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Application Engineering Europe

ENHANCED VAPOUR INJECTION (EVI) FOR ZH COPELAND™ SCROLL COMPRESSORS

1 Introduction

This Technical Information describes the principle of operation and the system design of the Enhanced Vapour Injection for Heat Pump optimized Copeland Scroll™ compressors including the ZH*KVE, ZHI*K1P and ZHW*K1P ranges, whether they are used in single or tandem configuration.

The purpose of this document is to provide the heating scroll compressor users first selection of components for their refrigerant circuit using vapour injection. These recommendations give a starting point for designing and building heat pump systems. Nevertheless, system performance and reliable operation have to be verified by the system manufacturer through system testing. Due care should be exercised when selecting Copeland™ brand products, refrigerants, oil and other components to ensure that all of them are operated according to their specification and relevant requirements at all times.

The vapour injection scroll compressor is for use with an economized vapour compression cycle heat pump. This cycle offers the advantages of more heat delivered and a better COP than with a conventional cycle. Both the heating capacity and the COP improvement effect are proportional to the temperature lift and this technology offers best results at high pressure ratio operation where capacity and efficiency are most needed. The cooling provided by inter-stage injection allows the operation of the compressor over a larger envelope compared to a conventional single-stage model, providing higher heat delivery temperatures at low evaporating temperatures. In addition, thanks to the increase in capacity, it is possible to specify a smaller displacement compressor for a given heating load.

2 Principle of operation

As shown in **Figure 1**, the liquid out of the condenser is separated into two parts. A smaller part of the liquid, ***i***, is expanded through an additional expansion valve, and then directed (or flows) into a counter-flow plate heat exchanger, ***HX***. The main part of the liquid out of the condenser, ***m***, is then cooled down through the economizer while evaporating and superheating the injection mass flow. This additional plate heat exchanger, more generally called economizer, acts therefore as a subcooler for the main mass flow ***m*** and as an evaporator for the injection mass flow. Superheated vapour is then injected into the intermediate vapour injection port in the scroll compressor.

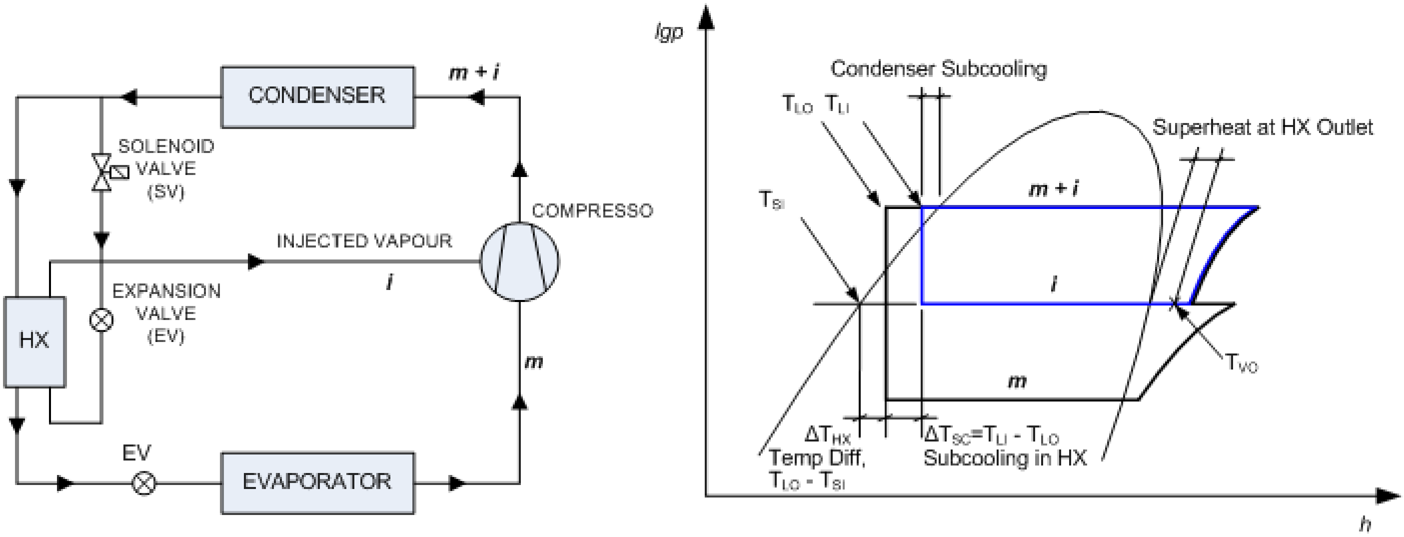
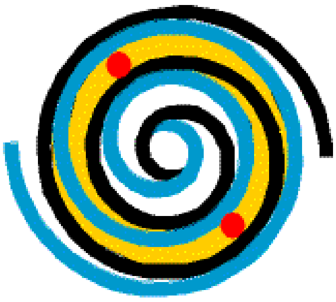


Figure 1: Circuit diagrams showing the main circuit, with mass flow rate *m*, and the economizer circuit, with mass flow rate *i*

The additional subcooling increases the evaporator capacity by reducing the temperature of the liquid from T_{LI} to T_{LO}, thus reducing its enthalpy. The additional condenser mass flow, ***i***, increases the heating capacity by the same amount.

Efficiency with vapour injection scroll compressor cycle is higher than that of a conventional single-stage scroll delivering the same capacity because the added capacity is achieved with proportionally less power. The injection mass flow created in the subcooling process is compressed only from the higher inter-stage pressure rather than from the lower suction pressure.

The operating envelope is also larger with vapour-injection, thanks to the cooling effect it provides. The envelope extends where compressor without injection is limited by the compressor high discharge gas temperature, ie, at higher pressure ratio zone. The cooling effect of the compression process is achieved by the addition of superheated vapour to the compression process at the intermediate pressure and at temperature $\mathbf{T}_{VO}$, controlled by the injection expansion valve. Superheated vapour is injected into the scroll set at the intermediate point of the compression process, via two symmetrically positioned ports as shown on the left hand side in **Figure 2**. The size and position of these ports have been optimized to ensure maximum COP and capacity benefit at typical operating conditions. The superheated vapour enters the compressor via an additional inlet connection on the compressor shell and flows to the injection ports of the fixed scroll via a tube as shown on the right. The tubing flexibility characteristics ensure that axial compliance is maintained.



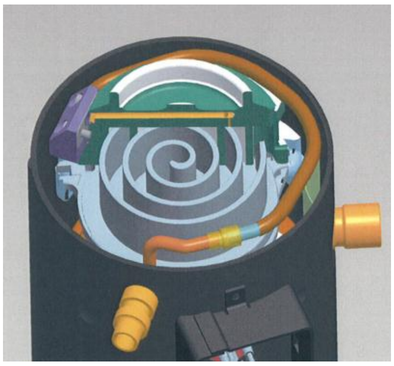


Figure 2: Position of the injection ports in the scroll set and the internal tubing connecting the injection inlet with the scroll set

3 Capacity effect

The vapour injection (VI) scroll is particularly suited to Air Source Heat Pumps (ASHP).

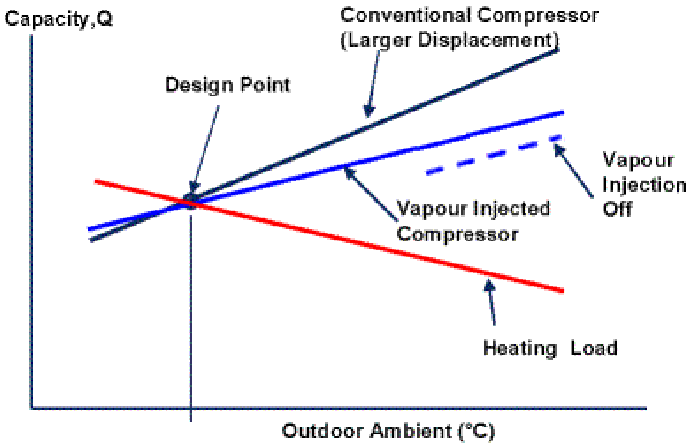


Figure 3: Capacity variation and heat load characteristics

The blue line in **Figure 3** representing the vapour injection scroll characteristic has a lower gradient than that of a conventional compressor. At low ambient conditions, a bigger capacity is available. On the other side, when the outdoor air temperature is above the design point, less capacity is delivered by the VI scroll compressor, resulting in less cycling than with a conventional compressor.

The vapour injection scroll offers advantages particularly in air/water heating applications where the water temperatures need to be high and where domestic hot water is needed.

Capacity can be further reduced if needed by switching off the vapour injection under certain limitations (see Chapter 12.1).

4 Operating envelope with vapour Injection

Figure 4 illustrates clearly the additional high condensing temperature capability at low evaporating temperatures due to the cooling effect of the vapour injection.

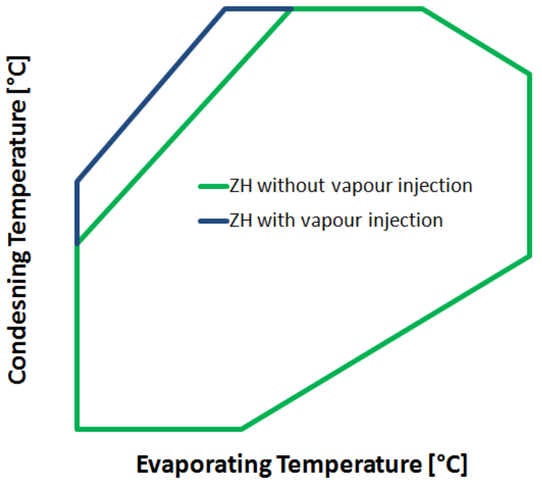


Figure 4: Enlarged operating envelope for vapour-injection models thanks to the cooling effect of the injection

The operating envelopes for all ZH Scroll compressor models with vapour injection are available in the dedicated application guidelines.

For air-to-water heat pump applications, a supplementary envelope extension may be required for high temperature water production in case of low outdoor temperature. This can be achieved by the use of wet vapour injection. For further information about wet vapour injection, contact the Application Engineering department at Emerson Climate Technologies.

5 Compressors in parallel configuration

Vapour injection compressors in parallel configuration can share one economizer (HX) and usually one expansion valve (**Figure 5**). For higher capacity systems, two injection expansion valves installed in parallel may be needed. Due to the larger capacity range achieved by parallel configuration, an electronic injection expansion valve is preferred to a thermostatic valve.

The solenoid valves must be positioned on the individual vapour injection lines in order for them to close when the compressor is switched off. This will avoid excessive quantities of liquid entering the compressor during standstill mode.

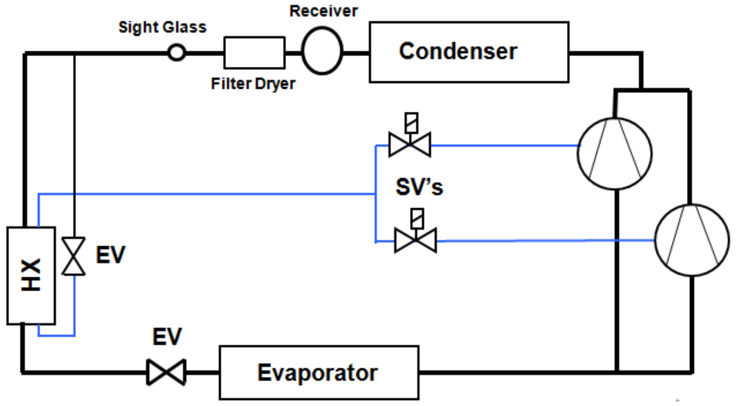


Figure 5: Multiple compressor configuration when one injection expansion valve is sufficient

***NOTE*: For further information about multiple ZH compressors possibilities, refer to Technical Information C7.17.3 "Paralleling of ZH Copeland Scroll™ compressors for heat pump applications".**

6 Economizer selection and application

The recommended Swep and Alfa Laval economizer size and inner diameter at the economizer ports for single or paralleling ZH heat pump scroll compressor applications are shown in **Tables 1 to 4**. These recommendations give the best economizer performance with the lowest number of economizer models. If the diameter of the pipe work does not fit the economizer ports, use reducers into the economizer at the inlet and outlet. Use Emerson Climate Technologies recommended pipe work sizes (see below). If heat exchangers with recommended port sizes are not available, order the same economizer with larger ports and use reducers to fit required port diameters.

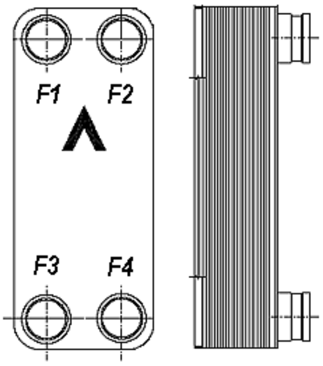


Figure 6: Nomenclature of connections for selected Swep economizers

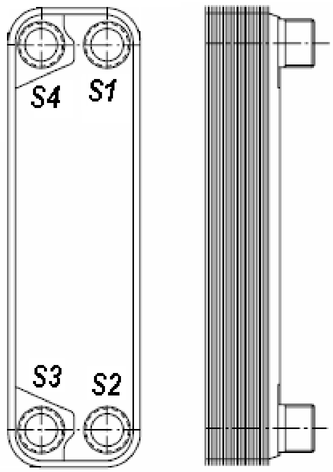


Figure 7: Nomenclature of connections for selected Alfa Laval economizers

	SWEP Selection						Alfa Laval Selection					
	BPHE Model	Number plates	Soldering connections (mm)				BPHE Model	Number plates	Diameter of connections			
			Vapour injection		Liquid				Liquid		Vapour injection	
Compressor			Inlet F3	Outlet F1	Inlet F2	Outlet F4			Inlet S1	Outlet S2	Inlet S3	Outlet S4
ZH06KVE	B8T M-class	6	6,5	12,8	12,8	12,8						
ZH09KVE	B8T M-Class	10	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	8	1/4"	1/4"	1/4"	3/8"
ZH13KVE	B8T M-Class	10	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	8	3/8"	3/8"	3/8"	3/8"
ZH18KVE	B8T M-Class	14	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	10	3/8"	3/8"	3/8"	3/8"
ZH24KVE	B8T M-Class	14	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	10	1/2"	1/2"	1/2"	5/8"
ZH33KVE	B8T M-Class	20	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	14	1/2"	1/2"	1/2"	5/8"
ZH40KVE	B8T M-Class	20	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	14	5/8"	5/8"	5/8"	5/8"
ZH48KVE	B16 S-Class	20	12.8 (1/2")	19.2 (3/4")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	20	5/8"	5/8"	5/8"	5/8"

Table 1: Economizer selection by Swep and Alfa Laval for single compressor applications with ZH06-48KVE compressor models

	SWEP Selection						Alfa Laval Selection					
	BPHE Model	Number plates	Soldering connections (mm)				BPHE Model	Number plates	Diameter of connections			
			Vapour injection		Liquid				Liquid		Vapour injection	
Tandem			Inlet F3	Outlet F1	Inlet F2	Outlet F4			Inlet S1	Outlet S2	Inlet S3	Outlet S4
2 x ZH09KVE	B8T M-Class	10	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	8	3/8"	3/8"	3/8"	3/8"
2 x ZH13KVE	B8T M-Class	14	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	10	1/2"	1/2"	3/8"	3/8"
2 x ZH18KVE	B8T M-Class	20	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	14	5/8"	5/8"	5/8"	5/8"
2 x ZH24KVE	B8T M-Class	20	6.5 (1/4")	12.8 (1/2")	12.8 (1/2")	12.8 (1/2")	AC30-EQ	16	5/8"	5/8"	5/8"	5/8"
2 x ZH33KVE	B16 S-Class	20	12.8 (1/2")	22 (7/8")	22 (7/8")	22 (7/8")	AC30-EQ	24	7/8"	7/8"	5/8"	7/8"
2 x ZH40KVE	B16 S-Class	24	12.8 (1/2")	22 (7/8")	22 (7/8")	22 (7/8")	AC30-EQ	28	7/8"	7/8"	5/8"	7/8"
2 x ZH48KVE	B16 S-Class	30	12.8 (1/2")	22 (7/8")	22 (7/8")	22 (7/8")	AC30-EQ	36	7/8"	7/8"	5/8"	7/8"

Table 2: Economizer selection by Swep and Alfa Laval for tandem application with ZH09-48KVE compressor models

	SWEP Selection						Alfa Laval Selection					
	BPHE Model	Number plates	Soldering connections (mm)				BPHE Model	Number plates	Diameter of connections			
			Vapour injection		Liquid				Liquid		Vapour injection	
Compressor			Inlet F3	Outlet F1	Inlet F2	Outlet F4			Inlet S1	Outlet S2	Inlet S3	Outlet S4
ZHI08K1P	B8T M-class	10	6.5	12.8	12.8	12.8	ACH16	10	1/2"	1/2"	3/8"	1/2"
ZHI11K1P	B8T M-class	10	6.5	12.8	12.8	12.8	ACH16	10	1/2"	1/2"	3/8"	1/2"
ZHI14K1P	B8T M-class	10	6.5	12.8	12.8	12.8	ACH16	10	1/2"	1/2"	3/8"	1/2"
ZHI18K1P	B8T M-class	14	6.5	12.8	12.8	12.8	ACH18	10	1/2"	1/2"	3/8"	1/2"
ZHI27K1P	B8T M-class	14	6.5	12.8	12.8	12.8	ACH18	10	1/2"	1/2"	3/8"	1/2"
ZHI32K1P	B8T M-class	20	9.65	16	12.8	12.8	ACH18	16	1/2"	1/2"	3/8"	1/2"
ZHI35K1P	B8T M-class	20	9.65	16	12.8	12.8	ACH18	16	1/2"	1/2"	3/8"	1/2"
ZHI40K1P	B8T M-class	20	9.65	16	12.8	12.8	ACH18	20	1/2"	1/2"	3/8"	1/2"
ZHW08K1P	B8T M-Class	8	1/2"	1/2"	1/4"	1/2"	ACH16	8	12mm	12mm	8mm	10mm
ZHW16K1P	B8T M-Class	10	1/2"	1/2"	1/4"	1/2"	ACH16	10	12mm	12mm	8mm	10mm

Table 3: Economizer selection by Swep and Alfa Laval for single compressor applications with ZHI08-40K1P and ZHW08-16K1P compressor models

	SWEP Selection						Alfa Laval Selection					
	BPHE Model	Number plates	Soldering connections (mm)				BPHE Model	Number plates	Diameter of connections			
			Vapour injection		Liquid				Liquid		Vapour injection	
Tandem			Inlet F3	Outlet F1	Inlet F2	Outlet F4			Inlet S1	Outlet S2	Inlet S3	Outlet S4
2 x ZHI08K1P	B8T M-class	10	6.5	12.8	12.8	12.8	ACH16	10	1/2"	1/2"	3/8"	1/2"
2 x ZHI11K1P	B8T M-class	14	6.5	12.8	12.8	12.8	ACH18	10	1/2"	1/2"	3/8"	1/2"
2 x ZHI14K1P	B8T M-class	14	6.5	12.8	12.8	12.8	ACH18	10	1/2"	1/2"	3/8"	1/2"
2 x ZHI18K1P	B8T M-class	20	9.65	16	12.8	12.8	ACH18	16	1/2"	1/2"	3/8"	1/2"
2 x ZHI27K1P	B10T H-class	20	9.65	16	12.8	12.8	ACH18	20	1/2"	1/2"	3/8"	1/2"
2 x ZHI32K1P	B10T H-class	26	9.65	16	12.8	12.8	ACH18	24	1/2"	1/2"	3/8"	1/2"
2 x ZHI35K1P	B10T H-class	26	9.65	16	12.8	12.8	ACH18	28	1/2"	1/2"	3/8"	1/2"
2 x ZHI40K1P	B10T H-class	26	9.65	16	12.8	12.8	ACH18	32	1/2"	1/2"	3/8"	1/2"
ZHI27K1P + ZHI32K1P	B10T H-class	20	9.65	16	12.8	12.8	ACH18	20	1/2"	1/2"	3/8"	1/2"
ZHI32K1P + ZHI35K1P	B10T H-class	26	9.65	16	12.8	12.8	ACH18	24	1/2"	1/2"	3/8"	1/2"
ZHI35K1P + ZHI40K1P	B10T H-class	26	10	16	12.8	12.8	ACH18	32	1/2"	1/2"	3/8"	1/2"

Table 4: Economizer selection by Swep and Alfa Laval for tandem compressor applications with ZHI08-40K1P compressor models

Details about required economizer capacity and saturated injection temperature $\mathbf{T_{SI}}$ are provided in Copeland™ brand products Select software to enable independent sizing of the economizer when required, as shown in **Figure 8** below.

The input subcooling is the natural condenser subcooling, not the subcooling at expansion valve inlet.

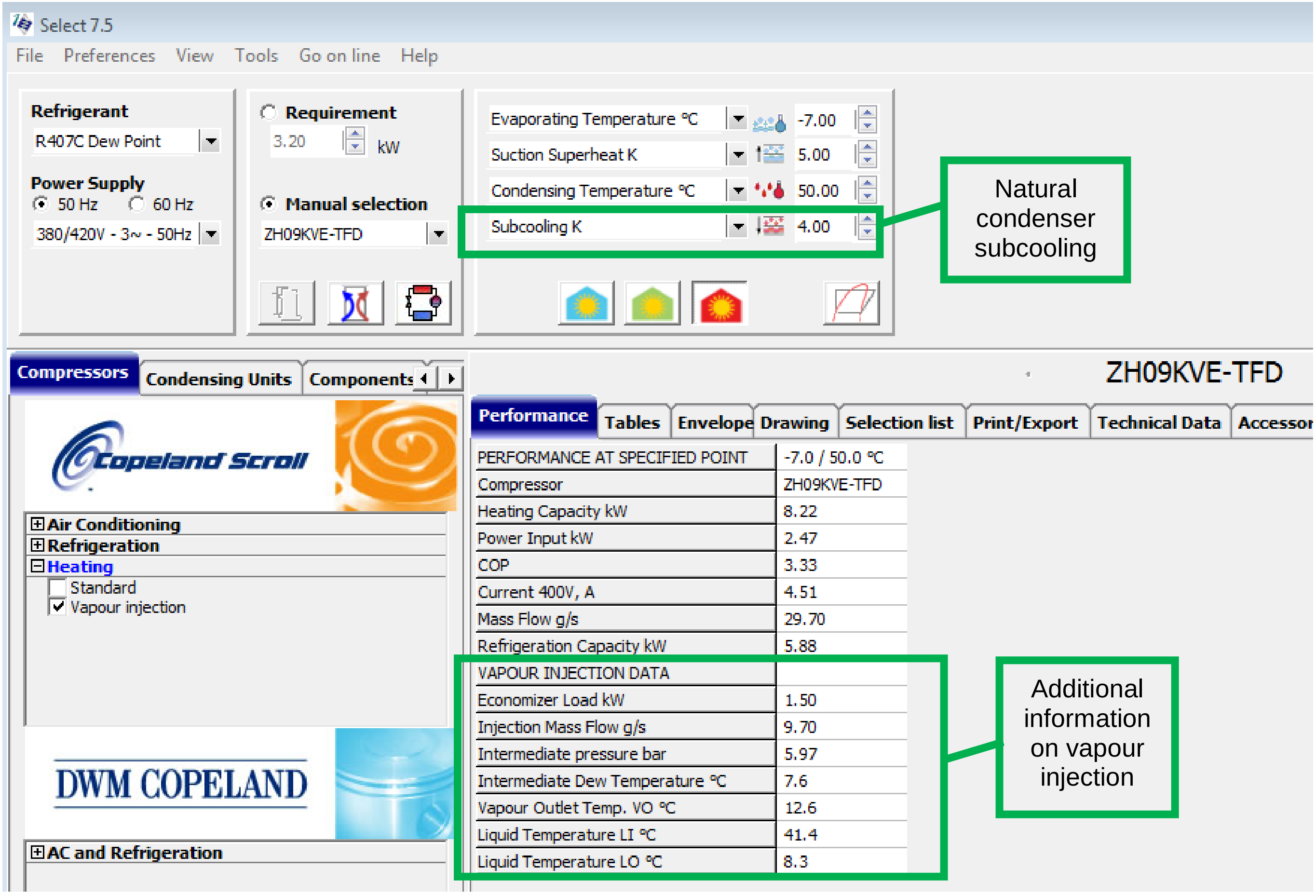


Figure 8: Selection Software Version 7 screen details

The values of the temperatures $\mathbf{T_{LO}}$ (temperature liquid out), $\mathbf{T_{LI}}$ (temperature liquid in) and $\mathbf{T_{VO}}$ (temperature vapour out) are also provided. It should be noted that the benefit of natural subcooling, ie, condenser subcooling, is limited to a maximum of approximately 5K. Additional natural subcooling leads to little further reduction in liquid temperature $\mathbf{T_{LO}}$. The compressor performance published in the Copeland brand products Selection Software are based on a temperature difference $\triangle$THX = $\mathbf{T_{LO}}$ - $\mathbf{T_{SI}}$ (T_{SI} in bubble) of 5K at the economizer and an injection superheat of 5K.

Downstream extraction shown in **Figure 9(b)** refers to taking the liquid for the economizer expansion device from the economizer liquid exit as shown. This method is sometimes proposed to ensure good subcooling at the expansion device inlet. While there is no overall heat gain or loss compared to the usual upstream extraction, it does mean that the injected mass flow, ***i***, is passing through the economizer twice and incurring extra pressure drop on the liquid cooling side. This may result in the need for a larger economizer. Also, downstream extraction requires more connections and tubing on the sub-cooled liquid side, all of which need to be insulated to ensure minimal heat gain. For these reasons, downstream extraction is less preferable than upstream (**Figure 9(a)**).

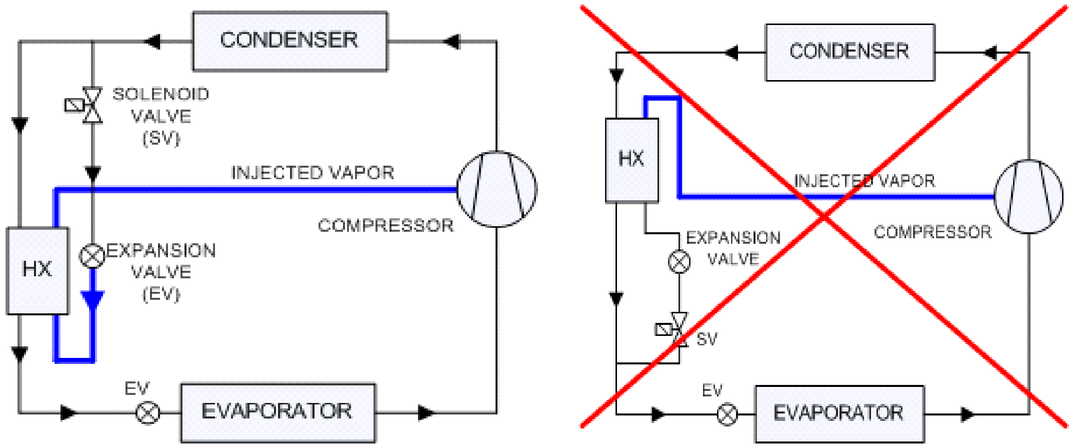


Figure 9: (a) upstream liquid extraction (highly recommended) – (b) downstream

The performance data published in Select are for the system design shown in **Figure 9(a)**. With other designs the injected mass flow changes which affects the performance of the compressor.

The economizer must be installed vertically with the vapour entry at the bottom. The expansion valve should be positioned at a distance between 150 and 200 mm from the entry expansion and at a position not lower than inlet connection, as shown in **Figure 10**.

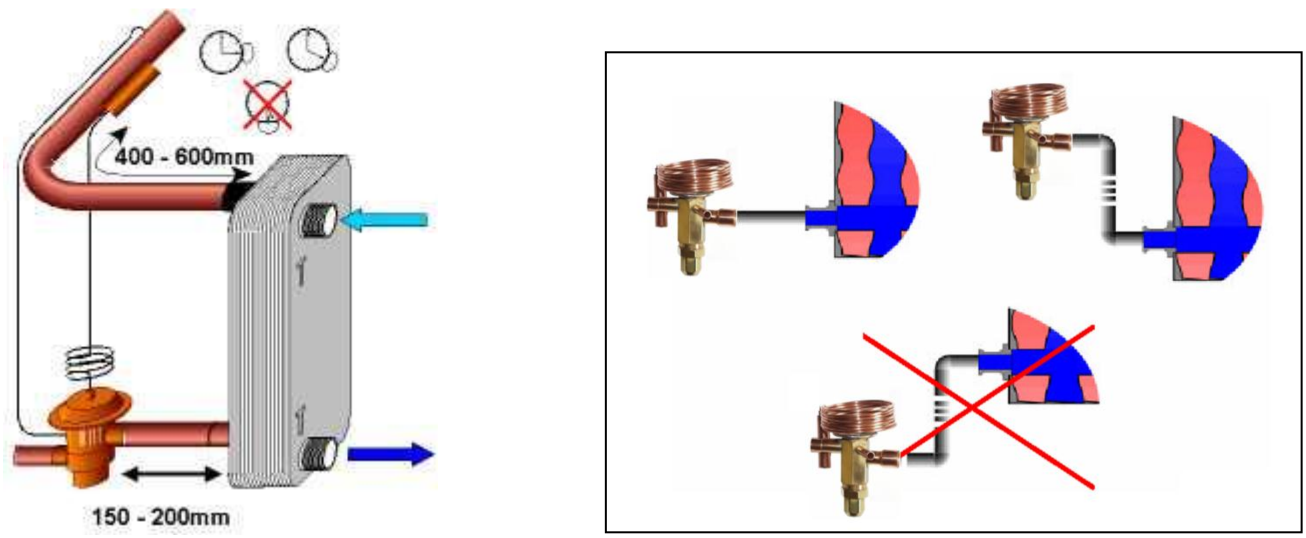


Figure 10: Position of the expansion valve and bulb when using a plate heat exchanger (copyright AL SWEP)

If a thermostatic expansion valve is used, its bulb should be located 400 – 600 mm from the vapour outlet, preferably after a bend and on the inside as shown on the left in **Figure 10**. The position of the bulb relative to the section of the tube is illustrated. It should not be attached underneath the tube. External equalisation is not essential. The tubing between the expansion valve and the economizer entry may either be straight or include a bend as shown on the right in **Figure 10**. It is most important that the connection diameter at the entry to the economizer is small enough to induce the turbulence required for uniform distribution and evaporation.

7 Liquid receiver

A liquid receiver may be necessary to accommodate charge variations over the operating condition range and to limit the condenser subcooling. It should always be fitted in the condenser outlet liquid line and not in the heat exchanger outlet liquid line (**Figure 11**). This is because vapour phase may be present in a receiver, and this is only possible with saturated liquid.

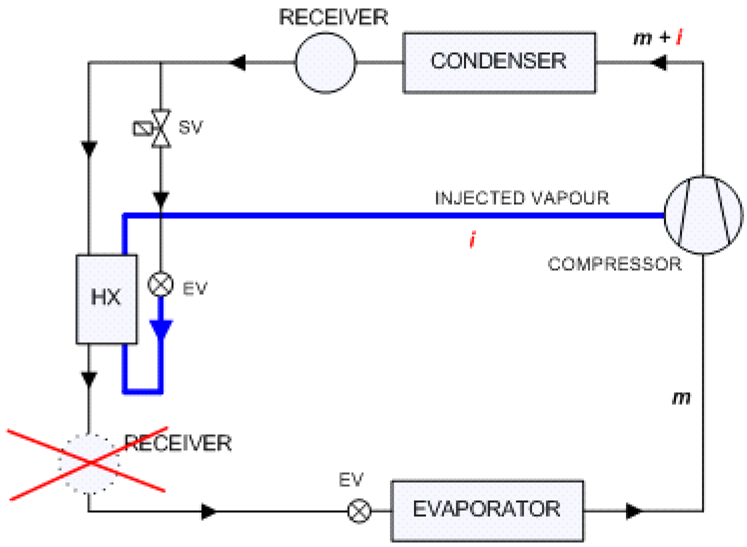


Figure 11: Receiver position

8 Expansion valve and solenoid valve selection for injection line

The injection expansion device used in conjunction with the economizer will be preferably electronic to operate in the whole wide capacity range that such vapour injection compressor models allow.

A solenoid valve should be added if the expansion device does not close completely. This will avoid liquid migration to the compressor during the off cycle. In single compressor configuration, the solenoid valve may be in the liquid line or the vapour line. A liquid line position is usually preferred because the valve is smaller. However, if the compressor rotates in reverse direction during the first seconds of the off cycle, the valve should be installed in the vapour line in order to limit the volume of refrigerant between the valve and the compressor. With multiple compressors used in parallel with one economizer it is required to install a solenoid valve in the single injection line of each compressor. This would avoid injection in idle compressor.

The solenoid valve selection considers a minimum pressure drop of 0.05 bar and a maximum pressure drop of around 0.5 bar across the compressor operating envelope. The selection of the solenoid valves in the single injection line can be carried out according to **Table 5**.

Compressor	Recommended Kv (m^3/h)	Valve model	Valve Kv (m^3/h)
ZHI18	0.8 – 1.3	ALCO 200 RH 4	0.9
ZHI23	1 – 1.5	Contact ALCO Application	
ZHI27	1 – 1.5	Contact ALCO Application	
ZHI32	1.3 – 1.8	ALCO 200 RH 6	1.6
ZHI35	1.6 – 2.1	ALCO 200 RH 6	1.6
ZHI40	1.8 – 2.3	Contact ALCO Application	
ZHI46	2.0 – 2.5	Contact ALCO Application	

Table 5: Selection of the solenoid valves in the single injection line

For additional ALCO solenoid valves please contact ALCO Application Engineering.

A selection of injection electronic expansion valves and expansion valve controllers is available in **Tables 6, 7 & 8**. This selection is a good starting point for designing and building systems. Nevertheless, system performance and reliable operation have to be verified by the system manufacturer through system testing.

For more information about the expansion valves and controllers offered by Emerson Climate Technologies, please contact your usual sales contact or the Application Engineering department at Emerson Climate Technologies.

Compressor	Economizer EXV	Controller for Economizer EXV
ZH06KVE	EXM-B0B	EXD-HP1/2
ZH09KVE	EXM-B0B	EXD-HP1/2
ZH13KVE	EXM-B0B	EXD-HP1/2
ZH18KVE	EXM-B0D	EXD-HP1/2
ZH24KVE	EXM-B0D	EXD-HP1/2
ZH33KVE	EXL-B0E	EXD-HP1
ZH40KVE	EXL-B1G	EXD-HP1
ZH48KVE	EXL-B1G	EXD-HP1

Table 6: Injection electronic expansion valve and controller selection for vapour injection – ZH*KVE models

Compressor	Economizer EXV	Controller for Economizer EXV
ZHI05K1P	EXM-B0A	EXD-HP1/2
ZHI08K1P	EXM-B0B	EXD-HP1/2
ZHI11K1P	EXM-B0B	EXD-HP1/2
ZHI14K1P	EXM-B0B	EXD-HP1/2
ZHI18K1P	EXM-B0D	EXD-HP1/2
ZHI23K1P	EXM-B0D	EXD-HP1
ZHI27K1P	EXL-B1F	EXD-TEVI
ZHI32K1P	EXL-B1F	EXD-TEVI
ZHI35K1P	EXL-B1F	EXD-TEVI
ZHI40K1P	EXL-B1F	EXD-TEVI
ZHW08K1P	EXM-B0B	SEC
ZHW16K1P	EXM-B0B	SEC

Table 7: Injection electronic expansion valve and controller selection for vapour injection – ZHI*K1P and ZHW*K1P models

Tandem configuration	Economizer EXV	Controller for Economizer EXV
2 x ZHI08K1P	1 x EXM-B0B	/
2 x ZHI11K1P	1 x EXM-B0D	/
2 x ZHI14K1P	1 x EXM-B0D	/
2 x ZHI18K1P	1 x EXL-B1F	EXD-TEVI
2 x ZHI23K1P	1 x EXL-B1G	EXD-TEVI
2 x ZHI27K1P	1 x EXL-B1G or 2 x EXL-B1F	EXD-TEVI
2 x ZHI32K1P	1 x EXL-B1G or 2 x EXL-B1F	EXD-TEVI
2 x ZHI35K1P	2 x EXL-B1F	EXD-TEVI
2 x ZHI40K1P	2 x EXL-B1F	EXD-TEVI

Table 8: Injection electronic expansion valve and controller selection for vapour injection in tandem of ZHI*K1P models

Due to its inherent smaller capacity range compared to an electronic valve, a thermostatic expansion valve will only operate adequately in a limited area of the envelope.

If an electronic expansion valve other than those shown in **Tables 6, 7 and 8** is used, it should be a variable orifice type. Pulse modulating types are unsuitable because the internal volume of the economizer is low, and they will give rise to unstable operating conditions which may result in an unacceptable quantity of liquid overfeed.

For some configurations in **Table 8**, two injection expansion valves in parallel are required to cover the capacity range. For others, it is optional but two valves in parallel can provide better control resolution.

9 Injection expansion valve setting

The injection expansion valve will be set to maintain the injection superheat around 5K throughout the operating envelope. This is a good compromise not to inject any liquid refrigerant into the scroll and to have a sufficient cooling of the compressed gas, and therefore limit the discharge temperature.

10 Injection line diameter

The injection line diameter should be correctly sized for vapour with minimal pressure drops if optimum performance is to be maintained. The size should follow the size of the compressor injection connection listed in **Tables 9 & 10**.

Compressor	Vapour injection line diameter
ZH06KVE	3/8"
ZH09KVE	3/8"
ZH13KVE	1/2"
ZH18KVE	1/2"
ZH24KVE	5/8"
ZH33KVE	5/8"
ZH40KVE	5/8"
ZH48KVE	5/8"

Table 9: Vapour injection line diameter for compressors ZH*KVE

Tandem configuration	Economizer EXV
ZHI08K1P	12.8
ZHI11K1P	12.8
ZHI14K1P	12.8
ZHI18K1P	12.8
ZHI27K1P	16.1
ZHI32K1P	16.1
ZHI35K1P	16.1
ZHI40K1P	16.1
ZHW08K1P	9.6
ZHW16K1P	9.6

Table 10: Vapour injection line diameter for compressors ZHI*K1P and ZHW*K1P

11 Line lengths and insulation

Injection lines between both expansion devices and the heat exchangers (evaporator and economizer) need to be kept as short as practical and well insulated. The economizer should also be insulated.

12 Additional application points

12.1 Operation without vapour injection

By high evaporating temperature, it may be interesting to limit the compressor capacity by operating without vapour injection. This is only acceptable at conditions indicated in **Table 11**.

Compressor	Conditions where operation without vapour injection is allowed
ZH06KVE to ZH18KVE	Dew evaporating T > 0°C
ZHI08K1P to ZHI23K1P	Dew evaporating T > 0°C
ZHI27K1P to ZHI40K1P	Dew evaporating T > 5°C and Dew condensing T < 65°C

Table 11: Evaporating temperatures allowed for operation without vapour injection

In order to avoid back flow through the injection line and hence loss of performance and possible noise generation, it is recommended to close the injection line (by means of the electronic expansion valve or a solenoid valve) when the pressure ratio is lower than 2.

Figure 12 shows the approximate percentage of heating capacity reduction obtained at various condensing temperatures when the vapour injection is shut off. The capacity reduction effect is limited, particularly at lower condensing temperatures.

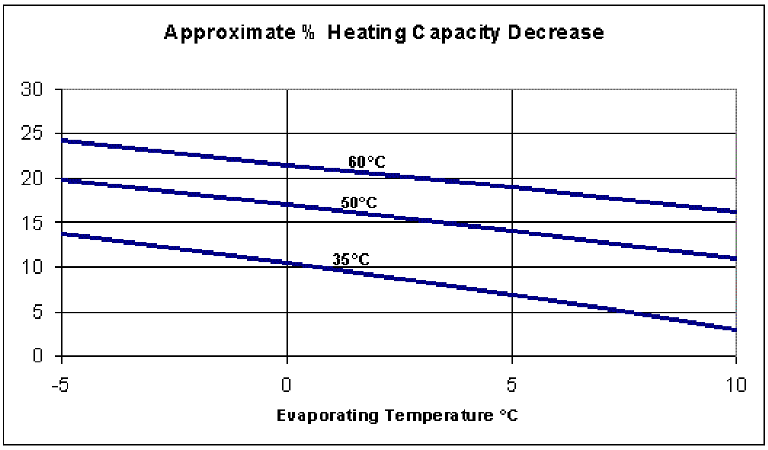


Figure 12: Approximate % heating capacity reduction obtained if changing to operation without VI

12.2 Discharge temperature protection

Discharge gas temperature protection is required for any application with Copeland brand compressors. For ZHW08-16K1P, ZHI18-23K1P tandem-ready (BOM 476) and ZHI27-40K1P, an integrated discharge gas temperature protector is included in the compressor standard delivery. For the other models, an external discharge gas temperature protector must be installed. This ensures the compressor cannot overheat in the event of loss of vapour injection cooling.

***NOTE*: For more details please refer to Application Guideline C6.2.26 "Scroll Compressors for Heat Pumps with R410A – ZH04K1P to ZH19K1P, ZHI08K1P to ZHI40K1P".**

12.3 Current sensing relay

For maximum protection of the compressor, compressor models with internal motor protection (ZH09-18KVE, ZHI08-40K1P) can be fitted with a current sensing relay in order to close the liquid line in the event of motor trip.

13 Reference list of Copeland Technical Information

- **C6.2.26 "Scroll Compressors for Heat Pumps with R410A – ZH04K1P to ZH19K1P, ZHI08K1P to ZHI40K1P"**
- **C6.2.9 "Scroll Compressors for Heat Pump Applications – ZH12K4E to ZH11M4E, ZH06KVE to ZH48KVE"**
- **C7.17.3 "Paralleling of ZH Copeland Scroll Compressors for Heat Pump Applications"**
- **C7.8.6 "Discharge Gas Temperature Protection with ZH Compressors"**

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