STATEMENT

Last update: May 2011

Capacity Rating of Thermostatic Expansion Valves

1 Purpose

The purpose of this statement is to provide common definitions of terminology and rating conditions for thermostatic expansion valves within the European refrigeration and air conditioning market.

2 Scope

This statement is valid for thermostatic expansion valves (hereinafter “TXV”). A TXV is a mechanical device which controls the refrigerant mass flow by sensing pressure and temperature. Other expansion devices such as electronic and automatic expansion valves, orifices, capillary tubes are excluded from this statement. This statement is valid for the evaporation temperature range of –50°C to +25°C.

3 Definitions

3.1 Capacity

The capacity of a valve is defined as the cooling capacity ($\dot{Q}_o$):

$$\dot{Q}_o = \dot{m} \times \Delta h = \dot{m} \times (h_o - h_c)$$

Where
$\dot{m}$ is the mass flow rate.
h_o is the specific enthalpy of the saturated gas at the outlet of the evaporator.
h_c is the specific enthalpy of the partly evaporated refrigerant at the inlet of the evaporator.

The enthalpy differential is seen to be dependent on t_c, (Bubble Point of condensation), ΔtEu (Subcooling of liquid refrigerant) and t_o, (Dew Point of evaporation) (see Fig. 1).

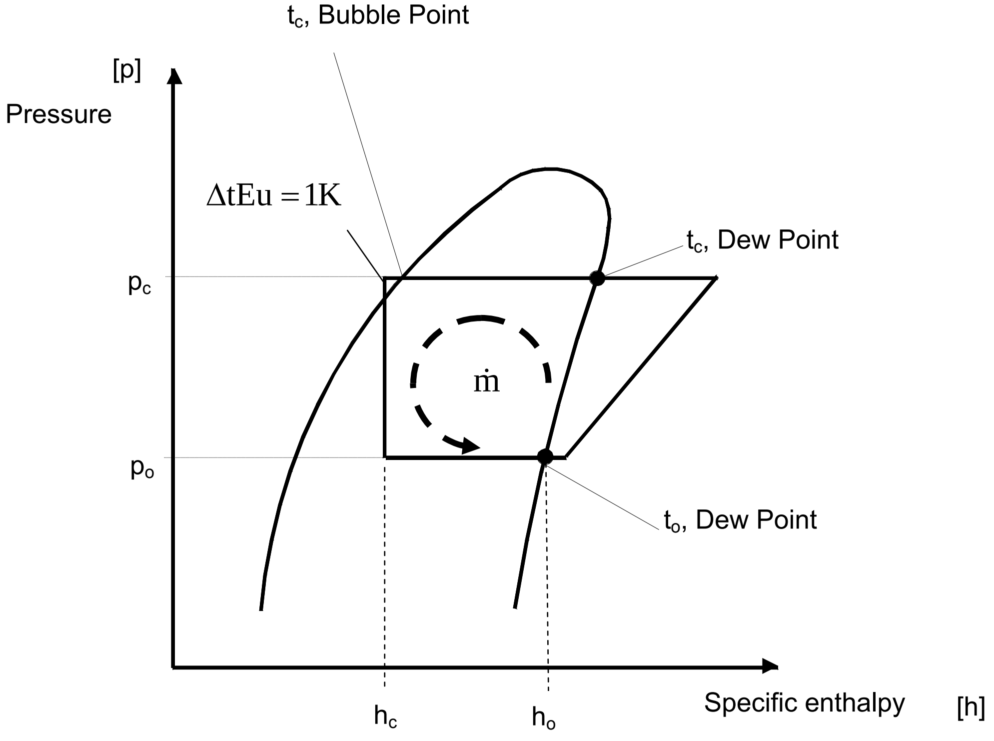

Fig. 1: Pressure – Enthalpy diagram

p_c: Condensing pressure at Bubble Point
p_o: Evaporating pressure at Dew Point

The mass flow through the valve depends on refrigerant type, opening degree of the valve and the pressure drop across the valve. Pressure drop in distributors and evaporator is assumed to be zero.

- Nominal capacity ($\dot{Q}n$) is defined as the capacity given by the valve manufacturer at nominal rating conditions (see Fig. 2).
- Maximum capacity ($\dot{Q}max.$) is defined as the highest capacity at nominal rating conditions.
- Reserve capacity ($\dot{Q}r$) is defined as difference between $\dot{Q}max.$ and $\dot{Q}n$.

3.2 Superheat

- Superheat (SH) is defined as the difference between the measured temperature and the saturated temperature of the refrigerant.
- Static Superheat (SS) relates only to the TXV and is defined as the superheat below which the valve remains closed and above which the valve starts to open.
- Opening superheat (OS) is the incremental superheat above SS required to achieve $\dot{Q}n$.
- Working Superheat (WS) is the sum of SS and OS and can be measured in the field.
- Factory setting is the preadjusted SS value from valve manufacturer as delivered.

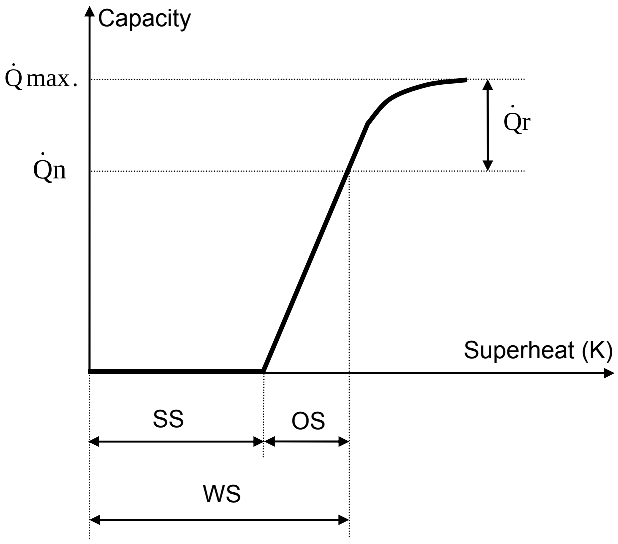

Fig. 2: Capacity – Superheat diagram

4 Nominal rating conditions for non zeotropic refrigerants

The nominal capacity of a TXV must be calculated for the following nominal rating conditions:

Evaporating temperature	+4°C
Condensing temperature	+38°C
Subcooling	1 K
Rated differential pressure across TXV	Rated differential pressure is the difference in pressures at rated condensing temperature and at rated evaporating temperature.
Static Superheat	3 to 4 K
Opening Superheat	Max. 5K for rated capacity - see note below

NOTE: Up to the rated capacity there is a linear relationship between capacity and opening superheat. Higher opening superheat results in higher capacity and vice versa.

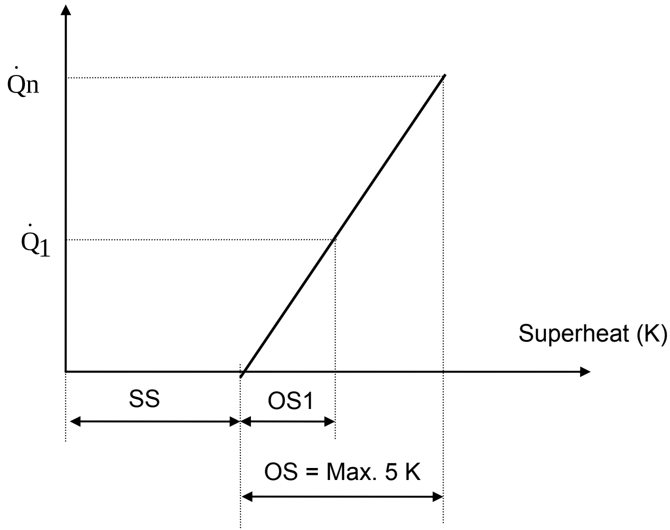

Fig. 3: Capacity – Superheat diagram

Rated differential pressure for some of common refrigerants

Refrigerant	Condensing pressure p_c at t_c = +38°C bara	Evaporating pressure p_o at t_o= +4°C bara	Rated differential pressure across TXV, bar
R134a	9.63	3.38	6.25
R410A	23.03	9.03	14.00
R404A	17.47	6.85	10.62
R507A	17.86	7.12	10.74
R22	14.60	5.66	8.94

NOTE 1: Not all refrigerants are listed

NOTE 2: R404A is a zeotropic blend but due to the small glide it behaves like a non-zeotropic refrigerant for TXV rating purposes

In practice a cooling system will have pressure losses in the system – therefore the effective differential pressure across the TXV is always lower than the rated differential pressure and can be calculated as follows:

$$\Delta p_{effective} = p_c - (p_o + \Delta p_L + \Delta p_F + \Delta p_{SI} + \Delta p_{SO} + \Delta p_{LD} + \Delta p_E)$$

Where:

p_c: Condensing pressure at Bubble Point
p_o: Evaporating pressure at Dew Point
Δp_L: Pressure drop through entire liquid line
Δp_F: Pressure drop through liquid line filter drier
Δp_{SI}: Pressure drop through liquid line sight glass
Δp_{SO}: Pressure drop through liquid line solenoid valve
Δp_{LD}: Pressure drop through liquid distributor to evaporator
Δp_E: Pressure drop through evaporator

NOTE: For calculating the rating capacity of the TXV all pressure drops are assumed to be zero. However, when selecting a TXV for a specific application / installation, the pressure drops in the system must be taken into consideration.

5 Nominal rating conditions for zeotropic blend refrigerant: Example R407C

As opposed to single substances (e.g. R134a, R22 etc.), where the phase change takes place at a constant temperature / pressure. The evaporation and condensation of zeotropic blend R407C is in a “gliding” form (e.g. at a constant pressure the temperature varies within a certain range) through evaporators and condensers.
This has an impact on the capacity of TXVs as well as other components such as compressor and must be taken into consideration.

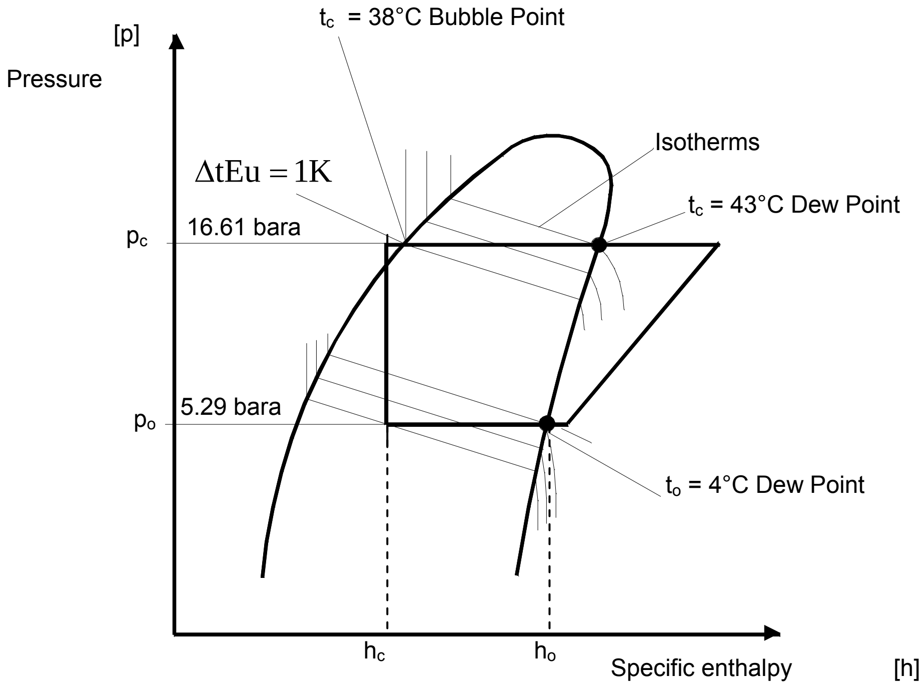

Fig. 4: Pressure – Enthalpy diagram

Evaporating temperature	+4°C Dew Point
Evaporating pressure	5.29 bara.
Condensing temperature	+38°C Bubble Point corresponding to +43°C Dew Point
Condensing pressure	16.61 bara. (the pressure drop across the condenser is neglected)
Subcooling	1 K
Rated differential pressure across TXV	11.32 bar differential
Static superheat (Factory setting)	3 to 4 K
Opening superheat	max. 5K

The correlation between Bubble Points and Dew Points for refrigerant R407C can be taken from appendix.

6 Capacity units and the conversion to ARI standard

The TXV capacity defined in this statement can not be directly converted to ARI defined capacities due to the different rating conditions.

This statement defines the thermodynamic differential pressure corresponding to rated temperatures.

The ARI standard rates TXVs at given differential pressures, which are not thermodynamically correlated to the rated temperatures.

ARI rating conditions for TXVs				Thermodynamic differential pressure corresponding to liquid and evaporating temperature, bar (psi)
Refrigerant	Liquid temperature, °C (F)	Evaporating temperature, °C (F)	ARI Rated differential pressure across TXV, bar (psi)	
R134a	+37.8°C (+100F)	+4.4 °C (+40F)	4.14 (60 psi)	6.16 (89 psi)
R404A			6.9 (100psi)	13.77 (200 psi)
R407C				10.46 (152 psi)
R507A				11.17 (162 psi)
R410A				10.56 (153 psi)
R22			11.03 (160psi)	8.80 (128 psi)

Comparison of differential pressure rating, bar (psi)

Refrigerant	ASERCOM statement +38.0 / +4.0 °C	ARI Standard +37.8 / +4.4 °C
R134a	6.25 (91 psi)	4.14 (60 psi)
R404A	10.62 (154 psi)	6.9 (100 psi)
R407C	11.32 (164 psi)	6.9 (100 psi)
R507A	10.74 (156 psi)	6.9 (100 psi)
R410A	14.00 (203 psi)	11.03 (160 psi)
R22	8.94 (130 psi)	6.9 (100 psi)

The metric kW capacities can be converted to ARI tonnage if the differences in rated differential pressures are taken into account.

7 Appendix: Effect of Glide in a condenser without pressure drops

R407C				
Saturated pressure		Bubble temperature	Dew temperature	Differential
pc, bara	pc, barg	tc, °C	to, °C	K
9.0	8.0	15	21	6
9.2	8.2	16	22	6
9.5	8.5	17	23	6
9.8	8.8	18	24	6
10.1	9.1	19	25	6
10.4	9.4	20	26	6
10.6	9.6	21	27	6
10.9	9.9	22	28	6
11.3	10.3	23	28	5
11.6	10.6	24	29	5
11.9	10.9	25	30	5
12.2	11.2	26	31	5
12.5	11.5	27	32	5
12.9	11.9	28	33	5
13.2	12.2	29	34	5
13.6	12.6	30	35	5
13.9	12.9	31	36	5
14.3	13.3	32	37	5
14.7	13.7	33	38	5
15.0	14.0	34	39	5
15.4	14.4	35	40	5
15.8	14.8	36	41	5
16.2	15.2	37	42	5
16.6	15.6	38	43	5
17.0	16.0	39	44	5
17.4	16.4	40	45	5
17.9	16.9	41	46	5
18.3	17.3	42	47	5
18.8	17.8	43	48	5
19.2	18.2	44	49	5
19.7	18.7	45	50	5
20.1	19.1	46	51	5
20.6	19.6	47	52	5
21.1	20.1	48	53	5
21.6	20.6	49	53	4
22.1	21.1	50	54	4
22.6	21.6	51	55	4
23.1	22.1	52	56	4
23.7	22.7	53	57	4
24.2	23.2	54	58	4
24.8	23.8	55	59	4
25.3	24.3	56	60	4

NOTE: The temperature values are rounded.