |
|         | EXTRACTOR HELICOIDAL DE PARED (EHP) |
|         | DIFUSOR CÓNICO (DC)                 |
|         | FILTRO METÁLICO (FM)                |
|         | LOUVER DE SUMINISTRO DE AIRE (LSA)  |
|         | CODO DE 90°                         |
|         | TUBERÍA DE LÍQUIDO, GAS Y DRENAJE   |
|         | CODO QUE BAJA                       |
|         | CABLEADO DE TERMOSTATO (T)          |
|         | CABLEADO DE HUMIDISTATO (H)         |

|   |  |                      |
|---|--|----------------------|
| PONTIFICIA UNIVERSIDAD CATOLICA DEL PERU<br>FACULTAD DE CIENCIAS E INGENIERIA - ESPECIALIDAD: ING. MECÁNICA |  |                      |
| METODO DE PROYECCION<br>  | VISTA PLANTA DE DOMO<br>GEODÉSICO 50M <sup>2</sup> CLIMATIZADO | ESCALA<br>1:20       |
| 20100341  | AURIS CASMA, OMAR TADEO  | FECHA:<br>2017.10.10 |
|   |  | LAMINA:<br>D1-A1     |



SECCION A  
ESC.: 1:20 D1

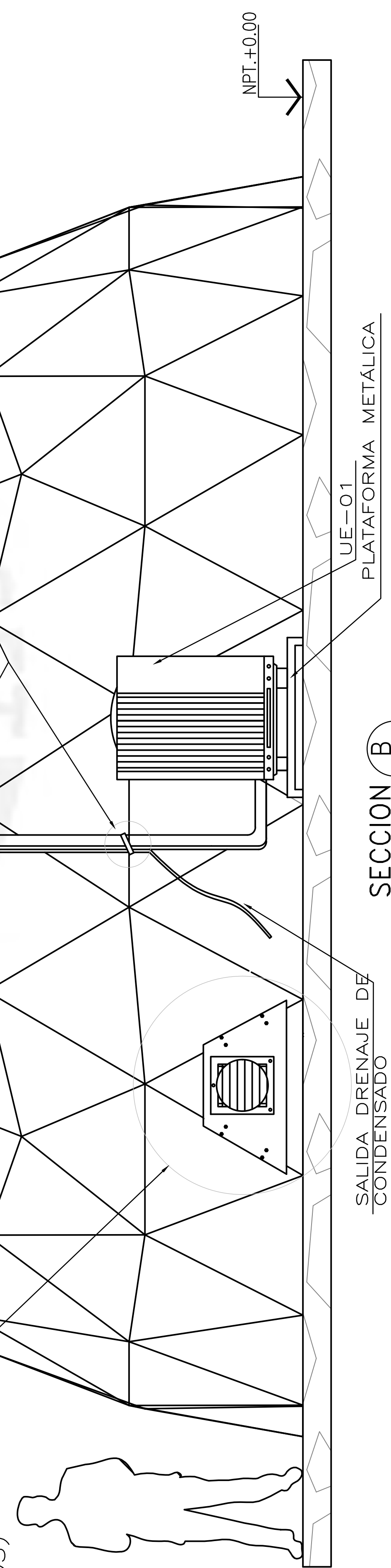
- VIENEN TUBERIAS DESDE UNIDAD INTERIOR DE SPLIT DUCTO:
- TUBERIA FLEXIBLE PVC Ø3/4" PARA DRENAJE
  - TUBERIA DE Cu Ø7/8"
  - TUBERIA DE Cu Ø3/8" CON AISLANTE TÉRMICO

INSTALACIÓN Y RECORRIDO SEGÚN PLANO D5

LOUVER DE AIRE SUMINISTRO DE AIRE HACIA DUCTO

TUBERÍAS SUJETAS A TUBO DE DOMO MEDIANTE ABRAZADERA DE 18 CM DE DIÁMETRO

EXTRACTOR HELICOIDAL DE PARED 1100 m<sup>3</sup>/h (VER DETALLE EN PLANO D3)



SECCION B  
ESC.: 1:20 D1

SALIDA DRENAJE DE CONDENSADO

PLATAFORMA METÁLICA

UE-01  
REFRIGERACIÓN  
8.8 kW (30,000 BTU/h)  
CALEFACCIÓN  
4.8 kW (16,500 BTU/h)

PLATAFORMA METÁLICA

NPT.+0.00

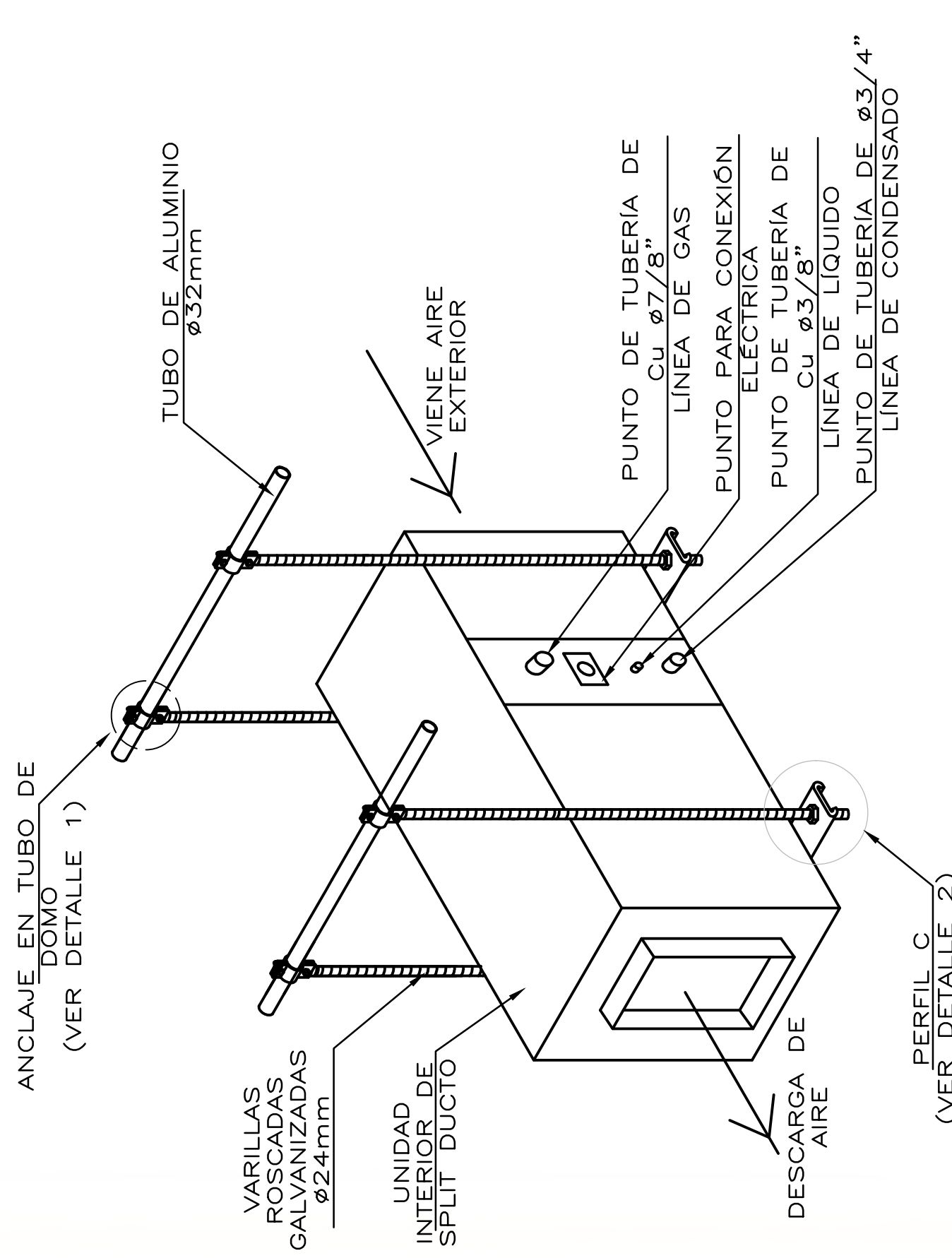
NPT.+0.00

|   |  |                         |            |
|---|--|-------------------------|------------|
| PONTIFICIA UNIVERSIDAD CATOLICA DEL PERU<br>FACULTAD DE CIENCIAS E INGENIERIA - ESPECIALIDAD: ING. MECÁNICA |  | ESCALA                  | 1:20       |
| METODO DE PROYECCION  | ELEVACIONES DE DOMO GEODÉSICO 50M <sup>2</sup> CLIMATIZADO | FECHA:                  | 2017.10.10 |
|   | 20100341   | LAMINA:                 | D2-A1      |
|   |  | AURIS CASMA, OMAR TADEO |            |

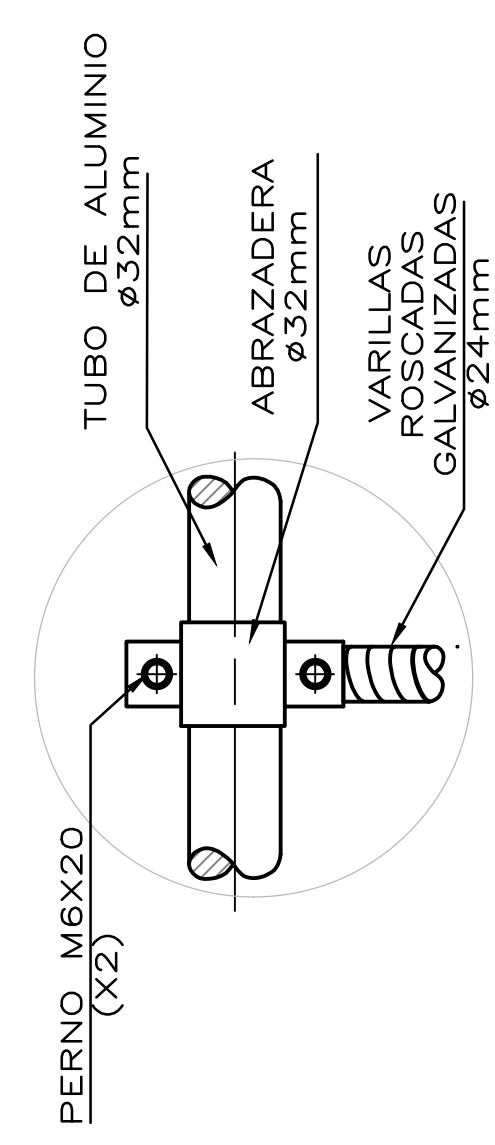




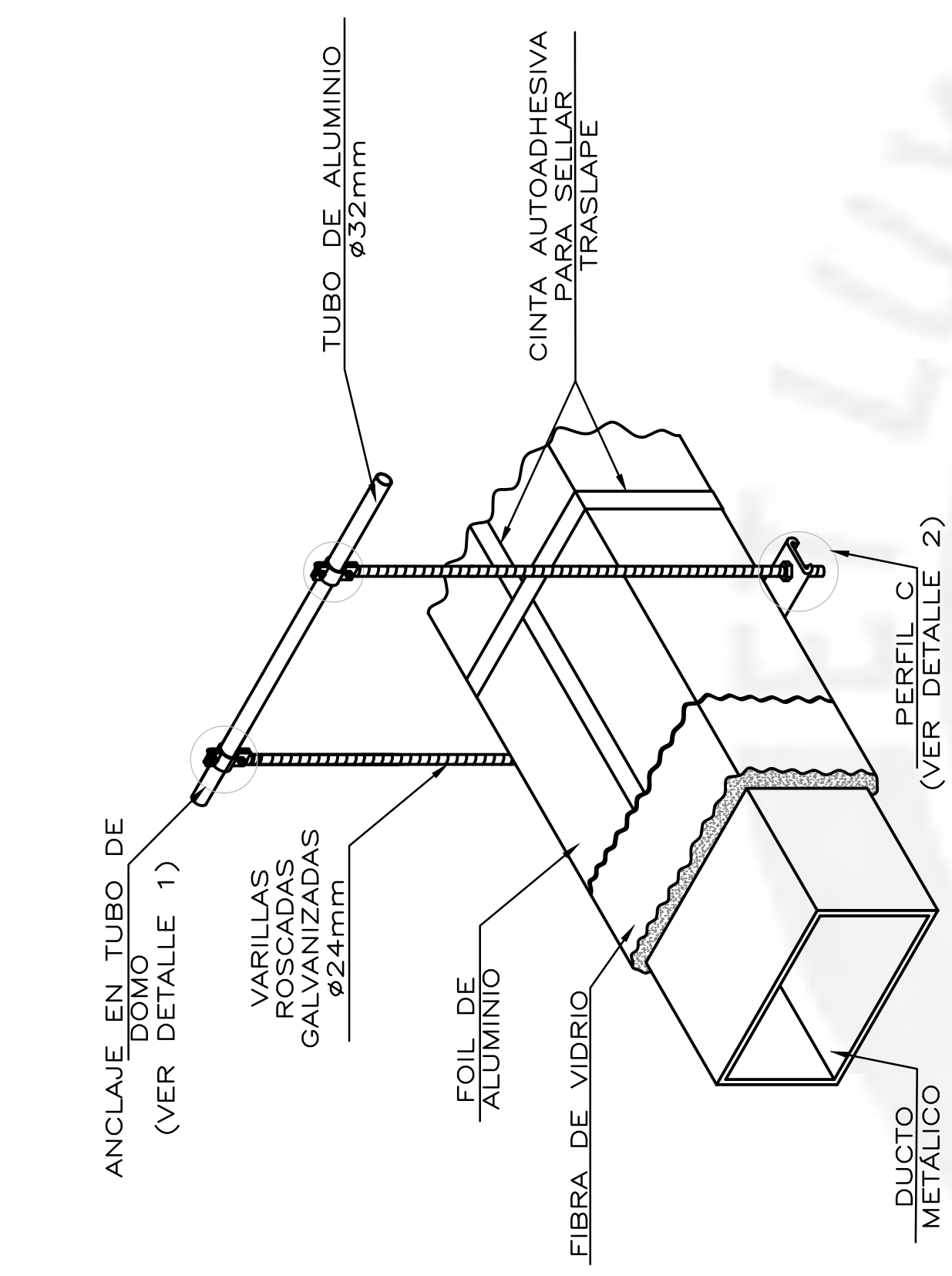




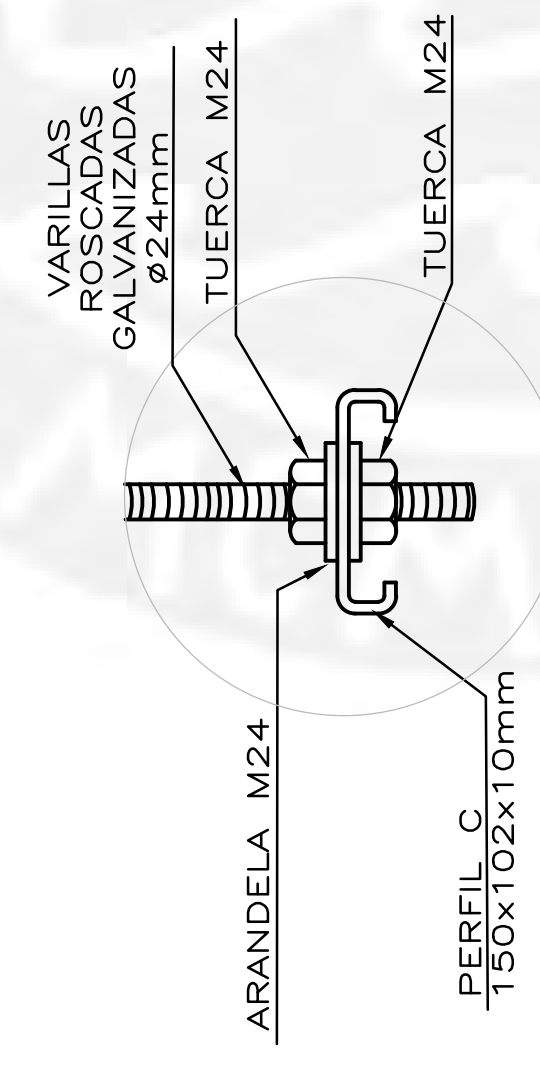
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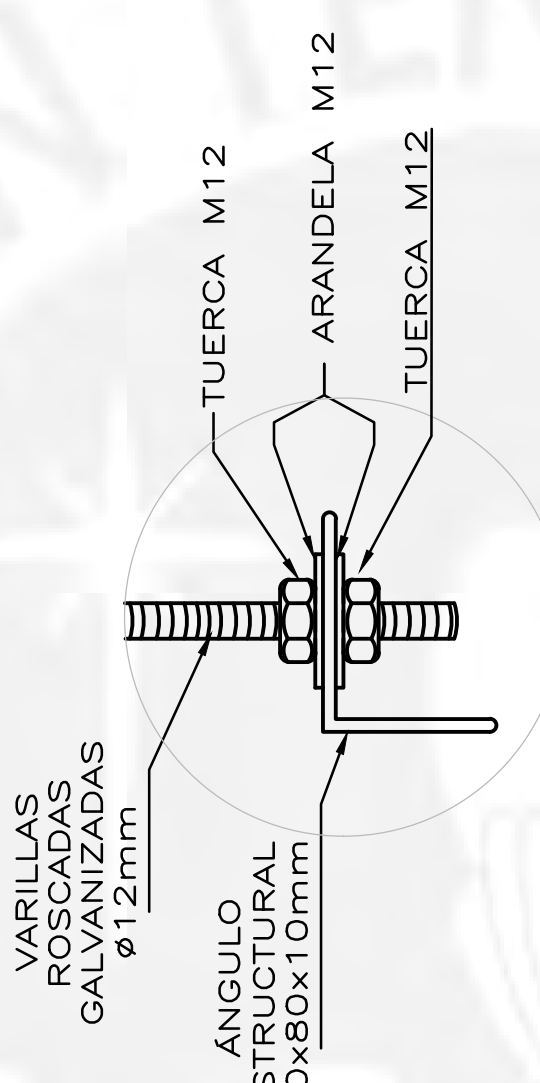
DETALLE 1 SIN ESCALA



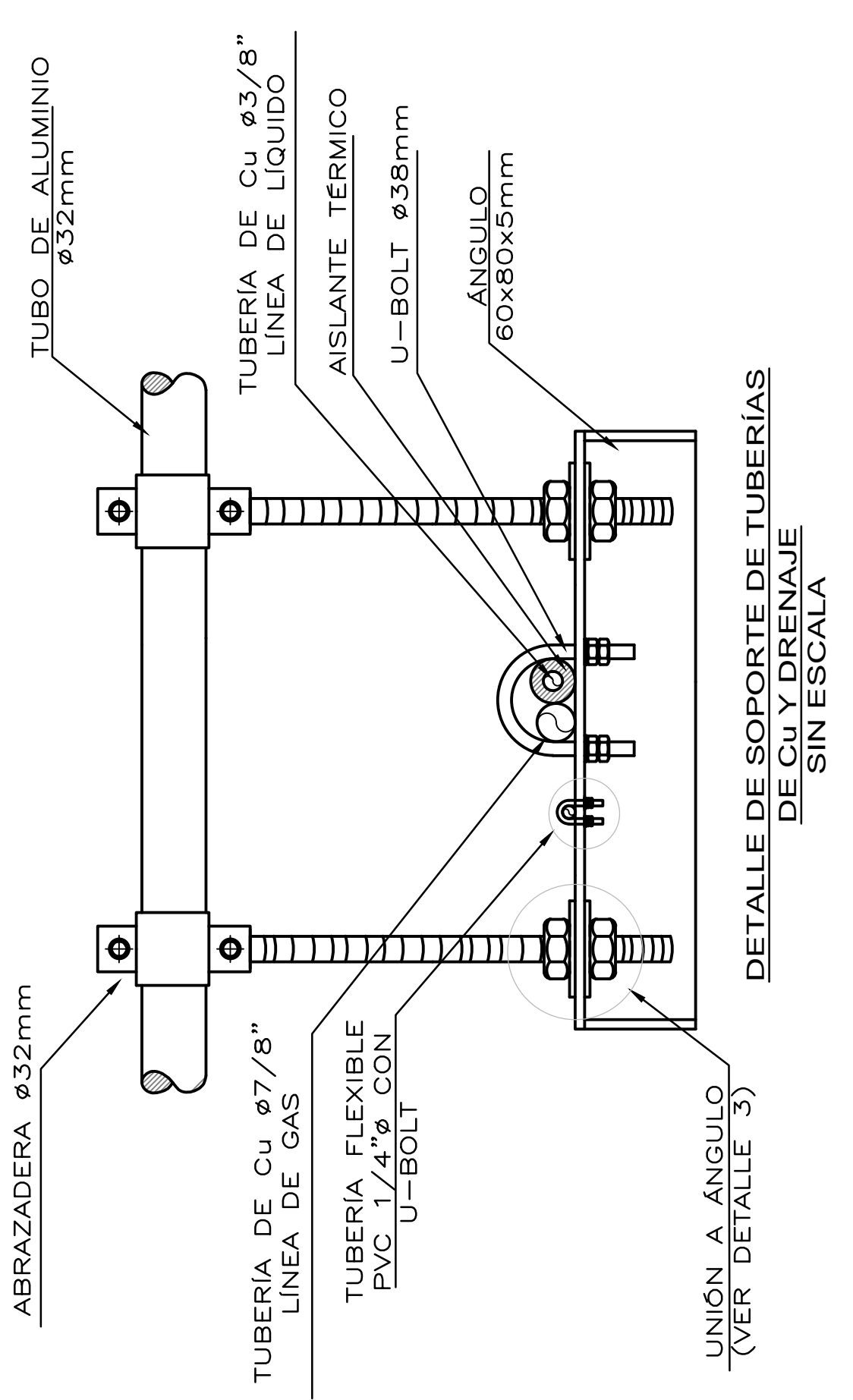
DETALLE DE SOPORTE DE DUCTO SIN ESCALA



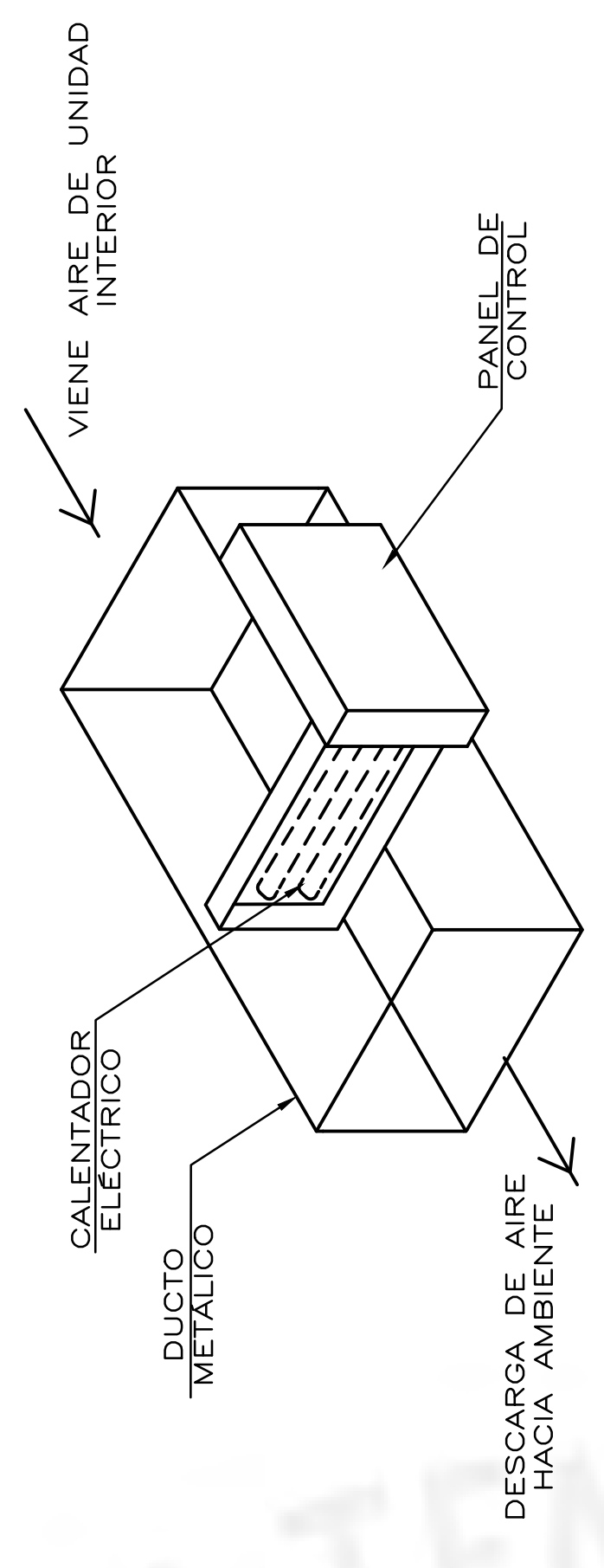
DETALLE 2 SIN ESCALA



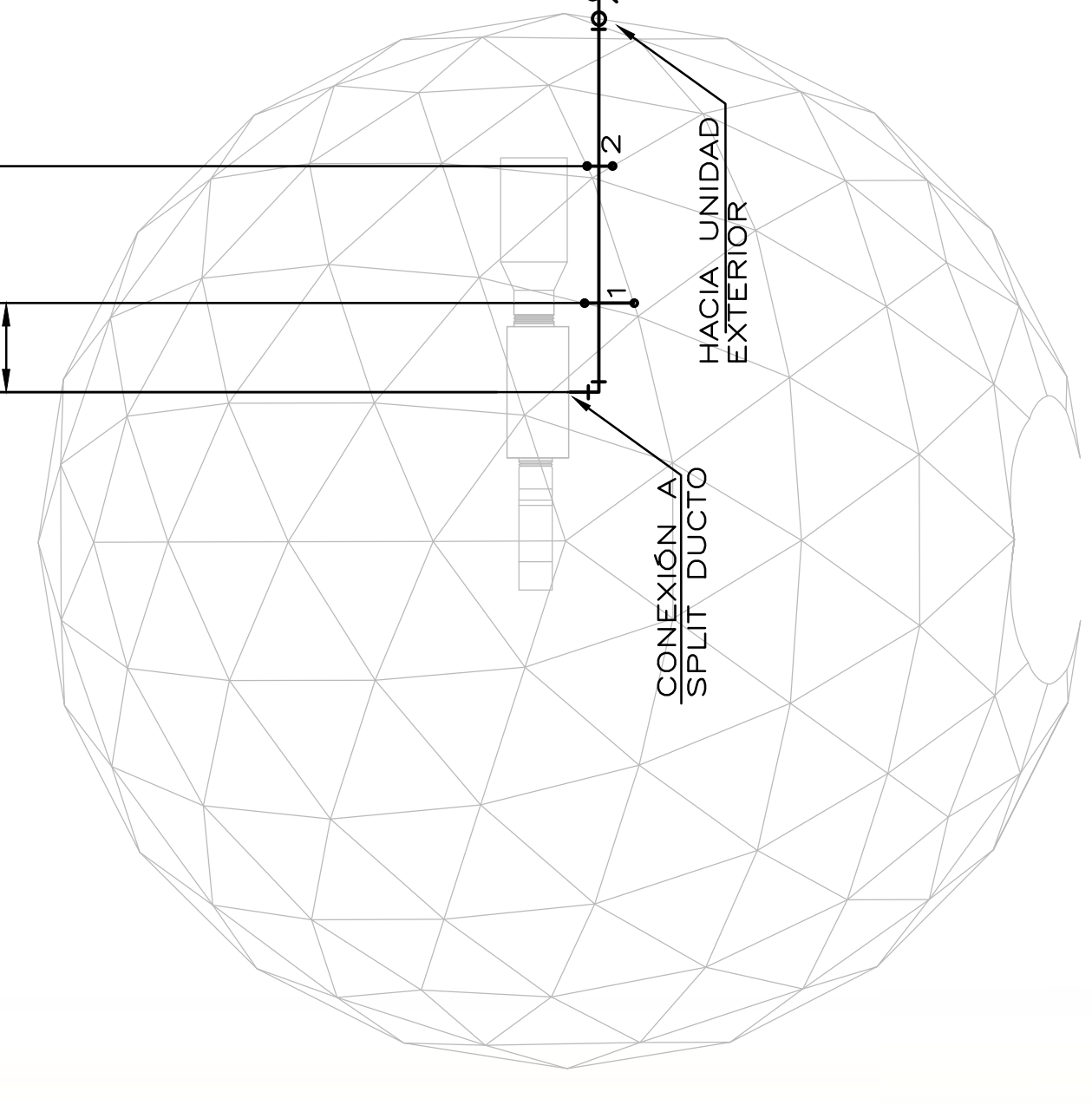
DETALLE 3 SIN ESCALA



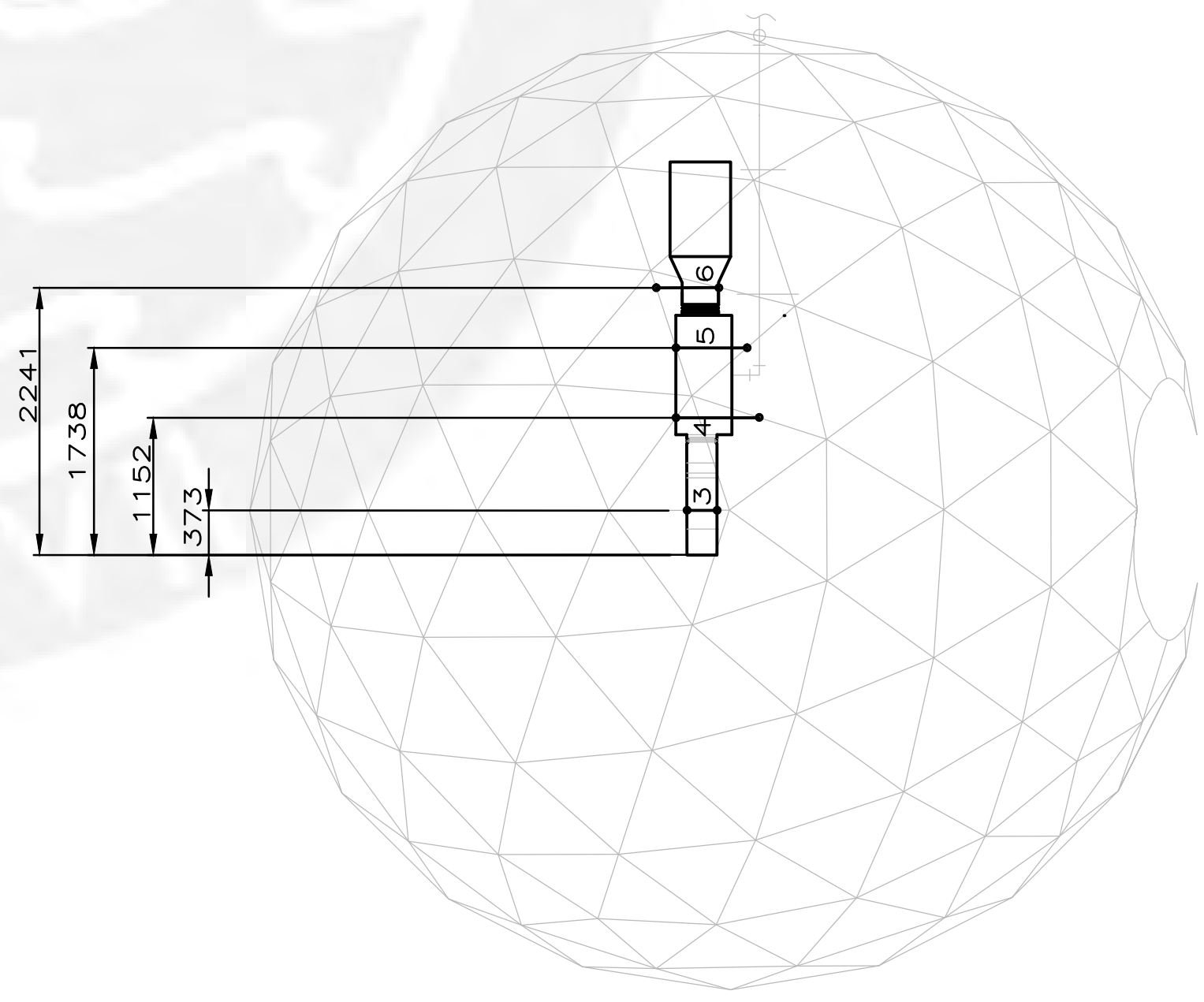
DETALLE DE SOPORTE DE TUBERIAS DE CU Y DRENAJE SIN ESCALA



DETALLE DE ENSAMBLE DE CALENTADOR ELECTRICO SIN ESCALA



UBICACIÓN DE SOPORTES PARA TUBERIAS ESCALA 1:50



UBICACIÓN DE SOPORTES PARA DUCTO ESCALA 1:50

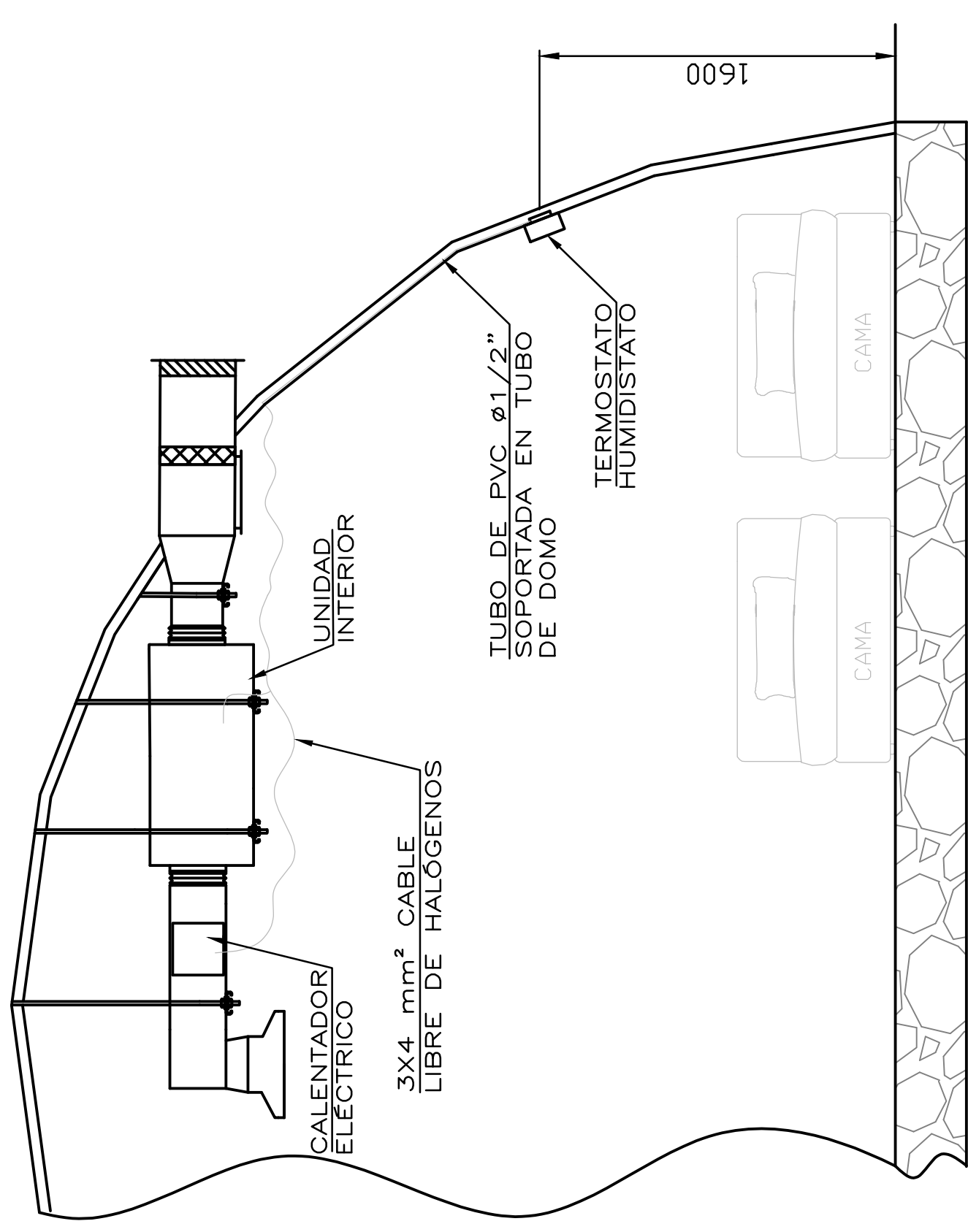
| LEYENDA |   |
|---------|---|
| ○       | PUNTO DE SOPORTE (SEGUN DETALLE 1, 2 y 3)       |
| 1       | N° DE SOPORTE (DE ACUERDO A CUADRO DE SOPORTES) |
| —       | SOPORTE   |
| ⊕       | CODO QUE BAJA                                   |

NOTAS:

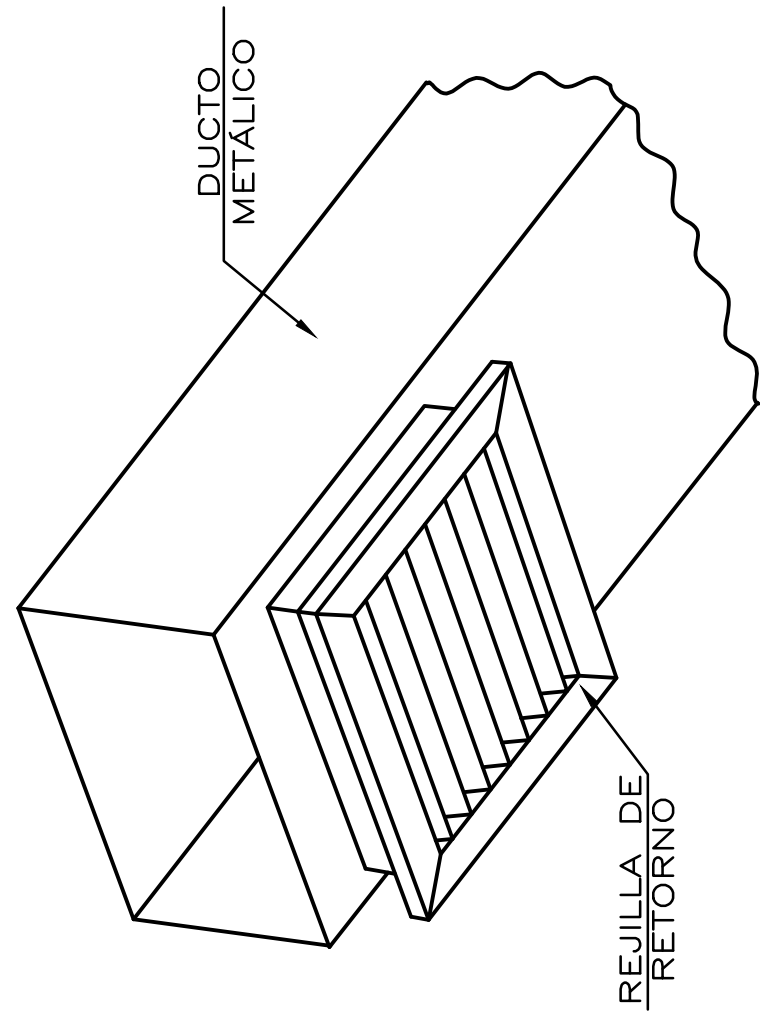
- 01.- LA LONGITUD PRESENTADA EN EL CUADRO DE SOPORTES SE REFIERE AL ANCHO DEL DUCTO o UNIDAD INTERIOR ACOPLADA A DUCTO o TUBERIAS.
- 02.- TODO LOS TAMAÑOS DE LOS DUCTOS MOSTRADOS EN LOS PLANOS INDICAN DIMENSIONES INTERIORES DE LOS DUCTOS.
- 03.- CORRERA POR CUENTA DEL CLIENTE LO SGTE:
  - PUNTO DE ALIMENTACIÓN ELÉCTRICA CERCANO A CADA EQUIPOS (MÁX. A 1m de DISTANCIA).
  - PUNTO DE PUESTA A TIERRA O POZO A TIERRA (MÁX. A 25m de DISTANCIA).
  - SISTEMA DE AGUA POTABLE Y DESAGÜE (INDISPENSABLE PARA REUBICAR PUNTO DE DRENAJE)

| CUADRO DE SOPORTES |          |                  |              |                    |                     |
|--------------------|----------|------------------|--------------|--------------------|---------------------|
| ITEM               | ELEMENTO | DIMENSIONES(1)   | PERFIL       | LONGITUD DE PERFIL | DIÁMETRO DE VARILLA |
| 1                  | TUBERIAS | 3/8", 7/8", 1/4" | 60x80x10mm   | 390 mm             | 12mm                |
| 2                  |          | 3/8", 7/8", 1/4" | 60x80x10mm   | 195 mm             | 12mm                |
| 3                  |          | 255 mm           | 150x102x10mm | 263 mm             | 24mm                |
| 4                  |          | 470 mm           | 150x102x10mm | 480 mm             | 24mm                |
| 5                  |          | 470 mm           | 150x102x10mm | 480 mm             | 24mm                |
| 6                  |          | 335 mm           | 150x102x10mm | 344 mm             | 24mm                |

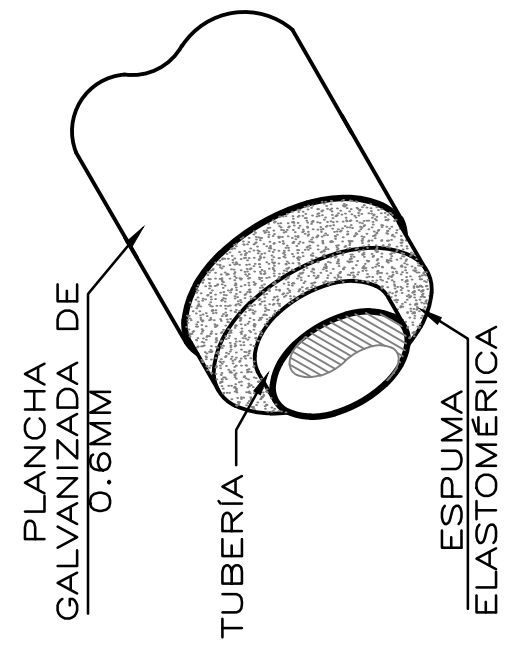




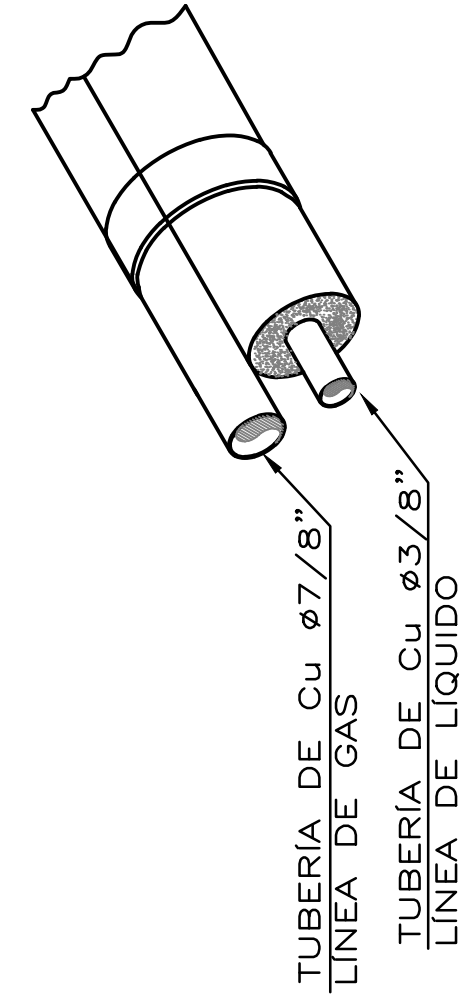
DETALLE DE CONEXIÓN DE TERMOSTATO - HUMIDISTATO  
ESCALA 1:50



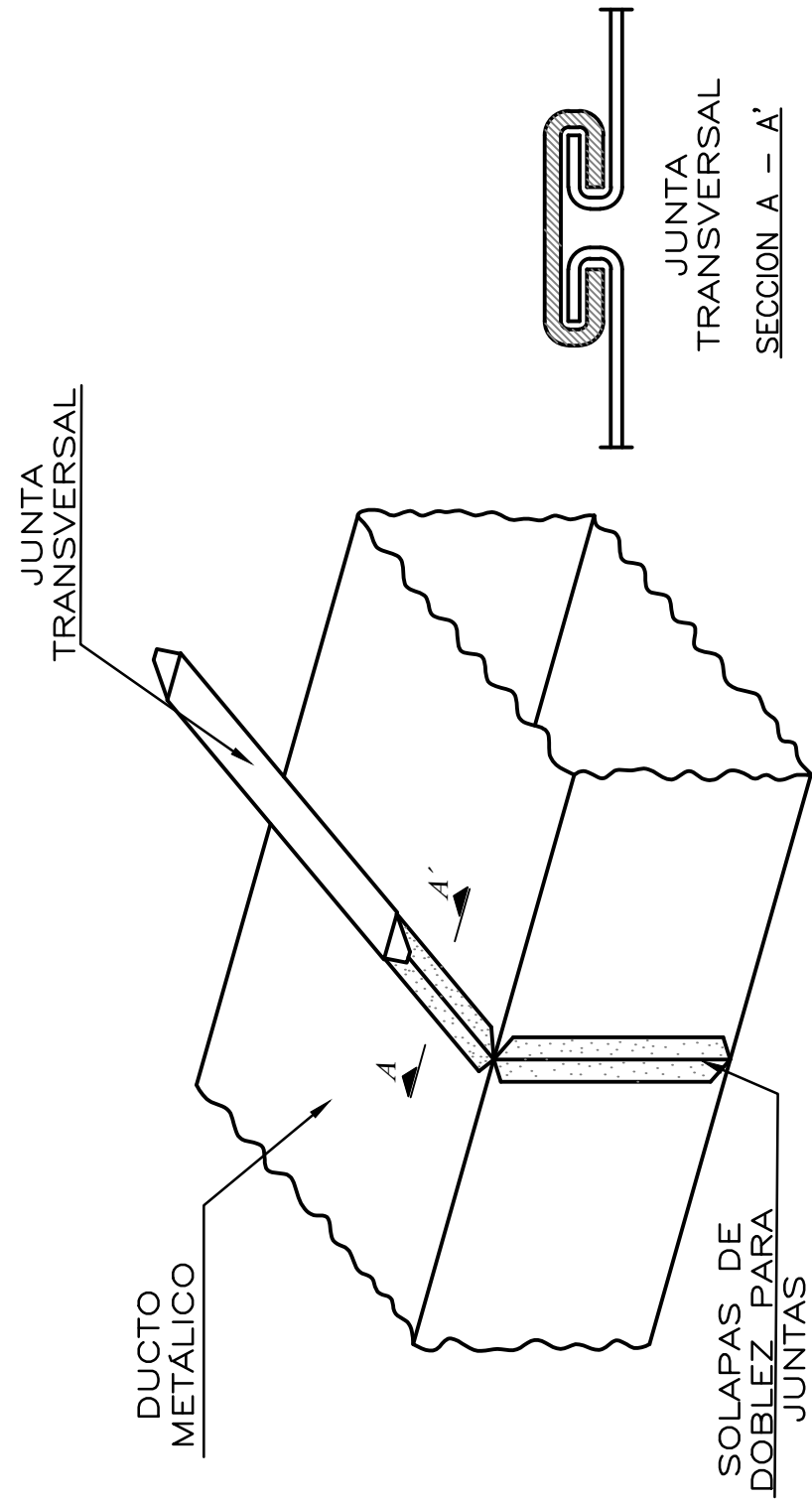
DETALLE DE REJILLA DE RETORNO  
SIN ESCALA



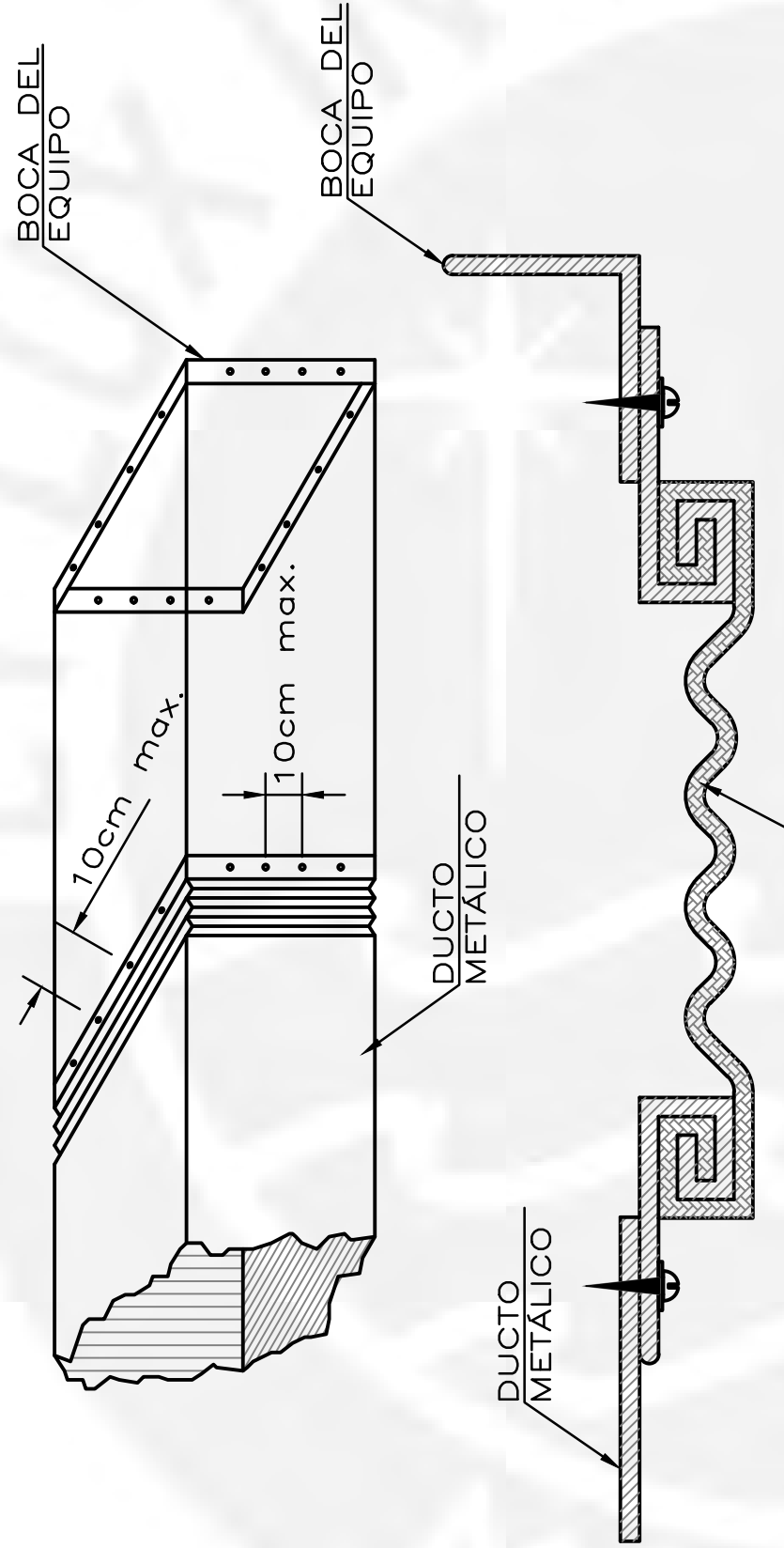
DETALLE DE AISLAMIENTO DE TUBERÍA DE CU  
SIN ESCALA



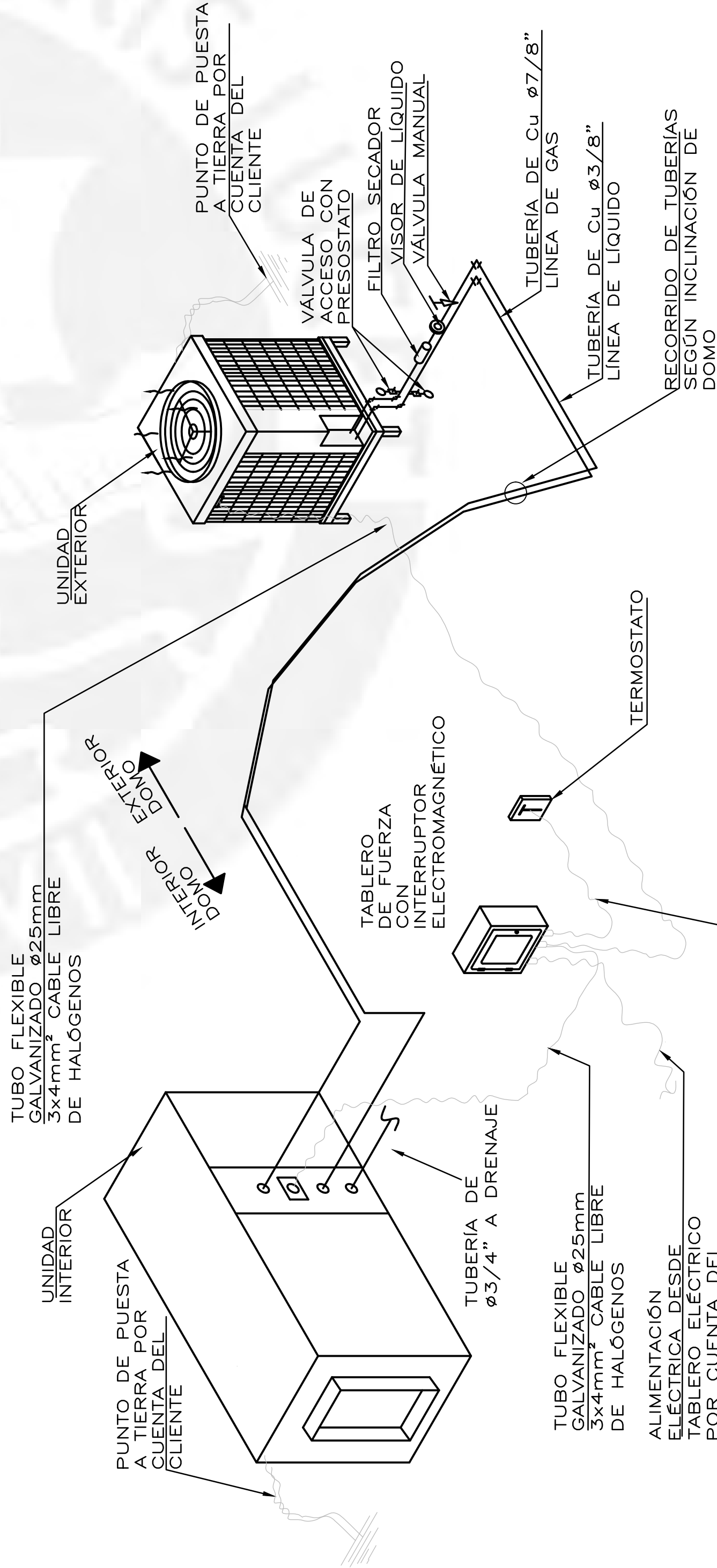
DETALLE DE INSTALACIÓN DE TUBERÍAS DE COBRE  
SIN ESCALA



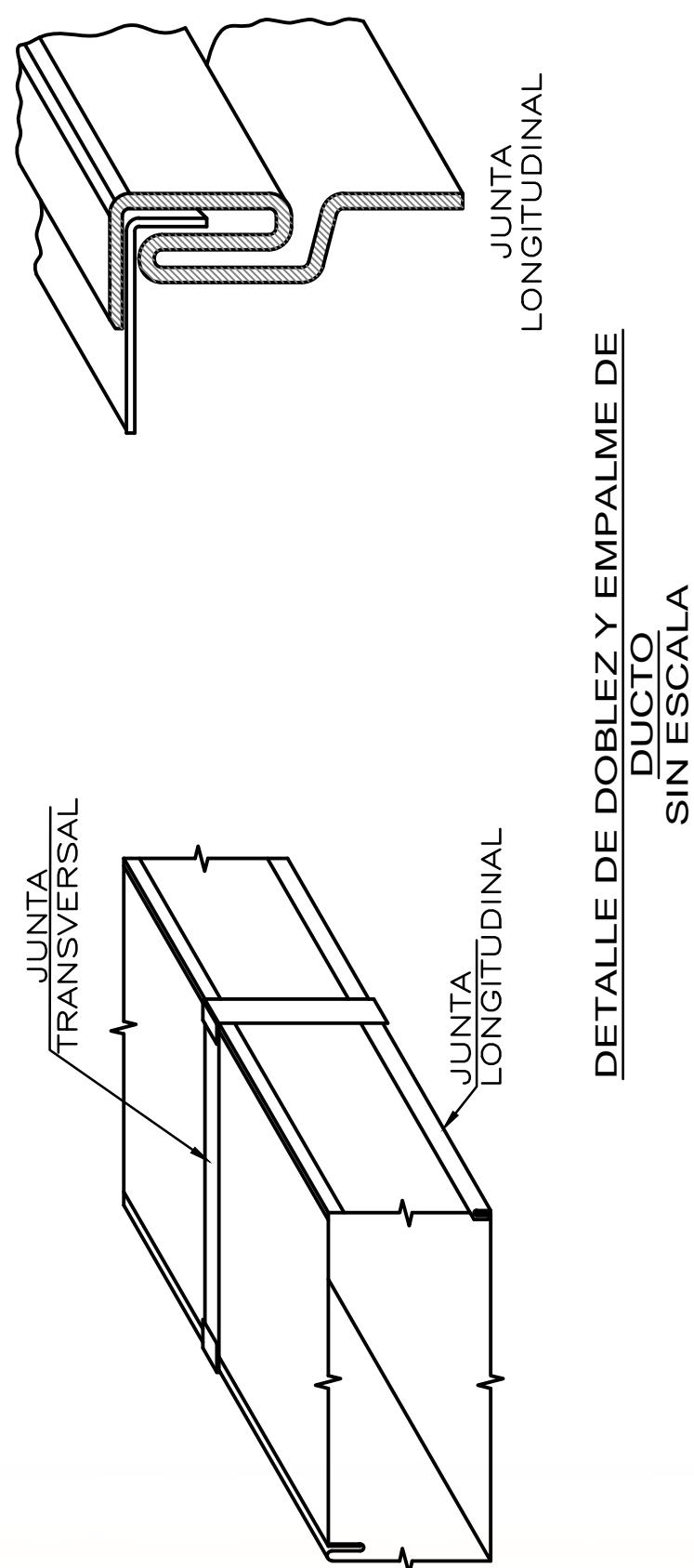
DETALLE DE DOBLEZ Y EMPALME DE DUCTO 2  
SIN ESCALA



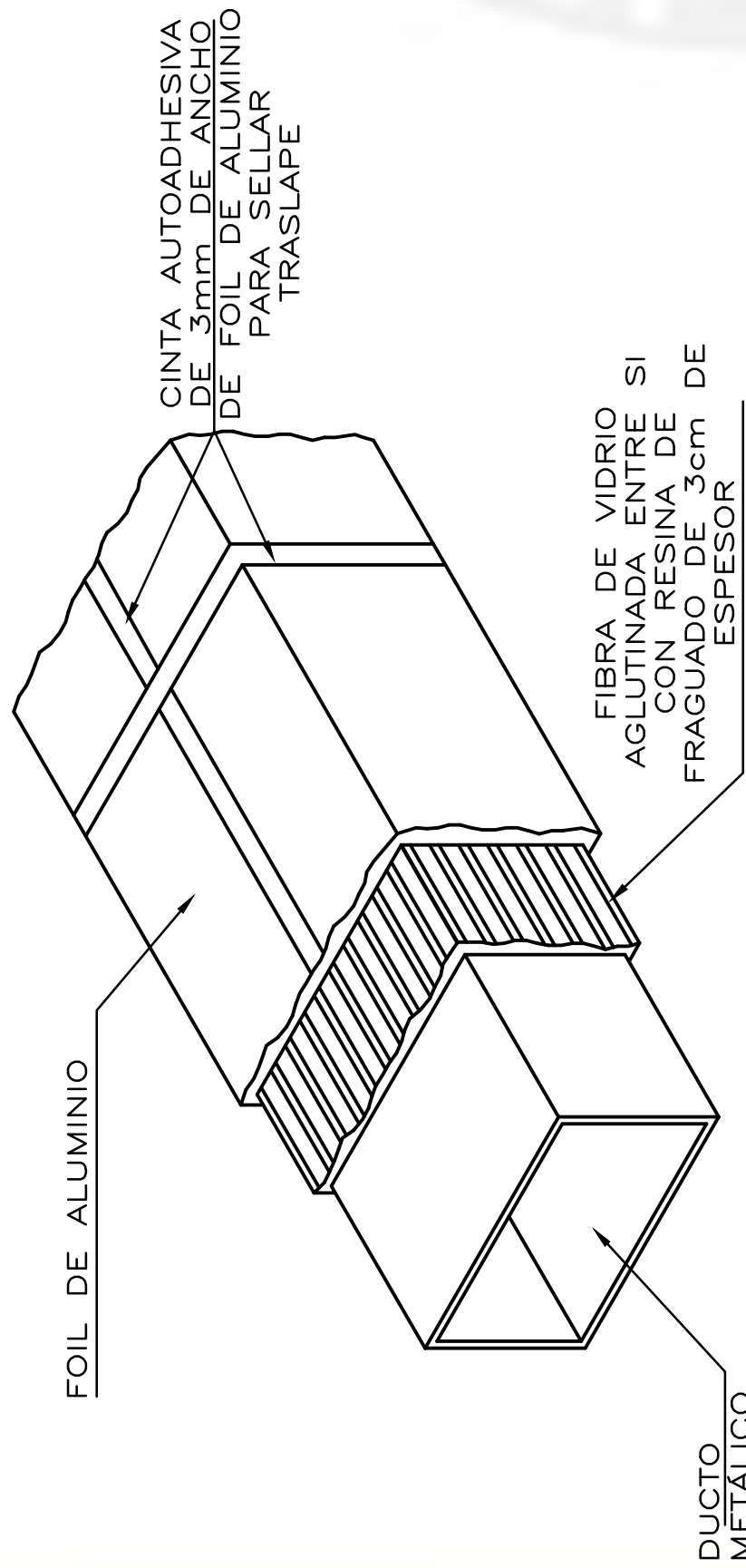
DETALLE TIPO PARA CONEXIÓN FLEXIBLE DE LONA DE VINYL PESADO  
SIN ESCALA



DETALLE DE CONEXIÓN DE SPLIT DUCTO  
SIN ESCALA



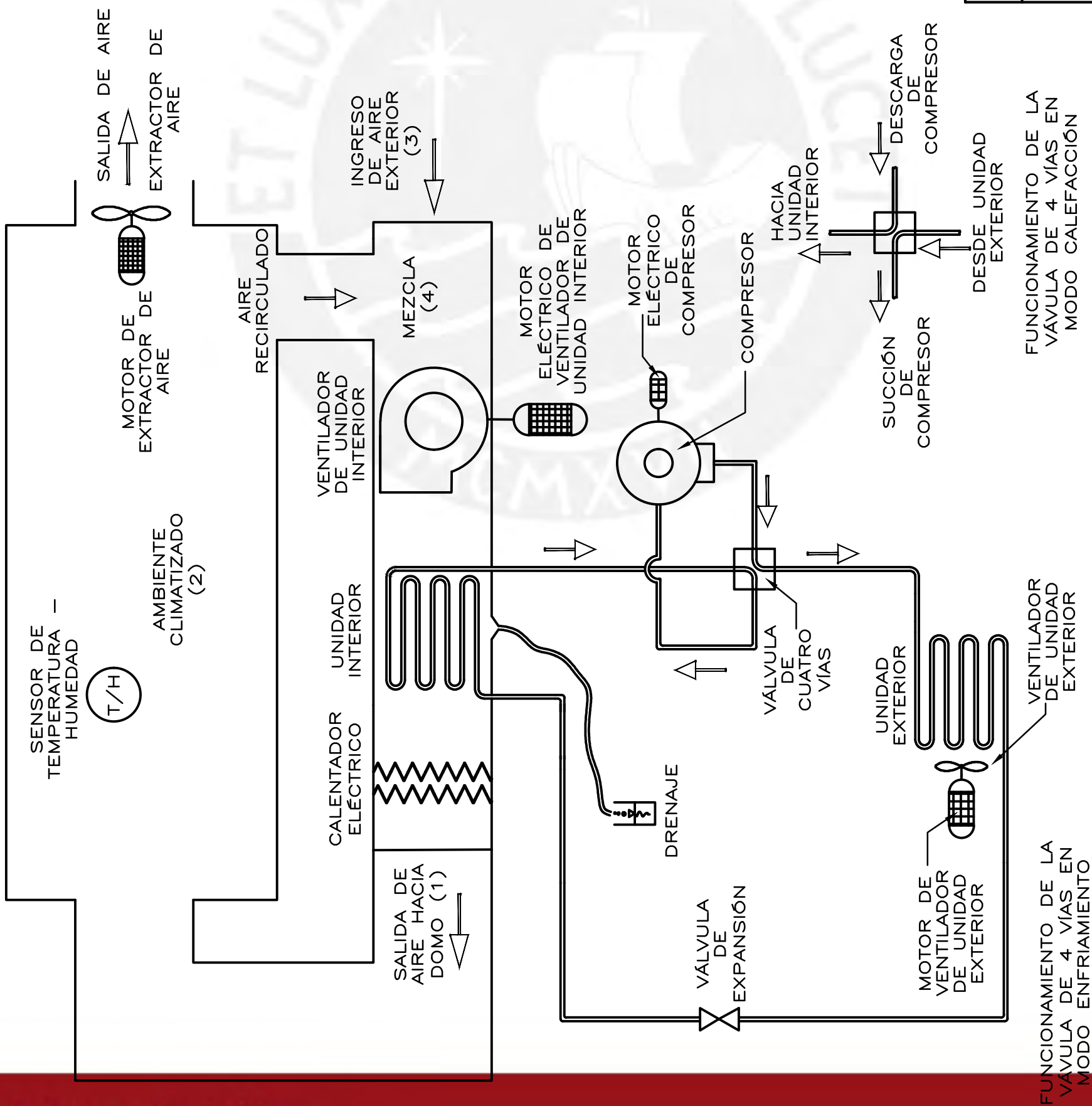
DETALLE DE DOBLEZ Y EMPALME DE DUCTO  
SIN ESCALA



DETALLE TÍPICO DE AISLAMIENTO DE DUCTO  
SIN ESCALA

|   |                   |
|---|-------------------|
| PONTIFICIA UNIVERSIDAD CATOLICA DEL PERU                        |                   |
| FACULTAD DE CIENCIAS E INGENIERIA - ESPECIALIDAD: ING. MECANICA |                   |
| METODO DE PROTECCION  | ESCALA            |
| INDICADA  | INDICADA          |
| 20100341  | FECHA: 2017.10.10 |
| AURIS CASMA, OMAR TADEO   | LAMINA: D5-A1     |





FUNCIONAMIENTO DE LA VÁLVULA DE 4 VIAS EN MODO CALEFACCIÓN

FUNCIONAMIENTO DE LA VÁLVULA DE 4 VIAS EN MODO ENFRÍAMIENTO

CUADRO DE PARÁMETROS PARA ENFRÍAMIENTO

| ITEM           | TEMPERATURA DE BULBO SECO (Tbs) | HUMEDAD RELATIVA (HR) | TEMPERATURA DE BULBO HÚMEDO (Tbh) |
|----------------|---------------------------------|-----------------------|-----------------------------------|
| ESTADO         |                                 |                       |                                   |
| SUMINISTRO (1) | 15°C                            | 90%                   | 14°C                              |
| INTERIOR (2)   | 23.8°C                          | 50%                   | 16.9°C                            |
| EXTERIOR (3)   | 28.2°C                          | 64.6%                 | 23°C                              |
| MEZCLA (4)     | 25.8°C                          | 60%                   | 20.2°C                            |

CUADRO DE PARÁMETROS PARA CALEFACCIÓN

| ITEM           | TEMPERATURA DE BULBO SECO (Tbs) | HUMEDAD RELATIVA (HR) | TEMPERATURA DE BULBO HÚMEDO (Tbh) |
|----------------|---------------------------------|-----------------------|-----------------------------------|
| ESTADO         |                                 |                       |                                   |
| SUMINISTRO (1) | 30°C                            | 15%                   | 8.4°C                             |
| INTERIOR (2)   | 21°C                            | 25%                   | 10.8°C                            |
| EXTERIOR (3)   | 12.8°C                          | 86.5%                 | 11.5°C                            |
| MEZCLA (4)     | 16.9°C                          | 45%                   | 10.6°C                            |

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FACULTAD DE CIENCIAS E INGENIERIA - ESPECIALIDAD: ING. MECANICA

METODO DE PROYECCION

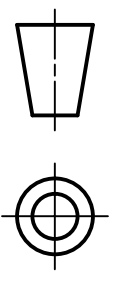


DIAGRAMA DE PRINCIPIO

ESCALA  
S/N

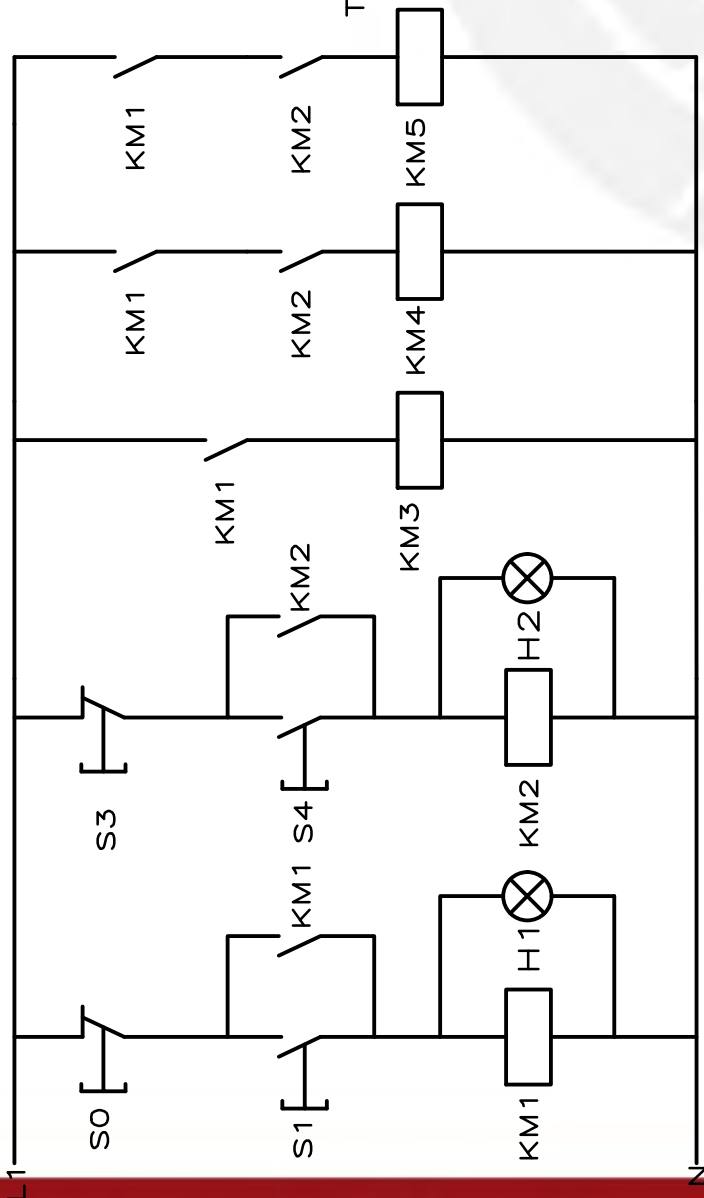
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OMAR TADEO AURIS CASMA

FECHA:  
2017.10.10

LAMINA:  
D6-A3

CIRCUITO DE MANDO



| LEYENDA |                            |
|---------|----------------------------|
| SÍMBOLO | DESCRIPCIÓN                |
|         | INTERRUPTOR TERMOMAGNÉTICO |
|         | FUSIBLE                    |
|         | RELÉ TÉRMICO               |
|         | PUESTA A TIERRA            |
|         | MOTOR ELÉCTRICO            |
|         | CONTACTOR                  |
|         | LÁMPARA PILOTO             |
|         | PULSADOR CERRADO           |
|         | PULSADOR ABIERTO           |
|         | CONTACTOR DE CALENTADOR    |

CIRCUITO DE FUERZA

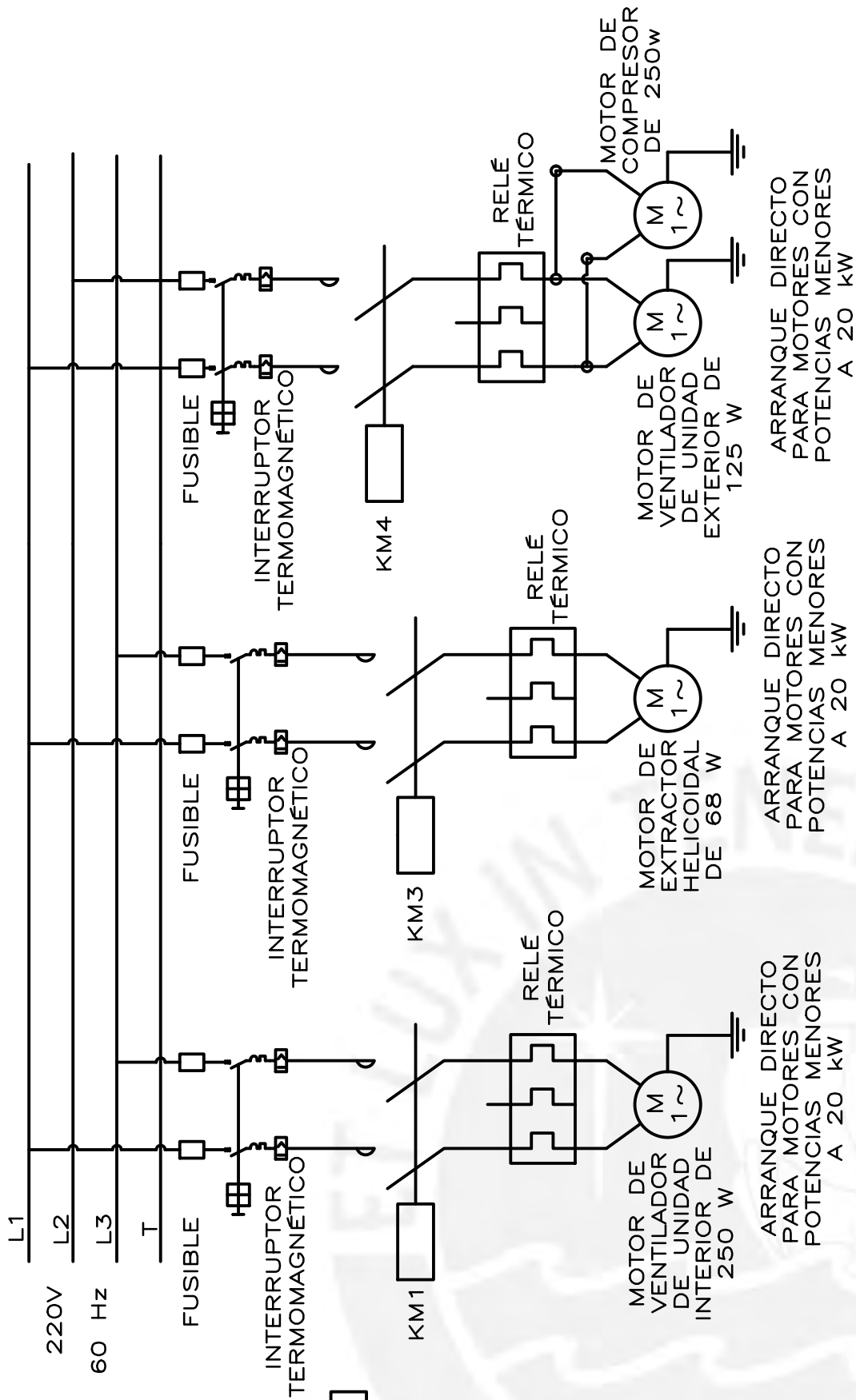
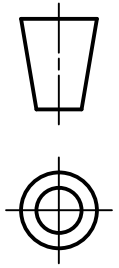


TABLA DE PARÁMETROS ELÉCTRICOS DE EQUIPOS PARA CLIMATIZACIÓN

| EQUIPO               | CÓDIGO | CANTIDAD | POTENCIA | FASES | FRECUENCIA | VOLTAJE | UBICACIÓN        |
|----------------------|--------|----------|----------|-------|------------|---------|------------------|
| VENTILADOR INTERIOR  | UI-01  | 01       | 250W     | 1 φ   | 60Hz       | 220V    | INTERIOR DE DOMO |
| VENTILADOR EXTERIOR  | UE-01  | 01       | 125W     | 1 φ   | 60Hz       | 220V    | EXTERIOR DE DOMO |
| EXTRACTOR HELICOIDAL | EH-01  | 01       | 68W      | 1 φ   | 60Hz       | 220V    | INTERIOR DE DOMO |
| CALENTADOR ELÉCTRICO | CE-01  | 01       | 3600W    | 1 φ   | 60Hz       | 220V    | INTERIOR DE DOMO |
| COMPRESOR            | UE-01  | 01       | 250W     | 1 φ   | 60Hz       | 220V    | EXTERIOR DE DOMO |

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METODO DE PROYECCION



ESCALA

DIAGRAMA ELÉCTRICO

S/N

20100341

OMAR TADEO AURIS CASMA

FECHA:  
2017.10.10

LAMINA:  
D6-A3

# HEAT PUMP OUTDOOR UNITS



**14HPX**  
MERIT® Series  
R-410A

## PRODUCT SPECIFICATIONS

Bulletin No. 210564  
April 2017  
Supersedes February 2017



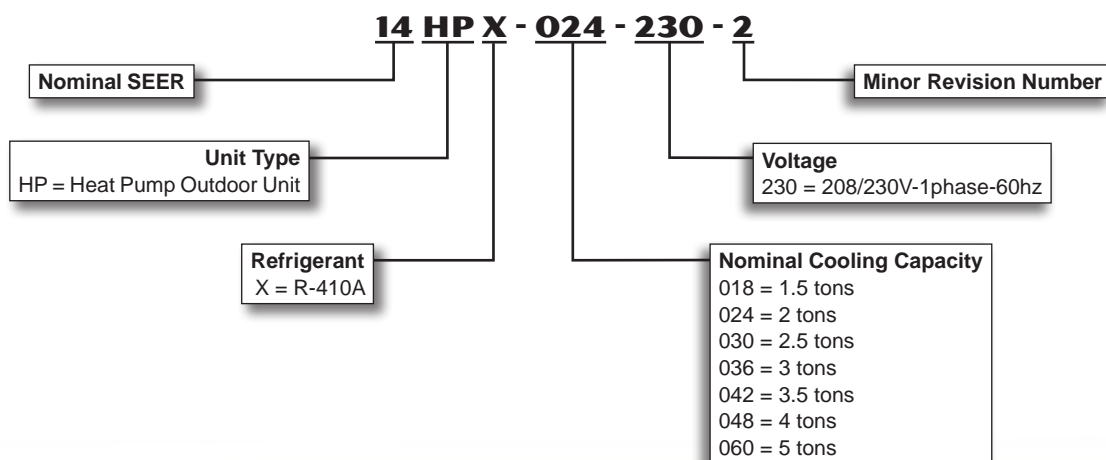
**MERIT®**  
SERIES



SEER up to 16.00  
1.5 to 5 Tons

Cooling Capacity - 18,000 to 61,000 Btuh  
Heating Capacity - 17,500 to 58,500 Btuh

## MODEL NUMBER IDENTIFICATION



## FEATURES

### CONTENTS

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| Electrical Data .....                   | 6  |
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### WARRANTY

**Compressor** - Limited warranty for **five years** in residential installations and five years in non-residential installations.

**All other covered components** - Five years in residential installations and one year in non-residential installations.

Refer to Lennox Equipment Limited Warranty certificate included with unit for specific details.

### APPROVALS

AHRI Certified to AHRI Standard 210/240-2008.

Sound rated in Lennox reverberant sound test room in Accordance with test conditions included in AHRI Standard 270-2008.

Tested in the Lennox Research Laboratory environmental test room.

Rated According to U.S. Department of Energy (DOE) test procedures.

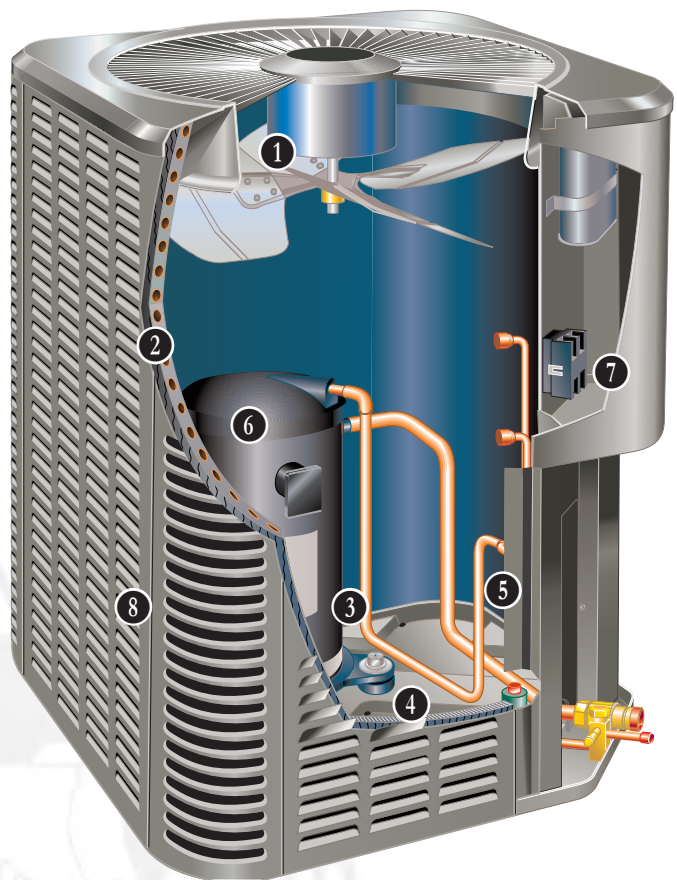
Units and components within bonded for grounding to meet safety standards for servicing required by UL, NEC and CEC.

Units are ETL certified for the U.S. and Canada.

ISO 9001 Registered Manufacturing Quality System.

For expanded ratings, see [www.LennoxPROs.com](http://www.LennoxPROs.com).

ENERGY STAR® certified units are designed to use less energy, help save money on utility bills, and help protect the environment. Many Lennox home comfort systems meet ENERGY STAR requirements when used with matching components.



### APPLICATIONS

SEER up to 16.00.

HSPF (Region IV) up to 9.50.

1.5 through 5 tons.

Single phase power supply.

Vertical air discharge allows concealment behind shrubs at grade level or out of sight on a roof.

Designed for applications with remotely located indoor air handler units or gas furnaces with indoor add-on coils.

When heat pumps are used with gas furnaces, a dual-fuel compatible thermostat or a zone control system with dual-fuel capabilities must be used (order separately).

See Indoor Coils and Air Handlers sections for indoor unit data.

Units shipped completely factory assembled, piped and wired. Each unit is test operated at the factory insuring proper operation.

Installer must set outdoor unit, connect refrigerant lines and make electrical connections to complete job.



## FEATURES

### REFRIGERATION SYSTEM

#### R-410A Refrigerant

Non-chlorine, ozone friendly, R-410A.

Unit is factory pre-charged with refrigerant.



Total system refrigerant charge is dependant on outdoor unit size, indoor unit size and refrigerant line length.

Refer to the unit-mounted charging sticker to determine correct amount of charge required.

#### 1 Outdoor Coil Fan

Direct drive fan moves large air volumes uniformly through entire outdoor coil for high refrigerant cooling and heating capacity.

Vertical air discharge minimizes operating sounds and eliminates damage to lawn and shrubs.

Fan motor has ball bearings and is inherently protected.

Motor totally enclosed for maximum protection from weather, dust and corrosion.

Louvered steel top fan guard furnished as standard.

Fan service access accomplished by removal of top panel.

#### 2 Copper Tube/Enhanced Fin Coil

Lennox designed and fabricated coil.

Ripple-edged aluminum fins.

Copper tube construction.

Lanced fins provide maximum exposure of fin surface to air stream resulting in excellent heat transfer.

Fin collars grip tubing for maximum contact area.

Flared shoulder tubing connections/silver soldering construction.

Coil is factory tested under high pressure to ensure leakproof construction.

Steel louvered panels provide complete coil protection.

Panels can be completely removed for servicing.

#### 3 Expansion Valve - Outdoor Unit

Designed and sized specifically for use in heat pump system.

Sensing bulb is located on the suction line between the reversing valve and the compressor to sense evaporator suction temperature in the heat cycle.

#### High Pressure Switch

Protects the system from high pressure conditions that can be a result of fan failure or a blocked/dirty coil.

Automatic reset.

#### Low Pressure Switch

Shuts off unit if suction pressure falls below setting.

Provides loss of charge and freeze-up protection.

Automatic reset.

#### 4 High Capacity Liquid Line Drier

Factory installed in the liquid line, the drier traps moisture or dirt that could contaminate the refrigerant system.

100% molecular-sieve, bead type bi-flow drier.

#### 5 Reversing Valve

4-way interchange reversing valve effects a rapid change in direction of refrigerant flow resulting in quick changeover from cooling to heating and vice versa.

Valve operates on pressure differential between outdoor unit and indoor unit of the system.

Factory installed.

### Optional Accessories

#### Check/Expansion Valve Kits

Must be ordered extra and field installed on certain indoor units. See TXV Usage table.

Chatleff-style fitting.

#### Loss of Charge Kit

Helps protect the compressor from damage due low refrigerant charge conditions.

SPST, normally-closed switch, automatic reset switch.

#### Refrigerant Line Kits

Refrigerant lines (suction & liquid) are shipped refrigeration clean.

Lines are cleaned, dried, pressurized and sealed at factory.

Suction line fully insulated.

Lines are stubbed at both ends.



## FEATURES

### COMPRESSOR

#### 6 Scroll Compressor

Compressor features high efficiency with uniform suction flow, constant discharge flow, high volumetric efficiency and quiet operation.

Compressor consists of two involute spiral scrolls matched together to generate a series of crescent shaped gas pockets between them.

During compression, one scroll remains stationary while the other scroll orbits around it.

Gas is drawn into the outer pocket, the pocket is sealed as the scroll rotates.

As the spiral movement continues, gas pockets are pushed to the center of the scrolls. Volume between the pockets is simultaneously reduced.

When the pocket reaches the center, gas is now at high pressure and is forced out of a port located in the center of the fixed scrolls.

During compression, several pockets are compressed simultaneously resulting in a smooth continuous compression cycle.

Continuous flank contact, maintained by centrifugal force, minimizes gas leakage and maximizes efficiency.

Scroll compressor is tolerant to the effects of slugging and contaminants. If this occurs, scrolls separate, allowing liquid or contaminants to be worked toward the center and discharged.

Low gas pulses during compression reduces operational sound levels.

Compressor motor is internally protected from excessive current and temperature.

Muffler in discharge line reduces operating sound levels.

Compressor is installed in the unit on resilient rubber mounts for vibration free operation.

#### Compressor Crankcase Heater (Factory installed on -036-042-048-060 models)

Protects against refrigerant migration that can occur during low ambient operation.

### Optional Accessories

#### Compressor Crankcase Heater (Optional for -018-024-030 models)

Protects against refrigerant migration that can occur during low ambient operation.

#### Compressor Sound Cover

A reinforced vinyl compressor cover containing a 1-1/2 inch thick batt of fiberglass insulation.

All open edges are sealed with a one-inch wide hook and loop fastening tape.

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No olvide citar esta tesis

14HPX 1.5 to 3 Ton Heat Pump / Page 4



### CONTROLS

#### 7 Defrost Control

Time/temperature defrost control is furnished as standard equipment.

Control initiates a defrost cycle every 30, 60 or 90 minutes of compressor "on" time at outdoor coil temperatures below 42°F. Factory setting is 90 minutes.

Anti-short cycle, timed-off control (5 minutes).

Compressor delay (30 seconds, field selectable) for cycling the compressor in and out of the defrost mode.

High and low pressure switch monitoring with five-trip lockout.

Two diagnostic LEDs furnished as an aid in troubleshooting.

Conveniently located in control box.

### Optional Accessories

#### Compressor Hard Start Kit

Single-phase units are equipped with a PSC compressor motor. This type of motor normally doesn't need a potential relay and start capacitor.

In conditions such as low voltage, this kit may be required to increase the compressor starting torque.

#### Compressor Low Ambient Cut-Off

Non-adjustable switch (low ambient cut-out) prevents compressor operation in cooling mode, when outdoor temperature is below 35°F.

Freezestat Installs on or near the vapor line of the indoor coil or on the suction line.

Senses suction line temperature and cycles the compressor off when suction line temperature falls below it's setpoint.

Opens at 29°F and closes at 58°F.

#### Indoor Blower Off Delay Relay Kit

Delays the indoor blower-off time during the cooling cycle.

See AHRI System Matches for usage.

#### Low Ambient Kit

Heat pump units will operate satisfactorily in the cooling mode down to 45°F outdoor air temperature without any additional controls.

Kit can be added in the field enabling unit to operate properly down to 30°F in the cooling mode.

Crankcase heater and freezestat should be installed on compressors equipped with a low ambient kit.

A compressor lock-out thermostat should be added to terminate compressor operation below recommended operation conditions.

#### Low Pressure Switch Bypass Thermostat

For use in applications where the heat pump is operated in outdoor ambient temperatures below 15°F.

Prevents nuisance trips from the low pressure switch.

Wired in parallel with the low pressure switch.

## FEATURES

### CONTROLS (continued)

#### Optional Accessories

##### Mild Weather Kit

Heat pump units operate satisfactorily in the heating mode at outdoor air temperatures up to 75°F.

Mild Weather Kit can be field installed, allowing heating operation above 75°F.

##### Monitor Kit - Service Light

Contains ambient compensating thermistor and service light thermostat.

For use with thermostats requiring input for indicator lights.

##### Outdoor Thermostat Kit

An outdoor thermostat can be used to lock out some of the electric heating elements on indoor units where two stage control is applicable.

Outdoor thermostat maintains the heating load on the low power input as long as possible before allowing the full power load to come on the line.

Thermostat kit and mounting box must be ordered separately.

##### Thermostat

Thermostat not furnished with unit.

See Thermostat bulletins in Controls Section and Lennox Price Book.

### 8 CABINET

Heavy gauge steel cabinet with five station metal wash process.

Louvered heavy gauge steel panels surround unit on all four sides to prevent damage to the coil.

Powder paint finish provides superior rust and corrosion protection.

Control box is conveniently located with all controls factory wired.

Corner patch plate allows access to compressor components.

Drainage holes are provided in base section for moisture removal.

##### PermaGuard™ Unit Base

Durable zinc-coated base section resists rust and corrosion.

##### Refrigerant Line Connections, Electrical Inlets, Service Valves

Sweat connection vapor and liquid lines are located on corner of unit cabinet.

Fully serviceable brass service valves prevent corrosion and provide access to refrigerant system.

Vapor valve can be fully shut off, while liquid valve may be front seated to manage refrigerant charge while servicing system.

Refrigerant line connections and field wiring inlets are located in one central area of cabinet for easy access.

See dimension drawing.

#### Optional Accessories

##### Unit Stand-Off Kit

Black high density polyethylene feet are available to raise unit off of mounting surface away from damaging moisture.

Four feet are furnished per order number.

## SPECIFICATIONS

| General Data                     |                                | Model No.               | 14HPX-018     | 14HPX-024     | 14HPX-030     | 14HPX-036    |
|----------------------------------|--------------------------------|-------------------------|---------------|---------------|---------------|--------------|
| Nominal Tonnage                  |                                |                         | 1.5           | 2             | 2.5           | 3            |
| <sup>1</sup> Sound Rating Number |                                |                         | 76            | 76            | 76            | 79           |
| Connections (sweat)              | Liquid line o.d. - in.         |                         | 3/8           | 3/8           | 3/8           | 3/8          |
|                                  | Vapor line o.d. - in.          |                         | 3/4           | 3/4           | 3/4           | 7/8          |
| <sup>2</sup> Refrigerant         |                                | R-410A charge furnished | 5 lbs. 11 oz. | 5 lbs. 14 oz. | 5 lbs. 10 oz. | 9 lbs. 6 oz. |
| Outdoor Coil                     | Net face area - sq. ft.        | Outer coil              | 21.00         | 21.00         | 21.00         | 18.67        |
|                                  |                                | Inner coil              | ---           | ---           | ---           | 18.01        |
|                                  | Tube diameter - in.            |                         | 5/16          | 5/16          | 5/16          | 5/16         |
|                                  | No. of rows                    |                         | 1             | 1             | 1             | 2            |
|                                  | Fins per inch                  |                         | 22            | 22            | 22            | 22           |
| Outdoor Fan                      | Diameter - in.                 |                         | 22            | 22            | 22            | 22           |
|                                  | No. of Blades                  |                         | 3             | 3             | 3             | 3            |
|                                  | Motor hp                       |                         | 1/6           | 1/6           | 1/6           | 1/6          |
|                                  | Cfm                            |                         | 2670          | 2670          | 2890          | 2870         |
|                                  | Rpm                            |                         | 867           | 867           | 847           | 839          |
|                                  | Watts                          |                         | 168           | 177           | 200           | 205          |
|                                  | Shipping Data - lbs. 1 package |                         |               | 177           | 177           | 177          |

## ELECTRICAL DATA

|  |                   |          |          |          |          |
|--|-------------------|----------|----------|----------|----------|
| Line voltage data - 60 hz - 1 ph                   |                   | 208/230V | 208/230V | 208/230V | 208/230V |
| <sup>3</sup> Maximum overcurrent protection (amps) |                   | 20       | 30       | 25       | 30       |
| <sup>4</sup> Minimum circuit ampacity              |                   | 12.2     | 17.9     | 17.1     | 18.7     |
| Compressor   | Rated Load Amps   | 8.96     | 13.5     | 12.8     | 14.1     |
|  | Locked Rotor Amps | 48       | 58       | 64       | 77       |
|  | Power Factor      | 0.98     | 0.98     | 0.98     | 0.99     |
| Outdoor Fan Motor                                  | Full Load Amps    | 1.0      | 1.1      | 1.1      | 1.1      |
|  | Locked Rotor Amps | 1.9      | 1.9      | 1.9      | 1.9      |

## OPTIONAL ACCESSORIES - ORDER SEPARATELY

|                                       |                      |   |   |   |   |
|---------------------------------------|----------------------|---|---|---|---|
| Compressor Crankcase Heater           | 93M04                | • | • | • | • |
|                                       | Factory              |   |   |   | • |
| Compressor Hard Start Kit             | 10J42                | • |   |   |   |
|                                       | 88M91                |   | • | • | • |
| Compressor Low Ambient Cut-Off        | 45F08                | • | • | • | • |
| Compressor Sound Cover                | 69J03                | • | • | • | • |
| Freezestat                            | 3/8 in. tubing 93G35 | • | • | • | • |
|                                       | 5/8 in. tubing 50A93 | • | • | • | • |
| Indoor Blower Off Delay Relay         | 58M81                | • | • | • | • |
| Loss of Charge Kit                    | 84M23                | • | • | • | • |
| <sup>5</sup> Low Ambient Kit          | 54M89                | • | • | • | • |
| Low Pressure Switch Bypass Thermostat | 13W07                | • | • | • | • |
| Mild Weather Kit                      | 33M07                | • | • | • | • |
| Monitor Kit - Service Light           | 76F53                | • | • | • | • |
| Outdoor Thermostat Kit                | Thermostat 56A87     | • | • | • | • |
|                                       | Mounting Box 31461   | • | • | • | • |
| Refrigerant Line Sets                 | L15-41-20 L15-41-40  | • | • | • |   |
|                                       | L15-41-30 L15-41-50  |   |   |   |   |
|                                       | L15-65-30 L15-65-40  |   |   |   | • |
|                                       | L15-65-50            |   |   |   |   |
| Unit Stand-Off Kit                    | 94J45                | • | • | • | • |

NOTE - Extremes of operating range are plus 10% and minus 5% of line voltage.

<sup>1</sup> Sound Rating Number rated in accordance with test conditions included in AHRI Standard 270.

<sup>2</sup> Refrigerant charge sufficient for 15 ft. length of refrigerant lines. For longer line set requirements see the Installation Instructions for information about line set length and additional refrigerant charge required.

<sup>3</sup> HACR type circuit breaker or fuse.

<sup>4</sup> Refer to National or Canadian Electrical Code manual to determine wire, fuse and disconnect size requirements.

<sup>5</sup> Crankcase Heater and Freezestat are recommended with Low Ambient Kit.

| <b>SPECIFICATIONS</b>                              |  |                                    |                |               |                |
|--|--|------------------------------------|----------------|---------------|----------------|
| General Data                                       |  | Model No.                          | 14HPX-042      | 14HPX-048     | 14HPX-060      |
|  |  | Nominal Tonnage                    | 3.5            | 4             | 5              |
| <sup>1</sup> Sound Rating Number                   |  |                                    | 79             | 80            | 80             |
| Connections (sweat)                                |  | Liquid line o.d. - in.             | 3/8            | 3/8           | 3/8            |
|  |  | Vapor line o.d. - in.              | 7/8            | 7/8           | 7/8            |
| <sup>2</sup> Refrigerant                           |  | R-410A charge furnished            | 11 lbs. 14 oz. | 10 lbs. 7 oz. | 12 lbs. 11 oz. |
| Outdoor Coil                                       |  | Net face area - sq. ft. Outer coil | 24.93          | 24.93         | 29.09          |
|  |  | Inner coil                         | 24.13          | 24.13         | 28.16          |
|  |  | Tube diameter - in.                | 5/16           | 5/16          | 5/16           |
|  |  | No. of rows                        | 2              | 2             | 2              |
|  |  | Fins per inch                      | 22             | 22            | 22             |
| Outdoor Fan  |  | Diameter - in.                     | 22             | 22            | 22             |
|  |  | No. of Blades                      | 4              | 4             | 4              |
|  |  | Motor hp                           | 1/3            | 1/3           | 1/3            |
|  |  | Cfm                                | 4347           | 4347          | 4500           |
|  |  | Rpm                                | 843            | 843           | 830            |
|  |  | Watts                              | 299            | 299           | 307            |
|  |  | Shipping Data - lbs. 1 package     |                | 272           | 273            |
| <b>ELECTRICAL DATA</b>                             |  |                                    |                |               |                |
| Line voltage data - 60 hz - 1ph                    |  |                                    | 208/230V       | 208/230V      | 208/230V       |
| <sup>3</sup> Maximum overcurrent protection (amps) |  |                                    | 40             | 50            | 50             |
| <sup>4</sup> Minimum circuit ampacity              |  |                                    | 24.2           | 29.0          | 29.4           |
| Compressor   |  | Rated Load Amps                    | 17.92          | 21.76         | 22.10          |
|  |  | Locked Rotor Amps                  | 112            | 117           | 125            |
|  |  | Power Factor                       | 0.99           | 0.99          | 0.99           |
| Outdoor Fan Motor                                  |  | Full Load Amps                     | 1.8            | 1.8           | 1.8            |
|  |  | Locked Rotor Amps                  | 2.9            | 2.9           | 2.9            |
| <b>OPTIONAL ACCESSORIES - ORDER SEPARATELY</b>     |  |                                    |                |               |                |
| Compressor Crankcase Heater                        |  | Factory                            | •              | •             | •              |
| Compressor Hard Start Kit                          |  | 88M91                              | •              | •             | •              |
| Compressor Low Ambient Cut-Off                     |  | 45F08                              | •              | •             | •              |
| Compressor Sound Cover                             |  | 69J03                              | •              | •             | •              |
| Freezestat   |  | 3/8 in. tubing                     | 93G35          | •             | •              |
|  |  | 5/8 in. tubing                     | 50A93          | •             | •              |
| Indoor Blower Off Delay Relay                      |  | 58M81                              | •              | •             | •              |
| Loss of Charge Kit                                 |  | 84M23                              | •              | •             | •              |
| <sup>5</sup> Low Ambient Kit                       |  | 54M89                              | •              | •             | •              |
| Low Pressure Switch Bypass Thermostat              |  | 13W07                              | •              | •             | •              |
| Mild Weather Kit                                   |  | 33M07                              | •              | •             | •              |
| Monitor Kit - Service Light                        |  | 76F53                              | •              | •             | •              |
| Outdoor Thermostat Kit                             |  | Thermostat                         | 56A87          | •             | •              |
|  |  | Mounting Box                       | 31461          | •             | •              |
| Refrigerant Line Sets                              |  | L15-65-30 L15-65-40<br>L15-65-50   | •              | •             | •              |
| Unit Stand-Off Kit                                 |  | 94J45                              | •              | •             | •              |

NOTE - Extremes of operating range are plus 10% and minus 5% of line voltage.

<sup>1</sup> Sound Rating Number rated in accordance with test conditions included in AHRI Standard 270.

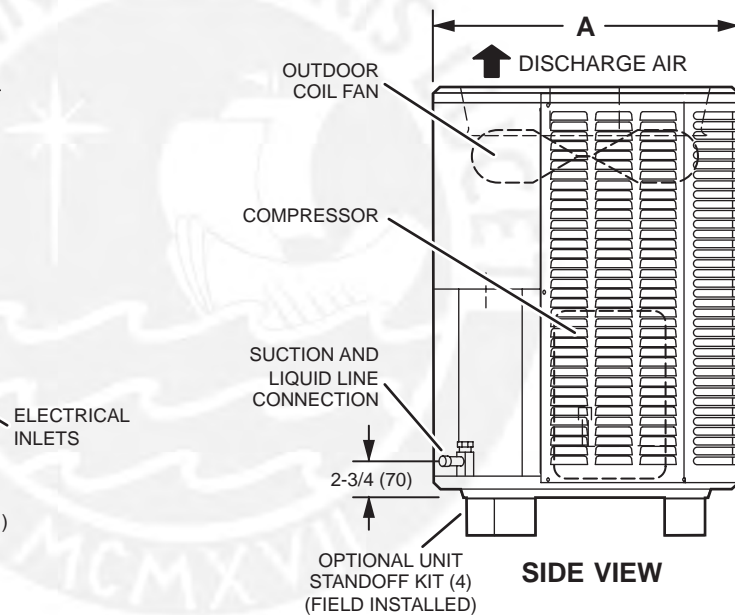
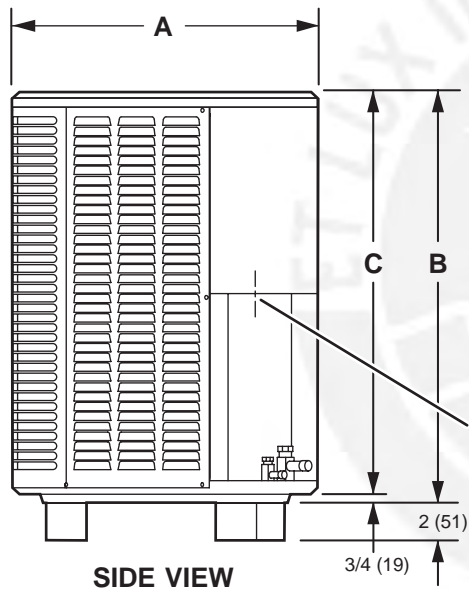
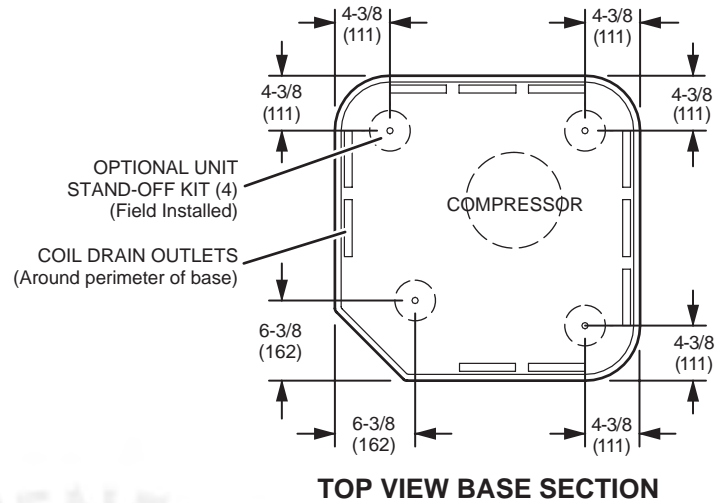
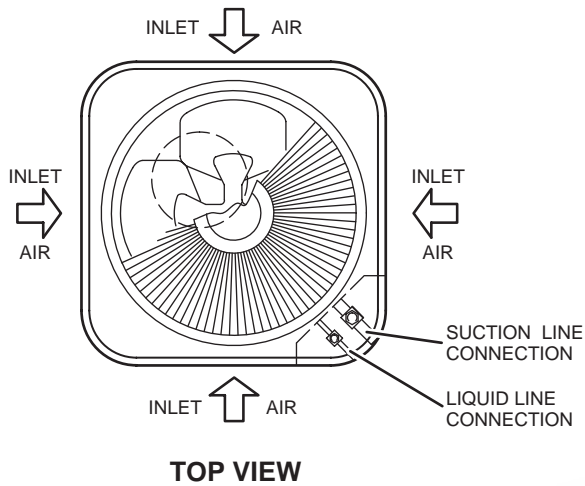
<sup>2</sup> Refrigerant charge sufficient for 15 ft. length of refrigerant lines.

<sup>3</sup> HACR type circuit breaker or fuse.

<sup>4</sup> Refer to National or Canadian Electrical Code manual to determine wire, fuse and disconnect size requirements.

<sup>5</sup> Crankcase Heater and Freezestat are recommended with Low Ambient Kit.

## DIMENSIONS - INCHES (MM)



| Model No.     | A      |     | B      |      | C      |      |
|---------------|--------|-----|--------|------|--------|------|
|               | inches | mm  | inches | mm   | inches | mm   |
| 14HPX-018-230 | 28-1/4 | 718 | 37-1/4 | 743  | 36-1/2 | 724  |
| 14HPX-024-230 | 28-1/4 | 718 | 37-1/4 | 946  | 36-1/2 | 927  |
| 14HPX-030-230 | 28-1/4 | 718 | 37-1/4 | 946  | 36-1/2 | 927  |
| 14HPX-036-230 | 28-1/4 | 718 | 33-1/4 | 845  | 32-1/2 | 826  |
| 14HPX-042-230 | 32-1/4 | 819 | 37-1/4 | 946  | 36-1/2 | 927  |
| 14HPX-048-230 | 32-1/4 | 819 | 37-1/4 | 946  | 36-1/2 | 927  |
| 14HPX-060-230 | 32-1/4 | 819 | 43-1/4 | 1099 | 42-1/4 | 1073 |



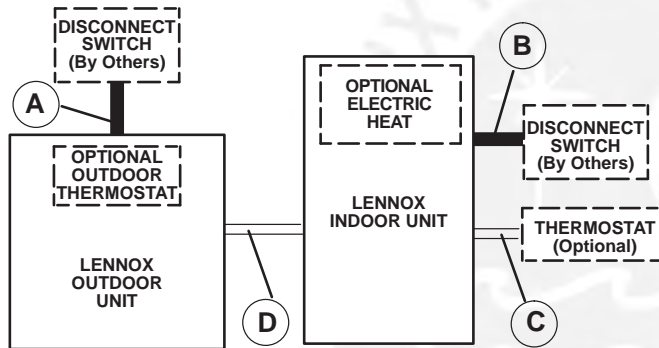
## SOUND DATA

| <sup>1</sup> Unit Model No. | Octave Band Linear Sound Power Levels dB, re 10 <sup>-12</sup> Watts Center Frequency - HZ |      |      |      |      |      |      | <sup>1</sup> Sound Rating Number (dB) |
|-----------------------------|--|------|------|------|------|------|------|---------------------------------------|
|                             | 125  | 250  | 500  | 1000 | 2000 | 4000 | 8000 |                                       |
| 14HPX-018                   | 72   | 70.5 | 68.5 | 68   | 65   | 59.5 | 53.5 | 76                                    |
| 14HPX-024                   | 71   | 74.5 | 72.5 | 71.5 | 68   | 62.5 | 56.5 | 76                                    |
| 14HPX-030                   | 70.5   | 70.5 | 71.5 | 71.5 | 66   | 62.5 | 59   | 76                                    |
| 14HPX-036                   | 78.5   | 77   | 77.5 | 74.5 | 69.5 | 63.5 | 61.5 | 79                                    |
| 14HPX-042                   | 76.5   | 78   | 78.5 | 73.5 | 69.5 | 63.5 | 58.5 | 79                                    |
| 14HPX-048                   | 75.5   | 78   | 78.5 | 75   | 70   | 63.5 | 58.5 | 80                                    |
| 14HPX-060                   | 75   | 77.5 | 77.5 | 75.5 | 70   | 65   | 65   | 80                                    |

NOTE - the octave sound power data does not include tonal correction.

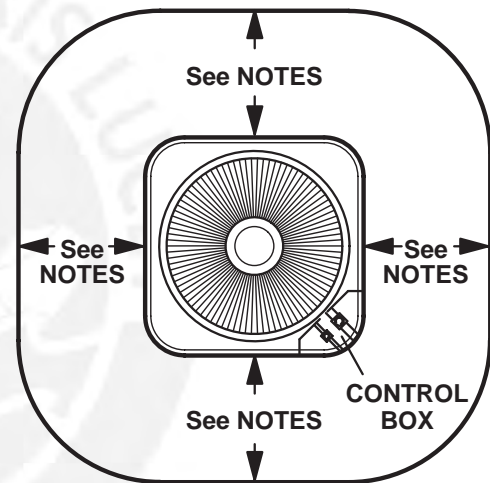
<sup>1</sup> Tested according to AHRI Standard 270-2008 test conditions.

## FIELD WIRING



- A - Two Wire Power (see Electrical Data)
  - B - Two or Three Wire Power (size to heater capacity)
  - C - Twelve Wire Low Voltage 18 ga. minimum  
Fourteen Wire Low Voltage with Optional Outdoor Thermostat
  - D - Eight Wire Low Voltage 18 ga. minimum  
Ten Wire Low Voltage with Optional Outdoor Thermostat
- NOTE - Field Wiring Not Furnished*
- All wiring must conform to NEC or CEC and local electrical codes.

## INSTALLATION CLEARANCES - IN. (MM)



### NOTES:

- Service clearance of 30 in. (762 mm) must be maintained on one of the sides adjacent to the control box.
- Clearance to one of the other three sides must be 36 in. (914 mm)
- Clearance to one of the remaining two sides may be 12 in. (305 mm) and the final side may be 6 in. (152 mm).
- A clearance of 24 in. must be maintained between two units.
- 48 in. (1219 mm) clearance required on top of unit.

## TXV USAGE

Use this table for C33, CH23, CH33 and CR33 Field Installed TXV Match-Ups.

| Model No. | Order No. |
|-----------|-----------|
| 14HPX-018 | 12J18     |
| 14HPX-024 | 12J18     |
| 14HPX-030 | 12J18     |
| 14HPX-036 | 12J19     |
| 14HPX-042 | 12J20     |
| 14HPX-048 | 12J20     |
| 14HPX-060 | 12J20     |

CX34 upflow coils and all Lennox air handlers are shipped with a factory installed TXV. In most cases, no change out of the valve is needed.

C33 and CH33 coils - Replace the factory installed orifice with the expansion valve listed.

CR33 and CH23 - Use the expansion valve listed.

## \*TXV SUBSTITUTIONS

Use this table to determine if the factory installed TXV in the indoor unit needs to be replaced.

| Model No. | Indoor Coil | Factory TXV | Replacement TXV |
|-----------|-------------|-------------|-----------------|
| 14HPX-030 | CX34-44/48  | 12J20       | 12J18           |

\*CX34 coils - The factory installed expansion valve must be replaced with the expansion valve listed (ordered separately).

If the combination is not listed above, the factory installed TXV is used.

## MOST POPULAR MATCHES

| Outdoor Unit Model No. | Indoor Unit Model No |
|------------------------|----------------------|
| 14HPX-018              | CBX25UH-018          |
| 14HPX-024              | CBX25UH-024          |
| 14HPX-030              | CBX25UH-030          |
| 14HPX-036              | CBX25UH-036          |
| 14HPX-042              | CBX25UH-042          |
| 14HPX-048              | CBX25UH-048          |
| 14HPX-060              | CBX25UH-060          |

## AHRI STANDARD 210/240

Cooling or heating capacities are net values, including the effects of blower motor heat, and do not include supplementary heat. Power input is the total power input to the compressor(s) and fan(s), plus any controls and other items required as part of the system for normal operation.

Units which do not have an indoor air-circulating blower furnished as part of the model, i.e., split system with indoor coil only, is established by subtracting from the total cooling capacity 1250 Btu/h per 1,000 cfm, and by adding the same amount to the heating capacity. Total power input for both heating and cooling is increased by 365 W per 1,000 cfm of indoor air circulated.



**AIR HANDLERS**  
**CBX25UH (-01)**  
**MERIT® Series**  
**R-410A - Upflow / Horizontal**

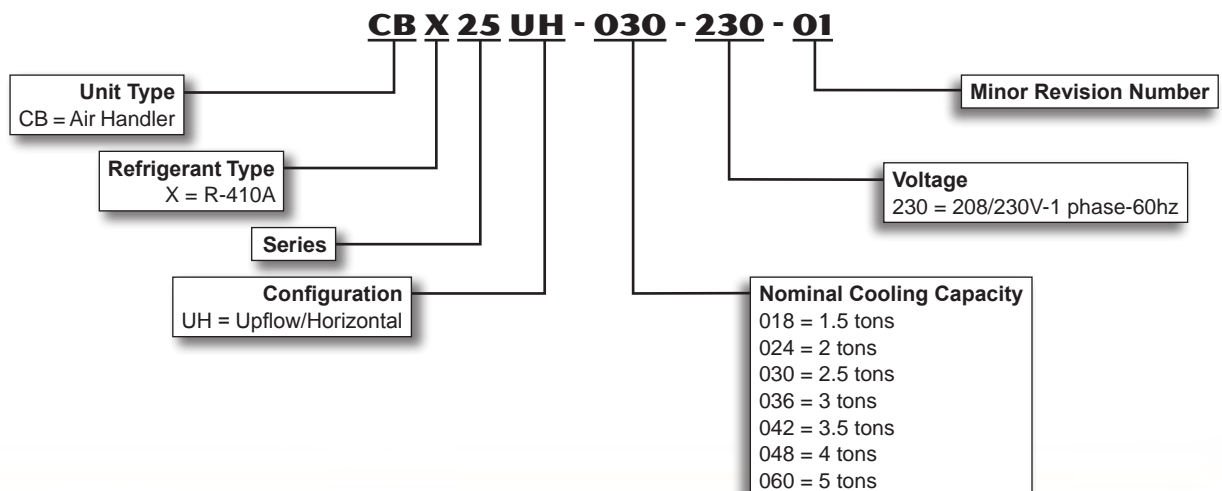
**PRODUCT SPECIFICATIONS**

Bulletin No. 210610  
March 2015  
Supersedes November 2014



Nominal Capacity - 1.5 to 5 Tons  
Optional Electric Heat - 2.5 to 20 kW

**MODEL NUMBER IDENTIFICATION**



## FEATURES

### CONTENTS

|   |    |
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| Dimensions - Unit .....                         | 13 |
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| Model Number Identification .....               | 1  |
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### WARRANTY

**All covered components** - Limited five years in residential applications, one year in non-residential applications.

Refer to Lennox Limited Warranty Certificate included with each unit for additional details.

### APPLICATIONS

1.5 to 5 ton nominal sizes.

Upflow or horizontal applications. Downflow applications with optional conversion kit.

CBX25UH models are applicable to R-410A expansion valve systems in cooling applications and check and expansion valve systems in heat pump applications.

See bulletins in section Air Conditioners for cooling capacities.

See bulletins in section Heat Pump Outdoor Units for cooling and heating capacities.

Optional field installed electric heaters available in several sizes for additive heating capacity.

### APPROVALS

Tested with matching air conditioners and heat pump units in the Lennox Research Laboratory environmental test room in accordance with AHRI Standard 210/240.

Optional electric heaters are rated in accordance with US Department of Energy (DOE) test procedures and Federal Trade Commission (FTC) labeling regulations.

Air handlers and components within are bonded for grounding to meet safety standards for servicing required by ETL, NEC and CEC.

Units are ETL certified for the U.S. and Canada.

ISO 9001 Registered Manufacturing Quality System.

### REFRIGERANT SYSTEM

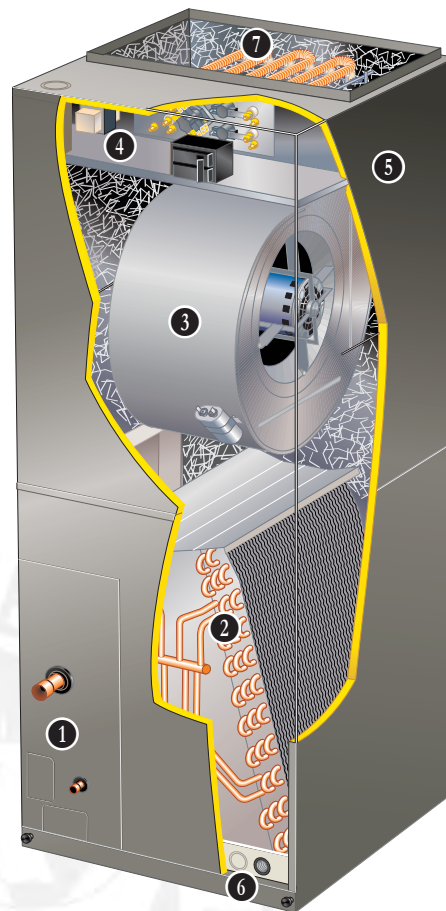
#### 1 Refrigerant Line Connections

Suction (vapor) and liquid lines have sweat connections that extended outside of the cabinet for ease of connection.

See dimension drawing for locations.

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#### Check and Expansion Valve Furnished

CBX25UH models have non-chlorine, ozone friendly, R-410A valve.

Wide range valve.

Chatleff style fitting.

Factory installed on all models internal to cabinet.



#### 2 Copper Tube/Enhanced Fin Evaporator Coil

Assembled in "A" configuration.

Provides extra large surface and contact area, excellent heat transfer and low air resistance for maximum efficiency.

Precise circuiting for uniform refrigerant distribution.

Precisely spaced ripple-edged aluminum fins fitted to durable seamless copper tubes.

Fins are strengthened to resist bending and are equipped with collars that grip tubing for maximum contact area.

Lanced fins provide maximum exposure of fin surface to air stream.

Long life copper tubing is easy to service.

Rifled tubing provides superior heat transfer.

Flared shoulder tubing joints and silver soldering provide tight, leakproof joints.

Coil thoroughly factory tested under high pressure to ensure leakproof construction.

## FEATURES

### FILTER

- Disposable 1 inch filter is furnished.
- Filter rack furnished in cabinet for easy filter installation.
- See Specifications tables for filter sizes.

### **3** BLOWER

- Multi-speed PSC motor.
- Choice of blower speeds. See blower performance tables.
- Speed changes easily accomplished by a simple wiring change.
- Blower is easily removed from unit for servicing.

#### **Time Delay Blower Relay**

Relay allows 30 second blower “on” delay before continuous fan or cooling operation and 45 second blower “off” delay after continuous fan or cooling operation.

### CONTROLS

### **4** Transformer and Blower Cooling Relay

- 24 volt transformer and blower cooling relay furnished as standard.
- Factory installed in the unit control box.

### **Optional Accessories**

#### **Thermostat**

See Thermostat bulletins in Controls section and Lennox Price Book for a complete list of thermostats.

### **5** CABINET

- Constructed of heavy gauge galvanized steel.
- Pre-painted cabinet finish.
- Completely insulated with foil faced fiberglass insulation.
- Removable panels provide complete service access.
- Filter access door for easy filter replacement.
- Thumbscrews hold filter door in place.
- Electrical inlets provided in sides and top of cabinet.
- See dimension drawing for locations.
- Knock-outs in cabinet for drain connections for upflow (left and right) and horizontal applications. See dimension drawing.

#### **Low Leakage Cabinet**

All models have less than 2% air leakage and meet ANSI/ASHRAE Standard 193-2010 “*Method of Test for Determining the Air Tightness of HVAC Equipment.*”

#### **Upflow/Horizontal Capability (Optional Downflow)**

- Shipped for upflow and horizontal left-hand discharge.
- May be field converted to horizontal right-hand air discharge by repositioning horizontal drain pan.
- Optional Downflow Conversion Kit available for field conversion.

### **6** Anti-Microbial Dual Position Drain Pans

Anti-Microbial additive resists growth of mold and mildew on drain pan which improves indoor air quality and reduces drain line blockage.



Factory installed drain pans designed for upflow or horizontal applications.

Deep, corrosion resistant high temperature engineered polymer drain pans have dual pipe drains.

See dimension drawing.

### **Optional Accessories**

#### **Downflow Conversion Kit**

Required for field conversion to downflow position. Kit consists of insulated downflow drain pan, insulated drain pan drip shields, coil drip shields, seal plates and support brackets for repositioning coil and drain pan.

See Specifications table.

#### **Horizontal Support Frame Kit**

Provides support of unit in horizontal applications.

Consists of (2) 1 x 1-1/2 x 32-5/8 in. and (2) 1 x 3 x 53-7/8 in. painted heavy gauge cold rolled steel support channels with assembly and suspending holes.

Bolts and nuts furnished for field assembly.

Suspending rods must be field provided.

#### **Side Return Unit Stand (Upflow Only)**

Raises unit 16 in. above floor for side return air duct connection.

Eliminates need for wooden platform construction.

All aluminum construction.

Two adjustable frames fit all sizes.

See Dimension Drawing.

#### **Wall Hanging Bracket Kit (Upflow Only)**

Allows unit to be hung on wall at any height.

Consists of heavy gauge steel support brackets (one for air handler unit, one for wall mount).

Screws furnished for fastening one bracket to unit.

Bolts for fastening one bracket to wall are field provided.



## FEATURES

### ELECTRICAL

#### Optional Accessories

##### 7 Electric Heat

Field install internal to unit cabinet.

Available in several kW sizes.

See Electric Heat tables.

Helix wound nichrome heating elements exposed directly in air stream resulting in instant heat transfer, low element temperatures and long service life.

Each element equipped with accurately located limit control with fixed temperature off setting and automatic reset.

Thermal sequencer relay brings elements on and off line, in sequence and equal increments, with time delay between each.

Initiates and terminates blower operation.

Heating control relay(s) furnished as standard.

Factory assembled with controls installed and wired.

Electric heat control wiring plugs into mating connector on air handler unit.



#### Circuit Breaker Models

ECB25-5CB, ECB25-7.5CB, ECB25-10CB, ECB25-12.5, ECB25-15CB, ECB25-20CB heaters are equipped with circuit breakers for overload and short circuit protection.

Factory wired and mounted on electric heat unit.

Current sensitive and temperature actuated.

Manual reset.

Flexible plastic circuit breaker cover protects circuit breaker in areas with high humidity or unconditioned areas to prevent nuisance tripping.

Circuit breakers qualify as disconnect means at unit in many areas, eliminate the need for field provided disconnect.

Consult local electrical code in your area.

#### Circuit Breaker Cover Kit

Flexible plastic cover protects circuit breaker.

Recommended in areas with high humidity or unconditioned areas to prevent nuisance tripping.

#### Single-Point Power Source Control Box

Control Box may be used with optional electric heat when single power supply is connected to multi-circuit electric heat.

Field installs external to the unit cabinet on either side or top.

Constructed of heavy gauge steel, baked enamel finish, prepunched mounting holes, electrical inlet knockouts, and terminal strip.

Removeable cover provides easy access.

Dimensions (H x W x D) - 7 x 7 x 4 in.

### INSTALLATION CLEARANCES WITH ELECTRIC HEAT

|                                       |                           |
|---------------------------------------|---------------------------|
| Cabinet                               | 0 inch (0 mm)             |
| To Plenum                             | 0 inch (0 mm)             |
| To Outlet Duct within 3 feet (914 mm) | 0 inch (0 mm)             |
| Floor                                 | 0 inch (0 mm) See Note #1 |
| Service / Maintenance                 | See Note #2               |

<sup>1</sup> Units installed on combustible floors in the downflow position with electric heat do not require a downflow combustible flooring base.

<sup>2</sup> Front service access - 24 inches (610 mm) minimum.

NOTE - If cabinet depth is more than 24 inches (610 mm), allow a minimum of the cabinet depth plus 2 inches (51 mm).

### REPLACEMENT CIRCUIT BREAKERS

| Voltage            | Description    | Catalog No.  |
|--------------------|----------------|--------------|
| 208/240V - 1 Phase | 25 amp, 2 pole | <b>41K13</b> |
|                    | 30 amp, 2 pole | <b>17K70</b> |
|                    | 35 amp, 2 pole | <b>72K07</b> |
|                    | 40 amp, 2 pole | <b>49K14</b> |
|                    | 45 amp, 2 pole | <b>17K71</b> |
|                    | 50 amp, 2 pole | <b>41K12</b> |
|                    | 60 amp, 2 pole | <b>17K72</b> |

## SPECIFICATIONS

| General Data                    |                                       | Model Number    | CBX25UH-018 | CBX25UH-024 | CBX25UH-030 | CBX25UH-036 |
|---------------------------------|---------------------------------------|-----------------|-------------|-------------|-------------|-------------|
|                                 |                                       | Nominal tonnage | 1.5         | 2           | 2.5         | 3           |
| Connections                     | Suction/Vapor line (o.d.) - in. sweat |                 | 3/4         | 3/4         | 3/4         | 7/8         |
|                                 | Liquid line (o.d.) - in. sweat        |                 | 3/8         | 3/8         | 3/8         | 3/8         |
|                                 | Condensate - in. fpt                  |                 | (2) 3/4     | (2) 3/4     | (2) 3/4     | (2) 3/4     |
| Indoor Coil                     | Net face area - ft. <sup>2</sup>      |                 | 3.11        | 3.56        | 4.00        | 4.89        |
|                                 | Tube outside diameter - in.           |                 | 3/8         | 3/8         | 3/8         | 3/8         |
|                                 | Number of rows                        |                 | 3           | 3           | 3           | 3           |
|                                 | Fins per inch                         |                 | 14          | 14          | 14          | 14          |
| Blower                          | Wheel nominal diameter x width - in.  |                 | 9 x 6       | 9 x 6       | 10 x 8      | 9 x 10      |
|                                 | Blower motor output - hp              |                 | 1/5         | 1/3         | 1/3         | 1/2         |
| <sup>1</sup> Filters            | Size of filter - in.                  |                 | 12 x 20 x 1 | 15 x 20 x 1 | 15 x 20 x 1 | 18 x 20 x 1 |
| Shipping Data -1 package - lbs. |                                       |                 | 105         | 123         | 126         | 161         |

## ELECTRICAL DATA

|  |  |   |          |          |          |          |
|--|--|---|----------|----------|----------|----------|
|  |  | Voltage - 1 phase (60 hz)                               | 208/240V | 208/240V | 208/240V | 208/240V |
|  |  | <sup>2</sup> Maximum overcurrent protection (unit only) | 15       | 15       | 15       | 15       |
|  |  | <sup>3</sup> Minimum circuit ampacity (unit only)       | 1.4      | 2.0      | 2.4      | 2.9      |
|  |  | Blower Motor Full Load Amps                             | 1.1      | 1.6      | 1.9      | 2.3      |

## SPECIFICATIONS

| General Data                    |                                       | Model Number    | CBX25UH-042 | CBX25UH-048 | CBX25UH-060 |
|---------------------------------|---------------------------------------|-----------------|-------------|-------------|-------------|
|                                 |                                       | Nominal tonnage | 3.5         | 4           | 5           |
| Connections                     | Suction/Vapor line (o.d.) - in. sweat |                 | 7/8         | 7/8         | 7/8         |
|                                 | Liquid line (o.d.) - in. sweat        |                 | 3/8         | 3/8         | 3/8         |
|                                 | Condensate - in. fpt                  |                 | (2) 3/4     | (2) 3/4     | (2) 3/4     |
| Indoor Coil                     | Net face area - ft. <sup>2</sup>      |                 | 5.83        | 7.00        | 7.00        |
|                                 | Tube outside diameter - in.           |                 | 3/8         | 3/8         | 3/8         |
|                                 | Number of rows                        |                 | 3           | 3           | 3           |
|                                 | Fins per inch                         |                 | 14          | 14          | 14          |
| Blower                          | Wheel nominal diameter x width - in.  |                 | 12 x 8      | 11 x 9      | 12 x 9      |
|                                 | Blower motor output - hp              |                 | 1/3         | 1/2         | 1/2         |
| <sup>1</sup> Filters            | Size of filter - in.                  |                 | 18 x 24 x 1 | 18 x 24 x 1 | 18 x 24 x 1 |
| Shipping Data -1 package - lbs. |                                       |                 | 163         | 186         | 186         |

## ELECTRICAL DATA

|  |  |   |          |          |          |
|--|--|---|----------|----------|----------|
|  |  | Voltage - 1 phase (60 hz)                               | 208/240V | 208/240V | 208/240V |
|  |  | <sup>2</sup> Maximum overcurrent protection (unit only) | 15       | 15       | 15       |
|  |  | <sup>3</sup> Minimum circuit ampacity (unit only)       | 2.4      | 4.9      | 4.9      |
|  |  | Blower Motor Full Load Amps                             | 1.9      | 3.9      | 3.9      |

<sup>1</sup> Disposable filter.

<sup>2</sup> HACR type circuit breaker or fuse.

<sup>3</sup> Refer to National or Canadian Electrical Code manual to determine wire, fuse and disconnect size requirements. Use wires suitable for at least 167°F.

## OPTIONAL ACCESSORIES - ORDER SEPARATELY

| Model   | -018  | -024<br>-030 | -036  | -042<br>-048<br>-060 |
|---|-------|--------------|-------|----------------------|
| Downflow Conversion Kit                                   | 96W37 | 96W38        | 97W95 | 97W96                |
| Horizontal Support Frame Kit                              | 56J18 | 56J18        | 56J18 | 56J18                |
| Side Return Unit Stand (Upflow Only)                      | 45K31 | 45K32        | 45K32 | 45K32                |
| Single-Point Power Source Control Box (for Electric Heat) | 21H39 | 21H39        | 21H39 | 21H39                |
| Wall Hanging Bracket Kit (Upflow Only)                    | 45K30 | 45K30        | 45K30 | 45K30                |

## BLOWER DATA - UPFLOW AND HORIZONTAL

### CBX25UH-018 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |     |
|--------------------------------------|--|--------|-----|
|                                      | High                                     | Medium | Low |
| 0.10                                 | 905                                      | 670    | 510 |
| 0.20                                 | 865                                      | 650    | 495 |
| 0.30                                 | 820                                      | 630    | 475 |
| 0.40                                 | 770                                      | 595    | 415 |
| 0.50                                 | 700                                      | 500    | 325 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-042 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |      |
|--------------------------------------|--|--------|------|
|                                      | High                                     | Medium | Low  |
| 0.10                                 | 1820                                     | 1490   | 1325 |
| 0.20                                 | 1770                                     | 1465   | 1315 |
| 0.30                                 | 1690                                     | 1440   | 1300 |
| 0.40                                 | 1600                                     | 1395   | 1275 |
| 0.50                                 | 1500                                     | 1315   | 1225 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-024 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |     |
|--------------------------------------|--|--------|-----|
|                                      | High                                     | Medium | Low |
| 0.10                                 | 1130                                     | 885    | 630 |
| 0.20                                 | 1100                                     | 875    | 625 |
| 0.30                                 | 1070                                     | 850    | 615 |
| 0.40                                 | 1010                                     | 820    | 610 |
| 0.50                                 | 950                                      | 780    | 580 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-048 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |      |
|--------------------------------------|--|--------|------|
|                                      | High                                     | Medium | Low  |
| 0.10                                 | 2070                                     | 1995   | 1775 |
| 0.20                                 | 1970                                     | 1895   | 1710 |
| 0.30                                 | 1850                                     | 1800   | 1645 |
| 0.40                                 | 1720                                     | 1685   | 1565 |
| 0.50                                 | 1595                                     | 1560   | 1470 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-030 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |     |
|--------------------------------------|--|--------|-----|
|                                      | High                                     | Medium | Low |
| 0.10                                 | 1240                                     | 1075   | 900 |
| 0.20                                 | 1210                                     | 1060   | 865 |
| 0.30                                 | 1170                                     | 1030   | 830 |
| 0.40                                 | 1135                                     | 985    | 785 |
| 0.50                                 | 1085                                     | 940    | 740 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-060 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |      |
|--------------------------------------|--|--------|------|
|                                      | High                                     | Medium | Low  |
| 0.10                                 | 2140                                     | 1965   | 1675 |
| 0.20                                 | 2085                                     | 1925   | 1630 |
| 0.30                                 | 2000                                     | 1875   | 1580 |
| 0.40                                 | 1895                                     | 1800   | 1520 |
| 0.50                                 | 1795                                     | 1695   | 1450 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-036 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at Specific Blower Taps (cfm) |        |      |
|--------------------------------------|--|--------|------|
|                                      | High                                     | Medium | Low  |
| 0.10                                 | 1660                                     | 1500   | 1160 |
| 0.20                                 | 1575                                     | 1445   | 1140 |
| 0.30                                 | 1495                                     | 1385   | 1115 |
| 0.40                                 | 1405                                     | 1300   | 1085 |
| 0.50                                 | 1390                                     | 1200   | 990  |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

## BLOWER DATA - DOWNFLOW

### CBX25UH-018 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |     |
|--------------------------------------|---|--------|-----|
|                                      | High  | Medium | Low |
| 0.10                                 | 670   | 600    | 495 |
| 0.20                                 | 630   | 565    | 460 |
| 0.30                                 | 590   | 500    | 420 |
| 0.40                                 | 515   | 465    | 380 |
| 0.50                                 | 470   | 410    | 330 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-042 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |      |
|--------------------------------------|---|--------|------|
|                                      | High  | Medium | Low  |
| 0.10                                 | 1460  | 1375   | 1310 |
| 0.20                                 | 1375  | 1295   | 1245 |
| 0.30                                 | 1315  | 1235   | 1180 |
| 0.40                                 | 1225  | 1150   | 1120 |
| 0.50                                 | 1145  | 1055   | 1025 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-024 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |     |
|--------------------------------------|---|--------|-----|
|                                      | High  | Medium | Low |
| 0.10                                 | 945   | 840    | 630 |
| 0.20                                 | 890   | 800    | 615 |
| 0.30                                 | 850   | 760    | 595 |
| 0.40                                 | 795   | 705    | 560 |
| 0.50                                 | 730   | 605    | 465 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-048 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |      |
|--------------------------------------|---|--------|------|
|                                      | High  | Medium | Low  |
| 0.10                                 | 1725  | 1665   | 1605 |
| 0.20                                 | 1640  | 1585   | 1520 |
| 0.30                                 | 1550  | 1495   | 1435 |
| 0.40                                 | 1455  | 1400   | 1350 |
| 0.50                                 | 1350  | 1280   | 1105 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-030 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |     |
|--------------------------------------|---|--------|-----|
|                                      | High  | Medium | Low |
| 0.10                                 | 1105  | 950    | 820 |
| 0.20                                 | 1065  | 915    | 780 |
| 0.30                                 | 1010  | 870    | 745 |
| 0.40                                 | 960   | 825    | 695 |
| 0.50                                 | 900   | 660    | 615 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

### CBX25UH-060 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |      |
|--------------------------------------|---|--------|------|
|                                      | High  | Medium | Low  |
| 0.10                                 | 1785  | 1730   | 1630 |
| 0.20                                 | 1700  | 1650   | 1555 |
| 0.30                                 | 1605  | 1570   | 1490 |
| 0.40                                 | 1505  | 1455   | 1390 |
| 0.50                                 | 1390  | 1370   | 1280 |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

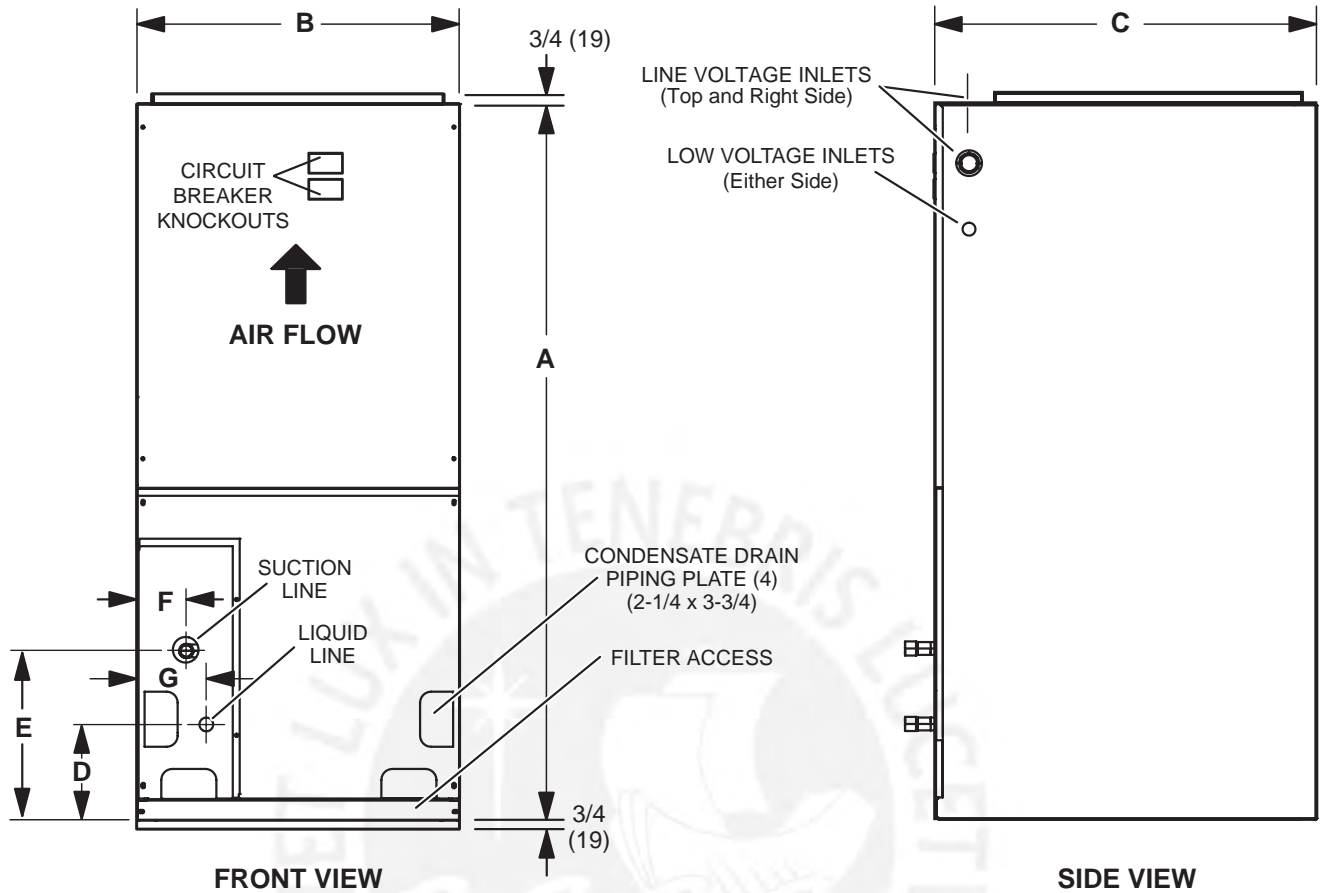
### CBX25UH-036 BLOWER PERFORMANCE

| External Static Pressure<br>in. w.g. | Air Volume at<br>Specific Blower Taps (cfm) |        |      |
|--------------------------------------|---|--------|------|
|                                      | High  | Medium | Low  |
| 0.10                                 | 1195  | 1160   | 1065 |
| 0.20                                 | 1090  | 1065   | 985  |
| 0.30                                 | 1020  | 990    | 935  |
| 0.40                                 | 960   | 925    | 865  |
| 0.50                                 | 885   | 850    | 805  |

NOTE - All air data measured external to unit with dry coil and 1 inch non-pleated air filter in place.  
Electric heaters have no appreciable air resistance.

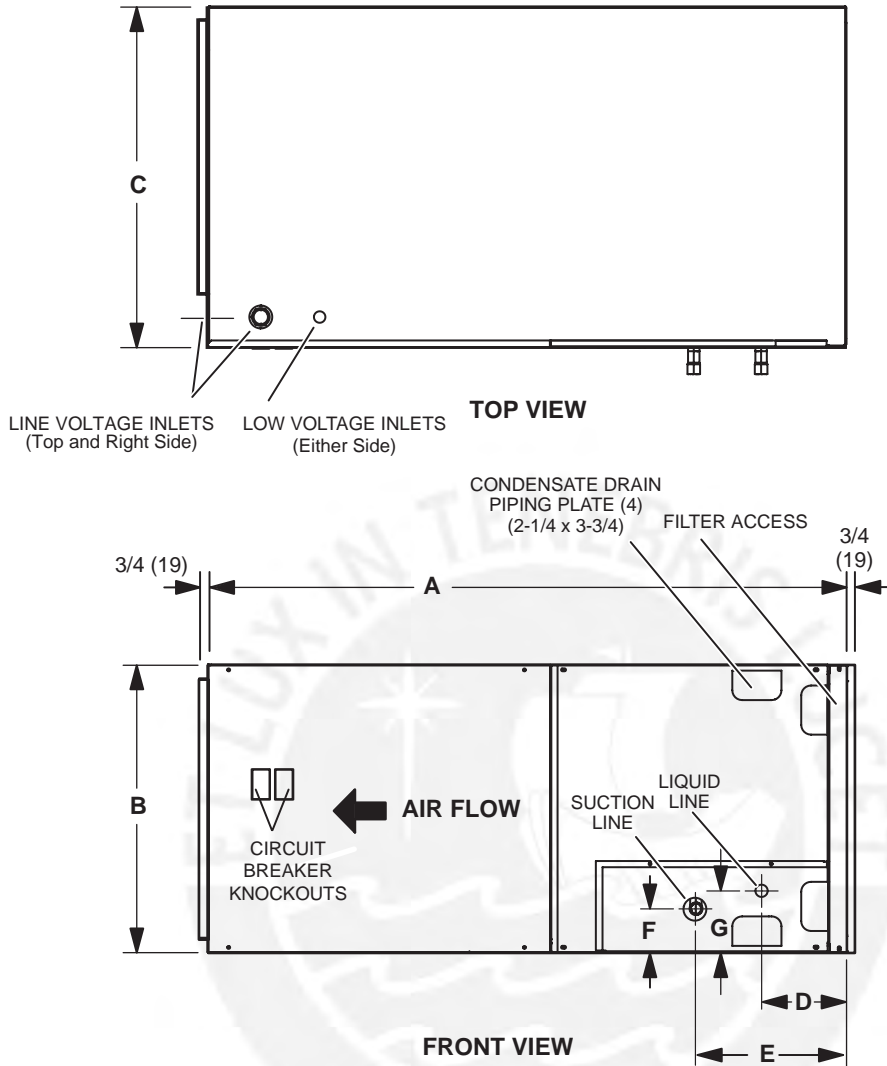


**DIMENSIONS - UNIT - UPFLOW - INCHES (MM)**



| Dimension                 | 018   |        | 024    |        | 030    |        | 036    |        | 042    |        | 048-060 |        |     |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|-----|
|                           | in.   | mm     | in.    | mm     | in.    | mm     | in.    | mm     | in.    | mm     | in.     | mm     |     |
| <b>A</b>                  | 38    | 965    | 40-1/2 | 1029   | 43     | 1092   | 48     | 1219   | 48     | 1219   | 52-1/2  | 1334   |     |
| <b>B</b>                  | 15    | 381    | 18-1/2 | 470    | 18-1/2 | 470    | 21-7/8 | 556    | 21-7/8 | 556    | 21-7/8  | 556    |     |
| <b>C</b>                  | 22    | 559    | 22     | 559    | 22     | 559    | 22     | 559    | 26     | 660    | 26      | 660    |     |
| <b>D</b>                  | 6     | 152    | 6      | 152    | 6      | 152    | 12-1/4 | 311    | 6-1/4  | 159    | 6-3/8   | 162    |     |
| <b>E</b>                  | 11    | 279    | 14     | 357    | 16     | 406    | 18-7/8 | 479    | 17-7/8 | 454    | 15-1/4  | 387    |     |
| <b>F</b>                  | 3-5/8 | 92     | 5-1/2  | 140    | 5-1/2  | 140    | 5-3/4  | 146    | 3-1/4  | 83     | 3-1/4   | 83     |     |
| <b>G</b>                  | 3-5/8 | 92     | 5-1/2  | 140    | 5-1/2  | 140    | 5-3/4  | 146    | 4-5/8  | 117    | 6-3/8   | 162    |     |
| <b>Supply Air Opening</b> | Depth | 17     | 432    | 17     | 432    | 17     | 432    | 17     | 432    | 21     | 533     | 21     | 533 |
|                           | Width | 13     | 330    | 16-1/2 | 419    | 16-1/2 | 419    | 19-7/8 | 505    | 19-7/8 | 505     | 19-7/8 | 505 |
| <b>Return Air Opening</b> | Depth | 20-3/4 | 527    | 20-3/4 | 527    | 20-3/4 | 527    | 20-3/4 | 527    | 24-3/4 | 629     | 24-3/4 | 629 |
|                           | Width | 12-1/2 | 318    | 16     | 406    | 16     | 406    | 19-3/8 | 492    | 19-3/8 | 492     | 19-3/8 | 492 |

## DIMENSIONS - UNIT - HORIZONTAL - INCHES (MM)



NOTE - Shipped for horizontal left-hand discharge.  
 May be field converted to horizontal right-hand air discharge by repositioning horizontal drain pan.

| Dimension                 | 018    |        | 024    |        | 030    |        | 036    |        | 042    |        | 048-060 |        |     |
|---------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|-----|
|                           | in.    | mm     | in.    | mm     | in.    | mm     | in.    | mm     | in.    | mm     | in.     | mm     |     |
| <b>A</b>                  | 38     | 965    | 40-1/2 | 1029   | 43     | 1092   | 48     | 1219   | 48     | 1219   | 52-1/2  | 1334   |     |
| <b>B</b>                  | 15     | 381    | 18-1/2 | 470    | 18-1/2 | 470    | 21-7/8 | 556    | 21-7/8 | 556    | 21-7/8  | 556    |     |
| <b>C</b>                  | 22     | 559    | 22     | 559    | 22     | 559    | 22     | 559    | 26     | 660    | 26      | 660    |     |
| <b>D</b>                  | 6      | 152    | 6      | 152    | 6      | 152    | 12-1/4 | 311    | 6-1/4  | 159    | 6-3/8   | 162    |     |
| <b>E</b>                  | 11     | 279    | 14     | 357    | 16     | 406    | 18-7/8 | 479    | 17-7/8 | 454    | 15-1/4  | 387    |     |
| <b>F</b>                  | 3-5/8  | 92     | 5-1/2  | 140    | 5-1/2  | 140    | 5-3/4  | 146    | 3-1/4  | 83     | 3-1/4   | 83     |     |
| <b>G</b>                  | 3-5/8  | 92     | 5-1/2  | 140    | 5-1/2  | 140    | 5-3/4  | 146    | 4-5/8  | 117    | 6-3/8   | 162    |     |
| <b>Supply Air Opening</b> | Depth  | 17     | 432    | 17     | 432    | 17     | 432    | 17     | 432    | 21     | 533     | 21     | 533 |
|                           | Height | 13     | 330    | 16-1/2 | 419    | 16-1/2 | 419    | 19-7/8 | 505    | 19-7/8 | 505     | 19-7/8 | 505 |
| <b>Return Air Opening</b> | Depth  | 20-3/4 | 527    | 20-3/4 | 527    | 20-3/4 | 527    | 20-3/4 | 527    | 24-3/4 | 629     | 24-3/4 | 629 |
|                           | Height | 12-1/2 | 318    | 16     | 406    | 16     | 406    | 19-3/8 | 492    | 19-3/8 | 492     | 19-3/8 | 492 |

# ELECTRIC DUCT HEATERS



**UL & CSA LISTED ELECTRIC DUCT HEATERS  
STOCK- LINE SERIES · QUICKSILVER SERIES · CUSTOM BUILT SERIES**



**WARREN** TECHNOLOGY, INC

2050 West 73 Street Hialeah, FL 33016 • Telephone: (305) 556-6933 • Fax: (305) 557-6157

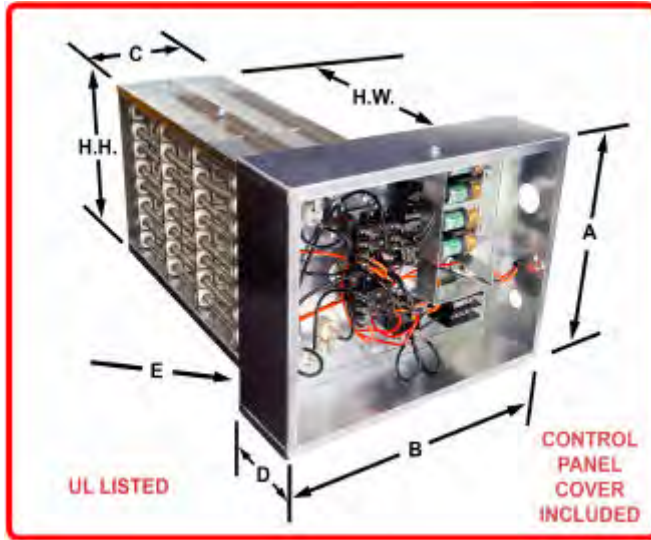
Website: [www.warrenvac.com](http://www.warrenvac.com) • E-Mail: [warren@warrenvac.com](mailto:warren@warrenvac.com)





# WARREN TECHNOLOGY STOCK-LINE ELECTRIC DUCT HEATERS

## FITS MOST DUCT SIZES



Stock-Line slip-in type duct heaters are designed to meet most residential and light commercial requirements for use in forced air duct systems. They may be used as the primary source of heat or as supplementary or stand-by heat to Heat Pump, Gas or Oil Fired Systems. Several units may be used in a large duct or systems with branch ducts for zoning or separate thermostat for zoning or separate thermostat control. The heaters are designed to operate in a variety of duct sizes.

Stock-Line units are UL listed and meet the requirements of the National Electric Code (NEC). The units have multi-voltage ratings, high grade nickel chrome elements, galvanized steel control panel and frame, and Warren's exclusive element support system. Built-in components include primary and secondary limit protection, magnetic disconnecting contactors (24 volt control), a fan relay, and circuit fusing where required by UL and NEC.

Custom built Model CBK electric duct heaters are available for units with accessories not furnished on Stock-Line electric duct heaters. (Consult representative for price and delivery information).

| MODEL  | KW   | VOLTS | PHASE | STEPS | AMPS | DUCT SIZE LIMITS |      |        |      | DIMENSIONS |    |   |   |   | H-W  | H-H  | SHIP WEIGHT |
|--------|------|-------|-------|-------|------|------------------|------|--------|------|------------|----|---|---|---|------|------|-------------|
|        |      |       |       |       |      | WIDTH            |      | HEIGHT |      | A          | B  | C | D | E |      |      |             |
|        |      |       |       |       |      | MIN.             | MAX. | MIN.   | MAX. |            |    |   |   |   |      |      |             |
| SL5A   | 4.8  | 240   | 1     | 1     | 20.0 | 8                | 16   | 8      | 12   | 9          | 11 | 3 | 4 | 1 | 7.5  | 7.25 | 10#         |
|        | 4.4  | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 4.0  | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 3.6  | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL5T   | 5.0  | 240   | 3     | 1     | 12.1 | 8                | 16   | 8      | 12   | 9          | 13 | 3 | 4 | 1 | 7.5  | 7.25 | 11#         |
|        | 4.6  | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 4.1  | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 3.7  | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL5TX  | 5.0  | 480   | 3     | 1     | 6.0  | 8                | 16   | 8      | 12   | 9          | 13 | 3 | 4 | 1 | 7.5  | 7.25 | 12#         |
| SL10A  | 9.6  | 240   | 1     | 1     | 40.0 | 12               | 20   | 8      | 14   | 9          | 12 | 3 | 4 | 1 | 11.5 | 7.25 | 12#         |
|        | 8.8  | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 8.0  | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 7.2  | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL10B  | 9.6  | 240   | 1     | 1     | 40.0 | 10               | 18   | 10     | 16   | 11         | 12 | 3 | 4 | 1 | 9.5  | 9.25 | 13#         |
|        | 8.8  | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 8.0  | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 7.2  | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL15A* | 14.4 | 240   | 1     | 2     | 60.0 | 18               | 24   | 8      | 12   | 9          | 19 | 3 | 4 | 1 | 17.5 | 7.25 | 20#         |
|        | 13.2 | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 12.0 | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 10.0 | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL15B* | 14.4 | 240   | 1     | 2     | 60.0 | 15               | 22   | 10     | 14   | 11         | 18 | 3 | 4 | 1 | 14.5 | 9.25 | 20#         |
|        | 13.2 | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 12.0 | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 10.0 | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL20A* | 19.2 | 240   | 1     | 2     | 80.0 | 16               | 22   | 10     | 14   | 11         | 20 | 6 | 4 | 1 | 15.5 | 9.25 | 25#         |
|        | 17.6 | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 16.1 | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 14.4 | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL10T  | 9.9  | 240   | 3     | 1     | 23.9 | 12               | 20   | 8      | 14   | 9          | 12 | 3 | 4 | 1 | 11.5 | 7.25 | 12#         |
|        | 9.0  | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 8.3  | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 7.4  | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL10TX | 10.0 | 480   | 3     | 1     | 12.0 | 12               | 20   | 8      | 14   | 9          | 13 | 3 | 4 | 1 | 11.5 | 7.25 | 13#         |
| SL15T  | 15.0 | 240   | 3     | 2     | 36.0 | 15               | 22   | 10     | 14   | 11         | 15 | 6 | 4 | 1 | 14.5 | 9.25 | 23#         |
|        | 13.6 | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 12.6 | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 11.2 | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL15TX | 15.0 | 480   | 3     | 2     | 18.1 | 15               | 22   | 10     | 14   | 11         | 14 | 6 | 4 | 1 | 14.5 | 9.25 | 22#         |
| SL20T  | 19.8 | 240   | 3     | 2     | 47.7 | 16               | 22   | 11     | 14   | 12         | 14 | 6 | 4 | 1 | 15.5 | 9.25 | 22#         |
|        | 18.0 | 230   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 16.6 | 220   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
|        | 14.8 | 208   |       |       |      |                  |      |        |      |            |    |   |   |   |      |      |             |
| SL20TX | 20.0 | 480   | 3     | 2     | 24.1 | 16               | 22   | 11     | 14   | 12         | 15 | 6 | 4 | 1 | 15.5 | 9.25 | 23#         |

\*DENOTES UNITS WITH CIRCUIT FUSING.

### STOCK-LINE ACCESSORY LIST

**CAUTION: In some installations provisions must be made to allow for adequate mixing of by-pass air and heater air to prevent stratification.**

#### PART NO. SLTR ( TRANSFORMER KIT)

The STOCK-LINE Transformer Kit (P / N SLTR) comes complete with all the necessary parts (transformer, wire leads, screws, terminals, etc.) and instructions for external mounting.



#### PART NO. SLAS (AIR PRESSURE SWITCH KIT)

The STOCK-LINE Air Pressure Switch Kit (P / N SLAS) comes complete with all the necessary parts (air pressure switch, wire leads, screws, terminals, etc.) and instructions for external mounting.



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 Website: www.warrenhvac.com  
 E-Mail: warren@warrenhvac.com

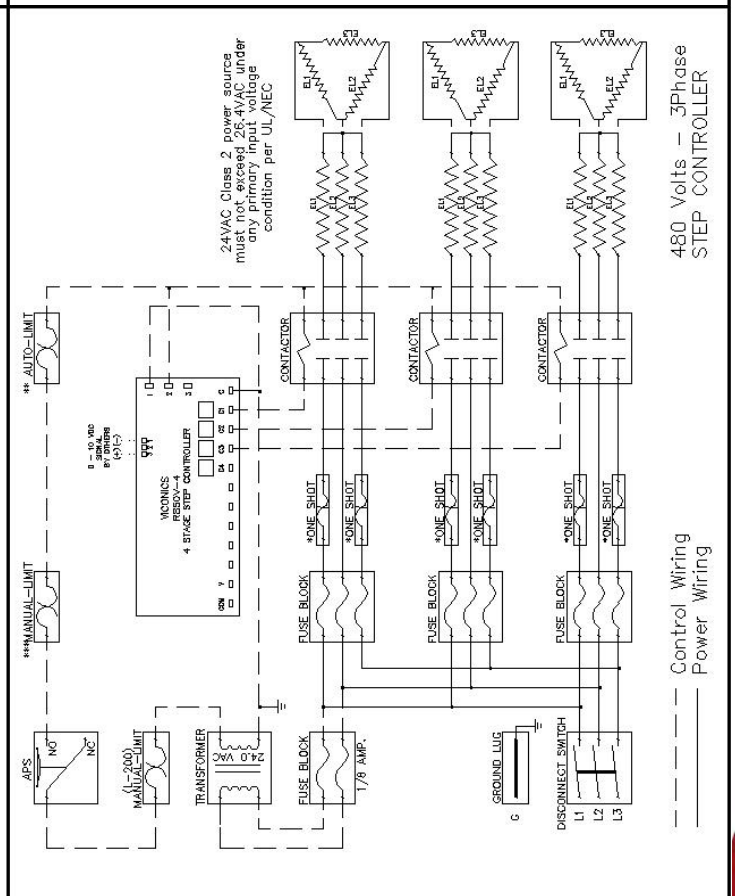
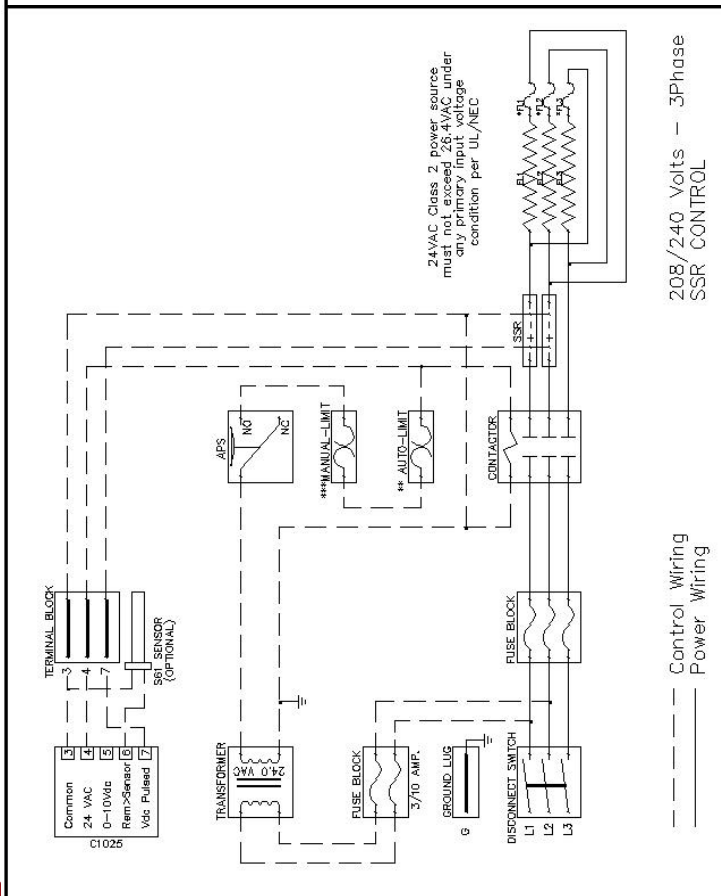
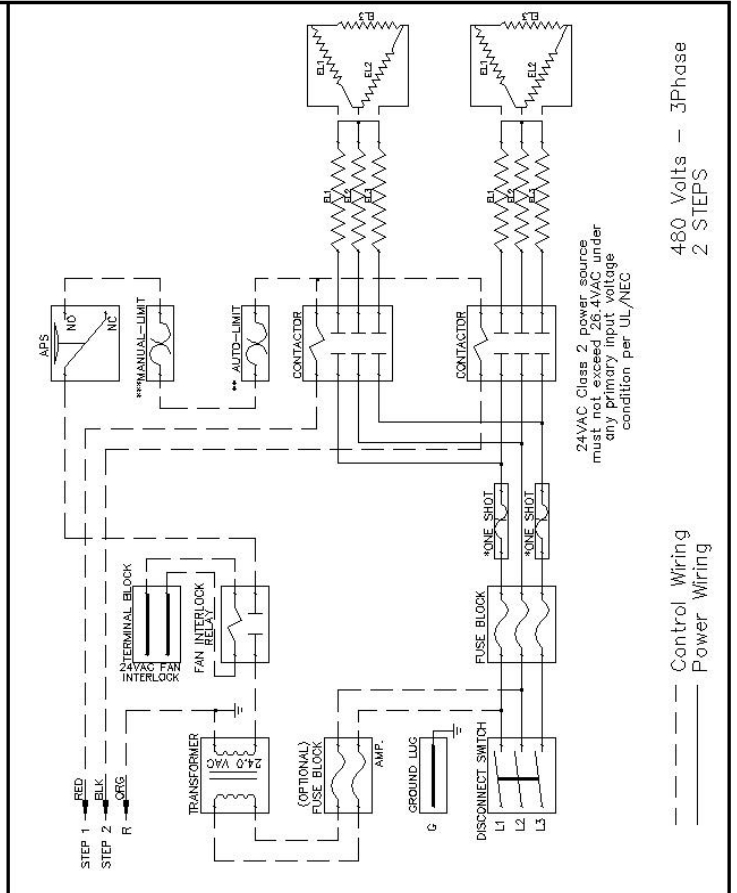
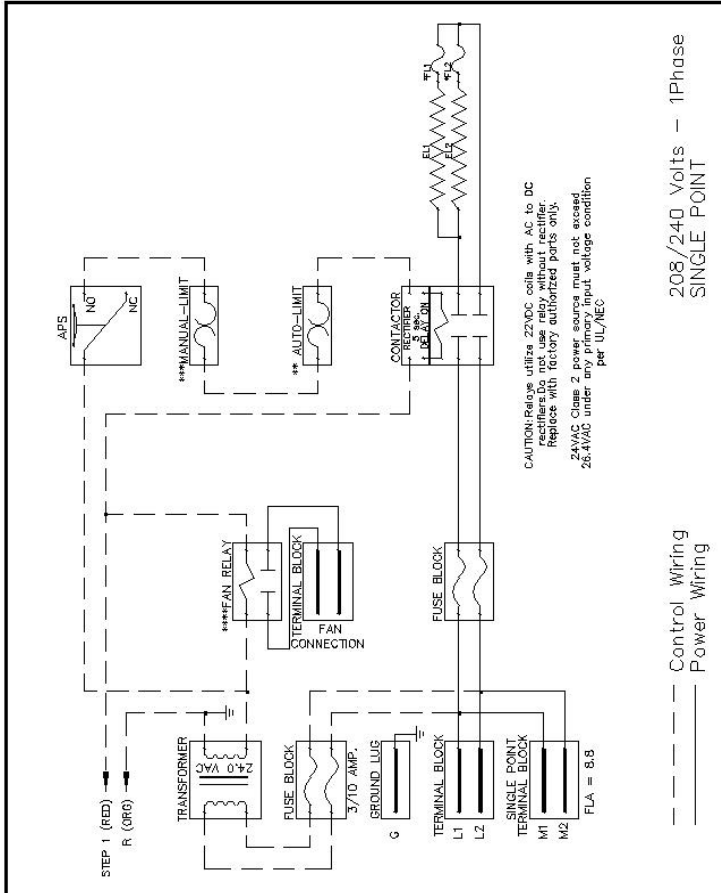
1 Tesis publicada con autorización del autor  
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# Warren Technology

2050 West 73 Street, Hialeah, Florida 33016 • Telephone (305) 556-6933 • Fax (305) 557-6157  
 Website: www.warrenhvac.com E-Mail: warren@warrenhvac.com





clima

## The new “all in one” thermostat-humidistat for cooling/heating and humidification systems

**Clima** is the new CAREL proposal for the management of simple air-conditioning and heating systems. The 0 to 10 V output can also be connected for the modulating control of the CAREL “compactSteam” humidifier in residential and light commercial applications.

When designing this controller special attention was focused on the appearance and simplicity of use, adopting a large icon-based display that allows the user to navigate the system parameters with ease.

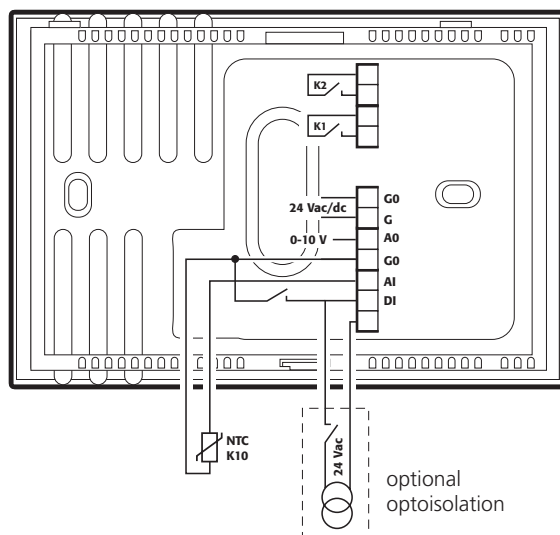
**Clima** comes with an inbuilt temperature or temperature/humidity sensor, multifunction digital input, up to two relays + one 0 to 10 V proportional output for 11 different control modes, including zone control for radiant underfloor installations.

In addition, an outside temperature sensor can be connected for automatic compensation of the temperature and humidity set points. The Real Time Clock manages a daily time band, and the optional RS485 serial interface completes the product, making it a technologically advanced solution.

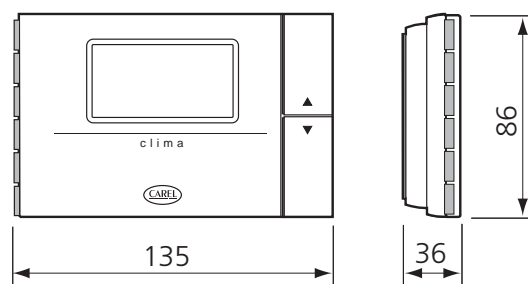
## Technical specifications

|                                    |  |
|------------------------------------|--|
| Power supply                       | 24 Vac/dc, -15 to +10%, 50/60 Hz<br>or directly from compactSteam  |
| Power input                        | 3 W  |
| Digital inputs                     | 1 multifunction: alarm from compactSteam,<br>remote ON/OFF, cooling/heating selection,<br>alternative set point (sleep)<br>With optional optical isolation |
| Analogue inputs                    | 1 x inbuilt temperature or temperature + humidity<br>1 x remote NTC  |
| Analogue outputs                   | 1 x 0 to 10 V  |
| Digital outputs                    | 2 x 230 V, 5 A relays  |
| Optional serial interface          | Modbus® / CAREL over RS485   |
| Operating range                    | 10T60 °C   |
| Temperature and humidity set point | 15T30 °C, 30 to 70% r.H.   |
| Operating conditions               | -0T60 °C, 10 to 90% r.H. non-condensing  |
| Storage conditions                 | -25T70 °C, 10 to 90% r.H. non-condensing   |
| Index of protection                | IP20   |

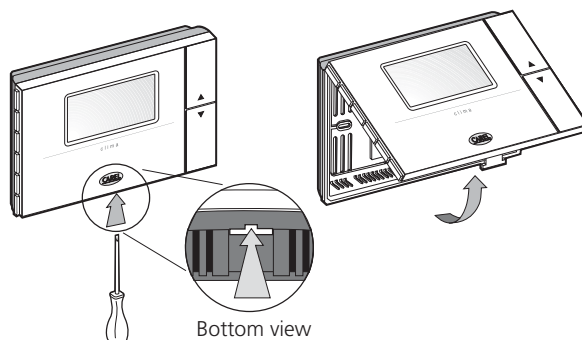
## Wiring diagram



## Dimensions



## Assembly



## Headquarters

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CAREL reserves the right to make modifications or changes to its products without prior warning.

Ventiladores helicoidales para instalar en cristal o pared, con carcasa de plástico ABS, persiana incorporada, motor 230V-50Hz, IPX4, Clase II. Gama compuesta por 3 diámetros: 150, 230 y 300 mm., con diferentes opciones de funcionamiento según las necesidades de la instalación.



**Persiana automática**  
Evita fugas de calefacción y la entrada de aire del exterior.



**Reversible**  
Extracción o impulsión.



**Ventilación natural**  
Con persiana abierta y ventilador cerrado.

**DISEÑO ELEGANTE ADAPTABLE A CUALQUIER AMBIENTE**





#### VERSIONES HV-AE



##### Modelos base

Posiciones de funcionamiento:

**HV-150 AE:** 2 Posiciones: Paro - Persiana cerrada  
Marcha como extractor

**HV-230 AE:** 3 Posiciones: Paro - Persiana cerrada  
**HV-300 AE:** Marcha como extractor  
Marcha como impulsor

Función extracción-impulsión mediante control REB-1R,  
como accesorio.

#### VERSIONES HV-M



##### Modelos accionados por cadena

Posiciones de funcionamiento:

**HV-150 M:** 3 Posiciones: Paro - Persiana cerrada  
Paro - Persiana abierta  
Marcha como extractor

**HV-230 M:** 5 Posiciones: Paro - Persiana cerrada  
**HV-300 M:** Paro - Persiana abierta  
Marcha rápida como extractor  
Marcha lenta como extractor  
Marcha rápida como impulsor

#### VERSIONES HV-A



##### Modelos accionados por control remoto

Posiciones de funcionamiento:

**HV-150 A:** 3 Posiciones: Paro - Persiana cerrada  
Paro - Persiana abierta  
Marcha como extractor

Accionamiento imprescindible mediante control CR-150,  
como accesorio.

**HV-230 A:** 5 Posiciones: Paro - Persiana cerrada  
**HV-300 A:** Paro - Persiana abierta  
Marcha rápida como extractor  
Marcha lenta como extractor  
Marcha rápida como impulsor

Accionamiento imprescindible mediante control CR-300,  
como accesorio.

VERSIONES HV-RC



**Modelos accionados por mando a distancia por radiocontrol**

Posiciones de funcionamiento:

- HV-230 RC:** 6 Posiciones: Paro - Persiana cerrada
- HV-300 RC:** Paro - Persiana abierta
- Marcha rápida como extractor
- Marcha lenta como extractor
- Marcha rápida como impulsor
- Marcha lenta como impulsor

VERSIONES HVE



**Modelos con cajón para encastrar en muro**

Posiciones de funcionamiento:

- HVE-230 AE:** 3 Posiciones idénticas al HV-230 AE
- HVE-230 A:** 5 Posiciones idénticas al HV-230 A
- HVE-230 RC:** 6 Posiciones idénticas al HV-230 RC

CARACTERÍSTICAS FUNCIONALES DE LA GAMA STYLVENT

| Modelo     | Versión encastrable | 1 Velocidad | 2 Velocidades | Reversible | Ventilación natural | Accionamiento por cadena | Accesorios eléctricos |        |        | Radio control |
|------------|---------------------|-------------|---------------|------------|---------------------|--------------------------|-----------------------|--------|--------|---------------|
|            |                     |             |               |            |                     |                          | REB-1R                | CR-150 | CR-300 |               |
| HV-150 M   |                     | •           |               |            |                     | •                        |                       |        |        |               |
| HV-230 M   |                     |             | •             | •          | •                   | •                        |                       |        |        |               |
| HV-300 M   |                     |             | •             | •          | •                   | •                        |                       |        |        |               |
| HV-150 AE  |                     | •           |               |            |                     |                          |                       |        |        |               |
| HV-230 AE  |                     | •           |               | •          |                     |                          | •                     | •      |        |               |
| HV-300 AE  |                     | •           |               | •          |                     |                          | •                     | •      |        |               |
| HV-150 A   |                     | •           |               |            | •                   |                          |                       | •      |        |               |
| HV-230 A   |                     |             | •             | •          | •                   |                          |                       |        | •      |               |
| HV-300 A   |                     |             | •             | •          | •                   |                          |                       |        | •      |               |
| HV-230 RC  |                     |             | •             | •          | •                   |                          |                       |        |        | •             |
| HV-300 RC  |                     |             | •             | •          | •                   |                          |                       |        |        | •             |
| HVE-230 AE | •                   | •           |               | •          |                     |                          | •                     |        |        |               |
| HVE-230 A  | •                   |             | •             | •          | •                   |                          |                       |        | •      |               |
| HVE-230 RC | •                   |             | •             | •          | •                   |                          |                       |        |        | •             |

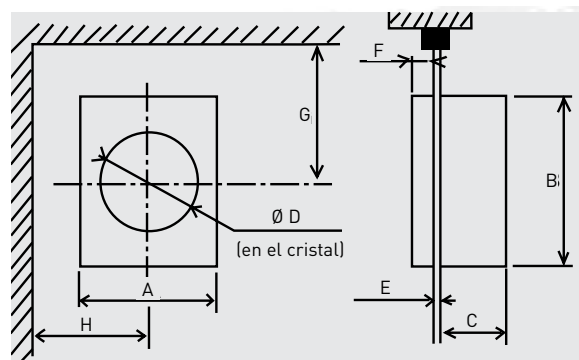
Temperatura ambiente máxima para todos los modelos: 45 °C.

Un solo mando a distancia puede controlar varios HV-EC. En esta situación, debe haber una distancia mínima entre los ventiladores de 1,5 metros.

### CARACTERÍSTICAS TÉCNICAS

| Modelo     | Velocidad (r.p.m.) | Potencia absorbida (W) | Intensidad absorbida (A) | Caudales (m <sup>3</sup> /h) |                 |           | Nivel presión sonora a 3 m (dB(A)) |                 | Peso (kg) |
|------------|--------------------|------------------------|--------------------------|------------------------------|-----------------|-----------|------------------------------------|-----------------|-----------|
|            |                    |                        |                          | Extracción                   |                 | Impulsión | Velocidad rápida                   | Velocidad lenta |           |
|            |                    |                        |                          | Velocidad rápida             | Velocidad lenta |           |                                    |                 |           |
| HV-150 AE  | 1800               | 32                     | 0,19                     | 225                          | -               | -         | 39                                 | -               | 2,0       |
| HV-150 M   | 1800               | 32                     | 0,19                     | 225                          | -               | -         | 39                                 | -               | 2,0       |
| HV-150 A   | 1800               | 32                     | 0,19                     | 225                          | -               | -         | 39                                 | -               | 2,0       |
| HV-230 AE  | 1250               | 34                     | 0,15                     | 600                          | -               | 330       | 43                                 | -               | 3,5       |
| HVE-230 AE | 1250               | 34                     | 0,15                     | 600                          | -               | 330       | 43                                 | -               | 3,5       |
| HV-230 M   | 1250               | 34                     | 0,15                     | 600                          | 450             | 330       | 43                                 | 37              | 3,5       |
| HV-230 A   | 1250               | 34                     | 0,15                     | 600                          | 450             | 330       | 43                                 | 37              | 3,5       |
| HVE-230 A  | 1250               | 34                     | 0,15                     | 600                          | 450             | 330       | 43                                 | 37              | 3,5       |
| HV-230 RC  | 1250               | 34                     | 0,15                     | 600                          | 450             | 330       | 43                                 | 37              | 3,5       |
| HVE-230 RC | 1250               | 34                     | 0,15                     | 600                          | 450             | 330       | 43                                 | 37              | 3,5       |
| HV-300 AE  | 1150               | 68                     | 0,30                     | 1100                         | -               | 700       | 46                                 | -               | 5,1       |
| HV-300 M   | 1150               | 68                     | 0,30                     | 1100                         | 750             | 700       | 46                                 | 38              | 5,1       |
| HV-300 A   | 1150               | 68                     | 0,30                     | 1100                         | 750             | 700       | 46                                 | 38              | 5,1       |
| HV-300 RC  | 1150               | 68                     | 0,30                     | 1100                         | 750             | 700       | 46                                 | 38              | 5,1       |

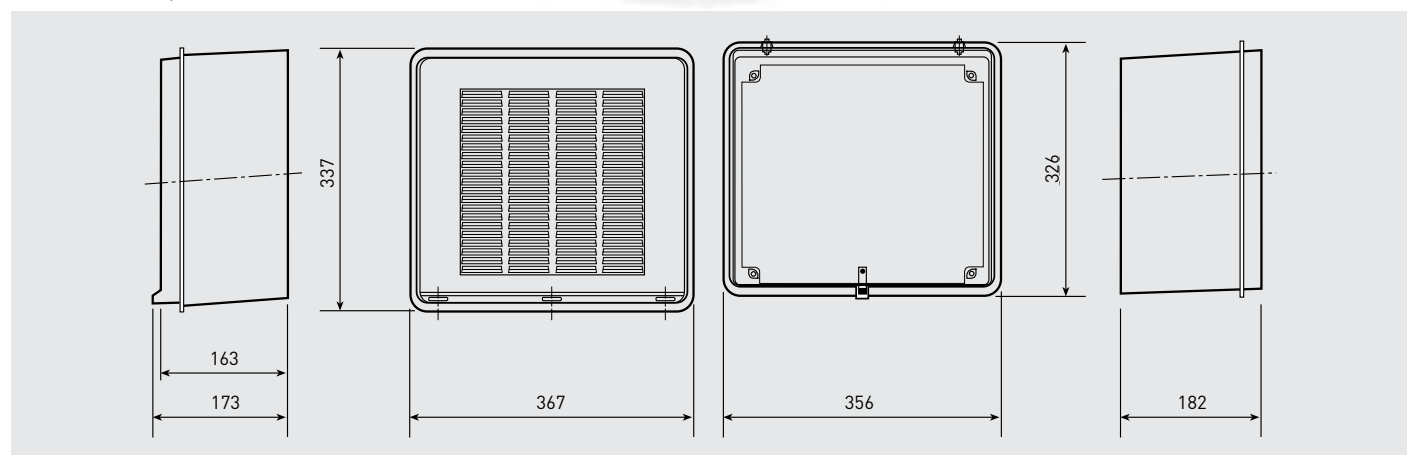
### DIMENSIONES (mm)



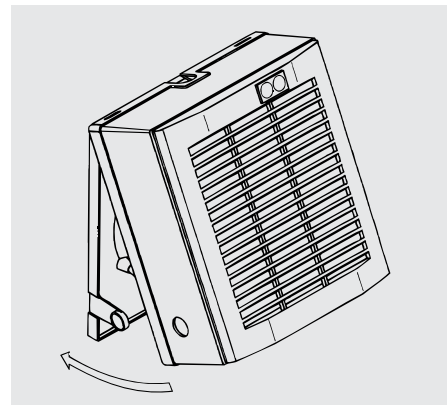
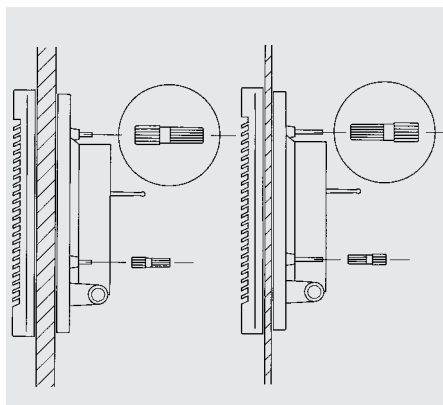
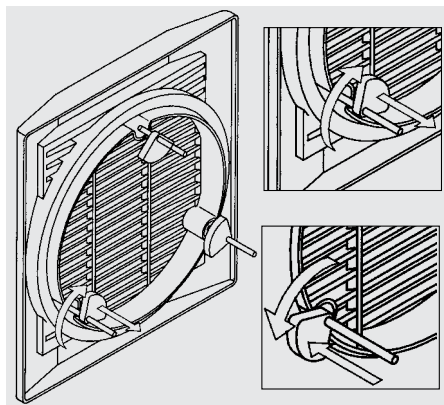
| Modelo | A   | B   | C   | Ø D  |      | E    |      | F  | G   | H   |
|--------|-----|-----|-----|------|------|------|------|----|-----|-----|
|        |     |     |     | Mín. | Máx. | Mín. | Máx. |    |     |     |
| HV-150 | 230 | 251 | 109 | 187  | 190  | 3    | 25   | 22 | 160 | 150 |
| HV-230 | 300 | 325 | 142 | 259  | 262  | 3    | 25   | 22 | 200 | 185 |
| HV-300 | 368 | 403 | 150 | 327  | 330  | 3    | 25   | 22 | 230 | 220 |

### DIMENSIONES (mm)

#### Versiónes HVE, encastrables



**MONTAJE EN CRISTALES O PAREDES DE 3 A 25 MM DE ESPESOR**



**Un montaje en tres etapas, muy rápido y muy sencillo**

Los aparatos de la serie HV-STYLVENT han sido diseñados para que el instalador pueda montarlos rápidamente y sin ningún problema.

**Rejilla exterior**

Una vez en posición, la rejilla exterior queda sujeta por tres tacos de goma que permiten dejar libres las manos del instalador para seguir el montaje sin dificultad.

**Pletina**

Para montar fácilmente la pletina, los agujeros tienen una entrada cónica y los tornillos de fijación pueden orientarse en función del espesor del vidrio o tabique:

3 mm < espesor < 10 mm ←

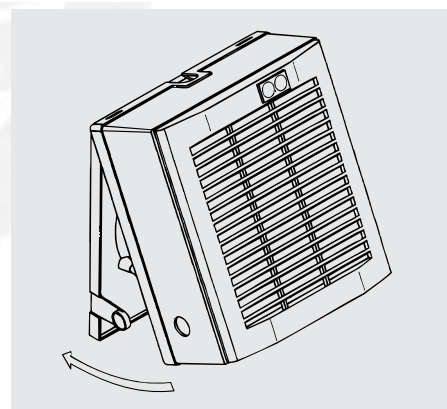
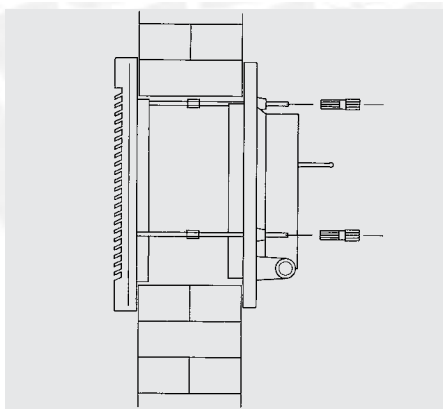
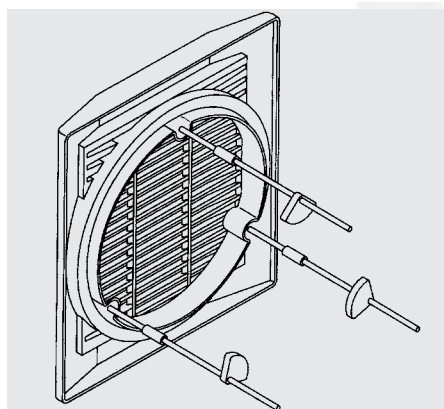
10 mm < espesor < 25 mm ←

**Carátula interior**

Para finalizar el montaje deben introducirse las dos pestañas de retención situadas en la parte superior de la pletina en las aberturas rectangulares de la carátula y bajar ésta hasta que dichas pestañas de retención estén bien colocadas.

Un movimiento rápido y sencillo...

**MONTAJE EN PAREDES DE 25 HASTA 300 MM DE ESPESOR**



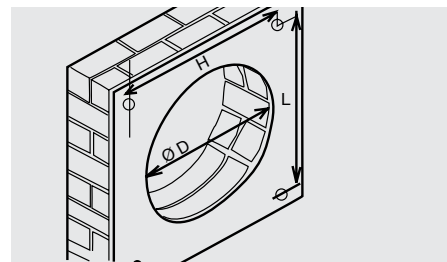
**Para el montaje en pared se tiene que prever unos espárragos (ver accesorios de montaje)**

Antes de montar el aparato debe medirse el espesor de la pared y recortar los espárragos, si es necesario, para que tengan una longitud igual a dicho espesor menos 5 mm.

El agujero en la pared debe tener las dimensiones indicadas en la tabla y un acabado interior lo más liso posible.

Desde el interior, utilizar la pletina para marcar los agujeros de fijación a la pared.

Los espárragos se atornillan a los tornillos de la rejilla exterior mediante los manguitos roscados y el conjunto se monta desde fuera. En este montaje, los tacos de goma también sirven para mantener la rejilla exterior en posición y así facilitar el trabajo del montador. Después, el proceso sigue como en el montaje en cristal, excepto en el caso de la pletina, que debe fijarse a la pared por medio de 2 ó 4 tornillos (modelos HV-150 y modelos HV-230 y HV-300 respectivamente).

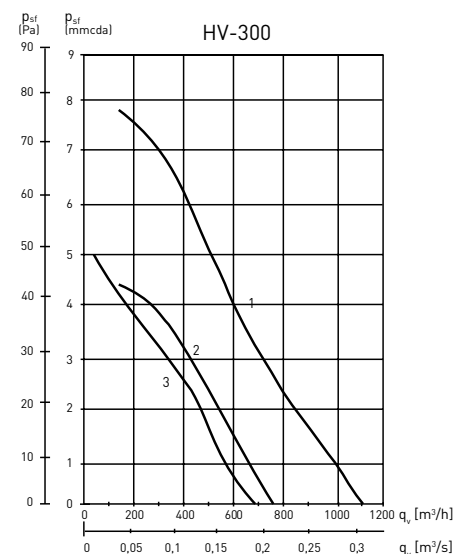
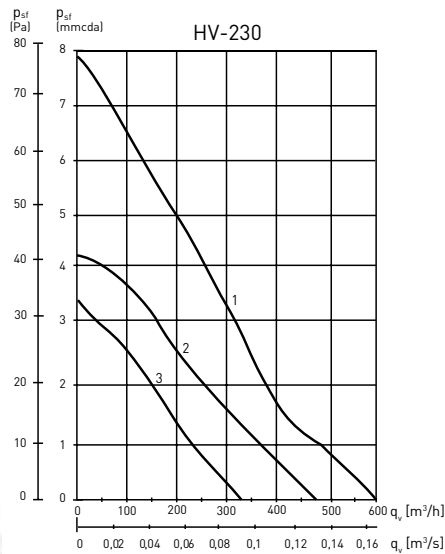
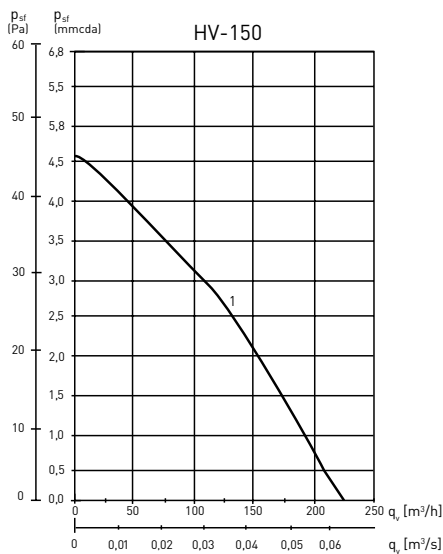


| Modelo | Ø D  |      | H*    | L*    |
|--------|------|------|-------|-------|
|        | Mín. | Máx. |       |       |
| HV-150 | 187  | 190  | 117   | 121   |
| HV-230 | 259  | 262  | 152   | 185   |
| HV-300 | 327  | 330  | 322,5 | 357,3 |

\* Para el modelo HV-150 solamente son dos agujeros en diagonal: el superior izquierdo y el inferior derecho.



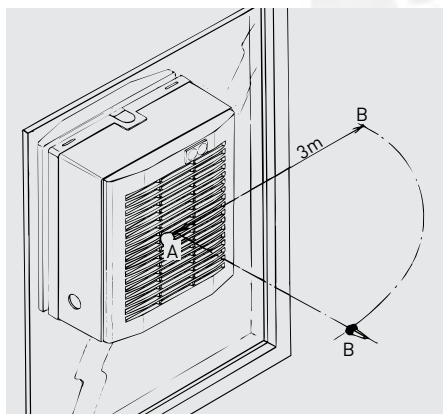
### CURVAS CARACTERÍSTICAS



- 1- Extracción velocidad rápida
- 2- Extracción velocidad lenta
- 3- Impulsión

- $q_v$  = Caudal en  $m^3/h$  y  $m^3/s$ .
- $p_{sf}$  = Presión estática en mmcdal y Pa.
- Aire seco normal a  $20^\circ C$  y 760 mmHg.
- Ensayos realizados de acuerdo a Norma ISO 5801 y AMCA 210-99.

### CARACTERÍSTICAS ACÚSTICAS



Los valores dados en la tabla de características técnicas, son niveles de presión sonora medidos a 3 metros (punto B) en dB(A) y aparato montado. A continuación se indican las correcciones para determinar los espectros de potencia sonora -LWS- en la aspiración (punto A) y la descarga, en velocidad rápida (en Hz).

| Aspiración |       |       |       |       |       |      |      |
|------------|-------|-------|-------|-------|-------|------|------|
| Lw(A)      | 125   | 250   | 500   | 1000  | 2000  | 4000 | 8000 |
| HV-150     | +5,5  | +12   | +16   | +14   | +13   | +7   | +4,5 |
| HV-230     | +10,5 | +10,5 | +13,5 | +16,5 | +13,5 | +5   | +0,5 |
| HV-300     | +8,5  | +8,5  | +14   | +16,5 | +13   | +6   | -0,5 |

| Descarga |      |       |       |       |       |      |      |
|----------|------|-------|-------|-------|-------|------|------|
| Lw(A)    | 125  | 250   | 500   | 1000  | 2000  | 4000 | 8000 |
| HV-150   | +6,5 | +10,5 | +18,5 | +16,5 | +14,5 | +8   | +4,5 |
| HV-230   | +9   | +11   | +16,5 | +18   | +15   | +6,5 | +0,5 |
| HV-300   | +7   | +11,5 | +17   | +19   | +15   | +6,5 | 0    |

ACCESORIOS



**CR-150**

Control remoto para los HV-150A  
Se compone de:  
- Un interruptor paro-marcha para el ventilador (☀-☀)  
- Un conmutador para la apertura y cierre de la persiana (ON-OFF).  
- Un solo CR-150 puede controlar 5 HV-150.



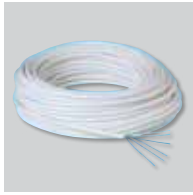
**CR-300**

Control remoto para los HV-230A, HV-300A y HVE-230A  
Se compone de:  
- Un selector para las diferentes marchas del ventilador (0, ●, ●, ●, ●)  
- Un conmutador que selecciona el sentido del aire (☐, ☐).  
- Un solo CR-300 puede controlar 5 HV-230 ó 300.



**REB-1R**

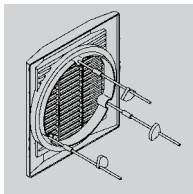
Regulador electrónico de velocidad. Incluye conmutador para invertir el sentido de giro del ventilador. Aplicable ÚNICAMENTE para los modelos HV-230-AE, HV-300-AE y HVE-230-AE.



**Cable eléctrico**

Cable eléctrico de 7 hilos que permite conectar los ventiladores HV-230A y HV-300A a la caja remota CR-300 (en rollos de 10 metros).

| Modelo                | Red eléctrica   |             | Índice de protección | Potencia (VA) | Intensidad máxima (A) | Aislamiento | Temperatura utilización | Dimensiones (mm) |    |    |
|-----------------------|-----------------|-------------|----------------------|---------------|-----------------------|-------------|-------------------------|------------------|----|----|
|                       | Frecuencia (Hz) | Tensión (V) |                      |               |                       |             |                         | L                | A  | H  |
| REB-1R                | 50              | 220-240     | IP40                 | 400           | 1                     | Clase II    | 0-40°C                  | 160              | 58 | 88 |
| Control Remoto CR-150 |                 |             |                      |               |                       |             |                         | 88               | 47 | 88 |
| Control Remoto CR-300 |                 |             |                      |               |                       |             |                         | 158              | 57 | 88 |



**Espárragos para montaje mural**

Juego de espárragos y manguitos roscados que permiten montar los HV en paredes de 25 a 300 mm de espesor.



## Product Information

### Models

#### Blade Louvers

39° Blade

**RSE5**

**Price RSE5** stationary drainable louvers feature alloy 6063-T5 extruded aluminum. The drainable louvers achieve optimum air performance and water penetration ratings with vertical and horizontal gutter systems that capture droplets before they cascade from blade to blade and are entrained in the airstream. This louver is available with visible mullions that are joined with an extruded aluminum "1" connection, or continuous horizontal blades that utilize concealed blade braces and hidden vertical supports in place of jamb frames to present uninterrupted horizontal blade appearance.

#### Features

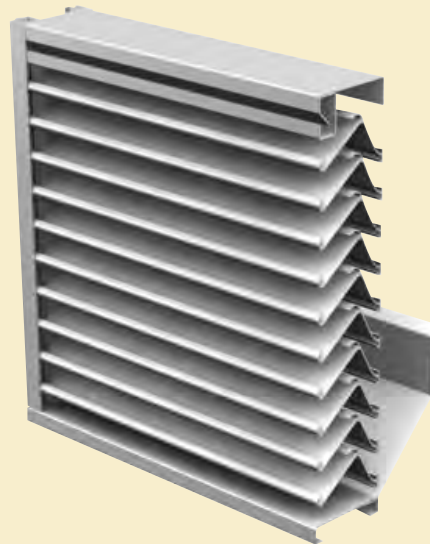
- Drainable Blade.
- .081" Extruded Aluminum Blades and Frames.
- Nominal **38.5%** free area (based on 48" x 48").
- Integral perimeter caulking stop.
- 1/2" x 1/2" (12 x 12) 16 gauge Expanded Aluminum Bird Screen without frame.
- Mill finish.

#### Options

- Welded Construction.
- Extended Sill (loose) 14 GA. Aluminum.
- Continuous Blade Sections (invisible mullions).
- Blank-offs are available in Aluminum with or without Insulation. Insulation is available in 1", 1.5", 2", or 3" thickness.
- Variety of Mounting options.
- Exterior or Interior Frame Mounting.
- Variety of Bird Screens, Insect Screens and Frames available.
- Wide variety of Finishes: Baked Enamel, Prime Coat, Custom Finishes, Clear Anodized and Colour Anodized.
- Select from PRICE Colour Chart or provide colour sample to match.
- Note: Colour variations can be expected within the same order and even on the same louver due to the anodizing process.

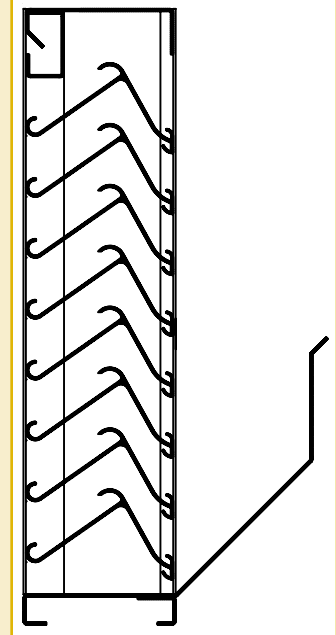
### Blade Louvers

**RSE5**



|                           |                                   |
|---------------------------|-----------------------------------|
| Louver Type:              | Storm Class                       |
| Material:                 | Extruded Aluminum (Alloy 6063-T5) |
| Front Blade:              | 0.081" (2.06mm)                   |
| Back Blade:               | N/A                               |
| Frame:                    | 0.081" (2.06mm)                   |
| Louver Depth:             | 5" (127.0mm)                      |
| Water Penetration Test:   | Simulated Rain                    |
| % Free Area:              | 38.5%                             |
| Free Area – 4' x 4' Unit: | 6.16 sq. ft. (0.572 sq m)         |
| Ext Wind Velocity:        | 29.1 mph (13 m/s)                 |
| Rainfall Rate:            | 2.95"/H (75 ml/H)                 |
| Effectiveness Ratio:      | 99.73%                            |

Ratings do not include the effect of a bird screen.

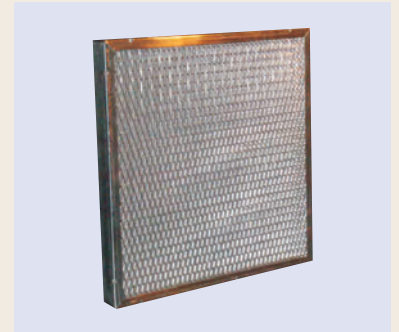


**WMF FILTRO METÁLICO LAVABLE DE ALUMINIO**

**WASHABLE METALIC FILTER**

Prefiltro lavable compuesto por capas de aluminio plisado como medio filtrante y marco de aluminio.

| Modelo (Model) | Dimensión Nominal (Pulgadas) | Dimensión Real (Pulgadas) | Caída de Presión Final Recomendada (Pulgadas C.A.) | Arrestancia Promedio @500 ft/min (%) |
|----------------|------------------------------|---------------------------|--|--------------------------------------|
| WMF-20-1       | 20 X 20 X 1                  | 19 3/8 X 19 3/8 X 7/8     | 0.5  | 50-55%                               |
| WMF-20-2       | 20 X 15 X 2                  | 19 3/8 X 19 3/8 X 1 3/4   | 1.0  | 50-55%                               |
| WMF-24-1       | 24 X 24 X 1                  | 23 3/8 X 23 3/8 X 7/8     | 0.5  | 50-55%                               |
| WMF-24-2       | 24 X 24 X 2                  | 23 3/8 X 23 3/8 X 1 3/4   | 1.0  | 50-55%                               |



**PPF-M7 FILTRO DE PANEL PLISADO-EFICIENCIA MERV 7 (25-30%)**

**PLEATED PANEL FILTER – MERV 7 (25-30% EFFICIENCY)**

Filtro desechable compuesto por capas de fibra poliéster y algodón plisadas como medio filtrante y marco de cartón 100% resistente a la humedad.

| Modelo (Model) | Dimensión Nominal (Pulgadas) | Dimensión Real (Pulgadas) | Caudal (CFM) Recomendado @500 ft/min | Caída de Presión Inicial @500 ft/min (Pulgadas C.A.) | Caída de Presión Final Recomendada (Pulgadas C.A.) | Temperatura Max. de Operación |    |
|----------------|------------------------------|---------------------------|--------------------------------------|--|--|-------------------------------|----|
|                |                              |                           |                                      |  |  | °F                            | °C |
| PPF-M7-20-2    | 20 X 20 X 2                  | 19 1/2 X 19 1/2 X 1 3/4   | 1400                                 | 0.30   | 1.0  | 170                           | 77 |
| PPF-M7-24-2    | 24 X 24 X 2                  | 23 3/8 X 23 3/8 X 1 3/4   | 2000                                 | 0.30   | 1.0  | 170                           | 77 |



**PPF-M8 FILTRO DE PANEL PLISADO-EFICIENCIA MERV 8**

**PLEATED PANEL FILTER – MERV 8 EFFICIENCY**

Filtro desechable compuesto por capas de fibra de poliéster antimicrobial como medio filtrante con una eficiencia de 65% para un rango de partículas de 3-10 micras y marco de cartón 100% resistente a la humedad.

| Modelo (Model) | Dimensión Nominal (Pulgadas) | Dimensión Real (Pulgadas) | Caudal (CFM) Recomendado @500 ft/min | Caída de Presión Inicial @500 ft/min (Pulgadas C.A.) | Caída de Presión Final Recomendada (Pulgadas C.A.) | Temperatura Max. de Operación |    |
|----------------|------------------------------|---------------------------|--------------------------------------|--|--|-------------------------------|----|
|                |                              |                           |                                      |  |  | °F                            | °C |
| PPF-M8-20-2    | 20 X 20 X 2                  | 19 1/2 X 19 1/2 X 1 3/4   | 1400                                 | 0.33   | 1.0  | 170                           | 77 |
| PPF-M8-24-2    | 24 X 24 X 2                  | 23 3/8 X 23 3/8 X 1 3/4   | 2000                                 | 0.33   | 1.0  | 170                           | 77 |



**CAF FILTRO DE CARBÓN ACTIVADO**

**CARBON ACTIVATED FILTER**

Filtro de carbón activado para la eliminación de olores y la retención de impurezas compuesto por fibras de poliéster y una esponja de poliuretano impregnada con carbón activado como medio filtrante y marco de cartón 100% resistente a la humedad.

| Modelo (Model) | Dimensión Nominal (Pulgadas) | Dimensión Real (Pulgadas) | Caudal (CFM) Recomendado @500 ft/min | Caída de Presión Inicial @500 ft/min (Pulgadas C.A.) | Caída de Presión Final Recomendada (Pulgadas C.A.) | Temperatura Max. de Operación |    |
|----------------|------------------------------|---------------------------|--------------------------------------|--|--|-------------------------------|----|
|                |                              |                           |                                      |  |  | °F                            | °C |
| CAF-24-2       | 24 X 24 X 2                  | 23 3/8 X 23 3/8 X 1 3/4   | 2000                                 | 0.75   | 1.2  | 120                           | 49 |





# Difusores de techo

Serie ARCV



## Descripción · Ejecuciones

Difusor de techo, en ejecución circular, de conos variables, construido en aluminio. Nos permite impulsar horizontal o verticalmente en función de la temperatura del aire. Son apropiados para un funcionamiento con diferencias de temperaturas de  $\pm 10K$ .

Los modelos de que podemos disponer son:

**ARCV-A:** Sin compuerta de regulación.

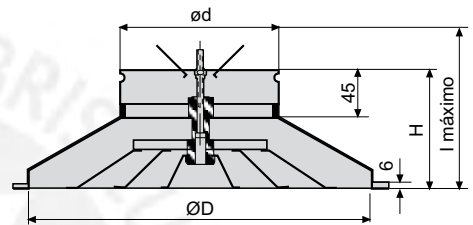
**ARCV-C:** Con compuerta de regulación tipo mariposa.

## Dimensiones · Plenums de conexión

| Tamaño | Ø d | Ø D | H   | l   |
|--------|-----|-----|-----|-----|
| 100    | 105 | 221 | 96  | 120 |
| 150    | 156 | 333 | 113 | 162 |
| 200    | 197 | 445 | 129 | 200 |
| 250    | 253 | 482 | 140 | 244 |
| 300    | 309 | 598 | 154 | 288 |

## Detalles de montaje

La colocación del difusor se realiza a través de un puente de montaje que se fija al techo o al conducto.



## Datos técnicos

| Tamaño | Velocidad Cuello en m/s | 2,0       | 3,5       | 5,0       | 6,5       | 7,5       | 9,0       | 10,5      |
|--------|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 100    | Q                       | 60        | 100       | 140       | 180       | 220       | 260       | 300       |
|        | V <sub>eff</sub>        | 3,0       | 5,1       | 7,1       | 9,1       | 11,1      | 13,1      | 15,2      |
|        | R <sub>0,5 - 0,25</sub> | 0,5 - 1   | 1 - 1,5   | 1 - 2     | 1,5 - 2,5 | 2 - 3     | 2,5 - 4   | 3 - 5     |
|        | Δp                      | 10        | 15        | 30        | 50        | 80        | 100       | 120       |
|        | dB(A)                   | 24        | 35        | 42        | 48        | 52        | 55        | 59        |
| 150    | Q                       | 130       | 215       | 300       | 390       | 475       | 560       | 650       |
|        | V <sub>eff</sub>        | 3,0       | 5,0       | 6,9       | 9,0       | 11,0      | 13,0      | 15,0      |
|        | R <sub>0,5 - 0,25</sub> | 0,7 - 1,5 | 1,5 - 2   | 1,5 - 2,3 | 1,8 - 2,8 | 2,3 - 3,5 | 2,8 - 4,2 | 3,3 - 5,4 |
|        | Δp                      | 10        | 15        | 30        | 50        | 80        | 100       | 120       |
|        | dB(A)                   | 24        | 35        | 42        | 48        | 52        | 55        | 59        |
| 200    | Q                       | 230       | 390       | 541       | 700       | 850       | 1.000     | 1.160     |
|        | V <sub>eff</sub>        | 3,0       | 5,0       | 7,0       | 9,1       | 11,0      | 12,9      | 15,0      |
|        | R <sub>0,5 - 0,25</sub> | 1 - 2     | 1,8 - 2,5 | 2 - 2,8   | 2,2 - 3   | 2,6 - 3,7 | 3 - 4,5   | 3,6 - 5,7 |
|        | Δp                      | 10        | 15        | 30        | 50        | 80        | 100       | 120       |
|        | dB(A)                   | 24        | 35        | 42        | 48        | 52        | 55        | 59        |
| 250    | Q                       | 360       | 600       | 840       | 1.080     | 1.320     | 1.560     | 1.800     |
|        | V <sub>eff</sub>        | 3,0       | 5,0       | 7,0       | 9,0       | 11,0      | 13,0      | 15,0      |
|        | R <sub>0,5 - 0,25</sub> | 1,5 - 2,5 | 2 - 3     | 2,5 - 3,5 | 2,8 - 3,8 | 3 - 4     | 3,5 - 5   | 4 - 6     |
|        | Δp                      | 10        | 15        | 30        | 50        | 80        | 100       | 120       |
|        | dB(A)                   | 24        | 35        | 42        | 48        | 52        | 55        | 59        |
| 300    | Q                       | 530       | 880       | 1.235     | 1.590     | 1.940     | 2.290     | 2.650     |
|        | V <sub>eff</sub>        | 3,0       | 5,0       | 7,0       | 9,0       | 11,0      | 13,0      | 15,0      |
|        | R <sub>0,5 - 0,25</sub> | 1,8 - 3   | 2,2 - 3,5 | 2,7 - 4   | 3 - 4,5   | 3,5 - 5   | 3,8 - 5,5 | 4,5 - 7   |
|        | Δp                      | 10        | 15        | 30        | 50        | 80        | 100       | 120       |
|        | dB(A)                   | 24        | 35        | 42        | 48        | 52        | 55        | 59        |

Calculados con regulación tipo ...-C Abierta.

### Definiciones:

Q en m<sup>3</sup>/h: Caudal de aire

V<sub>eff</sub> en m/s: Velocidad efectiva de salida

R<sub>0,5 - 0,25</sub> en m: Radio de difusión, máximo y mínimo

Δp en Pa: Pérdida de carga

dB(A): Nivel de potencia sonora

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## Serie AT



- Lamas horizontales aerodinámicas, con marco de 23 ó 27 mm
- Sujeción mediante fijación oculta
- Material: aluminio extruido

### DESCRIPCIÓN DE PRODUCTO

Rejilla con marco frontal de diseño aerodinámico, de 23 ó 27 mm, que incorporan bisel en el borde interior y una sección en ángulo en el exterior.

Lamas horizontales móviles, regulables individualmente. Sujeción mediante fijación oculta.

Bajo demanda, la sujeción puede suministrarse por muelles.

En la ejecución con marco de 27 mm las rejillas pueden ser suministradas con sujeción mediante tornillos vistos (taladros avellanados).

### TECNOLOGÍA

rectangular;  
disponibles diferentes anchuras de marco

90 – 5,600 m<sup>3</sup>/h

L: 225 – 1,225 mm

A: 125 – 525 mm

## TROX España

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