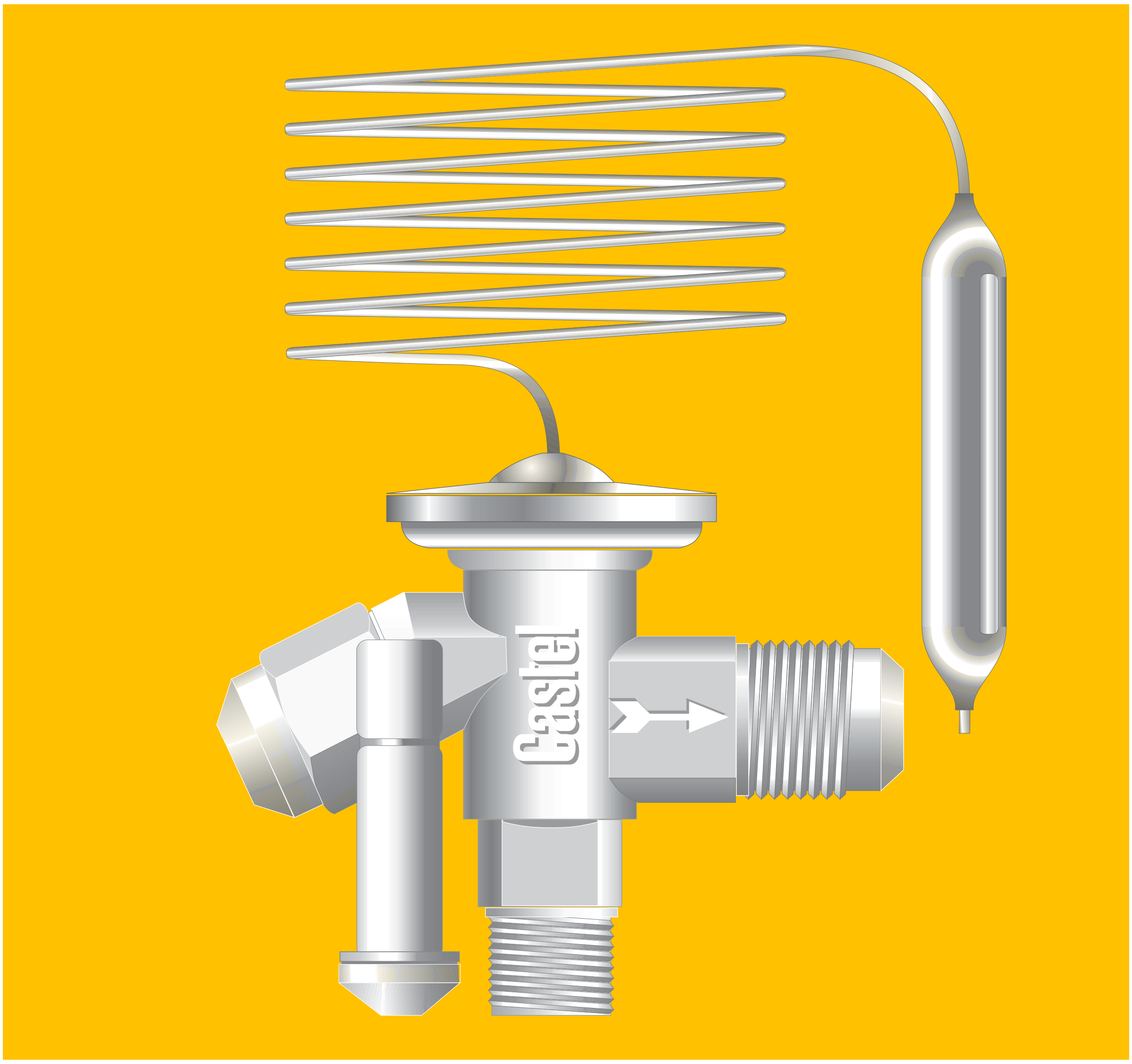
THERMOSTATIC EXPANSION VALVES



THERMOSTATIC EXPANSION VALVES SERIES 22 WITH INTERCHANGEABLE ORIFICE ASSEMBLY

APPLICATION

Castel thermostatic expansion valves series 22 regulate the flow of refrigerant liquid into evaporators; the liquid injection is controlled by the refrigerant superheat.
The new Castel "22" series are designed to work with interchangeable orifice assembly, to provide flexibility in selection of capacities, and can be used in a wide range of applications as listed below:

- Refrigeration systems (display cases in supermarkets, freezers, ice cream and ice maker machines, transport refrigeration etc).
- Air conditioning systems
- Heat pump systems
- Liquid chillers

which use refrigerant fluids proper to the Group II (as defined in Article 9, Section 2.2, of Directive 97/23/EC and referred to in Directive 67/548/EEC).

OPERATION

Castel thermostatic expansion valves acts as throttle device between the high pressure and the low pressure sides of refrigeration systems and ensure that the rate of refrigerant flow into the evaporator exactly matches the rate of evaporation of liquid refrigerant in the evaporator. If the actual superheat is higher than the set point the valve feeds the evaporator with more liquid refrigerant, if the actual superheat is lower than the set point the valve decreases the flow of liquid refrigerant to the evaporator. Thus the evaporator is fully utilized and no liquid refrigerant may reach the compressor.

CONSTRUCTION

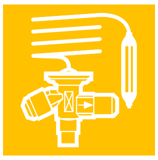
Castel thermostatic expansion valve series 22 is made up of two parts that must work together: the first is the body, which is the actuator of the regulator, and the second is the orifice, which contains the valve and attends the expansion of the refrigerating fluid.

Body assembly: two parts make it up: the thermostatic (power) element and the body with its inner elements.
The thermostatic element is the motor of the valve; a sensing bulb is connected to the diaphragm assembly by 1.5 meter length of capillary tubing, which transmits bulb pressure to the top of the valve's diaphragm. The sensing bulb pressure is a function of the temperature of the thermostatic charge that is the substance within the bulb.
The body is made from forged brass with connection in angle configuration. The interchangeable orifice assembly can be replaced through the inlet connection. A steel rod, inside the body, transfers the diaphragm movement to the plug inside the orifice assembly. When the thermostatic charge pressure increases, the diaphragm will be deflected downward transferring this motion to the plug, which lifts from seat and allows the liquid passing through orifice. A spring opposes the force underneath the diaphragm and the side spindle can adjust its tension. Static superheat increases by turning the side spindle clockwise and decreased by turning the spindle counter clockwise.
The thermostatic element is hardly connected by brazing to the forged brass body to avoid any leakage.
The body assembly can be supplied with internal or external equalizer; both types can also be supplied either with flare connections or with solder connections (outlet and external equalizer if present).

Table 1: General Caracteristics of Body Assemblies of Thermostatic Expansion Valves

Catalogue number		Connections							Refrigerant	Evaporating Temperature Range [°C]	MOP	Max bulb temperature [°C]	TS [°C]		PS [bar]	Risk Category according to PED
		SAE Flare			ODS [mm]		ODS [in]									
internal equalizer	external equalizer	IN	OUT	Equal.	OUT	Equal.	OUT	Equal.					min	max		
2210/4	–	3/8"	1/2"	–	–	–	–	–	R22 R407C	- 40 → + 10	without	100 (1)	-60	+120	34	Art. 3.3
2210/M12S			–	–	12	–	–	–								
2210/4S			–	–	–	–	1/2"	–								
–	2210/4E		1/2"	1/4"	–	–	–	–								
	2210/M12SE		–	–	12	6	–	–								
	2210/4SE		–	–	–	–	1/2"	1/4"								
2211/4	–		1/2"	–	–	–	–	–			+ 15 °C (95 psi)					
2211/M12S			–	–	12	–	–	–								
2211/4S			–	–	–	–	1/2"	–								
–	2211/4E		1/2"	1/4"	–	–	–	–								
	2211/M12SE		–	–	12	6	–	–								
	2211/4SE		–	–	–	–	1/2"	1/4"								
2220/4	–	3/8"	1/2"	–	–	–	–	–	R134a	- 40 → + 10	without					
2220/M12S			–	–	12	–	–	–								
2220/4S			–	–	–	–	1/2"	–								
–	2220/4E		1/2"	1/4"	–	–	–	–								
	2220/M12SE		–	–	12	6	–	–								
	2220/4SE		–	–	–	–	1/2"	1/4"								
2221/4	–		1/2"	–	–	–	–	–			+ 15 °C (55 psi)					
2221/M12S			–	–	12	–	–	–								
2221/4S			–	–	–	–	1/2"	–								
–	2221/4E		1/2"	1/4"	–	–	–	–								
	2221/M12SE		–	–	12	6	–	–								
	2221/4SE		–	–	–	–	1/2"	1/4"								
2230/4	–	3/8"	1/2"	–	–	–	–	–	R404A R507	- 40 → + 10	without					
2230/M12S			–	–	12	–	–	–								
2230/4S			–	–	–	–	1/2"	–								
–	2230/4E		1/2"	1/4"	–	–	–	–								
	2230/M12SE		–	–	12	6	–	–								
	2230/4SE		–	–	–	–	1/2"	1/4"								
2231/4	–		1/2"	–	–	–	–	–			+ 15 °C (120 psi)					
2231/M12S			–	–	12	–	–	–								
2231/4S			–	–	–	–	1/2"	–								
–	2231/4E		1/2"	1/4"	–	–	–	–								
	2231/M12SE		–	–	12	6	–	–								
	2231/4SE		–	–	–	–	1/2"	1/4"								
2234/4	–		1/2"	–	–	–	–	–		- 60 → - 25	- 20 °C (30 psi)					
2234/M12S			–	–	12	–	–	–								
2234/4S			–	–	–	–	1/2"	–								
–	2234/4E		1/2"	1/4"	–	–	–	–								
	2234/M12SE		–	–	12	6	–	–								
	2234/4SE		–	–	–	–	1/2"	1/4"								

(1) when valve is installed. 60 °C with element not mounted



The nuts for flare connection type and the inlet-brazing adapter for solder connection type can be ordered separately.

The main part of body assembly are made with the following materials:

- stainless steel for bulb, capillary tubing, diaphragm casing, diaphragm and rod
- hot forged brass EN 12420 – CW 617N for body
- brass EN 12164 – CW 614N for superheat setting spindle and spring holder
- steel DIN 17223-1 for spring
- copper tube EN 12735-1 – Cu DHP for solder connection

Orifice assembly: interchangeable orifice assembly provide a wide range of capacity from 0,5 up to 15,5 kW (nominal capacity with R22). The external cartridge contains the following elements: housing, plug (metering device), seat, spring and strainer. The rigid design of orifice assembly and its internal components make sure that plug and seat will withstand all types of critical operations (liquid hammering, cavitation, sudden variation of pressure and temperature contaminants). The spring holds the plug firmly to the seat to ensure the minimum leakage through the valve; for positive shut-off, the installation of a solenoid valve is required. Orifice assemblies are available in these two solutions:

- with conical flanged strainer, for valves with SAE Flare threaded connections.
- with flat flanged strainer, for valves with ODS solder connections, to use with adapter series 2271.

Orifice assemblies strainers can be cleaned or exchanged, in this last case it’s possible to order separately the following two types of strainers.

- strainer 2290 for valves with SAE Flare threaded connections.
- strainer 2290/S for valves with ODS solder connections.

THERMOSTATIC CHARGES

Liquid charge: the behaviour of valves with liquid charge is exclusively determined by temperature changes at the bulb and not subject to any cross-ambient interference. They feature a fast response time and thus react quickly in the control circuit. Castel thermostatic expansion valves with liquid charge cannot incorporate MOP functions.
Gas charge: the behaviour of valves with gas charge will be determined by the lowest temperature at any part of the expansion valve (thermostatic element, capillary tube or bulb). If any parts other than the bulb are subjected to the lowest temperature, malfunction of expansion valve may occur (charge migration). Castel thermostatic expansion valves with gas charge always feature MOP functions and include ballasted bulb. Ballast in the bulb has a damping effect on the valve regulation and leads to slow opening and fast closure of the valve.

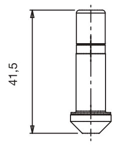
MOP (Maximum Operating Pressure): this functionality limits the evaporator pressure to a maximum value to protect the compressor from the overload condition (**M**otor **O**verload **P**rotection). MOP is the evaporating pressure at which the expansion valve will throttle liquid injection into the evaporator and thus prevent the evaporating pressure from rising. Expansion valve operates as superheat control in normal working range and operates as pressure regulator within MOP range. The MOP point will change if the factory superheat setting of the expansion valve is changed. Superheat adjustments influence the MOP point as following:

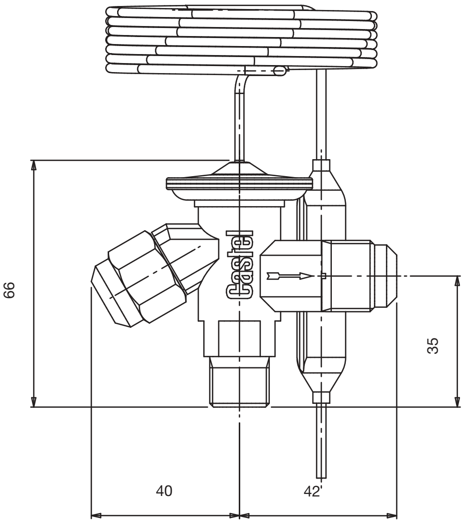
- increase of superheat → decrease of MOP
- decrease of superheat → increase of MOP

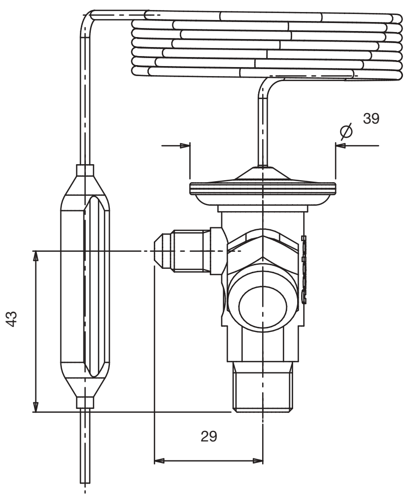
Superheat: this is the controlling parameter of the expansion valve. Superheat, measured at the evaporator outlet, is defined as the difference between actual bulb temperature and the evaporating temperature at the saturation point. In order to prevent liquid refrigerant from entering the compressor, a certain minimum superheat must be maintained. In expansion valve operation the following terms are used:

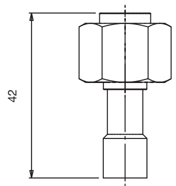
- Static superheat: it's the superheat above that the valve will begin to open. Castel thermo expansion valves are factory preset for optimum static superheat setting. This setting should be modified only if absolutely necessary. Static superheat for Castel valves without MOP is 5 °C and for Castel valves with MOP is 4°C.
- Opening superheat: it's the amount of superheat above the static superheat required to produce a given valve capacity
- Operating superheat: it's the sum of static and opening superheat

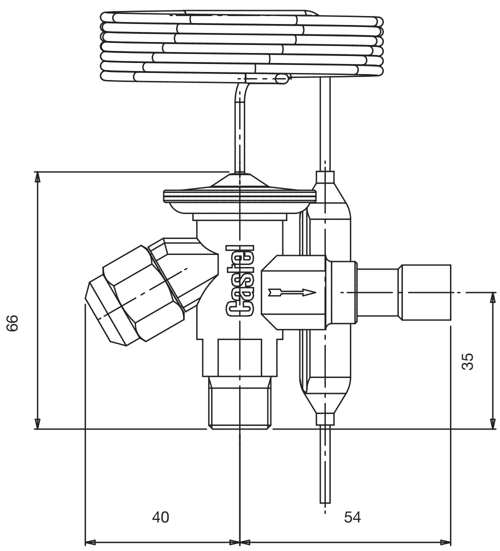
Subcooling: it's defined as the difference between the liquid refrigerant temperature and its saturation temperature. Subcooling generally increases the capacity of refrigeration system and may be accounted for when dimensioning an expansion valve. Depending on system design, subcooling may be necessary to prevent flash gas from forming in the liquid line. If flash gas forms in the liquid line, the capacity of expansion valve will be greatly reduced. All capacity tables, in this chapter, are calculated for a subcooling value of 4 °C; if the actual subcooling is higher than 4 °C the evaporator capacity must be divided by the appropriate correction factor shown is the tables below every capacity tables.

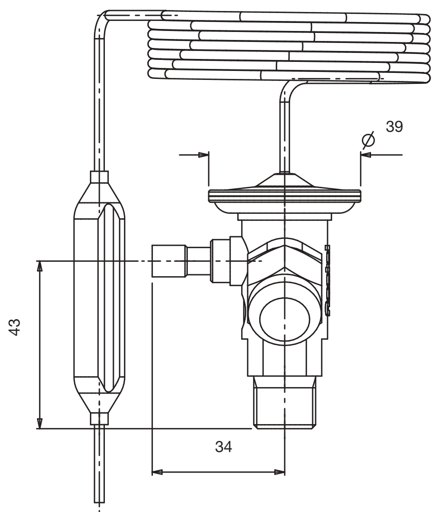












SELECTION

To correctly select a thermo expansion valve on a refrigerating system, the following design conditions must be available:
Type of refrigerant
Evaporator capacity, Q_e
Evaporating temperature/pressure, T_e / p_e
Lowest possible condensing temperature/ pressure, T_c / p_c
Liquid refrigerant temperature, T_l
Pressure drop in the liquid line, distributor and evaporator, Δp

The following procedure helps to select the correct valve for the system.

Step 1
Determine the pressure drop across the valve. The pressure drop is calculated by the formula:

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

where:
P_c = condensing pressure
P_e = evaporating pressure
Δp = sum of pressure drops in the liquid line, distributor and evaporator

Step 2
Determine required valve capacity. Use the evaporating capacity Q_e to select the required valve size at a given evaporating temperature. If necessary, correct the evaporator capacity for subcooling. Subcooling liquid refrigerant entering the evaporator increase the evaporator capacity, so that a smaller valve may be required.

The subcooling is calculated by the formula:

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

From the subcooling corrector factor table find the appropriate corrector factor F_{sub} corresponding to the ΔT_{sub} calculated and determine the required valve capacity by the formula:

$$\Delta Q_{sub} = Q_e / F_{sub}$$

Step 3
Determine required orifice size. Use the pressure drop across the valve, the evaporating temperature and the calculated evaporator capacity to select the corresponding orifice size from the capacity table corresponding to the chosen refrigerant.

Step 4
Select a thermostatic charge. Chose the type of charge, liquid without MOP or gas with MOP, and the temperature range, normal temperature or low temperature.

Step 5
Determine if external equalizer is required. External equalizer is always required if a distributor is used or if there is an appreciable difference in pressure from the valve outlet to the bulb location. Finally determine the type of connections and their sizes.

Table 2: Orifice Assemblies - Rated Capacities in kW

Catalogue Number		Evaporating Temperature Range [°C]			
		- 40 → + 10			-60→ -25
Valves with SAE Flare connections	Valves with ODS connections	R22 R407C	R134a	R404A R507	R404A R507
220X	220X/S	0,5	0,4	0,38	0,38
2200	2200/S	1,0	0,9	0,7	0,7
2201	2201/S	2,5	1,8	1,6	1,6
2202	2202/S	3,5	2,6	2,1	2,1
2203	2203/S	5,2	4,6	4,2	3,5
2204	2204/S	8,0	6,7	6,0	4,9
2205	2205/S	10,5	8,6	7,7	6,0
2206	2206/S	15,5	10,5	9,1	6,6

Rated capacities, for temperature range - 40 → + 10, are based on:
- *Evaporating temperature Tevap = + 5 °C*
- *Condensing temperature Tcond = + 32 °C*
- *Refrigerant liquid temperature ahead of valve Tliq = + 28 °C*

Rated capacities, for temperature range - 60 → - 25, are based on:
- *Evaporating temperature Tevap = - 30 °C*
- *Condensing temperature Tcond = + 32 °C*
- *Refrigerant liquid temperature ahead of valve Tliq = + 28 °C*

Table 3: Solder adapters

Catalogue Number	ODS Connections	
	[in]	[mm]
2271/M6S	–	6
2271/2S	1/4"	–
2271/3S	3/8"	–
2271/M10S	–	10

SIZING EXAMPLE

- Type of refrigerant — R134a
- Evaporator capacity, Q_e — 6 kW
- Evaporating temperature/ pressure, T_e — - 10 °C
- Lowest possible condensing temperature/pressure, T_c — + 30 °C
- Liquid refrigerant temperature, T_l — + 20 °C
- Pressure drop in the liquid line, distributor and evaporator, Δp — 1,5 bar

STEP 1 - Determine the pressure drop across the valve
- Condensing pressure at + 30 °C - p_c = 6,71 bar
- Evaporating pressure at - 10 °C - p_e = 1,01 bar

$$\Delta p_{tot} = 6{,}71 - (1{,}01 + 1{,}5) = 4{,}2 \cdot \text{bar}$$

STEP 2 - Determine required valve capacity

$$\Delta T_{sub} = 30 - 20 = 10 \cdot °C$$

From the subcooling corrector factor table 5b, we find the appropriate corrector factor F_{sub} equal to 1,08 for ΔT_{sub} = 10 °C. Required valve capacity is:

$$\Delta Q_{sub} = 6/1{,}08 = 5{,}55 \cdot \text{kW}$$

STEP 3 - Determine required orifice size
Using the capacity table for R134a on page 25 with:
- pressure drop across the valve = 4,2 bar
- evaporating temperature = - 10 °C
- calculated evaporator capacity = 5,55 kW
- select the corresponding orifice 2205 (N.B.: the expansion valve capacity must be equal or slightly more than the calculated evaporator capacity)

MARKING

Main valve data are indicated on the upper side of the thermostatic element and on the cartridge surface of the orifice assembly.
On the thermostatic element you may find the following data:
- The valve code number
- The refrigerant
- The evaporating temperature range
- The MOP value, if present
- The maximum allowable pressure PS
- The date of production

On the cartridge of orifice assembly you may find the following data:
- The size of the orifice
- The date of production

On the plastic cap of the orifice assembly package the orifice size is marked. The cap can easily be fastened around the valve capillary tube to clearly identify the valve size.

Table 4a: Refrigerant R22/R407C - Capacities in kW for temperature range - 40°C ? +10°C

Orifice code	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = +10 °C								
220X	0,37	0,48	0,55	0,60	0,63	0,65	0,65	0,67
2200	0,87	1,1	1,2	1,3	1,4	1,4	1,4	1,5
2201	2,2	2,8	3,2	3,4	3,6	3,7	3,8	3,8
2202	3,0	4,0	4,7	5,1	5,4	5,6	5,8	5,8
2203	5,4	7,2	8,3	9,1	9,7	10,0	10,2	10,3
2204	8,1	10,8	12,5	13,8	14,5	15,0	15,5	15,5
2205	10,2	13,6	15,7	17,2	18,3	18,9	19,3	19,5
2206	12,6	16,7	19,3	21,0	22,3	23,1	23,5	23,7
Evaporating temperature = -10 °C								
220X	0,37	0,47	0,53	0,57	0,60	0,63	0,64	0,64
2200	0,79	0,96	1,1	1,2	1,2	1,3	1,3	1,3
2201	1,6	2,0	2,3	2,5	2,6	2,7	2,8	2,8
2202	2,2	2,9	3,3	3,6	3,8	4,0	4,1	4,1
2203	3,9	5,1	5,9	6,4	6,8	7,1	7,3	7,3
2204	5,8	7,6	8,7	9,5	10,1	10,5	10,8	10,9
2205	7,4	9,6	11,0	12,0	12,8	13,3	13,6	13,8
2206	9,1	11,6	13,5	14,7	15,6	16,2	16,6	16,8
Evaporating temperature = -30 °C								
220X		0,40	0,45	0,49	0,52	0,55	0,56	0,57
2200		0,79	0,9	0,96	1,0	1,1	1,1	1,1
2201		1,4	1,5	1,7	1,8	1,8	1,9	1,9
2202		1,9	2,2	2,7	2,5	2,6	2,6	2,7
2203		3,4	3,9	4,2	4,4	4,6	4,7	4,8
2204		5,0	5,7	6,2	6,6	6,8	7,0	7,1
2205		6,4	7,2	7,8	8,3	8,6	8,8	9,0
2206		7,8	8,8	9,6	10,1	10,5	10,8	11,0

Orifice code	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = 0 °C								
220X	0,37	0,48	0,55	0,59	0,63	0,65	0,66	0,66
2200	0,84	1,0	1,2	1,3	1,3	1,4	1,4	1,4
2201	1,9	2,4	2,7	3,0	3,1	3,2	3,3	3,3
2202	2,6	3,4	4,0	4,3	4,6	4,8	4,9	5,0
2203	4,6	6,1	7,1	7,8	8,2	8,5	8,7	8,8
2204	6,9	9,1	10,5	11,5	12,2	12,7	13,0	13,2
2205	8,8	11,6	13,3	14,6	15,5	16,1	16,4	16,6
2206	10,8	14,2	16,3	17,8	18,9	19,6	20,0	20,2
Evaporating temperature = -20 °C								
220X		0,44	0,50	0,54	0,57	0,59	0,61	0,61
2200		0,88	1,0	1,1	1,1	1,2	1,2	1,2
2201		1,7	1,9	2,0	2,2	2,3	2,3	2,3
2202		2,4	2,7	2,9	3,1	3,2	3,3	3,3
2203		4,2	4,8	5,2	5,5	5,8	5,9	6,0
2204		6,2	7,1	7,7	8,2	8,5	8,7	8,8
2205		7,9	9,0	9,8	10,3	10,8	11,0	11,2
2206		9,6	11,0	11,9	12,6	13,1	13,5	13,7
Evaporating temperature = -40 °C								
220X			0,42	0,45	0,48	0,50	0,52	0,53
2200			0,8	0,86	0,92	0,95	0,98	0,99
2201			1,3	1,4	1,4	1,5	1,5	1,6
2202			1,7	1,9	2,0	2,0	2,1	2,1
2203			3,1	3,4	3,5	3,7	3,8	3,8
2204			4,6	4,9	5,2	5,4	5,6	5,7
2205			5,8	6,3	6,6	6,9	7,1	7,2
2206			7,1	7,7	8,1	8,4	8,7	8,8

Table 4b: Refrigerant R22/R407C - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,06	1,11	1,15	1,20	1,25	1,30	1,35	1,39	1,44

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 4b

Table 5a: Refrigerant R134a - Capacities in kW for temperature range - 40°C → +10°C

Orifice code	Pressure drop across valve [bar]					Orifice code	Pressure drop across valve [bar]				
	2	4	6	8	10		2	4	6	8	10
Evaporating temperature = +10 °C						Evaporating temperature = 0 °C					
220X	0,34	0,43	0,47	0,50	0,51	220X	0,33	0,42	0,46	0,47	0,49
2200	0,71	0,86	0,93	0,97	0,98	2200	0,65	0,78	0,86	0,89	0,91
2201	1,5	1,9	2,1	2,2	2,2	2201	1,3	1,6	1,7	1,8	1,8
2202	2,0	2,6	3,0	3,1	3,2	2202	1,7	2,2	2,4	2,6	2,6
2203	3,6	4,7	5,3	5,6	5,8	2203	3,0	3,9	4,4	4,6	4,7
2204	5,4	7,0	7,8	8,3	8,6	2204	4,5	5,7	6,4	6,8	7,0
2205	6,9	8,9	9,9	10,8	10,9	2205	5,7	7,3	8,1	8,6	8,8
2206	8,4	10,8	12,1	12,8	13,2	2206	7,0	8,9	1,0	10,5	10,8
Evaporating temperature = -10 °C						Evaporating temperature = -20 °C					
220X	0,30	0,36	0,43	0,44	0,44	220X	0,28	0,35	0,39	0,41	0,42
2200	0,59	0,70	0,77	0,81	0,82	2200	0,53	0,62	0,69	0,72	0,73
2201	1,0	1,3	1,4	1,5	1,5	2201	0,81	1,0	1,1	1,2	1,2
2202	1,4	1,8	2,0	2,1	2,1	2202	1,1	1,4	1,5	1,6	1,7
2203	2,5	3,1	3,5	3,7	3,8	2203	2,0	2,5	2,8	2,9	3,0
2204	3,6	4,6	5,1	5,4	5,6	2204	2,9	3,6	4,0	4,3	4,4
2205	4,6	5,8	6,5	6,9	7,1	2205	3,7	4,6	5,1	5,4	5,5
2206	5,7	7,1	8,0	8,4	8,6	2206	4,5	5,6	6,2	6,6	6,8
Evaporating temperature = -30 °C						Evaporating temperature = -40 °C					
220X	0,25	0,32	0,35	0,37	0,38	220X	0,23	0,28	0,32	0,33	0,34
2200	0,48	0,55	0,61	0,64	0,64	2200	0,44	0,50	0,54	0,56	0,57
2201	0,66	0,80	0,88	0,93	0,95	2201	0,54	0,65	0,72	0,78	0,77
2202	0,9	1,1	1,2	1,3	1,3	2202	0,7	0,9	1,0	1,0	1,0
2203	1,6	2,0	2,2	2,3	2,3	2203	1,3	1,6	1,8	1,9	1,9
2204	2,3	2,9	3,2	3,3	3,4	2204	1,9	2,3	2,6	2,7	2,7
2205	3,0	3,6	4,0	4,2	4,3	2205	2,4	2,9	3,2	3,5	3,5
2206	3,6	4,4	4,9	5,2	5,3	2206	3,0	3,6	4,0	4,2	4,3

Table 5b: Refrigerant R134a - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,08	1,13	1,19	1,25	1,31	1,37	1,42	1,48	1,54

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 5b

Table 6a: Refrigerant R404A/R507 - Capacities in kW for temperature range - 40°C → +10°C

Orifice code	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = +10 °C								
220X	0,28	0,35	0,40	0,42	0,43	0,43	0,42	0,41
2200	0,67	0,82	0,90	0,94	0,96	0,96	0,93	0,90
2201	1,70	2,10	2,30	2,42	2,48	2,46	2,41	2,34
2202	2,32	3,00	3,39	3,61	3,73	3,74	3,68	3,59
2203	4,15	5,36	6,03	6,43	6,63	6,66	6,55	6,39
2204	6,24	8,06	9,06	9,66	9,95	9,98	9,81	9,57
2205	7,91	10,17	11,43	12,16	12,53	12,56	12,34	12,03
2206	9,71	12,47	13,98	14,86	15,29	15,31	15,05	14,66
Evaporating temperature = -10 °C								
220X	0,30	0,37	0,40	0,42	0,42	0,42	0,41	0,41
2200	0,65	0,76	0,82	0,84	0,87	0,87	0,85	0,83
2201	1,31	1,61	1,74	1,81	1,84	1,85	1,84	1,78
2202	1,76	2,24	2,50	2,62	2,69	2,71	2,68	2,60
2203	3,14	4,02	4,47	4,69	4,81	4,84	4,79	4,65
2204	4,66	5,97	6,61	6,95	7,13	7,18	7,11	6,91
2205	5,93	7,57	8,39	8,81	9,02	9,08	8,99	8,73
2206	7,28	9,27	10,26	10,76	11,00	11,08	10,97	10,65
Evaporating temperature = -30 °C								
220X			0,35	0,37	0,36	0,37	0,36	0,35
2200			0,67	0,70	0,70	0,70	0,69	0,67
2201			1,18	1,21	1,23	1,21	1,20	1,17
2202			1,63	1,69	1,71	1,70	1,68	1,64
2203			2,93	3,04	3,07	3,06	3,02	2,93
2204			4,28	4,47	4,52	4,51	4,46	4,35
2205			5,45	5,68	5,74	5,74	5,67	5,52
2206			6,66	6,94	7,02	7,01	6,93	6,75

Orifice code	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = 0 °C								
220X	0,30	0,37	0,41	0,42	0,43	0,43	0,43	0,41
2200	0,68	0,80	0,87	0,90	0,92	0,93	0,91	0,87
2201	1,53	1,86	2,04	2,13	2,18	2,18	2,15	2,08
2202	2,06	2,64	2,95	3,13	3,22	3,25	3,21	3,11
2203	3,68	4,72	5,27	5,59	5,75	5,80	5,73	5,55
2204	5,49	7,15	7,86	8,33	8,58	8,64	8,53	8,27
2205	6,97	8,92	9,95	10,52	10,83	10,90	10,76	10,43
2206	8,57	10,93	12,16	12,85	13,21	13,30	13,12	12,72
Evaporating temperature = -20 °C								
220X		0,35	0,38	0,40	0,39	0,40	0,39	0,38
2200		0,70	0,75	0,77	0,79	0,79	0,79	0,76
2201		1,34	1,45	1,50	1,52	1,52	1,51	1,47
2202		1,85	2,04	2,14	2,17	2,18	2,16	2,09
2203		3,32	3,66	3,83	3,89	3,90	3,86	3,75
2204		4,88	5,40	5,64	5,75	5,77	5,71	5,56
2205		6,20	6,86	7,17	7,29	7,31	7,23	7,05
2206		7,60	8,39	8,75	8,91	8,93	8,84	8,61
Evaporating temperature = -40 °C								
220X			0,32	0,33	0,33	0,33	0,32	0,32
2200			0,60	0,61	0,62	0,61	0,60	0,59
2201			0,92	0,96	0,97	0,96	0,94	0,91
2202			1,27	1,32	1,33	1,31	1,28	1,24
2203			2,28	2,36	2,38	2,36	2,31	2,24
2204			3,34	3,47	3,50	3,48	3,42	3,33
2205			4,25	4,41	4,45	4,43	4,36	4,24
2206			5,19	5,39	5,45	5,42	5,33	5,19

Table 6b: Refrigerant R404A/R507 - Correction factor for subcooling ∆tsub > 4°C

∆tsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,10	1,20	1,29	1,37	1,46	1,54	1,63	1,70	1,78

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 6b

Table 7a: Refrigerant R404A/R507 - Capacities in kW for temperature range - 60°C → - 25°C

Evaporating temperature = -25 °C

Orifice code	Pressure drop across valve [bar] 2	4	6	8	10	12	14	16
2200	0,57	0,67	0,72	0,73	0,74	0,85	0,74	0,71
2201	0,98	1,20	1,31	1,36	1,37	1,37	1,35	1,31
2202	1,31	1,65	1,83	1,91	1,93	1,93	1,90	1,85
2203	2,35	2,97	3,28	3,42	3,47	3,46	3,42	3,32
2204	3,45	4,37	4,82	5,04	5,11	5,12	5,06	4,93
2205	4,40	5,56	6,14	6,40	6,49	6,49	6,42	6,26
2206	5,40	6,30	7,49	7,81	7,93	7,93	7,85	7,64

Evaporating temperature = -40 °C

Orifice code	2	4	6	8	10	12	14	16
2200		0,56	0,60	0,61	0,62	0,61	0,60	0,59
2201		0,65	0,72	0,75	0,77	0,77	0,77	0,75
2202		1,17	1,27	1,32	1,33	1,31	1,28	1,24
2203		2,09	2,28	2,36	2,38	2,36	2,31	2,24
2204		3,03	3,34	3,47	3,50	3,48	3,42	3,33
2205		3,87	4,25	4,41	4,45	4,43	4,36	4,24
2206		4,73	5,19	5,39	5,45	5,47	5,33	5,19

Evaporating temperature = -60 °C

Orifice code	2	4	6	8	10	12	14	16
2200			0,46	0,48	0,47	0,45	0,45	0,43
2201			0,58	0,60	0,60	0,58	0,56	0,54
2202			0,78	0,80	0,80	0,78	0,75	0,72
2203			1,40	1,44	1,43	1,40	1,36	1,30
2204			2,04	2,11	2,11	2,07	2,03	1,96
2205			2,59	2,69	2,66	2,65	2,59	2,50
2206			3,16	3,28	3,30	3,25	3,18	3,07

Evaporating temperature = -30 °C

Orifice code	Pressure drop across valve [bar] 2	4	6	8	10	12	14	16
2200	0,53	0,64	0,67	0,70	0,70	0,70	0,69	0,67
2201	0,88	1,07	1,18	1,21	1,23	1,21	1,20	1,17
2202	1,18	1,47	1,63	1,69	1,71	1,70	1,68	1,64
2203	2,12	2,65	2,93	3,04	3,07	3,05	3,02	2,93
2204	3,09	3,88	4,28	4,47	4,52	4,51	4,46	4,35
2205	3,94	4,94	5,45	5,68	5,74	5,74	5,67	5,52
2206	4,83	6,06	6,66	6,94	7,02	7,01	6,93	6,75

Evaporating temperature = -50 °C

Orifice code	2	4	6	8	10	12	14	16
2200		0,49	0,53	0,54	0,54	0,53	0,52	0,50
2201		0,51	0,57	0,60	0,60	0,60	0,60	0,59
2202		0,91	0,99	1,02	1,02	1,01	0,98	0,95
2203		1,63	1,73	1,84	1,84	1,81	1,78	1,72
2204		2,36	2,60	2,69	2,71	2,68	2,63	2,56
2205		3,02	3,30	3,43	3,45	3,42	3,35	3,26
2206		3,69	4,04	4,20	4,22	4,18	4,12	4,00

Table 7b: Refrigerant R404A/R507 - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,10	1,20	1,29	1,37	1,46	1,54	1,63	1,70	1,78

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 7b

HERMETIC THERMOSTATIC EXPANSION VALVES SERIES 23 WITH FIXED ORIFICE ASSEMBLY

APPLICATION

Castel thermostatic expansion valves series 23 regulate the flow of refrigerant liquid into evaporators; the liquid injection is controlled by the refrigerant superheat.
The new Castel “23” series are specifically developed for soldering into hermetic refrigeration systems; they are offered in rated capacities up to 15,5 kW (R22) and can be used in a wide range of applications as listed below:

- Refrigeration systems (display cases in supermarkets, freezers, ice cream and ice maker machines, transport refrigeration etc).
- Air conditioning systems
- Heat pump systems
- Liquid chillers

which use refrigerant fluids proper to the Group II (as defined in Article 9, Section 2.2, of Directive 97/23/EC and referred to in Directive 67/548/EEC).

OPERATION

Castel thermostatic expansion valves acts as throttle device between the high pressure and the low pressure sides of refrigeration systems and ensure that the rate of refrigerant flow into the evaporator exactly matches the rate of evaporation of liquid refrigerant in the evaporator. If the actual superheat is higher than the set point the valve feeds the evaporator with more liquid refrigerant, if the actual superheat is lower than the set point the valve decreases the flow of liquid refrigerant to the evaporator. Thus the evaporator is fully utilized and no liquid refrigerant may reach the compressor.

CONSTRUCTION

Four parts make up the Castel thermo expansion valve series 23: the thermostatic (power) element, the body with its inner elements, the orifice assembly and the inlet connection.
The thermostatic element is the motor of the valve; a sensing bulb is connected to the diaphragm assembly by a length of capillary tubing, which transmits bulb pressure to the top of the valve’s diaphragm. The sensing bulb pressure is a function of the temperature of the thermostatic charge that is the substance within the bulb.
The body is made from forged brass with connection in angle configuration. The fixed orifice assembly is screwed into the body through the inlet side. A steel rod, inside the body, transfers the diaphragm movement to the plug inside the orifice assembly. When the thermostatic charge pressure increases, the diaphragm will be deflected downward transferring this motion to the plug, which lifts from seat and allows the liquid passing through orifice. A spring opposes the force underneath the diaphragm and the side spindle can adjust its tension. Static superheat increases by turning the side spindle clockwise and decreased by turning the spindle counter clockwise.

Table 1: General Characteristics of Thermostatic Expansion Valves

Catalogue number		ODS Connections						Refrigerant	Evaporating Temperature Range [°C]	MOP	Max bulb temperature [°C]	TS [°C]		PS [bar]	Risk Category according to PED
		[in]			[mm]										
internal equalizer	external equalizer	IN	OUT	Equal.	IN	OUT	Equal.					min	max		
2310/M6 0X→06	–	–	–	–	6	12	–	R22 R407C	- 40 → + 10	without	100 (1)	-60	+120	34	Art. 3.3
2310/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2310/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2310/M10 0X → 06	–	–	–	–	10	12	–								
–	2310/M6E 0X → 06	–	–	–	6	12	6								
–	2310/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2310/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2310/M10E 0X → 06	–	–	–	10	12	6								
2311/M6 0X → 06	–	–	–	–	6	12	–			+ 15 °C (95 psi)					
2311/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2311/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2311/M10 0X → 06	–	–	–	–	10	12	–								
–	2311/M6E 0X → 06	–	–	–	6	12	6								
–	2311/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2311/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2311/M10E 0X → 06	–	–	–	10	12	6								
2320/M6 0X → 06	–	–	–	–	6	12	–	R134a	- 40 → + 10	without					
2320/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2320/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2320/M10 0X → 06	–	–	–	–	10	12	–								
–	2320/M6E 0X → 06	–	–	–	6	12	6								
–	2320/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2320/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2320/M10E 0X → 06	–	–	–	10	12	6								
2321/M6 0X → 06	–	–	–	–	6	12	–			+ 15 °C (55 psi)					
2321/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2321/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2321/M10 0X → 06	–	–	–	–	10	12	–								
–	2321/M6E 0X → 06	–	–	–	6	12	6								
–	2321/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2321/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2321/M10E 0X → 06	–	–	–	10	12	6								
2330/M6 0X → 06	–	–	–	–	6	12	–	R404A R507	- 40 → + 10	without					
2330/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2330/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2330/M10 0X → 06	–	–	–	–	10	12	–								
–	2330/M6E 0X → 06	–	–	–	6	12	6								
–	2330/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2330/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2330/M10E 0X → 06	–	–	–	10	12	6								
2331/M6 0X → 06	–	–	–	–	6	12	–			+ 15 °C (120 psi)					
2331/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2331/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2331/M10 0X → 06	–	–	–	–	10	12	–								
–	2331/M6E 0X → 06	–	–	–	6	12	6								
–	2331/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2331/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2331/M10E 0X → 06	–	–	–	10	12	6								
2334/M6 0X → 06	–	–	–	–	6	12	–		- 60 → - 25	- 20 °C (30 psi)					
2334/2 0X → 06	–	1/4"	1/2"	–	–	–	–								
2334/3 0X → 06	–	3/8"	1/2"	–	–	–	–								
2334/M10 0X → 06	–	–	–	–	10	12	–								
–	2334/M6E 0X → 06	–	–	–	6	12	6								
–	2334/2E 0X → 06	1/4"	1/2"	1/4"	–	–	–								
–	2334/3E 0X → 06	3/8"	1/2"	1/4"	–	–	–								
–	2334/M10E 0X → 06	–	–	–	10	12	6								

(1) when valve is installed. 60 °C with element not mounted

The fixed orifice assembly provide a wide range of capacity from 0,5 up to 15,5 kW (nominal capacity with R22). It contains the following elements: housing, plug (metering device), seat, spring and strainer. The rigid design of orifice assembly and its internal components make sure that plug and seat will withstand all types of critical operations (liquid hammering, cavitation, sudden variation of pressure and temperature contaminants). The spring holds the plug firmly to the seat to ensure the minimum leakage through the valve; for positive shut-off, the installation of a solenoid valve is required.
The thermostatic element is hardly connected by brazing to the forged brass body meanwhile the inlet connection is electrical welded to the forged brass body. This construction makes the valve hermetic and avoids any leakage.
The valve can be supplied with internal or external equalizer; both types are supplied with solder connections (inlet, outlet and external equalizer if present).
The main part of valve are made with the following materials:

- stainless steel for bulb, capillary tubing, diaphragm casing, diaphragm and rod
- hot forged brass EN 12420 – CW 617N for body
- brass EN 12164 – CW 614N for superheat setting spindle and spring holder
- steel DIN 17223-1 for spring
- copper tube EN 12735-1 – Cu DHP for solder connection

THERMOSTATIC CHARGES

Liquid charge: the behaviour of valves with liquid charge is exclusively determined by temperature changes at the bulb and not subject to any cross-ambient interference. They feature a fast response time and thus react quickly in the control circuit. Castel thermostatic expansion valves with liquid charge cannot incorporate MOP functions.

Gas charge: the behaviour of valves with gas charge will be determined by the lowest temperature at any part of the expansion valve (thermostatic element, capillary tube or bulb). If any parts other than the bulb are subjected to the lowest temperature, malfunction of expansion valve may occur (charge migration). Castel thermostatic expansion valves with gas charge always feature MOP functions and include ballasted bulb. Ballast in the bulb has a damping effect on the valve regulation and leads to slow opening and fast closure of the valve.

MOP (Maximum Operating Pressure): this functionality limits the evaporator pressure to a maximum value to protect the compressor from the overload condition (**M**otor **O**verload **P**rotection). MOP is the evaporating pressure at which the expansion valve will throttle liquid injection into the evaporator and thus prevent the evaporating pressure from rising. Expansion valve operates as superheat control in normal working range and operates as pressure regulator within MOP range. The MOP point will change if the factory superheat setting of the expansion valve is changed. Superheat adjustments influence the MOP point as following:

- increase of superheat → decrease of MOP
- decrease of superheat → increase of MOP

Superheat: this is the controlling parameter of the expansion valve. Superheat, measured at the evaporator outlet, is defined as the difference between actual bulb temperature and the evaporating temperature at the saturation point. In order to prevent liquid refrigerant from entering the compressor, a certain minimum superheat must be maintained. In expansion valve operation the following terms are used:

- Static superheat: it's the superheat above that the valve will begin to open. Castel thermo expansion valves are factory preset for optimum static superheat setting. This setting should be modified only if absolutely necessary. Static superheat for Castel valves without MOP is 5 °C and for Castel valves with MOP is 4°C.
- Opening superheat: it's the amount of superheat above the static superheat required to produce a given valve capacity
- Operating superheat: it's the sum of static and opening superheat

Subcooling: it's defined as the difference between the liquid refrigerant temperature and its saturation temperature. Subcooling generally increases the capacity of refrigeration system and may be accounted for when dimensioning an expansion valve. Depending on system design, subcooling may be necessary to prevent flash gas from forming in the liquid line. If flash gas forms in the liquid line, the capacity of expansion valve will be greatly reduced. All capacity tables, in this chapter, are calculated for a subcooling value of 4 °C; if the actual subcooling is higher than 4 °C the evaporator capacity must be divided by the appropriate correction factor shown is the tables below every capacity tables.

SELECTION

To correctly select a thermo expansion valve on a refrigerating system, the following design conditions must be available:

- Type of refrigerant
- Evaporator capacity, Q_e
- Evaporating temperature/pressure, T_e / p_e
- Lowest possible condensing temperature/pressure, T_c / p_c
- Liquid refrigerant temperature, T_l
- Pressure drop in the liquid line, distributor and evaporator, Δp

The following procedure helps to select the correct valve for the system.

Step 1

Determine the pressure drop across the valve. The pressure drop is calculated by the formula:

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

where:

p_c = condensing pressure

p_e = evaporating pressure

Δp = sum of pressure drops in the liquid line, distributor and evaporator

Step 2

Determine required valve capacity. Use the evaporating capacity Q_e to select the required valve size at a given evaporating temperature. If necessary, correct the evaporator capacity for subcooling. Subcooling liquid refrigerant entering the evaporator increase the evaporator capacity, so that a smaller valve may be required. The subcooling is calculated by the formula:

$$\Delta Q_{sub} = Q_e / F_{sub}$$

From the subcooling corrector factor table find the appropriate corrector factor F_{sub} corresponding to the ΔT_{sub} calculated and determine the required valve capacity by the formula:

Step 3

Determine required orifice size. Use the pressure drop across the valve, the evaporating temperature and the calculated valve capacity to select the corresponding orifice size from the capacity table corresponding to the chosen refrigerant.

Table 2: Fixed orifices - Rated Capacities in kW

Orifice Size	Evaporating Temperature Range [°C]			
	- 40 → + 10			-60→ -25
	R22 R407C	R134a	R404A R507	R404A R507
23--/-0X	0,5	0,4	0,38	0,38
23--/-00	1,0	0,9	0,7	0,7
23--/-01	2,5	1,8	1,6	1,6
23--/-02	3,5	2,6	2,1	2,1
23--/-03	5,2	4,6	4,2	3,5
23--/-04	8,0	6,7	6,0	4,9
23--/-05	10,5	8,6	7,7	6,0
23--/-06	15,5	10,5	9,1	6,6

Rated capacities, for temperature range - 40 → + 10, are based on:

- *Evaporating temperature Tevap = + 5 °C*
- *Condensing temperature Tcond = + 32 °C*
- *Refrigerant liquid temperature ahead of valve Tliq = + 28 °C*

Rated capacities, for temperature range - 60 → - 25, are based on:

- *Evaporating temperature Tevap = - 30 °C*
- *Condensing temperature Tcond = + 32 °C*
- *Refrigerant liquid temperature ahead of valve Tliq = + 28 °C*

Step 4

Select a thermostatic charge. Chose the type of charge, liquid without MOP or gas with MOP, and the temperature range, normal temperature or low temperature.

Step 5

Determine if external equalizer is required. External equalizer is always required if a distributor is used or if there is an appreciable difference in pressure from the valve outlet to the bulb location. Finally determine the type of connections and their sizes.

SIZING EXAMPLE

- Type of refrigerant R22
- Evaporator capacity, Q_e 3,8 kW
- Evaporating temperature/ pressure, T_e + 5 °C
- Lowest possible condensing temperature/pressure, T_c + 38 °C
- Liquid refrigerant temperature, T_l + 27 °C
- Pressure drop in the liquid line, distributor and evaporator, Δp 0,5 bar

STEP 1 - Determine the pressure drop across the valve

- Condensing pressure at + 38 °C - P_c = 13,6 bar
- Evaporating pressure at + 5 °C - P_e = 4.8 bar

$$\Delta p_{tot} = 13{,}6 - (4{,}8 + 0{,}5) = 8{,}3 \cdot \text{bar}$$

STEP 2 - Determine required valve capacity

$$\Delta T_{sub} = 38 - 27 = 11 \cdot °C$$

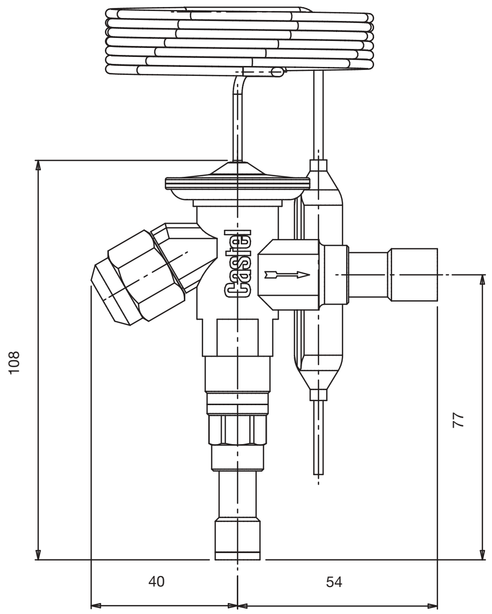
From the subcooling corrector factor table 3b we find the appropriate corrector factor F_{sub} equal to 1,07 for ΔT_{sub} = 11 °C. Required valve capacity is:

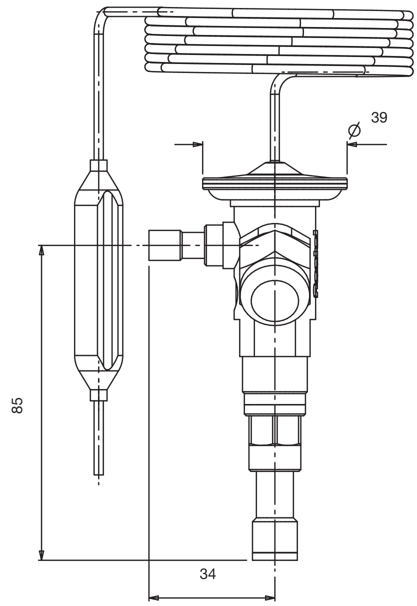
$$\Delta Q_{sub} = 3{,}8 / 1{,}07 = 3{,}55 \text{ kW}$$

STEP 3 - Determine required orifice size

Using the capacity table for R22 on page 33 with:

- pressure drop across the valve = 8,3 bar
- evaporating temperature = + 5 °C
- calculated evaporator capacity = 3,55 kW
- select the corresponding valve 23--/-02 (N.B.: the expansion valve capacity must be equal or slightly more than the calculated evaporator capacity)





MARKING

The following data are indicated on the upper side of the thermostatic element of the valve:

- The valve code number
- The refrigerant
- The evaporating temperature range
- The MOP value, if present
- The maximum allowable pressure PS
- The date of production
- The size of the orifice

Table 3a: Refrigerant R22/R407C - Capacities in kW for temperature range - 40°C → + 10°C

Orifice size	Pressure drop across valve [bar]								Orifice size	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16		2	4	6	8	10	12	14	16
Evaporating temperature = +10 °C									Evaporating temperature = 0 °C								
23--/-0X	0,37	0,48	0,55	0,60	0,63	0,65	0,65	0,67	23--/-0X	0,37	0,48	0,55	0,59	0,63	0,65	0,66	0,66
23--/-00	0,87	1,1	1,2	1,3	1,4	1,4	1,4	1,5	23--/-00	0,84	1,0	1,2	1,3	1,3	1,4	1,4	1,4
23--/-01	2,2	2,8	3,2	3,4	3,6	3,7	3,8	3,8	23--/-01	1,9	2,4	2,7	3,0	3,1	3,2	3,3	3,3
23--/-02	3,0	4,0	4,7	5,1	5,4	5,6	5,8	5,8	23--/-02	2,6	3,4	4,0	4,3	4,6	4,8	4,9	5,0
23--/-03	5,4	7,2	8,3	9,1	9,7	10,0	10,2	10,3	23--/-03	4,6	6,1	7,1	7,8	8,2	8,5	8,7	8,8
23--/-04	8,1	10,8	12,5	13,8	14,5	15,0	15,5	15,5	23--/-04	6,9	9,1	10,5	11,5	12,2	12,7	13,0	13,2
23--/-05	10,2	13,6	15,7	17,2	18,3	18,9	19,3	19,5	23--/-05	8,8	11,6	13,3	14,6	15,5	16,1	16,4	16,6
23--/-06	12,6	16,7	19,3	21,0	22,3	23,1	23,5	23,7	23--/-06	10,8	14,2	16,3	17,8	18,9	19,6	20,0	20,2
Evaporating temperature = -10 °C									Evaporating temperature = -20 °C								
23--/-0X	0,37	0,47	0,53	0,57	0,60	0,63	0,64	0,64	23--/-0X		0,44	0,50	0,54	0,57	0,59	0,61	0,61
23--/-00	0,79	0,96	1,1	1,2	1,2	1,3	1,3	1,3	23--/-00		0,88	1,0	1,1	1,1	1,2	1,2	1,2
23--/-01	1,6	2,0	2,3	2,5	2,6	2,7	2,8	2,8	23--/-01		1,7	1,9	2,0	2,2	2,3	2,3	2,3
23--/-02	2,2	2,9	3,3	3,6	3,8	4,0	4,1	4,1	23--/-02		2,4	2,7	2,9	3,1	3,2	3,3	3,3
23--/-03	3,9	5,1	5,9	6,4	6,8	7,1	7,3	7,3	23--/-03		4,2	4,8	5,2	5,5	5,8	5,9	6,0
23--/-04	5,8	7,6	8,7	9,5	10,1	10,5	10,8	10,9	23--/-04		6,2	7,1	7,7	8,2	8,5	8,7	8,8
23--/-05	7,4	9,6	11,0	12,0	12,8	13,3	13,6	13,8	23--/-05		7,9	9,0	9,8	10,3	10,8	11,0	11,2
23--/-06	9,1	11,6	13,5	14,7	15,6	16,2	16,6	16,8	23--/-06		9,6	11,0	11,9	12,6	13,1	13,5	13,7
Evaporating temperature = -30 °C									Evaporating temperature = -40 °C								
23--/-0X		0,40	0,45	0,49	0,52	0,55	0,56	0,57	23--/-0X			0,42	0,45	0,48	0,50	0,52	0,53
23--/-00		0,79	0,9	0,96	1,0	1,1	1,1	1,1	23--/-00			0,8	0,86	0,92	0,95	0,98	0,99
23--/-01		1,4	1,5	1,7	1,8	1,8	1,9	1,9	23--/-01			1,3	1,4	1,4	1,5	1,5	1,6
23--/-02		1,9	2,2	2,7	2,5	2,6	2,6	2,7	23--/-02			1,7	1,9	2,0	2,0	2,1	2,1
23--/-03		3,4	3,9	4,2	4,4	4,6	4,7	4,8	23--/-03			3,1	3,4	3,5	3,7	3,8	3,8
23--/-04		5,0	5,7	6,2	6,6	6,8	7,0	7,1	23--/-04			4,6	4,9	5,2	5,4	5,6	5,7
23--/-05		6,4	7,2	7,8	8,3	8,6	8,8	9,0	23--/-05			5,8	6,3	6,6	6,9	7,1	7,2
23--/-06		7,8	8,8	9,6	10,1	10,5	10,8	11,0	23--/-06			7,1	7,7	8,1	8,4	8,7	8,8

Table 3b: Refrigerant R22/R407C - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,06	1,11	1,15	1,20	1,25	1,30	1,35	1,39	1,44

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 3b

Orifice size	Pressure drop across valve [bar]					Orifice size	Pressure drop across valve [bar]				
	2	4	6	8	10		2	4	6	8	10
Evaporating temperature = +10 °C						Evaporating temperature = 0 °C					
23--/-0X	0,34	0,43	0,47	0,50	0,51	23--/-0X	0,33	0,42	0,46	0,47	0,49
23--/-00	0,71	0,86	0,93	0,97	0,98	23--/-00	0,65	0,78	0,86	0,89	0,91
23--/-01	1,5	1,9	2,1	2,2	2,2	23--/-01	1,3	1,6	1,7	1,8	1,8
23--/-02	2,0	2,6	3,0	3,1	3,2	23--/-02	1,7	2,2	2,4	2,6	2,6
23--/-03	3,6	4,7	5,3	5,6	5,8	23--/-03	3,0	3,9	4,4	4,6	4,7
23--/-04	5,4	7,0	7,8	8,3	8,6	23--/-04	4,5	5,7	6,4	6,8	7,0
23--/-05	6,9	8,9	9,9	10,8	10,9	23--/-05	5,7	7,3	8,1	8,6	8,8
23--/-06	8,4	10,8	12,1	12,8	13,2	23--/-06	7,0	8,9	1,0	10,5	10,8
Evaporating temperature = -10 °C						Evaporating temperature = -20 °C					
23--/-0X	0,30	0,36	0,43	0,44	0,44	23--/-0X	0,28	0,35	0,39	0,41	0,42
23--/-00	0,59	0,70	0,77	0,81	0,82	23--/-00	0,53	0,62	0,69	0,72	0,73
23--/-01	1,0	1,3	1,4	1,5	1,5	23--/-01	0,81	1,0	1,1	1,2	1,2
23--/-02	1,4	1,8	2,0	2,1	2,1	23--/-02	1,1	1,4	1,5	1,6	1,7
23--/-03	2,5	3,1	3,5	3,7	3,8	23--/-03	2,0	2,5	2,8	2,9	3,0
23--/-04	3,6	4,6	5,1	5,4	5,6	23--/-04	2,9	3,6	4,0	4,3	4,4
23--/-05	4,6	5,8	6,5	6,9	7,1	23--/-05	3,7	4,6	5,1	5,4	5,5
23--/-06	5,7	7,1	8,0	8,4	8,6	23--/-06	4,5	5,6	6,2	6,6	6,8
Evaporating temperature = -30 °C						Evaporating temperature = -40 °C					
23--/-0X	0,25	0,32	0,35	0,37	0,38	23--/-0X	0,23	0,28	0,32	0,33	0,34
23--/-00	0,48	0,55	0,61	0,64	0,64	23--/-00	0,44	0,50	0,54	0,56	0,57
23--/-01	0,66	0,80	0,88	0,93	0,95	23--/-01	0,54	0,65	0,72	0,78	0,77
23--/-02	0,9	1,1	1,2	1,3	1,3	23--/-02	0,7	0,9	1,0	1,0	1,0
23--/-03	1,6	2,0	2,2	2,3	2,3	23--/-03	1,3	1,6	1,8	1,9	1,9
23--/-04	2,3	2,9	3,2	3,3	3,4	23--/-04	1,9	2,3	2,6	2,7	2,7
23--/-05	3,0	3,6	4,0	4,2	4,3	23--/-05	2,4	2,9	3,2	3,5	3,5
23--/-06	3,6	4,4	4,9	5,2	5,3	23--/-06	3,0	3,6	4,0	4,2	4,3

Table 4a: Refrigerant R134a - Capacities in kW for temperature range - 40°C → + 10°C

Table 4b: Refrigerant R134a - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,08	1,13	1,19	1,25	1,31	1,37	1,42	1,48	1,54

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 4b

Table 5a: Refrigerant R404A/R507 - Capacities in kW for temperature range - 40°C → + 10°C

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

Table 5b: Refrigerant R404A/R507 - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,10	1,20	1,29	1,37	1,46	1,54	1,63	1,70	1,78

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 5b

Table 6a: Refrigerant R404A/R507 - Capacities in kW for temperature range - 60°C → - 25°C

Orifice size	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = -25 °C								
23--/-00	0,57	0,67	0,72	0,73	0,74	0,85	0,74	0,71
23--/-01	0,98	1,20	1,31	1,36	1,37	1,37	1,35	1,31
23--/-02	1,31	1,65	1,83	1,91	1,93	1,93	1,90	1,85
23--/-03	2,35	2,97	3,28	3,42	3,47	3,46	3,42	3,32
23--/-04	3,45	4,37	4,82	5,04	5,11	5,12	5,06	4,93
23--/-05	4,40	5,56	6,14	6,40	6,49	6,49	6,42	6,26
23--/-06	5,40	6,30	7,49	7,81	7,93	7,93	7,85	7,64
Evaporating temperature = -40 °C								
23--/-00		0,56	0,60	0,61	0,62	0,61	0,60	0,59
23--/-01		0,65	0,72	0,75	0,77	0,77	0,77	0,75
23--/-02		1,17	1,27	1,32	1,33	1,31	1,28	1,24
23--/-03		2,09	2,28	2,36	2,38	2,36	2,31	2,24
23--/-04		3,03	3,34	3,47	3,50	3,48	3,42	3,33
23--/-05		3,87	4,25	4,41	4,45	4,43	4,36	4,24
23--/-06		4,73	5,19	5,39	5,45	5,47	5,33	5,19
Evaporating temperature = -60 °C								
23--/-00			0,46	0,48	0,47	0,45	0,45	0,43
23--/-01			0,58	0,60	0,60	0,58	0,56	0,54
23--/-02			0,78	0,80	0,80	0,78	0,75	0,72
23--/-03			1,40	1,44	1,43	1,40	1,36	1,30
23--/-04			2,04	2,11	2,11	2,07	2,03	1,96
23--/-05			2,59	2,69	2,66	2,65	2,59	2,50
23--/-06			3,16	3,28	3,30	3,25	3,18	3,07

Orifice size	Pressure drop across valve [bar]							
	2	4	6	8	10	12	14	16
Evaporating temperature = -30 °C								
23--/-00	0,53	0,64	0,67	0,70	0,70	0,70	0,69	0,67
23--/-01	0,88	1,07	1,18	1,21	1,23	1,21	1,20	1,17
23--/-02	1,18	1,47	1,63	1,69	1,71	1,70	1,68	1,64
23--/-03	2,12	2,65	2,93	3,04	3,07	3,05	3,02	2,93
23--/-04	3,09	3,88	4,28	4,47	4,52	4,51	4,46	4,35
23--/-05	3,94	4,94	5,45	5,68	5,74	5,74	5,67	5,52
23--/-06	4,83	6,06	6,66	6,94	7,02	7,01	6,93	6,75
Evaporating temperature = -50 °C								
23--/-00		0,49	0,53	0,54	0,54	0,53	0,52	0,50
23--/-01		0,51	0,57	0,60	0,60	0,60	0,60	0,59
23--/-02		0,91	0,99	1,02	1,02	1,01	0,98	0,95
23--/-03		1,63	1,73	1,84	1,84	1,81	1,78	1,72
23--/-04		2,36	2,60	2,69	2,71	2,68	2,63	2,56
23--/-05		3,02	3,30	3,43	3,45	3,42	3,35	3,26
23--/-06		3,69	4,04	4,20	4,22	4,18	4,12	4,00

Table 6b: Refrigerant R404A/R507 - Correction factor for subcooling Δtsub > 4°C

Δtsub [°C]	4	10	15	20	25	30	35	40	45	50
Fsub	1,00	1,10	1,20	1,29	1,37	1,46	1,54	1,63	1,70	1,78

When subcooling ahead of the expansion valve is other than 4 °C, adjust the evaporatore capacity by dividing by the appropriate correction factor found in Table 6b