

Application guidelines

# Inverter scroll compressors **VZH028-035-044** single

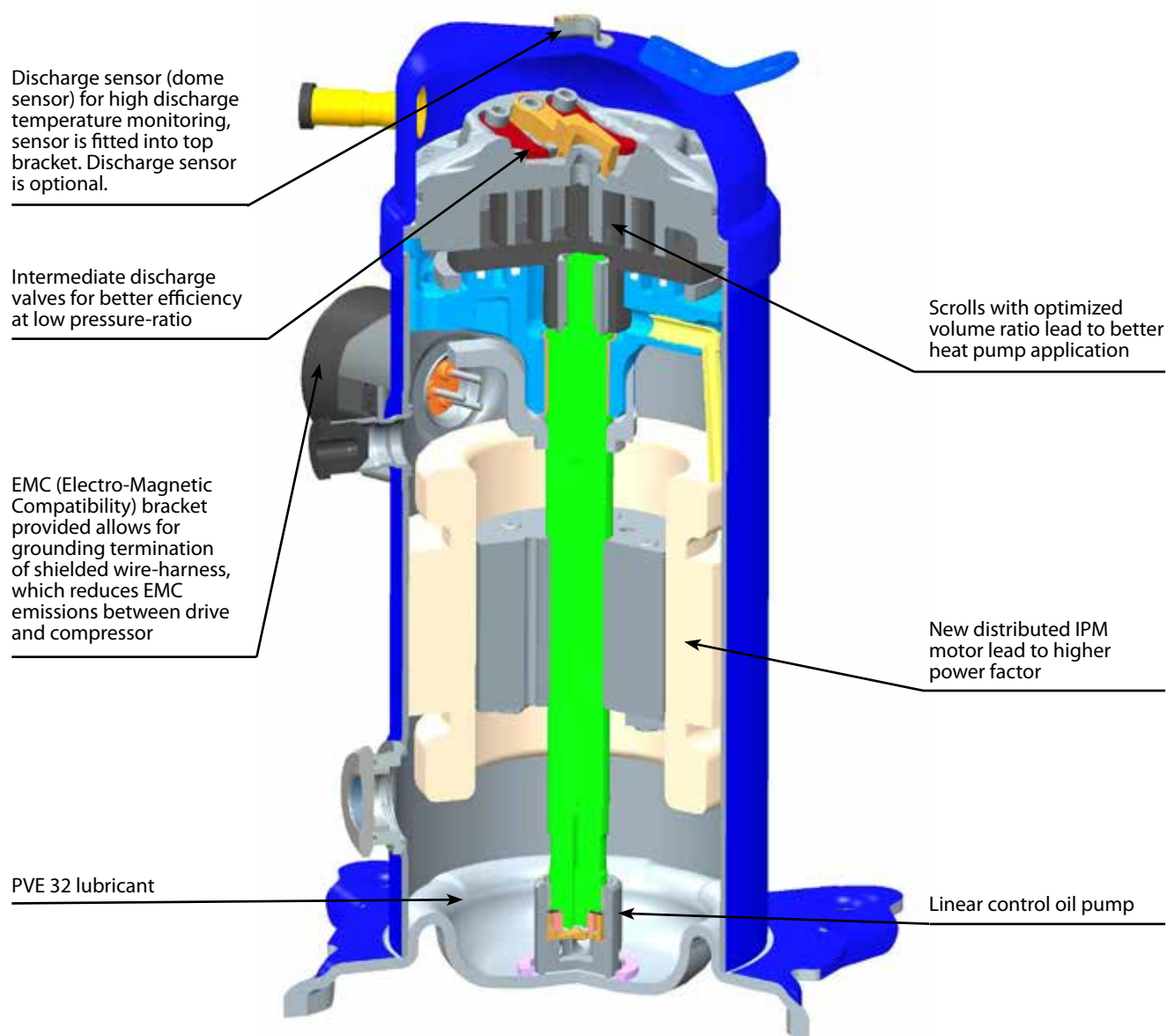
R410A





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**Compressor size**

Inverter technology offers more flexibility in compressor selection than fixed-speed compressors. Selection of the right inverter compressor size can be made by different methods:

1. Maximum cooling capacity: Select a compressor size which achieves the peak load system cooling capacity demand at its maximum speed.
2. Nominal cooling capacity: Select a compressor size which achieves the nominal system cooling capacity at a rotational speed of 3600 - 4500 rpm (60-75 rps).

3. Best Seasonal Efficiency Ratio: Select a compressor size which achieves the minimum system cooling demand at its minimum speed. Ensure that the compressor is able to cover the peak load system cooling capacity. This selection makes the compressor run for a maximum time at part load where the system efficiency is highest.

Performance tables at three speeds can be found in the following pages. Detailed performances can be found in datasheets and in selection programs.

**Frequency converter variants**

Different frequency converter variants are available according to:

Frequency converter for VZH028-035-044 200V&400V: CDS803

1. Mains supply voltage:
  - 200-240V/3ph/50-60Hz
  - 380-480V/3ph/50-60Hz
2. IP class (CDS803 drives are available in IP20 or IP21 (requiring additional kit) housings)

3. RFI (Radio Frequency Interference) class H4

4. Printed Circuit Board (PCB) coated

Frequency converter for VZH028-035-044 575V: CDS303

1. Mains supply voltage: 525-600V/3ph/50-60Hz
2. IP class: IP20
3. RFI class HX: No filter
4. PCB not coated

**Compressor and frequency converter combinations**

When the compressor size and mains voltage have been defined in the above selection criteria, the code number tables from the "Ordering information and packaging" section provides the appropriate frequency converter sizes and up to eight corresponding code numbers for each compressor model.

**⚠ Note this compressor is equipped with a four-pole electrical motor so the applied frequency from the inverter will be 30 Hz for 15 rps (900 rpm) up to 200 Hz for 100 rps (6000 rpm).**

Please refer to the table below

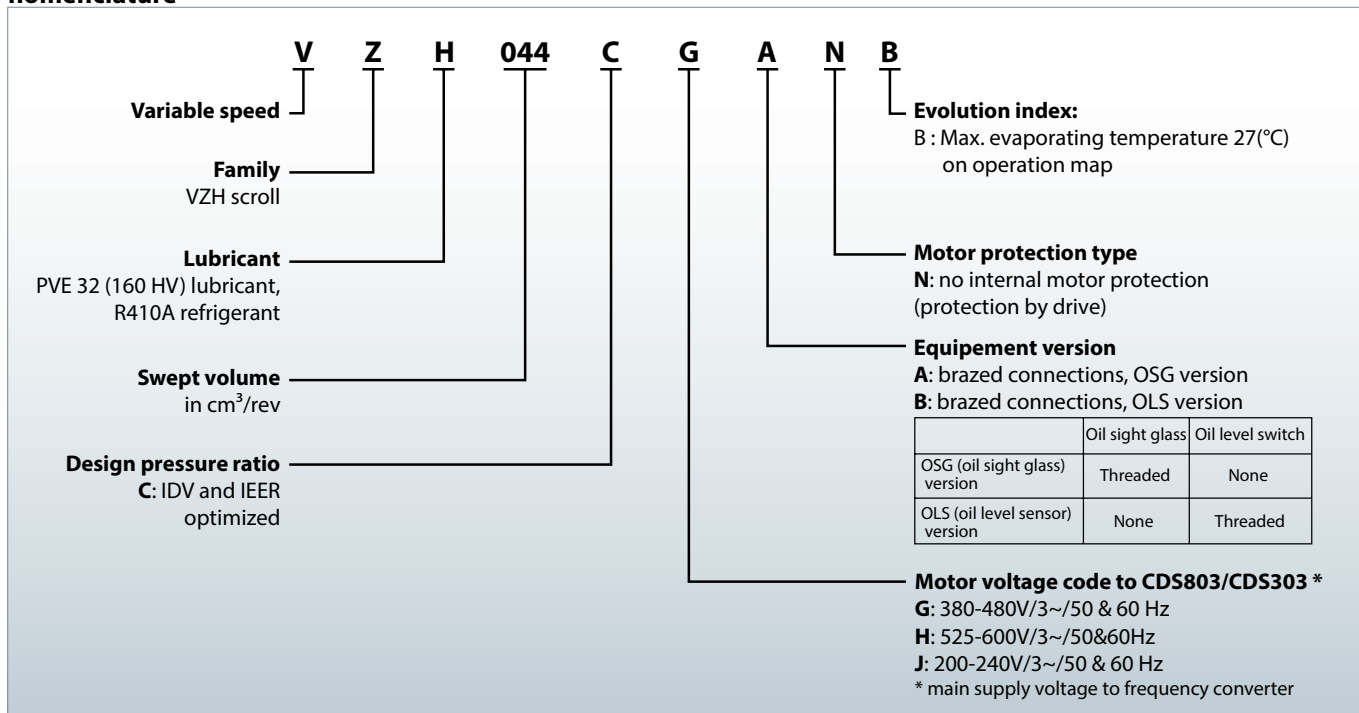
		min	max
Compressor speed	rps	15	100
	rpm	900	6000
Drive output frequency	Hz	30	200

**VLT Compressor Drives literatures**

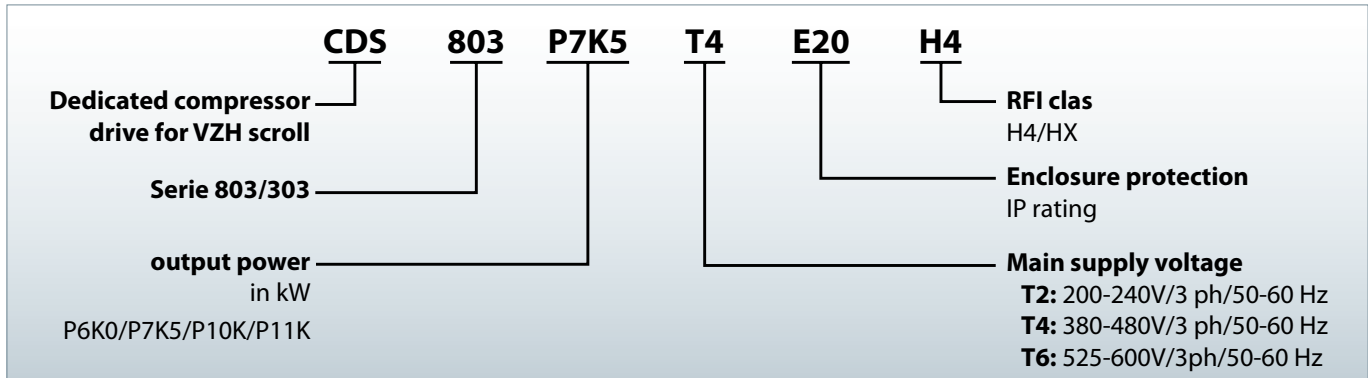
VLT Compressor Drives User's Manual ([FRCC.ES.017.A1.02](#)) introduces different VLT

Compressor Drives literatures: Operating instructions, MCT 10 set-up, Modbus RTU instructions, VLT drawings, etc..

**Compressor nomenclature**



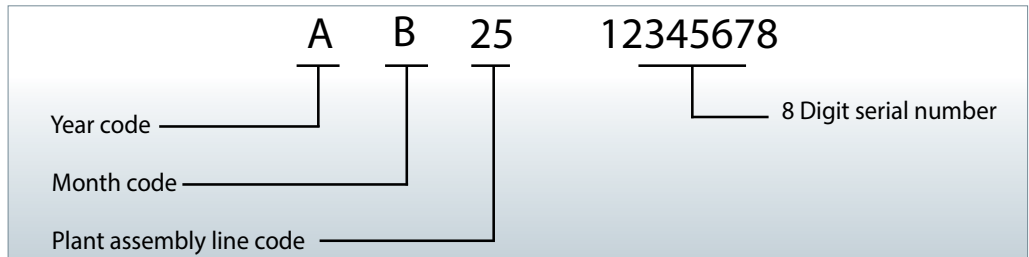
Frequency converter nomenclature



Label



Serial number





**Compressor specifications**

Compressor model	Swept volume (cm <sup>3</sup> /rev)	Displacement				Oil charge (Liters)	Net weight (kg)
		15 rps (m <sup>3</sup> /h)	50 rps (m <sup>3</sup> /h)	60 rps (m <sup>3</sup> /h)	100 rps (m <sup>3</sup> /h)		
VZH028	27.8	1.5	5.0	6.0	10.0	1.3	26
VZH035	34.9	1.9	6.3	7.5	12.6	1.3	27
VZH044	44.5	2.4	8.0	9.6	16.0	1.3	27

**Frequency converter specifications**

Mains supply voltage	CDS803-T2: 200 - 240 V +/-10% (3-phase)
	CDS803-T4: 380 - 480 V +/-10% (3-phase)
	CDS303-T6: 525 - 600V +/-10% (3-phase)
Supply frequency	50 / 60 Hz
Output voltage	0 - 100 % of supply voltage
Standby power	T2: P6K0/P7K5: 23.17W      P10K: 26.23W T4: P6K0/P7K5: 11.3W      P10K: 25.5W T6: P7K5: 17W                  P11K: 29kW
Inputs	CDS803: 4 digital (0 - 24 V), 2 analog (0 /±10 V or 4 - 20 mA, scalable) CDS303: 6 digital (0-24V), 2 analog (0/+ -10V or 4-20mA, scalable)
Programmable outputs	CDS803: 2 digital (0- 24 V), 2 analog (0-24 V), 2 relay CDS303: 2 digital(0-24V), 1 analogue(0-24V), 2 relay
Protection functions	Over-current protection, low / high current handling
Compressor functions	Pressostat / thermostat function (CDS303 only), short cycle protection, oil return management

**Oil return management**

Oil return management function only works under auto mode: After running at low rpm (less than 40 rps) for 120 minutes, the internal lubrication algorithm in the drive will accelerate the compressor speed to 60 rps or above for 60 seconds to ensure sufficient lubrication of compressor moving parts.

**Warning:**

This function is enabled by parameter 28-10 as default setting. Please notice when hands on mode is selected, oil return management will

not work even if parameter 28-10 (oil return management) is set to on. If compressors run below 40 rps for more than 120 minutes, oil return fault alarm (A208) will report on LCP and stop the compressor. Please select hands on mode carefully and only select hands on mode if the OEM has implemented oil return management in the system controller and qualified oil management. Under such conditions, the compressor could run below 40 rps continually and meanwhile disable drive oil return management 28-10.

**Bearings lubrication**

A specific oil pump ensures optimal bearing lubrication at all compressor speeds. The specific oil pump provides sufficient bearing lubrication

at low speeds as well as to avoid excessive Oil Circulation Ratio (OCR) at high speeds.





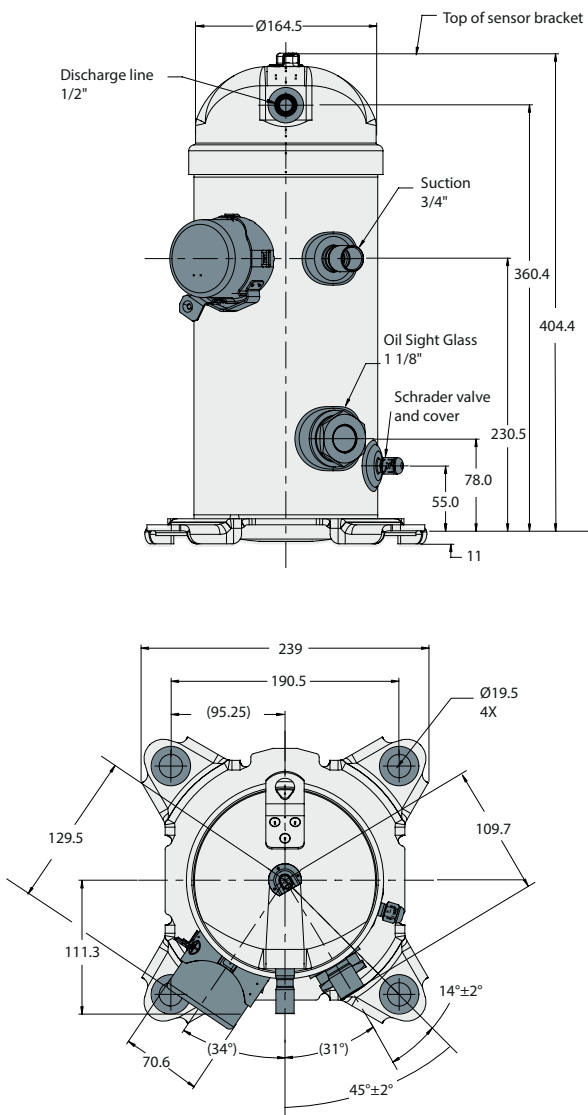




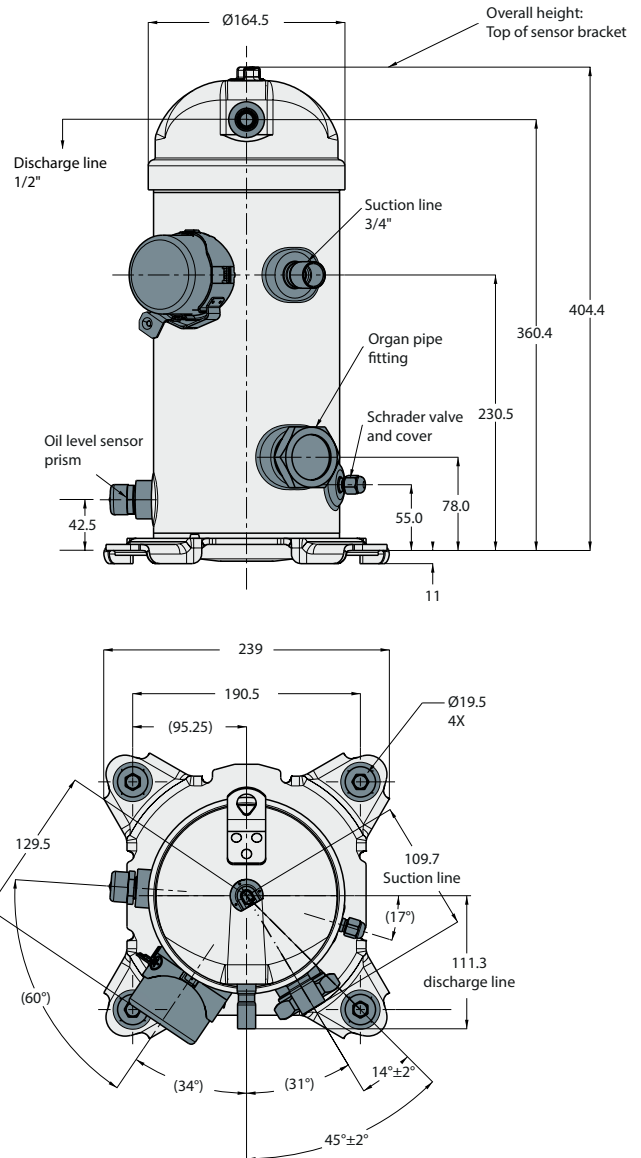




**VZH028-035-044G/J/H**  
OSG version



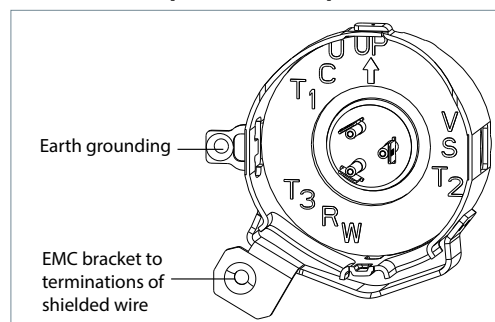
**VZH028-035-044G/J**  
OLS version



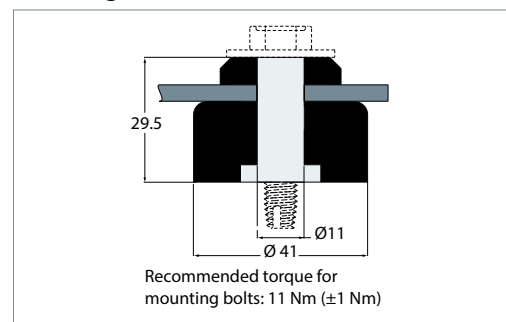
Note: Manifolding drawing is preliminary version

All dimensions in mm

**Terminal box (quick connect spade terminals)**



**Mounting Grommet**





**Sight glass / Oil level sensor**

VZH compressors OSG versions come equipped with a threaded oil sight glass with 1"1/8 – 18 UNEF connection. It can be used for a visual check of oil amount and condition.

VZH oil level sensor version compressors come equipped with a screw-in optical part on oil level switch port located below the electrical box.

**Schrader**

The oil fill connection and gauge port is a 1/4" male flare connector incorporating a schrader valve.

**Suction & discharge connections**

VZH compressors are all delivered with suction and discharge brazed connections only. They are copper-plated steel connections.

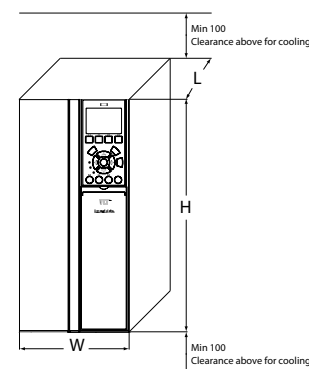
	Suction	Discharge
VZH028-035-044	3/4"	1/2"

Rotolock adaptors are available, refer to the "Accessories" section.

Compressor models	Brazed connection size		Rotolock adaptor set (①adaptor, ②gasket, ③sleeve, ④nut)			Rotolock adaptor (① adaptor only)
			Rotolock	Solder sleeve ODF	Code Number	Code Number
VZH028-044	Suction	3/4"	1-1/4"	3/4"	120Z0126	120Z0366
	Discharge	1/2"	1"	1/2"		120Z0365

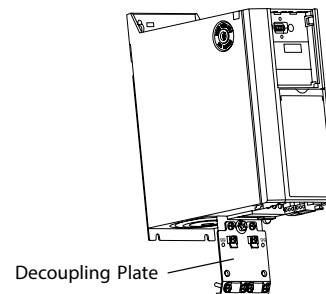
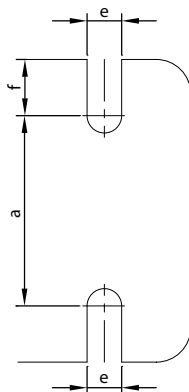
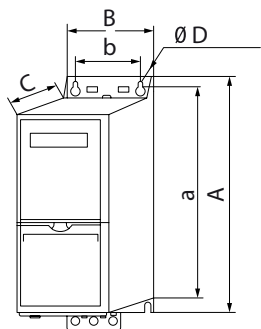

**Frequency converter dimensions**

Frequency converter dimensions depend on supply voltage, IP rating and power. The table below gives an overview of the overall dimensions and different drive enclosures (H3, H4, H5, A3 and B3). Details for each drive enclosure are on the following pages.



Drive supply voltage	Drive power kW	Compressor voltage code	Compressor model	IP20			
				Drive enclosure	Overall drive size (H x W x L) mm	Overall drive size (H x W x L) mm incl. decoupling plate	Clearance above/below (mm/inch)
T2: 200-240/3/50-60	6	J	VZH028	H4	296x135x241	359x135x241	100/4
	7.5		VZH035	H4	296x135x241	359x135x241	100/4
	10		VZH044	H5	334x150x255	402x150x255	100/4
T4: 380-480/3/50-60	6	G	VZH028	H3	255x100x206	329x100x206	100/4
	7.5		VZH035	H3	255x100x206	329x100x206	100/4
	10		VZH044	H4	296x135x241	359x135x241	100/4
T6: 525-600/3/50-60	7.5	H	VZH028	A3	268x130x205	374x130x205	100/4
	11		VZH035	B3	399x165x249	420x165x249	100/4
	11		VZH044	B3	399x165x249	420x165x249	100/4

CDS803 frequency converter



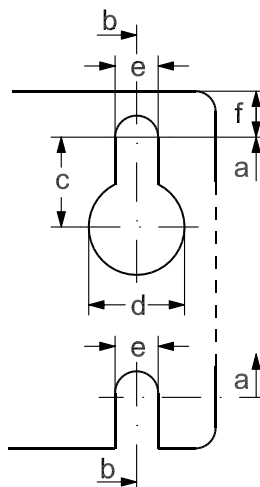
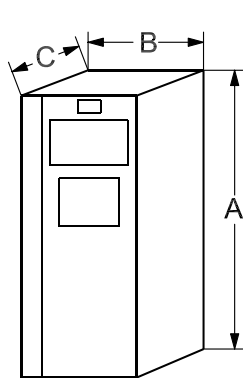
Decoupling Plate Illustration

Enclosure		Height (mm)			Width (mm)		Depth (mm)	Mounting hole (mm)			Max. Weight
Frame	IP Class	A	A <sup>1)</sup>	a	B	b	C	d	e	f	kg
H3	IP20	255	329	240	100	74	206	11	5.5	8.1	4.5
H4	IP20	296	359	275	135	105	241	12.6	7	8.4	7.9
H5	IP20	334	402	314	150	120	255	12.6	7	8.5	9.5

A<sup>1)</sup>Including decoupling plate.

The dimensions are only for the physical units, but when installing in an application it is necessary to add space for free air passage both above and below the units. The amount of space for free air passage is listed in "frequency converter dimensions - Clearance above/below (mm/inch)".

CDS303 frequency converter



Enclosure		Height (mm)			Width (mm)		Depth (mm)	Mounting hole (mm)			Max. Weight
Frame	IP Class	A	A <sup>1)</sup>	a	B	b	C	d	e	f	kg
A3	IP20	268	374	257	130	110	205	11	5.5	9	6.6
B3	IP20	399	420	380	165	140	249	12	6.8	7.9	12

A<sup>1)</sup>Including decoupling plate.

The dimensions are only for the physical units, but when installing in an application it is necessary to add space for free air passage both above and below the units. The amount of space for free air passage is listed in "frequency converter dimensions - Clearance above/below (mm/inch)".

**Supply voltage**

Because VZH compressors are powered by a frequency converter, the mains frequency, 50 or 60 Hz, is no longer an issue. Only the mains voltage is to be taken into account. With 3 motor voltage codes, the most common mains voltages and frequencies are covered. Never connect the VZH compressor directly to the mains power supply in the case motor burns out.

Voltage code	Mains voltage range of drive
J	200-240 V / 3 ph / 50 Hz & 200-240 V / 3 ph / 60 Hz (±10%)
G	380-480 V / 3 ph / 50 Hz & 380-480 V / 3 ph / 60 Hz (±10%)
H	525-600 V / 3ph / 50Hz & 525-600 V / 3ph / 60Hz (±10%)

**Compressor electrical specifications**

Compressor rated voltage (V)	Model	RW(Ω) at 20°C line to line	RLA (A)	Max Operating Current (A)
414 V max.	VZH044CG /VZH044CH	0.708±7%	15.5	17.8
	VZH035CG /VZH035CH		12.4	14.3
	VZH028CG /VZH028CH		10.3	11.8
210 V max.	VZH044CJ	0.185±7%	33.3	36
	VZH035CJ		26.6	30.6
	VZH028CJ		22.0	25.3

RW: Winding resistance per winding, measured at motor terminals  
 RLA: Rated load Amp

**RLA (Rated Load Amp)**

Rated Load Amp value is the current value at maximum load, in the operating envelope, and

at maximum speed and maximum drive input voltage.

**MOC (Max Operating Current)**

Max operating current is the maximum continuous current which is 115% (VZH044-J is

108%) of RLA. This value is printed on compressor nameplate.

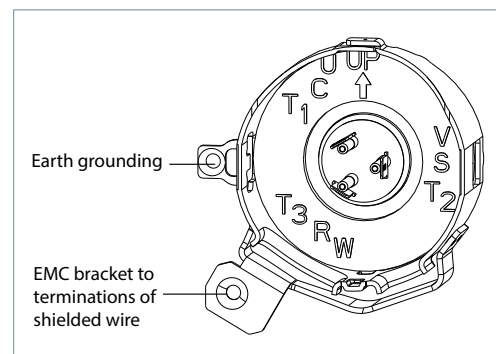
**Wiring connections**

VZH scroll compressors will only compress gas while rotating counter-clockwise (when viewed from the top of the compressor).

The drawing shows electrical terminal labeling and should be used as a reference when wiring the compressor.

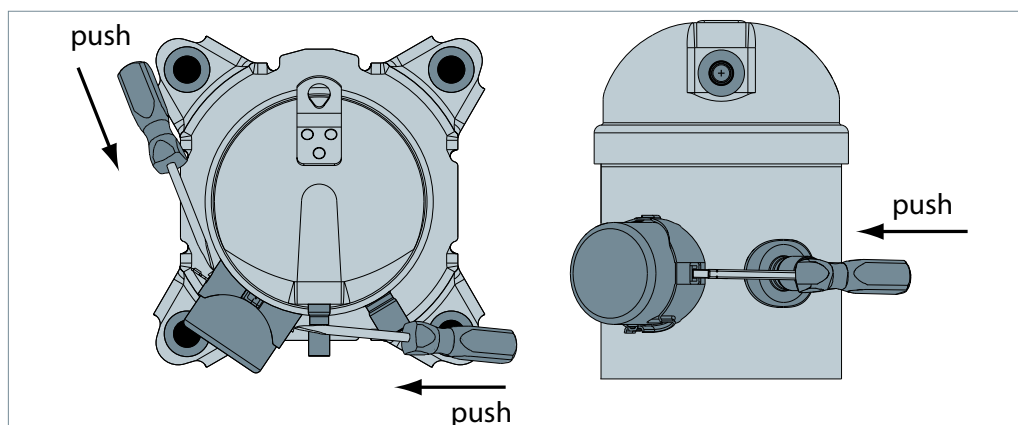
U, V & W of the drive and the compressor must be connected accordingly.

For use of EMC bracket with shielded cable, it is recommended to have a thread cutting screw (#10-32) having a torque of 3NM.


**Terminal cover mounting**

The terminal cover and gasket should be installed prior to operation of the compressor. The terminal cover has two outside tabs, 180 degrees apart,

that engage the terminal fence. When installing the cover, check that it is not pinching the lead wires.

**Terminal cover removal**


**Fuses**

Danfoss recommends using the fuses listed below to protect service personnel and property in case of component break-down in the frequency converter.

For circuit breakers, Moeller types have been tested and are recommended. Other types of circuit breakers may be used provided they limit the energy to a level equal to or lower than the Moeller types.

CDS 803	UL Compliant fuses					Recommended circuit breaker
	UL				Non UL	IP20
	Bussmann	Bussmann	Bussmann	Bussmann	Max fuse	Moeller type
	Type RK5	Type RK1	Type J	Type T	Type G	
<b>3x200-240 V IP20</b>						
4 TR/VZH028	FRS-R-50	KTN-R50	JKS-50	JJN-50	50	PKZM4-50
5 TR/VZH035	FRS-R-50	KTN-R50	JKS-50	JJN-50	50	PKZM4-50
6.5 TR/VZH044	FRS-R-60	KTN-R60	JKS-60	JJN-60	60	PKZM4-63
<b>3x380-480 V IP20</b>						
4 TR/VZH028	FRS-R-25	KTS-R25	JKS-25	JJS-25	25	PKZM4-25
5 TR/VZH035	FRS-R-25	KTS-R25	JKS-25	JJS-25	25	PKZM4-25
6.5 TR/VZH044	FRS-R-30	KTS-R30	JKS-30	JJS-30	30	PKZM4-36

CDS 303	EN50178 Compliant fuses		UL Compliant fuses						Recommended circuit breaker	
			Bussmann			SIBA	Little fuse		Moeller type	
	Size	Type	Type RK1	Type J	Type T	Type RK1	Type RK1	Type RK1		
525-600V	CDS303-7.5kW	20A	gG	KTS-R20	JKS-20	JJS-20	5017906-020	KLSR020	A6K-20R	PKZM4-50
	CDS303-11kW	30A	gG	KTS-R30	JKS-30	JJS-30	5017906-030	KLSR030	A6K-30R	PKZM4-50

**Wire sizes**

Below table lists recommended wiring sizes for the motor compressor power supply cables. These wiring sizes are valid for a cable length up to 20m.

	From network to frequency converter			From frequency converter to compressor		
	Type	mm <sup>2</sup>	AWG	Type	mm <sup>2</sup>	AWG
200 - 240 V	CDS803-6kW(IP20)	6	10	VZH028-J	6	10
	CDS803-7.5kW(IP20)	6	10	VZH035-J	6	10
	CDS803-10kW(IP20)	6	10	VZH044-J	6	10
380 - 400 V	CDS803-6kW(IP20)	4	10	VZH028-G	4	10
	CDS803-7.5kW(IP20)	4	10	VZH035-G	4	10
	CDS803-10kW(IP20)	4	10	VZH044-G	4	10
525 - 600 V	CDS303-7.5kW(IP20)	4	10	VZH028-H	6	10
	CDS303-11kW(IP20)	4	10	VZH035-H	6	10
	CDS303-11kW(IP20)	4	10	VZH044-H	6	10

Note: 1. The wire size here is the guideline but not the actual cable required. The required cable size should be specified by the OEM depending on the unit design, ambient temperature, the wire material, current, etc.

**Wiring & EMC protection**

The motor compressor power supply from the CDS803/303 frequency converter to the VZH compressor must be done with a braided screened/shielded cable. This cable needs to have its screen/shielding conduit connected to earth on both ends. Avoid terminating this cable connection with twisting ends (pigtailed) because that would result in an antenna phenomenon and decrease the effectiveness of the cable.

Control cables to the CDS803/303 frequency converter must use the same installation principles as the motor power supply cable.

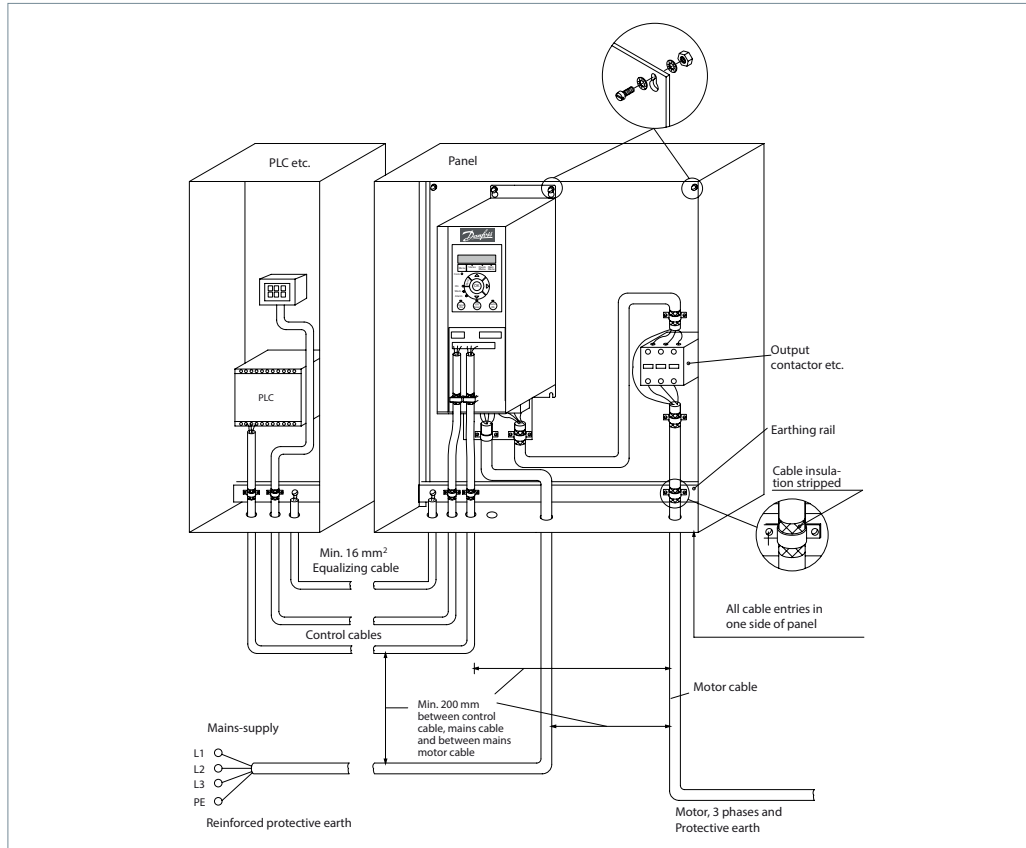
The motor compressor cable must be installed in a conduit separated from the control and mains cables.

Physical installation of the frequency converter on the mounting plate must ensure good electrical contact between the mounting plate and the metal chassis of the converter. Use star-washers and galvanically conductive installation plates to secure good electrical connections. Refer to instructions [MG18N202/MG34M402](#) for tightening torques and screw sizes.

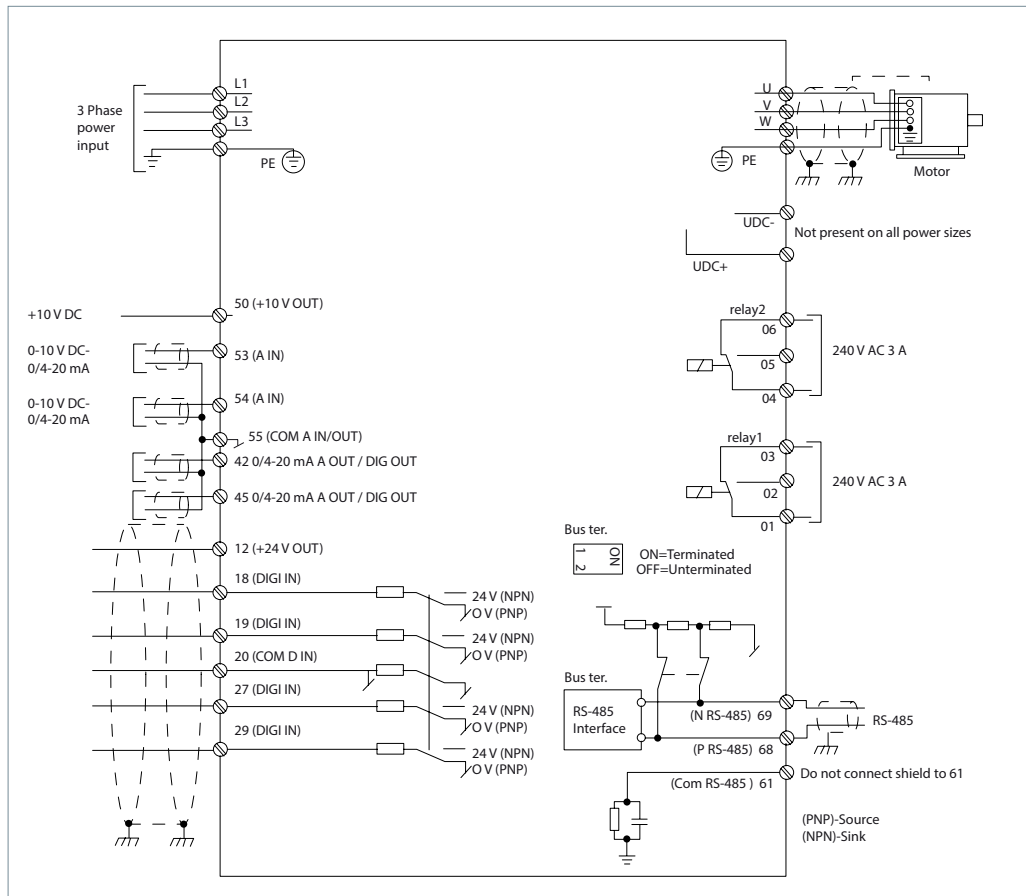
Note that the CDS803/303 must be mounted on a plain wall to ensure a good air flow through its heat exchanger.

**EMC correct installation of an IP20 frequency drive CDS803**

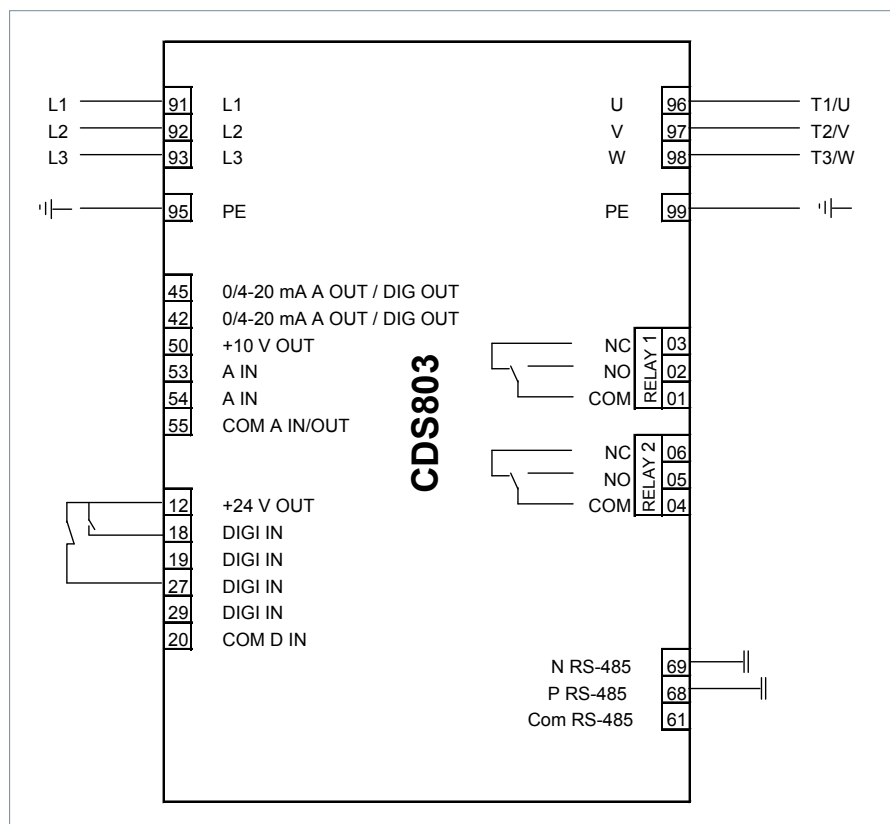
EMC qualification reports are available upon request to Danfoss technical support.



**Wiring diagram of CDS803**



**Wiring connections of CDS803**



- Legends:
- A: Analog
  - DIGI: Digital
  - IN: Input
  - OUT: Output
  - COM: Common
  - NC: Normally-closed
  - NO: Normally-open

		Open loop	Process loop
91,92,93	3 phases mains input	x	x
95	Earth	x	x
42,45	0/4-20 mA Analogue Output or Digital Output	-	-
50	+10V DC Output	-	-
53	0-10V or 4-20mA Analogue Input	x	-
54	0-10V or 4-20mA Analogue Input	-	x
55	Com Analogue In/Out	x	-
12	+24V output	-	-
18	External On/Off(NO)	x	x
19	Digital Input	-	-
27	Safety Device e.g.: HP/LP switch	x	x
29	Digital Input	-	-
20	Com Digital Input	-	-
98	To Compressor T3	x	x
97	To Compressor T2	x	x
96	To Compressor T1	x	x
99	Earth	x	x
03,02,01	Relay 1	-	-
06,05,04	Relay 2	-	-
69,68	RS485 Bus	-	-
61	RS485 Bus Com	-	-

-: Optional connection  
X: Mandatory connection

The CDS803 frequency converter is factory preset with parameters for the open loop control principle. The process loop control principle can be selected by changing parameters in the "Quick menu."

Open loop: preset on input 53

0 - 10 V control

Frequency converter in slave mode

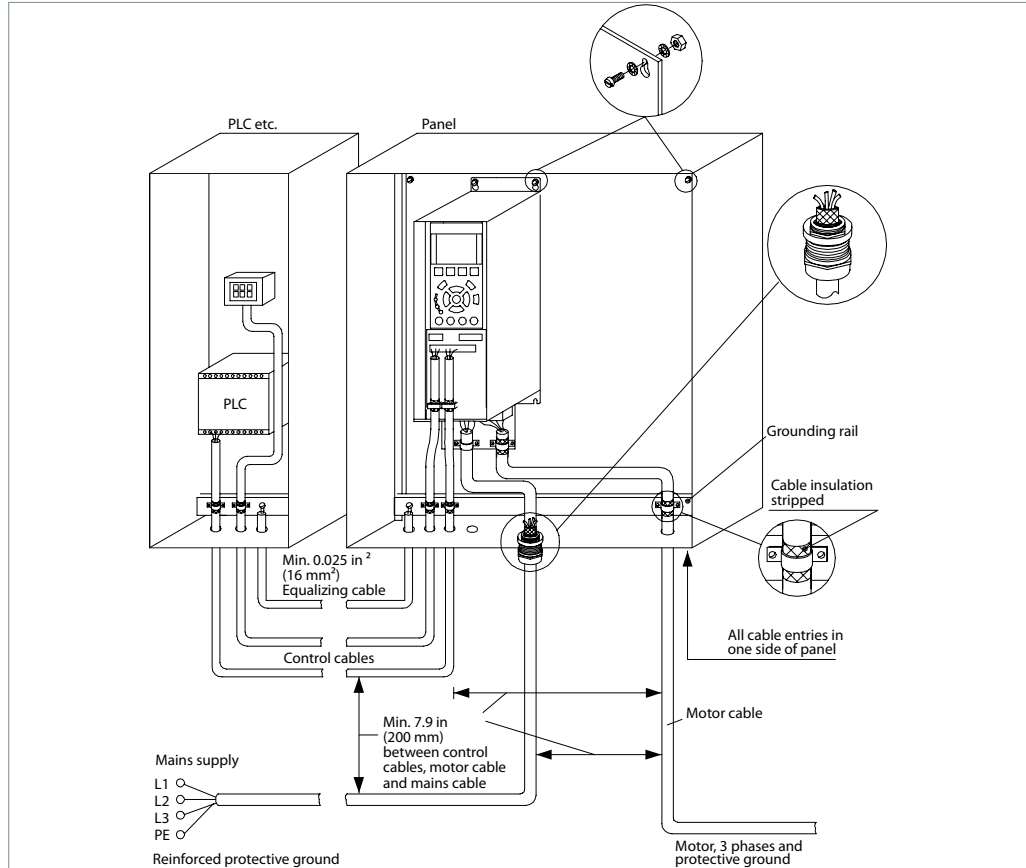
Process loop: preset on input 54

4 - 20 mA control

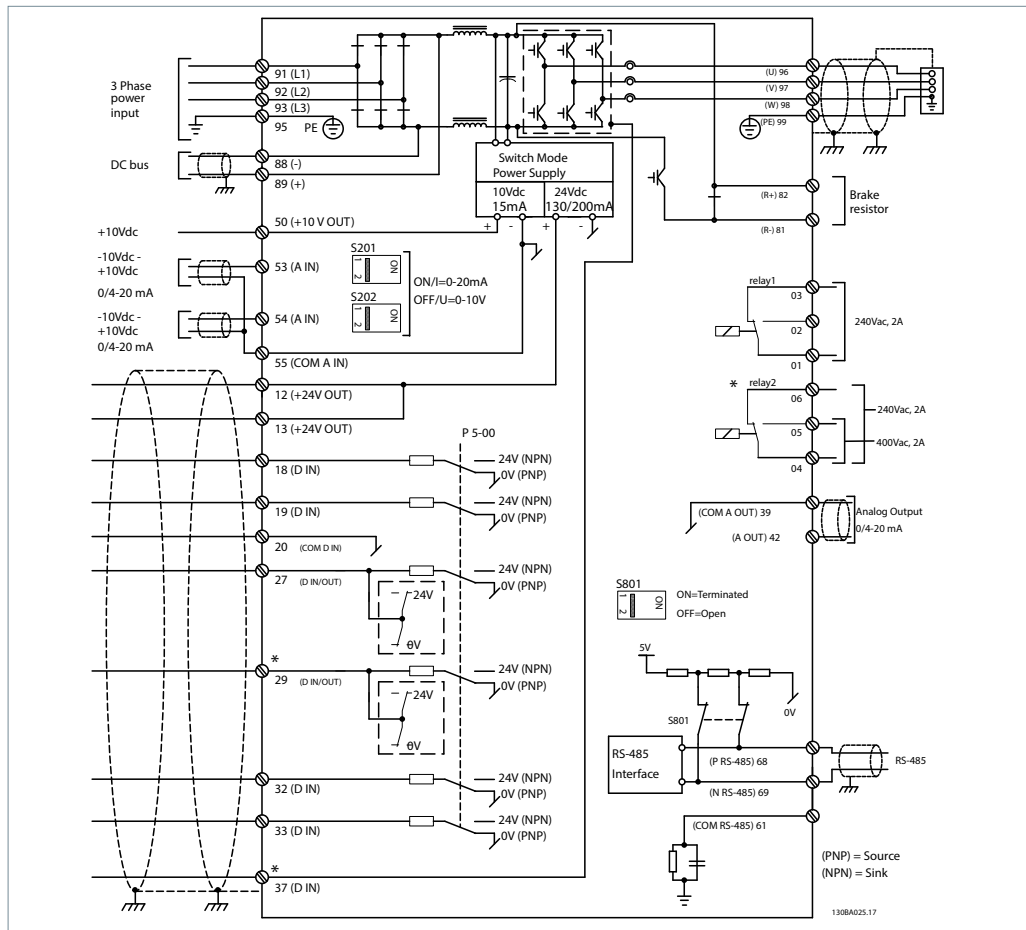
Frequency converter under own PID controller

EMC correct installation of an IP20 frequency drive CDS303

EMC qualification reports are available upon request to Danfoss technical support.

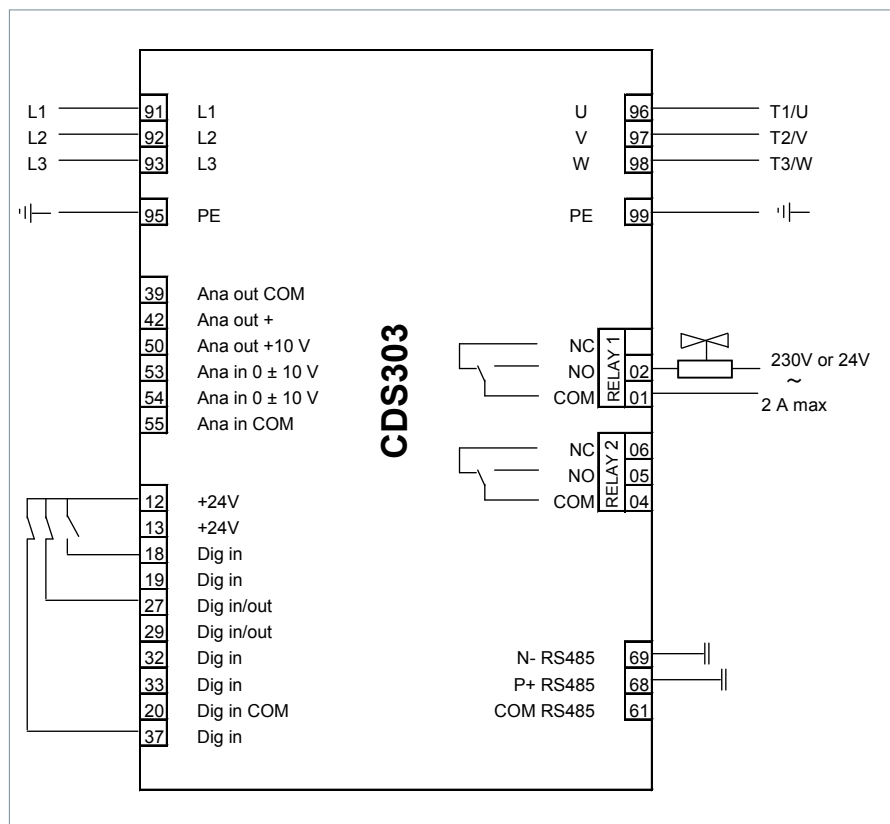


Wiring diagram of CDS303





**Wiring connections of CDS303**



- Legends:
- Ana: Analogue
  - Dig: Digital
  - in: Input
  - out: Output
  - COM: Common
  - NC: Normally-closed
  - NO: Normally-open

		Open loop	Process loop
91, 92, 93	3 Phase mains input	X	X
95	Earth	X	X
39, 42	Analogue output	-	-
50	Analogue output	-	-
53	PLC+ (0 to 10 V)	X	-
54	Sensor -	-	X
55	PLC-	X	-
12	HP/LP switch	X	X
12	External On/Off (NO)	X	X
13	Factory bridged to 37	X	X
13	Sensor +	-	X
18	External On/Off (NO)	X	X
19	Digital input	-	-
27	LP switch (NC) / safety devices	X	X
29	Digital input/output	-	-
32, 33	Digital input	-	-
20	Digital input Common	-	-
37	Factory bridged to 13 / HP switch	X	X
98	To compressor terminal T3	X	X
97	To compressor terminal T2	X	X
96	To compressor terminal T1	X	X
99	To compressor earth connection	X	X
02, 01	Relay 1 to oil solenoid valve	X	X
06, 05, 04	Relay 2	-	-
69, 68	RS485 Bus	-	-
61	RS485 Bus Common	-	-

The CDS303 frequency converter is factory preset with parameters for the open loop control principle. The process loop control principle can be selected by changing parameters in the «Quick menu».

Open loop: preset on input 53

0 - 10 V control

Frequency converter in slave mode

Process loop: preset on input 54

4 - 20 mA control

Frequency converter under own PID controller

T37 is CE and UL approved for STO, Safety Torque Function

-: Optional connection  
X: Mandatory connection

**Electrical connections**

VZH028/035/044 scroll compressors are designed to operate without any assistance.

**Soft-start control**

The CDS803/CDS303 frequency converter generates by design a compressor soft start with an default initial ramp up of 7.5s to 50 rps.

Basically seen from the mains the inrush peak reach a level which is only a few percent more than the rated nominal current.

Current inrush will not exceed the frequency converter maximum current.

**Phase sequency and reverse rotation protection**

The compressor will only operate properly in a single direction. If electrical connections are done correctly between the drive and the compressor terminals (compressor and drive terminals U, V & W matching), the drive will provide correct phase supply to the compressor, and reverse rotation will be not possible:

- CDS terminal U (96) to VZH terminal T1/U
- CDS terminal V (97) to VZH terminal T2/V
- CDS terminal W (98) to VZH terminal T3/W

discharge, and suction line warming rather than immediate cooling. The compressor can be rapidly damaged in these conditions. To protect compressors from reverse rotation, one of below actions is required:

- Use pressure sensors to monitor pressure difference between discharge and suction of the compressor, and for normal operation, discharge pressure should be at least 1 bar higher than suction pressure within 30 s running after compressor starting.

If compressor and drive U, V & W terminals are not matching, the compressor can operate in a reverse rotation. This results in excessive noise, no pressure differential between suction and

Mains connection to the CDS frequency converter order has no influence on the output phase sequence which is managed by the frequency converter.

**IP rating**

The compressor terminal box IP rating according to IEC529 is IP22.

Element	Numerals or letters	Meaning for the protection of equipment
First characteristic numeral	0	Against ingress of solid foreign objects  (non protected) ≥ 50 mm diameter ≥ 12.6 mm diameter ≥ 2.5 mm diameter ≥ 1.0 mm diameter dust protected dust tight
	1	
	2	
	3	
	4	
	5	
	6	
Second characteristic numeral	0	Agains ingress of water with harmful effects  (non protected) vertically dripping dripping (15° tilted) spraying splashing jetting powerful jetting temporary immersion continuous immersion
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	

**Motor protection**

VZH scroll compressors are not equipped with an internal motor protector. Motor protection is provided by the variable speed drive. All parameters are factory preset in order to guaranty locked rotor or overload current protection.

When a warning situation is reached in the current control, the CDS frequency converter will automatically reduce the compressor speed in order to keep the motor current of the compressor below the maximum allowed.

**Anti-reverse protection**

In some cases when compressors stop under low mass flow low speed condition, discharge valve may not seal discharge port fast enough, thus compressors may run in a reverse rotation due to the residual pressure difference and generate a big noise. Running in the wrong direction will reduce the reliability and lifetime

of the compressor. The drive shall prevent the compressors scroll set from running the wrong way during stop with anti reverse protection.

To activate the function, the customer must be able to enable and disable the ANTI-REVERSE PROTECTION.

**Temperature protection**

If the temperature in the drive is too high, an alarm (CDS303: Alarm 29, Heatsink Temp. CDS803: Alarm 69, Pwr. Card Temp) will be seen to trip the drive. When the drive shows this alarm, it's suggested that OEM controller has to

be programmed based on the reading of the heatsink temperature received from the drive to lower the load to avoid a trip-lock. Contact Danfoss for more details.

**Voltage imbalance**

The maximum allowable voltage imbalance between each phase is 3%. Voltage imbalance causes high amperage over one or several phases, which in turn leads to overheating and possible drive damage.

Mains imbalance function in CDS frequency converter can be set to "[0] Trip" or "[1] Warning"

in 14.12 parameter. It is, by default, factory preset to "[1] Warning".

Then the compressor electrical motor is never affected by main voltage imbalance situations which are made completely transparent by the frequency converter.

**Approvals and certificates**

VZH compressors comply with the following approvals and certificates.

<b>CE</b> (European Directive)		All VZH models
<b>UL</b> (Underwriters Laboratories)		All VZH models
<b>EMC</b> 2014/30/EU		VZH code G & code J
CCC		VZH code G

**Low voltage directive 2014/35/EU**

Products	VZH028-035-044
Declaration of conformity ref. Low voltage directive 2014/35/EU	Contact Danfoss

**Internal free volume**

Products	Internal free volume at LP side without oil (liter)
VZH028	3.2
VZH035	3.2
VZH044	3.2

**Application envelopes**

The operating envelopes for VZH scroll compressors are given in the figures below, where the condensing and evaporating temperatures represent the range for steady state operation. Under transient conditions, such as start-up and defrost, the compressor may operate outside this envelope for short periods.

The figures below show the operating envelopes for VZH compressors with refrigerants R410A.

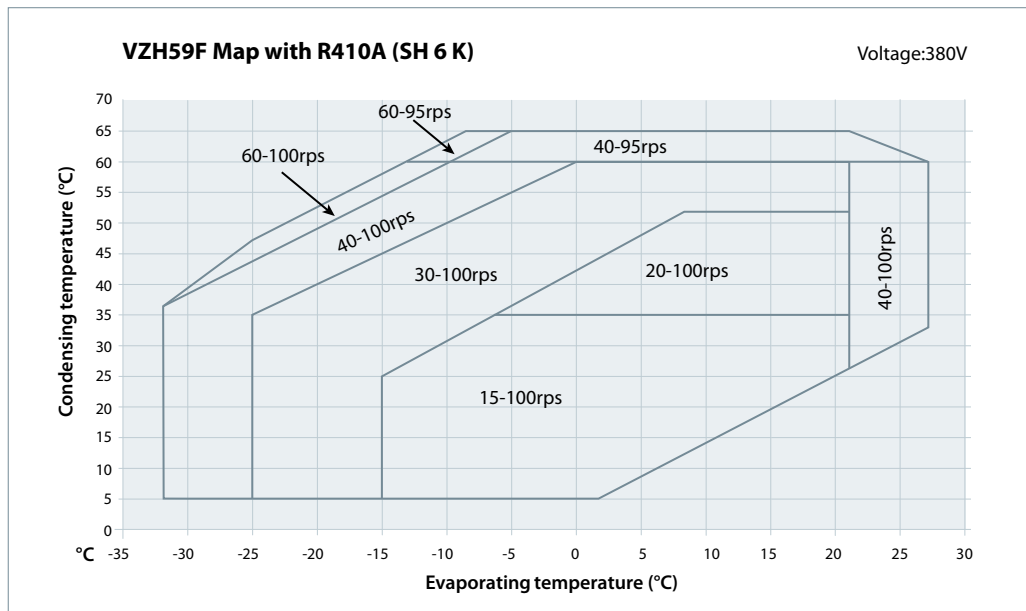
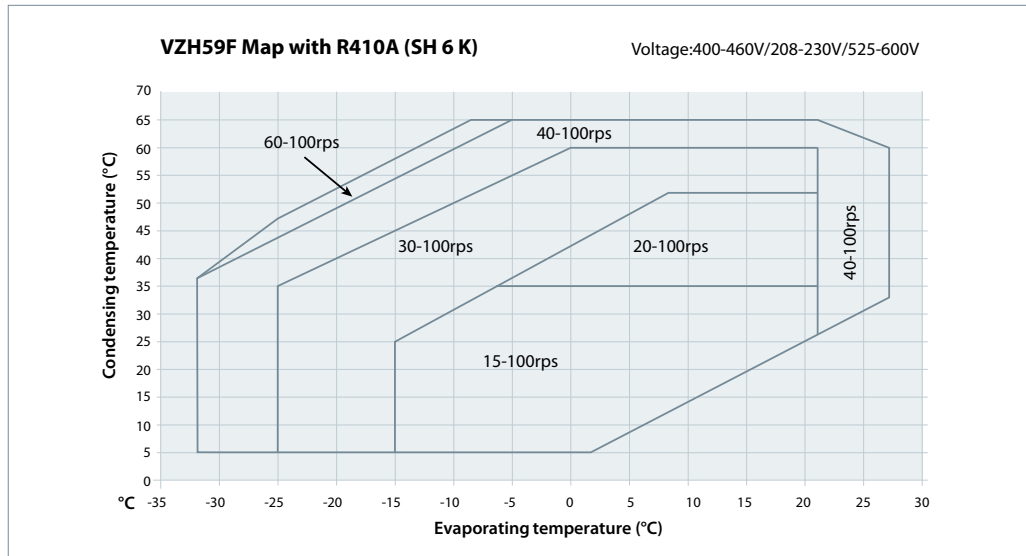
Due to bearing loads and scroll stability, there will be speed restrictions on the envelopes.

The operating limits serve to define the envelope within which reliable operation of the compressor is guaranteed:

- Maximum discharge gas temperature: +135°C.

- Minimum suction superheat should be above 5 K and minimum sump superheat should refer to the "off-cycle migration" chapter due to the risk of liquid flood back.
- Attention to suction line insulation to reduce useless superheat.
- Minimum and maximum evaporating and condensing temperatures as per the operating envelopes.
- VZH drive can only protect the compressor from over current. Customers need to have a high pressure, low pressure sensor and discharge temperature thermostat to fully protect the envelop. Since out of map running will threaten the reliability of compressor, customers must qualify map protection under all extreme conditions.

**Application envelopes for index B**



**Short cycle timer function**

Short cycle control is provided directly by the CDS frequency converter, when parameter 28-00 is enabled.

The function is factory set to enabled, with minimum running time to 60 seconds and the interval between starts to 300 seconds.

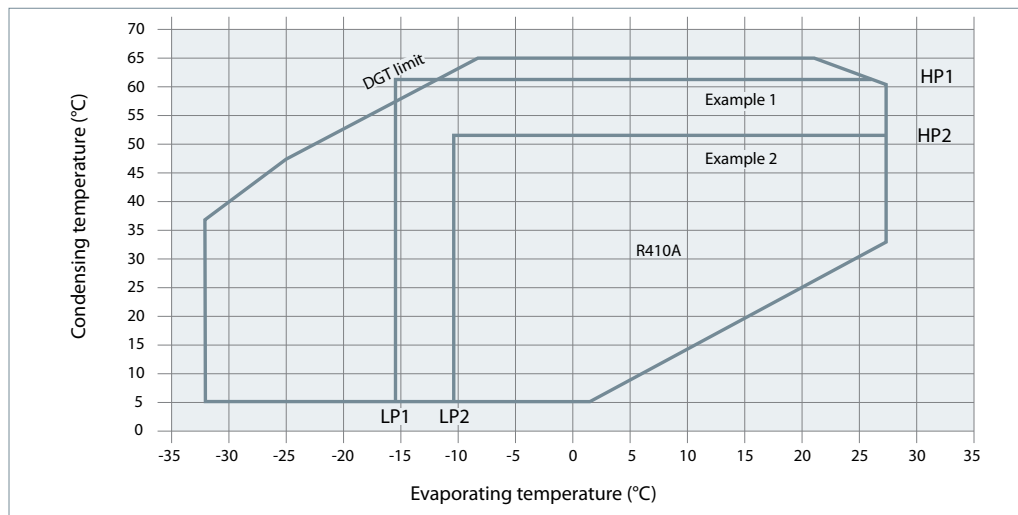
Short cycle settings are accessible in the parameter 28.0x list, in the “compressor functions” menu.

If system is fully controlled by an external main controller, it is recommended to limit the start/stop frequency to 12 times per hour.

**Discharge gas thermostat**

Discharge gas temperature (DGT) protection is required if the high and low pressure switch settings do not protect the compressor against operations beyond its specific application envelope. Please refer to the examples below,

which illustrate where DGT protection is required (Ex. 1) and where it is not (Ex. 2). Please notice the envelope boundaries change based on different speed limits.



**Example 1** (R410A, SH = 6 K)  
 LP switch setting:  
 LP1 = 3.3 bar (g) (-15.5°C)  
 HP switch setting:  
 HP1 = 38 bar (g) (62°C)  
 Risk of operation beyond the application envelope.  
 DGT protection required.

**Example 2** (R410A, SH = 6 K)  
 LP switch setting:  
 LP2 = 4.6 bar (g) (-10.5°C)  
 HP switch setting:  
 HP2 = 31 bar (g) (52°C)  
 No risk of operation beyond the application envelope.  
 No DGT protection required.

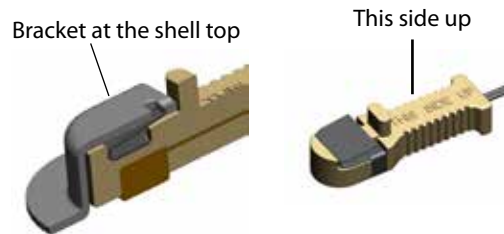
The discharge gas temperature must not exceed 135°C.

A discharge gas temperature protection device must be installed on all heat pumps. In reversible air-to-air and air-to-water heat pumps, the discharge temperature must be monitored during development test by the equipment manufacturer.

The compressor must not be allowed to cycle on the discharge gas thermostat. Continuous operations beyond the compressor’s operating range will cause serious damage to the compressor.

VZH028-044 can install a discharge sensor/ dome sensor at the top of shell through a bracket and the sensor has to be connected and

controlled by OEM controller. By installing it at the top of shell, the discharge sensor can monitor discharge temperature and work with OEM controller to limit discharge temperature within 135°C. A customer might select NTC thermistor, 10KOhm@25°C type from “TOD Company” and this type of sensor could be fit into VZH top shell directly. The thermostat could also be attached to the discharge line within 150 mm from the compressor discharge port and must be thermally insulated and tightly fixed to the pipe.



**Oil return management function (single compressor)**

An insufficient oil level can be the result of oil depositing itself in pipes and heat exchangers or low velocity of compressors. The oil return management could be achieved by increasing velocity for short periods, at regular time intervals.

CDS integrates oil return management function together with compressor internal lubrication protection.

Internal lubrication protection: If compressor runs below 40 rps (ORM Min Speed Limit, 28-15) for more than 120 minutes (low speed running time, 28-11), then CDS internal lubrication function will accelerate compressor speed to 60 rps (minimum ORM Boost Speed, 28-17) for 1 minute (minimum duration, includes ramp up time, 28-13) to guarantee compressor inner parts get lubricated. In case slow acceleration condition, please make sure compressor maintain minimum speed 40 rps (80Hz) for at least 1 minute running.

Oil return function: To double ensure well lubrication, compressor speed will boost to 60 rps (minimum ORM Boost Speed, 28-17) at a fixed time intervals (as programmed in parameter 28-12, default 24 hrs) any way. OEM could set 28-17 to a higher speed, such as 70 rps to secure oil management

According to different application requirements, OEM can either add oil separator (including to add more oil in the system) or adjust oil return parameters or might need both actions to keep oil safety for compressor.

Oil management related parameters, 28-11, 28-12, 28-13, 28-15 (CDS303 only), 28-17 (CDS303 only) could also be programmed by OEM.

**Considering oil return risk, a split system with more than 10 m piping length requires mandatory application approval by Danfoss application specialists.**

ID	Name	Factory setup	Unit
2810	Oil return management	ON	
2811	Low speed running time	120	min
2812	Fixed boost interval	24	h
2813	Boost duration	60	s
2815	ORM min speed limit	80	Hz
2817	ORM boost speed (Hz)	120	Hz

**High and low pressure protection**
**High pressure**

According to EN378-2, a high-pressure (HP) safety switch is required to shut down the compressor. The high-pressure switch can be set to lower values depending on the application and ambient conditions. The HP switch must either be placed in a lockout circuit or consist of a manual reset device to prevent cycling around the high-pressure limit. If a discharge valve is used, the HP switch must be connected to the service valve gauge port, which must not be isolated. The HP switch can be connected to the CDS803 input 27/ CDS303 input 37 or an external contactor which could be set before or after the drive.

Please note port 27 of CDS803 is not UL certificated and when connected with high pressure switch, no delay is permitted. OEM need to set port 27 to "coast reverse/coast and reset inverse" to get rid of minimum running time restriction.

For CDS303, port 37 is CE and UL approved for safety torque function.

If the contactor is placed between the drive and compressor, to make sure a proper start up, the contactor must be power on ahead of the drive gets fed at least 3 seconds earlier.

When the contactor acts as a high pressure switch, it has to be normally close switch. The contactor will only open when high pressure triggers or power off.

In case of HP cut out, the output contactor will open while compressor is running, thus a Motor Phase Loss alarm will occur.



**Low pressure**

A low-pressure (LP) safety switch must be used. Deep vacuum operations of a scroll compressor can cause internal electrical arcing and scroll instability. VZH compressors exhibit high volumetric efficiency and may draw very low vacuum levels, which could induce such a problem. The minimum low-pressure safety switch (loss-of-charge safety switch) setting is given in the following table. For systems without pump-down, the LP safety switch must either be a manual lockout device or an automatic switch wired into an electrical lockout circuit. The LP switch tolerance must not allow for vacuum

operations of the compressor. LP switch settings for pump-down cycles with automatic reset are also listed in the table below. The lock-out circuit or LP switch or series with other safety devices could be connected to CDS803/CDS303 input 27. The low pressure switch must have the highest priority that shall not be by passed. It means when low pressure switch is activated, compressor minimum running time should not work. OEM need to set port 27 to “coast reverse/coast and reset inverse” to get rid of minimum running time restriction.

**Pressure settings**

Pressure settings		R410A
Working pressure range high side	bar (g)	8.3 - 41.1 bar
Working pressure range low side	bar (g)	1.5-13.9 bar / 1.5-16.6 bar***
Maximum high pressure safety switch setting	bar (g)	43.75
Minimum low pressure safety switch setting *	bar (g)	1.0
Minimum low pressure pump-down switch setting **	bar (g)	1.18

\* LP safety switch shall never be bypassed.

\*\* Recommended pump-down switch settings: 2.2 bar below nominal evaporating temperature with minimum of 1.18

\*\*\*Only for index B

**Electronic expansion valve**

With variable capacity systems, an electronic expansion valve (EXV) is the strongly recommended solution to handle refrigerant mass flow variations. Danfoss recommends the use of ETS products. Ramp-up and ramp-down settings, of both EXV and compressor, must be done with great care.

compressor. The EXV can also be opened, up to a certain degree, before the start up of the compressor.

Ramp-down of the EXV must be longer than the ramp-down of the compressor, also to avoid low pressure operation (except with pump-down).

Ramp-up of the EXV must be shorter than the ramp-up of the compressor, to avoid any low pressure operation on suction side of the

EXV should be closed, and remain closed, when the compressor is off, to avoid any liquid refrigerant entering the compressor.

**Crankcase heating function**

There is no crankcase heating function in CDS drives for VZH028-035-044. An external crankcase

heater is required. Refer to accessory list for code numbers.

**Essential piping design considerations**

The working pressure in systems with R410A is about 60% higher than in systems with R22 or R407C. Consequently, all system components and piping must be designed for this higher pressure level.

Proper piping practices should be employed to ensure adequate oil return, even under minimum load conditions with special consideration given to the size and slope of the tubing coming from the evaporator. Tubing returns from the evaporator should be designed so as not to trap oil and to prevent oil and refrigerant migration back to the compressor during off-cycles. In systems with R410A, the refrigerant mass flow will be lower compared to R22/R407C systems. To maintain acceptable pressure drops and acceptable minimum gas velocities,

the refrigerant piping must be reduced in size compared to R22 / R407C systems. Take care also to not create overly high pressure drops as in R410A systems the negative impact of high pressure drops on the system efficiency is stronger than in R22/R407C systems.

The design in this guideline is for short circuit application. However, for long circuit and split system application, an oil separator and an external non-return valve are recommended for use based on system qualification status. CDS frequency converter integrates a special feature in the compressor functions in order to improve and secure the oil recovery from the system. Refer to "Oil Return Management" section.

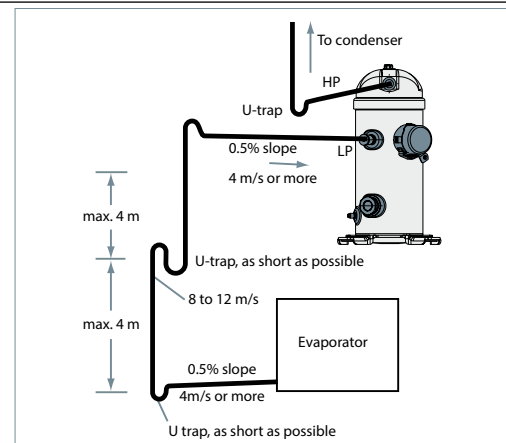
Piping should be designed with adequate three-dimensional flexibility. It should not be in contact with the surrounding structure, unless a proper tubing mount has been installed. This protection proves necessary to avoid excess vibration, which can ultimately result in connection or tube failure due to fatigue or wear

from abrasion. Aside from tubing and connection damage, excess vibration may also transmitted to the surrounding structure and generate an unacceptable noise level within that structure. For more information on noise and vibration, see "Sound and Vibration Management" section.

**Suction lines**

If the evaporator lies above the compressor, as is often the case in split or remote condenser systems, the addition of a pump-down cycle is strongly recommended. If a pump-down cycle were to be omitted, the suction line must have a loop at the evaporator outlet to prevent refrigerant from draining into the compressor during off-cycles.

If the evaporator were situated below the compressor, the suction riser must be trapped so as to prevent liquid refrigerant from collecting at the outlet of the evaporator while the system is idle, which would mislead the expansion valve's sensor (thermal bulb) at start-up.



**Discharge lines**

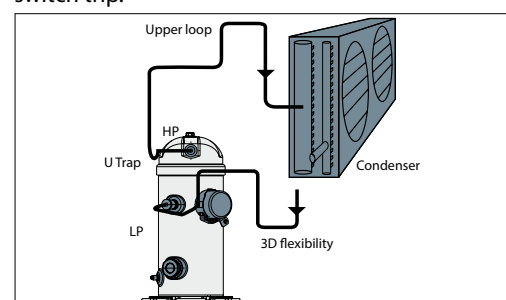
When the condenser is mounted at a higher position than the compressor, a suitably sized U-shaped trap close to the compressor is necessary to prevent oil leaving the compressor from draining back to the discharge side of the compressor during off cycle. The upper loop also helps avoid condensed liquid refrigerant from draining back to the compressor when stopped. For inverter applications with long lines we recommend the use of an oil separator even if it is only the condenser which is far away from the unit.

Piping must also be designed with care in order to make sure the remaining oil not trapped by the oil separator is properly carried over the system.

Basic principal is shown here. Note that for the discharge line, following the same principle as for the suction line with a U-trap every 4 m

must be applied between discharge U-trap and upper U-trap where the condenser is above the compressor unit.

We also recommend installing one check valve on the discharge line to the condenser next to the condenser to avoid the possibility of having the discharge tube full of liquid during off cycles; discharge lines flooded by liquid which may create start-up issues by drive over-torque or HP switch trip.



**Oil management**

Especially for split systems using variable speed compressor, in which every installation is unique and qualification of individual installations is not practical, Danfoss requires that OEMs install an oil separator (OS).

The requirement of an oil separator is also suitable for any other system with complex piping (long line set, U trap), multiple heat exchangers and elevation changes.

Many oil separator designs exist, the selection, requirements and recommendations of the oil Separator manufacturer should be followed.

Please note that Oil Separators are not 100% efficient and the OS efficiency will vary with different compressor running speeds. Customers should select the OS at the normal operating point at low speed.

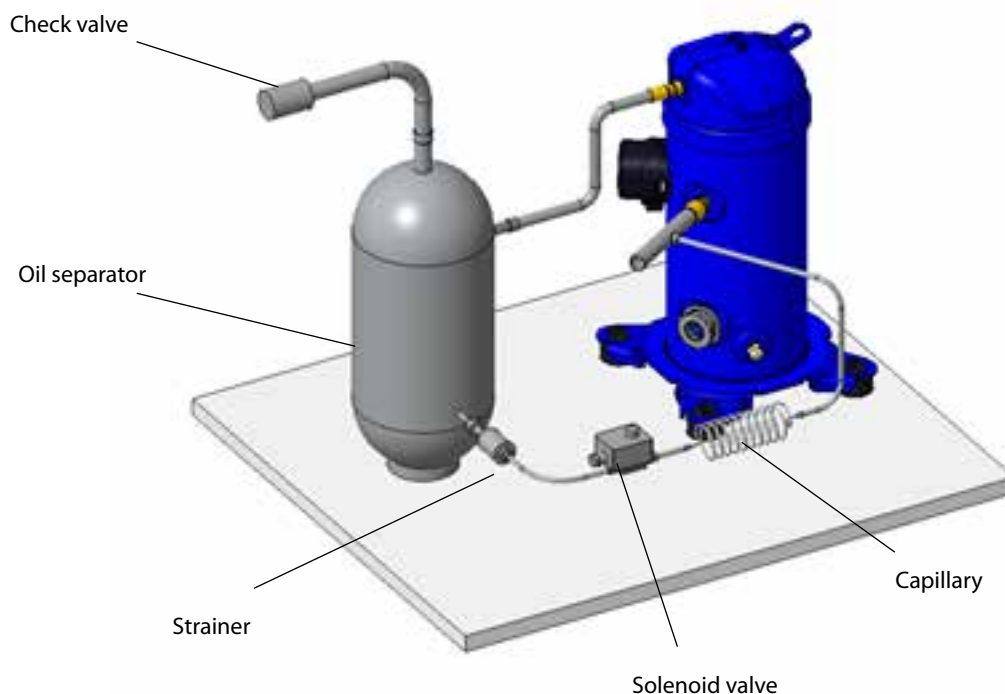
When oil separators are installed, OEM customers need to evaluate the system performance efficiency at key rating speeds to consider the flow loss impact with the selected OS.

Danfoss recommends customers to use cyclonic oil separators. The following principles are recommended:

- OEM should select a common low speed running point to evaluate OS max efficiency.
- Qualify oil management reliability at maximum and minimum mass flow conditions in the operating envelope with the OS selected
- Evaluate system efficiency at all rating conditions to consider flow loss impact from the OS

For VZH028-035-044, the Schrader valve connection is close to the internal oil pump. To avoid reliability risks, please connect the OS to the compressor suction tube. Never return oil to the Schrader valve in order to avoid a potential negative impact on reliability, such as oil turbulence to the oil pump, etc..

For an illustration for OS connections to the compressor, please refer as below:



**Heat exchangers**

To obtain optimum efficiency of the complete refrigerant system, optimized R410A heat exchangers must be used. R410A refrigerant has good heat transfer properties: it is worthwhile designing specific heat exchangers to gain in size and efficiency.

An evaporator with an optimized R410A distributor and circuit will give correct superheat at outlet and optimal use of the exchange surface. This is critical for plate evaporators that generally have a shorter circuit and a lower volume than shell & tubes and air cooled coils.

For all evaporator types, special care is required for superheat control leaving the evaporator and oil return.

A sub-cooler circuit in the condenser that creates high sub-cooling will increase efficiency at high condensing pressure. In R410A systems the positive effect of sub-cooling on system efficiency will be significantly larger than in R22/R407C systems.

Furthermore, for good operation of the expansion device and to maintain good efficiency in the evaporator it is important to have an adequate liquid sub-cooling. Without adequate sub-cooling, flash gas will be formed at the expansion device resulting in a high degree of vapor at the evaporator inlet leading to low efficiency.

**Refrigerant charge limits**

VZH compressors can tolerate liquid refrigerant up to a certain extend without major problems. However, excessive liquid refrigerant in the compressor is always unfavorable for service life. Besides, the installation cooling capacity may be reduced because of the evaporation taking place in the compressor and/or the suction line instead of the evaporator. System design must be such that the amount of liquid refrigerant in the compressor is limited. In this respect, follow the guidelines given in the section: "Essential piping design recommendations" as a priority.

If the refrigerant charge exceeds the values in table below, a suction line accumulator is strongly recommended.

Model	Refrigerant charge limit (kg)
VZH028-044	3.6

More detailed information can be found in the paragraphs hereafter. Please contact Danfoss technical support for any deviation from these guidelines.

**Off-cycle migration**

Liquid refrigerant can find its way into the compressor by means of off-cycle migration or liquid floodback during operation.

Off-cycle refrigerant migration is likely to occur when the compressor is located at the coldest part of the installation, when the system uses a bleed-type expansion device, or if liquid is allowed to migrate from the evaporator into the compressor sump by gravity. If too much liquid refrigerant accumulates in the sump it will saturate the oil and lead to a flooded start: when the compressor starts running again, the refrigerant evaporates abruptly under the sudden decrease of the bottom shell pressure, causing the oil to foam. In extreme situations, this might result in liquid slugging (liquid entering the scroll

elements), which must be avoided as it causes irreversible damage to the compressor.

The presence of liquid in the crankcase can be easily detected by checking the sump level through the oil sight glass. Foam in the oil sump indicates a flooded start.

VZH scroll compressors can tolerate occasional flooded starts as long as the total system charge does not exceed the maximum compressor refrigerant charge limit.

Off-cycle migration can be prevented by implementing a crankcase heating or adding a pump-down cycle to the operation cycle and a liquid line solenoid valve.

**Crankcase heater / sump heater:** A crankcase heater is only effective if capable of sustaining this level of temperature difference. Tests must be conducted to ensure that the appropriate oil temperature is maintained under all ambient conditions (temperature and wind).

Provide separate electrical supply for the heaters so that they remain energized even when the machine is out of service (eg. seasonal shut-down).

It's recommended that the heater be turned on for a minimum of 8 hours prior to starting the compressor.

**Liquid line solenoid valve (LLSV):** An LLSV may be used to isolate the liquid charge on the condenser side, thereby preventing against charge transfer or excessive migration to the compressor during off-cycles. When installed,

EXV also ensures this function. The quantity of refrigerant on the low-pressure side of the system can be further reduced by using a pump-down cycle in association with the LLSV.

**Pump-down cycle:** A pump-down cycle represents one of the most effective ways to protect against the off-cycle migration of liquid refrigerant. Once the system has reached its set point and is about to shut off, the LLSV on the condenser outlet closes. The compressor then pumps the majority of the refrigerant charge into the condenser and receiver before the system stops on the low pressure pump-down switch. This step reduces the amount of charge on the

low side in order to prevent off-cycle migration. The recommended low-pressure pump-down switch setting is 1.5 bar below the nominal evaporating pressure. It shall not be set lower than 2.3 bar.

An external non return valve is recommended to avoid liquid flood back from the high-pressure side.

**Liquid receiver:** Refrigerant charge optimization varies with compressor speed. To avoid flash gas at low speed, a receiver may be necessary. Receiver dimensioning requires special attention.

The receiver shall be large enough to contain part of the system refrigerant charge, but shall not be too large, to avoid refrigerant overcharging during maintenance operations.

### **Liquid floodback during operation**

Danfoss recommends the use of an electronic expansion valve for all air conditioning applications with VZH028-044 compressors. An EXV has two key benefits: it provides modulating control of the system under varying load

conditions, and it protects the compressors from flood back during adverse running conditions. Exceptions to the use of EXV's with Danfoss variable speed compressors must be approved by Danfoss application engineering.

**Manage superheat**

During normal operation, refrigerant enters the compressor as a superheated vapor. Liquid flood back occurs when a part of the refrigerant entering the compressor is still in liquid state.

Liquid flood back can cause oil dilution and, in extreme situations lead to liquid slugging that can damage compression parts.

**Requirement**

In steady state conditions the expansion device must ensure a suction superheat within 5K to 30K (9 to 54°F).

**System evaluation**

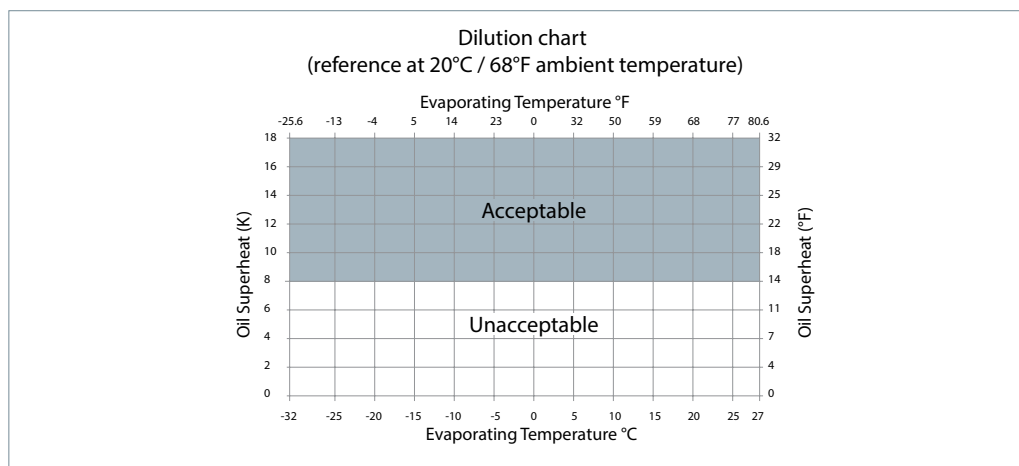
Use the table in relation with the application to quickly evaluate the potential tests to perform.

Application	Tests to perform
Non reversible	Liquid flood back test
Reversible	Liquid flood back test Defrost test

**Test, criteria and solutions**

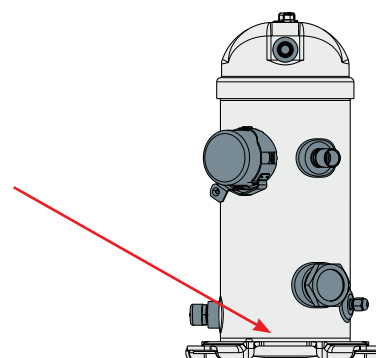
Test N°	Purpose	Test condition	Pass criteria	Solutions
Liquid flood back test	Steady-state	Liquid flood back testing must be carried out under expansion valve threshold operating conditions: •Lowest foreseeable evaporation, and highest foreseeable condensation. •Minimum speed running. For reversible system, perform test in both heating and cooling mode	Suction superheat >5K	<ol style="list-style-type: none"> <li>1. Check expansion valve selection and setting. -For Thermostatic expansion valve (TXV) check bulb position... -For Electronic expansion valve (EXV) check measurement chain and PID....</li> <li>2. Add a suction accumulator*.</li> </ol>
	Transient	Tests must be carried out with most unfavorable conditions : • fan staging, • compressor staging • ...	Oil superheat shall not be more than 30 sec below the safe limit defined in the Dilution Chart. (see graph above)	
Defrost test	Check liquid floodback during defrost cycle	Defrost test must be carried out in the most unfavorable condition at 0°C (32°F) evaporating temperature).	Oil superheat shall not be more than 30 sec below the safe limit defined in the Dilution Chart. (see graph above)	<ol style="list-style-type: none"> <li>1. Check defrost logic. In reversible systems, the defrost logic can be worked out to limit liquid floodback effect. (for more details see "Control Logic").</li> <li>2. Add a suction accumulator*.</li> </ol>

\*Suction accumulator offers protection by trapping the liquid refrigerant upstream from the compressor. The accumulator should be sized at least 50 % of the total system charge. Suction accumulator dimensions can impact oil return (gas velocity, oil return hole size...), therefore oil return has to be checked according to section "Manage oil in the circuit".



Oil temperature sensor must be placed between oil sight glass and compressor baseplate. Some thermal paste shall be used to improve the conductivity. The sensor must also be correctly thermally insulated from the ambience.

The Oil superheat is defined as:  
(Oil temperature - Evaporating temperature)



**Low ambient compressor operations**
**Low ambient start-up**

Under cold ambient conditions, upon start-up the pressure in the condenser may be so low that a sufficient pressure differential across the expansion device cannot be developed to properly feed the evaporator. As a result, the compressor may go into abnormal low suction pressure, which can lead to compressor failure. Under no circumstances should the compressor be allowed to operate under vacuum. The low-pressure control must be set in accordance with

the table section "Pressure settings" in order to prevent this from happening.

Low pressure differentials can also cause the expansion device to "hunt" erratically, which might cause surging conditions within the evaporator, with liquid spillover into the compressor. This effect is most pronounced during low load conditions, which frequently occur during low ambient conditions.

**Head pressure control under low ambient conditions**

Several possible solutions are available to prevent the compressor from drawing down to a vacuum upon start-up under low ambient conditions. In air-cooled machines, cycling the fans with a head pressure controller will ensure that the fans remain off until the condensing pressure has reached a satisfactory level. In water-cooled units, the same can be performed using a water regulator valve that is also operated by head pressure, thereby ensuring that the water valve does not open until the condensing pressure reaches a satisfactory level.

Under very low ambient conditions, in which testing has revealed that the above procedures might not ensure satisfactory condensing and suction pressures, the use of a liquid receiver with condenser and receiver pressure regulators would be possible.

Condensing pressure control is also strongly recommended to improve any system efficiency. The most accurate value is to control the condensing temperature at 12 K above the ambient temperature for air cooled condensers.

Note: The minimum condensing pressure must be set at the minimum saturated condensing temperature shown in the application envelopes.

For further information, please contact Danfoss Technical support.

**Crankcase heaters**

A crankcase heating will minimize refrigerant migration caused by the large temperature gradient between the compressor and the remainder of the system.

Belt type crankcase heaters can be used, see section "Accessory". They can be connected to CDS relay 1 or 2.

**Low load operations**

It is recommended that the unit is tested and monitored at minimum load and, if possible, during low ambient conditions as well. During conditions of low load on the system, the following considerations should be taken into account to ensure proper system operating characteristics.

- The superheat setting of the expansion device should be sufficient to ensure proper superheat levels during low loading periods. 6 K stable superheat is required. In addition, the refrigerant charge should be sufficient to ensure proper sub-cooling within the condenser so as to avoid the risk of flashing in the liquid line before the expansion device. The expansion device should be sized to ensure proper control of the refrigerant flow into the evaporator.



	<p>An oversized valve may result in erratic control. This can lead to liquid refrigerant entering the compressor if the expansion valve does not provide stable refrigerant super-heat control under varying loads.</p> <ul style="list-style-type: none"> <li>• Condenser fans should be cycled in such a way that the minimum pressure differential is maintained between the suction and discharge pressures. Inverter fans can also be used to control the amount of heat to be removed from the condenser.</li> </ul>	<ul style="list-style-type: none"> <li>• The compressors should be run for a minimum period in order to ensure that the oil has sufficient time to properly return to the compressor sump and that the motor has sufficient time to cool under conditions of lowest refrigerant mass flows.</li> </ul> <p>Refer to section "Oil return management function".</p>
<b>Brazed plate heat exchangers</b>	<p>A brazed plate heat exchanger needs very little internal volume to satisfy the set of heat transfer requirements. Consequently, the heat exchanger offers very little internal volume for the compressor to draw vapor from on the suction side. The compressor can then quickly enter into a vacuum condition. It is therefore important that the expansion device be sized correctly and that a sufficient pressure differential across the expansion device be available to ensure adequate refrigerant feed into the evaporator. This aspect is of special concern when operating the unit under low ambient and load conditions. For further information on these conditions, please refer to the previous sections.</p> <p>Due to the small volume of the brazed plate heat exchanger, no pump-down cycle is normally required.</p>	<p>The suction line running from the heat exchanger to the compressor must be trapped to avoid refrigerant migration to the compressor.</p> <p>When using a brazed plate condenser heat exchanger, a sufficient free volume for the discharge gas to accumulate is required in order to avoid excess pressure build-up. At least 1 meter of discharge line is necessary to generate this volume. To help reduce the gas volume immediately after start-up even further, the supply of cooling water to the heat exchanger may be opened before the compressor starts up so as to remove superheat and condense the incoming discharge gas more quickly.</p> <p>Because of the large compressor capacity variation and VZH capability to run at low condensing temperature an EXV (electronic expansion valve) is mandatory.</p>
<b>Reversible heat pump systems</b>	<p>Transients are likely to occur in reversible heat pump systems, i.e. a changeover cycle from cooling to heating, defrost or low-load short cycles. These transient modes of operation may lead to liquid refrigerant carry-over (or flood-back) or excessively wet refrigerant return conditions. As such, reversible cycle applications require specific precautions in order to ensure a long compressor life and satisfactory operational function. Compressors need to run at least</p>	<p>1 minute at 50 rps each time after reverse. Regardless of the refrigerant charge in the system, specific tests for repetitive flood-back are required to confirm whether or not a suction accumulator needs to be installed. The following considerations cover the most important issues when dealing with common applications. Each application design however should be thoroughly tested to ensure acceptable operating characteristics.</p>
<b>Discharge temperature monitoring</b>	<p>Heat pumps frequently utilize high condensing temperatures in order to achieve a sufficient temperature rise in the medium being heated. At the same time, they often require low evaporating pressures to obtain sufficient temperature differentials between the evaporator and the outside temperature. This situation may result in high discharge temperature; as such, it is mandatory that a discharge gas safety control is included to protect the compressor</p>	<p>from excessive temperatures. Operating the compressor at too high discharge temperatures can result in mechanical damage to the compressor as well as thermal degradation of the compressor lubricating oil and a lack of sufficient lubrication.</p> <p>Refer to the "Discharge gas thermostat" section for frequency converter settings and accessories availability.</p>

**Discharge line and reversing valve**

The VZH scroll compressor is a high volumetric machine and, as such, can rapidly build up pressure in the discharge line if gas in the line becomes obstructed even for a very short period of time which situation may occur with slow-acting, reversing valves in heat pumps. Discharge pressures exceeding the operating envelope may result in nuisance high-pressure switch cutouts and can generate excessive load on bearings and motor.

gas to collect and to reduce the pressure peak during the time it takes for the valve to change position. At the same time, it is important that the selection and sizing of the reversing or 4-way valve ensure that the valve switches quickly enough to prevent against too high discharge pressure and nuisance high-pressure cutouts.

Check with the valve manufacturer for optimal sizing and recommended mounting positions.

To prevent such occurrences, it is important that a 1-meter minimum discharge line length be allowed between the compressor discharge port and the reversing valve or any other restriction. This gives sufficient free volume for the discharge

It is strongly recommended to reduce the compressor speed to 25/30 rps before the 4-way valve is moved from a position to another.

Refer also to high and low pressure protection.

**Defrost and reverse cycle**

After the 4-way valve is moved to defrost position, and in order to shorten the defrost period, the compressor speed can be maintained at 70 rps or higher speed during the defrost period.

When the compressor is started again each time, compressor will run at 50 rps for at least 1 minute. Thus to avoid excessive liquid refrigerant to come back to the compressor sump.

**Suction line accumulator**

The use of a suction line accumulator is strongly recommended in reversible-cycle applications. This because of the possibility of a substantial quantity of liquid refrigerant remaining in the evaporator, which acts as a condenser during the heating cycle.

the cycle switches back to a defrost cycle or to normal cooling operations.

This liquid refrigerant can then return to the compressor, either flooding the sump with refrigerant or as a dynamic liquid slug when

Sustained and repeated liquid slugging and floodback can seriously impair the oil's ability to lubricate the compressor bearings. This situation can be observed in wet climates where it is necessary to frequently defrost the outdoor coil in an air source heat pump. In such cases a suction accumulator becomes mandatory.

**Water utilizing systems**

Apart from residual moisture in the system after commissioning, water could also enter the refrigeration circuit during operation. Water in the system should always be avoided. Not only because it can quickly lead to electrical failure, sludge in sump and corrosion but in particular because it can cause serious safety risks.

**Corrosion:** Materials in the system shall be safe to use with water and protected against corrosion.

Common causes for water leaks are corrosion and freezing.

**Freezing:** When water freezes into ice its volume expands which can damage heat exchanger walls and cause leaks. During off periods water inside heat exchangers could start freezing when ambient temperature is lower than 0°C. During on periods ice banking could occur when the circuit is running continuously at too low load. Both situations should be avoided by connecting a pressure and thermostat switch in the safety line.

**Running sound level**

For all VZH models, noise level given in table does not include bottom hood attenuation.

Model	Frequency RPS	200 V		400 V		575 V	
		Without acoustic hood (dBA)	With acoustic hood (dBA)	Without acoustic hood (dBA)	With acoustic hood (dBA)	Without acoustic hood (dBA)	With acoustic hood (dBA)
VZH028-044	60	77	70	77	70	77	70
	100	86	79	86	79	86	79

Average sound power for reference at ARI A/C conditions measured in free space.

Please notice below two phenomenon is also normal for variable speed compressor:

1. At light load and low speed condition the compressor may produce certain discharge pulsation.
2. In some situations when the compressor stops working, there may still be some noise which lasts around 2 seconds. The electromagnetic noise is caused by drive anti-reverse protection.

**Sound generation in a refrigeration or air conditioning system**

Typical sound and vibration in refrigeration and air conditioning systems encountered by design and service engineers may be broken down into the following three source categories.

**Sound radiation:** This generally takes an airborne path.

**Mechanical vibrations:** These generally extend along the parts of the unit and structure.

**Gas pulsation:** This tends to travel through the cooling medium, i.e. the refrigerant.

The following sections focus on the causes and methods of mitigation for each of the above sources.

**Compressor sound radiation**

For sound radiating from the compressor, the emission path is airborne and the sound waves travel directly from the machine in all directions.

The VZH scroll compressor is designed to be quiet and the frequency of the sound generated is pushed into the higher ranges, which not only are easier to reduce but also do not generate the penetrating power of lower-frequency sound.

Use of sound-insulation materials on the inside of unit panels is an effective means of substantially reducing the sound being transmitted to the

outside. Ensure that no components capable of transmitting sound/vibration within the unit come into direct contact with any non insulated parts on the walls of the unit.

Because of the VZH unique design of a full-suction gas-cooled motor, compressor body insulation across its entire operating range is possible. Acoustic hoods are available from Danfoss as accessories. These hoods are quick and easy to install and do not increase the overall size of the compressors to a great extent.

**Mechanical vibrations**

Vibration isolation constitutes the primary method for controlling structural vibration. VZH scroll compressors are designed to produce minimal vibration during operations. The use of rubber isolators on the compressor base plate or on the frame of a manifolded unit is very effective in reducing vibration being transmitted from the compressor(s) to the unit. Once the supplied rubber grommets have been properly mounted, vibrations transmitted from the compressor base

plate to the unit are held to a strict minimum. In addition, it is extremely important that the frame supporting the mounted compressor be of sufficient mass and stiffness to help dampen any residual vibration potentially transmitted to the frame.

For further information on mounting requirements, please refer to the section on mounting assembly.

**Speed by-pass**

If vibrations occurs at some typical frequencies of the VZH variable speed compressor system, design must be checked: frame, piping, pipes using cushioned clamps. But if some frequencies continue to produce unacceptable

vibration levels, speed by-pass is adjustable in the frequency converter, in order to avoid some frequency ranges. Four by-pass ranges are adjustable, and settings can be made in parameter group 4-6.

**Gas pulsation**

The VZH scroll compressor has been designed and tested to ensure that gas pulsation has been optimized for the most commonly encountered air conditioning pressure ratios. On heat pump installations and other installations where the pressure ratio lies beyond the typical range, testing should be conducted under all expected

conditions and operating configurations to ensure that minimum gas pulsation is present. If an unacceptable level is identified, a discharge muffler with the appropriate resonant volume and mass should be installed. This information can be obtained from the component manufacturer.

Each compressor is shipped with printed instructions for installation. These instructions can also be downloaded from:

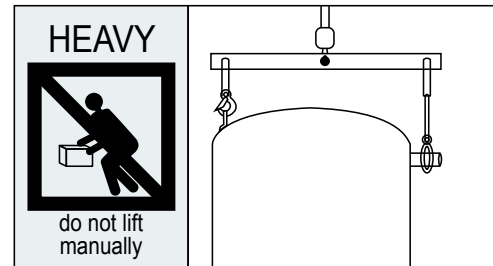
<http://instructions.cc.danfoss.com>

**Compressor handling**

Each VZH scroll compressor is equipped with one lift ring on the top shell. Always use the ring when lifting the compressor. Use lifting equipment rated and certified for the weight of the compressor. A spreader bar rated for the weight of the compressor is highly recommended to ensure a better load distribution. The use of lifting hooks closed with a clasp certified to lift the weight of the compressor is also highly recommended. Always respect the appropriate rules concerning lifting objects of the type and weight of these compressors. Maintain the compressor in an upright position during all handling operations.

or that the compressor could separate from the base frame with extensive damage and possible personal injury as a result.

Never apply force to the terminal box with the intention of moving the compressor, as the force placed upon the terminal box can cause

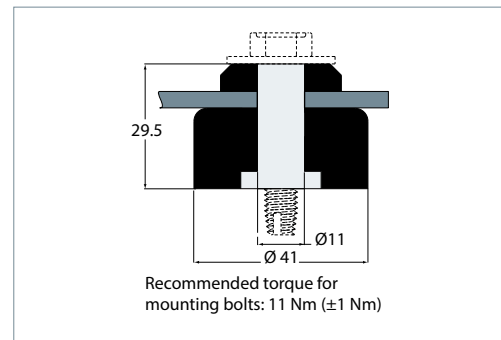


When the compressor is mounted as part of an installation, never use the lift rings on the compressor to lift the installation. The risk is that the lugs could separate from the compressor

extensive damage to both the box and the components contained inside.

**Mounting**

Maximum inclination from the vertical plane, while operating must not exceed 7 degrees. All compressors are delivered with four rubber grommets and metal sleeves. Compressors must always be mounted with these grommets. Recommended torque for mounting bolts: 11 Nm ( $\pm 1$  Nm).



**Removing connections shipping plugs**

Before the suction and discharge plugs are removed, the nitrogen holding charge must be released via the suction schrader valve to avoid an oil mist blowout. Remove the suction plug first and the discharge plug afterwards. The plugs should be removed only just before connecting

the compressor to the installation in order to avoid moisture from entering the compressor. When the plugs are removed, it is essential to keep the compressor in an upright position so as to avoid oil spillage.

**System cleanliness**

The refrigerant compression system, regardless of the type of compressor used, will only provide high efficiency and good reliability, along with a long operating life, if the system contains solely the refrigerant and oil it was designed for. Any other substances within the system will not improve performance and, in most cases, will be highly detrimental to a system's

operation. The presence of non-condensable substances and system contaminants such as metal shavings, solder and flux, have a negative impact on compressor service life. Many of these contaminants are small enough to pass through a mesh screen and can cause considerable damage within a bearing assembly.

The use of highly hygroscopic polyolester oil in R410A compressors requires that the oil be exposed to the atmosphere as little as possible. System contamination is one of main factors affecting equipment reliability and compressor service life. It is important therefore to take system cleanliness into account when assembling a refrigeration system. During the manufacturing process, circuit contamination may be caused by:

- Brazing and welding oxides,
- Filings and particles from the removal of burrs in pipe-work,
- Brazing flux,
- Moisture and air.

Consequently, when building equipment and assemblies, the precautions listed in the following paragraphs must be taken.

**Tubing**

Only use clean and dehydrated refrigeration grade copper tubing. Tube-cutting must be carried out so as not to deform the tubing roundness and to ensure that no foreign debris remains within the tubing. Only refrigerant grade fittings should be used and these must be of

both a design and size to allow for a minimum pressure drop through the completed assembly. Follow the brazing instructions below. Never drill holes into parts of the pipe-work where filings and particles can not be removed.

**Filter driers**

For new installations with VZH compressors with polyolester oil, Danfoss recommends using the Danfoss DML 100% molecular sieve, solid core filter drier. Molecular sieve filter driers with loose beads from third party suppliers shall be avoided. For servicing of existing installations where acid formation is present the Danfoss DCL solid core filter driers containing activated alumina are recommended.

The drier is to be oversized rather than undersized. When selecting a drier, always take into account its capacity (water content capacity), the system refrigeration capacity and the system refrigerant charge.

**Brazing and soldering**
**Copper to copper connections**

When brazing copper-to-copper connections, the use of copper/phosphorus brazing alloy containing 5% silver or higher with a melting

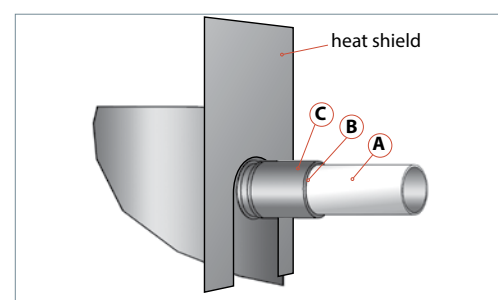
temperature of below 800°C is recommended. No flux is required during brazing.

**Dissimilar metals connections**

When manipulating dissimilar metals such as copper and brass or steel, the use of silver solder and anti-oxidant flux is required.

**Compressor connection**

When brazing the compressor fittings, do not overheat the compressor shell, which could severely damage certain internal components due to excessive heating. Use of a heat shield and/or a heat-absorbent compound is highly recommended. Due to the relatively sizable tubing and fitting diameters a double-tipped torch using acetylene is recommended for brazing operation on VZH compressors.



For brazing the suction and discharge connections, the following procedure is advised:

- Make sure that no electrical wiring is connected to the compressor.
- Protect painted surfaces on the terminal box and compressor from torch heat damage (see diagram).
- Remove the Teflon gaskets when brazing rotolock connectors with solder sleeves.
- Use only clean, refrigeration-grade copper tubing and clean all connections.
- Use brazing material with a minimum of 5% silver content.
- Purge nitrogen or CO<sub>2</sub> through the compressor in order to prevent against oxidation and flammable conditions. The compressor should not be exposed to the open air for extended periods.
- Use of a double-tipped torch is recommended.
- Apply heat evenly to area A until the brazing temperature is reached. Move the torch to area B and apply heat evenly until the brazing temperature has been reached there as well, and then begin adding the brazing material. Move the torch evenly around the joint, in applying only enough brazing material to flow the full circumference of the joint.
- Move the torch to area C only long enough to draw the brazing material into the joint, but not into the compressor.

- Remove all remaining flux “once the joint has been soldered” with a wire brush or a wet cloth. Remaining flux would cause corrosion of the tubing.

Ensure that no flux is allowed to enter into the tubing or compressor. Flux is acidic and can cause substantial damage to the internal parts of the system and compressor.

The polyolester oil used in VZH compressors is highly hygroscopic and will rapidly absorb moisture from the air. The compressor must therefore not be left open to the atmosphere for a long period of time. The compressor fitting plugs shall be removed just before brazing the compressor. The compressor should always be the last component brazed into the system

Before eventual unbrazing the compressor or any system component, the refrigerant charge must be removed from both the high- and low-pressure sides. Failure to do so may result in serious personal injury. Pressure gauges must be used to ensure all pressures are at atmospheric level.

For more detailed information on the appropriate materials required for brazing or soldering, please contact the product manufacturer or distributor. For specific applications not covered herein, please contact Danfoss for further information.

**High voltage test**

Carry out a high voltage test by short-circuiting terminals U, V, W, L1, L2 and L3. Energize by max. 1920 V DC for code G compressors and 1460 V DC for code J compressors for one second between this short-circuit and the chassis. When running high voltage tests of the entire installation, frequency converter and compressor electrical

motor compressor test can be conducted together. When conducting a high voltage test make sure the system is not under vacuum: this may cause electrical motor compressor failure. Please note, it is not recommended that a high-voltage test be carried out too often as it may damage the motor.

**System pressure test**

Always use an inert gas such as nitrogen for pressure testing. Never use other gases such as oxygen, dry air or acetylene as these may form

an inflammable mixture. Do not exceed the following pressures:

Maximum compressor test pressure (Low side)	30 bar
Maximum compressor test pressure (High side)	41.1 bar
Maximum pressure difference between high side and low side of the compressor	36 bar

Pressurize the system on HP side first then LP side to prevent rotation of the scroll. Never let the

pressure on LP side exceed the pressure on HP side with more than 5 bar.

**Leak detection**

Leak detection must be carried out using a mixture of nitrogen and refrigerant or nitrogen and helium, as indicated in the table below. Never use other gasses such as oxygen, dry air or acetylene as these may form an inflammable mixture.

Leak detection with refrigerant	Leak detection with a mass spectrometer
Nitrogen & R410A	Nitrogen & Helium

Pressurize the system on HP side first then LP side.

**Vacuum pump down and moisture removal**

Moisture obstructs the proper functioning of both the compressor and the refrigeration system. Air and moisture reduce service life and increase condensation pressure, which causes abnormally high discharge temperatures that are then capable of degrading the lubricating properties of the oil. The risk of acid formation is also increased by air and moisture, and this condition can also lead to copper plating. All

these phenomena may cause both mechanical and electrical compressor failures. The typical method for avoiding such problems is a vacuum pump-down executed with a vacuum pump, thus creating a minimum vacuum of 500 microns (0.67 mbar). Please refer to News bulletin T11-026-0302 "Vacuum pump down and dehydration procedure".

**Refrigerant charging**

For the initial charge, the compressor must not run and eventual service valves must be closed. Charge refrigerant as close as possible to the nominal system charge before starting the compressor. This initial charging operation must be done in liquid phase as far away as possible from the compressor. The best location is on the liquid line between the condenser outlet and the filter drier. Then during commissioning, when needed, a complement of charge can be done

in liquid phase: slowly throttling liquid in on the low pressure side as far away as possible from the compressor suction connection. The refrigerant charge quantity must be suitable for both summer and winter operations.

Refer to news bulletin FRCC.EN.050 "Danfoss Commercial Compressors recommended refrigerant system charging practice" for more details.

**Commissioning**

The system must be monitored after initial startup for a minimum of 60 minutes to ensure proper operating characteristics such as:

- Proper metering device operation and desired superheat readings
- Suction and discharge pressure are within acceptable levels
- Correct oil level in compressor sump indicating proper oil return
- Low foaming in sight glass and compressor sump temperature 10K above saturation temperature to show that there is no refrigerant migration taking place
- Acceptable cycling rate of compressors, including duration of run times.

A short cycling protection is provided in the CDS frequency converter. It is factory preset "enabled" with the following parameters in:

28.01 - interval between 2 starts: 300 secondes  
28.02 - minimum run time: 60 seconds.

This minimum run time is set to guaranty long enough running time at start up in order to create enough refrigerant flow velocity in the system to recover the oil to the compressor sump.

- Current draw of compressor within acceptable values (RLA ratings)
- No abnormal vibrations and noise.

**⚠ Note this compressor is equipped with a four-pole electrical motor so the applied frequency from the inverter will be 30 Hz for**

**15 rps(900 rpm) up to 200 Hz for 100 rps (6000 rpm).**

**Oil level checking and top-up**

In installations with good oil return and line runs up to 15 m, no additional oil is required. If installation lines exceed 15 m, additional oil may be needed. 1 or 2% of the total system refrigerant charge (in kg) can be used to roughly define the required oil top-up quantity (in liters) but in any case the oil charge has to be adjusted based on the oil level in the compressor sight glass.

When the compressor is running under stabilized conditions, the oil level must be visible in the sight glass.

The presence of foam filling in the sight glass indicates large concentration of refrigerant in the oil and / or presence of liquid returning to the compressor.

The oil level can also be checked a few minutes after the compressor stops, the level must be between  $\frac{1}{4}$  and  $\frac{3}{4}$  of sight glass.

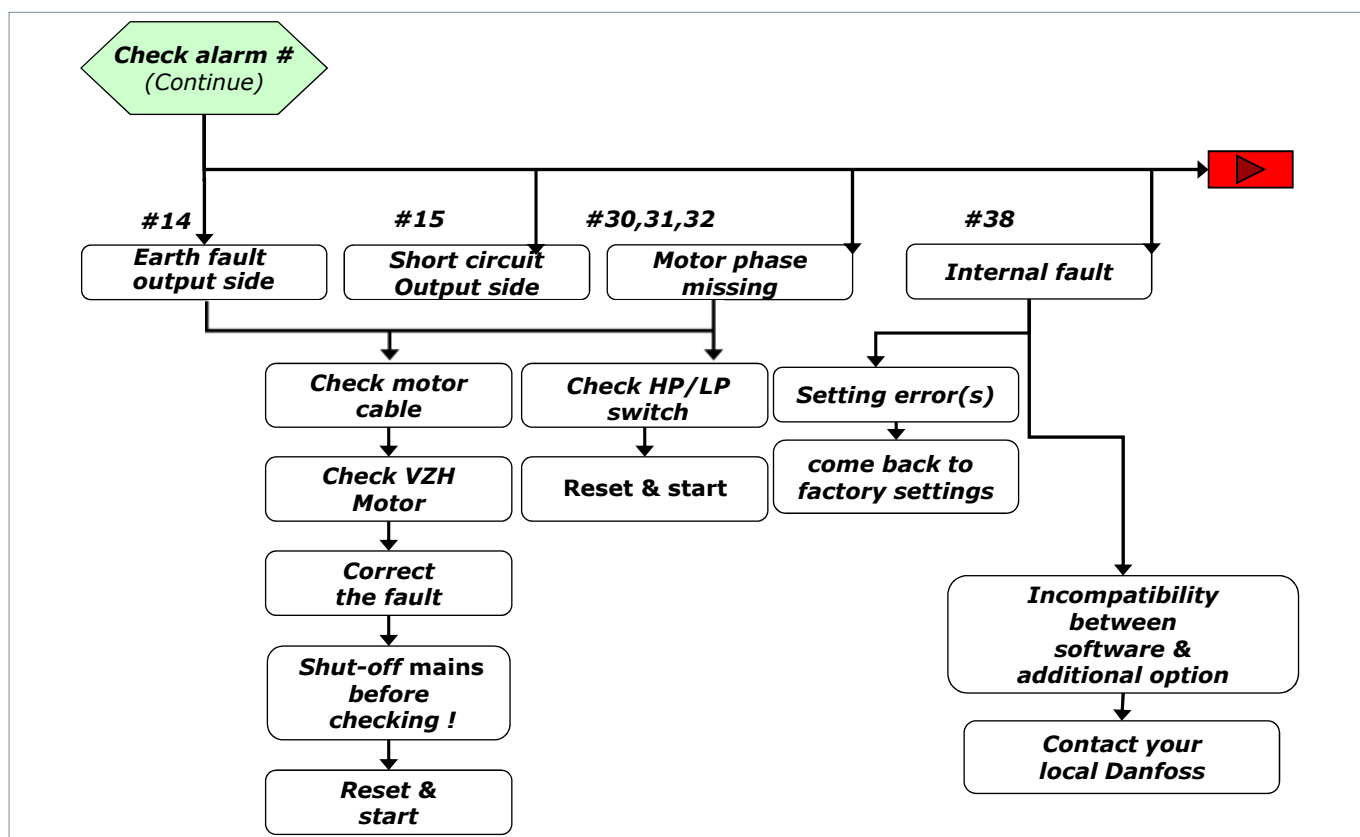
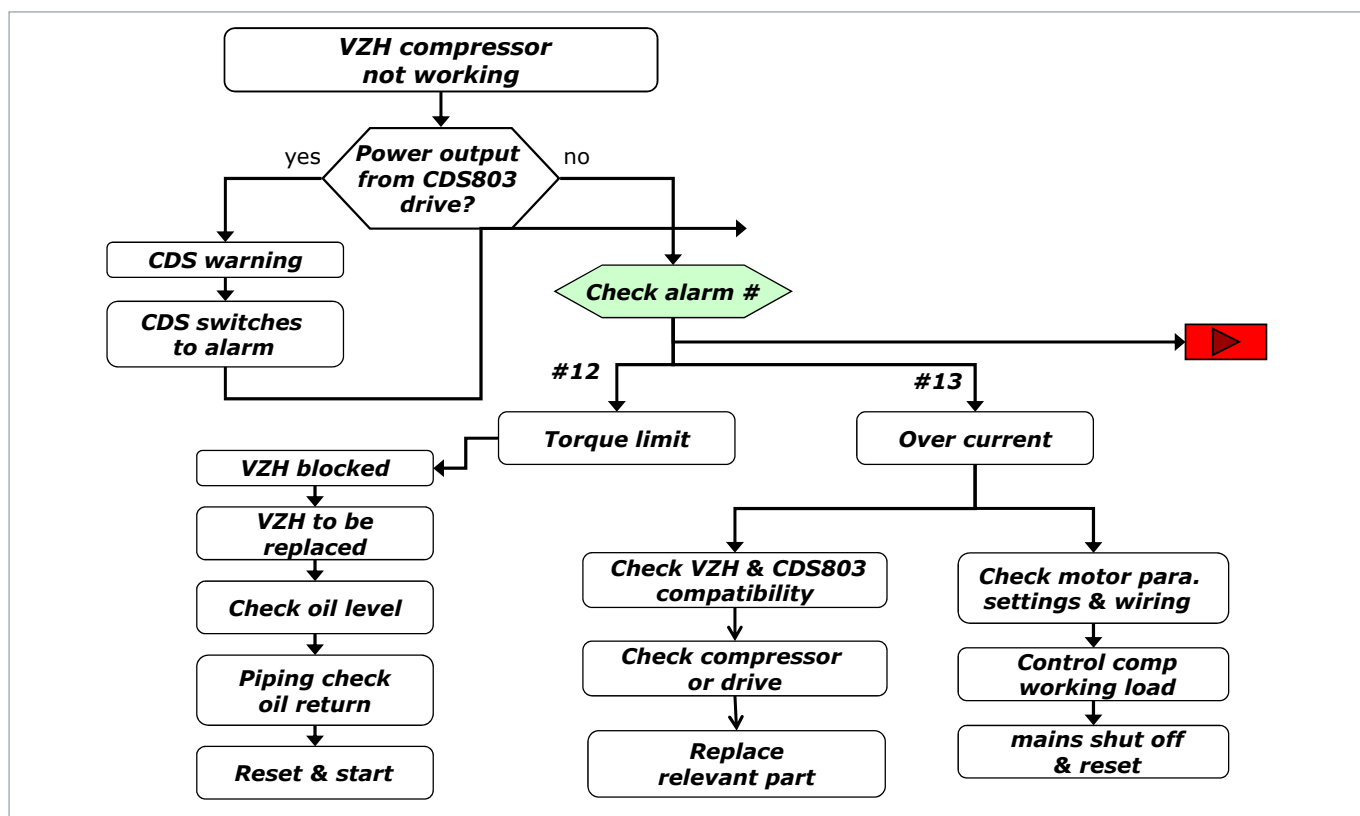
When the compressor is off, the level in the sight glass can be influenced by the presence of refrigerant in the oil.

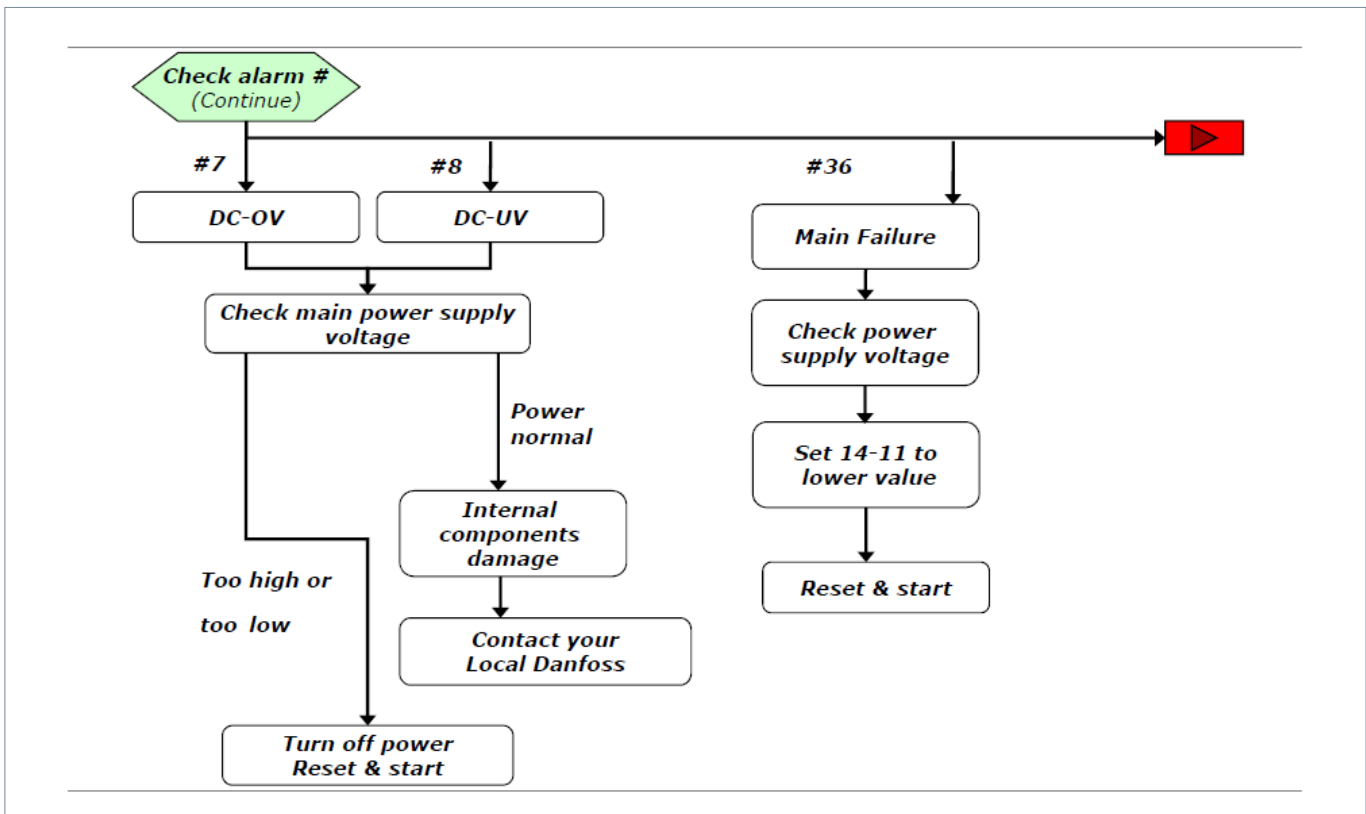
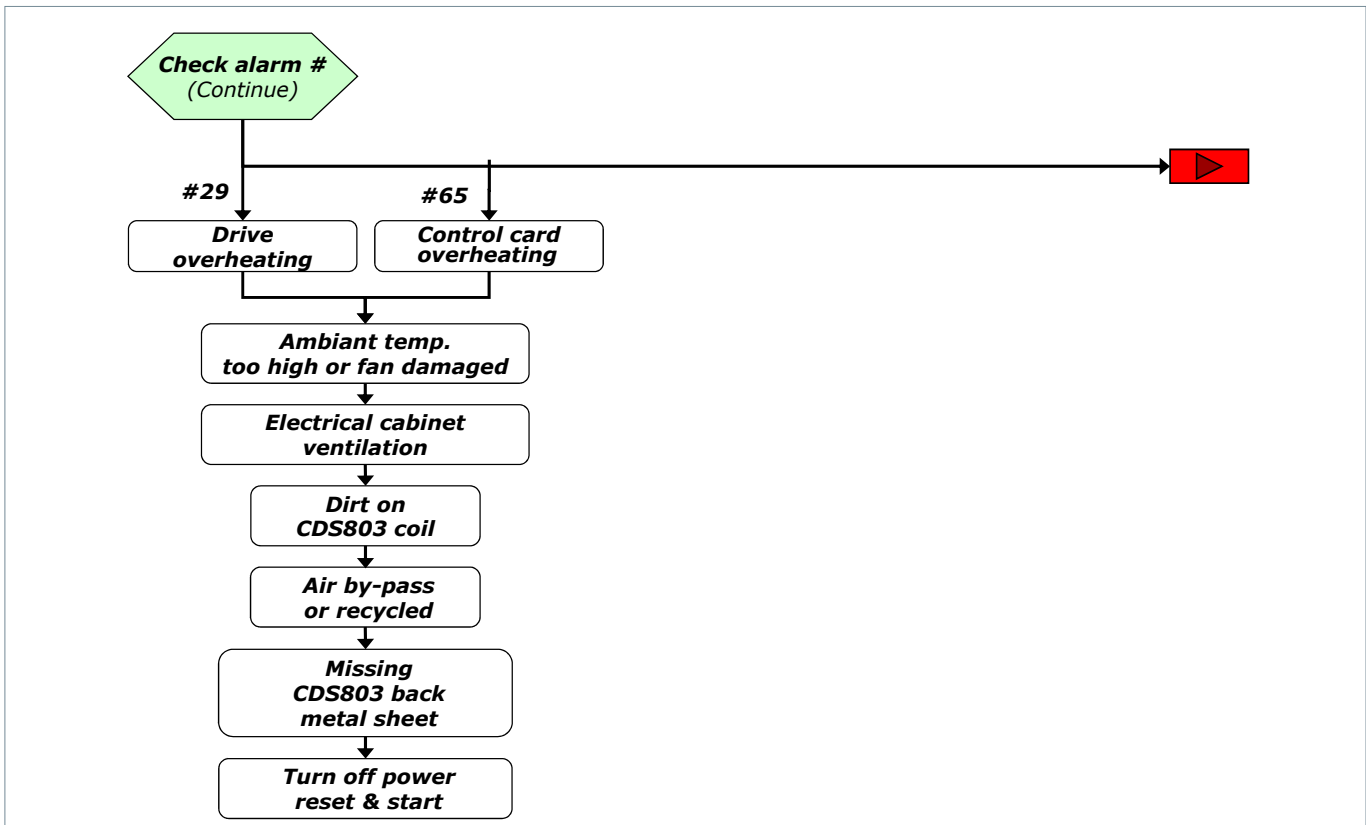
VZH028-035-044 are factory charged with PVE32(160HV), when topping up the compressor, customer could also use PVE68(320HV) lubricant. Danfoss supply PVE68 as accessory.

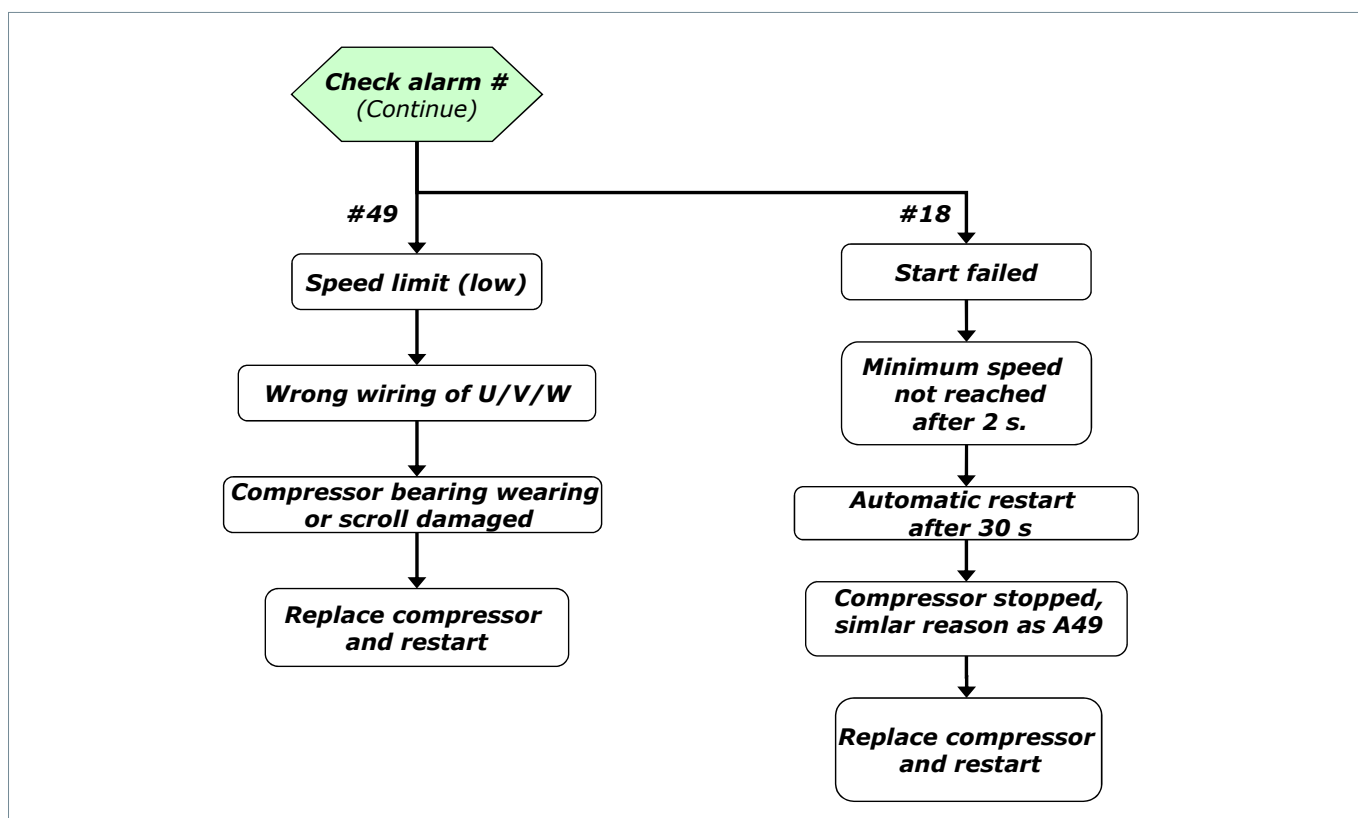
There will be no reliability risks even VZH is with 100% PVE68, but the mixture of PVE32 and PVE68 will cause performance drop.

Top-up the oil while the compressor is idle. Use the schrader connector or any other accessible connector on the compressor suction line and a suitable pump. See news bulletin "Lubricants filling in instructions for Danfoss Commercial Compressors."









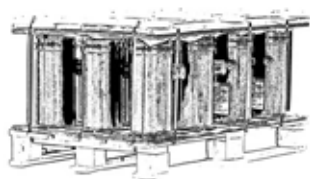
**Kit ordering and shipping**

The tables on the following pages give code numbers for ordering purposes for the VZH

compressor and CDS frequency converter kit packed and shipped separately.

**Packaging**
**Compressor single pack**


Compressor model	Height (mm)	Width (mm)	Depth (mm)	Weight (kg)
VZH028/035/044	464	292	286	30

**Compressor Industrial pack**


Compressors are not packed individually but are shipped all together on one pallet. They can be

ordered in quantities of full pallets only, multiples of 12 compressors, according below table.

Compressor model	Nbr*	Length (mm)	Width (mm)	Height (mm)	Gross Weight (kg)	Static stacking pallets
VZH028	12	1170	815	625	430	3
VZH035	12	1170	815	625	450	3
VZH044	12	1170	815	625	450	3

**Frequency converter single pack**


Drive supply voltage	Compressor	Drive enclosure	IP20			
			Height (mm)	Width (mm)	Depth (mm)	Weight (kg)
T2: Code J	VZH028/035	H4	380	250	375	7.9
	VZH044	H5	420	290	375	9.5
T4: Code G	VZH028/035	H3	255	100	206	4.5
	VZH044	H4	380	250	375	7.9
T6: Code H	VZH028	A3	390	196	301	6.6
	VZH035/044	B3	349	500	330	13

**Ordering information**

VZH scroll compressors can be ordered in single packs and industrial packs. Drive can be ordered

in single packs. Please use the code numbers from below tables for ordering.

**Compressors single pack**

Compressor model	Equipment version	G		J		H	
		Compressor Name	Code No	Compressor Name	Code No	Compressor Name	Code No
VZH028	OSG	VZH028CGANB	120G0188	VZH028CJANB	120G0186	VZH028CHANB	120G0187
	OLS	VZH028CGBNB	120G0263	VZH028CJBANB	120G0264	VZH028CHBNB	120G0301
VZH035	OSG	VZH035CGANB	120G0185	VZH035CJANB	120G0183	VZH035CHANB	120G0184
	OLS	VZH035CGBNB	120G0247	VZH035CJBANB	120G0246	VZH035CHBNB	120G0302
VZH044	OSG	VZH044CGANB	120G0182	VZH044CJANB	120G0180	VZH044CHANB	120G0181
	OLS	VZH044CGBNB	120G0245	VZH044CJBANB	120G0244	VZH044CHBNB	120G0243

**Compressor Industrial pack**

Compressor model	Equipment version	G		J		H	
		Compressor Name	Code No	Compressor Name	Code No	Compressor Name	Code No
VZH028	OSG	VZH028CGANB/I	120G0179	VZH028CJANB/I	120G0259	VZH028CHANB/I	120G0178
	OLS	VZH028CGBNB/I	120G0303	VZH028CJBNB/I	120G0304	-	-
VZH035	OSG	VZH035CGANB/I	120G0258	VZH035CJANB/I	120G0256	VZH035CHANB/I	120G0257
	OLS	VZH035CGBNB/I	120G0252	VZH035CJBNB/I	120G0251	-	-
VZH044	OSG	VZH044CGANB/I	120G0255	VZH044CJANB/I	120G0253	VZH044CHANB/I	120G0254
	OLS	VZH044CGBNB/I	120G0250	VZH044CJBNB/I	120G0249	-	-

**VZH converter order information**

CDS803 drive			
Voltage	Compressor	Description	Code NO
T2 200-240V/3ph/50&60Hz	VZH028	CDS803P6K0T2E20H4	134N4260
	VZH035	CDS803P7K5T2E20H4	134N4261
	VZH044	CDS803P10KT2E20H4	134L9470
T4 380-480V/3ph/50&60Hz	VZH028	CDS803P6K0T4E20H4	134N4262
	VZH035	CDS803P7K5T4E20H4	134N4263
	VZH044	CDS803P10KT4E20H4	134L9473

LCP: user interface 120Z0581 (accessory)

CDS303 drive			
Voltage	Compressor	Description	Code NO
T6 525-600V/3ph/50&60Hz	VZH028	CDS303P7K5T6E20HX	134X8358
	VZH035	CDS303P11KT6E20HX	135N3582
	VZH044	CDS303P11KT6E20HX	135N3582

LCP: user interface 120Z0326 (accessory)

**Rotolock adaptor**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z0366	Rotolock adaptor (1-1/4" ~ 3/4")	VZH028-044 suction	Multipack	10
	120Z0365	Rotolock adaptor (1" ~ 1/2")	VZH028-044 discharge	Multipack	10

**Valves, adapters, connectors & gaskets for use on suction and discharge connections**
**Solder sleeve adapter sets**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z0126	Solder sleeve adapter set (1"1/4 Rotolock, 3/4" ODF), (1" Rotolock, 1/2" ODF)	VZH028-044	Multipack	6

**Crankcase heaters & thermostats**
**Crankcase heaters**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z5040	Belt type crankcase heater,65W,230V,CE mark,UL(wire length: 1270mm)	VZH028-044	Multipack	4
	120Z5041	Belt type crankcase heater,55/70W,400/460V,CE mark,UL(wire length: 1270mm)		Multipack	4

**Lubricant, acoustic hoods and spare parts**
**Acoustic hoods**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z5083	Acoustic hood	VZH028-044	Single pack	1

**Oil level switch**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z0561	Oil level switch - electrical part (24V AC/DC)	All models	Single pack	1
	120Z0562	Oil level switch - electrical part (230V AC)	All models	Single pack	1

**Mounting kits**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z0622	Mounting kit for 1 scroll compressor including 4 grommets, 4 sleeves, 4 bolts, 4 washers, 2 grounding screws	VZH028-044	Single pack	1

**Terminal boxes, covers & T-block connectors**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z5015	Terminal box cover	VZH028-044	Multipack	10

**Lubricant**

Type	Code n°	Description	Application	Packaging	Pack size
320HV	120Z5034	PVE68 Lubricant, 2 liter can	VZH028-044	Multipack	12

**Spare parts frequency converter**
**LCP's**

Type	Code n°	Description	Application	Packaging	Pack size
	120Z0581	LCP	Frequency converter 803 / VZH028-044 code G & code J	Single pack	1
	120Z0617	LCP kit for remote mounting contains rubber sealing, 3m cable, bracket and screws	Frequency converter CDS803 / VZH028-044 code G & code J	Single pack	1
	120Z0326	LCP	Frequency converter CDS303/ VZH028-044 code H	Single pack	1

**Decoupling Plate**

Frame	Compressor		Decoupling plate	Packaging	Pack size
	200-240V	380-480V			
H3	-	VZH028/035	120Z0582	Single pack	1
H4	VZH028/035	VZH044	120Z0583	Single pack	1
H5	VZH044	-	120Z0583	Single pack	1

Note: use the decoupling plate for EMC correct installation

# Danfoss Commercial Compressors

is a worldwide manufacturer of compressors and condensing units for refrigeration and HVAC applications. With a wide range of high quality and innovative products we help your company to find the best possible energy efficient solution that respects the environment and reduces total life cycle costs.

We have 40 years of experience within the development of hermetic compressors which has brought us amongst the global leaders in our business, and positioned us as distinct variable speed technology specialists. Today we operate from engineering and manufacturing facilities spanning across three continents.



Danfoss Scrolls



Danfoss Inverter Scrolls



Danfoss Turbocor Compressors



Danfoss Light Commercial Refrigeration Compressors



Danfoss Maneurop Reciprocating Compressors



Danfoss Optyma Condensing Units

Our products can be found in a variety of applications such as rooftops, chillers, residential air conditioners, heatpumps, coldrooms, supermarkets, milk tank cooling and industrial cooling processes.

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