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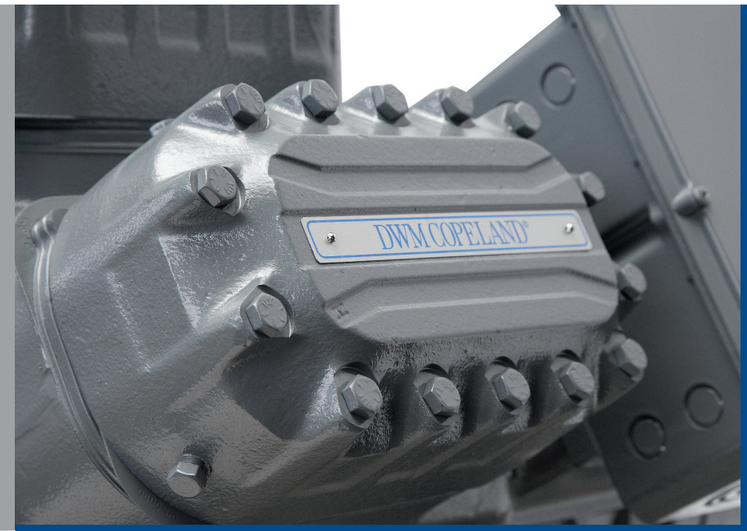
Copeland Discus™

Copeland Discus™
The Best Gets Even Better

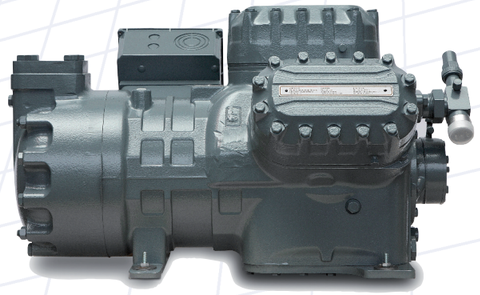


Copeland Discus™: the Best Gets Even Better

Emerson Climate Technologies is the world's leading refrigeration compressor manufacturer supporting the industry with Copeland® brand compressors featuring advanced technology which have demonstrated superior performance and reliability over many years. When Emerson Climate Technologies developed the scroll concept in the 1980's, the company was already a world leader in semi-hermetic technology. With its Discus® valve design, Emerson Climate Technologies had already been serving the market with a high efficiency compressor. The scroll compressor was a natural evolution in the sense that it dispensed with valves as a means of controlling the compression process, thus eliminating re-expansion losses and heat transfer to the incoming gas. Although the Copeland Scroll™ technology, with more than 60 million scroll compressors manufactured to date, has revolutionized the industry, the market still shows a significant demand for the traditional semi-hermetic products for larger commercial refrigeration applications which the scroll compressor range does not yet cover.

Applied in thousands of refrigeration applications worldwide, the Copeland Discus™ compressor is well known for its ruggedness, reliability and superior energy efficiency. The unique Discus® valve plate gives the lowest clearance volume of any piston type refrigeration compressor and thus gives the best capacity per cubic centimetre of displacement. Combined with a high efficiency motor and optimized gas flow passages, the Discus® compressor has gained a reputation as the benchmark for semi-hermetic compressor performance.

Over the past few years the design of Discus® compressor has been undergoing steady improvements. Whilst retaining all the essential features of the product, the operating range or "envelope" has been extended in the low condensing area offering system designers more opportunity to reduce the system running costs. An envelope extension was also implemented in the high evaporating area so that both low and medium temperature applications can now be covered with one single model with the smaller motor.



The Advantages of the Discus® Versus Reed Valve Technology

The key difference between Discus® and standard reciprocating technologies available on the market lies in the valve plate design (as shown in figure 1). The Discus® valve plate allows gas to flow into the cylinders with a minimum heat gain while suction cavities are designed to smoothly route the gas to minimize losses. These effects lead to superior capacity and efficiency of Discus® compressors compared to conventional "cost efficient" reed type compressors, giving the customer a choice of efficiency.

Figure1: Discus® (top) and reed (below) valve plates

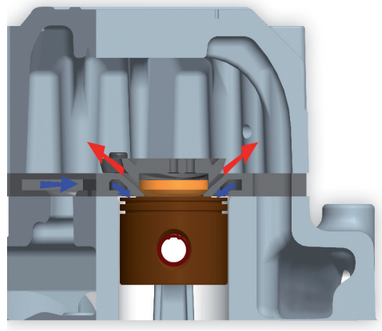


Figure 2a: Discus® technology

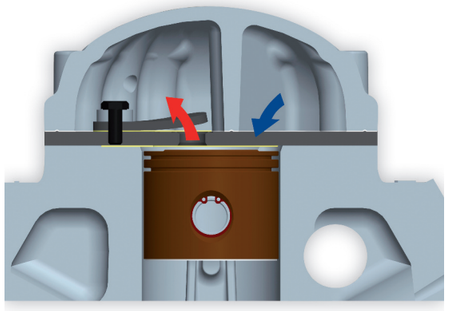


Figure 2b: Reed valve technology

The Discus® technology takes its name from the conical discharge valve. When closed, the Discus® "puck" is retained flush with the valve plate reducing the clearance volume to an absolute minimum when the piston is at the top of the cylinder (as shown in figure 2a). With a conventional machine (as shown in figure 2b), the suction valve reeds prevent the piston coming close to the top of the cylinder and there is an additional "dead volume" in the discharge ports in the valve plate.

Discus® Compressors Product Range

Copeland Discus™ compressors are suitable for a wide range of applications either in the form of single compressors or condensing units or as multi-compressor equipment. These provide refrigeration for multi-evaporator cold rooms, walk-ins, supermarket display cases, food and industrial process applications. A complete model line up is shown in figures 3 and 4.

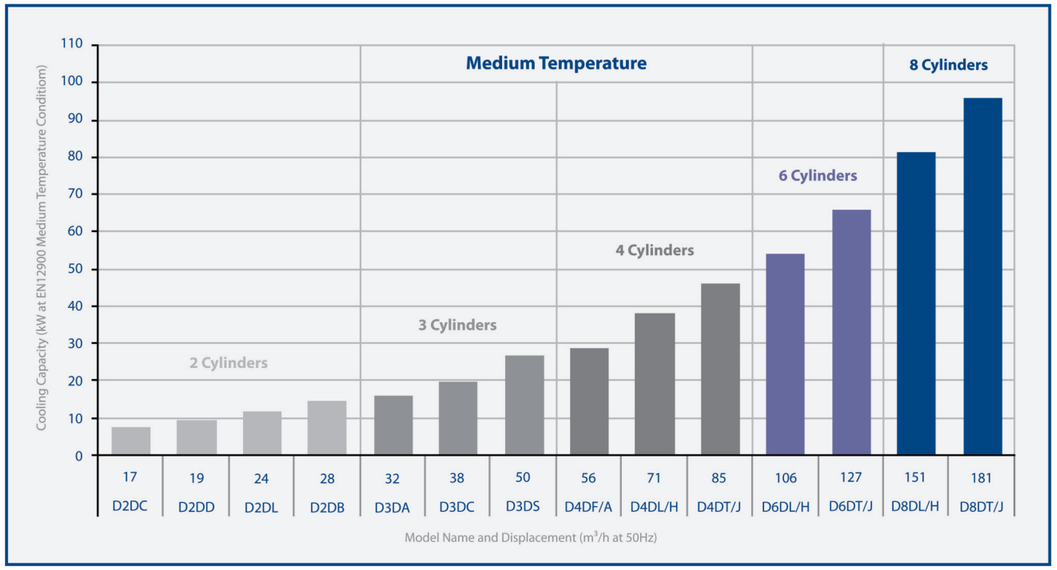


Figure 3: Medium temperature coverage from 7 – 95kW cooling capacity

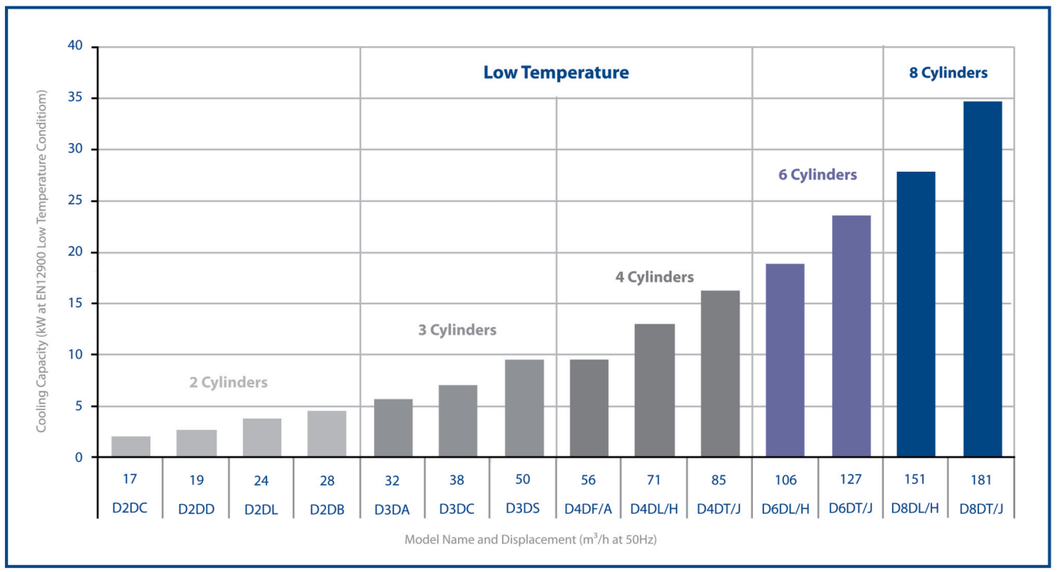


Figure 4: Low temperature coverage from 2 – 35kW cooling capacity

Latest Discus® Valve Design Improvement

The major design change has been the introduction of a new suction ring that is fixed to the valve plate at one side (see figure 5).

This fixed suction ring design eliminates the possibility of any slot wear. At the same time gas flow areas have been increased to further reduce internal pressure drops. The combined effect of these modifications has resulted in performance improvements and these are reflected in the Copeland® brand products "Selection Software" from Emerson Climate Technologies, version 6.6 and later.

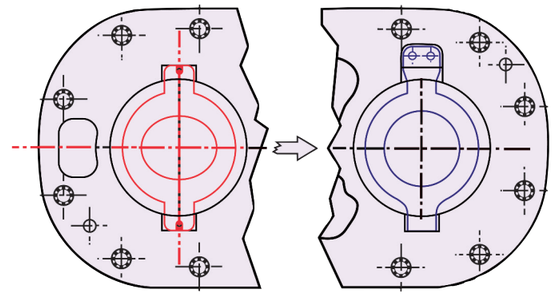


Figure 5: New Discus® suction ring design

Larger Range of Evaporating Temperatures

Each displacement has two motor sizes. Traditionally the small motor has been offered for the low temperature applications with the large motor for medium and high temperatures. The new, extended envelope of the Discus® compressor allows the small motor version to cover both low temperature and medium temperature applications as shown in figure 6, therefore reducing capital cost or minimizing stock requirements.

In the past, some models of the Discus® compressor had slightly different operating limits to others. This has now been eliminated and the envelopes have been extended and consolidated across the full range. Performance testing has been used to provide EN12900 data for operation down to -50°C and right up to -5°C evaporating temperature for all small motor Discus® models.

The larger motor version is designed for higher evaporating temperatures that have higher power requirements. This version is capable of operation over a very wide range of applications making it extremely versatile as shown in figure 7. The stronger motor gives extra pull down capability and this can avoid the need to use a pressure regulator.

The choice of motor version can be influenced by a number of factors such as capital cost, maximum operating current, versatility and minimisation of types held in stock. The large motor generally offers better efficiency especially at medium/high evaporating temperatures and gives a better operating envelope in most variable speed applications.

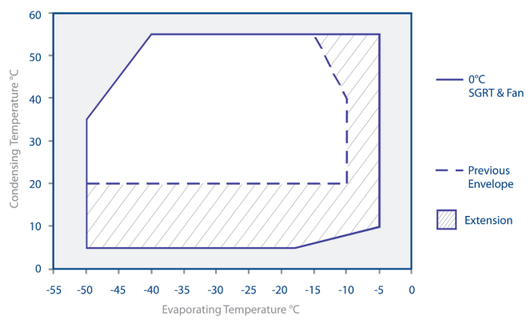


Figure 6: Medium / Low temperature R404A envelope for Discus® compressors with small motor

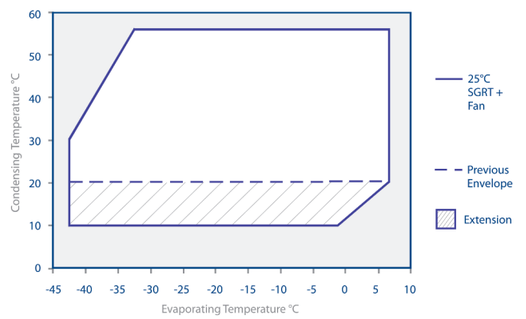


Figure 7: Medium / High temperature R404A envelope for Discus® compressors with large motor

Lower Condensing Temperature Capability

As shown in figure 6, the lower condensing temperature limit of the small motor version has been extended downwards to 5°C, so that during typical European winter conditions the condensing temperature can be reduced to the lowest value the system will allow. The end-user may continue to benefit from power and running cost reductions when the outside temperature falls below -5°C with suitably designed systems, and this can translate into a considerable carbon footprint reduction.

Reduction of Carbon Footprint

As mentioned in the previuos paragraph, lower condensing pressure capability gives a significant reduction in annual power consumption and a corresponding reduction in CO_2 emissions. The tables in figure 8 and 9 show that energy and carbon emission savings of up to 21% in medium temperature and 16% in low temperature can be made by choosing a Discus® compressor pack instead of a conventional reed valve compressor. Allowing the condensing temperature to fall to a minimum of 10°C instead of 20°C provides part of the savings and many conventional reed valve compressors are limited to a minimum condensing temperature of 20°C. Where conventional reed valve models have low condensing capability the efficiency at low pressure ratios tends to be poor as shown in figure 10 and this can negate the energy benefit of low condensing operation.

Medium Temperature, R404A Rack of Five Compressors, Load 300kW
Evaporating -10ºC, Condensing 10K above ambient, Superheat 20K, Subcooling 5K

		Frankfurt	Lyon	Moscow
Discus® D6DL-270X Minimum Condensing 10°C	Annual Energy Cost (thousands €)	43	46	40
	Seasonal COP	4,7	4,6	5,2
	Power Input (MWh)	540	575	505
	Delta CO_2 Emissions (tons of CO_2)	Base	Base	Base
	Delta CO_2 Emissions (%)	Base	Base	Base
Discus® D6DL-270X Minimum Condensing 20°C	Annual Energy Cost (thousands €)	48	48	46
	Seasonal COP	4,4	4,3	4,5
	Power Input (MWh)	600	605	580
	Delta CO_2 Emissions (tons of CO_2)	**36**	**18**	**45**
	Delta CO_2 Emissions (%)	**11%**	**5%**	**15%**
Competitive Product Minimum Condensing 20°C	Annual Energy Cost (thousands €)	50	51	49
	Seasonal COP	4,2	4,1	4,3
	Power Input (MWh)	630	640	610
	Delta CO_2 Emissions (tons of CO_2)	**54**	**39**	**63**
	Delta CO_2 Emissions (%)	**17%**	**11%**	**21%**

Energy Cost: 0.08 € / kWh / CO_2 Emission: 0.6 kg / kWh

Figure 8: Medium temperature: Impact of condensing at 20°C versus 10°C and comparison of Discus® compressor's running cost and indirect CO_2 emissions with competitive standard compressors

Low Temperature, R404A Rack of Five Compressors, Load 60kW
Evaporating -35ºC, Condensing 10K above ambient, Superheat 20K, Subcooling 5K

		Frankfurt	Lyon	Moscow
Discus® D4DL-150X Minimum Condensing 10°C	Annual Energy Cost (thousands €)	19	19	17
	Seasonal COP	2,2	2,2	2,4
	Power Input (MWh)	236	240	217
	Delta CO_2 Emissions (tons of CO_2)	Base	Base	Base
	Delta CO_2 Emissions (%)	Base	Base	Base
Discus® D4DL-150X Minimum Condensing 20°C	Annual Energy Cost (thousands €)	20	20	19
	Seasonal COP	2,1	2,1	2,2
	Power Input (MWh)	248	251	241
	Delta CO_2 Emissions (tons of CO_2)	**7**	**9**	**3**
	Delta CO_2 Emissions (%)	**5%**	**5%**	**11%**
Competitive Product Minimum Condensing 20°C	Annual Energy Cost (thousands €)	21	21	20
	Seasonal COP	2,0	2,0	2,1
	Power Input (MWh)	259	261	251
	Delta CO_2 Emissions (tons of CO_2)	**14**	**15**	**9**
	Delta CO_2 Emissions (%)	**10%**	**9%**	**16%**

Energy Cost: 0.08 € / kWh / CO_2 Emission: 0.6 kg / kWh

Figure 9: Low temperature: Impact of condensing at 20°C versus 10°C and comparison of Discus® compressor's running cost and indirect CO_2 emissions with competitive standard compressors

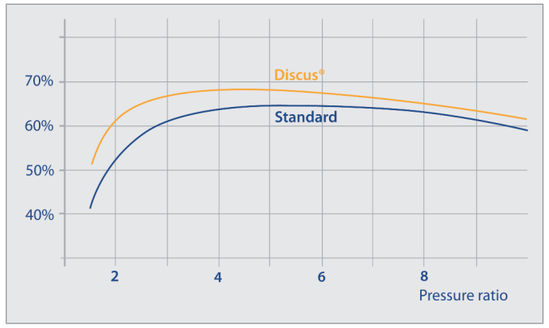


Figure 10: Typical Discus® and standard reed valve compressor isentropic efficiencies at low condensing pressures below 20°C

Lubrication Protection

All Discus® compressors are fitted with the sensor element to accommodate the OPS1/2 Oil Pressure protection device. This is screwed directly into the pump housing eliminating the need for connection tubes and it is hermetically sealed, eliminating the potential loss of refrigerant and associated environmental impact. The electrical components can be replaced without refrigerant loss. Being self contained, no associated control box is necessary making for ease and speed of mounting.

A fail-safe mode is important for any oil pressure device and the new OPS2 will stop the compressor if the monitoring device is not ready to detect. In addition, the manual reset button is designed as anti tie-down to avoid overriding an alarm condition.

Capacity Control and Inverter Drive

Most of the refrigeration systems are supplying less capacity than their full capability for the majority of the running hours and a solution of reducing compressor output is needed in almost every application. With the emphasis today on saving energy by reducing head pressures, an effective capacity control method can bring enormous benefits.

All Discus® compressors, with the exception of the smallest 2-cylinder versions, have an option for efficient built-in stepped capacity control. For 3-cylinder models MODULOAD provides reduced output and larger 4-, 6- and 8-cylinder models have cylinder unloading options, details of which are given in the technical literature.

In some situations stepped capacity control does not offer sufficiently fine adjustment. This is when motor speed control may be used.

The advantages of capacity modulation are closer pressure and temperature control, better system efficiency at part load condition and a reduced number of compressor cycles translating into extended equipment lifetime.

As shown in figure 11, an inverter is used to deliver the variable frequency supply to the motor and a certain amount of power loss occurs in this process, so it is always worthwhile checking the application in detail to establish the overall energy benefits of this method. All Discus® models are suitable for speed control over the frequency range, 25 – 60Hz with the standard AWM motors (400V/3/50). The range of capacity modulation becomes 50 to 120%. Details of the operating envelope, which are slightly reduced with inverter operation, are provided in the technical information.

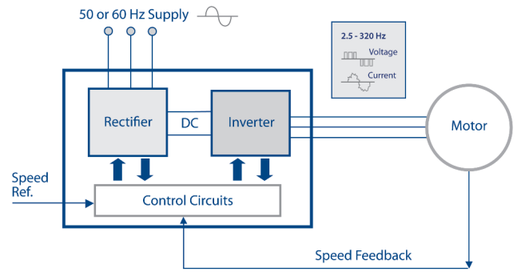


Figure 11: Operation with inverter

Conclusion

The design of the Discus® compressor has evolved over the years to bring continuous performance improvements to the refrigeration industry. Today, it offers unsurpassed levels of efficiency and reliability, which is entirely recognized across the industry.

The development of the Discus® product family has not been finished. A natural evolution of the product can be to integrate means of stepless capacity modulation. Emerson Climate Technologies recently introduced the digital modulation for refrigeration Copeland Scroll™ compressors, providing a unique way to modulate the capacity output from 10% to 100% with favourable energy savings. It can be expected that this patented Digital Scroll™ technology be applied to the Discus® range as a simple, efficient and affordable alternative to inverter technology.