

## REFRIGERATION – CONTROLLING STREAM DIGITAL

### 1 Introduction

In refrigeration applications where the load may vary over a wide range, some means of capacity control is often desirable for optimum system performance and control. In addition, compressor capacity modulation can reduce power and energy consumption, reduce compressor cycling, and decrease the starting electrical load. In order to achieve the above objectives, Emerson Climate Technologies has developed Stream Digital, a method for variable capacity in semi-hermetic compressors. Digital technology will, for the first time, permit digital modulation of semi-hermetic compressors for high, medium, and low temperature applications.

### 2 How Digital works

#### 2.1 Theory of operation

Digital capacity control is achieved by using a proven internal unloading method, based on blocking gas to the valve plate suction area / blocked suction. Capacity control between 0 and 100% on the Digital bank (between 10 and 100% for 3-cylinder compressors) can be achieved by varying the percentage of duty cycle when the compressor is loaded and unloaded. During blocked suction operation, the flow of suction gas is blocked to all cylinders on a single bank; therefore there is no gas to compress and the power consumption is significantly lower. The unloader piston mechanism that controls the flow of suction gas into the cylinders is driven by a solenoid valve. See the descriptions and figures below for the unloaded and loaded states for Copeland Stream Digital operation.

Digital technology is now available on the 4M\*D and 6M\*D Stream compressors. Applied to one bank on a 4M\*D compressor it provides 50 to 100% capacity modulation. When combined with a blocked suction bank on a 6M\*D compressor, it provides 33 to 100%.

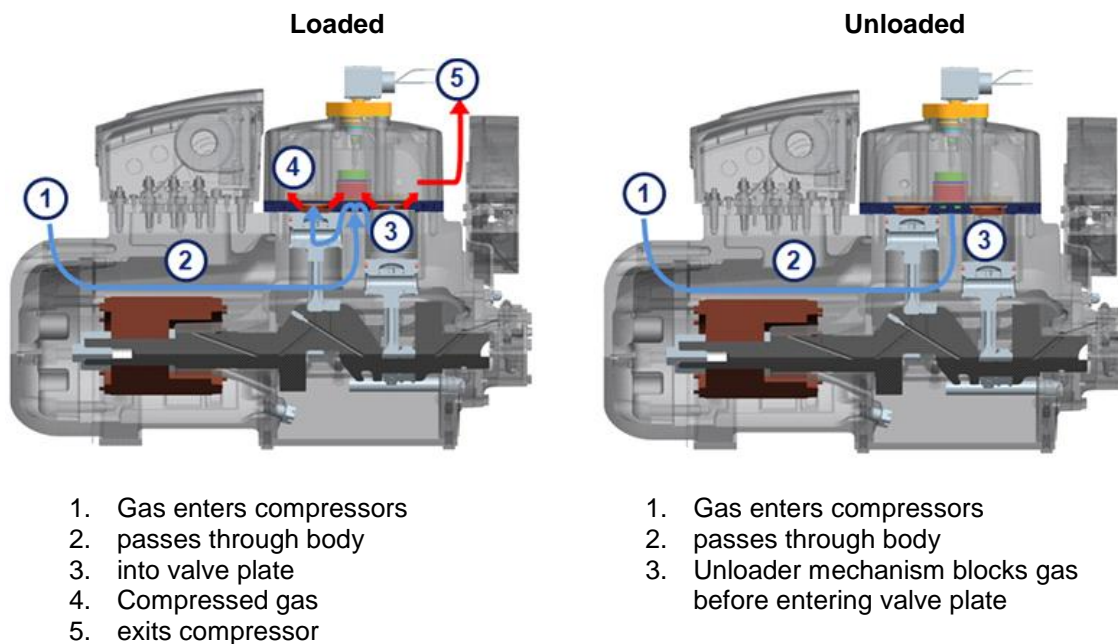
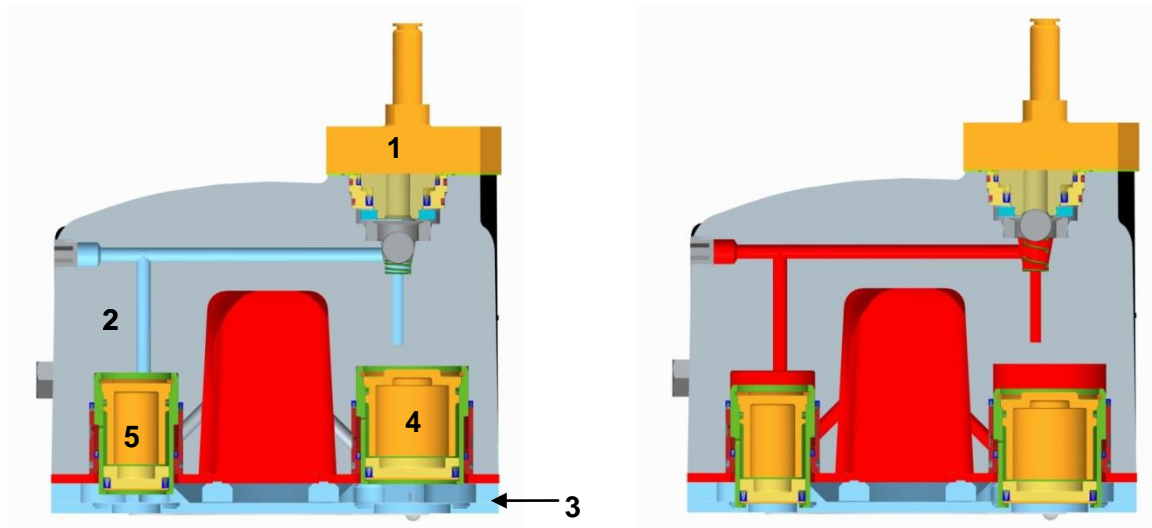


Figure 1: Gas flow

Loaded – Valve de-energized (100% capacity)

Unloaded – Valve energized (0% capacity)



1 = Solenoid valve      2 = Cylinder head      3 = Valve plate      4 & 5 = Unloading piston

Figure 2: Cutaway view of the Digital cylinder head loaded and unloaded

## 2.2 Control - Pulse Width Modulation

Capacity modulation is achieved by energizing and de-energizing the solenoid valve. When the solenoid valve is de-energized, the digital bank capacity is 100%. When the solenoid valve is energized, the digital bank capacity is zero. Therefore, the capacity achieved is the time average capacity.

Example: In a 20-second cycle, if the solenoid is de-energized for 16 seconds, and then energized for 4 seconds, the resulting capacity will be approximately 80%.

For 4M\*D Stream compressors, one bank of the compressor remains loaded 100% while the Digital bank will modulate 0 to 100% to provide the additional capacity.

On a 6M\*D with blocked suction, the blocked suction bank will unload when demand capacity is less than 67% and load when the demand capacity is higher than 67%. The Digital bank will continue to load and unload providing continuous capacity across the 33 to 100% range.

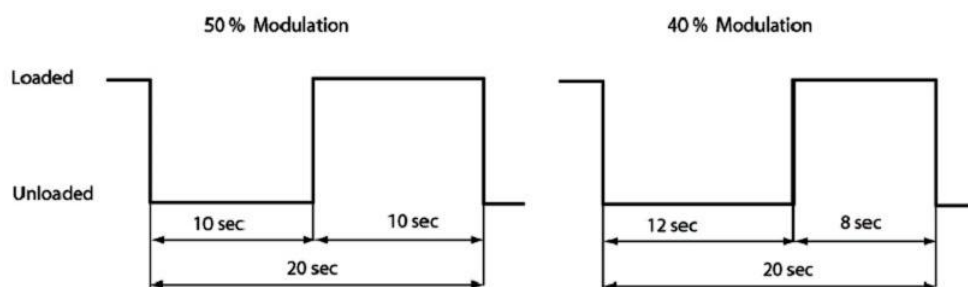
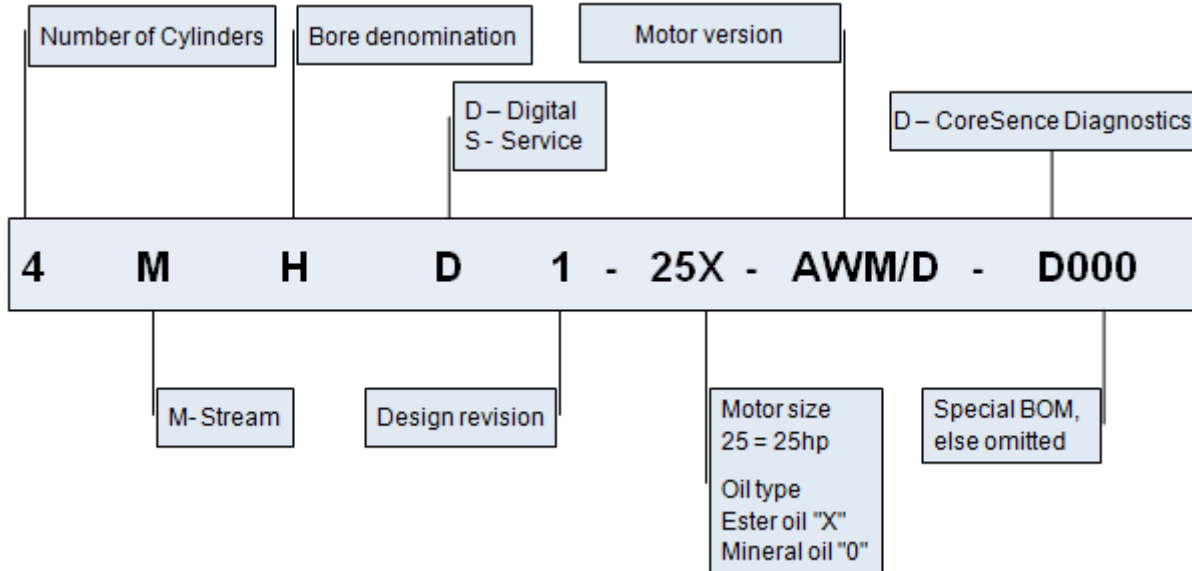


Figure 3: The digital signal from the controller activates the unloading

## 3 Components for Digital control

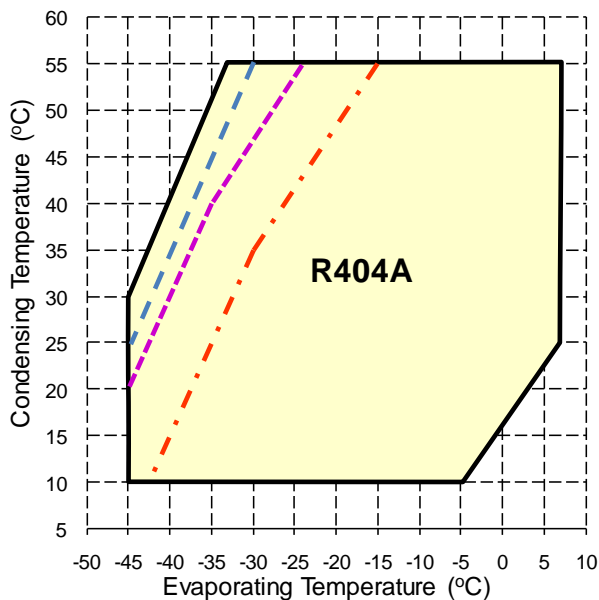
### 3.1 Compressor

Stream Digital models are designated by a letter “D” in the 4<sup>th</sup> character of the nomenclature. Please refer to Copeland® brand products Selection Software for available models.

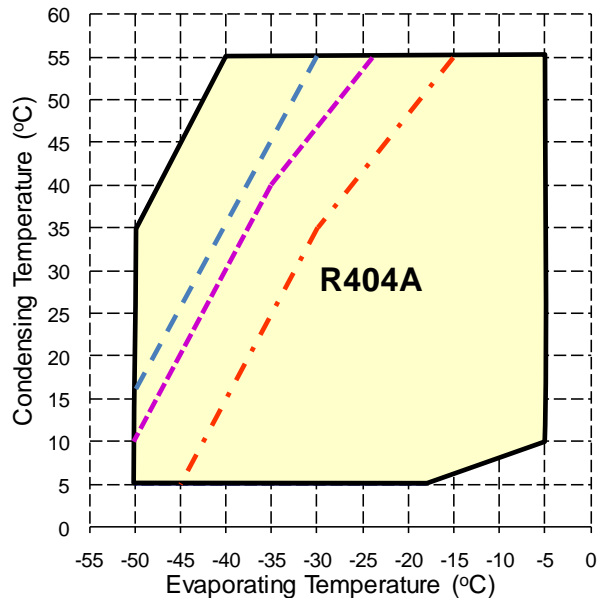


#### 3.1.1 Operating envelopes – R404A

4MAD1-22X, 4MHD1-25X, 4MID1-30X  
4MJD1-33X, 4MKD1-35X



4MFD1-13X, 4MLD1-15X, 4MMD1-20X  
4MTD1-22X, 4MUD1-25X



- Full capacity (100%)
- · - · - 25°C Suction Gas Return
- - - - - 0°C Suction Gas Return
- - - - - 0°C Suction Gas Return + Fan

Figure 4: Medium and high temp 4MD\* @ 50%

Figure 5: Low and medium temp 4MD\* @ 50%

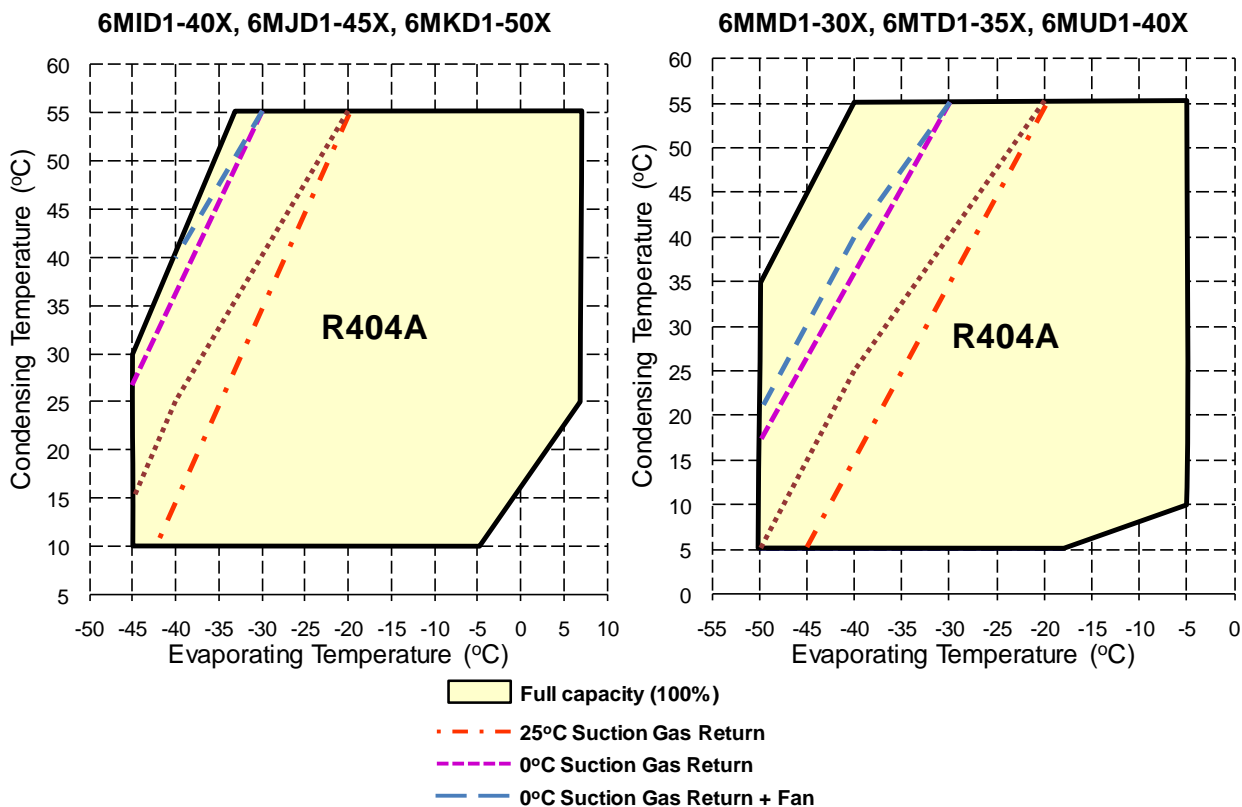


Figure 6: Medium and high temp 6M\* @ 67%

Figure 7: Low and medium temp 6M\* @ 67%

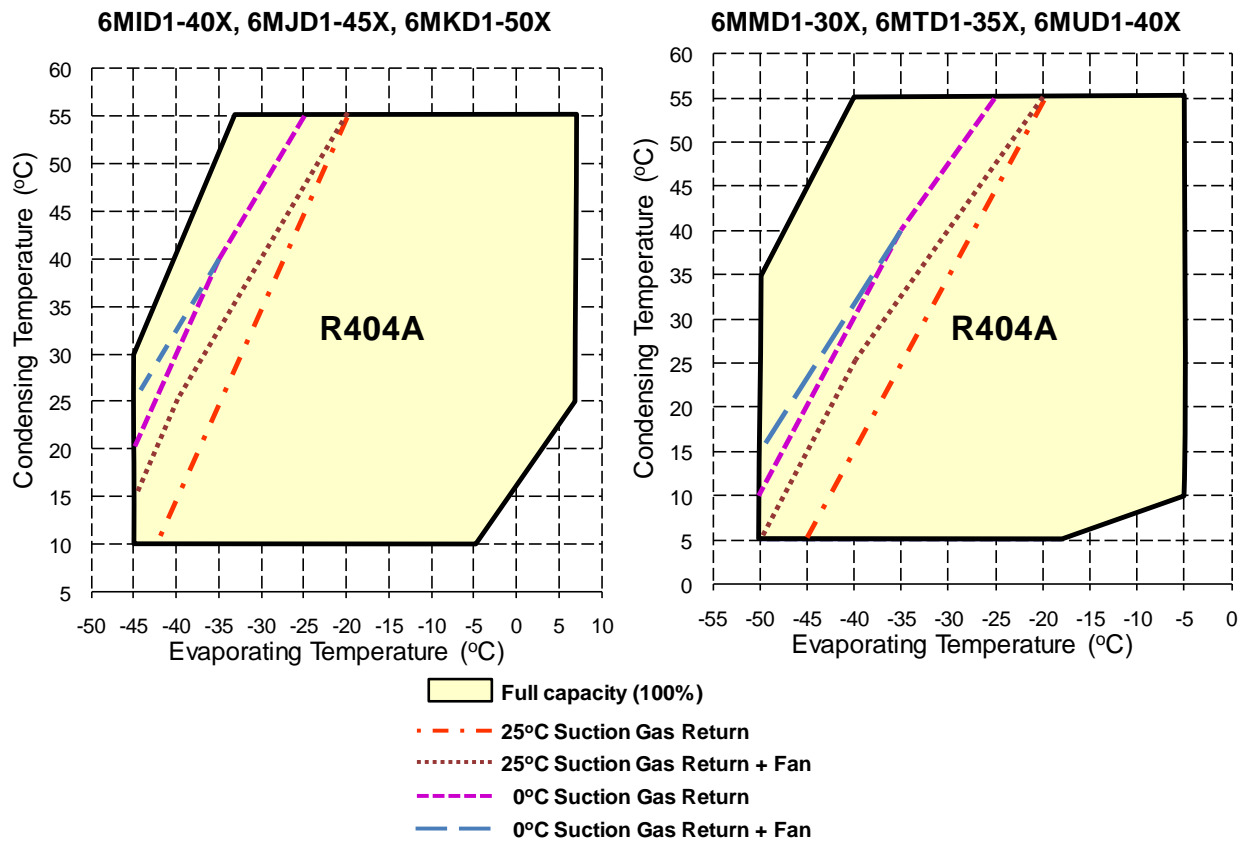


Figure 8: Medium and high temp 6M\* @ 33%

Figure 9: Low and medium temp 6M\* @ 33%

### 3.1.2 Operating envelopes – R134a

4MAD1-22X, 4MHD1-25X, 4MID1-30X  
4MJD1-33X, 4MKD1-35X

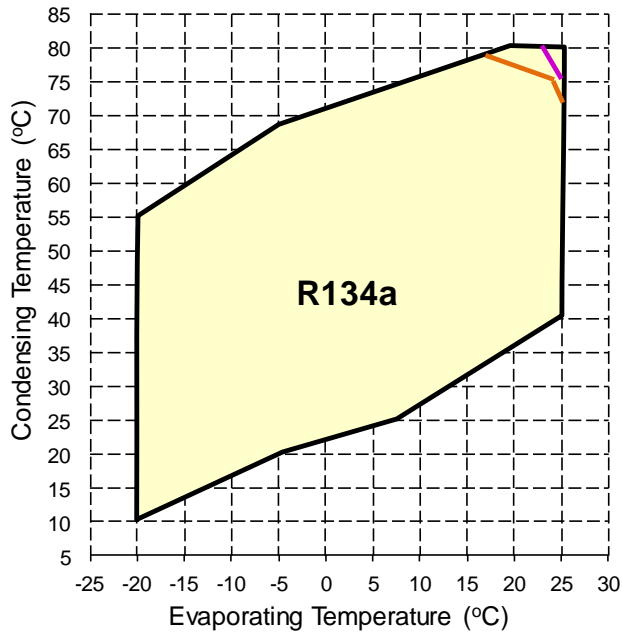


Figure 10: High temp 4MD\* @ 50%

4MFD1-13X, 4MLD1-15X, 4MMD1-20X  
4MTD1-22X, 4MUD1-25X

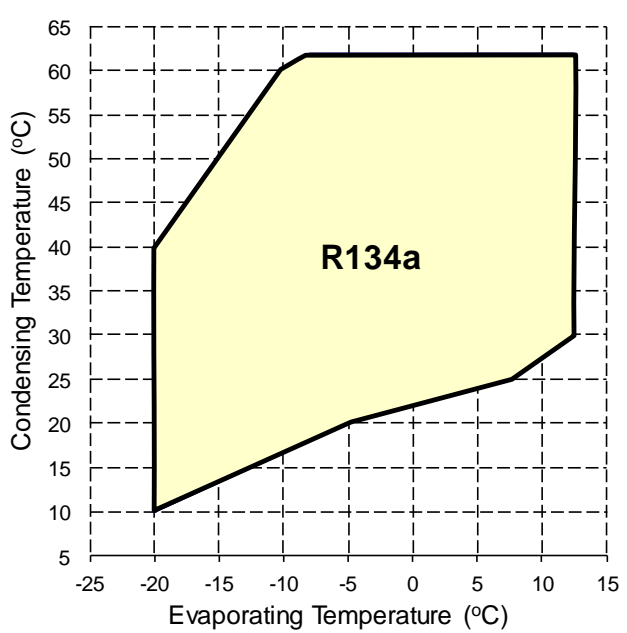


Figure 11: Medium and high temp 4MD\* @ 50%

6MID1-40X, 6MJD1-45X, 6MKD1-50X

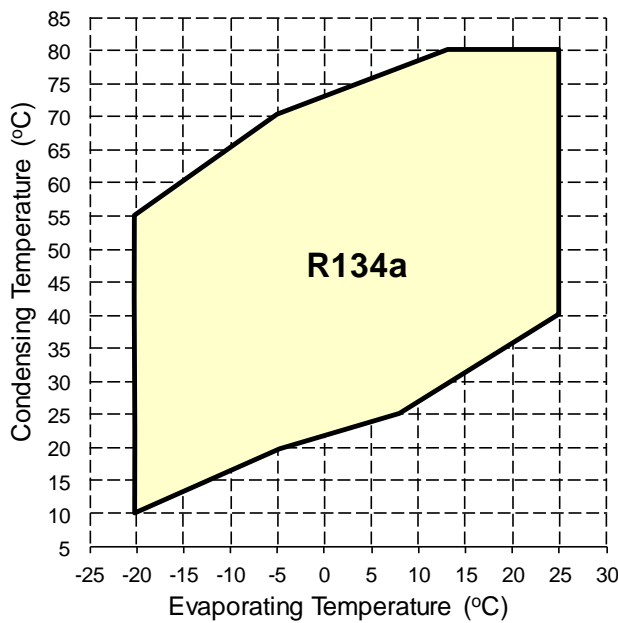


Figure 12: High temp 6M\* @ 67%

6MMD1-30X, 6MTD1-35X, 6MUD1-40X

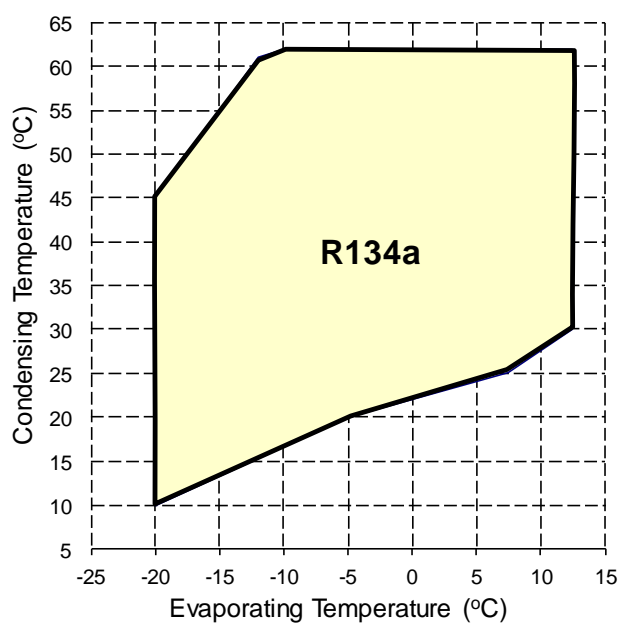


Figure 13: Medium and high temp 6M\* @ 67%

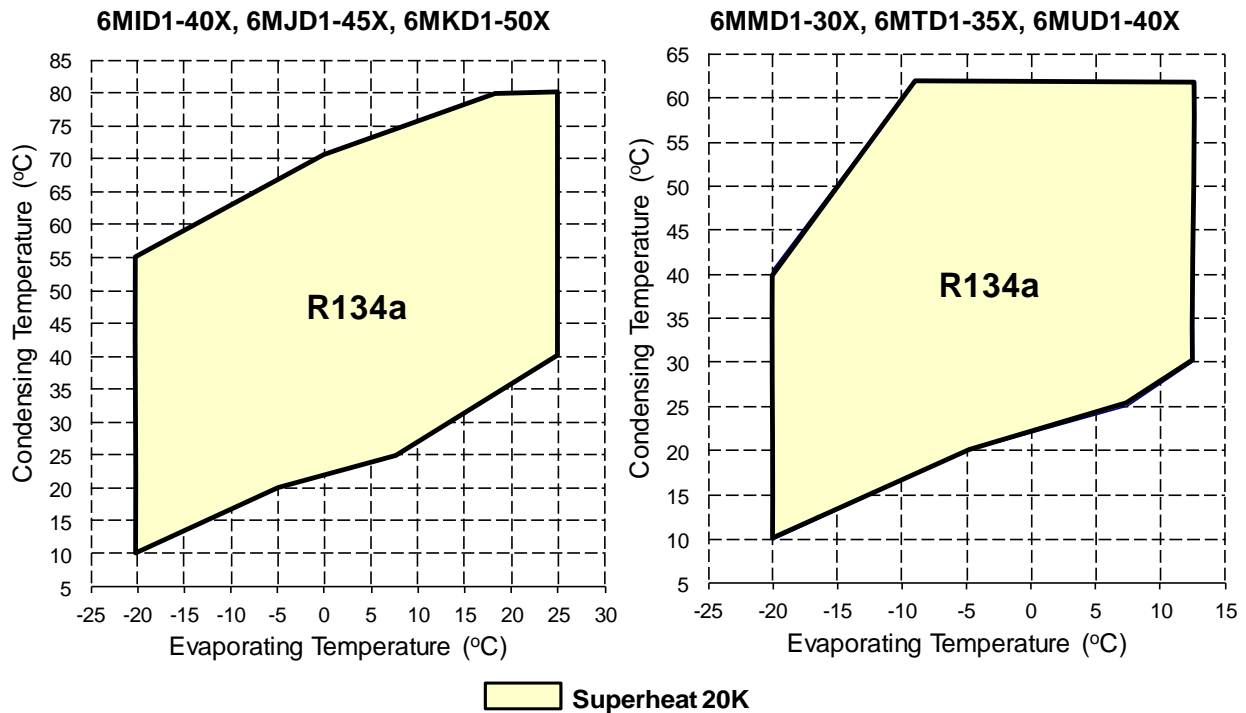


Figure 14: High temp 6M\* @ 33%

Figure 15: Medium and high temp 6M\* @ 33%

**NOTE:** Application envelopes with other refrigerants are available on request.

### 3.2 Solenoid valve

Due to the high life cycle requirements in a hot gas environment, a special valve has been developed. Due to reliability requirements, only Emerson solenoid valves may be used. All compressor warranties are null and void if the Emerson valve is not used. Solenoid coils will be sold separately for all Stream Digital compressors.

The solenoid coil is available for several voltages: 24V, 120V and 240V (AC only).

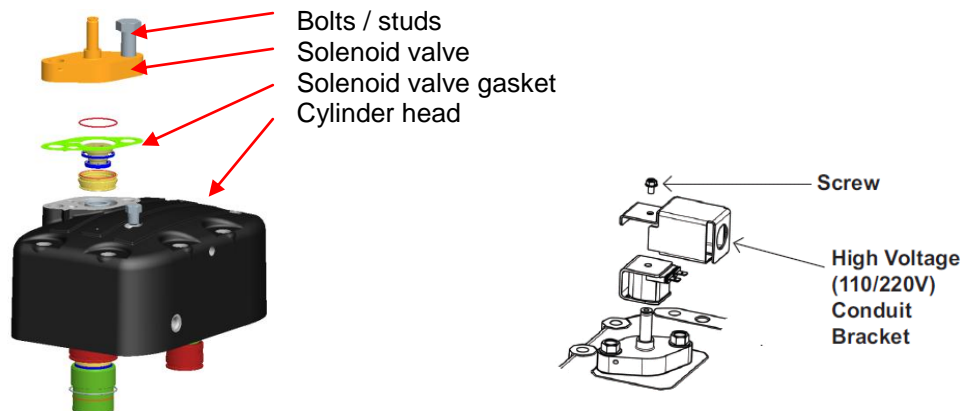


Figure 16: Configuration for solenoid valve

Furthermore, Stream Digital compressors use special head and valve plate gaskets which have modifications to ensure gas flow for proper digital modulation. Only Emerson gaskets may be used. All compressor warranties are null and void if the Emerson gaskets are not used.

### 3.3 Control components

Components required for control are an electronic controller and a suction pressure transmitter. The electronic controller sends the PWM signal modified in accordance with the pressure deviation from the set point using a built-in algorithm.

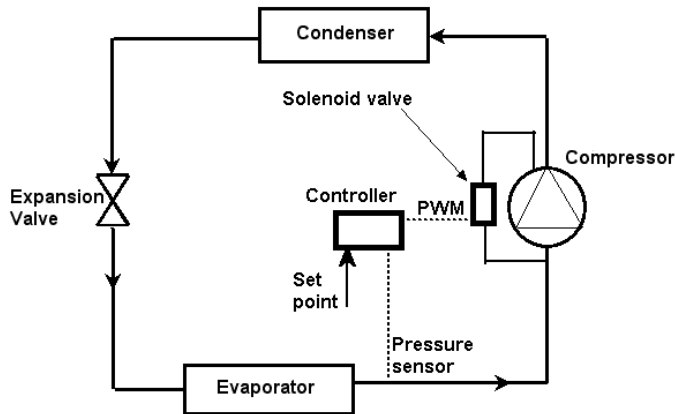


Figure 17: Control principle

## 4 Controlling Stream Digital

### EC3-D23

The EC3-D23 series is a stand-alone controller for Stream Digital. The EC3-D23 receives an input signal from an existing system controller (0...10V, 1 ... 6V or 4...20mA) and activates Stream Digital solenoid valves for capacity control of the Stream Digital compressor.

An input allows to monitor the discharge temperature or the compressors DLT signal and to send an alarm signal if the specified temperature is exceeded.

The list of parameters can be found in "EC3-D23 Stream Digital Driver and ECD-00 Keypad / Display Unit" - Operating Instructions, available on [www.emersonclimate.eu](http://www.emersonclimate.eu).



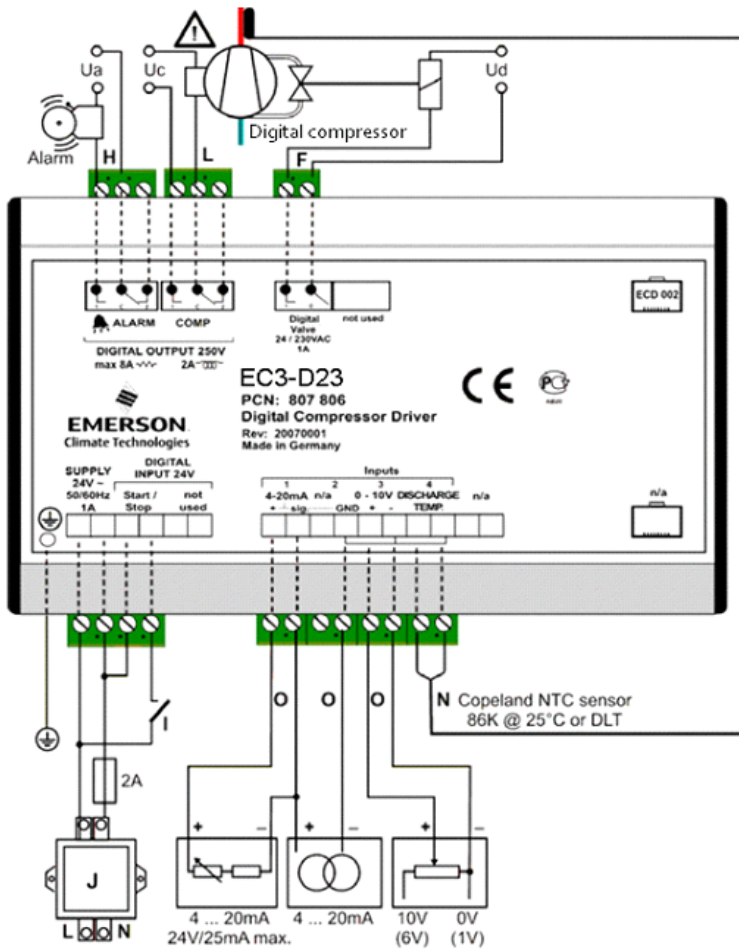


Figure 18: EC3-D23 Stream Digital driver

### ECD-000 Display Module

Available as an option; it displays the system temperatures, indicates system status and enables parameters to be modified.



Figure 19: ECD-000 Display