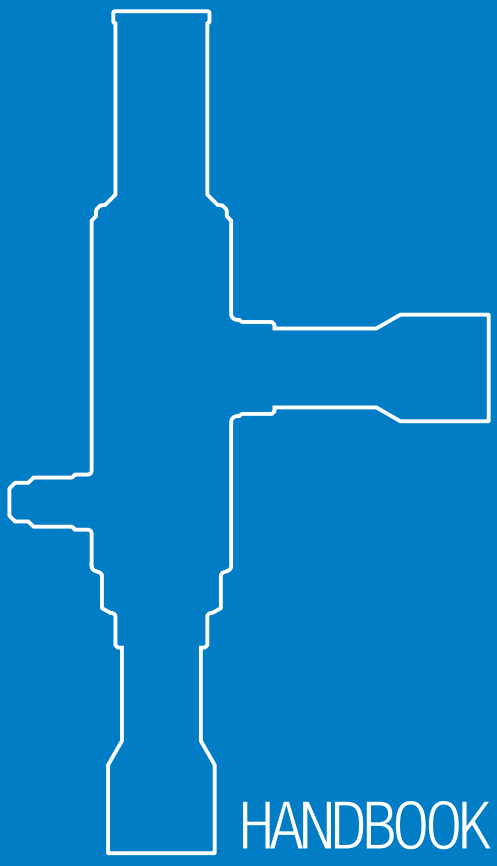


HANDBOOK

REGULATOR VALVES

Castel®
Italian technology

Ed. 2017

CHAPTER 6
CONDENSING PRESSURE REGULATORS
FOR REFRIGERATION PLANTS THAT USE THE R744 REFRIGERANT

APPLICATIONS
When designing air conditioning and refrigerating systems that use air cooled condensing units, subject to wide range of ambient temperatures, it is very important to provide accurate condenser capacity control. Since a properly sized condensing unit operates satisfactorily at high ambient temperature, capacity control is needed at low ambient temperatures. Good condensing pressure control during low ambient temperature avoids problems during system operation and facilitates start-up. Specifically, this control maintains a sufficient pressure differential across the thermostatic expansion valve ensuring correct refrigerant feed to the evaporator.
Condensing pressure regulators, together with the differential valves in series 3136, are the solution to this control need. The regulators in series 3345EL restrict the liquid flow from the condenser to the receiver, reducing the active condenser surface and raising the condensing pressure. The differential valve 3136W by-passes hot gas from the compressor discharge to the receiver, raising the liquid pressure in the receiver.
The condensing pressure regulators 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 evaporating pressure regulators in this chapter cannot be used with other refrigerant fluids.

OPERATION
Condensing pressure regulators adjust the flow of the liquid (hot gas) according to changes of condensation pressure (compressor discharge), upstream of the regulator. When the condensation pressure (discharge) is less than the regulator calibration pressure, the shutter remains closed. As the condensation pressure (discharge) rises above the regulator's calibration setting, the shutter begins to open and modulates in proportion to the variation in condensation pressure (discharge). As the condensing pressure (discharge) continues to rise, the shutter continues to open, until the stroke limit is reached and the regulator is open completely. When the shutter is fully open, a further increase in the valve capacity can be obtained only by increasing the load loss across the valve. Condensing pressure regulators only modulate based on the inlet pressure change, pressure changes on the outlet side do not affect their opening as the valve is equipped with an equalizer bellow with an area equal to that of the valve seat

The factory pressure settings for regulators in series 3345EL is 12 bar. This means that until the condensation (discharge) pressure is below 12 bar, the regulator remains closed. When it rises above 12 bar, the regulator begins to open. According to the characteristics of the refrigerating system it may be necessary to change the factory setting by adjusting the adjustment ring on the top of the regulator body. Turn this ring clockwise to increase the regulator's calibration pressure; turn it counter-clockwise to decrease the calibration pressure. Each turn of the ring corresponds to an increase/decrease of 2.5 bar in calibration pressure. The calibration range varies from 12 to 36 bar.

CONSTRUCTION
The main parts of regulators in series 3340 and 3345 are manufactured with the following materials:
- Hot forged brass EN 12420 – CW 617N for the body
- Copper pipe EN 12735-1 – Cu-DHP for solder connections
- Austenitic stainless steel AISI 321 for the bellows
- Austenitic stainless steel AISI 303 for the shutter
- Brass bar EN 12164 – CW 614N for regulator ring
- Spring steel DIN 17223/84 Class C/D for setting spring
- Chloroprene rubber (CR) for outlet seal gaskets

The main parts of the differential valves 3136W are made with the following materials:
- Hot forged brass EN 12420 – CW 617N for body and cover
- Copper pipe EN 12735-1 – Cu-DHP for solder connections
- Austenitic stainless steel AISI 302 for the spring
- PTFE for seat gaskets

INSTALLATION
Condensing pressure regulators can be mounted in two locations of the refrigerating system:

- In the liquid line between the condenser and the liquid receiver (for regulator selection see Table 34A related to liquid line). Valve 3136W is mounted between the compressor discharge and the inlet of liquid receiver. This choice requires a smaller sized regulator as it is controlling liquid refrigerant. It is most suitable for installations in temperate climates (see installation example 1).
- In the discharge line between the compressor and the condenser (for regulator selection see Table 34B related to the hot gas line). Valve 3136W is mounted between the compressor discharge and the inlet of liquid receiver. A check valve 3132W must be installed between the condenser discharge and receiver inlet to prevent liquid migration during an off cycle. This choice requires a larger sized regulator as it is controlling gaseous refrigerant. It is most suitable for installations in cold climates (see installation example 2).

SELECTION

To correctly select condensing pressure regulators, all information on the system where it will be installed must be available. Selection is based on the following data:

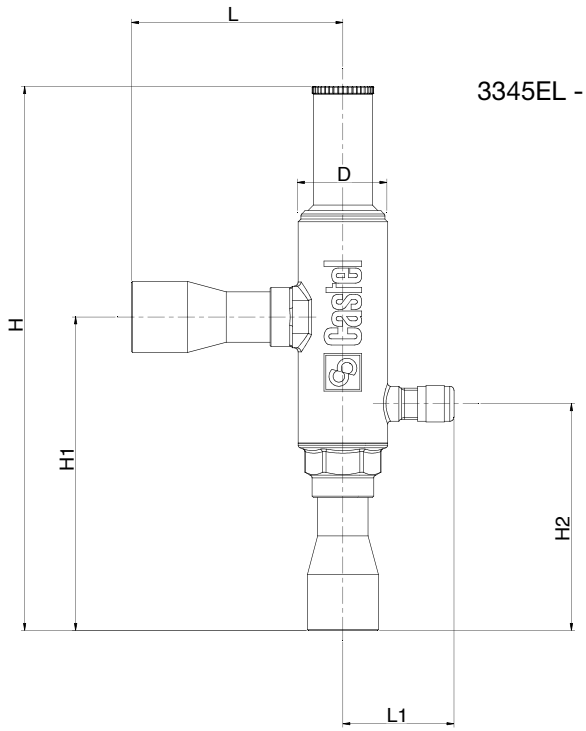
1. Type of refrigerant = R744
2. Designed evaporator (system) capacity.
3. Evaporating temperature.
4. Condensing temperature.
5. Allowable condensing pressure change.
6. Allowable pressure drop across the regulator.

The refrigerating capacities indicated in Tables 34A and 34B are calculated as a function of a reference evaporating temperature of -28.9 °C.
With liquid temperatures other than -28.9 °C, the required cooling capacity of regulator is:

$$\frac{Q_{evap}}{K_{T\,evap}} = Q_{valve}$$

where:

Q_{evap} = Evaporator capacity [kW]
$K_{T\,evap}$ = Correction factor for $T_{evap} \neq$ -28.9 °C. (See Table 34C.)
Q_{valve} = Refrigerating capacity requested at regulator. [kW]



3345EL - ODS

TABLE 32A: General characteristics of condensing pressure regulators for R744

Catalogue Number	Connections			Kv Factor [m^3/h]	Regulating range [bar]		Factory setting [bar]	PS [bar]	TS [°C]		TA [°C]		Risk Category according to PED Recast
	SAE Flare	ODS			min.	max.			min.	max.	min.	max.	
		Ø [in.]	Ø [mm]										
3345EL/M12S	–	–	12	2,70	12	36	12	45	– 40	+120	– 40	+50	Art. 4.3
3345EL/4S	–	1/2"	–										
3345EL/5S	–	5/8"	16										
3345EL/7S	–	7/8"	22										

TABLE 33: Dimensions and weights of condensing pressure regulators for R744

Catalogue Number	Dimensions [mm]								Weight [g]
	H	H_1	H_2	L	L_1	D	Ch1	Ch2	
3345EL/M12S	183	100,5	69,5	64	37	32	-	-	506
3345EL/4S	183	100,5	69,5	64					506
3345EL/5S	183	100,5	69,5	64					506
3345EL/7S	194	112	81	75,5					570

TABLE 34A : Refrigerant Flow Capacity of condensing pressure regulators 3345EL [kW]. Liquid line

Catalogue Number	Condensing pressure change [bar] (1)	Pressure drop across regulator [bar]	Condensing temperature [°C]							
			-15	-10	-5	-2,5	0	2,5	5	10
3345EL/4S 3345EL/M12S	1,5	0,07	33,07	31,63	29,72	27,64	25,73	23,81	22,57	21,33
		0,14	47,29	45,24	42,55	39,62	36,94	34,23	32,44	30,64
		0,31	77,71	73,67	68,99	63,93	59,26	54,55	50,79	47,02
		0,65	110,51	104,77	98,22	91,13	84,59	78,00	72,62	67,20
		1,03	135,98	128,91	120,99	112,40	104,47	96,50	89,82	83,11
		1,68	184,59	174,96	163,51	151,17	139,72	128,21	119,36	110,46
	3	0,07	48,20	46,51	45,19	41,52	40,20	38,74	37,04	35,20
		0,14	69,08	66,70	64,74	59,42	57,46	55,30	52,95	50,40
		0,31	113,59	109,20	105,46	96,28	92,54	88,45	84,15	79,51
		0,65	161,55	155,40	149,94	136,75	131,30	125,33	119,40	113,00
		1,03	199,17	191,71	184,81	168,39	161,49	153,95	146,87	139,21
		1,68	263,04	253,62	244,22	222,25	212,85	202,59	193,97	184,63
	5	0,07	55,427	53,483	51,965	47,749	46,231	44,555	42,601	40,483
		0,14	79,445	76,704	74,451	68,335	66,081	63,598	60,892	57,957
		0,31	130,63	125,58	121,28	110,72	106,43	101,72	96,77	91,436
		0,65	185,78	178,71	172,43	157,27	150,99	144,12	137,31	129,94
		1,03	229,05	220,46	212,53	193,65	185,71	177,04	168,9	160,09
		1,68	302,5	291,67	280,85	255,59	244,78	232,97	223,07	212,32
3345EL/5S	1,5	0,07	55,11	52,72	49,53	46,07	42,89	39,68	37,62	35,55
		0,14	78,82	75,39	70,91	66,04	61,56	57,05	54,07	51,07
		0,31	129,51	122,78	114,98	106,55	98,76	90,92	84,66	78,36
		0,65	184,18	174,61	163,70	151,89	140,98	130,00	121,03	112,01
		1,03	226,63	214,86	201,65	187,33	174,12	160,83	149,70	138,51
		1,68	307,65	291,60	272,52	251,95	232,87	213,68	198,94	184,11
	3	0,07	80,33	77,51	75,31	69,20	67,00	64,57	61,74	58,67
		0,14	115,14	111,17	107,90	99,04	95,77	92,17	88,25	84,00
		0,31	189,32	182,00	175,77	160,47	154,24	147,42	140,26	132,52
		0,65	269,25	259,00	249,90	227,92	218,83	208,88	199,00	188,33
		1,03	331,96	319,51	308,01	280,65	269,15	256,58	244,79	232,02
		1,68	438,40	422,70	407,03	370,42	354,75	337,64	323,29	307,71
	5	0,07	92,378	89,139	86,609	79,581	77,051	74,259	71,002	67,472
		0,14	132,41	127,84	124,09	113,89	110,14	106	101,49	96,595
		0,31	217,71	209,3	202,14	184,54	177,38	169,53	161,29	152,39
		0,65	309,63	297,85	287,39	262,11	251,65	240,21	228,85	216,57
		1,03	381,75	367,44	354,21	322,75	309,52	295,07	281,51	266,82
		1,68	504,16	486,11	468,09	425,99	407,97	388,29	371,78	353,87

Standard rating conditions according to AHRI Standard 770-2014

Condensing temperature	30°F	-1,2°C
Liquid temperature	20°F	-6,7°C
Subcooling	10° R	5,5°K
Evaporating temperature	-20°F	-28,9°C
Suction temperature	-5°F	-15°C
Superheating	15°R	8,4°K
Discharge temperature	80°F	26,6°C

Continued

(1) : pressure change required to move the valve shutter from “start to open” position to rated opening position

R744

TABLE 34A : Refrigerant Flow Capacity of condensing pressure regulators 3345EL [kW]. Liquid line										
Catalogue Number	Condensing pressure change [bar] (1)	Pressure drop across regulator [bar]	Condensing temperature [°C]							
			-15	-10	-5	-2,5	0	2,5	5	10
3345EL/7S	1,5	0,07	81,79	80,42	78,64	77,44	75,66	73,29	72,59	71,51
		0,14	115,84	113,91	111,53	109,98	107,60	104,41	103,36	101,77
		0,31	189,89	184,37	179,58	176,20	171,41	165,21	160,70	155,06
		0,65	264,99	257,34	250,98	246,57	240,21	231,92	225,54	217,58
		1,03	322,36	313,10	305,76	300,75	293,41	283,75	275,90	266,10
		1,68	430,84	418,04	406,17	397,59	385,72	370,56	360,38	347,66
	3	0,07	96,31	94,64	94,67	95,38	95,41	94,73	93,10	90,75
		0,14	136,72	134,45	134,32	135,19	135,05	133,91	131,79	128,67
		0,31	223,55	218,52	216,99	217,23	215,70	212,40	207,72	201,31
		0,65	313,23	306,38	303,90	303,94	301,46	296,47	290,33	281,82
		1,03	381,70	373,61	370,19	369,87	366,44	359,92	352,95	343,15
		1,68	492,87	483,44	478,37	477,37	472,30	463,14	455,81	445,02
	5	0,07	110,75	108,84	108,87	109,69	109,72	108,94	107,07	104,37
		0,14	157,23	154,62	154,46	155,46	155,31	154	151,56	147,97
		0,31	257,09	251,3	249,54	249,81	248,05	244,27	238,88	231,51
		0,65	360,21	352,34	349,49	349,53	346,67	340,94	333,88	324,1
		1,03	438,96	429,65	425,72	425,35	421,41	413,9	405,89	394,62
		1,68	566,8	555,96	550,12	548,98	543,14	532,61	524,18	511,78

Standard rating conditions according to AHRI Standard 770-2014

Condensing temperature	30°F	-1,2°C
Liquid temperature	20°F	-6,7°C
Subcooling	10° R	5,5°K
Evaporating temperature	-20°F	-28,9°C

Suction temperature	-5°F	-15°C
Superheating	15°R	8,4°K
Discharge temperature	80°F	26,6°C

(1) : pressure change required to move the valve shutter from “start to open” position to rated opening position

TABLE 34B : Refrigerant Flow Capacity of condensing pressure regulators 3345EL [kW]. Hot gas line

Catalogue Number	Condensing pressure change [bar] (1)	Pressure drop across regulator [bar]	Condensing temperature [°C]							
			-15	-10	-5	-2,5	0	2,5	5	10
3345EL/4S 3345EL/M12S	1,5	0,07	5,78	5,81	5,80	5,81	5,83	5,85	5,87	5,88
		0,14	8,19	8,24	8,22	8,24	8,26	8,29	8,31	8,34
		0,31	12,91	12,98	12,94	12,98	13,02	13,06	13,10	13,13
		0,65	18,20	18,30	18,24	18,30	18,35	18,41	18,46	18,52
		1,03	22,20	22,32	22,26	22,32	22,39	22,46	22,52	22,59
		1,68	28,50	28,66	28,58	28,66	28,75	28,83	28,92	29,00
	3	0,07	11,32	11,92	11,60	11,92	12,25	12,58	12,91	13,24
		0,14	16,04	16,91	16,44	16,91	17,37	17,83	18,30	18,76
		0,31	25,30	26,66	25,92	26,66	27,39	28,12	28,85	29,59
		0,65	35,61	37,52	36,49	37,52	38,55	39,58	40,61	41,65
		1,03	43,45	45,79	44,53	45,79	47,05	48,31	49,56	50,82
		1,68	55,82	58,83	57,21	58,83	60,44	62,06	63,68	65,29
	5	0,07	13,013	13,713	13,336	13,713	14,09	14,466	14,843	15,22
		0,14	18,449	19,441	18,907	19,441	19,976	20,51	21,045	21,579
		0,31	29,09	30,655	29,813	30,655	31,498	32,341	33,183	34,026
		0,65	40,946	43,149	41,963	43,149	43,335	45,521	46,707	47,893
		1,03	49,969	52,656	51,209	52,656	54,104	55,551	56,998	58,446
		1,68	64,196	67,649	65,79	67,649	69,508	71,368	73,227	75,087
3345EL/5S	1,5	0,07	9,64	9,69	9,66	9,69	9,72	9,75	9,78	9,81
		0,14	13,66	13,73	13,69	13,73	13,77	13,82	13,86	13,90
		0,31	21,51	21,63	21,57	21,63	21,70	21,76	21,83	21,89
		0,65	30,33	30,50	30,41	30,50	30,59	30,68	30,77	30,86
		1,03	37,00	37,20	37,09	37,20	37,32	37,43	37,54	37,65
		1,68	47,51	47,77	47,63	47,77	47,91	48,05	48,20	48,34
	3	0,07	18,86	19,87	19,33	19,87	20,42	20,97	21,51	22,06
		0,14	26,74	28,18	27,40	28,18	28,95	29,72	30,50	31,27
		0,31	42,16	44,43	43,21	44,43	45,65	46,87	48,09	49,31
		0,65	59,34	62,53	60,82	62,53	64,25	65,97	67,69	69,41
		1,03	72,42	76,31	74,22	76,31	78,41	80,51	82,61	84,70
		1,68	93,04	98,04	95,35	98,04	100,74	103,43	106,13	108,82
	5	0,07	21,688	22,854	22,226	22,854	23,483	24,111	24,739	25,367
		0,14	30,748	32,402	31,512	32,402	33,293	34,184	35,074	35,965
		0,31	48,484	51,092	49,688	51,092	52,497	53,901	55,305	56,710
		0,65	68,244	71,915	69,938	71,915	73,892	75,868	77,845	79,822
		1,03	83,281	87,761	85,349	87,761	90,173	92,585	94,997	97,410
		1,68	106,99	112,75	109,65	112,75	115,85	118,95	122,05	125,14

Standard rating conditions according to AHRI Standard 770-2014

Condensing temperature	30°F	-1,2°C
Liquid temperature	20°F	-6,7°C
Subcooling	10° R	5,5°K
Evaporating temperature	-20°F	-28,9°C
Suction temperature	-5°F	-15°C
Superheating	15°R	8,4°K
Discharge temperature	80°F	26,6°C

Continued

(1) : pressure change required to move the valve shutter from “start to open” position to rated opening position

R744

TABLE 34B : Refrigerant Flow Capacity of condensing pressure regulators 3345EL [kW]. Hot gas line										
Catalogue Number	Condensing pressure change [bar] (1)	Pressure drop across regulator [bar]	Condensing temperature [°C]							
			-15	-10	-5	-2,5	0	2,5	5	10
3345EL/7S	1,5	0,07	14,65	16,24	15,39	16,24	17,10	17,95	18,81	19,67
		0,14	20,57	22,80	21,60	22,80	24,00	25,21	26,41	27,61
		0,31	32,18	35,67	33,79	35,67	37,55	39,43	41,31	43,19
		0,65	44,53	49,36	46,76	49,36	51,97	54,57	57,17	59,77
		1,03	53,72	59,55	56,41	59,55	62,69	65,83	68,97	72,11
		1,68	67,80	75,16	71,20	75,16	79,12	83,09	87,05	91,01
	3	0,07	23,56	26,64	24,98	26,64	28,30	29,96	31,62	33,27
		0,14	33,08	37,40	35,07	37,40	39,73	42,06	44,39	46,72
		0,31	51,72	58,49	54,85	58,49	62,13	65,77	69,42	73,06
		0,65	71,72	81,10	76,05	81,10	86,15	91,20	96,25	101,30
		1,03	86,50	97,81	91,72	97,81	103,90	109,99	116,08	122,17
		1,68	108,67	122,88	115,22	122,88	130,53	138,18	145,83	153,48
	5	0,07	27,093	30,635	28,728	30,635	32,543	34,451	36,359	38,266
		0,14	38,04	43,014	40,335	43,014	45,692	48,371	51,049	53,728
		0,31	59,484	67,262	63,074	67,262	71,451	75,639	79,828	84,016
		0,65	82,477	93,263	87,455	93,263	99,07	104,88	110,69	116,49
		1,03	99,473	112,481	105,48	112,48	119,48	126,49	133,49	140,5
		1,68	124,97	141,31	132,51	141,31	150,11	158,91	167,71	176,5

Standard rating conditions according to AHRI Standard 770-2014

Condensing temperature	30°F	-1,2°C
Liquid temperature	20°F	-6,7°C
Subcooling	10° R	5,5°K
Evaporating temperature	-20°F	-28,9°C

Suction temperature	-5°F	-15°C
Superheating	15°R	8,4°K
Discharge temperature	80°F	26,6°C

(1) : pressure change required to move the valve shutter from “start to open” position to rated opening position

TABLE 34C : Correction factor for evaporator temperature different from nominal value									
Evaporator temperature [°C]									
-40	-35	-30	-25	-20	-15	-10	-5	0	5
1,08	1,04	1,01	0,98	0,95	0,92	0,89	0,87	0,84	0,82

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