

HANDBOOK  
**EXPANSION VALVES**

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 **Castel**<sup>®</sup>  
Italian technology

# CHAPTER 3 ■ SOLENOID EXPANSION VALVES

FOR REFRIGERATION PLANTS THAT USE HCFC OR HFC REFRIGERANTS, HFO



## APPLICATIONS

The solenoid expansion valves in series 2028 illustrated in this chapter can be used in a wide range of applications as listed below:

- Refrigeration systems (display cases in supermarkets, freezers, ice cream and icemaker machines, refrigerated shipping, etc.).
- Air conditioning systems
- Heat pump systems
- Liquid chillers

That use the following refrigerant fluids:

- HCFC (R22)
- HFC (R134a, R404A, R407C, R410A, or R507)
- HFO and HFO/HFC mixtures (R1234ze, R448A, R449A, R450A, and R452A)

belonging to Group 2, as defined in Article 13, Chapter 1(b) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

The same solenoid valves can also be installed on systems that use the following refrigeration fluids:

- HFC (R32)
- HFO (R1234yf)

classified as A2L in the ASHRAE 34-2013 standard, and belonging to Group 1, as defined in Article 13, Chapter 1, Point (a) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

For specific applications with refrigerant fluids not listed above, please contact Castel Technical Department.

## OPERATION

The valve in series 2028 is a throttling device that receives liquid from the condenser and injects it into the evaporator, creating the necessary pressure drop across the expansion orifice. It regulates the refrigerant flow into the evaporator by modulating the opening time phase of the shutter, allowing for a wide power range. It is an ON/OFF valve that must be regulated with the **Pulse Width Modulation (PWM)** principle and it can be actuated by a very simple electronic controller. According to the PWM principle, the evaporator refrigerant flow rate,  $Q_T$ , required in a fixed period "T", is delivered by the valve in a time interval "t", shorter than "T", during which the maximum flow rate is allowed (ON step). In time period that remains,  $T - t$ , the valve stays closed (OFF phase).

For an effective regulation, the PWM valve must be sized in such a way that, under the most severe operating load conditions, the orifice of the valve is large enough to deliver the refrigerant required. In these extreme conditions, the valve will stay open for the entire period "T".

The use of an electronic regulator allows a more accurate metering of the refrigerant, obtaining a greater efficiency in time (and a sensible decrease in machinery management costs) and a faster response to the variations of the evaporator load.

## CONSTRUCTION

The valves in series 2028 are supplied complete with orifice. Nine different orifices with nine different maximum capacities that range from orifice 01 to orifice 09 can be assembled. The last two numbers in the part number identify the type of orifice that has been mounted on the valve at the factory. For example, part number 2028/3S02 identifies a 3/8" valve with solder connections and size 02 orifice. The orifices are interchangeable and can be mounted even after the valve is soldered on the system. If you wish to change orifice, purchase the corresponding spare parts kit, according to the part number indicated in Table 14. Inside the valve body is a ring mesh filter that traps dirt and contaminants at the valve inlet.

Valves in series 2028 are sold exclusively in the model without coil (suffix S).

The main parts of the valves in series 2028 are manufactured with the following materials:

- Hot forged brass EN 12420 – CW617N for the body
- Hot forged brass EN 12420 – CW724R for mobile plunger valve sleeve

- Ferritic stainless steel EN 10088-3 – 1.4105 for the fixed and mobile plungers
- Austenitic stainless steel EN 10088-3 – 1.4301 for the mesh filter
- Austenitic stainless steel EN 10088-3 – 1.4305 for orifice
- Copper pipe EN 12735-1 – Cu--DHP for solder connections
- P.T.F.E. for seat gaskets
- Chloroprene rubber (CR) for outlet seal gaskets

## SELECTION

To dimension a valve in series 2028 for a refrigerating system correctly, the following design parameters must be available:

- Type of refrigerant
- Evaporator capacity,  $Q_e$
- Evaporating temperature/pressure,  $T_e / p_e$
- Minimum condensing temperature/pressure,  $T_c / p_c$
- Liquid refrigerant temperature at valve inlet,  $T_l$
- Pressure drop in the liquid line, distributor and evaporator,  $\Delta p$

The following procedure helps the correct dimensioning of an expansion valve for a refrigeration plant.

### Step 1

*Determine the pressure drop across the valve.* The pressure drop is calculated using the equation:

$$\Delta p_{\text{tot}} = p_c - (p_e + \Delta p)$$

where:

- $p_c$  = condensing pressure
- $p_e$  = evaporating pressure
- $\Delta p$  = sum of pressure drops in the liquid line, distributor and evaporator at the maximum flow rate, that is with the valve always open

### Step 2

*Evaporator capacity correction with subcooling.* The evaporator capacity,  $Q_e$ , must be suitably sized based on the subcooling value. The subcooling is calculated using the equation:

$$\Delta T_{\text{sub}} = T_c - T_l$$

In the subcooling correction factor table, find the appropriate correction factor,  $F_{\text{sub}}$ , corresponding to the calculated  $\Delta T_{\text{sub}}$  value and determine the required valve capacity using the equation:

$$Q_{\text{sub}} = \frac{Q_e}{F_{\text{sub}}}$$

### Step 3

*Capacity correction based on the application.* To obtain a correct regulation with this valve, it is necessary it be oversized so that its closing period is 25% to 50% of the regulator's total period,  $T$ . The correct choice of this potential margin depends on the application, which can have variable flow rate peaks, and on the control algorithm used by the electronic control unit.

Generally, however, this correction factor,  $F_{\text{ev}}$ , is highly dependent by the evaporation temperature,  $T_e$ , so it be assumed equal to 125% for  $T_e \geq -15$  °C and 150% for  $T_e < -15$  °C. These generic values must be verified based on the specific application.

The capacity of the valve must be at least equal to:

$$Q_{\text{ev}} = F_{\text{ev}} \cdot Q_{\text{sub}}$$

### Step 4

*Determine required orifice size.* Use the pressure drop across the valve, the evaporating temperature and the correct evaporator capacity,  $Q_e$ , calculated above, to select the corresponding orifice size from the capacity table corresponding to the chosen refrigerant fluid.

### Step 5

*Liquid line sizing.* Since the valve operates under ON/OFF criteria, during the opening phase, the flow rate can be much higher than the average flow rate in the time period. For this reason, the designer must size the diameter of the pipes of the liquid line according to the maximum flow rate across the orifice in the real conditions of  $\Delta p_{\text{tot}}$  and to avoid that a drop-in load cause a reduction in the maximum valve power.

## DIMENSIONING EXAMPLE

- Type of refrigerant: R404A
- Evaporator capacity,  $Q_e$ : 2.8 kW
- Evaporating temperature,  $T_e$ : - 10°C
- Minimum condensing temperature,  $T_c$ : +35°C
- Liquid refrigerant temperature,  $T_l$ : +20°C
- Pressure drop in the liquid line, distributor and evaporator,  $\Delta p$  2 bar

*Step 1 - Determine the pressure drop across the valve.*

- Condensing pressure at + 35 °C -  $p_c = 16.9$  bar
- Evaporating pressure at - 10 °C -  $p_e = 4.4$  bar

$$\Delta p_{\text{tot}} = 16,9 - (4,4 + 2) = 10,5 \cdot \text{bar}$$

*Step 2 - Determine required valve capacity*

$$\Delta T_{\text{sub}} = 35 - 20 = 15 \cdot \text{°K}$$

From the subcooling correction factor Table 18B, we find the appropriate correction factor,  $F_{\text{sub}}$ , equal to 1.17 for  $\Delta T_{\text{sub}} = 15$  °K. The required valve capacity is

$$Q_{\text{sub}} = \frac{2,8}{1,17} = 2,39 \cdot \text{kW}$$

*Step 3 - Capacity correction based on the application*

According to the above criterion, a correction of + 25% is applied to the calculated capacity:

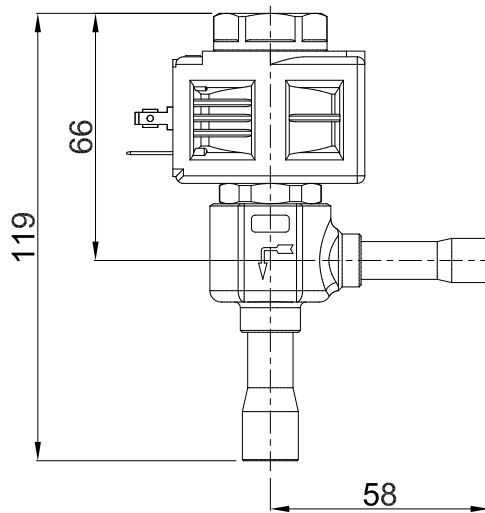
$$Q_{\text{ev}} = 1,25 \cdot 2,39 = 3 \cdot \text{kW}$$

*Step 4 - Determine required orifice dimension.*

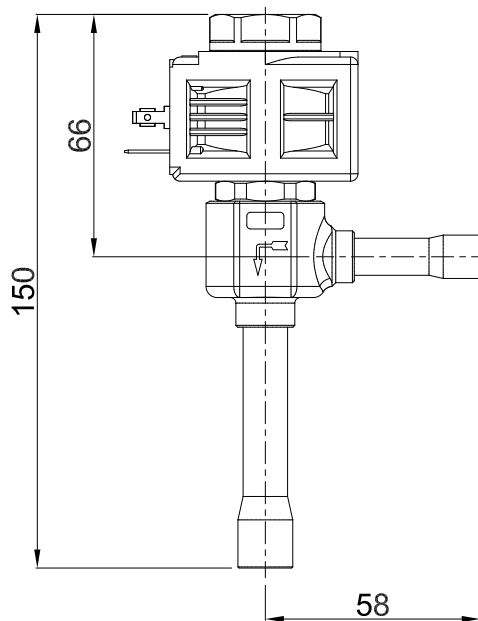
Using table for the capacity for refrigerant fluid R404A, enter the data:

- Pressure drop across the valve = 10.5 bar
- Evaporating temperature = - 10 °C
- Calculated evaporator capacity = 3 kW

Select the corresponding orifice, O4 (Note: the expansion valve capacity must be equal to or slightly greater than the calculated evaporator capacity).



2028/3  
2028/M10



2028/4  
2028/M12

**TABLE 13: General characteristics of PWM expansion valves**

| Catalogue number | Orifice Type | ODS Connections |      |      |     | Kv Factor [m³/h] | Opening Pressure Differential [bar] |           |           |           | Operating principles         | Minimum Working Time [s] | PS [bar] | TS [°C] |      | TA [°C] |      | Risk Category according to PED Recast |           |
|------------------|--------------|-----------------|------|------|-----|------------------|-------------------------------------|-----------|-----------|-----------|------------------------------|--------------------------|----------|---------|------|---------|------|---------------------------------------|-----------|
|                  |              | [in]            |      | [mm] |     |                  | MinOPD                              | MOPD      |           |           |                              |                          |          | min.    | max. | min.    | max. |                                       |           |
|                  |              | IN              | OUT  | IN   | OUT |                  |                                     | 9160 (AC) | 9160 (DC) | 9320 (AC) |                              |                          |          |         |      |         |      |                                       | 9320 (DC) |
| 2028/3S01        | 01           | 3/8"            | 1/2" | -    | -   | 0                | 37                                  | 37        | 37        | 37        | PWM (Pulse Width Modulating) | 1                        | 45       | -40     | +100 | -40     | +50  | Art.4.3                               |           |
| 2028/M10S01      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/3S02        | 02           | 3/8"            | 1/2" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M10S02      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/3S03        | 03           | 3/8"            | 1/2" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M10S03      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/3S04        | 04           | 3/8"            | 1/2" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M10S04      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/3S05        | 05           | 3/8"            | 1/2" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M10S05      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/3S06        | 06           | 3/8"            | 1/2" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M10S06      |              | -               | -    | 10   | 12  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/4S07        | 07           | 1/2"            | 5/8" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M12S07      |              | -               | -    | 12   | 16  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/4S08        | 08           | 1/2"            | 5/8" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M12S08      |              | -               | -    | 12   | 16  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/4S09        | 09           | 1/2"            | 5/8" | -    | -   |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |
| 2028/M12S09      |              | -               | -    | 12   | 16  |                  |                                     |           |           |           |                              |                          |          |         |      |         |      |                                       |           |

**TABLE 14: Orifices - Rated capacities in kW**

| Catalogue number | Orifice Type | Orifice Size [mm] | Refrigerant |       |       |       |       |       |       |         |         |       |       |       |       |
|------------------|--------------|-------------------|-------------|-------|-------|-------|-------|-------|-------|---------|---------|-------|-------|-------|-------|
|                  |              |                   | R134a       | R22   | R32   | R404A | R407C | R410A | R507A | R1234yf | R1234ze | R448A | R449A | R450A | R452A |
| 9150/R63         | 01           | 0,5               | 0,74        | 1,04  | 2,44  | 0,73  | 1,18  | 1,16  | 0,76  | 0,56    | 0,59    | 1,02  | 1,13  | 0,63  | 0,90  |
| 9150/R64         | 02           | 0,7               | 1,47        | 2,08  | 4,88  | 1,47  | 2,35  | 2,31  | 1,52  | 1,12    | 1,17    | 2,04  | 2,26  | 1,26  | 1,81  |
| 9150/R65         | 03           | 0,8               | 1,74        | 2,46  | 5,74  | 1,73  | 2,77  | 2,72  | 1,79  | 1,32    | 1,39    | 2,40  | 2,66  | 1,49  | 2,13  |
| 9150/R66         | 04           | 1,1               | 2,81        | 3,99  | 9,34  | 2,81  | 4,50  | 4,42  | 2,91  | 2,13    | 2,24    | 3,90  | 4,32  | 2,40  | 3,46  |
| 9150/R67         | 05           | 1,3               | 4,81        | 6,81  | 15,91 | 4,78  | 7,68  | 7,54  | 4,96  | 3,65    | 3,84    | 6,64  | 7,37  | 4,11  | 5,90  |
| 9150/R68         | 06           | 1,7               | 6,67        | 9,44  | 22,06 | 6,63  | 10,65 | 10,45 | 6,88  | 5,06    | 5,33    | 9,21  | 10,22 | 5,71  | 8,19  |
| 9150/R69         | 07           | 2,3               | 10,52       | 14,92 | 34,94 | 10,49 | 16,83 | 16,54 | 10,88 | 7,98    | 8,39    | 14,57 | 16,15 | 8,98  | 12,95 |
| 9150/R78         | 08           | 2,5               | 12,68       | 17,96 | 42,00 | 12,62 | 20,26 | 19,89 | 13,09 | 9,62    | 10,12   | 17,53 | 19,44 | 10,84 | 15,58 |
| 9150/R79         | 09           | 2,7               | 14,07       | 19,91 | 46,54 | 13,99 | 22,46 | 22,05 | 14,51 | 10,67   | 11,23   | 19,43 | 21,55 | 12,03 | 17,27 |

Rated capacities are based on:

- Evaporating temperature  $T_{\text{evap}} = + 5 \text{ °C}$
- Condensing temperature  $T_{\text{cond}} = + 32 \text{ °C}$
- Refrigerant liquid temperature ahead of valve  $T_{\text{liq}} = + 28 \text{ °C}$

**TABLE 15A: Refrigerant R134a - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,62                             | 0,73  | 0,82  | 0,90  | 0,96  | 1,01  | 1,04  | 1,06  | 1,07  | 01                             | 0,63                             | 0,74  | 0,83  | 0,90  | 0,96  | 1,00  | 1,03  | 1,05  | 1,05  |
| 02                             | 1,23                             | 1,46  | 1,65  | 1,80  | 1,92  | 2,01  | 2,08  | 2,12  | 2,13  | 02                             | 1,26                             | 1,48  | 1,66  | 1,81  | 1,92  | 2,00  | 2,06  | 2,09  | 2,10  |
| 03                             | 1,46                             | 1,72  | 1,94  | 2,12  | 2,26  | 2,37  | 2,44  | 2,49  | 2,50  | 03                             | 1,50                             | 1,75  | 1,96  | 2,13  | 2,26  | 2,35  | 2,42  | 2,46  | 2,46  |
| 04                             | 2,35                             | 2,79  | 3,15  | 3,45  | 3,68  | 3,86  | 3,99  | 4,06  | 4,08  | 04                             | 2,42                             | 2,84  | 3,18  | 3,46  | 3,68  | 3,84  | 3,95  | 4,01  | 4,02  |
| 05                             | 4,03                             | 4,77  | 5,38  | 5,87  | 6,27  | 6,57  | 6,78  | 6,90  | 6,95  | 05                             | 4,14                             | 4,85  | 5,43  | 5,90  | 6,26  | 6,53  | 6,72  | 6,82  | 6,83  |
| 06                             | 5,60                             | 6,62  | 7,46  | 8,15  | 8,69  | 9,10  | 9,40  | 9,56  | 9,63  | 06                             | 5,75                             | 6,73  | 7,53  | 8,18  | 8,68  | 9,06  | 9,32  | 9,45  | 9,47  |
| 07                             | 8,80                             | 10,43 | 11,78 | 12,88 | 13,76 | 14,42 | 14,90 | 15,17 | 15,27 | 07                             | 9,04                             | 10,61 | 11,90 | 12,94 | 13,75 | 14,35 | 14,77 | 14,99 | 15,02 |
| 08                             | 10,63                            | 12,58 | 14,18 | 15,50 | 16,54 | 17,33 | 17,90 | 18,22 | 18,34 | 08                             | 10,92                            | 12,79 | 14,33 | 15,56 | 16,53 | 17,24 | 17,75 | 18,00 | 18,03 |
| 09                             | 11,80                            | 13,95 | 15,73 | 17,18 | 18,33 | 19,20 | 19,83 | 20,18 | 20,31 | 09                             | 12,13                            | 14,19 | 15,89 | 17,25 | 18,32 | 19,11 | 19,66 | 19,94 | 19,98 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,64                             | 0,75  | 0,83  | 0,90  | 0,95  | 0,99  | 1,01  | 1,02  | 1,02  | 01                             | 0,65                             | 0,75  | 0,82  | 0,88  | 0,93  | 0,96  | 0,98  | 0,98  | 0,99  |
| 02                             | 1,29                             | 1,49  | 1,66  | 1,80  | 1,90  | 1,97  | 2,02  | 2,04  | 2,03  | 02                             | 1,30                             | 1,49  | 1,65  | 1,77  | 1,86  | 1,92  | 1,96  | 1,96  | 1,97  |
| 03                             | 1,53                             | 1,77  | 1,96  | 2,11  | 2,23  | 2,32  | 2,37  | 2,39  | 2,39  | 03                             | 1,55                             | 1,76  | 1,94  | 2,08  | 2,19  | 2,26  | 2,30  | 2,30  | 2,32  |
| 04                             | 2,46                             | 2,86  | 3,18  | 3,44  | 3,63  | 3,78  | 3,87  | 3,90  | 3,90  | 04                             | 2,49                             | 2,85  | 3,15  | 3,38  | 3,56  | 3,68  | 3,75  | 3,76  | 3,78  |
| 05                             | 4,22                             | 4,88  | 5,43  | 5,86  | 6,19  | 6,43  | 6,58  | 6,64  | 6,63  | 05                             | 4,27                             | 4,88  | 5,38  | 5,77  | 6,06  | 6,27  | 6,37  | 6,40  | 6,43  |
| 06                             | 5,86                             | 6,77  | 7,53  | 8,13  | 8,58  | 8,91  | 9,12  | 9,21  | 9,19  | 06                             | 5,93                             | 6,77  | 7,46  | 8,00  | 8,41  | 8,69  | 8,83  | 8,87  | 8,92  |
| 07                             | 9,20                             | 10,68 | 11,89 | 12,85 | 13,58 | 14,12 | 14,45 | 14,60 | 14,57 | 07                             | 9,31                             | 10,67 | 11,78 | 12,65 | 13,31 | 13,76 | 14,00 | 14,07 | 14,14 |
| 08                             | 11,12                            | 12,87 | 14,32 | 15,46 | 16,33 | 16,97 | 17,36 | 17,53 | 17,50 | 08                             | 11,25                            | 12,86 | 14,18 | 15,22 | 16,00 | 16,54 | 16,82 | 16,89 | 16,98 |
| 09                             | 12,34                            | 14,28 | 15,87 | 17,14 | 18,10 | 18,80 | 19,24 | 19,42 | 19,38 | 09                             | 12,49                            | 14,27 | 15,73 | 16,88 | 17,73 | 18,33 | 18,64 | 18,71 | 18,81 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,65                             | 0,74  | 0,81  | 0,86  | 0,90  | 0,93  | 0,94  | 0,93  | 0,92  | 01                             | 0,64                             | 0,72  | 0,78  | 0,82  | 0,86  | 0,87  | 0,88  | 0,87  | 0,85  |
| 02                             | 1,30                             | 1,48  | 1,61  | 1,72  | 1,80  | 1,85  | 1,87  | 1,87  | 1,84  | 02                             | 1,28                             | 1,43  | 1,56  | 1,65  | 1,71  | 1,75  | 1,76  | 1,74  | 1,69  |
| 03                             | 1,55                             | 1,75  | 1,90  | 2,03  | 2,12  | 2,17  | 2,20  | 2,19  | 2,16  | 03                             | 1,52                             | 1,69  | 1,83  | 1,94  | 2,01  | 2,05  | 2,06  | 2,04  | 1,99  |
| 04                             | 2,49                             | 2,82  | 3,09  | 3,30  | 3,45  | 3,54  | 3,59  | 3,58  | 3,52  | 04                             | 2,44                             | 2,74  | 2,98  | 3,15  | 3,28  | 3,35  | 3,36  | 3,33  | 3,25  |
| 05                             | 4,27                             | 4,82  | 5,27  | 5,62  | 5,87  | 6,03  | 6,10  | 6,09  | 5,99  | 05                             | 4,18                             | 4,68  | 5,08  | 5,38  | 5,59  | 5,70  | 5,72  | 5,66  | 5,52  |
| 06                             | 5,94                             | 6,70  | 7,31  | 7,80  | 8,14  | 8,36  | 8,46  | 8,44  | 8,30  | 06                             | 5,81                             | 6,49  | 7,05  | 7,46  | 7,75  | 7,90  | 7,93  | 7,84  | 7,65  |
| 07                             | 9,33                             | 10,56 | 11,55 | 12,34 | 12,89 | 13,25 | 13,41 | 13,39 | 13,17 | 07                             | 9,13                             | 10,24 | 11,13 | 11,79 | 12,26 | 12,52 | 12,58 | 12,43 | 12,14 |
| 08                             | 11,27                            | 12,73 | 13,91 | 14,84 | 15,50 | 15,92 | 16,11 | 16,08 | 15,81 | 08                             | 11,03                            | 12,34 | 13,40 | 14,19 | 14,74 | 15,04 | 15,11 | 14,93 | 14,57 |
| 09                             | 12,51                            | 14,12 | 15,42 | 16,45 | 17,18 | 17,64 | 17,85 | 17,82 | 17,52 | 09                             | 12,24                            | 13,69 | 14,86 | 15,73 | 16,34 | 16,67 | 16,74 | 16,54 | 16,14 |

**TABLE: 15B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| $F_{sub}$                   | 1,00 | 1,06 | 1,12 | 1,17 | 1,23 | 1,29 | 1,35 | 1,44 | 1,49 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 15B

**TABLE 16A: Refrigerant R22 - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,68                             | 0,84  | 0,97  | 1,08  | 1,18  | 1,27  | 1,34  | 1,39  | 1,44  | 01                             | 0,72                             | 0,87  | 1,00  | 1,12  | 1,22  | 1,30  | 1,37  | 1,43  | 1,47  |
| 02                             | 1,37                             | 1,67  | 1,93  | 2,16  | 2,36  | 2,53  | 2,68  | 2,79  | 2,87  | 02                             | 1,43                             | 1,74  | 2,00  | 2,24  | 2,43  | 2,60  | 2,74  | 2,85  | 2,94  |
| 03                             | 1,62                             | 1,98  | 2,28  | 2,55  | 2,78  | 2,98  | 3,14  | 3,27  | 3,37  | 03                             | 1,70                             | 2,06  | 2,36  | 2,63  | 2,86  | 3,06  | 3,22  | 3,35  | 3,45  |
| 04                             | 2,62                             | 3,20  | 3,70  | 4,14  | 4,53  | 4,85  | 5,12  | 5,34  | 5,51  | 04                             | 2,74                             | 3,33  | 3,84  | 4,28  | 4,66  | 4,98  | 5,25  | 5,47  | 5,63  |
| 05                             | 4,48                             | 5,46  | 6,32  | 7,06  | 7,71  | 8,26  | 8,72  | 9,09  | 9,36  | 05                             | 4,70                             | 5,69  | 6,55  | 7,29  | 7,93  | 8,48  | 8,94  | 9,30  | 9,58  |
| 06                             | 6,22                             | 7,58  | 8,77  | 9,80  | 10,69 | 11,45 | 12,09 | 12,59 | 12,98 | 06                             | 6,52                             | 7,89  | 9,08  | 10,12 | 11,00 | 11,76 | 12,39 | 12,89 | 13,28 |
| 07                             | 9,78                             | 11,95 | 13,85 | 15,49 | 16,92 | 18,14 | 19,16 | 19,97 | 20,59 | 07                             | 10,25                            | 12,44 | 14,34 | 16,00 | 17,41 | 18,63 | 19,64 | 20,44 | 21,06 |
| 08                             | 11,82                            | 14,40 | 16,67 | 18,64 | 20,35 | 21,80 | 23,02 | 23,99 | 24,72 | 08                             | 12,38                            | 15,00 | 17,27 | 19,25 | 20,93 | 22,39 | 23,59 | 24,55 | 25,29 |
| 09                             | 13,12                            | 15,98 | 18,49 | 20,66 | 22,55 | 24,15 | 25,50 | 26,57 | 27,38 | 09                             | 13,75                            | 16,64 | 19,15 | 21,34 | 23,20 | 24,81 | 26,14 | 27,20 | 28,02 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,74                             | 0,90  | 1,03  | 1,14  | 1,24  | 1,32  | 1,38  | 1,44  | 1,48  | 01                             | 0,77                             | 0,92  | 1,04  | 1,15  | 1,24  | 1,32  | 1,39  | 1,44  | 1,47  |
| 02                             | 1,49                             | 1,79  | 2,05  | 2,28  | 2,47  | 2,63  | 2,77  | 2,88  | 2,96  | 02                             | 1,54                             | 1,83  | 2,08  | 2,30  | 2,49  | 2,64  | 2,77  | 2,87  | 2,95  |
| 03                             | 1,77                             | 2,12  | 2,42  | 2,68  | 2,91  | 3,10  | 3,25  | 3,38  | 3,47  | 03                             | 1,82                             | 2,16  | 2,46  | 2,71  | 2,93  | 3,11  | 3,26  | 3,37  | 3,46  |
| 04                             | 2,85                             | 3,43  | 3,93  | 4,36  | 4,73  | 5,05  | 5,30  | 5,52  | 5,67  | 04                             | 2,94                             | 3,50  | 3,99  | 4,41  | 4,77  | 5,06  | 5,31  | 5,50  | 5,64  |
| 05                             | 4,87                             | 5,85  | 6,70  | 7,43  | 8,06  | 8,59  | 9,03  | 9,38  | 9,64  | 05                             | 5,03                             | 5,98  | 6,81  | 7,51  | 8,12  | 8,62  | 9,03  | 9,35  | 9,60  |
| 06                             | 6,77                             | 8,12  | 9,29  | 10,31 | 11,18 | 11,91 | 12,51 | 13,00 | 13,36 | 06                             | 6,99                             | 8,31  | 9,44  | 10,42 | 11,26 | 11,95 | 12,52 | 12,97 | 13,31 |
| 07                             | 10,64                            | 12,81 | 14,68 | 16,30 | 17,69 | 18,87 | 19,83 | 20,62 | 21,19 | 07                             | 10,99                            | 13,09 | 14,91 | 16,48 | 17,82 | 18,93 | 19,85 | 20,56 | 21,11 |
| 08                             | 12,85                            | 15,44 | 17,68 | 19,61 | 21,27 | 22,67 | 23,83 | 24,77 | 25,45 | 08                             | 13,27                            | 15,79 | 17,96 | 19,83 | 21,42 | 22,75 | 23,85 | 24,70 | 25,34 |
| 09                             | 14,26                            | 17,13 | 19,60 | 21,74 | 23,57 | 25,12 | 26,40 | 27,44 | 28,19 | 09                             | 14,73                            | 17,51 | 19,91 | 21,98 | 23,74 | 25,21 | 26,42 | 27,36 | 28,07 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,78                             | 0,92  | 1,04  | 1,15  | 1,23  | 1,31  | 1,37  | 1,41  | 1,44  | 01                             | 0,80                             | 0,93  | 1,04  | 1,14  | 1,22  | 1,29  | 1,34  | 1,38  | 1,41  |
| 02                             | 1,56                             | 1,84  | 2,09  | 2,29  | 2,47  | 2,62  | 2,73  | 2,82  | 2,89  | 02                             | 1,59                             | 1,86  | 2,09  | 2,28  | 2,45  | 2,58  | 2,69  | 2,77  | 2,82  |
| 03                             | 1,85                             | 2,18  | 2,46  | 2,70  | 2,90  | 3,07  | 3,21  | 3,31  | 3,39  | 03                             | 1,89                             | 2,19  | 2,46  | 2,69  | 2,88  | 3,03  | 3,16  | 3,25  | 3,31  |
| 04                             | 2,99                             | 3,53  | 3,99  | 4,39  | 4,73  | 5,01  | 5,23  | 5,40  | 5,53  | 04                             | 3,04                             | 3,55  | 3,99  | 4,37  | 4,68  | 4,94  | 5,15  | 5,30  | 5,40  |
| 05                             | 5,11                             | 6,03  | 6,81  | 7,48  | 8,05  | 8,52  | 8,90  | 9,19  | 9,40  | 05                             | 5,21                             | 6,07  | 6,81  | 7,44  | 7,98  | 8,41  | 8,76  | 9,01  | 9,19  |
| 06                             | 7,10                             | 8,36  | 9,45  | 10,38 | 11,17 | 11,82 | 12,33 | 12,74 | 13,03 | 06                             | 7,24                             | 8,42  | 9,45  | 10,32 | 11,06 | 11,66 | 12,14 | 12,50 | 12,73 |
| 07                             | 11,16                            | 13,19 | 14,92 | 16,41 | 17,68 | 18,72 | 19,55 | 20,21 | 20,67 | 07                             | 11,37                            | 13,28 | 14,92 | 16,33 | 17,51 | 18,47 | 19,25 | 19,81 | 20,20 |
| 08                             | 13,49                            | 15,90 | 17,97 | 19,74 | 21,25 | 22,50 | 23,49 | 24,27 | 24,82 | 08                             | 13,74                            | 16,01 | 17,97 | 19,64 | 21,05 | 22,20 | 23,12 | 23,80 | 24,25 |
| 09                             | 14,97                            | 17,63 | 19,92 | 21,88 | 23,55 | 24,93 | 26,02 | 26,89 | 27,50 | 09                             | 15,25                            | 17,75 | 19,92 | 21,77 | 23,33 | 24,60 | 25,62 | 26,36 | 26,87 |

**TABLE 16B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,05 | 1,10 | 1,15 | 1,20 | 1,25 | 1,29 | 1,40 | 1,45 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 16B

**TABLE 17A: Refrigerant R32 - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 1,16                             | 1,46  | 1,74  | 2,01  | 2,26  | 2,50  | 2,72  | 2,93  | 3,13  | 01                             | 1,24                             | 1,55  | 1,85  | 2,12  | 2,38  | 2,63  | 2,86  | 3,07  | 3,28  |
| 02                             | 2,32                             | 2,92  | 3,48  | 4,01  | 4,52  | 4,99  | 5,44  | 5,86  | 6,26  | 02                             | 2,48                             | 3,11  | 3,69  | 4,24  | 4,76  | 5,25  | 5,71  | 6,15  | 6,56  |
| 03                             | 2,75                             | 3,45  | 4,11  | 4,73  | 5,31  | 5,87  | 6,39  | 6,88  | 7,34  | 03                             | 2,95                             | 3,67  | 4,35  | 4,99  | 5,60  | 6,17  | 6,71  | 7,21  | 7,69  |
| 04                             | 4,43                             | 5,58  | 6,66  | 7,69  | 8,65  | 9,56  | 10,42 | 11,22 | 11,98 | 04                             | 4,75                             | 5,94  | 7,06  | 8,12  | 9,12  | 10,05 | 10,94 | 11,78 | 12,56 |
| 05                             | 7,59                             | 9,54  | 11,37 | 13,10 | 14,73 | 16,27 | 17,72 | 19,09 | 20,38 | 05                             | 8,13                             | 10,15 | 12,05 | 13,84 | 15,53 | 17,12 | 18,62 | 20,03 | 21,36 |
| 06                             | 10,55                            | 13,24 | 15,78 | 18,17 | 20,43 | 22,56 | 24,57 | 26,47 | 28,24 | 06                             | 11,29                            | 14,09 | 16,72 | 19,20 | 21,53 | 23,73 | 25,81 | 27,76 | 29,61 |
| 07                             | 16,58                            | 20,87 | 24,92 | 28,73 | 32,33 | 35,74 | 38,95 | 41,97 | 44,80 | 07                             | 17,74                            | 22,22 | 26,41 | 30,36 | 34,08 | 37,59 | 40,90 | 44,03 | 46,97 |
| 08                             | 20,03                            | 25,16 | 30,00 | 34,57 | 38,87 | 42,96 | 46,79 | 50,40 | 53,80 | 08                             | 21,43                            | 26,78 | 31,80 | 36,52 | 40,98 | 45,18 | 49,14 | 52,88 | 56,39 |
| 09                             | 22,23                            | 27,91 | 33,27 | 38,32 | 43,08 | 47,60 | 51,84 | 55,84 | 59,59 | 09                             | 23,79                            | 29,71 | 35,26 | 40,48 | 45,42 | 50,06 | 54,44 | 58,58 | 62,47 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 1,26                             | 1,58  | 1,87  | 2,15  | 2,41  | 2,66  | 2,89  | 3,10  | 3,31  | 01                             | 1,30                             | 1,62  | 1,91  | 2,19  | 2,45  | 2,70  | 2,93  | 3,15  | 3,35  |
| 02                             | 2,53                             | 3,16  | 3,74  | 4,30  | 4,82  | 5,31  | 5,77  | 6,21  | 6,62  | 02                             | 2,61                             | 3,24  | 3,83  | 4,38  | 4,91  | 5,40  | 5,86  | 6,30  | 6,71  |
| 03                             | 3,00                             | 3,73  | 4,42  | 5,06  | 5,67  | 6,24  | 6,78  | 7,29  | 7,77  | 03                             | 3,10                             | 3,83  | 4,52  | 5,16  | 5,77  | 6,34  | 6,88  | 7,39  | 7,87  |
| 04                             | 4,83                             | 6,04  | 7,17  | 8,23  | 9,23  | 10,17 | 11,06 | 11,89 | 12,69 | 04                             | 4,99                             | 6,20  | 7,33  | 8,39  | 9,39  | 10,33 | 11,22 | 12,06 | 12,85 |
| 05                             | 8,28                             | 10,32 | 12,23 | 14,02 | 15,72 | 17,31 | 18,82 | 20,23 | 21,57 | 05                             | 8,55                             | 10,59 | 12,51 | 14,30 | 16,00 | 17,59 | 19,10 | 20,52 | 21,85 |
| 06                             | 11,50                            | 14,32 | 16,97 | 19,45 | 21,79 | 24,00 | 26,09 | 28,04 | 29,90 | 06                             | 11,87                            | 14,70 | 17,35 | 19,84 | 22,18 | 24,39 | 26,47 | 28,44 | 30,28 |
| 07                             | 18,08                            | 22,57 | 26,79 | 30,76 | 34,50 | 38,02 | 41,35 | 44,47 | 47,43 | 07                             | 18,66                            | 23,18 | 27,41 | 31,38 | 35,12 | 38,64 | 41,96 | 45,09 | 48,04 |
| 08                             | 21,84                            | 27,21 | 32,26 | 37,01 | 41,48 | 45,69 | 49,68 | 53,41 | 56,95 | 08                             | 22,54                            | 27,94 | 33,00 | 37,75 | 42,22 | 46,43 | 50,41 | 54,16 | 57,68 |
| 09                             | 24,24                            | 30,19 | 35,77 | 41,02 | 45,97 | 50,63 | 55,04 | 59,17 | 63,09 | 09                             | 25,02                            | 30,99 | 36,59 | 41,85 | 46,79 | 51,45 | 55,85 | 60,00 | 63,89 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 1,34                             | 1,65  | 1,94  | 2,22  | 2,48  | 2,72  | 2,95  | 3,16  | 3,37  | 01                             | 1,36                             | 1,66  | 1,95  | 2,22  | 2,48  | 2,72  | 2,94  | 3,15  | 3,35  |
| 02                             | 2,67                             | 3,30  | 3,88  | 4,43  | 4,95  | 5,44  | 5,90  | 6,33  | 6,74  | 02                             | 2,71                             | 3,33  | 3,90  | 4,44  | 4,95  | 5,43  | 5,88  | 6,31  | 6,71  |
| 03                             | 3,17                             | 3,90  | 4,58  | 5,22  | 5,82  | 6,39  | 6,92  | 7,43  | 7,90  | 03                             | 3,22                             | 3,93  | 4,60  | 5,23  | 5,82  | 6,38  | 6,91  | 7,40  | 7,87  |
| 04                             | 5,11                             | 6,31  | 7,43  | 8,49  | 9,48  | 10,41 | 11,30 | 12,12 | 12,91 | 04                             | 5,19                             | 6,36  | 7,47  | 8,50  | 9,48  | 10,40 | 11,27 | 12,08 | 12,85 |
| 05                             | 8,75                             | 10,78 | 12,68 | 14,46 | 16,15 | 17,73 | 19,22 | 20,62 | 21,95 | 05                             | 8,88                             | 10,87 | 12,74 | 14,49 | 16,15 | 17,70 | 19,17 | 20,55 | 21,85 |
| 06                             | 12,16                            | 14,97 | 17,60 | 20,06 | 22,39 | 24,58 | 26,65 | 28,58 | 30,42 | 06                             | 12,34                            | 15,09 | 17,68 | 20,10 | 22,39 | 24,54 | 26,58 | 28,48 | 30,28 |
| 07                             | 19,11                            | 23,60 | 27,79 | 31,73 | 35,44 | 38,94 | 42,23 | 45,32 | 48,25 | 07                             | 19,40                            | 23,79 | 27,92 | 31,79 | 35,44 | 38,88 | 42,12 | 45,16 | 48,04 |
| 08                             | 23,09                            | 28,45 | 33,47 | 38,17 | 42,62 | 46,79 | 50,74 | 54,43 | 57,94 | 08                             | 23,43                            | 28,69 | 33,62 | 38,25 | 42,62 | 46,73 | 50,60 | 54,24 | 57,68 |
| 09                             | 25,63                            | 31,56 | 37,11 | 42,31 | 47,23 | 51,85 | 56,21 | 60,30 | 64,18 | 09                             | 26,01                            | 31,82 | 37,28 | 42,40 | 47,23 | 51,78 | 56,07 | 60,09 | 63,89 |

**TABLE: 17B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| $F_{sub}$                   | 1,00 | 1,06 | 1,11 | 1,16 | 1,22 | 1,27 | 1,32 | 1,43 | 1,48 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 17B



**TABLE 18A: Refrigerant R404A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,48                             | 0,58  | 0,66  | 0,72  | 0,76  | 0,80  | 0,82  | 0,83  | 0,83  | 01                             | 0,51                             | 0,61  | 0,69  | 0,75  | 0,79  | 0,83  | 0,85  | 0,86  | 0,85  |
| 02                             | 0,97                             | 1,16  | 1,31  | 1,43  | 1,53  | 1,60  | 1,64  | 1,66  | 1,65  | 02                             | 1,02                             | 1,22  | 1,37  | 1,50  | 1,59  | 1,66  | 1,70  | 1,71  | 1,70  |
| 03                             | 1,15                             | 1,37  | 1,55  | 1,69  | 1,80  | 1,88  | 1,93  | 1,94  | 1,94  | 03                             | 1,22                             | 1,44  | 1,62  | 1,76  | 1,87  | 1,95  | 1,99  | 2,01  | 1,99  |
| 04                             | 1,85                             | 2,21  | 2,51  | 2,75  | 2,93  | 3,06  | 3,14  | 3,17  | 3,16  | 04                             | 1,96                             | 2,33  | 2,63  | 2,86  | 3,04  | 3,17  | 3,25  | 3,28  | 3,26  |
| 05                             | 3,16                             | 3,78  | 4,28  | 4,68  | 4,99  | 5,21  | 5,34  | 5,40  | 5,38  | 05                             | 3,35                             | 3,97  | 4,48  | 4,88  | 5,18  | 5,40  | 5,53  | 5,58  | 5,54  |
| 06                             | 4,40                             | 5,24  | 5,94  | 6,49  | 6,92  | 7,22  | 7,41  | 7,48  | 7,45  | 06                             | 4,66                             | 5,52  | 6,22  | 6,77  | 7,19  | 7,49  | 7,66  | 7,73  | 7,68  |
| 07                             | 6,91                             | 8,27  | 9,38  | 10,27 | 10,95 | 11,44 | 11,74 | 11,86 | 11,82 | 07                             | 7,32                             | 8,70  | 9,82  | 10,71 | 11,37 | 11,86 | 12,14 | 12,25 | 12,18 |
| 08                             | 8,35                             | 9,97  | 11,29 | 12,36 | 13,17 | 13,75 | 14,11 | 14,25 | 14,20 | 08                             | 8,84                             | 10,49 | 11,82 | 12,88 | 13,68 | 14,25 | 14,59 | 14,72 | 14,62 |
| 09                             | 9,27                             | 11,05 | 12,52 | 13,70 | 14,59 | 15,24 | 15,63 | 15,78 | 15,73 | 09                             | 9,82                             | 11,63 | 13,11 | 14,28 | 15,16 | 15,79 | 16,16 | 16,30 | 16,19 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,54                             | 0,63  | 0,71  | 0,77  | 0,81  | 0,84  | 0,86  | 0,86  | 0,86  | 01                             | 0,57                             | 0,64  | 0,72  | 0,77  | 0,81  | 0,84  | 0,85  | 0,85  | 0,84  |
| 02                             | 1,07                             | 1,26  | 1,41  | 1,53  | 1,62  | 1,68  | 1,72  | 1,73  | 1,71  | 02                             | 1,13                             | 1,29  | 1,43  | 1,54  | 1,62  | 1,68  | 1,70  | 1,71  | 1,68  |
| 03                             | 1,27                             | 1,49  | 1,67  | 1,80  | 1,90  | 1,97  | 2,01  | 2,03  | 2,01  | 03                             | 1,34                             | 1,52  | 1,69  | 1,82  | 1,91  | 1,97  | 2,00  | 2,00  | 1,97  |
| 04                             | 2,05                             | 2,41  | 2,70  | 2,93  | 3,10  | 3,22  | 3,29  | 3,31  | 3,28  | 04                             | 2,16                             | 2,47  | 2,74  | 2,95  | 3,11  | 3,21  | 3,26  | 3,27  | 3,22  |
| 05                             | 3,51                             | 4,12  | 4,61  | 4,99  | 5,28  | 5,48  | 5,59  | 5,62  | 5,57  | 05                             | 3,70                             | 4,21  | 4,68  | 5,03  | 5,30  | 5,46  | 5,55  | 5,56  | 5,48  |
| 06                             | 4,87                             | 5,72  | 6,40  | 6,93  | 7,32  | 7,59  | 7,75  | 7,80  | 7,72  | 06                             | 5,15                             | 5,85  | 6,49  | 6,98  | 7,35  | 7,58  | 7,69  | 7,71  | 7,60  |
| 07                             | 7,66                             | 9,01  | 10,10 | 10,96 | 11,59 | 12,03 | 12,29 | 12,36 | 12,25 | 07                             | 8,09                             | 9,22  | 10,25 | 11,04 | 11,63 | 12,00 | 12,19 | 12,22 | 12,06 |
| 08                             | 9,25                             | 10,86 | 12,17 | 13,18 | 13,94 | 14,46 | 14,76 | 14,85 | 14,71 | 08                             | 9,77                             | 11,11 | 12,34 | 13,29 | 13,98 | 14,42 | 14,65 | 14,68 | 14,48 |
| 09                             | 10,27                            | 12,05 | 13,49 | 14,61 | 15,45 | 16,02 | 16,35 | 16,45 | 16,30 | 09                             | 10,85                            | 12,33 | 13,69 | 14,73 | 15,50 | 15,98 | 16,23 | 16,26 | 16,04 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,57                             | 0,65  | 0,72  | 0,77  | 0,80  | 0,83  | 0,83  | 0,83  | 0,81  | 01                             | 0,59                             | 0,66  | 0,72  | 0,76  | 0,79  | 0,80  | 0,81  | 0,79  | 0,77  |
| 02                             | 1,13                             | 1,30  | 1,44  | 1,54  | 1,61  | 1,65  | 1,67  | 1,66  | 1,63  | 02                             | 1,17                             | 1,32  | 1,43  | 1,52  | 1,58  | 1,61  | 1,61  | 1,59  | 1,54  |
| 03                             | 1,35                             | 1,54  | 1,69  | 1,81  | 1,89  | 1,94  | 1,96  | 1,95  | 1,91  | 03                             | 1,39                             | 1,56  | 1,69  | 1,79  | 1,85  | 1,89  | 1,89  | 1,86  | 1,81  |
| 04                             | 2,17                             | 2,49  | 2,75  | 2,94  | 3,08  | 3,16  | 3,20  | 3,18  | 3,12  | 04                             | 2,24                             | 2,52  | 2,75  | 2,91  | 3,02  | 3,08  | 3,08  | 3,04  | 2,95  |
| 05                             | 3,72                             | 4,26  | 4,69  | 5,01  | 5,25  | 5,39  | 5,44  | 5,41  | 5,31  | 05                             | 3,84                             | 4,31  | 4,69  | 4,96  | 5,14  | 5,24  | 5,25  | 5,17  | 5,02  |
| 06                             | 5,16                             | 5,91  | 6,51  | 6,96  | 7,28  | 7,47  | 7,54  | 7,50  | 7,36  | 06                             | 5,33                             | 5,98  | 6,50  | 6,88  | 7,13  | 7,26  | 7,28  | 7,17  | 6,96  |
| 07                             | 8,11                             | 9,32  | 10,28 | 11,00 | 11,52 | 11,83 | 11,95 | 11,90 | 11,67 | 07                             | 8,38                             | 9,43  | 10,27 | 10,88 | 11,29 | 11,50 | 11,53 | 11,37 | 11,05 |
| 08                             | 9,80                             | 11,24 | 12,38 | 13,23 | 13,85 | 14,22 | 14,36 | 14,29 | 14,01 | 08                             | 10,12                            | 11,37 | 12,36 | 13,09 | 13,57 | 13,82 | 13,86 | 13,65 | 13,26 |
| 09                             | 10,88                            | 12,47 | 13,72 | 14,67 | 15,35 | 15,75 | 15,91 | 15,83 | 15,52 | 09                             | 11,24                            | 12,62 | 13,71 | 14,51 | 15,04 | 15,31 | 15,35 | 15,12 | 14,69 |

**TABLE 18B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,09 | 1,17 | 1,26 | 1,34 | 1,42 | 1,50 | 1,56 | 1,63 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 18B

**TABLE 19A: Refrigerant R407C - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,76                             | 0,93  | 1,09  | 1,23  | 1,36  | 1,48  | 1,58  | 1,66  | 1,74  | 01                             | 0,78                             | 0,96  | 1,12  | 1,26  | 1,39  | 1,50  | 1,60  | 1,69  | 1,76  |
| 02                             | 1,52                             | 1,87  | 2,18  | 2,47  | 2,72  | 2,95  | 3,15  | 3,33  | 3,48  | 02                             | 1,57                             | 1,92  | 2,24  | 2,52  | 2,77  | 3,00  | 3,20  | 3,37  | 3,52  |
| 03                             | 1,80                             | 2,21  | 2,57  | 2,91  | 3,20  | 3,47  | 3,70  | 3,91  | 4,08  | 03                             | 1,86                             | 2,27  | 2,64  | 2,97  | 3,26  | 3,52  | 3,76  | 3,96  | 4,13  |
| 04                             | 2,90                             | 3,57  | 4,18  | 4,72  | 5,21  | 5,65  | 6,04  | 6,37  | 6,66  | 04                             | 3,00                             | 3,68  | 4,28  | 4,82  | 5,31  | 5,74  | 6,13  | 6,46  | 6,75  |
| 05                             | 4,96                             | 6,10  | 7,13  | 8,05  | 8,87  | 9,62  | 10,27 | 10,84 | 11,33 | 05                             | 5,14                             | 6,28  | 7,30  | 8,22  | 9,05  | 9,77  | 10,42 | 10,99 | 11,47 |
| 06                             | 6,89                             | 8,47  | 9,89  | 11,17 | 12,31 | 13,33 | 14,24 | 15,03 | 15,71 | 06                             | 7,14                             | 8,72  | 10,13 | 11,41 | 12,54 | 13,55 | 14,45 | 15,23 | 15,90 |
| 07                             | 10,83                            | 13,35 | 15,62 | 17,66 | 19,48 | 21,12 | 22,57 | 23,83 | 24,91 | 07                             | 11,22                            | 13,74 | 16,00 | 18,04 | 19,86 | 21,47 | 22,91 | 24,15 | 25,23 |
| 08                             | 13,09                            | 16,09 | 18,81 | 21,25 | 23,42 | 25,38 | 27,11 | 28,62 | 29,92 | 08                             | 13,55                            | 16,57 | 19,27 | 21,70 | 23,88 | 25,80 | 27,52 | 29,01 | 30,29 |
| 09                             | 14,53                            | 17,85 | 20,85 | 23,55 | 25,96 | 28,13 | 30,04 | 31,71 | 33,14 | 09                             | 15,04                            | 18,38 | 21,37 | 24,06 | 26,46 | 28,59 | 30,49 | 32,14 | 33,55 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,81                             | 0,98  | 1,14  | 1,28  | 1,40  | 1,51  | 1,61  | 1,70  | 1,77  | 01                             | 0,83                             | 1,00  | 1,15  | 1,28  | 1,40  | 1,51  | 1,60  | 1,68  | 1,75  |
| 02                             | 1,62                             | 1,97  | 2,28  | 2,56  | 2,81  | 3,03  | 3,22  | 3,39  | 3,54  | 02                             | 1,65                             | 1,99  | 2,30  | 2,57  | 2,81  | 3,02  | 3,20  | 3,36  | 3,50  |
| 03                             | 1,92                             | 2,33  | 2,69  | 3,01  | 3,30  | 3,56  | 3,78  | 3,98  | 4,15  | 03                             | 1,96                             | 2,36  | 2,71  | 3,02  | 3,30  | 3,55  | 3,76  | 3,95  | 4,11  |
| 04                             | 3,10                             | 3,77  | 4,36  | 4,90  | 5,38  | 5,80  | 6,17  | 6,49  | 6,77  | 04                             | 3,16                             | 3,81  | 4,39  | 4,91  | 5,37  | 5,78  | 6,13  | 6,44  | 6,71  |
| 05                             | 5,31                             | 6,44  | 7,44  | 8,35  | 9,16  | 9,87  | 10,50 | 11,05 | 11,52 | 05                             | 5,42                             | 6,51  | 7,49  | 8,37  | 9,15  | 9,84  | 10,43 | 10,96 | 11,40 |
| 06                             | 7,37                             | 8,93  | 10,33 | 11,59 | 12,70 | 13,69 | 14,55 | 15,31 | 15,96 | 06                             | 7,52                             | 9,04  | 10,40 | 11,61 | 12,69 | 13,64 | 14,46 | 15,19 | 15,80 |
| 07                             | 11,58                            | 14,08 | 16,31 | 18,32 | 20,10 | 21,68 | 23,07 | 24,28 | 25,32 | 07                             | 11,82                            | 14,26 | 16,42 | 18,37 | 20,08 | 21,61 | 22,92 | 24,08 | 25,07 |
| 08                             | 13,99                            | 16,98 | 19,64 | 22,04 | 24,16 | 26,06 | 27,71 | 29,16 | 30,41 | 08                             | 14,28                            | 17,19 | 19,78 | 22,10 | 24,15 | 25,97 | 27,54 | 28,92 | 30,10 |
| 09                             | 15,53                            | 18,84 | 21,78 | 24,43 | 26,78 | 28,87 | 30,70 | 32,30 | 33,68 | 09                             | 15,85                            | 19,06 | 21,93 | 24,49 | 26,76 | 28,78 | 30,51 | 32,04 | 33,35 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,84                             | 1,00  | 1,15  | 1,27  | 1,39  | 1,49  | 1,58  | 1,65  | 1,72  | 01                             | 0,85                             | 1,01  | 1,15  | 1,27  | 1,38  | 1,48  | 1,56  | 1,63  | 1,69  |
| 02                             | 1,67                             | 2,00  | 2,29  | 2,55  | 2,78  | 2,98  | 3,16  | 3,31  | 3,43  | 02                             | 1,71                             | 2,02  | 2,30  | 2,54  | 2,76  | 2,96  | 3,12  | 3,26  | 3,38  |
| 03                             | 1,99                             | 2,37  | 2,70  | 3,00  | 3,27  | 3,50  | 3,71  | 3,88  | 4,03  | 03                             | 2,03                             | 2,38  | 2,71  | 3,00  | 3,25  | 3,47  | 3,66  | 3,83  | 3,97  |
| 04                             | 3,20                             | 3,83  | 4,39  | 4,88  | 5,32  | 5,71  | 6,04  | 6,33  | 6,58  | 04                             | 3,26                             | 3,86  | 4,39  | 4,87  | 5,29  | 5,66  | 5,98  | 6,25  | 6,48  |
| 05                             | 5,48                             | 6,54  | 7,48  | 8,32  | 9,06  | 9,71  | 10,29 | 10,77 | 11,18 | 05                             | 5,59                             | 6,59  | 7,49  | 8,30  | 9,01  | 9,64  | 10,17 | 10,63 | 11,01 |
| 06                             | 7,62                             | 9,08  | 10,38 | 11,54 | 12,57 | 13,47 | 14,26 | 14,93 | 15,50 | 06                             | 7,76                             | 9,15  | 10,40 | 11,52 | 12,50 | 13,36 | 14,10 | 14,74 | 15,26 |
| 07                             | 11,97                            | 14,31 | 16,40 | 18,25 | 19,90 | 21,34 | 22,60 | 23,67 | 24,58 | 07                             | 12,20                            | 14,43 | 16,42 | 18,21 | 19,78 | 21,16 | 22,34 | 23,37 | 24,21 |
| 08                             | 14,46                            | 17,25 | 19,74 | 21,95 | 23,92 | 25,64 | 27,15 | 28,43 | 29,52 | 08                             | 14,73                            | 17,39 | 19,78 | 21,91 | 23,79 | 25,44 | 26,84 | 28,07 | 29,07 |
| 09                             | 16,05                            | 19,13 | 21,89 | 24,33 | 26,51 | 28,41 | 30,08 | 31,50 | 32,70 | 09                             | 16,35                            | 19,29 | 21,93 | 24,29 | 26,36 | 28,19 | 29,74 | 31,10 | 32,21 |

**TABLE: 19B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,06 | 1,12 | 1,19 | 1,25 | 1,31 | 1,37 | 1,44 | 1,49 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 19B

**TABLE 20A: Refrigerant R410A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,63                             | 0,78  | 0,91  | 1,02  | 1,12  | 1,21  | 1,28  | 1,35  | 1,40  | 01                             | 0,68                             | 0,83  | 0,96  | 1,08  | 1,19  | 1,28  | 1,36  | 1,42  | 1,48  |
| 02                             | 1,27                             | 1,56  | 1,82  | 2,05  | 2,25  | 2,42  | 2,57  | 2,69  | 2,79  | 02                             | 1,35                             | 1,66  | 1,93  | 2,17  | 2,37  | 2,56  | 2,71  | 2,84  | 2,95  |
| 03                             | 1,50                             | 1,84  | 2,14  | 2,41  | 2,64  | 2,85  | 3,02  | 3,16  | 3,27  | 03                             | 1,61                             | 1,96  | 2,27  | 2,55  | 2,79  | 3,00  | 3,18  | 3,34  | 3,46  |
| 04                             | 2,42                             | 2,98  | 3,48  | 3,92  | 4,30  | 4,64  | 4,92  | 5,16  | 5,35  | 04                             | 2,59                             | 3,17  | 3,69  | 4,15  | 4,55  | 4,89  | 5,20  | 5,45  | 5,65  |
| 05                             | 4,14                             | 5,09  | 5,93  | 6,68  | 7,33  | 7,90  | 8,37  | 8,77  | 9,09  | 05                             | 4,43                             | 5,42  | 6,30  | 7,07  | 7,74  | 8,33  | 8,84  | 9,27  | 9,61  |
| 06                             | 5,76                             | 7,07  | 8,23  | 9,26  | 10,16 | 10,95 | 11,61 | 12,16 | 12,60 | 06                             | 6,16                             | 7,53  | 8,73  | 9,80  | 10,74 | 11,55 | 12,26 | 12,85 | 13,32 |
| 07                             | 9,05                             | 11,14 | 13,00 | 14,64 | 16,09 | 17,34 | 18,40 | 19,29 | 19,99 | 07                             | 9,68                             | 11,87 | 13,79 | 15,50 | 17,00 | 18,30 | 19,42 | 20,37 | 21,14 |
| 08                             | 10,93                            | 13,43 | 15,65 | 17,62 | 19,35 | 20,84 | 22,10 | 23,16 | 24,00 | 08                             | 11,69                            | 14,31 | 16,61 | 18,65 | 20,44 | 21,99 | 23,34 | 24,47 | 25,38 |
| 09                             | 12,13                            | 14,90 | 17,35 | 19,53 | 21,44 | 23,09 | 24,49 | 25,66 | 26,58 | 09                             | 12,98                            | 15,87 | 18,42 | 20,68 | 22,65 | 24,37 | 25,85 | 27,10 | 28,11 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,77                             | 0,93  | 1,07  | 1,20  | 1,31  | 1,40  | 1,49  | 1,56  | 1,62  | 01                             | 0,75                             | 0,90  | 1,04  | 1,16  | 1,26  | 1,36  | 1,43  | 1,50  | 1,55  |
| 02                             | 1,54                             | 1,86  | 2,14  | 2,39  | 2,62  | 2,81  | 2,97  | 3,11  | 3,23  | 02                             | 1,49                             | 1,80  | 2,08  | 2,32  | 2,53  | 2,71  | 2,86  | 3,00  | 3,10  |
| 03                             | 1,83                             | 2,20  | 2,53  | 2,82  | 3,08  | 3,30  | 3,49  | 3,65  | 3,79  | 03                             | 1,77                             | 2,13  | 2,45  | 2,73  | 2,97  | 3,18  | 3,36  | 3,52  | 3,64  |
| 04                             | 2,95                             | 3,56  | 4,10  | 4,58  | 5,01  | 5,37  | 5,69  | 5,97  | 6,19  | 04                             | 2,85                             | 3,45  | 3,97  | 4,44  | 4,84  | 5,19  | 5,49  | 5,74  | 5,94  |
| 05                             | 5,04                             | 6,08  | 7,00  | 7,81  | 8,53  | 9,15  | 9,69  | 10,15 | 10,53 | 05                             | 4,89                             | 5,90  | 6,78  | 7,56  | 8,24  | 8,83  | 9,34  | 9,76  | 10,11 |
| 06                             | 7,01                             | 8,44  | 9,72  | 10,84 | 11,83 | 12,68 | 13,43 | 14,07 | 14,59 | 06                             | 6,79                             | 8,18  | 9,41  | 10,49 | 11,43 | 12,25 | 12,94 | 13,53 | 14,01 |
| 07                             | 11,01                            | 13,31 | 15,34 | 17,14 | 18,72 | 20,09 | 21,29 | 22,31 | 23,14 | 07                             | 10,67                            | 12,90 | 14,86 | 16,59 | 18,09 | 19,40 | 20,52 | 21,45 | 22,23 |
| 08                             | 13,30                            | 16,05 | 18,48 | 20,62 | 22,51 | 24,15 | 25,57 | 26,79 | 27,79 | 08                             | 12,89                            | 15,55 | 17,89 | 19,96 | 21,76 | 23,32 | 24,65 | 25,77 | 26,69 |
| 09                             | 14,76                            | 17,80 | 20,49 | 22,85 | 24,95 | 26,76 | 28,33 | 29,68 | 30,78 | 09                             | 14,31                            | 17,25 | 19,84 | 22,13 | 24,11 | 25,84 | 27,31 | 28,55 | 29,56 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,77                             | 0,92  | 1,06  | 1,18  | 1,28  | 1,37  | 1,44  | 1,50  | 1,56  | 01                             | 0,79                             | 0,94  | 1,07  | 1,18  | 1,28  | 1,37  | 1,44  | 1,50  | 1,55  |
| 02                             | 1,54                             | 1,85  | 2,12  | 2,35  | 2,56  | 2,73  | 2,89  | 3,01  | 3,11  | 02                             | 1,58                             | 1,88  | 2,14  | 2,36  | 2,56  | 2,73  | 2,88  | 3,00  | 3,09  |
| 03                             | 1,83                             | 2,19  | 2,50  | 2,77  | 3,01  | 3,21  | 3,39  | 3,53  | 3,65  | 03                             | 1,88                             | 2,22  | 2,52  | 2,78  | 3,01  | 3,21  | 3,38  | 3,52  | 3,63  |
| 04                             | 2,95                             | 3,54  | 4,05  | 4,50  | 4,89  | 5,24  | 5,53  | 5,76  | 5,97  | 04                             | 3,02                             | 3,59  | 4,09  | 4,53  | 4,90  | 5,24  | 5,51  | 5,74  | 5,92  |
| 05                             | 5,06                             | 6,04  | 6,91  | 7,67  | 8,33  | 8,91  | 9,40  | 9,80  | 10,14 | 05                             | 5,17                             | 6,13  | 6,97  | 7,71  | 8,35  | 8,91  | 9,37  | 9,77  | 10,07 |
| 06                             | 7,03                             | 8,39  | 9,59  | 10,64 | 11,56 | 12,36 | 13,03 | 13,59 | 14,06 | 06                             | 7,19                             | 8,51  | 9,67  | 10,70 | 11,58 | 12,36 | 12,99 | 13,54 | 13,96 |
| 07                             | 11,04                            | 13,22 | 15,14 | 16,83 | 18,30 | 19,58 | 20,66 | 21,54 | 22,30 | 07                             | 11,30                            | 13,41 | 15,28 | 16,92 | 18,33 | 19,58 | 20,60 | 21,47 | 22,15 |
| 08                             | 13,34                            | 15,94 | 18,23 | 20,25 | 22,00 | 23,53 | 24,82 | 25,87 | 26,78 | 08                             | 13,65                            | 16,17 | 18,40 | 20,35 | 22,04 | 23,53 | 24,74 | 25,79 | 26,59 |
| 09                             | 14,80                            | 17,68 | 20,22 | 22,45 | 24,38 | 26,07 | 27,50 | 28,66 | 29,67 | 09                             | 15,15                            | 17,94 | 20,40 | 22,56 | 24,43 | 26,07 | 27,41 | 28,57 | 29,46 |

**TABLE 20B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,07 | 1,14 | 1,21 | 1,28 | 1,34 | 1,41 | 1,48 | 1,54 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 20B

**TABLE 21A: Refrigerant R507A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,50                             | 0,60  | 0,68  | 0,74  | 0,80  | 0,84  | 0,86  | 0,87  | 0,87  | 01                             | 0,52                             | 0,63  | 0,71  | 0,78  | 0,83  | 0,87  | 0,89  | 0,90  | 0,90  |
| 02                             | 0,99                             | 1,19  | 1,36  | 1,49  | 1,59  | 1,67  | 1,72  | 1,74  | 1,74  | 02                             | 1,05                             | 1,25  | 1,42  | 1,55  | 1,65  | 1,73  | 1,78  | 1,80  | 1,80  |
| 03                             | 1,18                             | 1,41  | 1,60  | 1,75  | 1,88  | 1,96  | 2,02  | 2,04  | 2,04  | 03                             | 1,24                             | 1,48  | 1,67  | 1,83  | 1,95  | 2,03  | 2,09  | 2,11  | 2,11  |
| 04                             | 1,90                             | 2,28  | 2,60  | 2,85  | 3,05  | 3,20  | 3,29  | 3,33  | 3,32  | 04                             | 2,00                             | 2,39  | 2,71  | 2,97  | 3,17  | 3,31  | 3,41  | 3,45  | 3,44  |
| 05                             | 3,25                             | 3,89  | 4,43  | 4,86  | 5,20  | 5,44  | 5,60  | 5,67  | 5,65  | 05                             | 3,43                             | 4,09  | 4,62  | 5,06  | 5,40  | 5,64  | 5,80  | 5,87  | 5,85  |
| 06                             | 4,51                             | 5,40  | 6,15  | 6,74  | 7,21  | 7,55  | 7,76  | 7,86  | 7,83  | 06                             | 4,76                             | 5,67  | 6,41  | 7,02  | 7,48  | 7,82  | 8,04  | 8,13  | 8,10  |
| 07                             | 7,09                             | 8,52  | 9,71  | 10,66 | 11,42 | 11,96 | 12,30 | 12,47 | 12,43 | 07                             | 7,49                             | 8,94  | 10,13 | 11,10 | 11,84 | 12,39 | 12,74 | 12,89 | 12,86 |
| 08                             | 8,57                             | 10,27 | 11,69 | 12,83 | 13,73 | 14,37 | 14,78 | 14,97 | 14,92 | 08                             | 9,05                             | 10,78 | 12,20 | 13,35 | 14,24 | 14,89 | 15,30 | 15,49 | 15,44 |
| 09                             | 9,51                             | 11,39 | 12,96 | 14,22 | 15,21 | 15,92 | 16,38 | 16,59 | 16,53 | 09                             | 10,04                            | 11,96 | 13,53 | 14,80 | 15,78 | 16,50 | 16,95 | 17,16 | 17,10 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,55                             | 0,65  | 0,73  | 0,79  | 0,84  | 0,88  | 0,90  | 0,91  | 0,91  | 01                             | 0,57                             | 0,66  | 0,74  | 0,80  | 0,85  | 0,88  | 0,90  | 0,90  | 0,90  |
| 02                             | 1,09                             | 1,29  | 1,45  | 1,59  | 1,68  | 1,76  | 1,80  | 1,82  | 1,81  | 02                             | 1,13                             | 1,32  | 1,48  | 1,60  | 1,69  | 1,76  | 1,80  | 1,81  | 1,80  |
| 03                             | 1,30                             | 1,53  | 1,72  | 1,87  | 1,98  | 2,06  | 2,11  | 2,14  | 2,12  | 03                             | 1,34                             | 1,57  | 1,75  | 1,89  | 1,99  | 2,07  | 2,11  | 2,12  | 2,11  |
| 04                             | 2,09                             | 2,47  | 2,78  | 3,04  | 3,23  | 3,36  | 3,45  | 3,49  | 3,47  | 04                             | 2,16                             | 2,53  | 2,83  | 3,07  | 3,25  | 3,37  | 3,44  | 3,46  | 3,44  |
| 05                             | 3,58                             | 4,22  | 4,75  | 5,17  | 5,49  | 5,72  | 5,87  | 5,93  | 5,90  | 05                             | 3,70                             | 4,33  | 4,83  | 5,23  | 5,53  | 5,74  | 5,85  | 5,89  | 5,85  |
| 06                             | 4,97                             | 5,86  | 6,59  | 7,18  | 7,62  | 7,94  | 8,14  | 8,22  | 8,18  | 06                             | 5,15                             | 6,01  | 6,70  | 7,25  | 7,67  | 7,96  | 8,12  | 8,16  | 8,10  |
| 07                             | 7,81                             | 9,24  | 10,41 | 11,35 | 12,06 | 12,57 | 12,90 | 13,04 | 12,97 | 07                             | 8,09                             | 9,47  | 10,59 | 11,47 | 12,13 | 12,60 | 12,86 | 12,95 | 12,86 |
| 08                             | 9,43                             | 11,14 | 12,53 | 13,65 | 14,50 | 15,11 | 15,49 | 15,66 | 15,58 | 08                             | 9,77                             | 11,42 | 12,75 | 13,80 | 14,59 | 15,14 | 15,45 | 15,55 | 15,44 |
| 09                             | 10,47                            | 12,36 | 13,89 | 15,13 | 16,07 | 16,74 | 17,17 | 17,34 | 17,26 | 09                             | 10,85                            | 12,67 | 14,14 | 15,29 | 16,17 | 16,78 | 17,12 | 17,23 | 17,10 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,58                             | 0,67  | 0,74  | 0,80  | 0,84  | 0,87  | 0,88  | 0,88  | 0,87  | 01                             | 0,59                             | 0,67  | 0,74  | 0,79  | 0,83  | 0,85  | 0,86  | 0,85  | 0,86  |
| 02                             | 1,16                             | 1,34  | 1,48  | 1,60  | 1,68  | 1,73  | 1,76  | 1,77  | 1,74  | 02                             | 1,18                             | 1,34  | 1,48  | 1,58  | 1,65  | 1,70  | 1,71  | 1,71  | 1,73  |
| 03                             | 1,37                             | 1,58  | 1,75  | 1,88  | 1,97  | 2,04  | 2,07  | 2,07  | 2,04  | 03                             | 1,40                             | 1,59  | 1,74  | 1,86  | 1,94  | 1,99  | 2,01  | 2,00  | 2,03  |
| 04                             | 2,21                             | 2,56  | 2,84  | 3,06  | 3,21  | 3,32  | 3,38  | 3,38  | 3,34  | 04                             | 2,25                             | 2,57  | 2,83  | 3,02  | 3,16  | 3,25  | 3,28  | 3,27  | 3,31  |
| 05                             | 3,79                             | 4,37  | 4,84  | 5,21  | 5,47  | 5,65  | 5,75  | 5,75  | 5,68  | 05                             | 3,86                             | 4,39  | 4,82  | 5,15  | 5,38  | 5,53  | 5,58  | 5,56  | 5,63  |
| 06                             | 5,26                             | 6,07  | 6,72  | 7,22  | 7,59  | 7,84  | 7,96  | 7,97  | 7,87  | 06                             | 5,36                             | 6,10  | 6,69  | 7,14  | 7,47  | 7,67  | 7,74  | 7,71  | 7,80  |
| 07                             | 8,27                             | 9,57  | 10,61 | 11,42 | 12,01 | 12,42 | 12,62 | 12,65 | 12,49 | 07                             | 8,42                             | 9,61  | 10,57 | 11,29 | 11,82 | 12,14 | 12,27 | 12,22 | 12,37 |
| 08                             | 9,99                             | 11,54 | 12,77 | 13,74 | 14,44 | 14,92 | 15,17 | 15,19 | 14,99 | 08                             | 10,17                            | 11,59 | 12,73 | 13,59 | 14,21 | 14,59 | 14,74 | 14,68 | 14,85 |
| 09                             | 11,09                            | 12,80 | 14,16 | 15,24 | 16,00 | 16,53 | 16,80 | 16,82 | 16,61 | 09                             | 11,29                            | 12,86 | 14,11 | 15,06 | 15,75 | 16,17 | 16,33 | 16,26 | 16,45 |

**TABLE: 21B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| $F_{sub}$                   | 1,00 | 1,09 | 1,18 | 1,26 | 1,35 | 1,44 | 1,52 | 1,60 | 1,67 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 21B

**TABLE 22A: Refrigerant R1234yf - Capacities in kW**

| Evaporating Temperature 20 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,47                             | 0,55  | 0,61  | 0,65  | 0,67  | 0,68  | 0,67  | 0,65  | 0,61  | 01                             | 0,49                             | 0,57  | 0,62  | 0,66  | 0,68  | 0,68  | 0,67  | 0,65  | 0,61  |
| 02                             | 0,94                             | 1,10  | 1,21  | 1,29  | 1,34  | 1,36  | 1,34  | 1,30  | 1,23  | 02                             | 0,98                             | 1,13  | 1,24  | 1,32  | 1,36  | 1,37  | 1,35  | 1,30  | 1,22  |
| 03                             | 1,12                             | 1,30  | 1,43  | 1,52  | 1,58  | 1,60  | 1,58  | 1,52  | 1,44  | 03                             | 1,17                             | 1,34  | 1,47  | 1,55  | 1,60  | 1,61  | 1,58  | 1,52  | 1,43  |
| 04                             | 1,80                             | 2,10  | 2,32  | 2,48  | 2,57  | 2,60  | 2,57  | 2,49  | 2,35  | 04                             | 1,88                             | 2,17  | 2,38  | 2,52  | 2,60  | 2,62  | 2,58  | 2,49  | 2,33  |
| 05                             | 3,08                             | 3,59  | 3,96  | 4,22  | 4,37  | 4,43  | 4,38  | 4,23  | 4,00  | 05                             | 3,21                             | 3,71  | 4,06  | 4,30  | 4,43  | 4,46  | 4,39  | 4,23  | 3,97  |
| 06                             | 4,28                             | 4,98  | 5,50  | 5,85  | 6,07  | 6,14  | 6,07  | 5,87  | 5,54  | 06                             | 4,47                             | 5,14  | 5,63  | 5,96  | 6,15  | 6,18  | 6,09  | 5,87  | 5,50  |
| 07                             | 6,73                             | 7,85  | 8,68  | 9,26  | 9,60  | 9,72  | 9,62  | 9,31  | 8,79  | 07                             | 7,02                             | 8,11  | 8,89  | 9,43  | 9,73  | 9,79  | 9,66  | 9,31  | 8,73  |
| 08                             | 8,13                             | 9,46  | 10,46 | 11,14 | 11,54 | 11,69 | 11,56 | 11,18 | 10,55 | 08                             | 8,48                             | 9,78  | 10,71 | 11,35 | 11,70 | 11,77 | 11,60 | 11,18 | 10,48 |
| 09                             | 9,02                             | 10,50 | 11,59 | 12,35 | 12,79 | 12,95 | 12,81 | 12,38 | 11,69 | 09                             | 9,41                             | 10,85 | 11,88 | 12,58 | 12,96 | 13,04 | 12,85 | 12,38 | 11,61 |
| Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,50                             | 0,58  | 0,63  | 0,66  | 0,67  | 0,67  | 0,66  | 0,63  | 0,58  | 01                             | 0,51                             | 0,58  | 0,62  | 0,65  | 0,66  | 0,65  | 0,63  | 0,60  | 0,55  |
| 02                             | 1,01                             | 1,15  | 1,25  | 1,31  | 1,35  | 1,35  | 1,32  | 1,26  | 1,17  | 02                             | 1,02                             | 1,15  | 1,24  | 1,29  | 1,31  | 1,30  | 1,26  | 1,19  | 1,09  |
| 03                             | 1,20                             | 1,36  | 1,48  | 1,55  | 1,58  | 1,58  | 1,55  | 1,48  | 1,37  | 03                             | 1,22                             | 1,36  | 1,46  | 1,52  | 1,54  | 1,53  | 1,48  | 1,40  | 1,28  |
| 04                             | 1,93                             | 2,20  | 2,39  | 2,52  | 2,58  | 2,58  | 2,52  | 2,41  | 2,24  | 04                             | 1,96                             | 2,21  | 2,38  | 2,48  | 2,51  | 2,49  | 2,42  | 2,28  | 2,09  |
| 05                             | 3,30                             | 3,76  | 4,08  | 4,29  | 4,39  | 4,39  | 4,29  | 4,10  | 3,81  | 05                             | 3,36                             | 3,77  | 4,05  | 4,22  | 4,28  | 4,24  | 4,11  | 3,88  | 3,55  |
| 06                             | 4,59                             | 5,22  | 5,67  | 5,95  | 6,09  | 6,08  | 5,95  | 5,68  | 5,28  | 06                             | 4,66                             | 5,23  | 5,63  | 5,85  | 5,94  | 5,89  | 5,70  | 5,38  | 4,92  |
| 07                             | 7,21                             | 8,23  | 8,95  | 9,41  | 9,64  | 9,64  | 9,43  | 9,00  | 8,38  | 07                             | 7,33                             | 8,25  | 8,89  | 9,26  | 9,40  | 9,32  | 9,03  | 8,52  | 7,81  |
| 08                             | 8,71                             | 9,92  | 10,78 | 11,32 | 11,59 | 11,58 | 11,33 | 10,81 | 10,06 | 08                             | 8,85                             | 9,95  | 10,70 | 11,14 | 11,30 | 11,20 | 10,85 | 10,24 | 9,38  |
| 09                             | 9,67                             | 11,00 | 11,95 | 12,55 | 12,84 | 12,83 | 12,55 | 11,98 | 11,14 | 09                             | 9,83                             | 11,03 | 11,86 | 12,35 | 12,53 | 12,41 | 12,02 | 11,34 | 10,39 |
| Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,52                             | 0,57  | 0,61  | 0,63  | 0,63  | 0,62  | 0,59  | 0,55  | 0,50  | 01                             | 0,51                             | 0,56  | 0,59  | 0,60  | 0,60  | 0,58  | 0,55  | 0,50  | 0,44  |
| 02                             | 1,03                             | 1,14  | 1,22  | 1,26  | 1,26  | 1,23  | 1,18  | 1,10  | 0,99  | 02                             | 1,03                             | 1,12  | 1,18  | 1,21  | 1,20  | 1,16  | 1,09  | 1,00  | 0,87  |
| 03                             | 1,23                             | 1,35  | 1,44  | 1,48  | 1,48  | 1,45  | 1,39  | 1,29  | 1,16  | 03                             | 1,22                             | 1,33  | 1,39  | 1,42  | 1,41  | 1,36  | 1,28  | 1,17  | 1,02  |
| 04                             | 1,97                             | 2,19  | 2,33  | 2,41  | 2,42  | 2,36  | 2,27  | 2,11  | 1,90  | 04                             | 1,97                             | 2,15  | 2,26  | 2,31  | 2,29  | 2,22  | 2,09  | 1,91  | 1,67  |
| 05                             | 3,38                             | 3,74  | 3,98  | 4,10  | 4,12  | 4,02  | 3,85  | 3,59  | 3,23  | 05                             | 3,37                             | 3,67  | 3,86  | 3,93  | 3,91  | 3,78  | 3,56  | 3,25  | 2,84  |
| 06                             | 4,70                             | 5,19  | 5,52  | 5,69  | 5,71  | 5,58  | 5,34  | 4,97  | 4,47  | 06                             | 4,68                             | 5,10  | 5,35  | 5,46  | 5,42  | 5,24  | 4,94  | 4,50  | 3,94  |
| 07                             | 7,38                             | 8,18  | 8,71  | 9,00  | 9,03  | 8,84  | 8,47  | 7,89  | 7,09  | 07                             | 7,36                             | 8,04  | 8,45  | 8,63  | 8,58  | 8,31  | 7,83  | 7,14  | 6,25  |
| 08                             | 8,91                             | 9,87  | 10,49 | 10,83 | 10,86 | 10,62 | 10,17 | 9,47  | 8,51  | 08                             | 8,89                             | 9,69  | 10,18 | 10,38 | 10,32 | 9,98  | 9,40  | 8,57  | 7,51  |
| 09                             | 9,89                             | 10,95 | 11,63 | 12,00 | 12,04 | 11,77 | 11,27 | 10,49 | 9,43  | 09                             | 9,86                             | 10,75 | 11,29 | 11,51 | 11,43 | 11,06 | 10,42 | 9,50  | 8,32  |

**TABLE 22B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,07 | 1,15 | 1,22 | 1,29 | 1,36 | 1,43 | 1,49 | 1,55 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 22B

**TABLE 23A: Refrigerant R1234ze - Capacities in kW**

| Evaporating Temperature 20 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,54                             | 0,62  | 0,69  | 0,74  | 0,77  | 0,79  | 0,79  | 0,78  | 0,75  | 01                             | 0,55                             | 0,63  | 0,70  | 0,74  | 0,77  | 0,78  | 0,77  | 0,76  | 0,72  |
| 02                             | 1,07                             | 1,25  | 1,38  | 1,48  | 1,54  | 1,58  | 1,58  | 1,55  | 1,50  | 02                             | 1,10                             | 1,27  | 1,39  | 1,48  | 1,53  | 1,55  | 1,55  | 1,51  | 1,45  |
| 03                             | 1,27                             | 1,48  | 1,63  | 1,74  | 1,82  | 1,85  | 1,86  | 1,82  | 1,76  | 03                             | 1,31                             | 1,50  | 1,64  | 1,74  | 1,80  | 1,83  | 1,82  | 1,78  | 1,70  |
| 04                             | 2,05                             | 2,39  | 2,65  | 2,83  | 2,96  | 3,02  | 3,03  | 2,98  | 2,88  | 04                             | 2,11                             | 2,42  | 2,66  | 2,83  | 2,93  | 2,98  | 2,96  | 2,90  | 2,78  |
| 05                             | 3,52                             | 4,08  | 4,51  | 4,83  | 5,03  | 5,14  | 5,15  | 5,07  | 4,89  | 05                             | 3,61                             | 4,14  | 4,54  | 4,82  | 4,99  | 5,07  | 5,04  | 4,93  | 4,72  |
| 06                             | 4,88                             | 5,67  | 6,26  | 6,70  | 6,98  | 7,13  | 7,14  | 7,02  | 6,78  | 06                             | 5,02                             | 5,75  | 6,30  | 6,69  | 6,93  | 7,02  | 6,99  | 6,83  | 6,55  |
| 07                             | 7,68                             | 8,94  | 9,89  | 10,60 | 11,05 | 11,30 | 11,32 | 11,14 | 10,75 | 07                             | 7,88                             | 9,06  | 9,96  | 10,58 | 10,96 | 11,13 | 11,08 | 10,83 | 10,38 |
| 08                             | 9,27                             | 10,77 | 11,91 | 12,75 | 13,29 | 13,58 | 13,60 | 13,37 | 12,91 | 08                             | 9,52                             | 10,93 | 11,99 | 12,72 | 13,18 | 13,37 | 13,32 | 13,01 | 12,47 |
| 09                             | 10,29                            | 11,95 | 13,21 | 14,13 | 14,72 | 15,05 | 15,07 | 14,82 | 14,30 | 09                             | 10,57                            | 12,12 | 13,29 | 14,10 | 14,61 | 14,82 | 14,75 | 14,41 | 13,81 |
| Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,56                             | 0,64  | 0,69  | 0,73  | 0,75  | 0,76  | 0,66  | 0,63  | 0,58  | 01                             | 0,56                             | 0,63  | 0,68  | 0,71  | 0,72  | 0,72  | 0,70  | 0,67  | 0,63  |
| 02                             | 1,13                             | 1,28  | 1,39  | 1,46  | 1,50  | 1,52  | 1,31  | 1,25  | 1,17  | 02                             | 1,13                             | 1,26  | 1,36  | 1,42  | 1,44  | 1,44  | 1,41  | 1,35  | 1,26  |
| 03                             | 1,34                             | 1,51  | 1,64  | 1,72  | 1,77  | 1,78  | 1,54  | 1,47  | 1,37  | 03                             | 1,34                             | 1,49  | 1,60  | 1,67  | 1,70  | 1,69  | 1,65  | 1,58  | 1,48  |
| 04                             | 2,16                             | 2,45  | 2,66  | 2,80  | 2,88  | 2,90  | 2,51  | 2,40  | 2,24  | 04                             | 2,16                             | 2,41  | 2,59  | 2,71  | 2,76  | 2,76  | 2,69  | 2,58  | 2,41  |
| 05                             | 3,69                             | 4,18  | 4,54  | 4,77  | 4,91  | 4,94  | 4,27  | 4,09  | 3,81  | 05                             | 3,69                             | 4,12  | 4,43  | 4,62  | 4,71  | 4,69  | 4,58  | 4,39  | 4,10  |
| 06                             | 5,13                             | 5,80  | 6,29  | 6,62  | 6,81  | 6,85  | 5,92  | 5,67  | 5,28  | 06                             | 5,13                             | 5,73  | 6,14  | 6,41  | 6,53  | 6,51  | 6,36  | 6,08  | 5,69  |
| 07                             | 8,07                             | 9,14  | 9,94  | 10,47 | 10,77 | 10,85 | 9,38  | 8,99  | 8,38  | 07                             | 8,07                             | 9,02  | 9,70  | 10,14 | 10,33 | 10,31 | 10,07 | 9,64  | 9,02  |
| 08                             | 9,74                             | 11,02 | 11,97 | 12,59 | 12,95 | 13,05 | 11,27 | 10,79 | 10,06 | 08                             | 9,74                             | 10,88 | 11,68 | 12,20 | 12,42 | 12,39 | 12,10 | 11,58 | 10,83 |
| 09                             | 10,81                            | 12,23 | 13,27 | 13,96 | 14,36 | 14,46 | 12,49 | 11,96 | 11,14 | 09                             | 10,81                            | 12,07 | 12,95 | 13,52 | 13,77 | 13,73 | 13,41 | 12,83 | 12,00 |
| Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,57                             | 0,62  | 0,66  | 0,69  | 0,69  | 0,68  | 0,66  | 0,62  | 0,57  | 01                             | 0,56                             | 0,60  | 0,63  | 0,65  | 0,65  | 0,63  | 0,60  | 0,56  | 0,50  |
| 02                             | 1,13                             | 1,25  | 1,33  | 1,37  | 1,38  | 1,37  | 1,32  | 1,24  | 1,15  | 02                             | 1,12                             | 1,21  | 1,27  | 1,30  | 1,30  | 1,26  | 1,20  | 1,11  | 1,00  |
| 03                             | 1,35                             | 1,47  | 1,56  | 1,61  | 1,63  | 1,61  | 1,55  | 1,46  | 1,34  | 03                             | 1,32                             | 1,43  | 1,50  | 1,53  | 1,53  | 1,49  | 1,41  | 1,31  | 1,17  |
| 04                             | 2,17                             | 2,39  | 2,54  | 2,62  | 2,65  | 2,62  | 2,53  | 2,38  | 2,19  | 04                             | 2,13                             | 2,31  | 2,43  | 2,49  | 2,48  | 2,42  | 2,30  | 2,13  | 1,91  |
| 05                             | 3,72                             | 4,08  | 4,33  | 4,47  | 4,51  | 4,45  | 4,30  | 4,06  | 3,73  | 05                             | 3,65                             | 3,95  | 4,15  | 4,24  | 4,23  | 4,12  | 3,92  | 3,63  | 3,25  |
| 06                             | 5,16                             | 5,66  | 6,01  | 6,21  | 6,26  | 6,17  | 5,96  | 5,62  | 5,17  | 06                             | 5,07                             | 5,48  | 5,75  | 5,88  | 5,87  | 5,71  | 5,43  | 5,03  | 4,51  |
| 07                             | 8,11                             | 8,92  | 9,49  | 9,81  | 9,90  | 9,78  | 9,45  | 8,92  | 8,20  | 07                             | 7,97                             | 8,64  | 9,09  | 9,30  | 9,29  | 9,05  | 8,61  | 7,97  | 7,15  |
| 08                             | 9,80                             | 10,76 | 11,43 | 11,81 | 11,91 | 11,75 | 11,35 | 10,71 | 9,85  | 08                             | 9,63                             | 10,41 | 10,94 | 11,19 | 11,17 | 10,88 | 10,35 | 9,58  | 8,58  |
| 09                             | 10,88                            | 11,93 | 12,67 | 13,09 | 13,20 | 13,02 | 12,58 | 11,86 | 10,91 | 09                             | 10,69                            | 11,55 | 12,13 | 12,41 | 12,37 | 12,05 | 11,46 | 10,61 | 9,51  |

**TABLE: 23B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,06 | 1,12 | 1,18 | 1,24 | 1,30 | 1,36 | 1,44 | 1,49 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 23B

**TABLE 24A: Refrigerant R448A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,63                             | 0,77  | 0,89  | 1,00  | 1,09  | 1,17  | 1,24  | 1,29  | 1,33  | 01                             | 0,66                             | 0,80  | 0,93  | 1,03  | 1,13  | 1,20  | 1,27  | 1,32  | 1,36  |
| 02                             | 1,26                             | 1,54  | 1,79  | 2,00  | 2,19  | 2,35  | 2,48  | 2,58  | 2,66  | 02                             | 1,32                             | 1,61  | 1,85  | 2,07  | 2,25  | 2,41  | 2,54  | 2,64  | 2,73  |
| 03                             | 1,50                             | 1,83  | 2,11  | 2,36  | 2,58  | 2,76  | 2,91  | 3,03  | 3,12  | 03                             | 1,57                             | 1,90  | 2,19  | 2,43  | 2,65  | 2,83  | 2,98  | 3,10  | 3,20  |
| 04                             | 2,42                             | 2,96  | 3,43  | 3,84  | 4,19  | 4,49  | 4,74  | 4,94  | 5,10  | 04                             | 2,53                             | 3,07  | 3,55  | 3,96  | 4,31  | 4,61  | 4,86  | 5,06  | 5,22  |
| 05                             | 4,14                             | 5,05  | 5,84  | 6,54  | 7,14  | 7,65  | 8,07  | 8,41  | 8,67  | 05                             | 4,34                             | 5,25  | 6,05  | 6,75  | 7,35  | 7,85  | 8,27  | 8,61  | 8,88  |
| 06                             | 5,75                             | 7,01  | 8,11  | 9,07  | 9,90  | 10,60 | 11,19 | 11,66 | 12,02 | 06                             | 6,02                             | 7,29  | 8,40  | 9,36  | 10,19 | 10,88 | 11,47 | 11,94 | 12,30 |
| 07                             | 9,04                             | 11,05 | 12,81 | 14,34 | 15,67 | 16,80 | 17,74 | 18,49 | 19,07 | 07                             | 9,47                             | 11,49 | 13,26 | 14,80 | 16,13 | 17,24 | 18,17 | 18,93 | 19,52 |
| 08                             | 10,92                            | 13,32 | 15,42 | 17,25 | 18,85 | 20,19 | 21,31 | 22,20 | 22,90 | 08                             | 11,44                            | 13,86 | 15,97 | 17,80 | 19,39 | 20,72 | 21,83 | 22,74 | 23,44 |
| 09                             | 12,13                            | 14,78 | 17,10 | 19,12 | 20,89 | 22,37 | 23,61 | 24,60 | 25,37 | 09                             | 12,69                            | 15,37 | 17,71 | 19,73 | 21,49 | 22,96 | 24,19 | 25,19 | 25,96 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,69                             | 0,83  | 0,95  | 1,05  | 1,14  | 1,22  | 1,20  | 1,25  | 1,28  | 01                             | 0,71                             | 0,84  | 0,96  | 1,06  | 1,15  | 1,22  | 1,28  | 1,33  | 1,36  |
| 02                             | 1,37                             | 1,65  | 1,90  | 2,11  | 2,29  | 2,44  | 2,41  | 2,50  | 2,57  | 02                             | 1,41                             | 1,68  | 1,92  | 2,12  | 2,30  | 2,44  | 2,56  | 2,66  | 2,73  |
| 03                             | 1,63                             | 1,96  | 2,24  | 2,48  | 2,69  | 2,87  | 2,83  | 2,94  | 3,01  | 03                             | 1,68                             | 1,99  | 2,27  | 2,50  | 2,70  | 2,87  | 3,01  | 3,12  | 3,20  |
| 04                             | 2,63                             | 3,16  | 3,63  | 4,03  | 4,38  | 4,67  | 4,61  | 4,79  | 4,92  | 04                             | 2,70                             | 3,22  | 3,68  | 4,07  | 4,40  | 4,68  | 4,91  | 5,09  | 5,22  |
| 05                             | 4,50                             | 5,41  | 6,19  | 6,87  | 7,46  | 7,95  | 7,85  | 8,15  | 8,36  | 05                             | 4,62                             | 5,50  | 6,27  | 6,93  | 7,49  | 7,96  | 8,35  | 8,65  | 8,88  |
| 06                             | 6,25                             | 7,50  | 8,60  | 9,54  | 10,35 | 11,03 | 10,88 | 11,30 | 11,59 | 06                             | 6,42                             | 7,64  | 8,70  | 9,61  | 10,39 | 11,04 | 11,58 | 12,00 | 12,30 |
| 07                             | 9,82                             | 11,83 | 13,58 | 15,08 | 16,38 | 17,47 | 17,24 | 17,92 | 18,39 | 07                             | 10,09                            | 12,05 | 13,74 | 15,20 | 16,44 | 17,48 | 18,35 | 19,02 | 19,52 |
| 08                             | 11,86                            | 14,26 | 16,35 | 18,14 | 19,70 | 21,00 | 20,72 | 21,52 | 22,08 | 08                             | 12,19                            | 14,52 | 16,55 | 18,29 | 19,77 | 21,01 | 22,04 | 22,84 | 23,44 |
| 09                             | 13,16                            | 15,82 | 18,12 | 20,11 | 21,83 | 23,27 | 22,95 | 23,84 | 24,46 | 09                             | 13,53                            | 16,11 | 18,35 | 20,27 | 21,91 | 23,28 | 24,42 | 25,31 | 25,96 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,72                             | 0,85  | 0,96  | 1,06  | 1,14  | 1,21  | 1,27  | 1,31  | 1,34  | 01                             | 0,73                             | 0,86  | 0,96  | 1,05  | 1,13  | 1,19  | 1,24  | 1,28  | 1,31  |
| 02                             | 1,44                             | 1,70  | 1,93  | 2,12  | 2,29  | 2,42  | 2,53  | 2,62  | 2,68  | 02                             | 1,47                             | 1,71  | 1,93  | 2,11  | 2,26  | 2,39  | 2,49  | 2,56  | 2,61  |
| 03                             | 1,71                             | 2,01  | 2,27  | 2,50  | 2,69  | 2,85  | 2,97  | 3,07  | 3,14  | 03                             | 1,74                             | 2,03  | 2,27  | 2,48  | 2,66  | 2,81  | 2,92  | 3,01  | 3,06  |
| 04                             | 2,75                             | 3,26  | 3,69  | 4,06  | 4,38  | 4,64  | 4,85  | 5,01  | 5,13  | 04                             | 2,81                             | 3,28  | 3,69  | 4,04  | 4,33  | 4,57  | 4,76  | 4,91  | 5,00  |
| 05                             | 4,72                             | 5,56  | 6,30  | 6,92  | 7,46  | 7,90  | 8,26  | 8,52  | 8,73  | 05                             | 4,81                             | 5,60  | 6,30  | 6,88  | 7,38  | 7,78  | 8,10  | 8,35  | 8,51  |
| 06                             | 6,55                             | 7,72  | 8,73  | 9,60  | 10,34 | 10,95 | 11,45 | 11,82 | 12,10 | 06                             | 6,68                             | 7,78  | 8,73  | 9,55  | 10,23 | 10,79 | 11,23 | 11,57 | 11,79 |
| 07                             | 10,30                            | 12,17 | 13,79 | 15,19 | 16,37 | 17,34 | 18,14 | 18,74 | 19,19 | 07                             | 10,50                            | 12,26 | 13,79 | 15,10 | 16,19 | 17,10 | 17,80 | 18,35 | 18,70 |
| 08                             | 12,44                            | 14,67 | 16,61 | 18,27 | 19,68 | 20,84 | 21,79 | 22,50 | 23,04 | 08                             | 12,69                            | 14,78 | 16,61 | 18,17 | 19,47 | 20,55 | 21,39 | 22,03 | 22,45 |
| 09                             | 13,81                            | 16,28 | 18,42 | 20,26 | 21,81 | 23,09 | 24,15 | 24,93 | 25,52 | 09                             | 14,08                            | 16,40 | 18,42 | 20,14 | 21,58 | 22,77 | 23,70 | 24,41 | 24,87 |

**TABLE 24B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,07 | 1,14 | 1,20 | 1,27 | 1,33 | 1,40 | 1,48 | 1,54 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 24B

**TABLE 25A: Refrigerant R449A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,76                             | 0,93  | 1,08  | 1,21  | 1,33  | 1,43  | 1,52  | 1,60  | 1,66  | 01                             | 0,74                             | 0,90  | 1,05  | 1,18  | 1,29  | 1,39  | 1,48  | 1,55  | 1,61  |
| 02                             | 1,51                             | 1,85  | 2,15  | 2,42  | 2,66  | 2,87  | 3,05  | 3,20  | 3,33  | 02                             | 1,48                             | 1,81  | 2,10  | 2,36  | 2,58  | 2,78  | 2,95  | 3,10  | 3,21  |
| 03                             | 1,79                             | 2,19  | 2,54  | 2,85  | 3,13  | 3,37  | 3,58  | 3,76  | 3,90  | 03                             | 1,76                             | 2,14  | 2,47  | 2,77  | 3,04  | 3,27  | 3,47  | 3,63  | 3,77  |
| 04                             | 2,89                             | 3,54  | 4,12  | 4,63  | 5,09  | 5,49  | 5,83  | 6,13  | 6,38  | 04                             | 2,83                             | 3,46  | 4,02  | 4,51  | 4,95  | 5,33  | 5,65  | 5,93  | 6,15  |
| 05                             | 4,95                             | 6,05  | 7,03  | 7,90  | 8,67  | 9,34  | 9,93  | 10,43 | 10,84 | 05                             | 4,84                             | 5,91  | 6,85  | 7,69  | 8,43  | 9,07  | 9,62  | 10,08 | 10,46 |
| 06                             | 6,88                             | 8,40  | 9,75  | 10,95 | 12,02 | 12,95 | 13,76 | 14,46 | 15,03 | 06                             | 6,73                             | 8,20  | 9,51  | 10,66 | 11,69 | 12,57 | 13,34 | 13,98 | 14,50 |
| 07                             | 10,81                            | 13,24 | 15,40 | 17,32 | 19,03 | 20,52 | 21,81 | 22,93 | 23,84 | 07                             | 10,58                            | 12,93 | 15,01 | 16,86 | 18,50 | 19,92 | 21,14 | 22,16 | 23,01 |
| 08                             | 13,05                            | 15,96 | 18,54 | 20,84 | 22,88 | 24,66 | 26,21 | 27,54 | 28,63 | 08                             | 12,78                            | 15,59 | 18,08 | 20,29 | 22,24 | 23,94 | 25,40 | 26,62 | 27,62 |
| 09                             | 14,49                            | 17,70 | 20,56 | 23,10 | 25,35 | 27,33 | 29,04 | 30,51 | 31,71 | 09                             | 14,18                            | 17,29 | 20,04 | 22,49 | 24,65 | 26,53 | 28,14 | 29,49 | 30,60 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,77                             | 0,93  | 1,07  | 1,20  | 1,31  | 1,41  | 1,49  | 1,56  | 1,62  | 01                             | 0,78                             | 0,94  | 1,08  | 1,21  | 1,32  | 1,41  | 1,49  | 1,55  | 1,61  |
| 02                             | 1,53                             | 1,86  | 2,15  | 2,40  | 2,63  | 2,82  | 2,99  | 3,13  | 3,24  | 02                             | 1,57                             | 1,89  | 2,17  | 2,42  | 2,63  | 2,82  | 2,98  | 3,11  | 3,22  |
| 03                             | 1,82                             | 2,20  | 2,53  | 2,83  | 3,09  | 3,31  | 3,51  | 3,67  | 3,80  | 03                             | 1,86                             | 2,23  | 2,56  | 2,84  | 3,09  | 3,31  | 3,50  | 3,65  | 3,77  |
| 04                             | 2,93                             | 3,56  | 4,11  | 4,60  | 5,03  | 5,40  | 5,72  | 5,99  | 6,21  | 04                             | 3,00                             | 3,61  | 4,15  | 4,62  | 5,04  | 5,40  | 5,70  | 5,96  | 6,16  |
| 05                             | 5,02                             | 6,08  | 7,01  | 7,84  | 8,56  | 9,19  | 9,73  | 10,19 | 10,55 | 05                             | 5,14                             | 6,17  | 7,08  | 7,88  | 8,58  | 9,19  | 9,70  | 10,13 | 10,48 |
| 06                             | 6,97                             | 8,43  | 9,73  | 10,87 | 11,88 | 12,75 | 13,49 | 14,12 | 14,63 | 06                             | 7,13                             | 8,57  | 9,83  | 10,93 | 11,90 | 12,74 | 13,45 | 14,04 | 14,53 |
| 07                             | 10,95                            | 13,30 | 15,36 | 17,19 | 18,80 | 20,19 | 21,38 | 22,40 | 23,20 | 07                             | 11,21                            | 13,50 | 15,52 | 17,29 | 18,84 | 20,18 | 21,32 | 22,27 | 23,04 |
| 08                             | 13,23                            | 16,03 | 18,50 | 20,68 | 22,60 | 24,27 | 25,69 | 26,90 | 27,86 | 08                             | 13,54                            | 16,28 | 18,68 | 20,80 | 22,65 | 24,25 | 25,61 | 26,75 | 27,67 |
| 09                             | 14,69                            | 17,78 | 20,51 | 22,93 | 25,05 | 26,89 | 28,46 | 29,80 | 30,86 | 09                             | 15,03                            | 18,06 | 20,72 | 23,06 | 25,10 | 26,87 | 28,37 | 29,63 | 30,65 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,80                             | 0,95  | 1,09  | 1,20  | 1,31  | 1,40  | 1,47  | 1,53  | 1,58  | 01                             | 0,82                             | 0,96  | 1,09  | 1,21  | 1,31  | 1,39  | 1,46  | 1,52  | 1,57  |
| 02                             | 1,59                             | 1,90  | 2,17  | 2,41  | 2,61  | 2,79  | 2,94  | 3,06  | 3,16  | 02                             | 1,63                             | 1,93  | 2,19  | 2,42  | 2,61  | 2,78  | 2,93  | 3,04  | 3,13  |
| 03                             | 1,89                             | 2,25  | 2,56  | 2,84  | 3,07  | 3,28  | 3,45  | 3,59  | 3,71  | 03                             | 1,94                             | 2,28  | 2,58  | 2,84  | 3,07  | 3,27  | 3,43  | 3,57  | 3,67  |
| 04                             | 3,05                             | 3,64  | 4,16  | 4,61  | 5,00  | 5,34  | 5,63  | 5,87  | 6,05  | 04                             | 3,12                             | 3,69  | 4,19  | 4,62  | 5,00  | 5,33  | 5,60  | 5,82  | 6,00  |
| 05                             | 5,22                             | 6,21  | 7,09  | 7,86  | 8,52  | 9,10  | 9,58  | 9,98  | 10,30 | 05                             | 5,35                             | 6,30  | 7,14  | 7,88  | 8,52  | 9,08  | 9,53  | 9,91  | 10,21 |
| 06                             | 7,25                             | 8,62  | 9,84  | 10,90 | 11,82 | 12,61 | 13,29 | 13,83 | 14,27 | 06                             | 7,43                             | 8,75  | 9,91  | 10,93 | 11,82 | 12,58 | 13,22 | 13,73 | 14,15 |
| 07                             | 11,39                            | 13,59 | 15,54 | 17,23 | 18,71 | 19,98 | 21,06 | 21,93 | 22,64 | 07                             | 11,68                            | 13,79 | 15,65 | 17,29 | 18,71 | 19,93 | 20,95 | 21,77 | 22,44 |
| 08                             | 13,76                            | 16,39 | 18,71 | 20,73 | 22,50 | 24,01 | 25,30 | 26,34 | 27,18 | 08                             | 14,11                            | 16,62 | 18,85 | 20,80 | 22,50 | 23,96 | 25,17 | 26,15 | 26,95 |
| 09                             | 15,28                            | 18,18 | 20,74 | 22,98 | 24,93 | 26,60 | 28,03 | 29,18 | 30,11 | 09                             | 15,66                            | 18,44 | 20,90 | 23,06 | 24,93 | 26,55 | 27,88 | 28,97 | 29,85 |

**TABLE: 25B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,07 | 1,14 | 1,21 | 1,27 | 1,34 | 1,40 | 1,48 | 1,54 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 25B



**TABLE 26A: Refrigerant R450A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,57                             | 0,67  | 0,75  | 0,81  | 0,85  | 0,88  | 0,89  | 0,89  | 0,87  | 01                             | 0,59                             | 0,68  | 0,75  | 0,80  | 0,84  | 0,86  | 0,87  | 0,86  | 0,85  |
| 02                             | 1,15                             | 1,34  | 1,50  | 1,61  | 1,70  | 1,75  | 1,78  | 1,78  | 1,75  | 02                             | 1,18                             | 1,36  | 1,50  | 1,61  | 1,68  | 1,73  | 1,74  | 1,73  | 1,69  |
| 03                             | 1,36                             | 1,59  | 1,76  | 1,90  | 2,00  | 2,06  | 2,09  | 2,08  | 2,05  | 03                             | 1,40                             | 1,61  | 1,77  | 1,89  | 1,98  | 2,03  | 2,04  | 2,03  | 1,98  |
| 04                             | 2,20                             | 2,57  | 2,86  | 3,09  | 3,25  | 3,36  | 3,41  | 3,40  | 3,35  | 04                             | 2,25                             | 2,60  | 2,87  | 3,08  | 3,22  | 3,31  | 3,33  | 3,31  | 3,24  |
| 05                             | 3,76                             | 4,39  | 4,88  | 5,26  | 5,53  | 5,71  | 5,80  | 5,79  | 5,70  | 05                             | 3,85                             | 4,44  | 4,90  | 5,24  | 5,48  | 5,63  | 5,67  | 5,63  | 5,51  |
| 06                             | 5,22                             | 6,09  | 6,77  | 7,30  | 7,67  | 7,92  | 8,04  | 8,02  | 7,90  | 06                             | 5,35                             | 6,16  | 6,80  | 7,27  | 7,60  | 7,80  | 7,86  | 7,81  | 7,64  |
| 07                             | 8,21                             | 9,60  | 10,70 | 11,54 | 12,15 | 12,54 | 12,74 | 12,72 | 12,53 | 07                             | 8,41                             | 9,71  | 10,74 | 11,50 | 12,03 | 12,36 | 12,46 | 12,38 | 12,12 |
| 08                             | 9,92                             | 11,57 | 12,88 | 13,89 | 14,60 | 15,08 | 15,30 | 15,27 | 15,04 | 08                             | 10,16                            | 11,71 | 12,93 | 13,84 | 14,47 | 14,85 | 14,97 | 14,87 | 14,55 |
| 09                             | 11,01                            | 12,84 | 14,28 | 15,40 | 16,19 | 16,71 | 16,95 | 16,92 | 16,66 | 09                             | 11,27                            | 12,98 | 14,33 | 15,34 | 16,03 | 16,46 | 16,59 | 16,47 | 16,12 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,60                             | 0,68  | 0,74  | 0,79  | 0,82  | 0,84  | 0,84  | 0,83  | 0,80  | 01                             | 0,60                             | 0,67  | 0,73  | 0,77  | 0,80  | 0,81  | 0,80  | 0,78  | 0,75  |
| 02                             | 1,19                             | 1,36  | 1,48  | 1,58  | 1,64  | 1,67  | 1,68  | 1,65  | 1,60  | 02                             | 1,20                             | 1,35  | 1,46  | 1,54  | 1,59  | 1,61  | 1,60  | 1,57  | 1,50  |
| 03                             | 1,41                             | 1,60  | 1,75  | 1,86  | 1,93  | 1,97  | 1,97  | 1,94  | 1,88  | 03                             | 1,42                             | 1,59  | 1,72  | 1,82  | 1,87  | 1,89  | 1,88  | 1,84  | 1,76  |
| 04                             | 2,28                             | 2,59  | 2,84  | 3,02  | 3,14  | 3,21  | 3,21  | 3,17  | 3,07  | 04                             | 2,29                             | 2,58  | 2,80  | 2,95  | 3,05  | 3,09  | 3,07  | 3,00  | 2,88  |
| 05                             | 3,90                             | 4,43  | 4,85  | 5,15  | 5,35  | 5,46  | 5,47  | 5,39  | 5,23  | 05                             | 3,92                             | 4,40  | 4,77  | 5,03  | 5,19  | 5,26  | 5,22  | 5,11  | 4,90  |
| 06                             | 5,42                             | 6,15  | 6,73  | 7,15  | 7,42  | 7,57  | 7,58  | 7,47  | 7,25  | 06                             | 5,45                             | 6,11  | 6,62  | 6,98  | 7,20  | 7,29  | 7,24  | 7,08  | 6,79  |
| 07                             | 8,51                             | 9,70  | 10,63 | 11,30 | 11,74 | 11,99 | 12,01 | 11,85 | 11,49 | 07                             | 8,56                             | 9,63  | 10,46 | 11,04 | 11,39 | 11,54 | 11,47 | 11,22 | 10,77 |
| 08                             | 10,28                            | 11,70 | 12,79 | 13,60 | 14,12 | 14,40 | 14,43 | 14,23 | 13,80 | 08                             | 10,34                            | 11,62 | 12,60 | 13,29 | 13,70 | 13,87 | 13,78 | 13,48 | 12,93 |
| 09                             | 11,41                            | 12,97 | 14,19 | 15,08 | 15,65 | 15,96 | 15,99 | 15,76 | 15,29 | 09                             | 11,48                            | 12,89 | 13,97 | 14,73 | 15,18 | 15,37 | 15,27 | 14,93 | 14,33 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,60                             | 0,66  | 0,71  | 0,74  | 0,76  | 0,76  | 0,75  | 0,73  | 0,69  | 01                             | 0,61                             | 0,66  | 0,70  | 0,73  | 0,74  | 0,74  | 0,73  | 0,70  | 0,66  |
| 02                             | 1,20                             | 1,33  | 1,42  | 1,49  | 1,52  | 1,53  | 1,51  | 1,46  | 1,38  | 02                             | 1,21                             | 1,32  | 1,41  | 1,46  | 1,49  | 1,49  | 1,45  | 1,40  | 1,31  |
| 03                             | 1,42                             | 1,57  | 1,68  | 1,75  | 1,79  | 1,80  | 1,77  | 1,71  | 1,62  | 03                             | 1,44                             | 1,56  | 1,66  | 1,72  | 1,75  | 1,75  | 1,71  | 1,64  | 1,54  |
| 04                             | 2,29                             | 2,54  | 2,72  | 2,85  | 2,92  | 2,93  | 2,88  | 2,79  | 2,64  | 04                             | 2,31                             | 2,53  | 2,70  | 2,80  | 2,85  | 2,85  | 2,78  | 2,67  | 2,51  |
| 05                             | 3,92                             | 4,34  | 4,65  | 4,86  | 4,97  | 4,98  | 4,91  | 4,74  | 4,49  | 05                             | 3,96                             | 4,32  | 4,60  | 4,78  | 4,86  | 4,84  | 4,74  | 4,55  | 4,27  |
| 06                             | 5,45                             | 6,02  | 6,45  | 6,74  | 6,89  | 6,91  | 6,80  | 6,57  | 6,23  | 06                             | 5,51                             | 6,00  | 6,39  | 6,63  | 6,73  | 6,72  | 6,57  | 6,31  | 5,92  |
| 07                             | 8,56                             | 9,49  | 10,19 | 10,65 | 10,90 | 10,94 | 10,78 | 10,43 | 9,88  | 07                             | 8,65                             | 9,46  | 10,09 | 10,48 | 10,66 | 10,64 | 10,41 | 10,00 | 9,39  |
| 08                             | 10,34                            | 11,44 | 12,27 | 12,82 | 13,10 | 13,15 | 12,95 | 12,52 | 11,86 | 08                             | 10,45                            | 11,40 | 12,14 | 12,61 | 12,82 | 12,79 | 12,51 | 12,01 | 11,27 |
| 09                             | 11,47                            | 12,69 | 13,60 | 14,21 | 14,52 | 14,57 | 14,35 | 13,87 | 13,14 | 09                             | 11,60                            | 12,65 | 13,47 | 13,97 | 14,20 | 14,17 | 13,86 | 13,30 | 12,49 |

**TABLE 26B - Correction factors for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,06 | 1,12 | 1,18 | 1,24 | 1,30 | 1,36 | 1,40 | 1,45 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 26B

**TABLE 27A: Refrigerant R452A - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,57                             | 0,69  | 0,80  | 0,89  | 0,97  | 1,03  | 1,08  | 1,12  | 1,14  | 01                             | 0,60                             | 0,72  | 0,83  | 0,92  | 1,00  | 1,06  | 1,11  | 1,15  | 1,17  |
| 02                             | 1,14                             | 1,38  | 1,60  | 1,78  | 1,93  | 2,06  | 2,16  | 2,23  | 2,28  | 02                             | 1,19                             | 1,44  | 1,66  | 1,84  | 1,99  | 2,12  | 2,22  | 2,29  | 2,34  |
| 03                             | 1,35                             | 1,64  | 1,88  | 2,10  | 2,27  | 2,42  | 2,54  | 2,62  | 2,67  | 03                             | 1,41                             | 1,70  | 1,95  | 2,17  | 2,35  | 2,49  | 2,61  | 2,69  | 2,75  |
| 04                             | 2,17                             | 2,65  | 3,06  | 3,41  | 3,70  | 3,94  | 4,14  | 4,28  | 4,37  | 04                             | 2,28                             | 2,76  | 3,17  | 3,52  | 3,82  | 4,06  | 4,25  | 4,39  | 4,49  |
| 05                             | 3,72                             | 4,52  | 5,21  | 5,81  | 6,31  | 6,72  | 7,04  | 7,27  | 7,42  | 05                             | 3,90                             | 4,71  | 5,41  | 6,00  | 6,50  | 6,91  | 7,23  | 7,47  | 7,63  |
| 06                             | 5,17                             | 6,28  | 7,23  | 8,06  | 8,75  | 9,31  | 9,76  | 10,08 | 10,29 | 06                             | 5,42                             | 6,54  | 7,51  | 8,32  | 9,02  | 9,58  | 10,03 | 10,36 | 10,57 |
| 07                             | 8,12                             | 9,90  | 11,42 | 12,74 | 13,85 | 14,75 | 15,46 | 15,98 | 16,32 | 07                             | 8,51                             | 10,30 | 11,85 | 13,16 | 14,28 | 15,18 | 15,90 | 16,43 | 16,77 |
| 08                             | 9,81                             | 11,93 | 13,75 | 15,33 | 16,65 | 17,73 | 18,58 | 19,20 | 19,60 | 08                             | 10,28                            | 12,42 | 14,27 | 15,84 | 17,16 | 18,24 | 19,10 | 19,73 | 20,14 |
| 09                             | 10,89                            | 13,23 | 15,25 | 16,99 | 18,45 | 19,64 | 20,58 | 21,27 | 21,71 | 09                             | 11,41                            | 13,78 | 15,83 | 17,56 | 19,02 | 20,21 | 21,16 | 21,86 | 22,31 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,62                             | 0,74  | 0,85  | 0,94  | 1,01  | 1,07  | 1,12  | 1,16  | 1,18  | 01                             | 0,63                             | 0,75  | 0,86  | 0,94  | 1,01  | 1,07  | 1,12  | 1,15  | 1,17  |
| 02                             | 1,23                             | 1,48  | 1,69  | 1,87  | 2,03  | 2,15  | 2,24  | 2,31  | 2,36  | 02                             | 1,27                             | 1,51  | 1,71  | 1,89  | 2,03  | 2,14  | 2,23  | 2,29  | 2,33  |
| 03                             | 1,47                             | 1,75  | 2,00  | 2,21  | 2,38  | 2,52  | 2,63  | 2,72  | 2,76  | 03                             | 1,51                             | 1,78  | 2,02  | 2,22  | 2,38  | 2,52  | 2,62  | 2,69  | 2,73  |
| 04                             | 2,36                             | 2,83  | 3,24  | 3,59  | 3,88  | 4,11  | 4,29  | 4,43  | 4,51  | 04                             | 2,43                             | 2,89  | 3,28  | 3,61  | 3,88  | 4,11  | 4,27  | 4,39  | 4,46  |
| 05                             | 4,04                             | 4,84  | 5,53  | 6,12  | 6,61  | 7,00  | 7,31  | 7,54  | 7,67  | 05                             | 4,15                             | 4,93  | 5,60  | 6,16  | 6,61  | 6,99  | 7,27  | 7,47  | 7,59  |
| 06                             | 5,62                             | 6,72  | 7,68  | 8,48  | 9,16  | 9,70  | 10,13 | 10,45 | 10,63 | 06                             | 5,77                             | 6,85  | 7,77  | 8,54  | 9,17  | 9,69  | 10,08 | 10,36 | 10,52 |
| 07                             | 8,83                             | 10,59 | 12,13 | 13,42 | 14,50 | 15,37 | 16,06 | 16,57 | 16,87 | 07                             | 9,07                             | 10,80 | 12,27 | 13,50 | 14,52 | 15,35 | 15,98 | 16,43 | 16,69 |
| 08                             | 10,66                            | 12,77 | 14,60 | 16,14 | 17,44 | 18,47 | 19,29 | 19,90 | 20,26 | 08                             | 10,95                            | 13,02 | 14,77 | 16,24 | 17,45 | 18,45 | 19,19 | 19,73 | 20,05 |
| 09                             | 11,84                            | 14,17 | 16,19 | 17,89 | 19,33 | 20,46 | 21,37 | 22,05 | 22,44 | 09                             | 12,16                            | 14,44 | 16,38 | 18,01 | 19,34 | 20,44 | 21,26 | 21,86 | 22,20 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,64                             | 0,76  | 0,85  | 0,94  | 1,00  | 1,05  | 1,09  | 1,12  | 1,13  | 01                             | 0,65                             | 0,76  | 0,85  | 0,93  | 0,99  | 1,03  | 1,07  | 1,09  | 1,10  |
| 02                             | 1,29                             | 1,52  | 1,71  | 1,87  | 2,00  | 2,11  | 2,19  | 2,24  | 2,27  | 02                             | 1,31                             | 1,52  | 1,70  | 1,85  | 1,97  | 2,07  | 2,14  | 2,18  | 2,20  |
| 03                             | 1,53                             | 1,80  | 2,02  | 2,20  | 2,36  | 2,48  | 2,57  | 2,63  | 2,66  | 03                             | 1,56                             | 1,80  | 2,01  | 2,18  | 2,32  | 2,43  | 2,51  | 2,56  | 2,58  |
| 04                             | 2,46                             | 2,91  | 3,27  | 3,58  | 3,84  | 4,04  | 4,19  | 4,29  | 4,35  | 04                             | 2,50                             | 2,91  | 3,26  | 3,55  | 3,78  | 3,96  | 4,09  | 4,18  | 4,21  |
| 05                             | 4,22                             | 4,97  | 5,58  | 6,11  | 6,54  | 6,87  | 7,12  | 7,30  | 7,39  | 05                             | 4,29                             | 4,98  | 5,56  | 6,05  | 6,44  | 6,74  | 6,96  | 7,10  | 7,16  |
| 06                             | 5,86                             | 6,89  | 7,74  | 8,47  | 9,07  | 9,53  | 9,88  | 10,11 | 10,24 | 06                             | 5,96                             | 6,91  | 7,72  | 8,39  | 8,93  | 9,35  | 9,65  | 9,84  | 9,92  |
| 07                             | 9,20                             | 10,86 | 12,23 | 13,39 | 14,35 | 15,09 | 15,66 | 16,04 | 16,25 | 07                             | 9,36                             | 10,89 | 12,19 | 13,27 | 14,14 | 14,81 | 15,30 | 15,61 | 15,74 |
| 08                             | 11,12                            | 13,10 | 14,73 | 16,11 | 17,26 | 18,14 | 18,81 | 19,26 | 19,51 | 08                             | 11,31                            | 13,13 | 14,68 | 15,97 | 17,00 | 17,80 | 18,38 | 18,75 | 18,90 |
| 09                             | 12,34                            | 14,53 | 16,33 | 17,86 | 19,12 | 20,10 | 20,84 | 21,34 | 21,61 | 09                             | 12,56                            | 14,57 | 16,28 | 17,70 | 18,84 | 19,72 | 20,37 | 20,77 | 20,94 |

**TABLE: 27B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,14 | 1,15 | 1,23 | 1,30 | 1,37 | 1,45 | 1,49 | 1,56 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 25B

# CHAPTER 4 ■

## SOLENOID EXPANSION VALVES

### CERTIFIED BY UNDERWRITERS LABORATORIES INC.

#### FOR REFRIGERATION PLANTS THAT USE HCFC OR HFC REFRIGERANTS, HFO



### APPLICATIONS

The solenoid expansion valves in series 2028UL illustrated in this chapter can be used in a wide range of applications as listed below:

- Refrigeration systems (display cases in supermarkets, freezers, ice cream and icemaker machines, refrigerated shipping, etc.).
- Air conditioning systems
- Heat pump systems
- Liquid chillers

That use the following refrigerant fluids:

- HCFC (R22)
- HFC (R134a, R404A, R407C, R410A, or R507)
- HFO and HFO/HFC mixtures (R1234ze, R448A, R449A, R450A, and R452A)

belonging to Group 2, as defined in Article 13, Chapter 1(b) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

For specific applications with refrigerant fluids not listed above, please contact Castel Technical Department.

### OPERATION

Please refer to Chapter 3, second paragraph, for the description of the operation of the valves in series 2028UL, as it is identical to that of valves in series 2028.

### CONSTRUCTION

The valves in series 2028UL are supplied complete with orifice. Nine different orifices with nine different maximum capacities that range from orifice 01 to orifice 09 can be assembled. The last two numbers in the part number identify the type of orifice that has been mounted on the valve at the factory. For example, part number 2028UL/3S02 identifies a 3/8" valve with solder connections and size 02

orifice. The orifices are interchangeable and can be mounted even after the valve is soldered on the system. If you wish to change orifice, purchase the corresponding spare parts kit, according to the part number indicated in Table 29. Inside the valve body is a ring mesh filter that traps dirt and contaminants at the valve inlet.

Valves in series 2028UL are sold exclusively in the model without coil (suffix S).

### SELECTION

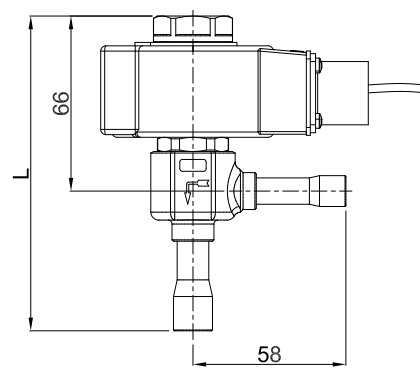
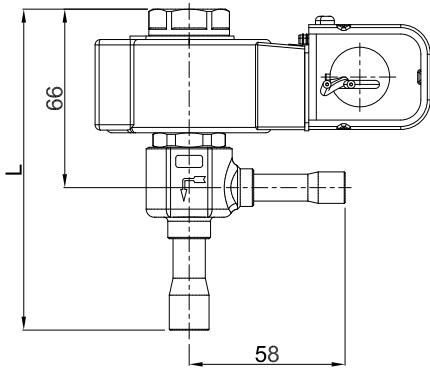
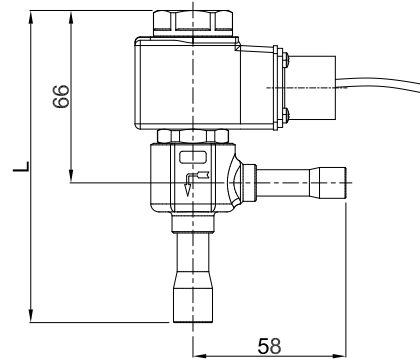
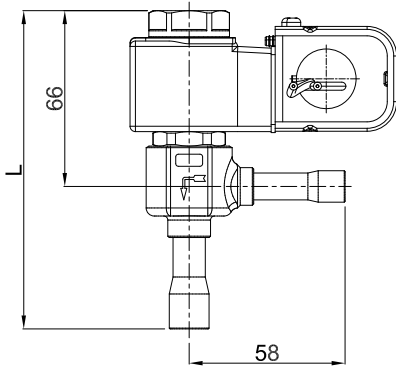
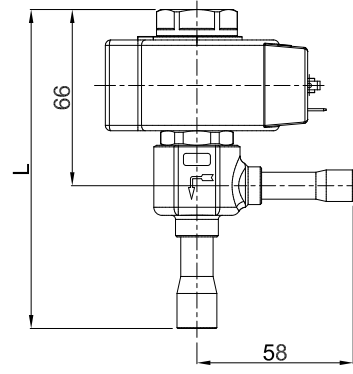
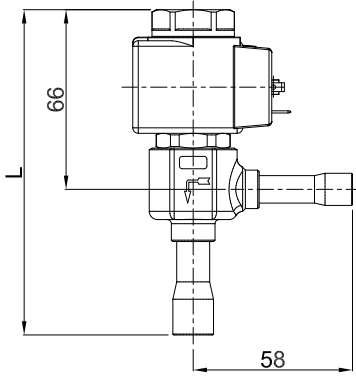
Please refer to Chapter 3, paragraph 4, for the description of the operation of the valves in series 2028UL, as it is identical to that of valves in series 2028.

### CERTIFICATIONS

Le Solenoid expansion valves serie 2028UL sono The American certification authority Underwriters Laboratories Inc. has approved the expansion valves in series 2028UL. The valves are certified **UL-CSA Listed** for the USA and Canada with file MH50005, in compliance with American standard UL 429 and Canadian standard C22.2 No. 139-13.

**N.B.: The UL Listed certification is valid only if the above-listed valves are coupled with the coils in series 9115, 9116, 9185, or 9186 illustrated in Chapter 9. If the same valves are coupled with coils in series 9105 and 9125, again illustrated in Chapter 9, a "UL Listed" certified valve is not obtained; rather, you obtain a "UL Recognized" certified valve.**

The coils in series 9105, 9115, 9116, 9125, 9185, and 9186 with voltages of 120 VAC, 208 VAC, 220/230 VAC, 240 VAC comply with the Low Voltage Directive, 2006/95/EC and the Electromagnetic Compatibility Directive (EMC) 2004/108/EC.



2028UL/3 → L=119  
 2028UL/M10 → L=119

2028UL/4 → L=150  
 2028UL/M12 → L=150

**TABLE 28: General characteristics of PWM expansion valves, UL Listed approved**

| Catalogue number | Orifice Type | ODS Connections |      |      |     | Kv Factor [m³/h] | Opening Pressure Differential [bar] |      |      | Operating principles         | Minimum Working Time [s] | PS [bar] | TS [°C] |      | TA[°C] |      | Risk Category according to PED Recast |      |
|------------------|--------------|-----------------|------|------|-----|------------------|-------------------------------------|------|------|------------------------------|--------------------------|----------|---------|------|--------|------|---------------------------------------|------|
|                  |              | [in]            |      | [mm] |     |                  | MinOPD                              | MOPD |      |                              |                          |          | min.    | max. | min.   | max. |                                       |      |
|                  |              | IN              | OUT  | IN   | OUT |                  |                                     | 9105 | 9125 |                              |                          |          |         |      |        |      |                                       | 9125 |
|                  |              |                 |      |      |     |                  |                                     | 9115 | 9185 |                              |                          |          |         |      |        |      |                                       | 9185 |
| 2028UL/3S01      | 01           | 3/8"            | 1/2" | -    | -   | 0                | 37                                  | 37   | 37   | PWM (Pulse Width Modulating) | 1                        | 45       | -40     | +100 | -20    | +50  | Art.4.3                               |      |
| 2028UL/M10S01    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/3S02      | 02           | 3/8"            | 1/2" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M10S02    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/3S03      | 03           | 3/8"            | 1/2" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M10S03    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/3S04      | 04           | 3/8"            | 1/2" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M10S04    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/3S05      | 05           | 3/8"            | 1/2" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M10S05    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/3S06      | 06           | 3/8"            | 1/2" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M10S06    |              | -               | -    | 10   | 12  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/4S07      | 07           | 1/2"            | 5/8" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M12S07    |              | -               | -    | 12   | 16  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/4S08      | 08           | 1/2"            | 5/8" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M12S08    |              | -               | -    | 12   | 16  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/4S09      | 09           | 1/2"            | 5/8" | -    | -   |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |
| 2028UL/M12S09    |              | -               | -    | 12   | 16  |                  |                                     |      |      |                              |                          |          |         |      |        |      |                                       |      |

**TABLE 29: Orifices - Rated capacities in kW**

| Catalogue number | Orifice Type | Orifice Size [mm] | Refrigerant |       |       |       |       |       |       |         |         |       |       |       |       |
|------------------|--------------|-------------------|-------------|-------|-------|-------|-------|-------|-------|---------|---------|-------|-------|-------|-------|
|                  |              |                   | R134a       | R22   | R32   | R404A | R407C | R410A | R507A | R1234yf | R1234ze | R448A | R449A | R450A | R452A |
| 9150/R63         | 01           | 0,5               | 0,74        | 1,04  | 2,44  | 0,73  | 1,18  | 1,16  | 0,76  | 0,56    | 0,59    | 1,02  | 1,13  | 0,63  | 0,90  |
| 9150/R64         | 02           | 0,7               | 1,47        | 2,08  | 4,88  | 1,47  | 2,35  | 2,31  | 1,52  | 1,12    | 1,17    | 2,04  | 2,26  | 1,26  | 1,81  |
| 9150/R65         | 03           | 0,8               | 1,74        | 2,46  | 5,74  | 1,73  | 2,77  | 2,72  | 1,79  | 1,32    | 1,39    | 2,40  | 2,66  | 1,49  | 2,13  |
| 9150/R66         | 04           | 1,1               | 2,81        | 3,99  | 9,34  | 2,81  | 4,50  | 4,42  | 2,91  | 2,13    | 2,24    | 3,90  | 4,32  | 2,40  | 3,46  |
| 9150/R67         | 05           | 1,3               | 4,81        | 6,81  | 15,91 | 4,78  | 7,68  | 7,54  | 4,96  | 3,65    | 3,84    | 6,64  | 7,37  | 4,11  | 5,90  |
| 9150/R68         | 06           | 1,7               | 6,67        | 9,44  | 22,06 | 6,63  | 10,65 | 10,45 | 6,88  | 5,06    | 5,33    | 9,21  | 10,22 | 5,71  | 8,19  |
| 9150/R69         | 07           | 2,3               | 10,52       | 14,92 | 34,94 | 10,49 | 16,83 | 16,54 | 10,88 | 7,98    | 8,39    | 14,57 | 16,15 | 8,98  | 12,95 |
| 9150/R78         | 08           | 2,5               | 12,68       | 17,96 | 42,00 | 12,62 | 20,26 | 19,89 | 13,09 | 9,62    | 10,12   | 17,53 | 19,44 | 10,84 | 15,58 |
| 9150/R79         | 09           | 2,7               | 14,07       | 19,91 | 46,54 | 13,99 | 22,46 | 22,05 | 14,51 | 10,67   | 11,23   | 19,43 | 21,55 | 12,03 | 17,27 |

Rated capacities are based on:

- Evaporating temperature  $T_{evap} = + 5 \text{ °C}$
- Condensing temperature  $T_{cond} = + 32 \text{ °C}$
- Refrigerant liquid temperature ahead of valve  $T_{liq} = + 28 \text{ °C}$

# CHAPTER 5 ■

## SOLENOID EXPANSION VALVES FOR VERY LOW TEMPERATURE

### FOR REFRIGERATION PLANTS THAT USE THE R23 REFRIGERANT



#### APPLICATIONS

The solenoid expansion valves in series 2028R illustrated in this chapter have been designed for installation in very low temperature refrigeration plants that use R23 refrigerant fluid

#### OPERATION

Please refer to Chapter 3, second paragraph, for the description of the operation of the valves in series 2028R, as it is identical to that of valves in series 2028.

#### CONSTRUCTION

The valves in series 2028R are supplied complete with orifice. Nine different orifices with nine different maximum potentials that range from orifice O1 to orifice O9 can be assembled. The last two numbers in the part number identify the type of orifice that has been mounted on the valve at the factory. For example, part number 2028R/3S02 identifies a 3/8" valve with solder connections and size O2 orifice. **The orifices are NOT interchangeable because it is strictly prohibited to disassemble this valve for any reason, including for brazing on the system.** Inside the valve body is a ring mesh filter that traps dirt and contaminants at the valve inlet.

Valves in series 2028R are sold exclusively in the model without coil (suffix S).

The main parts of the valves in series 2028R are made from the same materials as the valves in series 2028, with the exception of:

- Copper EN 1625 – Cu-DHP for the outlet gaskets

#### SELECTION

Please refer to Chapter 3, paragraph 4, for the description of the operation of the valves in series 2028R, as it is identical to that of valves in series 2028.

#### DIMENSIONING EXAMPLE

- Type of refrigerant: R23
- Evaporator capacity,  $Q_e$ : 2.8 kW
- Evaporating temperature,  $T_e$ : -40°C
- Minimum condensing temperature,  $T_c$ : -5°C
- Liquid refrigerant temperature,  $T_l$ : -15°C
- Pressure drop in the liquid line, distributor and evaporator,  $\Delta p$  2 bar

*Step 1 - Determine the pressure drop across the valve.*

- Condensing pressure at -5 °C -  $P_c = 21.7$  bar
- Evaporating pressure at -40 °C -  $P_e = 7.06$  bar

$$\Delta p_{tot} = 21,7 - (7,06 + 2) = 12,6 \cdot \text{bar}$$

*Step 2 - Determine required valve capacity*

$$\Delta T_{sub} = -5 - (-15) = 10 \cdot ^\circ\text{K}$$

From the subcooling correction factor Table 31B, we find the appropriate correction factor,  $F_{sub}$ , equal to 1.05 for  $\Delta T_{sub} = 10$  °K. The required valve capacity is

$$Q_{sub} = \frac{2,8}{1,05} = 2,67 \cdot \text{kW}$$

*Step 3 - Capacity correction based on the application*

According to the above criterion, a correction of + 25% is applied to the calculated capacity:

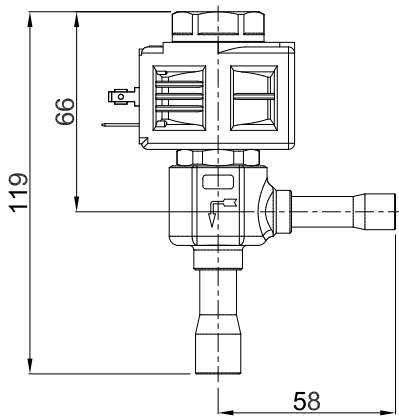
$$Q_{ev} = 1,25 \cdot 2,67 = 3,34 \cdot \text{kW}$$

*Step 4 - Determine the orifice size.*

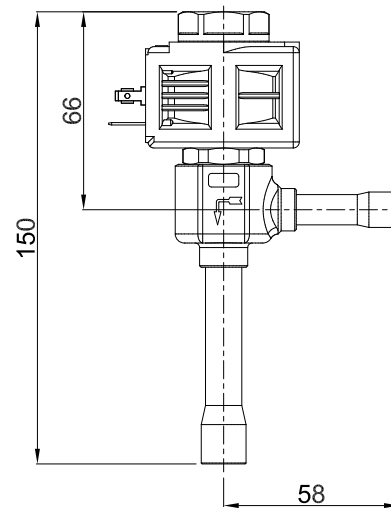
Using the capacity table 31A for R23 refrigerant, enter the data:

- Pressure drop across the valve = 12.6 bar
- Evaporating temperature = -40 °C
- Calculated evaporator capacity = 3.34 kW

Select the corresponding orifice, O3 (Note: the expansion valve capacity must be equal to or slightly greater than the calculated evaporator capacity)



2028R/3  
2028R/M10



2028R/4  
2028R/M12

TABLE 30: General characteristics of PWM expansion valves, suitable for R23

| Catalogue number | Ori-<br>fice<br>Type | ODS Connections |      |      |     | Orifice<br>Size<br>[mm] | Kv<br>Factor<br>[m³/h] | Rated<br>capac-<br>ities<br>R23<br>[kW] | Opening Pressure<br>Differential [bar] |                                       |              |              | Operating<br>principles | Mini-<br>mum<br>Working<br>Time<br>[s] | PS<br>[bar] | TS [°C] |         | TA [°C] |      | Risk<br>Cat-<br>egory<br>accord-<br>ing to<br>PED<br>Recast |              |
|------------------|----------------------|-----------------|------|------|-----|-------------------------|------------------------|---|--|---------------------------------------|--------------|--------------|-------------------------|--|-------------|---------|---------|---------|------|---|--------------|
|                  |                      | [in]            |      | [mm] |     |                         |                        |   | MinOPD                                 | MOPD                                  |              |              |                         |  |             | min.    | max.    | min.    | max. |   |              |
|                  |                      | IN              | OUT  | IN   | OUT |                         |                        |   |  | 9160<br>(AC)                          | 9160<br>(DC) | 9320<br>(AC) |                         |  |             |         |         |         |      |   | 9320<br>(DC) |
| 2028R/3S01       | 01                   | 3/8"            | 1/2" | -    | -   | 0,500                   | 0,010                  | 1,50                                    | 0                                      | PWM<br>(Pulse<br>Width<br>Modulating) | 1            | 45           | -80                     | +60                                    | -40         | +50     | Art.4.3 |         |      |   |              |
| 2028R/M10S01     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/3S02       | 02                   | 3/8"            | 1/2" | -    | -   | 0,7                     | 0,017                  | 3,00                                    |  |                                       |              |              |                         |  |             |         |         | 37      | 37   | 37  | 37           |
| 2028R/M10S02     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/3S03       | 03                   | 3/8"            | 1/2" | -    | -   | 0,8                     | 0,023                  | 3,52                                    |  |                                       |              |              |                         |  |             |         |         | 27      | 18   | 32  | 32           |
| 2028R/M10S03     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/3S04       | 04                   | 3/8"            | 1/2" | -    | -   | 1,1                     | 0,043                  | 5,74                                    |  |                                       |              |              |                         |  |             |         |         | 18      | 14   | 22  | 22           |
| 2028R/M10S04     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/3S05       | 05                   | 3/8"            | 1/2" | -    | -   | 1,3                     | 0,065                  | 9,77                                    |  |                                       |              |              |                         |  |             |         |         | 10      | 22   | 22  | 22           |
| 2028R/M10S05     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/3S06       | 06                   | 3/8"            | 1/2" | -    | -   | 1,7                     | 0,113                  | 13,54                                   |  |                                       |              |              |                         |  |             |         |         | 18      | 14   | 22  | 22           |
| 2028R/M10S06     |                      | -               | -    | 10   | 12  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/4S07       | 07                   | 1/2"            | 5/8" | -    | -   | 2,300                   | 0,200                  | 21,45                                   |  |                                       |              |              |                         |  |             |         |         | 10      | 22   | 22  | 22           |
| 2028R/M12S07     |                      | -               | -    | 12   | 16  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/4S08       | 08                   | 1/2"            | 5/8" | -    | -   | 2,500                   | 0,230                  | 25,78                                   |  |                                       |              |              |                         |  |             |         |         | 10      | 22   | 22  | 22           |
| 2028R/M12S08     |                      | -               | -    | 12   | 16  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |
| 2028R/4S09       | 09                   | 1/2"            | 5/8" | -    | -   | 2,700                   | 0,250                  | 28,57                                   |  |                                       |              |              |                         |  |             |         |         | 10      | 22   | 22  | 22           |
| 2028R/M12S09     |                      | -               | -    | 12   | 16  |                         |                        |   |  |                                       |              |              |                         |  |             |         |         |         |      |   |              |

Rated capacities are based on:

- Evaporating temperature  $T_{\text{evap}} = -30 \text{ }^\circ\text{C}$
- Condensing temperature  $T_{\text{cond}} = -4 \text{ }^\circ\text{C}$
- Refrigerant liquid temperature ahead of valve  $T_{\text{liq}} = -8 \text{ }^\circ\text{C}$

**TABLE 31A: Refrigerant R23 - Capacities in kW**

| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,72                             | 0,90  | 1,07  | 1,22  | 1,37  | 1,50  | 1,62  | 1,73  | 1,83  | 01                             | 0,76                             | 0,95  | 1,12  | 1,28  | 1,42  | 1,56  | 1,69  | 1,80  | 1,91  |
| 02                             | 1,44                             | 1,80  | 2,14  | 2,44  | 2,73  | 3,00  | 3,24  | 3,46  | 3,67  | 02                             | 1,52                             | 1,89  | 2,24  | 2,56  | 2,85  | 3,12  | 3,37  | 3,60  | 3,82  |
| 03                             | 1,71                             | 2,13  | 2,52  | 2,88  | 3,21  | 3,52  | 3,81  | 4,07  | 4,30  | 03                             | 1,81                             | 2,24  | 2,64  | 3,01  | 3,35  | 3,67  | 3,96  | 4,23  | 4,48  |
| 04                             | 2,76                             | 3,45  | 4,09  | 4,68  | 5,23  | 5,74  | 6,21  | 6,64  | 7,03  | 04                             | 2,91                             | 3,62  | 4,28  | 4,89  | 5,46  | 5,98  | 6,46  | 6,90  | 7,31  |
| 05                             | 4,72                             | 5,89  | 6,97  | 7,98  | 8,91  | 9,77  | 10,56 | 11,29 | 11,95 | 05                             | 4,99                             | 6,19  | 7,31  | 8,34  | 9,29  | 10,18 | 10,99 | 11,74 | 12,43 |
| 06                             | 6,56                             | 8,18  | 9,67  | 11,06 | 12,35 | 13,54 | 14,64 | 15,65 | 16,57 | 06                             | 6,93                             | 8,60  | 10,14 | 11,57 | 12,89 | 14,11 | 15,24 | 16,27 | 17,23 |
| 07                             | 10,31                            | 12,89 | 15,28 | 17,50 | 19,56 | 21,45 | 23,21 | 24,81 | 26,28 | 07                             | 10,89                            | 13,55 | 16,01 | 18,29 | 20,40 | 22,35 | 24,16 | 25,81 | 27,33 |
| 08                             | 12,45                            | 15,55 | 18,40 | 21,05 | 23,51 | 25,78 | 27,88 | 29,80 | 31,55 | 08                             | 13,16                            | 16,33 | 19,28 | 22,00 | 24,53 | 26,86 | 29,02 | 30,99 | 32,82 |
| 09                             | 13,82                            | 17,24 | 20,40 | 23,33 | 26,06 | 28,57 | 30,89 | 33,01 | 34,95 | 09                             | 14,60                            | 18,12 | 21,38 | 24,39 | 27,18 | 29,77 | 32,15 | 34,33 | 36,35 |
| Evaporating Temperature -50 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -60 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,84                             | 1,03  | 1,21  | 1,37  | 1,52  | 1,66  | 1,79  | 1,91  | 2,02  | 01                             | 0,82                             | 1,01  | 1,18  | 1,34  | 1,49  | 1,62  | 1,75  | 1,86  | 1,97  |
| 02                             | 1,68                             | 2,06  | 2,42  | 2,74  | 3,04  | 3,32  | 3,58  | 3,82  | 4,04  | 02                             | 1,64                             | 2,01  | 2,36  | 2,68  | 2,97  | 3,24  | 3,49  | 3,72  | 3,94  |
| 03                             | 2,00                             | 2,44  | 2,85  | 3,23  | 3,58  | 3,91  | 4,21  | 4,48  | 4,74  | 03                             | 1,95                             | 2,38  | 2,78  | 3,15  | 3,49  | 3,81  | 4,10  | 4,37  | 4,62  |
| 04                             | 3,22                             | 3,95  | 4,62  | 5,25  | 5,83  | 6,37  | 6,86  | 7,32  | 7,74  | 04                             | 3,14                             | 3,85  | 4,52  | 5,12  | 5,69  | 6,21  | 6,69  | 7,13  | 7,54  |
| 05                             | 5,51                             | 6,75  | 7,89  | 8,95  | 9,93  | 10,84 | 11,68 | 12,45 | 13,17 | 05                             | 5,38                             | 6,59  | 7,70  | 8,73  | 9,69  | 10,58 | 11,39 | 12,14 | 12,82 |
| 06                             | 7,65                             | 9,36  | 10,94 | 12,41 | 13,77 | 15,02 | 16,19 | 17,26 | 18,25 | 06                             | 7,47                             | 9,14  | 10,69 | 12,12 | 13,44 | 14,66 | 15,79 | 16,82 | 17,77 |
| 07                             | 12,03                            | 14,76 | 17,28 | 19,63 | 21,80 | 23,80 | 25,66 | 27,37 | 28,95 | 07                             | 11,74                            | 14,41 | 16,88 | 19,16 | 21,27 | 23,23 | 25,02 | 26,68 | 28,19 |
| 08                             | 14,53                            | 17,80 | 20,81 | 23,61 | 26,21 | 28,60 | 30,83 | 32,87 | 34,76 | 08                             | 14,18                            | 17,37 | 20,33 | 23,05 | 25,57 | 27,91 | 30,06 | 32,04 | 33,85 |
| 09                             | 16,13                            | 19,74 | 23,08 | 26,18 | 29,05 | 31,69 | 34,16 | 36,41 | 38,50 | 09                             | 15,74                            | 19,27 | 22,54 | 25,55 | 28,34 | 30,93 | 33,31 | 35,49 | 37,49 |
| Evaporating Temperature -70 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -80 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,92                             | 1,09  | 1,26  | 1,42  | 1,56  | 1,70  | 1,82  | 1,94  | 2,04  | 01                             | 1,08                             | 1,11  | 1,26  | 1,42  | 1,55  | 1,69  | 1,81  | 1,92  | 2,02  |
| 02                             | 1,84                             | 2,19  | 2,52  | 2,83  | 3,12  | 3,39  | 3,64  | 3,87  | 4,08  | 02                             | 2,15                             | 2,21  | 2,53  | 2,83  | 3,11  | 3,37  | 3,61  | 3,83  | 4,04  |
| 03                             | 2,18                             | 2,58  | 2,97  | 3,33  | 3,67  | 3,98  | 4,27  | 4,54  | 4,79  | 03                             | 2,55                             | 2,62  | 2,98  | 3,33  | 3,66  | 3,96  | 4,24  | 4,50  | 4,73  |
| 04                             | 3,52                             | 4,18  | 4,82  | 5,42  | 5,98  | 6,49  | 6,97  | 7,41  | 7,82  | 04                             | 4,11                             | 4,23  | 4,84  | 5,42  | 5,95  | 6,45  | 6,92  | 7,34  | 7,73  |
| 05                             | 6,02                             | 7,14  | 8,22  | 9,24  | 10,18 | 11,05 | 11,86 | 12,61 | 13,29 | 05                             | 7,04                             | 7,24  | 8,26  | 9,24  | 10,14 | 10,99 | 11,77 | 12,49 | 13,15 |
| 06                             | 8,36                             | 9,92  | 11,41 | 12,81 | 14,11 | 15,32 | 16,45 | 17,48 | 18,42 | 06                             | 9,78                             | 10,04 | 11,46 | 12,81 | 14,07 | 15,23 | 16,31 | 17,32 | 18,22 |
| 07                             | 13,14                            | 15,63 | 18,02 | 20,26 | 22,34 | 24,27 | 26,07 | 27,72 | 29,22 | 07                             | 15,38                            | 15,83 | 18,10 | 20,26 | 22,26 | 24,13 | 25,86 | 27,46 | 28,91 |
| 08                             | 15,88                            | 18,85 | 21,70 | 24,37 | 26,86 | 29,17 | 31,31 | 33,30 | 35,09 | 08                             | 18,57                            | 19,09 | 21,80 | 24,37 | 26,77 | 29,00 | 31,06 | 32,98 | 34,71 |
| 09                             | 17,63                            | 20,90 | 24,06 | 27,02 | 29,77 | 32,32 | 34,69 | 36,89 | 38,87 | 09                             | 20,62                            | 21,17 | 24,17 | 27,02 | 29,67 | 32,13 | 34,42 | 36,53 | 38,45 |

**TABLE: 31B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| $F_{sub}$                   | 1,00 | 1,05 | 1,10 | 1,15 | 1,20 | 1,25 | 1,29 | 1,40 | 1,45 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 31B



# CHAPTER 6

## SOLENOID EXPANSION VALVES

### FOR REFRIGERATION PLANTS THAT USE HC REFRIGERANTS



#### APPLICATIONS

The solenoid expansion valves illustrated in this chapter have been developed by Castel for all those refrigeration applications that use the following HC refrigeration fluids: R290, R600, or R600a, belonging to Group 1, defined in Article 13, Chapter 1, Point (a) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

**The solenoid valves in series 2028N must be employed only in refrigeration systems located in areas not classified as at risk of explosion, according to the definition in Annex I of Directive 1999/92/EC.**

**The solenoid expansion valves in series 2028EX comply with the European standard EN 13463-1:2009 and, therefore, comply with the ESR of Directive 2014/34/EU – ATEX. This equipment is suitable for use on refrigeration systems located in areas classified as “Zone 2” risk of explosion, according to the definition in Annex I of Directive 1999/92/EC.**

**CAUTION!:** The solenoid expansion valves in this chapter cannot be used with mineral oils or alkylbenzenes.

#### OPERATION

Please refer to Chapter 3, second paragraph, for the description of the operation of the valves in series 2028N and 2028EX, as it is identical to that of valves in series 2028.

#### CONSTRUCTION

The valves in series 2028N and 2028EX are supplied complete with orifice. Nine different orifices with nine different maximum capacities that range from orifice 01 to orifice 09 can be assembled. The last two numbers in the part number identify the type of orifice that has been mounted on the valve at the factory. For example, part number 2028N/3S02 identifies a 3/8” valve with solder connections and size 02 orifice. The orifices are interchangeable and can be mounted even after the valve is soldered on the system. If you wish to change orifice, purchase the corresponding spare parts kit, according to the part number indicated in Table 33.

Valves in series 2028N are sold exclusively in the model without coil (suffix S).

The valves in series 2028EX are sold only in the version with coil series 9100EX (A6 suffix with coil, 9100EX-220/230 VAC, ATEX certified).

The main parts of the valves in series 2028N and 2028EX are made from the same materials as the valves in series 2028, with the exception of:

- Hydrogenated nitrile butadiene rubber (HNBR) for outlet seal gaskets

#### SELECTION

Please refer to Chapter 3, paragraph 4, for the description of the operation of the valves in series 2028N and 2028EX, as it is identical to that of valves in series 2028.

#### DIMENSIONING EXAMPLE

- Type of refrigerant: R290
- Evaporator capacity,  $Q_e$ : 2.8 kW
- Evaporating temperature,  $T_e$ : 0°C
- Minimum condensing temperature,  $T_c$ : +35°C
- Liquid refrigerant temperature,  $T_l$ : +20°C
- Pressure drop in the liquid line, distributor and evaporator,  $\Delta p$  2 bar

*Step 1 - Determine the pressure drop across the valve.*

- Condensing pressure at + 35 °C -  $P_c = 12.2$  bar
- Evaporating pressure at 0 °C -  $P_e = 4.7$  bar

$$\Delta p_{tot} = 12,2 - (4,7 + 2) = 5,5 \cdot \text{bar}$$

*Step 2 - Determine required valve capacity*

$$\Delta T_{sub} = 35 - 20 = 15 \cdot \text{°K}$$

From the subcooling correction factor Table 34B, we find the

appropriate correction factor,  $F_{sub}$ , equal to 1.12 for  $\Delta T_{sub} = 15$  °K. The required valve capacity is

$$Q_{sub} = \frac{2,8}{1,12} = 2,5 \cdot kW$$

*Step 3 - Capacity correction based on the application*

According to the above sizing criterion, a correction of + 25% is applied to the calculated capacity:

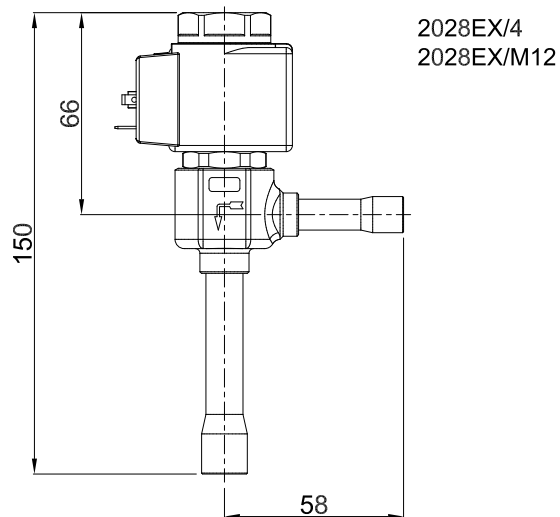
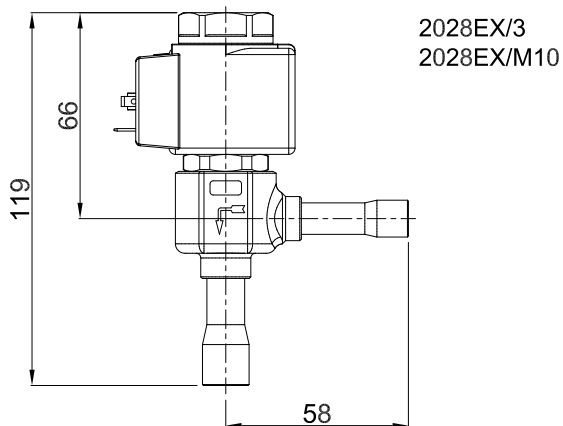
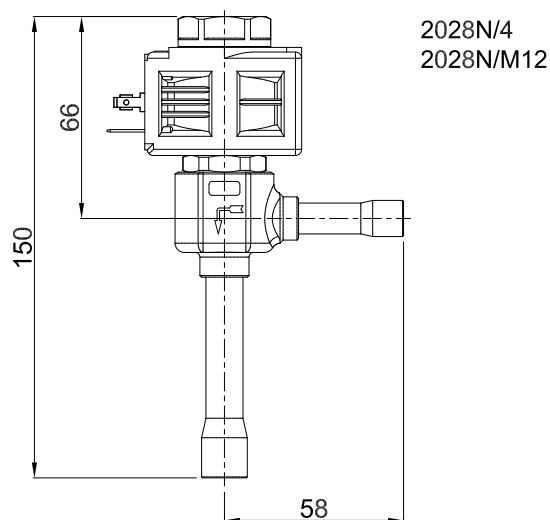
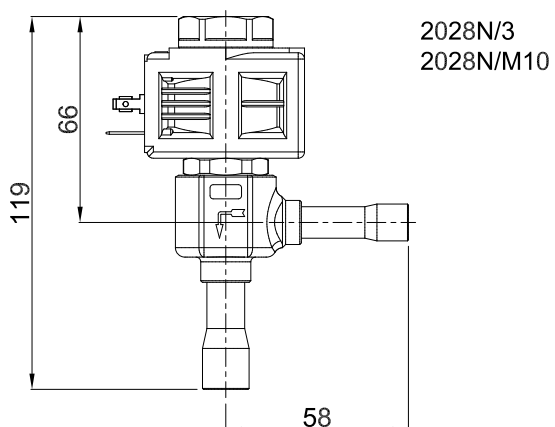
$$Q_{ev} = 1,25 \cdot 2,5 = 3,1 \cdot kW$$

*Step 4 - Determine required orifice size.*

Using the capacity Table 34A for R290 refrigerant, enter the data:

- Pressure drop across the valve = 5.5 bar
- Evaporating temperature = 0 °C
- Calculated evaporator capacity = 3.1 kW

Select the corresponding orifice, 04 (Note: the expansion valve capacity must be equal to or slightly greater than the calculated evaporator capacity)



**TABLE 32: General characteristics of PWM expansion valves, suitable for HC (R290, R600, R600a)**

| Catalogue number   |                                      | Orifice Type | ODS Connections |      |      |     | Kv Factor [m³/h] | Opening Pressure Differential [bar] |                          |              |                                 | Operating principles | Minimum Working Time [s] | PS [bar] | TS [°C] |      | TA [°C] |         | Risk Category according to PED Recast |
|--------------------|--------------------------------------|--------------|-----------------|------|------|-----|------------------|-------------------------------------|--------------------------|--------------|---------------------------------|----------------------|--------------------------|----------|---------|------|---------|---------|---------------------------------------|
| ATEX No compliance | ATEX Compliance for use in EX Zone 2 |              | [in]            |      | [mm] |     |                  | MinOPD                              | MOPD                     |              |                                 |                      |                          |          | min.    | max. | min.    | max.    |                                       |
|                    |                                      |              | IN              | OUT  | IN   | OUT |                  |                                     | 9100EX<br>9110EX<br>(AC) | 9160<br>(AC) | 9160<br>(DC)                    |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S01         | 2028EX/3A601                         | 01           | 3/8"            | 1/2" | -    | -   | 0                | 37                                  | 37                       | 37           | PWM<br>(Pulse Width Modulating) | 1                    | 45                       | -40      | +100    | -20  | +50     | Art.4.3 |                                       |
| 2028N/M10S01       | 2028EX/M10A601                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S02         | 2028EX/3A602                         | 02           | 3/8"            | 1/2" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M10S02       | 2028EX/M10A602                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S03         | 2028EX/3A603                         | 03           | 3/8"            | 1/2" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M10S03       | 2028EX/M10A603                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S04         | 2028EX/3A604                         | 04           | 3/8"            | 1/2" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M10S04       | 2028EX/M10A604                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S05         | 2028EX/3A605                         | 05           | 3/8"            | 1/2" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M10S05       | 2028EX/M10A605                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/3S06         | 2028EX/3A606                         | 06           | 3/8"            | 1/2" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M10S06       | 2028EX/M10A606                       |              | -               | -    | 10   | 12  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/4S07         | 2028EX/4A607                         | 07           | 1/2"            | 5/8" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M12S07       | 2028EX/M12A607                       |              | -               | -    | 12   | 16  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/4S08         | 2028EX/4S08                          | 08           | 1/2"            | 5/8" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M12S08       | 2028EX/M12S08                        |              | -               | -    | 12   | 16  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/4S09         | 2028EX/4S09                          | 09           | 1/2"            | 5/8" | -    | -   |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |
| 2028N/M12S09       | 2028EX/M12S09                        |              | -               | -    | 12   | 16  |                  |                                     |                          |              |                                 |                      |                          |          |         |      |         |         |                                       |

**TABLE 33: Orifices - Rated capacities in kW**

| Catalogue number | Orifice Type | Orifice Size [mm] | Refrigerant |       |       |
|------------------|--------------|-------------------|-------------|-------|-------|
|                  |              |                   | R290        | R600  | R600a |
| 9150N/R63        | 01           | 0,5               | 1,10        | 0,60  | 0,70  |
| 9150N/R64        | 02           | 0,7               | 2,20        | 1,30  | 1,50  |
| 9150N/R65        | 03           | 0,8               | 2,70        | 1,50  | 1,70  |
| 9150N/R66        | 04           | 1,1               | 4,20        | 2,30  | 2,60  |
| 9150N/R67        | 05           | 1,3               | 7,40        | 4,10  | 4,60  |
| 9150N/R68        | 06           | 1,7               | 10,10       | 6,40  | 7,30  |
| 9150N/R69        | 07           | 2,3               | 16,10       | 10,30 | 11,10 |
| 9150N/R78        | 08           | 2,5               | 19,40       | 13,20 | 13,40 |
| 9150N/R79        | 09           | 2,7               | 21,60       | 14,70 | 14,90 |

Rated capacities are based on:

- Evaporating temperature  $T_{\text{evap}} = + 5 \text{ °C}$
- Condensing temperature  $T_{\text{cond}} = + 32 \text{ °C}$
- Refrigerant liquid temperature ahead of valve  $T_{\text{liq}} = + 28 \text{ °C}$

**TABLE 34A: Refrigerant R290 - Capacities in kW**

| Evaporating Temperature 10 °C  |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,85                             | 0,98  | 1,08  | 1,16  | 1,21  | 1,25  | 1,25  | 1,24  | 1,19  | 01                             | 0,88                             | 1,00  | 1,10  | 1,18  | 1,23  | 1,26  | 1,27  | 1,26  | 1,22  |
| 02                             | 1,75                             | 2,05  | 2,26  | 2,38  | 2,41  | 2,34  | 2,18  | 1,92  | 1,57  | 02                             | 1,88                             | 2,11  | 2,28  | 2,38  | 2,42  | 2,39  | 2,30  | 2,14  | 1,91  |
| 03                             | 1,99                             | 2,43  | 2,74  | 2,92  | 2,99  | 2,92  | 2,74  | 2,43  | 1,99  | 03                             | 2,15                             | 2,50  | 2,76  | 2,93  | 3,01  | 3,00  | 2,91  | 2,73  | 2,45  |
| 04                             | 3,12                             | 3,80  | 4,29  | 4,58  | 4,67  | 4,58  | 4,29  | 3,80  | 3,13  | 04                             | 3,37                             | 3,91  | 4,32  | 4,59  | 4,72  | 4,71  | 4,56  | 4,27  | 3,85  |
| 05                             | 5,50                             | 6,68  | 7,51  | 8,01  | 8,17  | 8,00  | 7,49  | 6,64  | 5,46  | 05                             | 5,94                             | 6,87  | 7,57  | 8,03  | 8,24  | 8,22  | 7,95  | 7,44  | 6,69  |
| 06                             | 7,47                             | 9,07  | 10,21 | 10,90 | 11,12 | 10,89 | 10,20 | 9,06  | 7,45  | 06                             | 8,06                             | 9,34  | 10,29 | 10,91 | 11,21 | 11,18 | 10,82 | 10,14 | 9,13  |
| 07                             | 12,00                            | 14,55 | 16,36 | 17,44 | 17,80 | 17,42 | 16,30 | 14,46 | 11,89 | 07                             | 12,94                            | 14,98 | 16,49 | 17,47 | 17,94 | 17,88 | 17,30 | 16,20 | 14,57 |
| 08                             | 14,31                            | 17,43 | 19,66 | 21,00 | 21,45 | 21,02 | 19,70 | 17,49 | 14,40 | 08                             | 15,44                            | 17,94 | 19,81 | 21,03 | 21,63 | 21,58 | 20,90 | 19,59 | 17,64 |
| 09                             | 15,91                            | 19,38 | 21,87 | 23,37 | 23,88 | 23,40 | 21,93 | 19,47 | 16,03 | 09                             | 17,16                            | 19,95 | 22,04 | 23,41 | 24,08 | 24,03 | 23,28 | 21,82 | 19,65 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       | Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       | Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |
| 01                             | 0,91                             | 1,02  | 1,11  | 1,18  | 1,23  | 1,25  | 1,26  | 1,25  | 1,21  | 01                             | 0,93                             | 1,03  | 1,11  | 1,17  | 1,22  | 1,24  | 1,25  | 1,23  | 1,20  |
| 02                             | 2,02                             | 2,19  | 2,30  | 2,38  | 2,40  | 2,39  | 2,33  | 2,23  | 2,08  | 02                             | 2,12                             | 2,23  | 2,31  | 2,36  | 2,37  | 2,35  | 2,30  | 2,21  | 2,09  |
| 03                             | 2,33                             | 2,59  | 2,78  | 2,92  | 2,99  | 3,00  | 2,95  | 2,84  | 2,67  | 03                             | 2,45                             | 2,65  | 2,79  | 2,89  | 2,94  | 2,94  | 2,90  | 2,80  | 2,66  |
| 04                             | 3,65                             | 4,05  | 4,36  | 4,56  | 4,67  | 4,69  | 4,60  | 4,42  | 4,15  | 04                             | 3,84                             | 4,14  | 4,37  | 4,53  | 4,61  | 4,61  | 4,54  | 4,39  | 4,16  |
| 05                             | 6,43                             | 7,12  | 7,64  | 7,99  | 8,17  | 8,19  | 8,04  | 7,73  | 7,24  | 05                             | 6,75                             | 7,28  | 7,67  | 7,93  | 8,07  | 8,07  | 7,94  | 7,68  | 7,29  |
| 06                             | 8,73                             | 9,66  | 10,37 | 10,86 | 11,11 | 11,14 | 10,93 | 10,50 | 9,84  | 06                             | 9,17                             | 9,88  | 10,42 | 10,78 | 10,96 | 10,96 | 10,78 | 10,43 | 9,90  |
| 07                             | 14,02                            | 15,50 | 16,63 | 17,38 | 17,78 | 17,81 | 17,48 | 16,79 | 15,73 | 07                             | 14,73                            | 15,86 | 16,70 | 17,27 | 17,55 | 17,55 | 17,26 | 16,69 | 15,84 |
| 08                             | 16,73                            | 18,57 | 19,97 | 20,93 | 21,44 | 21,50 | 21,13 | 20,31 | 19,04 | 08                             | 17,59                            | 19,00 | 20,07 | 20,79 | 21,16 | 21,18 | 20,86 | 20,19 | 19,18 |
| 09                             | 18,60                            | 20,66 | 22,22 | 23,29 | 23,86 | 23,94 | 23,53 | 22,61 | 21,21 | 09                             | 19,55                            | 21,13 | 22,32 | 23,13 | 23,55 | 23,58 | 23,22 | 22,47 | 21,34 |
| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       |                                |                                  |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |                                |                                  |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    |                                |                                  |       |       |       |       |       |       |       |       |
| 01                             | 0,94                             | 1,03  | 1,11  | 1,16  | 1,20  | 1,22  | 1,23  | 1,21  | 1,18  |                                |                                  |       |       |       |       |       |       |       |       |
| 02                             | 2,17                             | 2,25  | 2,31  | 2,33  | 2,33  | 2,30  | 2,25  | 2,16  | 2,05  |                                |                                  |       |       |       |       |       |       |       |       |
| 03                             | 2,52                             | 2,68  | 2,79  | 2,86  | 2,90  | 2,89  | 2,84  | 2,76  | 2,63  |                                |                                  |       |       |       |       |       |       |       |       |
| 04                             | 3,95                             | 4,19  | 4,36  | 4,47  | 4,52  | 4,51  | 4,43  | 4,29  | 4,08  |                                |                                  |       |       |       |       |       |       |       |       |
| 05                             | 6,96                             | 7,36  | 7,65  | 7,84  | 7,92  | 7,89  | 7,75  | 7,51  | 7,15  |                                |                                  |       |       |       |       |       |       |       |       |
| 06                             | 9,44                             | 9,99  | 10,39 | 10,65 | 10,76 | 10,71 | 10,52 | 10,19 | 9,70  |                                |                                  |       |       |       |       |       |       |       |       |
| 07                             | 15,16                            | 16,03 | 16,66 | 17,06 | 17,22 | 17,14 | 16,83 | 16,29 | 15,51 |                                |                                  |       |       |       |       |       |       |       |       |
| 08                             | 18,12                            | 19,21 | 20,02 | 20,53 | 20,76 | 20,70 | 20,35 | 19,71 | 18,78 |                                |                                  |       |       |       |       |       |       |       |       |
| 09                             | 20,14                            | 21,37 | 22,27 | 22,85 | 23,11 | 23,05 | 22,66 | 21,95 | 20,92 |                                |                                  |       |       |       |       |       |       |       |       |

**TABLE: 34B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| $F_{sub}$                   | 1,00 | 1,06 | 1,12 | 1,18 | 1,24 | 1,30 | 1,35 | 1,40 | 1,45 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 34B

**TABLE 35A: Refrigerant R600 - Capacities in kW**

| Evaporating Temperature 12 °C  |                                  |       |       |       |       |       |       |    |    | Evaporating Temperature 4 °C  |                                  |       |       |       |       |       |       |    |    |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|----|----|-------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|----|----|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    | Orifice Type                  | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |
| 01                             | 0,60                             | 0,62  | 0,65  | 0,69  | 0,72  | 0,73  | 0,71  |    |    | 01                            | 0,61                             | 0,62  | 0,64  | 0,68  | 0,70  | 0,71  | 0,70  |    |    |
| 02                             | 0,99                             | 1,17  | 1,37  | 1,62  | 1,78  | 1,91  | 2,01  |    |    | 02                            | 1,04                             | 1,19  | 1,35  | 1,55  | 1,67  | 1,77  | 1,84  |    |    |
| 03                             | 1,05                             | 1,28  | 1,57  | 1,92  | 2,15  | 2,34  | 2,50  |    |    | 03                            | 1,10                             | 1,31  | 1,55  | 1,83  | 2,02  | 2,17  | 2,29  |    |    |
| 04                             | 1,65                             | 2,01  | 2,46  | 3,00  | 3,37  | 3,66  | 3,91  |    |    | 04                            | 1,73                             | 2,05  | 2,42  | 2,87  | 3,17  | 3,39  | 3,58  |    |    |
| 05                             | 2,93                             | 3,56  | 4,33  | 5,27  | 5,91  | 6,41  | 6,83  |    |    | 05                            | 3,07                             | 3,62  | 4,27  | 5,04  | 5,55  | 5,94  | 6,27  |    |    |
| 06                             | 4,58                             | 5,58  | 6,79  | 8,27  | 9,28  | 10,07 | 10,73 |    |    | 06                            | 4,80                             | 5,67  | 6,70  | 7,91  | 8,71  | 9,33  | 9,85  |    |    |
| 07                             | 7,39                             | 8,98  | 10,92 | 13,27 | 14,87 | 16,12 | 17,17 |    |    | 07                            | 7,75                             | 9,13  | 10,76 | 12,68 | 13,96 | 14,95 | 15,76 |    |    |
| 08                             | 9,41                             | 11,48 | 14,02 | 17,12 | 19,24 | 20,91 | 22,29 |    |    | 08                            | 9,86                             | 11,67 | 13,82 | 16,36 | 18,06 | 19,38 | 20,46 |    |    |
| 09                             | 10,44                            | 12,75 | 15,58 | 19,04 | 21,41 | 23,27 | 24,82 |    |    | 09                            | 10,94                            | 12,96 | 15,36 | 18,20 | 20,10 | 21,56 | 22,78 |    |    |
| Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |    |    | Evaporating Temperature -8 °C |                                  |       |       |       |       |       |       |    |    |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    | Orifice Type                  | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |
| 01                             | 0,61                             | 0,62  | 0,64  | 0,67  | 0,69  | 0,70  | 0,69  |    |    | 01                            | 0,61                             | 0,62  | 0,64  | 0,66  | 0,67  | 0,67  | 0,66  |    |    |
| 02                             | 1,06                             | 1,20  | 1,35  | 1,52  | 1,63  | 1,71  | 1,78  |    |    | 02                            | 1,10                             | 1,21  | 1,33  | 1,47  | 1,55  | 1,61  | 1,66  |    |    |
| 03                             | 1,13                             | 1,32  | 1,54  | 1,80  | 1,97  | 2,10  | 2,21  |    |    | 03                            | 1,17                             | 1,33  | 1,52  | 1,74  | 1,87  | 1,98  | 2,07  |    |    |
| 04                             | 1,77                             | 2,06  | 2,41  | 2,82  | 3,08  | 3,29  | 3,46  |    |    | 04                            | 1,84                             | 2,09  | 2,38  | 2,72  | 2,93  | 3,10  | 3,23  |    |    |
| 05                             | 3,14                             | 3,65  | 4,25  | 4,95  | 5,40  | 5,76  | 6,04  |    |    | 05                            | 3,26                             | 3,70  | 4,20  | 4,77  | 5,14  | 5,42  | 5,65  |    |    |
| 06                             | 4,91                             | 5,72  | 6,66  | 7,76  | 8,48  | 9,04  | 9,49  |    |    | 06                            | 5,11                             | 5,80  | 6,58  | 7,47  | 8,05  | 8,48  | 8,84  |    |    |
| 07                             | 7,92                             | 9,21  | 10,71 | 12,45 | 13,60 | 14,48 | 15,19 |    |    | 07                            | 8,22                             | 9,33  | 10,59 | 12,02 | 12,95 | 13,65 | 14,22 |    |    |
| 08                             | 10,08                            | 11,77 | 13,75 | 16,07 | 17,59 | 18,77 | 19,73 |    |    | 08                            | 10,47                            | 11,93 | 13,59 | 15,49 | 16,72 | 17,65 | 18,40 |    |    |
| 09                             | 11,19                            | 13,08 | 15,28 | 17,87 | 19,57 | 20,88 | 21,96 |    |    | 09                            | 11,61                            | 13,25 | 15,12 | 17,25 | 18,63 | 19,68 | 20,54 |    |    |
| Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |                               |                                  |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               |                                  |       |       |       |       |       |       |    |    |
| 01                             | 0,60                             | 0,61  | 0,62  | 0,63  | 0,64  | 0,63  | 0,62  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 02                             | 1,14                             | 1,22  | 1,30  | 1,39  | 1,44  | 1,48  | 1,51  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 03                             | 1,21                             | 1,34  | 1,49  | 1,65  | 1,75  | 1,82  | 1,88  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 04                             | 1,91                             | 2,11  | 2,33  | 2,58  | 2,73  | 2,85  | 2,94  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 05                             | 3,38                             | 3,73  | 4,11  | 4,53  | 4,79  | 4,99  | 5,15  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 06                             | 5,30                             | 5,84  | 6,44  | 7,10  | 7,52  | 7,83  | 8,08  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 07                             | 8,54                             | 9,40  | 10,35 | 11,40 | 12,05 | 12,55 | 12,94 |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 08                             | 10,87                            | 12,02 | 13,29 | 14,71 | 15,60 | 16,27 | 16,80 |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 09                             | 12,06                            | 13,35 | 14,77 | 16,35 | 17,35 | 18,10 | 18,70 |    |    |                               |                                  |       |       |       |       |       |       |    |    |

**TABLE: 35B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub}$ [°K] | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------|------|------|------|------|------|------|------|------|------|
| Fsub                  | 1,00 | 1,06 | 1,09 | 1,14 | 1,19 | 1,23 | 1,28 | 1,38 | 1,43 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 35B

**TABLE 36A: Refrigerant R600a - Capacities in kW**

| Evaporating Temperature 12 °C  |                                  |       |       |       |       |       |       |    |    | Evaporating Temperature 4 °C  |                                  |       |       |       |       |       |       |    |    |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|----|----|-------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|----|----|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    | Orifice Type                  | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |
| 01                             | 0,61                             | 0,64  | 0,68  | 0,72  | 0,75  | 0,76  | 0,78  |    |    | 01                            | 0,60                             | 0,64  | 0,68  | 0,73  | 0,75  | 0,77  | 0,79  |    |    |
| 02                             | 1,04                             | 1,22  | 1,42  | 1,66  | 1,82  | 1,94  | 2,03  |    |    | 02                            | 1,12                             | 1,27  | 1,43  | 1,61  | 1,72  | 1,81  | 1,88  |    |    |
| 03                             | 1,11                             | 1,34  | 1,62  | 1,96  | 2,20  | 2,38  | 2,53  |    |    | 03                            | 1,19                             | 1,39  | 1,63  | 1,90  | 2,08  | 2,22  | 2,34  |    |    |
| 04                             | 1,74                             | 2,10  | 2,54  | 3,08  | 3,44  | 3,72  | 3,96  |    |    | 04                            | 1,87                             | 2,18  | 2,55  | 2,98  | 3,26  | 3,48  | 3,66  |    |    |
| 05                             | 3,08                             | 3,72  | 4,48  | 5,40  | 6,03  | 6,51  | 6,92  |    |    | 05                            | 3,32                             | 3,86  | 4,50  | 5,23  | 5,72  | 6,09  | 6,39  |    |    |
| 06                             | 4,84                             | 5,85  | 7,05  | 8,51  | 9,50  | 10,27 | 10,91 |    |    | 06                            | 5,22                             | 6,08  | 7,08  | 8,24  | 9,01  | 9,60  | 10,08 |    |    |
| 07                             | 7,41                             | 8,92  | 10,75 | 12,95 | 14,44 | 15,60 | 16,56 |    |    | 07                            | 7,98                             | 9,28  | 10,79 | 12,54 | 13,69 | 14,58 | 15,30 |    |    |
| 08                             | 8,75                             | 10,59 | 12,82 | 15,51 | 17,35 | 18,78 | 19,97 |    |    | 08                            | 9,43                             | 11,01 | 12,86 | 15,02 | 16,45 | 17,55 | 18,45 |    |    |
| 09                             | 9,71                             | 11,76 | 14,24 | 17,25 | 19,30 | 20,90 | 22,23 |    |    | 09                            | 10,46                            | 12,23 | 14,29 | 16,71 | 18,31 | 19,53 | 20,54 |    |    |
| Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |    |    | Evaporating Temperature -8 °C |                                  |       |       |       |       |       |       |    |    |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    | Orifice Type                  | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |
| 01                             | 0,60                             | 0,64  | 0,68  | 0,72  | 0,75  | 0,77  | 0,78  |    |    | 01                            | 0,61                             | 0,64  | 0,68  | 0,72  | 0,74  | 0,75  | 0,77  |    |    |
| 02                             | 1,16                             | 1,29  | 1,43  | 1,59  | 1,68  | 1,76  | 1,82  |    |    | 02                            | 1,24                             | 1,33  | 1,44  | 1,55  | 1,62  | 1,67  | 1,71  |    |    |
| 03                             | 1,23                             | 1,42  | 1,63  | 1,88  | 2,04  | 2,16  | 2,26  |    |    | 03                            | 1,31                             | 1,47  | 1,64  | 1,83  | 1,96  | 2,05  | 2,13  |    |    |
| 04                             | 1,93                             | 2,22  | 2,56  | 2,94  | 3,19  | 3,38  | 3,54  |    |    | 04                            | 2,06                             | 2,30  | 2,57  | 2,87  | 3,07  | 3,21  | 3,33  |    |    |
| 05                             | 3,43                             | 3,93  | 4,51  | 5,16  | 5,59  | 5,92  | 6,18  |    |    | 05                            | 3,65                             | 4,07  | 4,53  | 5,05  | 5,37  | 5,62  | 5,82  |    |    |
| 06                             | 5,40                             | 6,19  | 7,10  | 8,14  | 8,82  | 9,33  | 9,75  |    |    | 06                            | 5,74                             | 6,40  | 7,13  | 7,95  | 8,47  | 8,86  | 9,17  |    |    |
| 07                             | 8,25                             | 9,45  | 10,81 | 12,38 | 13,40 | 14,17 | 14,80 |    |    | 07                            | 8,78                             | 9,77  | 10,87 | 12,09 | 12,87 | 13,46 | 13,93 |    |    |
| 08                             | 9,75                             | 11,21 | 12,90 | 14,83 | 16,10 | 17,06 | 17,85 |    |    | 08                            | 10,37                            | 11,60 | 12,96 | 14,49 | 15,47 | 16,20 | 16,79 |    |    |
| 09                             | 10,82                            | 12,45 | 14,33 | 16,50 | 17,91 | 18,99 | 19,87 |    |    | 09                            | 11,51                            | 12,88 | 14,41 | 16,12 | 17,21 | 18,03 | 18,69 |    |    |
| Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |    |    |                               |                                  |       |       |       |       |       |       |    |    |
|                                | 0,5                              | 1     | 2     | 4     | 6     | 8     | 10    | 12 | 16 |                               |                                  |       |       |       |       |       |       |    |    |
| 01                             | 0,62                             | 0,65  | 0,67  | 0,69  | 0,71  | 0,72  | 0,73  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 02                             | 1,31                             | 1,38  | 1,47  | 1,56  | 1,61  | 1,65  | 1,68  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 03                             | 1,42                             | 1,52  | 1,64  | 1,77  | 1,85  | 1,90  | 1,95  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 04                             | 2,22                             | 2,39  | 2,57  | 2,77  | 2,89  | 2,98  | 3,05  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 05                             | 3,94                             | 4,23  | 4,53  | 4,86  | 5,07  | 5,22  | 5,34  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 06                             | 6,19                             | 6,65  | 7,14  | 7,66  | 7,99  | 8,23  | 8,42  |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 07                             | 9,47                             | 10,15 | 10,88 | 11,66 | 12,14 | 12,49 | 12,78 |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 08                             | 11,19                            | 12,05 | 12,97 | 13,97 | 14,59 | 15,04 | 15,40 |    |    |                               |                                  |       |       |       |       |       |       |    |    |
| 09                             | 12,42                            | 13,38 | 14,42 | 15,53 | 16,23 | 16,74 | 17,14 |    |    |                               |                                  |       |       |       |       |       |       |    |    |

**TABLE: 36B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 1,00 | 1,06 | 1,11 | 1,16 | 1,21 | 1,26 | 1,31 | 1,40 | 1,45 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 36B

# CHAPTER 7 ■ SOLENOID EXPANSION VALVES

## FOR REFRIGERATION PLANTS THAT USE THE R744 REFRIGERANT



### APPLICATIONS

The solenoid expansion valves in series 2028E illustrated in this chapter have been developed by Castel for all the applications that use the sub-critical R744 refrigeration fluid belonging to Group 2, defined in Article 13, Chapter 1, Point (b) of Directive 2014/68/EU, with reference to EC Regulation No. 1272/2008.

**CAUTION!: the solenoid valves in this chapter cannot be used with other refrigerant fluids.**

### OPERATION

Please refer to Chapter 3, second paragraph, for the description of the operation of the valves in series 2028E, as it is identical to that of valves in series 2028.

### CONSTRUCTION

The valves in series 2028E are supplied complete with orifice. Ten different orifices with ten different maximum potentials that range from orifice 00 to orifice 09 can be assembled. The last two numbers in the part number identify the type of orifice that has been mounted on the valve at the factory. For example, part number 2028E/3S02 identifies a 3/8" valve with solder connections and size 02 orifice. The orifices are interchangeable and can be mounted even after the valve is soldered on the system. If you wish to change orifice, purchase the corresponding spare parts kit, according to the part number indicated in Table 38.

Valves in series 2028E are sold exclusively in the model without coil (suffix S).

The main parts of the valves in series 2028E are made from the same materials as the valves in series 2028, with the exception of:

- Ethylene propylene rubber (EPDM) for outlet seal gaskets

### SELECTION

Please refer to Chapter 3, paragraph 4, for the description of the operation of the valves in series 2028E, as it is identical to that of valves in series 2028.

### DIMENSIONING EXAMPLE

- Type of refrigerant: R744
- Evaporator capacity,  $Q_e$ : 2.8 kW
- Evaporating temperature,  $T_e$ : -30°C
- Minimum condensing temperature,  $T_c$ : -5°C
- Liquid refrigerant temperature,  $T_l$ : -15°C
- Pressure drop in the liquid line, distributor and evaporator,  $\Delta p$  2 bar

*Step 1 - Determine the pressure drop across the valve.*

- Condensing pressure at - 5 °C -  $P_c = 30.4$  bar
- Evaporating pressure at - 30 °C -  $P_e = 14.3$  bar

$$\Delta p_{tot} = 30,4 - (14,3 + 2) = 14,1 \cdot \text{bar}$$

*Step 2 - Determine required valve capacity*

$$\Delta T_{sub} = -5 - (-15) = 10 \cdot ^\circ\text{K}$$

From the subcooling correction factor Table 39B, we find the appropriate correction factor,  $F_{sub}$ , equal to 1.05 for  $\Delta T_{sub} = 10$  °K. The required valve capacity is

$$Q_{sub} = \frac{2,8}{1,05} = 2,67 \cdot \text{kW}$$

*Step 3 - Capacity correction based on the application*

According to the above sizing criterion, a correction of + 25% is applied to the calculated capacity:

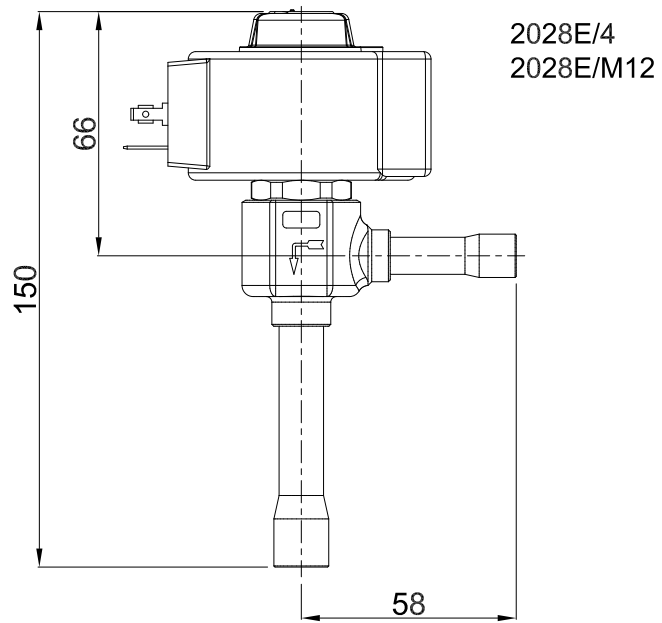
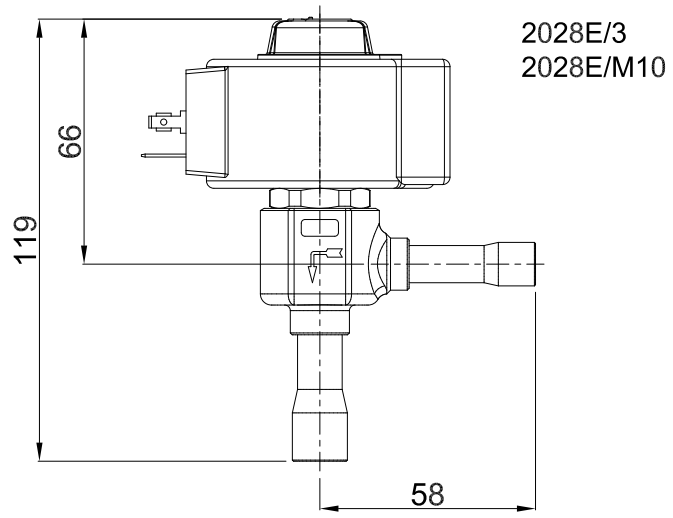
$$Q_{ev} = 1,25 \cdot 2,67 = 3,33 \cdot \text{kW}$$

*Step 4 - Determine required orifice size.*

Using the capacity Table 39A for R744 refrigerant, enter the data:

- Pressure drop across the valve = 14.1 bar
- Evaporating temperature = - 30 °C
- Calculated evaporator capacity = 3.33 kW

Select the corresponding orifice, 02 (Note: the expansion valve capacity must be equal to or slightly greater than the calculated evaporator capacity).





**TABLE 37: General characteristics of PWM expansion valves, suitable for R744**

| Catalogue number | Orifice Type | ODS Connections |      |      |     | Kv Factor [m <sup>3</sup> /h] | Opening Pressure Differential [bar] |           |                              | Operating principles | Minimum Working Time [s] | PS [bar] | TS [°C] |      | TA [°C] |         | Risk Category according to PED Recast |
|------------------|--------------|-----------------|------|------|-----|-------------------------------|-------------------------------------|-----------|------------------------------|----------------------|--------------------------|----------|---------|------|---------|---------|---------------------------------------|
|                  |              | [in]            |      | [mm] |     |                               | MinOPD                              | MOPD      |                              |                      |                          |          | min.    | max. | min.    | max.    |                                       |
|                  |              | IN              | OUT  | IN   | OUT |                               |                                     | 9320 (AC) | 9320 (DC)                    |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S00       | 00           | 3/8"            | 1/2" | -    | -   | 0                             | 37                                  | 37        | PWM (Pulse Width Modulating) | 1                    | 80                       | -50      | +100    | -40  | +50     | Art.4.3 |                                       |
| 2028E/M10S00     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S01       | 01           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S01     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S02       | 02           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S02     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S03       | 03           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S03     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S04       | 04           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S04     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S05       | 05           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S05     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/3S06       | 06           | 3/8"            | 1/2" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M10S06     |              | -               | -    | 10   | 12  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/4S07       | 07           | 1/2"            | 5/8" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M12S07     |              | -               | -    | 12   | 16  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/4S08       | 08           | 1/2"            | 5/8" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M12S08     |              | -               | -    | 12   | 16  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/4S09       | 09           | 1/2"            | 5/8" | -    | -   |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |
| 2028E/M12S09     |              | -               | -    | 12   | 16  |                               |                                     |           |                              |                      |                          |          |         |      |         |         |                                       |

**TABLE 38: Orifices - Rated capacities in kW**

| Catalogue number | Orifice Type | Orifice Size [mm] | Refrigerant |
|------------------|--------------|-------------------|-------------|
|                  |              |                   | R744        |
| 9151E/R13        | 00           | 0,3               | 0,94        |
| 9150E/R63        | 01           | 0,5               | 2,30        |
| 9150E/R64        | 02           | 0,7               | 4,10        |
| 9150E/R65        | 03           | 0,8               | 5,40        |
| 9150E/R66        | 04           | 1,1               | 8,22        |
| 9150E/R67        | 05           | 1,3               | 14,50       |
| 9150E/R68        | 06           | 1,7               | 20,20       |
| 9150E/R69        | 07           | 2,3               | 32,10       |
| 9150E/R78        | 08           | 2,5               | 38,10       |
| 9150E/R79        | 09           | 2,7               | 43,40       |

Rated capacities are based on:

- Evaporating temperature  $T_{\text{evap}} = -25 \text{ °C}$
- Condensing temperature  $T_{\text{cond}} = 0 \text{ °C}$
- Refrigerant liquid temperature ahead of valve  $T_{\text{liq}} = -4 \text{ °C}$

**TABLE 39A: Refrigerant R744 - Capacities in kW**

| Evaporating Temperature 5 °C   |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,34                             | 0,42  | 0,49  | 0,55  | 0,60  | 0,64  | 0,67  | 0,68  | 0,69  | 0,69  | 0,64  | 0,61  | 0,56  | 0,43  |
| 01                             | 0,81                             | 1,01  | 1,18  | 1,33  | 1,45  | 1,55  | 1,62  | 1,66  | 1,68  | 1,68  | 1,59  | 1,50  | 1,40  | 1,10  |
| 02                             | 1,74                             | 2,02  | 2,27  | 2,48  | 2,64  | 2,76  | 2,84  | 2,88  | 2,88  | 2,84  | 2,63  | 2,47  | 2,26  | 1,72  |
| 03                             | 2,11                             | 2,54  | 2,91  | 3,23  | 3,48  | 3,68  | 3,81  | 3,89  | 3,91  | 3,88  | 3,62  | 3,41  | 3,14  | 2,42  |
| 04                             | 3,30                             | 3,98  | 4,56  | 5,04  | 5,44  | 5,74  | 5,96  | 6,08  | 6,11  | 6,05  | 5,65  | 5,32  | 4,89  | 3,76  |
| 05                             | 5,72                             | 6,86  | 7,85  | 8,68  | 9,35  | 9,87  | 10,23 | 10,43 | 10,48 | 10,37 | 9,68  | 9,10  | 8,36  | 6,43  |
| 06                             | 8,01                             | 9,61  | 11,00 | 12,16 | 13,11 | 13,84 | 14,35 | 14,64 | 14,71 | 14,56 | 13,61 | 12,80 | 11,78 | 9,07  |
| 07                             | 12,32                            | 14,76 | 16,87 | 18,65 | 20,09 | 21,20 | 21,97 | 22,40 | 22,50 | 22,27 | 20,80 | 19,56 | 17,98 | 13,83 |
| 08                             | 14,83                            | 17,85 | 20,46 | 22,65 | 24,44 | 25,82 | 26,78 | 27,34 | 27,48 | 27,22 | 25,46 | 23,96 | 22,06 | 17,01 |
| 09                             | 16,31                            | 19,64 | 22,52 | 24,95 | 26,92 | 28,44 | 29,51 | 30,13 | 30,29 | 30,00 | 28,07 | 26,43 | 24,33 | 18,77 |
| Evaporating Temperature 0 °C   |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,36                             | 0,45  | 0,53  | 0,60  | 0,65  | 0,69  | 0,72  | 0,74  | 0,75  | 0,74  | 0,70  | 0,66  | 0,60  | 0,46  |
| 01                             | 0,89                             | 1,11  | 1,30  | 1,47  | 1,60  | 1,71  | 1,78  | 1,83  | 1,86  | 1,85  | 1,75  | 1,66  | 1,54  | 1,22  |
| 02                             | 1,91                             | 2,22  | 2,49  | 2,72  | 2,90  | 3,03  | 3,12  | 3,17  | 3,17  | 3,12  | 2,89  | 2,71  | 2,48  | 1,89  |
| 03                             | 2,24                             | 2,70  | 3,10  | 3,43  | 3,70  | 3,91  | 4,05  | 4,14  | 4,16  | 4,12  | 3,85  | 3,63  | 3,34  | 2,57  |
| 04                             | 3,46                             | 4,17  | 4,77  | 5,28  | 5,70  | 6,02  | 6,24  | 6,37  | 6,40  | 6,34  | 5,92  | 5,57  | 5,12  | 3,94  |
| 05                             | 6,12                             | 7,34  | 8,39  | 9,28  | 10,00 | 10,55 | 10,94 | 11,15 | 11,20 | 11,09 | 10,35 | 9,73  | 8,95  | 6,87  |
| 06                             | 8,31                             | 9,97  | 11,41 | 12,62 | 13,60 | 14,36 | 14,88 | 15,18 | 15,26 | 15,10 | 14,11 | 13,28 | 12,22 | 9,41  |
| 07                             | 13,37                            | 16,02 | 18,31 | 20,24 | 21,80 | 23,00 | 23,84 | 24,31 | 24,42 | 24,16 | 22,57 | 21,22 | 19,51 | 15,01 |
| 08                             | 15,96                            | 19,21 | 22,01 | 24,38 | 26,30 | 27,78 | 28,82 | 29,42 | 29,58 | 29,29 | 27,40 | 25,79 | 23,74 | 18,31 |
| 09                             | 17,69                            | 21,30 | 24,43 | 27,06 | 29,20 | 30,85 | 32,01 | 32,68 | 32,86 | 32,55 | 30,45 | 28,66 | 26,39 | 20,36 |
| Evaporating Temperature -10 °C |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,40                             | 0,49  | 0,58  | 0,65  | 0,71  | 0,75  | 0,78  | 0,80  | 0,81  | 0,81  | 0,76  | 0,71  | 0,66  | 0,50  |
| 01                             | 0,98                             | 1,23  | 1,44  | 1,62  | 1,77  | 1,88  | 1,97  | 2,02  | 2,05  | 2,04  | 1,93  | 1,83  | 1,70  | 1,34  |
| 02                             | 2,19                             | 2,55  | 2,86  | 3,12  | 3,32  | 3,48  | 3,58  | 3,63  | 3,63  | 3,58  | 3,32  | 3,11  | 2,84  | 2,17  |
| 03                             | 2,51                             | 3,02  | 3,46  | 3,84  | 4,14  | 4,37  | 4,54  | 4,63  | 4,66  | 4,61  | 4,31  | 4,06  | 3,74  | 2,88  |
| 04                             | 3,96                             | 4,76  | 5,45  | 6,04  | 6,51  | 6,88  | 7,13  | 7,28  | 7,31  | 7,24  | 6,76  | 6,36  | 5,85  | 4,50  |
| 05                             | 6,94                             | 8,32  | 9,52  | 10,52 | 11,34 | 11,96 | 12,40 | 12,65 | 12,70 | 12,57 | 11,74 | 11,03 | 10,14 | 7,79  |
| 06                             | 9,42                             | 11,31 | 12,93 | 14,31 | 15,42 | 16,28 | 16,87 | 17,22 | 17,30 | 17,12 | 16,00 | 15,06 | 13,85 | 10,67 |
| 07                             | 15,16                            | 18,17 | 20,76 | 22,95 | 24,72 | 26,08 | 27,03 | 27,56 | 27,69 | 27,40 | 25,59 | 24,06 | 22,13 | 17,02 |
| 08                             | 18,07                            | 21,75 | 24,93 | 27,60 | 29,78 | 31,46 | 32,63 | 33,31 | 33,49 | 33,17 | 31,02 | 29,20 | 26,88 | 20,73 |
| 09                             | 20,10                            | 24,20 | 27,75 | 30,74 | 33,17 | 35,05 | 36,37 | 37,13 | 37,33 | 36,97 | 34,59 | 32,56 | 29,98 | 23,13 |
| Evaporating Temperature -20 °C |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,48                             | 0,56  | 0,63  | 0,70  | 0,76  | 0,81  | 0,85  | 0,89  | 0,91  | 0,93  | 0,95  | 0,94  | 0,93  | 0,88  |
| 01                             | 1,19                             | 1,39  | 1,58  | 1,75  | 1,89  | 2,02  | 2,12  | 2,21  | 2,28  | 2,32  | 2,35  | 2,34  | 2,30  | 2,18  |
| 02                             | 2,60                             | 2,89  | 3,14  | 3,37  | 3,57  | 3,73  | 3,86  | 3,96  | 4,03  | 4,07  | 4,05  | 4,00  | 3,91  | 3,65  |
| 03                             | 3,01                             | 3,43  | 3,81  | 4,14  | 4,44  | 4,68  | 4,89  | 5,05  | 5,17  | 5,24  | 5,27  | 5,21  | 5,11  | 4,79  |
| 04                             | 4,74                             | 5,41  | 6,00  | 6,53  | 6,99  | 7,38  | 7,71  | 7,96  | 8,16  | 8,28  | 8,33  | 8,25  | 8,11  | 7,61  |
| 05                             | 8,32                             | 9,45  | 10,47 | 11,38 | 12,17 | 12,84 | 13,40 | 13,84 | 14,16 | 14,37 | 14,44 | 14,30 | 14,04 | 13,18 |
| 06                             | 11,29                            | 12,84 | 14,23 | 15,46 | 16,53 | 17,45 | 18,21 | 18,80 | 19,24 | 19,53 | 19,61 | 19,42 | 19,07 | 17,89 |
| 07                             | 18,16                            | 20,63 | 22,84 | 24,80 | 26,51 | 27,96 | 29,16 | 30,11 | 30,81 | 31,25 | 31,38 | 31,07 | 30,50 | 28,61 |
| 08                             | 21,67                            | 24,70 | 27,42 | 29,83 | 31,94 | 33,73 | 35,22 | 36,40 | 37,27 | 37,83 | 38,04 | 37,68 | 37,01 | 34,75 |
| 09                             | 24,10                            | 27,48 | 30,52 | 33,22 | 35,57 | 37,57 | 39,24 | 40,56 | 41,53 | 42,16 | 42,39 | 41,99 | 41,24 | 38,72 |

Continued

**TABLE 39A: Refrigerant R744 - Capacities in kW**

| Evaporating Temperature -30 °C |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,61                             | 0,67  | 0,73  | 0,78  | 0,82  | 0,86  | 0,90  | 0,93  | 0,96  | 0,98  | 1,01  | 1,02  | 1,02  | 1,01  |
| 01                             | 1,52                             | 1,67  | 1,81  | 1,94  | 2,05  | 2,16  | 2,26  | 2,34  | 2,41  | 2,47  | 2,56  | 2,59  | 2,61  | 2,60  |
| 02                             | 3,21                             | 3,39  | 3,56  | 3,72  | 3,85  | 3,97  | 4,08  | 4,16  | 4,23  | 4,28  | 4,34  | 4,34  | 4,32  | 4,24  |
| 03                             | 3,78                             | 4,07  | 4,34  | 4,58  | 4,80  | 5,00  | 5,17  | 5,32  | 5,44  | 5,54  | 5,67  | 5,69  | 5,70  | 5,63  |
| 04                             | 5,96                             | 6,41  | 6,84  | 7,22  | 7,57  | 7,88  | 8,15  | 8,39  | 8,59  | 8,75  | 8,97  | 9,02  | 9,04  | 8,96  |
| 05                             | 10,43                            | 11,21 | 11,92 | 12,58 | 13,17 | 13,69 | 14,15 | 14,55 | 14,88 | 15,15 | 15,50 | 15,57 | 15,59 | 15,42 |
| 06                             | 14,16                            | 15,22 | 16,20 | 17,09 | 17,90 | 18,62 | 19,25 | 19,79 | 20,24 | 20,61 | 21,09 | 21,20 | 21,22 | 20,99 |
| 07                             | 22,76                            | 24,45 | 26,01 | 27,42 | 28,70 | 29,84 | 30,84 | 31,71 | 32,43 | 33,02 | 33,77 | 33,95 | 33,98 | 33,63 |
| 08                             | 27,22                            | 29,31 | 31,23 | 32,99 | 34,57 | 35,98 | 37,22 | 38,29 | 39,19 | 39,92 | 40,87 | 41,09 | 41,14 | 40,73 |
| 09                             | 30,28                            | 32,62 | 34,78 | 36,74 | 38,52 | 40,10 | 41,49 | 42,70 | 43,72 | 44,54 | 45,63 | 45,88 | 45,95 | 45,52 |
| Evaporating Temperature -40 °C |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,71                             | 0,76  | 0,81  | 0,85  | 0,89  | 0,93  | 0,96  | 0,99  | 1,02  | 1,04  | 1,08  | 1,09  | 1,10  | 1,12  |
| 01                             | 1,77                             | 1,89  | 2,01  | 2,11  | 2,21  | 2,30  | 2,39  | 2,46  | 2,53  | 2,59  | 2,69  | 2,72  | 2,75  | 2,78  |
| 02                             | 3,65                             | 3,79  | 3,92  | 4,03  | 4,14  | 4,24  | 4,32  | 4,39  | 4,45  | 4,51  | 4,57  | 4,59  | 4,59  | 4,57  |
| 03                             | 4,35                             | 4,58  | 4,79  | 4,99  | 5,17  | 5,33  | 5,48  | 5,60  | 5,72  | 5,81  | 5,95  | 6,00  | 6,02  | 6,03  |
| 04                             | 6,85                             | 7,21  | 7,54  | 7,85  | 8,13  | 8,38  | 8,61  | 8,81  | 8,99  | 9,13  | 9,35  | 9,42  | 9,46  | 9,47  |
| 05                             | 11,98                            | 12,59 | 13,15 | 13,67 | 14,15 | 14,58 | 14,96 | 15,29 | 15,59 | 15,83 | 16,19 | 16,30 | 16,36 | 16,35 |
| 06                             | 16,27                            | 17,10 | 17,87 | 18,58 | 19,23 | 19,81 | 20,34 | 20,80 | 21,19 | 21,53 | 22,01 | 22,16 | 22,24 | 22,23 |
| 07                             | 26,14                            | 27,46 | 28,68 | 29,80 | 30,83 | 31,75 | 32,58 | 33,30 | 33,93 | 34,46 | 35,22 | 35,45 | 35,58 | 35,54 |
| 08                             | 31,30                            | 32,95 | 34,47 | 35,87 | 37,15 | 38,31 | 39,35 | 40,26 | 41,06 | 41,73 | 42,71 | 43,01 | 43,20 | 43,21 |
| 09                             | 34,84                            | 36,68 | 38,38 | 39,95 | 41,39 | 42,68 | 43,84 | 44,87 | 45,76 | 46,51 | 47,61 | 47,96 | 48,16 | 48,18 |
| Evaporating Temperature -50 °C |                                  |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Orifice Type                   | Pressure drop across valve [bar] |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                | 2                                | 4     | 6     | 8     | 10    | 12    | 14    | 16    | 18    | 20    | 24    | 26    | 28    | 32    |
| 00                             | 0,80                             | 0,83  | 0,87  | 0,90  | 0,94  | 0,97  | 1,00  | 1,03  | 1,06  | 1,08  | 1,12  | 1,14  | 1,15  | 1,18  |
| 01                             | 1,95                             | 2,05  | 2,15  | 2,24  | 2,33  | 2,40  | 2,47  | 2,53  | 2,59  | 2,64  | 2,71  | 2,74  | 2,75  | 2,77  |
| 02                             | 4,04                             | 4,13  | 4,22  | 4,30  | 4,37  | 4,43  | 4,49  | 4,54  | 4,59  | 4,62  | 4,67  | 4,69  | 4,70  | 4,69  |
| 03                             | 4,76                             | 4,95  | 5,13  | 5,29  | 5,44  | 5,58  | 5,70  | 5,81  | 5,91  | 5,99  | 6,11  | 6,15  | 6,18  | 6,19  |
| 04                             | 7,50                             | 7,79  | 8,07  | 8,33  | 8,56  | 8,77  | 8,96  | 9,13  | 9,28  | 9,40  | 9,59  | 9,65  | 9,69  | 9,70  |
| 05                             | 13,10                            | 13,61 | 14,07 | 14,51 | 14,90 | 15,26 | 15,58 | 15,86 | 16,11 | 16,32 | 16,63 | 16,73 | 16,80 | 16,81 |
| 06                             | 17,79                            | 18,48 | 19,12 | 19,71 | 20,25 | 20,74 | 21,18 | 21,57 | 21,91 | 22,19 | 22,62 | 22,75 | 22,84 | 22,86 |
| 07                             | 28,58                            | 29,67 | 30,68 | 31,61 | 32,47 | 33,24 | 33,93 | 34,54 | 35,08 | 35,53 | 36,19 | 36,40 | 36,54 | 36,56 |
| 08                             | 34,26                            | 35,63 | 36,89 | 38,06 | 39,13 | 40,11 | 40,98 | 41,76 | 42,43 | 43,01 | 43,87 | 44,16 | 44,34 | 44,42 |
| 09                             | 38,13                            | 39,67 | 41,09 | 42,40 | 43,60 | 44,69 | 45,68 | 46,55 | 47,31 | 47,97 | 48,95 | 49,27 | 49,49 | 49,59 |

**TABLE: 39B - Correction factor for subcooling  $\Delta t_{sub} \neq 4^\circ K$**

| $\Delta t_{sub} [^\circ K]$ | 1    | 4    | 10   | 15   | 20   | 25   | 30   | 35   | 40   | 45   |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|
| Fsub                        | 0,96 | 1,00 | 1,05 | 1,10 | 1,15 | 1,20 | 1,25 | 1,29 | 1,39 | 1,43 |

When subcooling ahead of the expansion valve is other than 4 °K , adjust the evaporator capacity by dividing by the appropriate correction factor found in Table 39B

# CHAPTER 8 ■ STANDARD COILS AND CONNECTORS



## APPLICATIONS

For the solenoid expansion valves presented in Chapters 3 (series 2028), 5 (series 2028R), and 6 (series 2028N), the coils in series 9160 (coils type HM4) and the coils in series 9320 (coils type HF3) are available.

For the solenoid expansion valves presented in Chapter 7 (series 2028E) the coils in series 9320 (coils type HF3) are available.

The coils in series 9320 must be coupled only with connectors 9150/R02 or 9900/X66. The protection rating guaranteed by the coil + connector system is IP65 according to the EN 60529 standard.

Coils in series 9160 must be used preferably with connector type 9155 / R01 and 9155/R02. The protection rating of the coil + connector 9155/R01 system is IP65/IP68 according to the EN 60529 standard. Alternatively, these coils can be coupled with connectors in series 9150/R02 or 9900/X66. In this case, the protection rating of this system is IP65 according to the EN 60529 standard.

## CONSTRUCTION

In compliance with IEC 85 standard, the coils in series 9160 and 9320 have Class F encapsulation and their production is compliant with standards EN 60730-1 and EN 60730-2-8. The windings are made of copper wire, with insulation class H (180 °C), in compliance with IEC standard 85. The outer casing is made of waterproof, dielectric resins that guarantee reinforced insulation and allow any type of assembly.

All coils have Class I protection ratings against electric contacts. Consequently, their safety requires an efficient ground system. Rubber gaskets assembled on the upper and lower ends of the coils (only on the lower end for coils in series 9320) complete the protection of the windings from humidity.

The terminals of the coils in series 9160 and 9320 consist

of two Faston connectors plus a Faston ground connector. All coils in this chapter are designed for continuous use. The solid construction of these coils makes them suitable for use in refrigeration systems operating in heavy-duty environments.

## CERTIFICATIONS

Coils in series 9160 with 110 VAC, 220/230 VAC and 240 VAC power supply, and coils in series 9320 with 220/230 VAC power supply are manufactured according to the Low Voltage (LV) Directive (2006/95/EC). All coils in this chapter comply with the Electromagnetic Compatibility (EMC) Directive (2004/108/EC).

## CONNECTORS

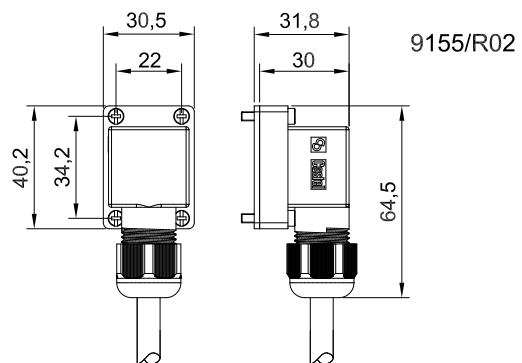
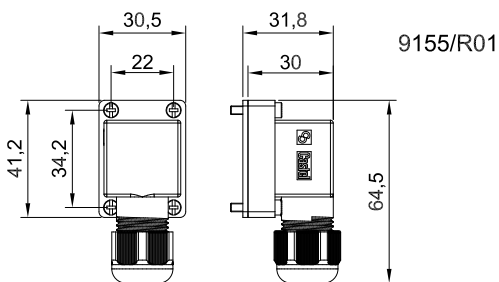
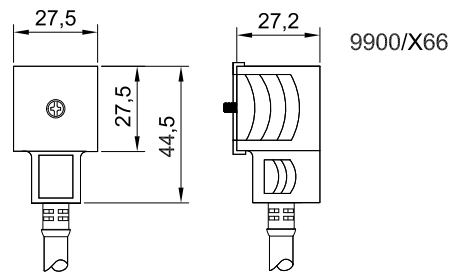
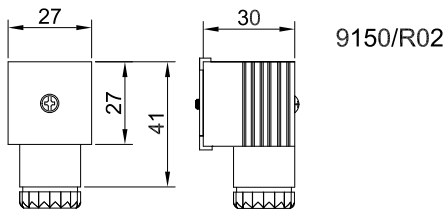
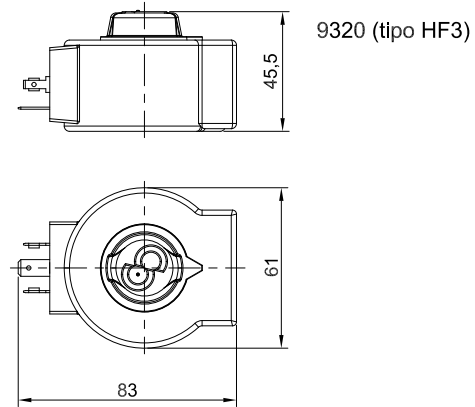
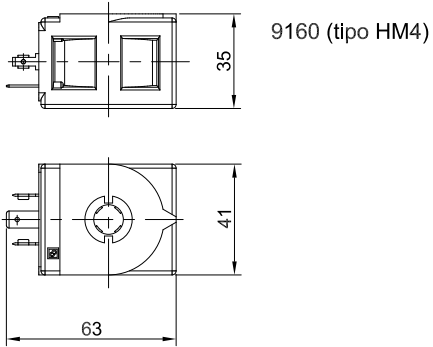
DIN 43650 standardized connectors 9150/R02 represent an effective system for the connection of the coil to the power system, thus ensuring safety also in the presence of moisture. Based on the assembly requirements, these connectors allow you to choose the orientation of the outer casing with respect to the inner terminal block. The gland nut of the outer casing is suitable for receiving cables with an external diameter of 6 to 9 mm and is equipped with a self-locking device. Three-pole cables with a cross-section greater than or equal to 0.75 mm<sup>2</sup> are recommended. The connectors in series 9900/X66 are available with co-moulded cables, 1 m long. In this version, the orientation of the casing cannot be changed with respect to the terminal block.

Castel developed specific connectors, series 9155/R01, suitable for use in refrigeration systems operating in heavy-duty environments, for example:

- exposure to the atmospheric conditions
- rooms with high degree of moisture
- cyclic condensing / evaporation on the valve
- cyclic icing / defrosting on the valve

Based on the assembly requirements, these connectors allow you to choose the side orientation of the outer casing with respect to the inner terminal block. It is not possible to point the exit of the cable upwards. The gland nut of the outer casing is suitable for receiving cables with an external diameter of 6 to 9 mm and is equipped with a self-locking

device. It is again recommended that three-pole cables with a cross-section greater than or equal to 0.75 mm<sup>2</sup> be used. The connectors in series 9155/R02 are available with co-moulded cables, 1 m long. In this version, the orientation of the casing cannot be changed with respect to the terminal block.



**TABLE 40: General characteristics of coils**

| Catalogue Number | Coil Type | Voltage [V]  | Voltage tolerance [%] | Frequency [Hz] | Insulation class EN 60730 | TA [°C] |      | Connection                     | Connectors                                   | Protection Degree  |
|------------------|-----------|--------------|-----------------------|----------------|---------------------------|---------|------|--------------------------------|--|--|
|                  |           |              |                       |                |                           | min.    | max. |                                |  |  |
| 9160/RA2         | HM4       | 24 A.C.      | +10 / -10             | 50 / 60        | F                         | -20     | +50  | Terminal block for DIN 43650/A | 9150/R02<br>9155/R01<br>9155/R02<br>9900/X## | IP 65<br>(with connectors 9150 , 9900)<br><br>IP 65 / IP 68<br>(with connector 9155) |
| 9160/RA4         |           | 110 A.C.     |                       |                |                           |         |      |                                |  |  |
| 9160/RA6         |           | 220/230 A.C. |                       |                |                           |         |      |                                |  |  |
| 9160/RA7         |           | 240 A.C.     | +10 / -10             |                |                           |         |      |                                |  |  |
| 9160/RD1         |           | 12 D.C.      |                       | -              |                           |         |      |                                |  |  |
| 9160/RD2         |           | 24 D.C.      |                       |                |                           |         |      |                                |  |  |
| 9320/RA6         | HF3       | 220/230 A.C. | +6 / -10              |                | 50 / 60                   | F       | -20  | +50                            | Terminal block for DIN 43650/A               | 9150/R02<br>9900/X##   |
| 9320/RD1         |           | 12 D.C.      | +10 / -5              | -              |                           |         |      |                                |  |  |
| 9320/RD2         |           | 24 D.C.      |                       |                |                           |         |      |                                |  |  |

**TABLE 41: Consumptions and weights of coils**

| Catalogue Number | Coil Type | Voltage [V]  | Power [W] | Consumption at 20 °C [mA] |         |      |         |         |      | Weight [g] |
|------------------|-----------|--------------|-----------|---------------------------|---------|------|---------|---------|------|------------|
|                  |           |              |           | Start                     |         |      | Working |         |      |            |
|                  |           |              |           | 50 [Hz]                   | 60 [Hz] | D.C. | 50 [Hz] | 60 [Hz] | D.C. |            |
| 9160/RA2         | HM4       | 24 A.C.      | 8         | 1490                      | 1320    | -    | 700     | 530     | -    | 220        |
| 9160/RA4         |           | 110 A.C.     |           | 330                       | 300     |      | 156     | 118     |      |            |
| 9160/RA6         |           | 220/230 A.C. |           | 162                       | 142     |      | 76      | 57      |      |            |
| 9160/RA7         |           | 240 A.C.     |           | 147                       | 130     |      | 70      | 53      |      |            |
| 9160/RD1         |           | 12 D.C.      | 17        | -                         | -       | 1300 | -       | -       | 1300 |            |
| 9160/RD2         |           | 24 D.C.      | 15,5      | -                         | -       | 650  | -       | -       | 650  |            |
| 9320/RA6         | HF3       | 220/230 A.C. | 12        | 190                       | 160     | -    | 110     | 80      | -    | 500        |
| 9320/RD1         |           | 12 D.C.      | 20        | -                         | -       | 1720 | -       | -       | 1720 |            |
| 9320/RD2         |           | 24 D.C.      | 20        | -                         | -       | 895  | -       | -       | 895  |            |

**TABLE 42: General characteristics of connectors**

| Catalogue Number | Cable length [m] | Cable thickness [mm <sup>2</sup> ] | Standard  | Degree of protection  | Class of insulation        | Approval |
|------------------|------------------|------------------------------------|-----------|-----------------------|----------------------------|----------|
| 9150/R02         | -                | -                                  | DIN 43650 | IP65<br>EN 60529      | Group C<br>VDE 0110-1 / 89 | -        |
| 9900/X66         | 1                | 3 x 0,75                           |           |                       |                            | -        |
| 9155/R01         | -                | -                                  | -         | IP65/IP68<br>EN 60529 |                            | -        |
| 9155/R02         | 1                | 3 x 0,75                           |           |                       |                            | -        |

# CHAPTER 9 ■ COILS AND CONNECTORS

CERTIFIED BY UNDERWRITERS LABORATORIES INC.



## APPLICATIONS

For the solenoid expansion valves approved by the American certification authority, Underwriters Laboratories Inc. and presented in Chapter 4 (series 2028UL), the following coils are available:

- **Series 9105** (coil type HM2), with connection type DIN 43650
- **Series 9125** (coil type HM3), with connection type DIN 43650
- **Series 9115** (coil type CM2-N2), with connection type “Junction Box NEMA 2”.
- **Series 9116** (coil type CM2-N4), with connection type “Conduit Hub NEMA 4”.
- **Series 9185** (coil type CM3-N2), with connection type “Junction Box NEMA 2”.
- **Series 9186** (coil type CM3-N4), with connection type “Conduit Hub NEMA 4”.

Coils in series 9105 and 9125 must be coupled with connector type 9150UL/R02. The protection rating of the coil + connector system is IP65 according to the EN 60529 standard.

The coils in series 9115 and 9185 are complete with a connection system to a metal sheath. The protection rating guaranteed by the “Junction Box” connection system is similar to IP12-32 according to the EN 60529 standard.

The coils in series 9116 and 9186 are complete with a connection system to a metal sheath. The protection rating guaranteed by the “Conduit Hub” connection system is similar to IP54 according to the EN 60529 standard.

## CONSTRUCTION

In compliance with IEC standard 85, the coils in series 9105, 9125, 9115, 9116, 9185 and 9186 have Class F encapsulation and their production is compliant with standards EN 60730-1 and EN 60730-2-8. The windings are made of copper wire, with insulation class H (155°C), in compliance with IEC standard 85. The outer casing is made of waterproof, dielectric resins that guarantee reinforced insulation and allow any type of assembly.

All coils have Class I protection ratings against electric contacts. Consequently, their safety requires an efficient ground system. Rubber gaskets assembled on the upper and lower ends of the coils complete the protection of the windings from humidity.

The coils in series 9105 and 9125 are equipped with three flat terminals, two Faston connections in line plus a Faston ground connection.

The coils in series 9115 and 9185 are equipped with two cables, at least 153 mm long, and ground screw incorporated in the body of the metal casing. The body of the casing is screwed onto the metal reinforcement of the coil and there are two semi-sheared slots to screw on a metal sheath. A metal cover screwed on the body closes the casing and encloses the joints between the power cable and the coil wires.

Coils in series 9116 and 9186 are equipped with two wires, at least 457 mm long. The flange of the nozzle is screwed to the metal reinforcement of the coil. The nozzle is threaded in order to screw on a metal sheath.

All coils in this chapter are designed for continuous use. The solid construction of these coils makes them suitable for use in refrigeration systems operating in heavy-duty environments.

## CERTIFICATIONS

The American certification authority Underwriters Laboratories Inc. has approved coils in series 9015, 9125, 9115, 9116, 9185, and 1986. These coils are certified **UL-CSA Recognized** for the USA and Canada with file E243604, in compliance with American standard UL 429 and Canadian standard C22.2 No. 139-13.

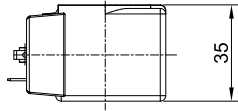
**Only when a coil in series 9115, 9116, 9185 or 9186 is used with a coil-less valve in Chapter 4 (valve in series 2028UL) is a solenoid expansion valve obtained that is “UL Listed” certified according to file MH50005, in compliance with American standard UL 429 and Canadian standard C22.2 No. 139-13.**

**Note: coupling a coil in series 9105 or 9125 with the same valve in series 2028UL does not result in a**

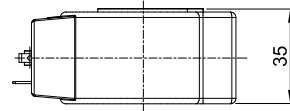
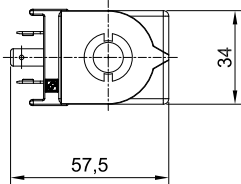
**“UL Listed” certified valve; rather, you obtain a “UL Recognized” certified valve.**

The coils in series 9015, 9125, 9115, 9116, 9185, and 9186 with voltages of 120 VAC, 208 VAC, 220/230 VAC, 240

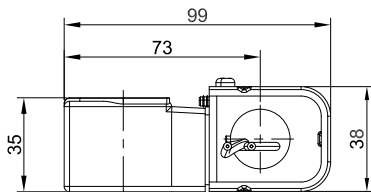
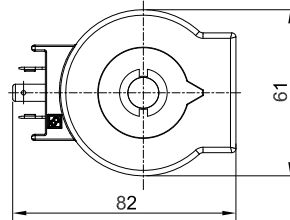
VAC comply with the Low Voltage Directive (2006/95/EC). All coils in this chapter comply with the Electromagnetic Compatibility (EMC) Directive (2004/108/EC).



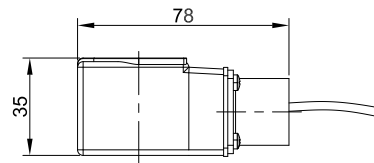
9105 (tipo HM2)



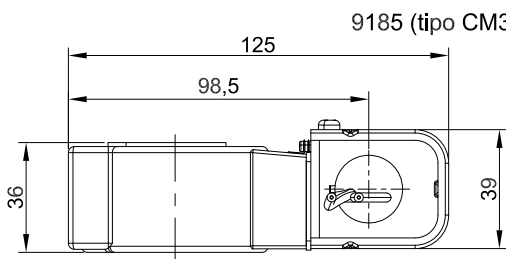
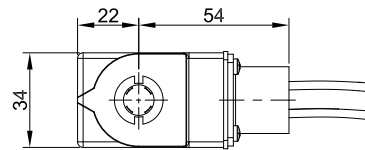
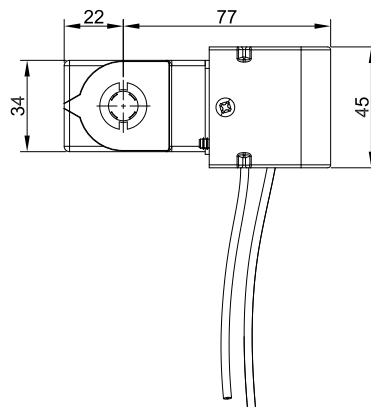
9125 (tipo HM3)



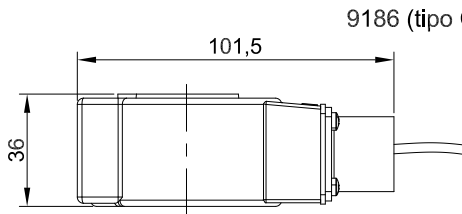
9115 (Tipo CM2-N2)



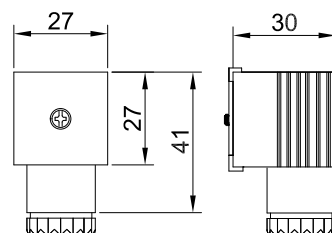
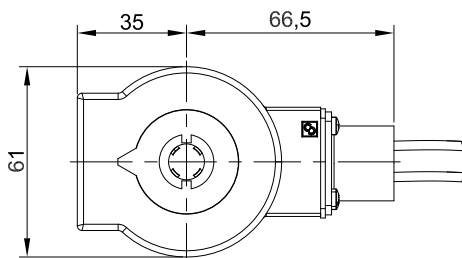
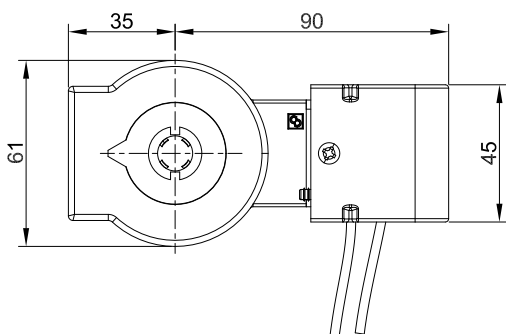
9116 (Tipo CM2-N4)



9185 (tipo CM3-N2)



9186 (tipo CM3-N4)



9150UL/R02



**TABLE 43: General characteristics of coils, UL Recognized approved**

| Catalogue Number | Coil Type | Voltage [V]  | Voltage tolerance [%] | Frequency [Hz] | Insulation class IEC 85 | TA [°C] |      | Connection                     | Connectors | Protection Degree      |
|------------------|-----------|--------------|-----------------------|----------------|-------------------------|---------|------|--------------------------------|------------|------------------------|
|                  |           |              |                       |                |                         | min.    | max. |                                |            |                        |
| 9105/RA2         | HM2       | 24 A.C.      | +10 / -10             | 60             | F                       | -20     | +50  | Terminal block for DIN 43650/A | 9150UL/R02 | IP 65 (with connector) |
| 9105/RA4         |           | 120 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9105/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9105/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9105/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9115/RA2         | CM2-N2    | 24 A.C.      | +10 / -10             | 60             | F                       | -20     | +50  | Junction box NEMA 2            | -          | ~ IP 12-32             |
| 9115/RA4         |           | 120 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9115/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9115/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9115/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9116/RA2         | CM2-N4    | 24 A.C.      | +10 / -10             | 60             | F                       | -20     | +50  | Conduit hub NEMA 4             | -          | ~ IP 54                |
| 9116/RA4         |           | 120 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9116/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9116/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9116/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9125/RD1         | HM3       | 12 D.C.      | +10 / -5              | -              | F                       | -20     | +50  | Terminal block for DIN 43650/A | 9150UL/R02 | IP 65 (with connector) |
| 9125/RD2         |           | 24 D.C.      |                       |                |                         |         |      |                                |            |                        |
| 9125/RA2         |           | 24 A.C.      |                       |                |                         |         |      |                                |            |                        |
| 9125/RA4         |           | 120 A.C.     | +10 / -10             | 60             |                         |         |      |                                |            |                        |
| 9125/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9125/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9125/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9185/RD1         | CM3-N2    | 12 D.C.      | +10 / -5              | -              | F                       | -20     | +50  | Junction box NEMA 2            | -          | ~ IP 12-32             |
| 9185/RD2         |           | 24 D.C.      |                       |                |                         |         |      |                                |            |                        |
| 9185/RA2         |           | 24 A.C.      |                       |                |                         |         |      |                                |            |                        |
| 9185/RA4         |           | 120 A.C.     | +10 / -10             | 60             |                         |         |      |                                |            |                        |
| 9185/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9185/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9185/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9186/RD1         | CM3-N4    | 12 D.C.      | +10 / -5              | -              | F                       | -20     | +50  | Conduit hub NEMA 4             | -          | ~ IP 54                |
| 9186/RD2         |           | 24 D.C.      |                       |                |                         |         |      |                                |            |                        |
| 9186/RA2         |           | 24 A.C.      |                       |                |                         |         |      |                                |            |                        |
| 9186/RA4         |           | 120 A.C.     | +10 / -10             | 60             |                         |         |      |                                |            |                        |
| 9186/RA5         |           | 208 A.C.     |                       |                |                         |         |      |                                |            |                        |
| 9186/RA6         |           | 220/230 A.C. | +6 / -10              |                |                         |         |      |                                |            |                        |
| 9186/RA7         |           | 240 A.C.     |                       |                |                         |         |      |                                |            |                        |

**CONNECTOR**

The American certification authority Underwriters Laboratories Inc. has approved connector 9150UL/R02. This connector is certified **UL-CSA Recognized** for the USA and Canada with file E333724, in compliance with American standard UL 1977 and Canadian standard C22.2 No. 182.3. The DIN 43650 standardized connector 9150UL/R02 represents an effective system for the connection of the coil to the power system, thus ensuring safety also in the

presence of moisture. Based on the assembly requirements, this connector allows you to choose the orientation of the outer casing with respect to the inner terminal block. The gland nut of the outer casing is suitable for receiving cables with an external diameter of 6 to 9 mm and is equipped with a self-locking device. Three-pole cables with a cross-section greater than or equal to 0.75 mm<sup>2</sup> are recommended.

**TABLE 44: Consumptions and weights of coils**

| Catalogue Number | Coil Type | Voltage [V]  | Power [W] | Consumption at 20 °C [mA] |      |         |      | Weight [g] |
|------------------|-----------|--------------|-----------|---------------------------|------|---------|------|------------|
|                  |           |              |           | Start                     |      | Working |      |            |
|                  |           |              |           | 60 [Hz]                   | D.C. | 60 [Hz] | D.C. |            |
| 9105/RA2         | HM2       | 24 A.C.      | 11        | 1746                      | -    | 725     | -    | 170        |
| 9105/RA4         |           | 120 A.C.     |           | 353                       |      | 154     |      |            |
| 9105/RA5         |           | 208 A.C.     |           | 195                       |      | 84      |      |            |
| 9105/RA6         |           | 220/230 A.C. |           | 140                       |      | 63      |      |            |
| 9105/RA7         |           | 240 A.C.     |           | 140                       |      | 63      |      |            |
| 9115/RA2         | CM2-N2    | 24 A.C.      | 11        | 1746                      | -    | 725     | -    | 310        |
| 9115/RA4         |           | 120 A.C.     |           | 353                       |      | 154     |      |            |
| 9115/RA5         |           | 208 A.C.     |           | 195                       |      | 84      |      |            |
| 9115/RA6         |           | 220/230 A.C. |           | 140                       |      | 63      |      |            |
| 9115/RA7         |           | 240 A.C.     |           | 140                       |      | 63      |      |            |
| 9116/RA2         | CM2-N4    | 24 A.C.      | 11        | 1746                      | -    | 725     | -    | 240        |
| 9116/RA4         |           | 120 A.C.     |           | 353                       |      | 154     |      |            |
| 9116/RA5         |           | 208 A.C.     |           | 195                       |      | 84      |      |            |
| 9116/RA6         |           | 220/230 A.C. |           | 140                       |      | 63      |      |            |
| 9116/RA7         |           | 240 A.C.     |           | 140                       |      | 63      |      |            |
| 9125/RD1         | HM3       | 12 D.C.      | 24        | -                         | 1720 | -       | 1720 | 470        |
| 9125/RD2         |           | 24 D.C.      |           | -                         | 895  | -       | 895  |            |
| 9125/RA2         |           | 24 A.C.      | 20        | 2060                      | -    | 1015    | -    |            |
| 9125/RA4         |           | 120 A.C.     |           | 506                       |      | 261     |      |            |
| 9125/RA5         |           | 208 A.C.     |           | 286                       |      | 152     |      |            |
| 9125/RA6         |           | 220/230 A.C. |           | 260                       |      | 133     |      |            |
| 9125/RA7         |           | 240 A.C.     |           | 235                       |      | 122     |      |            |
| 9185/RD1         | CM3-N2    | 12 D.C.      | 24        | -                         | 1720 | -       | 1720 | 590        |
| 9185/RD2         |           | 24 D.C.      |           | -                         | 895  | -       | 895  |            |
| 9185/RA2         |           | 24 A.C.      | 20        | 2060                      | -    | 1015    | -    |            |
| 9185/RA4         |           | 120 A.C.     |           | 506                       |      | 261     |      |            |
| 9185/RA5         |           | 208 A.C.     |           | 286                       |      | 152     |      |            |
| 9185/RA6         |           | 220/230 A.C. |           | 260                       |      | 133     |      |            |
| 9185/RA7         |           | 240 A.C.     |           | 235                       |      | 122     |      |            |
| 9186/RD1         | CM3-N4    | 12 D.C.      | 24        | -                         | 1720 | -       | 1720 | 530        |
| 9186/RD2         |           | 24 D.C.      |           | -                         | 895  | -       | 895  |            |
| 9186/RA2         |           | 24 A.C.      | 20        | 2060                      | -    | 1015    | -    |            |
| 9186/RA4         |           | 120 A.C.     |           | 506                       |      | 261     |      |            |
| 9186/RA5         |           | 208 A.C.     |           | 286                       |      | 152     |      |            |
| 9186/RA6         |           | 220/230 A.C. |           | 260                       |      | 133     |      |            |
| 9186/RA7         |           | 240 A.C.     |           | 235                       |      | 122     |      |            |

**TABLE 45: General characteristics of connectors, UL Recognized approved**

| Catalogue Number | Standard  | Degree of protection | Class of insulation        | Approval      |
|------------------|-----------|----------------------|----------------------------|---------------|
| 9150UL/R02       | DIN 43650 | IP65<br>EN 60529     | Group C VDE<br>0110-1 / 89 | UL Recognized |

# CHAPTER 10

## COILS AND CONNECTORS, ATEX-CERTIFIED



### APPLICATIONS

For the solenoid expansion valves compliant with the ATEX Directive and presented in Chapter 6 (series 2028EX), the following coils are available:

- Series 9100EX (coils type HM2)
- Series 9110EX (coils type CM2)

These coils are classified as Group II, Category 3 equipment according to the ATEX Directive (2014/34/EU). This equipment is suitable for use on refrigeration systems located in areas classified as “Zone 2” potentially explosive environments according to the definitions in Annex I of Directive 1999/92/EC.

Coils in series 9100EX must be used only with connector type 9150EX/R02. The protection rating of the coil + connector system is IP65 according to the EN 60529 standard.

### CONSTRUCTION

The coils in series 9100EX and 9120EX are manufactured in compliance with European standards EN 60079-0:2009 and 60079-18:2009, which ensure their compliance to the Essential Health and Safety Requirements of Directive 2014/34/EU. The two series of coils are Class F encapsulated and have Class H enamelled copper wire windings, in compliance with IEC standard 85. The outer casing is made of waterproof, dielectric resins that guarantee reinforced insulation and allow any type of assembly.

All coils have Class I protection ratings against electric contacts. Consequently, their safety requires an efficient ground system. Rubber gaskets assembled on the upper and lower ends of the coils complete the protection of the windings from humidity.

The terminals of the coils in series 9100EX consist of two Faston connectors plus a Faston ground connector. Coils in series 9110EX are equipped with a 1 m long power supply cable incorporated in the encapsulated section. The cable has a polyurethane sheath with operating temperature of up to 125 °C and cable insulation in special PVC with an operating temperature of up to 125 °C. All coils in this

chapter are suitable for continuous operation. The solid construction of these coils makes them suitable for use in refrigeration systems operating in heavy-duty environments

### CERTIFICATIONS

Compliance of the coils in series 9100EX to Directive 2014/34/EU is certified by the Italian notified body IMQ, with certificate No. IMQ 13 ATEX 002X (Certified Type Test).

Protection type of the coils in series 9100EX: Ex mc IIC T5 Gc / Ex mc IIIC T100°C Dc IP65.

Compliance of the coils in series 9110EX to Directive 94/9/EC is certified by the Italian notified body IMQ, with certificate No. IMQ 13 ATEX 001X (Certified Type Test).

Protection type of the coils in series 9110EX: Ex mc IIC T4 Gc / Ex mc IIIC T135°C Dc IP65.

Coils in series 9100EX and 9110EX with 110 VAC, 220/230 VAC and 240 VAC voltages are produced in accordance with the Low Voltage Directive (2006/95/EC). All coils in series 9100EX and 9110EX comply with the Electromagnetic Compatibility (EMC) Directive (2004/108/EC).

### CONNETTORE

Connector 9150EX/R02 is classified as Group II, Category 3 equipment according to the ATEX Directive (2014/34/EU). This equipment is suitable for use on refrigeration systems located in areas classified as “Zone 2” potentially explosive environments according to the definitions in Annex I of Directive 1999/92/EC.

The DIN 43650 standardized connector 9150EX/R02 represents an effective system for the connection of the coil to the power system, thus ensuring safety also in the presence of moisture. Based on the assembly requirements, this connector allows you to choose the orientation of the outer casing with respect to the inner terminal block. The gland nut of the outer casing is suitable for receiving cables with an external diameter of 6 to 9 mm and is equipped with a self-locking device. Three-pole cables with a cross-section greater than or equal to 0.75 mm<sup>2</sup> are recommended.



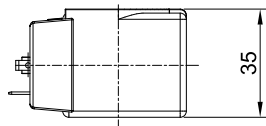
### N.B.: PRODUCT SUITABLE FOR HYDROCARBON REFRIGERANTS

The products in this chapter can be used with HC refrigerants classified as flammable fluids and that are in Safety Group A3 according to Standard EN 378-1:2016. These products must be used exclusively in refrigeration systems that comply with the current regulations for

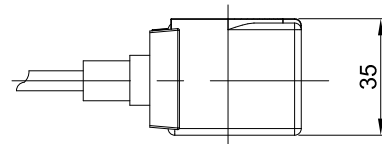
flammable refrigerant fluids (series EN 60335).

Only authorized personnel, qualified to work on flammable refrigeration systems, must perform installation, maintenance and repair operations.

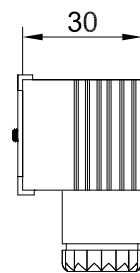
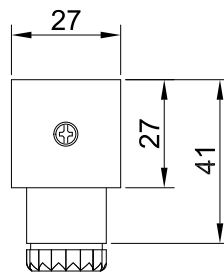
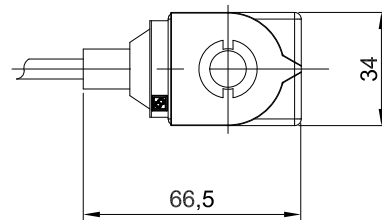
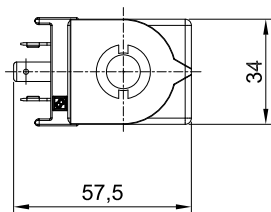
**N.B.: The personnel must carefully follow the operating instructions provided in the packaging of said valves.**



9100EX (tipo HM2)



9120EX (tipo CM2)



9150EX/R02

**TABLE 46: General characteristics of coils ATEX compliance for use in EX Zone 2**

| Catalogue Number | Coil Type | Voltage [V]  | Voltage tolerance [%] | Frequency [Hz] | Insulation class EN 60730 | TA [°C] |      | Connection                     | Connectors | Protection Degree      |
|------------------|-----------|--------------|-----------------------|----------------|---------------------------|---------|------|--------------------------------|------------|------------------------|
|                  |           |              |                       |                |                           | min.    | max. |                                |            |                        |
| 9100EX/RA2       | HM2       | 24 A.C.      | +10 / -10             | 50 / 60        | H                         | -20     | +50  | Terminal block for DIN 43650/A | 9150EX/R02 | IP 65 (with connector) |
| 9100EX/RA4       |           | 110 A.C.     |                       |                |                           |         |      |                                |            |                        |
| 9100EX/RA6       |           | 220/230 A.C. | +6 / -10              |                |                           |         |      |                                |            |                        |
| 9100EX/RA7       |           | 240 A.C.     | +10 / -10             |                |                           |         |      |                                |            |                        |
| 9110EX/RA2       | CM2       | 24 A.C.      | +10 / -10             | 50 / 60        | H                         | -20     | +50  | Three wires cable              | -          | IP 66                  |
| 9110EX/RA4       |           | 110 A.C.     |                       |                |                           |         |      |                                |            |                        |
| 9110EX/RA6       |           | 220/230 A.C. | +6 / -10              |                |                           |         |      |                                |            |                        |
| 9110EX/RA7       |           | 240 A.C.     | +10 / -10             |                |                           |         |      |                                |            |                        |

**TABLE 47: Consumptions and weights of coils**

| Catalogue Number | Coil Type | Voltage [V]  | Power [W] | Consumption at 20 °C [mA] |         |      |         |         |      | Weight [g] |
|------------------|-----------|--------------|-----------|---------------------------|---------|------|---------|---------|------|------------|
|                  |           |              |           | Start                     |         |      | Working |         |      |            |
|                  |           |              |           | 50 [Hz]                   | 60 [Hz] | D.C. | 50 [Hz] | 60 [Hz] | D.C. |            |
| 9100EX/RA2       | HM2       | 24 A.C.      | 8         | 920                       | 825     | -    | 527     | 420     | -    | 230        |
| 9100EX/RA4       |           | 110 A.C.     |           | 230                       | 205     |      | 128     | 114     |      |            |
| 9100EX/RA6       |           | 220/230 A.C. |           | 120                       | 105     |      | 68      | 58      |      |            |
| 9100EX/RA7       |           | 240 A.C.     |           | 100                       | 87      |      | 54      | 43      |      |            |
| 9110EX/RA2       | CM2       | 24 A.C.      | 8         | 920                       | 825     | -    | 527     | 420     | -    | 230        |
| 9110EX/RA4       |           | 110 A.C.     |           | 230                       | 205     |      | 128     | 114     |      |            |
| 9110EX/RA6       |           | 220/230 A.C. |           | 120                       | 105     |      | 68      | 58      |      |            |
| 9110EX/RA7       |           | 240 A.C.     |           | 100                       | 87      |      | 54      | 43      |      |            |

**TABLE 48: General characteristics of connectors**

| Catalogue Number | Standard  | Degree of protection | Class of insulation        | Approval                             |
|------------------|-----------|----------------------|----------------------------|--------------------------------------|
| 9150EX/R02       | DIN 43650 | IP65<br>EN 60529     | Group C<br>VDE 0110-1 / 89 | ATEX compliance for use in EX Zone 2 |

# CHAPTER 11 ■

## “SMART CONNECTOR” SYSTEM



### APPLICATIONS

The “SMART CONNECTOR” systems series 9910 are formed by coupling a connector in series 9152, equipped with an integrated electronic circuit in the connector, with a specific series 9300 coil designed for the connector. These systems have been designed by Castel to be installed on:

- Normally-closed solenoid valves in series 1024, 1028, 1034, 1038, 1040, 1048, 1050, 1058, 1059, 1064, 1068, 1070, 1078, 1079, 1090, 1098 and 1099
- Solenoid expansion valves in series: 2028, 2028N, 2028R, and 2028E, if suitably sized to have opening / closing cycles with a frequency greater than 0.6 seconds.

and allow:

- a reduction in energy consumption when fully operational
- a consequent reduction in the operating temperature
- an extension of the coil life
- an increase in the MOPD value

**N.B.:** Castel does not sell the two parts (coil and connector) that make up a “SMART CONNECTOR” system separately.

### CONNECTION CONSTRUCTION

EN 175301-803 (former DIN 43650) standardized connectors 9152 represent an effective system for the connection of the coil to the power system, thus ensuring safety also in the presence of moisture.

Connectors 9152 are available in both the direct current version (with 12 VDC and 24 VDC voltages) and in the alternating current version (with 24 VAC or 220/240 VAC voltages).

The direct current versions are equipped with polarity inversion protection.

The alternating current versions are equipped with a bridge rectifier circuit integrated on the circuit.

All versions, both direct current and alternating current, are equipped with a diode device that guarantees surge protection. All versions have the voltage for use and the wiring diagram printed on the casing. The gland nut of the outer casing is suitable for receiving cables with an external diameter of 6 to 9 mm and is equipped with a self-locking device. It is recommended that three-pole cables with a cross-section greater than or equal to 0.75 mm<sup>2</sup> be used. There are no versions with co-moulded cables.

**Each connector in a “SMART CONNECTOR” system must be used only for the type of coil with which it is coupled in the system. Incorrect use of the connector with other types of coils produced by Castel will quickly damage the coil and the connector.**

### COIL CONSTRUCTION

Coils in series HF2 (9300) used in the “SMART CONNECTOR” systems are special coils available in both the direct current version (with 12 VDC and 24 VDC voltages) and rectified current version (with 24 VRAC, 220 VRAC, or 240 VRAC).

These coils are in Class H, in accordance with IEC standard 85 and their production is compliant with standards EN 60730-1 and EN 60730-2-8. The windings are made of enamelled copper wire, with insulation class H (180 °C), in compliance with IEC standard 85. The terminals of the coils consist of two Faston connectors plus a Faston ground connector. The outer casing is made of waterproof, dielectric resins that guarantee reinforced insulation and allow any type of assembly.

They have Class I protection ratings against electric contacts. Consequently, their safety requires an efficient ground system. A rubber gasket assembled on the lower end of the coil completes the protection of the windings from humidity. When coupled with connectors 9152, these coils guarantee an IP65 protection rating according to standard EN 60529.

The coils are designed for continuous use. The solid construction of these coils makes them suitable for use in refrigeration systems operating in heavy-duty environments. The maximum ambient temperature for all coils is 50 °C.

**Each coil in a “SMART CONNECTOR” system must be used only in combination with the type of connector with which it is coupled in the system. Incorrect use of the coil with other types of connectors produced by Castel will quickly damage the coil and the connector.**

### OPERATION

Through the integrated circuit in the connector, and coupling with the specific coil, connectors 9152 are capable of improving the MOPD characteristics of Castel solenoid expansion valves, reducing the power consumption by up

to 50% over time, extending the coil life, and decreasing the noise.

The integrated circuit located inside the connector works in different modes based on the power supply voltage. Specifically, there are two main families with different operating logics.

Connectors 9152/RD (direct current) supercharge the dedicated coil 9300 to its maximum allowed power for a short, pre-set interval. This is called the “Boost” time. It generates a greater attraction force on the valve’s magnetic unit, and consequently increases the MOPD value. At the end of the “Boost” phase, during normal operation, connectors 9152/RD maintain the electric consumption of the dedicated coil 9300 at a lower value, from 45% to 55% lower than the power absorbed by the coil. The power reduction occurs by powering the coil with a high-frequency pulsed current (ON/OFF cycles), from 15 to 30 kHz. This frequency is aimed at guaranteeing the minimum magnetic force to keep the valve open during operation.

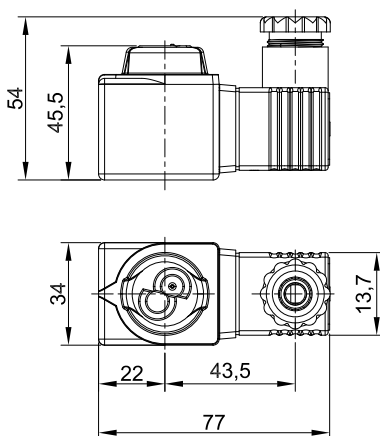
Connectors 9152/RA (alternating current) supercharge the coils 9300 for a pre-set interval. This is called the “Boost” time. It generates a greater attraction force on the valve’s magnetic unit, and consequently increases the MOPD value. Once this period is over, the electronics remove one phase wave every second one, with an effect comparable to powering the coil with pulsed/rectified current with a frequency half of that of the network. By using this system, you obtain an electric power consumption reduction of the unit to a value from 35% to 45%, while maintaining the

minimum magnetic force that allows the valve to be opened. This operating logic makes the “Smart Connector” system powered in alternating current very quiet, reducing the normal noise level, which can be up to 13 dB, to values less than 4 dB based on the valve installation.

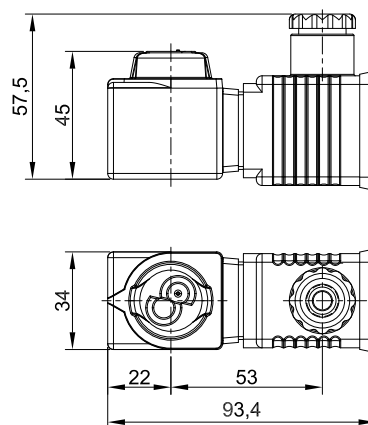
Using the afore-mentioned logic, it is possible to significantly reduce the electricity consumption (which can be important considering the system of refrigerator aisles in a supermarket). Also, it leads to a lower operating temperature of the coil and therefore, in conclusion, less wear on the electromechanical drive system. Obviously, these reductions in consumption are strictly related to the use of the coils. For proper evaluation of the real energy savings, it is necessary to consider the number of coil interventions with respect to the normal power supply time of the valve. If the number of interventions is reduced, the consumption is reduced; if the number of interventions increases, the consumption grows. Table 49 shows the main characteristics of the “SMART CONNECTOR” systems. Table 50 indicates the MOPD values that can be attained by the solenoid expansion valves produced by Castel if coupled with the various models of the “SMART CONNECTOR” system.

## CERTIFICATIONS

All connectors and coils in this chapter comply with the Electromagnetic Compatibility (EMC) Directive (2004/108/EC). The connectors with 220/240 VAC voltage and the coils with 220 VRAC and 240 VRAC voltage comply with the Low Voltage Directive (2006/95/EC).



9910/RD



9910/RA



**TABELLA 49: General characteristics of systems SMART CONNECTOR**

| Catalogue Number | Voltage [V] | Voltage tolerance [%] | Frequency [Hz] | Working nominal power [W] | Nominal power tolerance [%] | Insulation class IEC 85 | TA [°C] |     | Boost Time [msec] | Protection degree |
|------------------|-------------|-----------------------|----------------|---------------------------|-----------------------------|-------------------------|---------|-----|-------------------|-------------------|
|                  |             |                       |                |                           |                             |                         | min     | max |                   |                   |
| 9910/RD1 (1)     | 12 VDC      | +/-10                 | -              | 3                         | +/-10                       | H                       | -20     | +50 | 130               | IP65              |
| 9910/RD2 (1)     | 24 VDC      | +/-10                 | -              | 5                         | +/-10                       | H                       | -20     | +50 | 130               | IP65              |
| 9910/RA2         | 24 VAC      | +/-10                 | 50/60          | 7                         | +/-10                       | H                       | -20     | +50 | 200               | IP65              |
| 9910/RA6         | 220 VAC     | +/-10                 | 50/60          | 7                         | +/-10                       | H                       | -20     | +50 | 200               | IP65              |
| 9910/RA7         | 240 VAC     | +/-10                 | 50/60          | 7                         | +/-10                       | H                       | -20     | +50 | 200               | IP65              |

(1): Warning if these connectors are supplied via unidirectional direct current or rectified by means of the Graetz bridge, they could not perform a correct cycle of operation but always remain in Boost conditions, leading to fast damage of the

coil. For correct operation the kits series 9910/RD MUST be powered by direct current stabilized or rectified.

**TABELLA 50: PWM expansion valves with SMART CONNECTOR: MOPD values [bar]**

| PWM Valves Codes |              |                |              | SMART CONNECTOR |          |          |          |          |                |            |    |    |    |    |
|------------------|--------------|----------------|--------------|-----------------|----------|----------|----------|----------|----------------|------------|----|----|----|----|
|                  |              |                |              | 9910/RD1        | 9910/RD2 | 9910/RA2 | 9910/RA6 | 9910/RA7 | Codes          |            |    |    |    |    |
| Refrigerants     |              |                |              | 12 VDC          | 24 VDC   | 24 VAC   | 220 VAC  | 240 VAC  | Voltage [V]    |            |    |    |    |    |
| HCFC - HFC - HFO | R23          | HFC - HC - HFO | R744         |                 |          |          |          |          | Frequency [Hz] |            |    |    |    |    |
| 2028/3S01        | 2028R/3S01   | 2028N/3S01     | -            | 37              | 37       | 37       | 37       | 37       |                |            |    |    |    |    |
| 2028/M10S01      | 2028R/M10S01 | 2028N/M10S01   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/3S02        | 2028R/3S02   | 2028N/3S02     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M10S02      | 2028R/M10S02 | 2028N/M10S02   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/3S03        | 2028R/3S03   | 2028N/3S03     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M10S03      | 2028R/M10S03 | 2028N/M10S03   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/3S04        | 2028R/3S04   | 2028N/3S04     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M10S04      | 2028R/M10S04 | 2028N/M10S04   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/3S05        | 2028R/3S05   | 2028N/3S05     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M10S05      | 2028R/M10S05 | 2028N/M10S05   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/3S06        | 2028R/3S06   | 2028N/3S06     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M10S06      | 2028R/M10S06 | 2028N/M10S06   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/4S07        | 2028R/4S07   | 2028N/4S07     |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/M12S07      | 2028R/M12S07 | 2028N/M12S07   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/4S08        | 2028R/4S08   | 2028N/4S08     |              |                 |          |          |          |          |                | 32         | 32 |    |    |    |
| 2028/M12S08      | 2028R/M12S08 | 2028N/M12S08   |              |                 |          |          |          |          |                |            |    |    |    |    |
| 2028/4S09        | 2028R/4S09   | 2028N/4S09     |              |                 |          |          |          |          |                | 22         | 22 | 32 | 32 | 32 |
| 2028/M12S09      | 2028R/M12S09 | 2028N/M12S09   |              |                 |          |          |          |          |                |            |    |    |    |    |
| -                | -            | -              |              |                 |          |          |          |          |                | 2028E/3S00 | 37 | 37 | 37 | 37 |
|                  |              |                | 2028E/M10S00 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S01   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S01 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S02   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S02 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S03   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S03 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S04   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S04 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S05   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S05 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/3S06   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M10S06 |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/4S07   |                 |          |          |          |          |                |            |    |    |    |    |
|                  |              |                | 2028E/M12S07 |                 |          |          |          |          |                |            |    |    |    |    |



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