Multicompressor refrigeration units

Equipped with Reciprocating Compressors and Scroll Compressors

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Contents

1. Introduction

1.1 Development History

Up to the mid-1980s, every refrigeration point of a multiple-point installation was operated with its own stand-alone condensing unit. This has since been replaced by integrating the full complement of refrigeration points, especially refrigerated display cabinets, into systems serviced by a single central **multicompressor refrigeration unit** and dividing them as required into separate temperature ranges - e.g., for normal-temperature cooling (NT) and low-temperature cooling (LT).

As the name implies, a multicompressor refrigeration unit is equipped with a multiple number of compressors connected in parallel, usually packaged in a single frame.

The present manual applies to multicompressor refrigeration units equipped with semihermetic and hermetic reciprocating compressors.

Several reasons played a part in technical development leading up to the design of multicompressor refrigeration units, among them:

- Economical factory construction of a key refrigeration system component
- Capability of efficiently controlling refrigeration systems
- Usability of hermetic and semihermetic compressors also for systems requiring high refrigeration capacities
- High reliability resulting from the use of more than one compressor unit for production of refrigeration
- Reduced size of piping layouts in supermarkets and cold stores

1.2 Type Identification Key

V P P 3 2 0 - 4 23 0

Der Typenschlüssel ist anhand der Typenbezeichnung VPP 320 - 4230 erläutert .
Type VPP 320-4230 multicompressor refrigeration unit is used as an example to explain the identification key..
La clé des types est expliquée à l'exemple de la désignation VPP 320 - 4230.

Revision index

Reserved for major design modifications.

Compressor type

S e e : Motor-Compressor Type Identification Key

Compressor make

1 = *COPELAND* (Standard und Discus type)
2 = *COPELAND* (Scroll type)
3 =
4 = *BITZER*
6 = *DORIN*
8 = *L'Unité hermétique*
9 = *Other*

Auxiliaries

0 = Excluding refrigerant subcooler, excluding heat recovery
1 = Excluding refrigerant subooler, including heat recovery
5 = Including refrigerant subcooler, excluding heat recovery
6 = Including refrigerant subcooler, including heat recovery

Refrigeration unit controller

0 = *Excluding* mounted control cabinet and controller
1 = Electronic controller *T y p e VS 1000,* including control cabinet
2 = Electronic controller *T y p e VS 2000,* including control cabinet
3 = Thermostatic controller, including control cabinet
4 = Electronic controller *T y pe VS 2000 BS, for NT and LT compressors, including control cabinet*
6 = Electronic controller *T y p e CS 100,* including refrigeration controller and control cabinet
8 = controller *T y p e Carel EP1*

Number of compressor

Application

P = Normal-temperature refrigeration (Plus)
M = Low-temperature refrigeration (Minus)

Regrigerant

H = *R 22*
N = *R 134 a*
P = *R 404 A*
Z = *Special*

Multicompressor refrigeraiton unit

V = *Refrigeration unit*
B = *Booster compressor unit*
S = *Satellit compressor unitt*

Table 1

COPELAND COMPRESSOR UNITS

NORMAL-TEMPERATURE COOLING

Compressor Number	Compressor Type	Refrigerant R22	Refrigerant R134a R404A
101	D4DH - 150	0	
102	D4DJ - 200	0	
103	D6DH - 200	0	
104	D6DJ - 300	0	
105	D2DC - 50	0	X
106	DKM - 7	5	X
107	DKSJ - 10	0	X
108			
109			
110	DLHA - 50	0	X
111	DNRB - 40	0	
112	DNHB - 40	3	
113	DNRA - 50	0	
114	DNHA - 50	3	
115	DNHM - 60	3	
116	DMRH - 75	0	
117	D9RC - 100	0	
118	D9RS - 150	0	
119	D4SA - 200	0	
120	D4SH - 250	0	
121	D4SJ - 300	0	
122	D6SA - 300	0	
123	D6SH - 350	0	
124	D6SJ - 400	0	
125	D8RH - 500	0	
126	D8RJ - 600	0	
127	D2DD - 50	0	X
128	D2DL - 75	0	X
129	D2DB - 75	0	X
130	D3DA - 75	0	X
131	D3DC - 100	0	X
132	D3DS - 150	0	X
133	DLJ - 30	1	X
134	DKSL - 15	0	X
135	DKJ - 10	0	X
136	DKSJ - 15	0	X
137	DLE - 20	1	X
138	DLF - 30	1	X
139	DLL - 40	1	X
140	D3DA - 50	0	X
141	D3DC - 75	0	X
142	D3DS - 100	0	X
143	D2DB - 50	0	X
144	D2DL - 40	0	X
145	DKL - 15	0	X
146	DLF - 20	1	X
147	DLJ - 20	1	X
148	DLLF - 30	1	X
149	DLSGF - 40	1	X

LOW-TEMPERATURE COOLING

Compressor Number	Compressor Type	Refrigerant R22	Refrigerant R404A
101			
102			
103			
104			
105	D2DC - 50	0	X
106			
107			
108			
109			
110	DLHA - 50	0	X
111			
112			
113			
114			
115			
116			
117			
118			
119			
120			
121			
122			
123			
124			
125			
126			
127			
128			
129			
130			
131			
132			
133			
134			
135			
136			
137			
138			
139			
140	D3DA - 50	0	X
141	D3DC - 75	0	X
142	D3DS - 100	0	X
143	D2DB - 50	0	X
144	D2DL - 40	0	X
145	DKL - 15	0	
146	DLF - 20	1	
147	DLJ - 20	1	
148	DLLF - 30	1	
149	DLSGF - 40	1	X

Table 2

COPELAND COMPRESSOR UNITS

NORMAL-TEMPERATURE COOLING				***LOW-TEMPERATURE COOLING***			
		Refrigerant				***Refrigerant***	
Compressor Number	***Compressor Type***	***R22***	***R134a R404A***	***Compressor Number***	***Compressor Type***	***R22***	***R404A***
150	DMDH - 75	0		150			
151	D9DC - 100	0		151			
152	D9DS - 100	0		152			
153	D4DA - 200	0	X	153			
154	D4DH - 250	0	X	154			
155	D4DJ - 300	0	X	155			
156	D6DH - 350	0	X	156			
157	D6DJ - 400	0	X	157			
158	D8DH - 500	0		158			
159	D8DJ - 600	0		159			
160	DMDH - 50	0		160	DMDH - 50	0	
161	D9DA - 50	0		161			
162	D9DC - 75	0		162			
163	D9DS - 100	0		163			
164	D4DA - 100	0	X	164	D4DA - 100	0	
165	D4DL - 150	0	X	165	D4DL - 150	0	X
166	D4DT - 220	0	X	166	D4DT - 220	0	X
167	D6DL - 270	0	X	167	D6DL - 270	0	X
168	D6DT - 300	0	X	168	D6DT - 300	0	X
169	D8DL - 370	0	X	169			
170	D8DT - 450	0		170	D8DT - 450	0	X
171	D4DF - 100	0	X	171			
172	D9RA - 50	0L		172	D9RA - 50	0L	
173	D9RC - 75	0L		173	D9RC - 75	0L	
174	D9RS - 100	0L		174	D9RS - 100	0L	
175	D4RA - 100	0		175	D4RA - 100	0	
176	D4SF - 100	0		176	D4SF - 100	0	
177	D4SL - 150	0		177	D4SL - 150	0	
178	D6RA - 200	0		178	D6RA - 200	0	
179	D6SF - 200	0		179	D6SF - 200	0	
180	D6SL - 250	0		180	D6SL - 250	0	
181	D6ST - 300	0		181	D6ST - 300	0	
182				182			
183				183			
184				184			
185				185	D9TK - 076	0	
186				186	D9TL - 076	0	
187				187	D9TH - 076	0	
188				188	D9TH - 101	0	
189				189	D6RB - 100	0	
190				190	D6TM - 200	0	
191				191	D6TA - 150	0	
192				192	D6TH - 200	0	
193				193	D6TJ - 250	0	
194				194			
195				195			
196				196			
197				197			
198				198			
199				199			

Table 3

BITZER COMPRESSOR UNITS

NORMAL-TEMPERATURE COOLING

Compressor Number	*Compressor Type*	*Refrigerant* *R22*	*R134a R404A*
401	4 H – 15. 2	•	Y
402	4 H – 25. 2		
403	4 G – 20. 2	•	Y
404	4 G – 30. 2		
405	6 H – 25. 2	•	Y
406	6 H – 35. 2		
407	6 G – 30. 2	•	Y
408	6 G – 40. 2		
409	6 F – 40. 2	•	Y
410	6 F – 50. 2		
411	2 U – 3. 2	•	Y
412	2 U – 5. 2		
413	2 Q – 4. 2	•	Y
414	2 Q – 6. 2		
415			
416	2 N – 5. 2	•	Y
417	4 Z – 5. 2		
418	4 Z – 8. 2		
419	4 V – 6. 2	•	Y
420	4 V – 10. 2		
421	4 T – 8. 2	•	Y
422	4 T – 12. 2		
423	4 P – 10. 2	•	Y
424	4 P – 15. 2		
425	4 N – 12. 2	•	Y
426	4 N – 20. 2		
427	4 J – 13. 2	•	Y
428	4 J – 22. 2		
429	6 J – 22. 2	•	Y
430	6 J – 33. 2		
431	2 DL – 2. 2	•	Y
432	2 DL – 3. 2		
433			
434			
435			
436	2 EL – 2. 2		
437	2 EL – 3. 2		
438	2 CL – 3. 2	•	Y
439	2 CL – 4. 2		
440	2 N – 7. 2		
441			
442			
443	2 HC – 1. 2	•	Y
444	2 GC – 2. 2	•	Y
445	2 FC – 2. 2	•	Y
446			
447			
448			
449			
450			

LOW-TEMPERATURE COOLING

Compressor Number	*Compressor Type*	*Refrigerant* *R22*	*R404A*
401	4 H – 15. 2	•	Y
402			
403	4 G – 20. 2	•	Y
404			
405	6 H – 25. 2	•	Y
406			
407	6 G – 30. 2	•	Y
408			
409	6 F – 40. 2	•	Y
410			
411	2 U – 3. 2	•	Y
412			
413	2 Q – 4. 2	•	Y
414			
415	2 N – 4. 2		
416	2 N – 5. 2	•	Y
417			
418			
419	4 V – 6. 2	•	Y
420			
421	4 T – 8. 2	•	Y
422			
423	4 P – 10. 2	•	Y
424			
425	4 N – 12. 2	•	Y
426			
427	4 J – 13. 2	•	Y
428			
429	6 J – 22. 2	•	Y
430			
431	2 DL – 2. 2	•	Y
432	2 DL – 3. 2		
433			
434			
435			
436	2 EL – 2. 2		
437	2 EL – 3. 2		
438	2 CL – 3. 2	•	Y
439	2 CL – 4. 2		
440			
441			
442			
443	2 HC – 1. 2	•	Y
444	2 GC – 2. 2	•	Y
445	2 FC – 2. 2	•	Y
. . .			
. . .			
450	S 4 T – 5. 2	•	Y
451	S 4 N – 8. 2	•	Y
452	S 4 G – 12. 2	•	Y
453	S 6 J – 16. 2	•	Y
454	S 6 H – 20. 2	•	Y
455	S 6 G – 25. 2	•	Y
456	S 6 F – 30. 2	•	Y

• = Compressors for standard multicompressor refrigeration units

Table 4

BITZER COMPRESSOR UNITS

NORMAL-TEMPERATURE COOLING				*LOW-TEMPERATURE COOLING*			
		Refrigerant				*Refrigerant*	
Compressor Number	***Compressor Type***	***R22***	***R134a R404A***	***Compressor Number***	***Compressor Type***	***R22***	***R404A***
201				201			
202				202			
203				203			
204				204			
205				205			
206				206			
207				207			
208				208			
209				209			
210				210			
211	ZS 21 K4		•	211			
212	ZS 26 K4		•	212			
213	ZS 30 K4		•	213			
214	ZS 38 K4		•	214			
215	ZS 45 K4		•	215			
216				216			
217				217			
218				218			
219				219			
220				220			
221				221	ZF 09 K4		•
222				222	ZF 11 K4		•
223				223	ZF 13 K4		•
224				224	ZF 15 K4		•
225				225	ZF 18 K4		•

• = Compressors for standard multicompressor refrigeration units

1.3 Refrigerants Used

Primarily the multicompressor refrigeration systems work with **R404 A refrigerant.**

R404A, a refrigerant for normal-temperature and low-temperature refrigeration.
Tertiary mixture of R125 (52 %), R143a (44 %) and R134a (4 %).
Ozone depletion potential ODP = 0.0
Global warming potential HGWP = 0.94

R134a, chemical formula CH_2F-CF_3
Ozone depletion potential ODP = 0.0
Global warming potential HGWP = 0.27

R22, an HCFC compound, chemical formula $CHClF_2$.
Ozone depletion potential ODP = 0.05
Global warming potential HGWP = 0.35

R402A, drop-in refrigerant to replace R502 in conversion of refrigeration systems from CFCs.
Tertiary mixture of R22 (38 %), R125 (60 %) and R290 (2 %).
Ozone depletion potential ODP = 0.02
Global warming potential HGWP = 0.63
(See Installation Notes for Conversion from R502 to R402A [HP80])

Currently the following non-chlorine refrigerants are also used:

R717, ammonia, which is dealt with in separate instructions.

The minimum requirements to be fulfilled by these refrigerants are laid down in German Standard DIN 8960 and Tentative European Standard EN 378.

1.4 Oil in Refrigerant Circuit

In refrigeration systems working with oil-lubricated compressors, oil is entrained out of the compressor with the refrigerant vapor and enters the condenser. There it dissolves in the liquid refrigerant and is thus carried into the evaporator. The oil concentration in the liquid refrigerant progressively increases in the evaporator tubes and at the evaporator outlet (compressor suction line) droplets of oil are present in the evaporated vapor and on the sides of the tubes. This oil returns to the refrigeration unit with the flow of refrigerant vapor through the suction line.

With single-compressor refrigeration systems, return flow of the oil entrained from the compressor is not a problem provided the refrigerant piping is correctly sized due to the refrigerant flow remaining at almost constant velocity. The oil returns to the compressor via the suction line.

With multicompressor systems it is necessary for the suction line (see 1.6.4., page 20) to be designed so that oil return is properly maintained at all load conditions. Moreover the return oil flow must be distributed among the separate compressors of the unit according to need.

One way to do this is to install **oil level regulators**, namely mechanical float valves, on the crankcase of each compressor. In Linde multicompressor refrigeration units such oil level regulators are now only used on booster and satellite compressors.
Electronic oil level regulators can be used in multicompressor refrigeration units euqipped with scroll-type satellite compressors (Linde employs Trax-Oil made by Sporlan).

All other systems employ dynamic distribution of the oil to the separate compressors of the multicompressor unit, avoiding use of mechanical parts prone to wear.

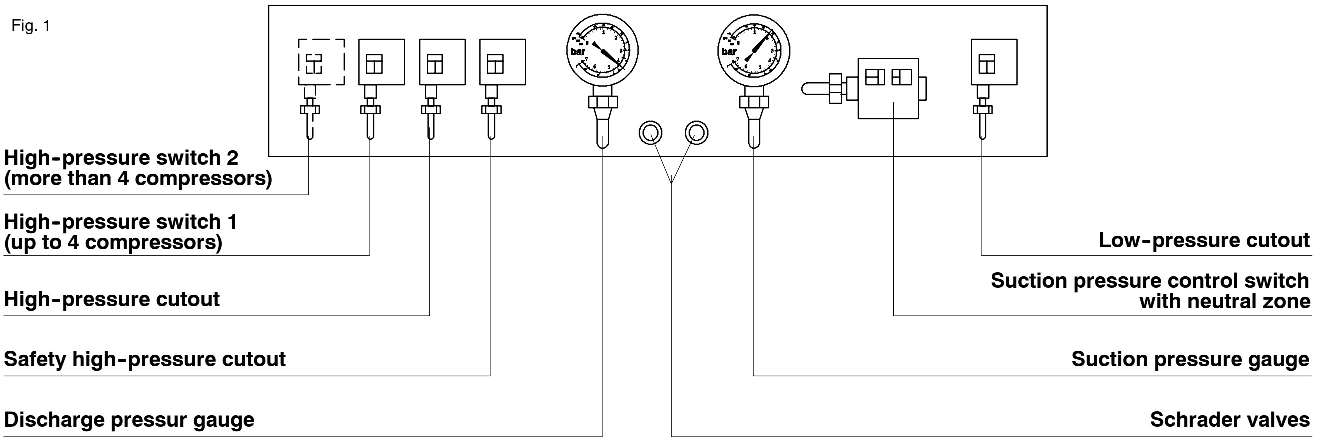
These units contain a specially designed **suction receiver** matched to the size and capacity of the unit and fitted with the internals necessary to provide for dynamic oil distribution (Linde patent). This is a multifunction vessel serving also as the oil receiver, oil cooler and, where required, liquid separator.

Single-stage multicompressor units have the suction receiver installed on the low-pressure (LP) side of the compressors. In two-stage multicompressor units it is installed between the LP stage discharge and the high-pressure (HP) stage suction, meaning that it is loaded by interstage pressure (see 4.1, page 36).

1.5 Instruments, Controls and Safety Devices

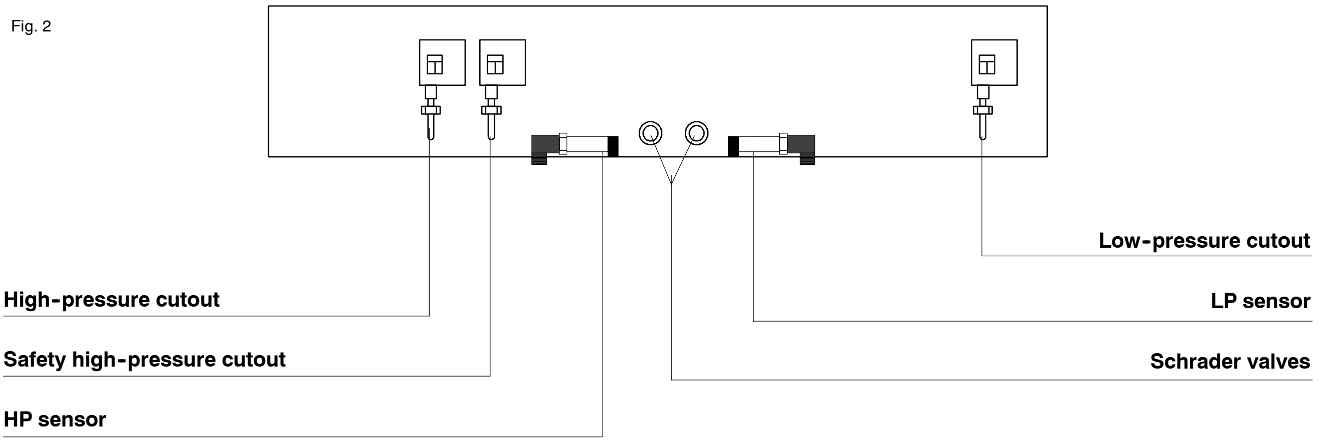
All instruments, controls and safety devices required for operation of the multicompressor refrigeration unit are neatly grouped on a control panel mounted on the unit. The devices illustrated are not all provided on every unit.

Fig. 1



Control panel for control by VS2000/VS1000 controller

Fig. 2



See the respective Sales Manual for exact details of instruments, controls and safety devices.

No suction or discharge pressure gauge is used on multicompressor refrigeration units equipped with the VS2000 controller, as the operating temperatures and pressures can be read out on the controller display.

Electronic capacity control ensures regulation of the refrigeration unit output to the system refrigeration load at all times.

For the most part the units are equipped with the Linde **VS2000** multicompressor system controller (or VS1000 for systems with more than four compressors). These microprocessor controllers incorporate considerably more functions necessary for operation of a multicompressor refrigeration unit than are provided by plain compressor controllers (see Service Manuals for VS1000 and VS2000).

Controllers supplied by other manufacturers, e.g., Kriwan, are also used. Separate instructions for these are supplied where necessary. Multicompressor refrigeration units equipped with scroll compressors are fitted with the Kriwan INT 2000 SD2 controller as standard.

All controls have a cyclic **compressor running sequence** function, which alternates running sequence of the compressors (e.g., every 2 hours) and thus provides for essentially equal running time of all compressors in the unit while enhancing reliability of dynamic oil distribution.

All multicompressor refrigeration units are fitted with safety devices to pertinent standards (in Germany VBG 20 Safety Code for Refrigeration Systems, Heat Pumps and Coolers and DIN Standard 8975).

Stipulated safety devices may include:	**High-pressure cutout, safety high-pressure cutout, high-pressure switch, low-pressure cutout**
For compressors with lube oil pump:	**Low oil pressure cutout, high-temperature cutout** monitoring cylinder head temperature (various devices)
Where necessary:	**High-pressure cutout** downstream of bursting disk

The control cabinet for the multicompressor unit is either mounted on the machine frame and fully wired or it is installed and connected on site.

Basic features of multicompressor refrigeration unit controllers

All Linde multicompressor refrigeration units have an identical control structure. The descriptions following cover all currently available options, which are however not implemented in their entirety in all multicompressor units. The actual scope of control functions and devices is defined in the circuit diagram applicable to the respective installation.

Circuit diagrams are divided as follows:

- *General control,* meaning the master control devices of the multicompressor unit.

Normal-temperature (NT) section

- *Compressors:* Power, control, oil sump heater
- *Condenser:* Power, control
- *Refrigeration points* (refrigeration consumers including defrosting): Power, control

Low-temperature (LT) section

- *Compressors:* Power, control, oil sump heater
- *Condenser:* Power, control
- *Refrigeration points* (refrigeration consumers including defrosting): Power, control

Power feed to the control cabinet is via the main switch and associate fuse.

Separate fuses are provided for general control and for control of compressors, heaters, condenser fans and refrigeration points.

Terminals are provided in the control power circuit for connection of an *emergency stop switch*, which may be required to be installed outside the machine room under pertinent safety codes or local regulations. If not required, these terminals must be jumpered.

Emergency stop switches must have a mechanical reset lock which maintains them in open position when actuated.

Compressors driven by motors with star-delta starting circuit (option) can be equipped with an external *starting unloader* (solenoid valve in bypass between discharge and suction lines). This solenoid valve is actuated during the star phase. Motors equipped for direct on-line or part-winding starting do not require external starting unload.

Internal starting unloaders installed by the compressor manufacturer in the cylinder heads may operate to other control criteria (see respective manufacturer's compressor manual).

Compressor run time is recorded by the VS2000/VS1000 controller, where installed. This controller will in future be replaced by the VS3000. Separate operating hours recorders are normally used with thermostatic compressor controllers.

Compressor running sequence is automatically alternated after an adjustable time (normally about 2 hours) with all controllers.

Most controllers incorporate a *load rejection* feature, which means that one or more compressors can be disabled and re-enabled by external control signal for the purpose of matching system power requirement to the pertinent power rate tariffs.

In the standard design *enabling of refrigeration points* is made as soon as one or more compressors is operative.

The following devices are designed to stop the compressors when the respective maximum or minimum setting is exceeded and to restart them without need to reset the device once the fault condition causing them to trip no longer exists:

> *High-pressure switch*, trips only one compressor of the unit. For example this will prevent the full number of compressors being tripped by the high-pressure cutout in the event of fouling of the condenser. No separate high-pressure switch is required when the VS2000/VS1000 is installed, as thus function is internal to the VS controller.
>
> Low-pressure cutout, simultaneously trips all running compressors. When suction pressure increases, the compressors are only restarted one at a time by the VS2000/VS1000 or other controller.

Vertical refrigerant receivers above about 40 litres capacity, or horizontal above about 25 litres, can be fitted with a *liquid level monitor*. Low liquid level is alarmed with time delay (about 1 hour). Thermostatic controllers use the same signal lamp to alarm *low suction pressure* and *low liquid level*.

The full number of compressors is shut down by the *high-pressure cutout* and *safety high-pressure cutout* on the respective pressure setting being exceeded.

Oil pressure is monitored on compressors equipped with a lube oil pump (excepting Bitzer Series 2U, 2Q and 2N compressors). The *low oil pressure cutouts* disable the respective compressor on oil differential pressure falling below the set level.

High-pressure cutout, safety high-pressure cutout and low oil pressure cutout must be manually reset on the device itself after being actuated.

After actuation of a *motor overload cutout* (compressor, auxiliary fan or condenser fan motor) or *high cylinder head temperature cutout*, the reset button on the control cabinet must be pressed. With the VS2000 controller, initialization of these two fault conditions does not require reset to be made on return to ”no fault” condition. Provision is however included for disabling automatic restarting.

Multicompressor unit capacity control is made as a function of suction pressure. See the VS2000/VS1000 Controller Service Manual or the respective manual for other controllers.

Compressor controllers of other make similarly use suction pressure as a control variable. The controller responds either to a suction pressure control switch with neutral zone (e.g., Danfoss RT200L or RT1A) or to a pressure transducer.

Provided no fault condition exists, the compressors can be started and stopped at any time by their *Manual-O-Automatic control switch.*

The *solenoid valves* in the *oil return lines* of two-stage multicompressor units open when the first compressor starts and close when the last compressor stops. The solenoid valves in the oil supply lines from oil level regulators on hermetic compressors however actuate only for a limited period (adjustable to about 1-5 minutes in 24 hours) so as to prevent overfilling the compressors with oil in the event of a leak on the oil level regulators.

The *solenoid valves* in the *refrigerant supply line* to the subcooler and desuperheater are usually connected so as to similarly open and close respectively on starting the first and stopping the last compressor. On multicompressor units equipped with more than four compressors, two solenoid valves rather than one are used for subcooling and desuperheating. They are installed upstream of two thermostatic expansion valves of different size. When the fourth compressor is loaded, cutover is made from the smaller to the larger expansion valve.

On two-stage multicompressor units for LT cold stores (more than four compressors), subcooler and desuperheater are supplied separately with refrigerant, similarly requiring two solenoid valves. The solenoid valve upstream of the subcooler expansion valve (which in this instance is a temperature controller) opens on starting the first compressor and closes on stopping the last compressor as described above. The solenoid valve upstream of the desuperheater expansion valve is controlled in response to compressor cylinder head temperature (sensed by the VS1000) or HP discharge line temperature on the multicompressor unit. The solenoid valve opens at 95 °C and closes at 85 °C.

Linde VS2000/VS1000 controllers are also usable to control the *condenser fans*. When using compressor controllers of other manufacture, the condenser fans must be controlled by pressure switches.
Program controllers are frequently used when the number of fans is two or more.

See the respective circuit diagram for control of variable-speed condenser fans.

Provided no fault condition exists, the fans can be started and stopped by a *Manual-O-Automatic control switch*.

With conventional controllers (not VS2000/VS1000), signal lamps are installed to indicate the following:

- *Control power*
- Compressor *running* and *fault*. Fault condition means motor overload (compressor and/or auxiliary fan), high cylinder head temperature or low oil pressure.
- *Low suction pressure, low liquid level*
- Condenser fan *running* and *fault*. Fault condition means motor overload.

Fault signals must be cancelled after correcting the fault condition, by resetting either on the device itself or on the control cabinet.

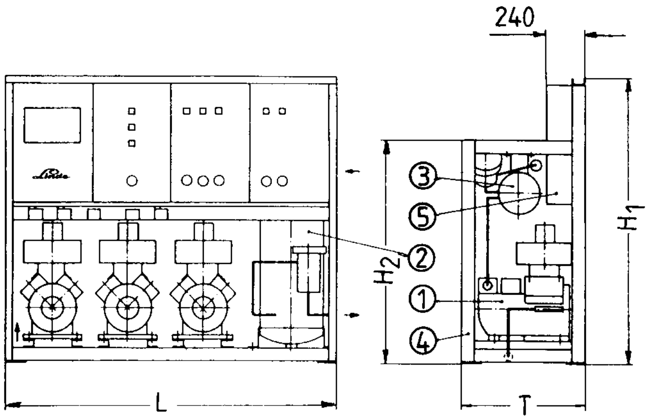
A collective fault alarm output (floating contact) is standardly provided and may be divided into Priority 1 and Priority 2 alarms.

The valid basis for system design is the circuit diagram supplied for the particular order. This is part of the equipment supply and is contained inside the control cabinet.

1.6 Installation

1.6.1 Measurements and weights

① Compressor
② Refrigerant receiver assembly
③ Suction receiver with filter-dryer
④ Machine frame
⑤ VS2000 and load control cabinet



Note:
Length 500 mm shorter if refrigerant receiver assembly not integrated; shortest overall length 1600 mm.
Not applicable to Mini multicompressor units.

Table 5

Type VHP	Type VRM	Length L mm	Width W mm	Height H_1 / H_2 mm
300-1331	300-1491	2100	790	1800/1400
300-1391	300-1721			
300-1151	300-1601			
300-1161	300-1401			
300-1501	300-1411			
300-1311	300-1421			
300-1321	300-4111			
300-4111	300-4131			
300-4131	300-4151			
300-4161	300-4191			
300-4191	300-4211			
300-4211	300-4231			
300-4231	300-4251			
300-4251				
300-1531	300-1641	2600	790	1800/1400
300-1541	300-1651			
300-1551	300-1661			
300-4271	300-4271			
300-4011	300-4011			
300-4031	300-4031			
300-4291	300-4291			
300-4051	300-4051			
300-4071	300-4071			
300-4091	300-4091			
400-4091			1250[1])	1800/1600[2])

Type VHP	Type VRM/VHM	Length L mm	Width W mm	Height H_1 / H_2 mm
	305-1491	2100	790	1800
	405-1491	2600		
	305-1851			
	305-1861			
	305-1871			
	305-1891			1950
	305-1901			
	305-4501			1800
	305-4511			
	305-4521			1830
	305-4531			1950
	305-4541			
	305-4551			
	405-1871	3100	790	1830
	305-4561			1950
300-1561	300-1671			1800/1400
300-1571	300-1681			
400-4071	400-4071			
	400-4091			
500-4091			1250[1])	1800/1600
	405-4551	3600	790	1950
	405-4561			2050
	505-4561			2100
400-1561	400-1671			1800/1600
400-1571	400-1681			
500-1571			1250[1])	
	605-4561	4100	790	2100
	500-1681			1800/1600
	500-4091			
600-1571	600-1681		1250[1])	
500-4091	600-4091			
500-1591	500-1701		1700	1800/1800
600-1591	600-1701			

1) Refrigerant receiver assembly behind machine frame
2) Suction header on machine frame
H_1) Height of VS2000 and load control cabinet
H_2) Height excluding VS2000 and load control cabinet, including subcooler

Table 6

Copeland Standard Compressors for Mini Multicompressor Unit

Type VHP	1) kg	2) kg	Type VHP	1) kg	2) kg	Type VHP	1) kg	3) kg
300-1351	290		300-1451	290		300-1451	290	300
300-1361	290		300-1461	290		300-1461	290	300
300-1371	400		300-1471	400		300-1471	400	420
300-1381	410		300-1481	400		300-1481	400	420

Copeland Standard Compressors

Type VHP	1) kg	2) kg	Type VRM	1) kg	2) kg
300-1331	510	650	300-1491	720	860
300-1391	530	670	300-1721	890	1030
300-1151	910	1050	300-1601	850	990
300-1161	880	1020	300-1401	930	1070
300-1501	850	990	300-1411	970	1110
300-1311	980	1120	300-1421	1030	1170
300-1321	1040	1180	300-1641	1140	1320
300-1531	1140	1320	300-1651	1230	1410
300-1541	1250	1430	300-1661	1250	1430
300-1551	1310	1490	300-1671	1380	1610
300-1561	1410	1640	300-1681	1460	1690
300-1571	1500	1730	400-1671	1710	1990
400-1561	1730	2010	400-1681	1800	2080
400-1571	1840	2120	500-1681	2110	2440
500-1571	2150	2430	600-1681	2390	2720
600-1571	2490	2820	500-1701	2680	3010
500-1591	2720	3050	600-1701	3070	3400
600-1591	3120	3450			

Type VHM	1) kg	2) kg
305-1491	740	
405-1491	875	
305-1851	1030	1250
305-1861	1035	1260
305-1871	1035	1260
405-1871	1290	1570
305-1891	1190	1415
305-1901	1295	1520

BITZER Standard Compressors

Type VHP	1) kg	2) kg	Type VRM	1) kg	2) kg
300-4111	650	790	300-4111	640	780
300-4131	660	800	300-4131	650	790
300-4161	700	840	300-4151	680	820
300-4191	840	980	300-4191	820	960
300-4211	860	1000	300-4211	830	970
300-4231	880	1020	300-4231	860	1000
300-4251	920	1060	300-4251	870	1010
300-4271	1075	1255	300-4271	1020	1200
300-4011	1090	1270	300-4011	1050	1230
300-4031	1130	1310	300-4031	1100	1280
300-4291	1230	1410	300-4291	1160	1340
300-4051	1270	1450	300-4051	1230	1410
300-4071	1300	1480	300-4071	1240	1420
300-4091	1340	1520	300-4091	1300	1480
400-4071	1610	1840	400-4071	1590	1820
400-4091	1640	1820	400-4091	1650	1880
500-4091	1970	2200	500-4091	2030	2360
600-4091	2370	2700	600-4091	2320	2650

Type VHM	1) kg	2) kg
305-4501	930	1155
305-4511	955	1180
305-4521	1110	1335
305-4531	1290	1515
305-4541	1330	1555
305-4551	1390	1615
405-4551	1780	2115
305-4561	1465	1745
405-4561	1865	2195
505-4561	2210	2605
605-4561	2530	2930

1) Excluding auxiliary components, excluding fluids

2) Excluding auxiliary components, excluding fluids, including VS1000/2000 and load control cabinet

3) Excluding auxiliary components, excluding fluids, including subcooler

Table 7

NT - Bitzer R134a

No.	Type VNP	Dimensions L mm	Prof. mm	mm	mm	Weight without/with cabinet kg	kg
1	320-4110	2100	790	1800	1400	650	840
2	320-4130	2100	790	1800	1400	660	850
3	320-4160	2100	790	1800	1400	685	870
4	320-4190	2100	790	1800	1400	825	1010
5	320-4210	2100	790	1800	1400	845	1030
6	320-4230	2100	790	1800	1400	865	1050
7	320-4250	2100	790	1800	1400	900	1090
8	320-4270	2600	790	1800	1400	1055	1280
9	320-4010	2600	790	1800	1400	1070	1295
10	320-4030	2600	790	1800	1400	1110	1335
11	320-4290	2600	790	1800	1400	1190	1415
12	320-4050	2600	790	1800	1400	1230	1455
13	320-4070	2600	790	1800	1400	1270	1495
14	320-4090	2600	790	1800	1400	1310	1535
15	420-4070	3100	790	1800	1400	1600	1890
16	420-4090	3100	790	1800	1400	1660	1960
17	510-4090	4100	790	1800	1400	2030	2310
18	610-4090	4100	1250	1800	1600	2320	2720

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 8

NT - Copeland R134a

No.	Type VNP	Dimensions L mm	Prof. mm	mm	mm	Weight without/with cabinet kg	kg
	MINI						
1	300-1450	1600	600	1000	---	290	---
2	300-1340	1600	600	1000	---	290	---
3	300-1460	1600	600	1000	---	400	---
4	300-1470	1600	600	1000	---	410	---
5	300-1480	1600	600	1000	---	410	---
6	320-1490	2100	790	1800	1400	720	905
7	320-1430	2100	790	1800	1400	925	1110
8	320-1400	2100	790	1800	1400	930	1115
9	320-1410	2100	790	1800	1400	970	1155
10	320-1420	2100	790	1800	1400	1050	1235
11	320-1640	2600	790	1800	1400	1160	1385
12	320-1010	2600	790	1800	1400	1230	1455
13	320-1020	2600	790	1800	1400	1250	1475
14	320-1030	3100	790	1800	1400	1360	1645
15	320-1040	3100	790	1800	1400	1470	1755
16	420-1030	3600	790	1800	1400	1680	2010
17	420-1040	3600	790	1800	1400	1815	2145
18	510-1040	4100	790	1800	1400	2125	2520
19	610-1040	4100	1250	1800	1600	2410	2805

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 9

NT - Bitzer R404A

No.	Type	Dimensions				Weight	
		L	Prof.		H2	without/with cabinet	
	VPP	mm	mm	mm	mm	kg	kg
1	320-4110	2100	790	1800	1400	650	840
2	320-4130	2100	790	1800	1400	660	850
3	320-4160	2100	790	1800	1400	700	890
4	320-4190	2100	790	1800	1400	840	1030
5	320-4210	2100	790	1800	1400	860	1050
6	320-4230	2100	790	1800	1400	880	1070
7	320-4250	2100	790	1800	1400	920	1110
8	320-4270	2600	790	1800	1400	1075	1300
9	320-4010	2600	790	1800	1400	1090	1315
10	320-4030	2600	790	1800	1400	1160	1385
11	320-4290	2600	790	1800	1400	1230	1455
12	320-4050	2600	790	1800	1400	1245	1470
13	320-4070	2600	790	1800	1400	1300	1525
14	320-4090	2600	790	1800	1400	1340	1565
15	420-4070	3100	790	1800	1400	1610	1890
16	420-4090	2600	1250	1800	1600	1640	2320
17	510-4090	3100	1250	1800	1600	1995	2280
18	610-4090	4100	1250	1800	1600	2340	2740

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 10

NT - Copeland R404A

No.	Type	Dimensions				Weight	
	Type						
No.	Type	L	Prof.	H1	H2	without/with cabinet	
	VPP	mm	mm	mm	mm	kg	kg
	MINI						
1	300-1350	1600	600	1000	---	290	---
2	300-1360	1600	600	1000	---	290	---
3	300-1370	1600	600	1000	---	400	---
4	300-1380	1600	600	1000	---	410	---
	Standard						
5	320-1330	2100	790	1800	1400	510	695
6	320-1390	2100	790	1800	1400	530	715
7	320-1440	2100	790	1800	1400	910	1095
8	320-1290	2100	790	1800	1400	950	1135
9	320-1310	2100	790	1800	1400	980	1165
10	320-1320	2100	790	1800	1400	1040	1225
11	320-1530	2600	790	1800	1400	1160	1385
12	320-1540	2600	790	1800	1400	1250	1475
13	320-1550	2600	790	1800	1400	1310	1535
14	320-1560	3100	790	1800	1400	1410	1695
15	320-1570	3100	790	1800	1400	1500	1785
16	420-1560	3600	790	1800	1400	1730	2060
17	420-1570	3600	790	1800	1400	1840	2170
18	510-1570	3600	1250	1800	1400	2150	2480
19	610-1570	4100	1250	1800	1400	2450	2850

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 11

NT - Bitzer R22

No.	Type Type **VHP**	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight without/with cabinet kg	kg
1	320-4111	2100	790	1800	1400	650	790
2	320-4131	2100	790	1800	1400	660	800
3	320-4161	2100	790	1800	1400	700	840
4	320-4191	2100	790	1800	1400	840	980
5	320-4211	2100	790	1800	1400	860	1000
6	320-4231	2100	790	1800	1400	880	1020
7	320-4251	2100	790	1800	1400	920	1060
8	320-4271	2600	790	1800	1400	1075	1255
9	320-4011	2600	790	1800	1400	1090	1270
10	320-4031	2600	790	1800	1400	1130	1310
11	320-4291	2600	790	1800	1400	1230	1410
12	320-4051	2600	790	1800	1400	1230	1450
13	320-4071	2600	790	1800	1400	1300	1480
14	320-4091	2600	790	1800	1400	1340	1520
15	420-4071	3100	790	1800	1400	1610	1840
16	420-4091	2600	1250	1800	1600	1640	1820
17	510-4091	3100	1250	1800	1600	1970	2200
18	610-4091	4100	1250	1800	1600	2340	2700

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 12

Froid positif - Copeland R22

No.	Type Type **VHP**	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight without/with cabinet kg	kg
	MINI						
1	300-1351	1600	600	1000	---	290	---
2	300-1361	1600	600	1000	---	290	---
3	300-1371	1600	600	1000	---	400	---
4	300-1381	1600	600	1000	---	410	---
	Standard						
1	320-1331	2100	790	1800	1400	510	650
2	320-1391	2100	790	1800	1400	530	670
3	320-1271	2100	790	1800	1400	900	1040
4	320-1441	2100	790	1800	1400	910	1050
5	320-1291	2100	790	1800	1400	910	1050
6	320-1311	2100	790	1800	1400	980	1120
7	320-1321	2100	790	1800	1400	1040	1180
8	320-1531	2600	790	1800	1400	1140	1320
9	320-1541	2600	790	1800	1400	1250	1430
10	320-1551	2600	790	1800	1400	1310	1490
11	320-1561	3100	790	1800	1400	1410	1640
12	320-1571	3100	790	1800	1400	1500	1730
13	420-1561	3600	790	1800	1600	1730	2010
14	420-1571	3600	790	1800	1600	1840	2120
15	510-1571	3600	1250	1800	1600	2150	2430
16	610-1571	4100	1250	1800	1600	2490	2820
17	510-1591	4100	1700	1800	1800	2720	3050
18	610-1591	4100	1700	1800	1800	3120	3450

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 13

No.	Type VPP	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight without/with cabinet kg	kg
1	325-4110	2100	790	1800	1400	640	825
2	325-4130	2100	790	1800	1400	650	835
3	325-4160	2100	790	1800	1400	700	885
4	325-4190	2100	790	1800	1400	820	1005
5	325-4210	2100	790	1800	1400	840	1025
6	325-4230	2100	790	1800	1400	860	1045
7	325-4250	2100	790	1800	1400	870	1055
8	325-4270	2600	790	1800	1400	1025	1250
9	325-4010	2600	790	1800	1400	1050	1275
10	325-4030	2600	790	1800	1400	1100	1325
11	325-4290	2600	790	1800	1400	1160	1385
12	325-4050	2600	790	1800	1400	1230	1455
13	325-4070	2600	790	1800	1400	1240	1465
14	325-4090	2600	790	1800	1400	1300	1525
15	425-4070	3100	790	1800	1400	1565	1845
16	425-4090	3100	790	1800	1400	1650	1955
17	515-4090	4100	790	1800	1400	2030	2425
18	615-4090	4100	1250	1800	1400	2320	2715

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 14

No.	Type VPP	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight Poids without/with cabinet kg	kg
	MINI						
1	305-1450	1600	600	1000	---	290	---
2	305-1460	1600	600	1000	---	410	---
3	305-1470	1600	600	1000	---	400	---
4	305-1480	1600	600	1000	---	430	---
	Standard						
1	325-1490	2100	790	1800	1400	720	905
2	325-1440	2100	790	1800	1400	910	1095
3	325-1430	2100	790	1800	1400	910	1095
4	325-1400	2100	790	1800	1400	940	1125
5	325-1410	2100	790	1800	1400	970	1125
6	325-1420	2100	790	1800	1400	1030	1215
7	325-1650	2600	790	1800	1400	1230	1455
8	325-1660	2600	790	1800	1400	1250	1475
9	325-1670	3100	790	1800	1400	1380	1660
10	325-1680	3100	790	1800	1400	1460	1740
11	425-1670	3600	790	1800	1400	1710	2040
12	425-1680	3600	790	1800	1400	1800	2130
13	515-1680	4100	790	1800	1400	2110	2505
14	615-1680	4100	1250	1800	1400	2390	2785

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 15

No.	Type VHM	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight Poids without/with cabinet kg	kg
	Varicool						
1	305-4111	2100	790	1800	1400	670	---
2	305-4131	2100	790	1800	1400	680	---
3	305-4161	2100	790	1800	1400	725	---
	2-stage						
1	305-4501	2600	790	1800	---	930	1155
2	305-4511	2600	790	1800	---	955	1180
3	305-4521	2600	790	1830	---	1110	1335
4	305-4531	2600	790	1950	---	1290	1515
5	305-4541	2600	790	1950	---	1330	1555
6	305-4551	2600	790	1950	---	1390	1615
7	305-4561	2600	790	1950	---	1465	1745
8	405-4551	3100	790	1950	---	1780	2115
9	405-4561	3100	790	2050	---	1865	2195
10	505-4561	3600	790	2100	---	2210	2605
11	605-4561	4100	790	2100	---	2530	2930

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 16

No.	Type VHM	Dimensions L mm	Prof. mm	H1 mm	H2 mm	Weight Poids without/with cabinet kg	kg
	MINI						
1	305-1451	1600	600	1000	---	300	---
2	305-1461	1600	600	1000	---	420	---
3	305-1471	1600	600	1000	---	420	---
4	305-1481	1600	600	1000	---	450	---
	Standard						
1	305-1491	2100	790	1800	---	740	880
2	405-1491	2600	790	1800	---	875	1045
	Demand						
1	305-1431	2100	790	1800	---	895	---
2	305-1411	2100	790	1800	---	990	---
3	305-1421	2100	790	1800	---	1055	---
4	405-1421	2600	790	1800	---	1245	---
	2-stage						
1	305-1911	2600	790	1950	---	1275	1500
2	305-1921	2600	790	1950	---	1345	1570
3	305-1931	2600	790	1950	---	1380	1605
4	405-1921	3100	790	1950	---	1670	1955
5	405-1931	3100	790	1950	---	1770	1985

Note: H1 = Height incl. VS.... and load control cabinet
H2 = Height excl. VS.... and load control cabinet, including subcooler

Table 17

SCROLL

No.	Type **VPP**	Dimensions Length	Width	Height	No. of compressors	Weight incl. control cabinet kg
1	230-2110	1000	750	910	2	210
2	230-2120	1000	750	910	2	210
3	230-2130	1000	750	910	2	225
4	230-2140	1000	750	910	2	225
5	230-2150	1000	750	910	2	230
6	330-2140	1340	750	910	3	300
7	330-2150	1340	750	910	3	310
8	430-2140	1685	750	910	4	400
9	430-2150	1685	750	910	4	415

No.	Type **SPM**	Dimensions	No. of compressor	weight incl. control cabinet kg
1	105-2210	Dimensions (set) in dependence of NT compressors Length 1685 mmmax. for 6 compressors in all for NT and LT	1	+45
2	105-2220		1	+46
3	105-2230		1	+57
4	105-2240		1	+58
5	105-2250		1	+60
6	205-2210		2	+90
7	205-2220		2	+92
8	205-2230		2	+114
9	205-2240		2	+116
10	205-2250		2	+120

1.6.2 Handling the equipment

The machine frame is fitted with lifting lugs enabling the multicompressor unit to be lifted and transported by hoist or crane using suitable rope slings. Slings must never be attached to vessels, piping or the control cabinet.

The unit is usually transported at the installation site by platform or fork lift truck. The antivibration mounts on the base of the unit are located to afford entry for lifting forks or platforms.

As a rule, multicompressor refrigeration units are shipped to the site without packing or transport retainers.

As a precaution against causing damage, it is prohibited to climb or walk on the piping of the unit.

As supplied, all compressor stop valves are open, requiring them to be closed before commencing installation (and requiring appropriate attention at the time of commissioning). Refrigerant-containing equipment - piping, compressors, vessels - are filled with inert gas at excess pressure (10 bar).

Where possible the unit should be installed in a frostproof location. Otherwise special precautions must be taken to protect the equipment while shut down (e.g., higher-capacity heater in compressor oil sump).

1.6.3 Siting the multicompressor refrigeration unit

Note: The floor on which the unit is to be installed must be capable of supporting the total mass of the unit, which requires attention to the permissible total weight per unit area.

Depending on type, the unit can be installed either on a smooth, level concrete floor and fastened with suitable anchors and bolts or it is installed on antivibration mounts. Mini multicompressor refrigeration units do not require fastening to the floor.

When multicompressor refrigeration units are installed in the vicinity of residential quarters or work areas, consideration is required to structure-borne transmission of noise as well as transmission of vibrations. Appropriate insulation measures need to be established in advance at the time of planning the system or building.

Antivibration mounts are designed for the weight of specific multicompressor units and must not be installed or exchanged indiscriminately.

The machine frame must always be aligned. So as to ensure proper oil distribution, the suction receiver must be aligned exactly horizontal. To do so, measure with a spirit level in both horizontal directions and align with shims under the antivibration mounts. If the unit is fastened directly to the floor, alignment shims must be inserted directly under the machine frame. Place Mini multicompressor units equipped with hermetic compressors on a level floor surface. Vibration control is accomplished by supporting each compressor in the machine frame on rubber mounts.

1.6.4 Rising suction lines

Suction lines running from the floor duct to the multicompressor unit must be of smaller bore size than the incoming ring main in order to ensure correct oil return. The pressure drop incurred within this section of the line is negligibly small.

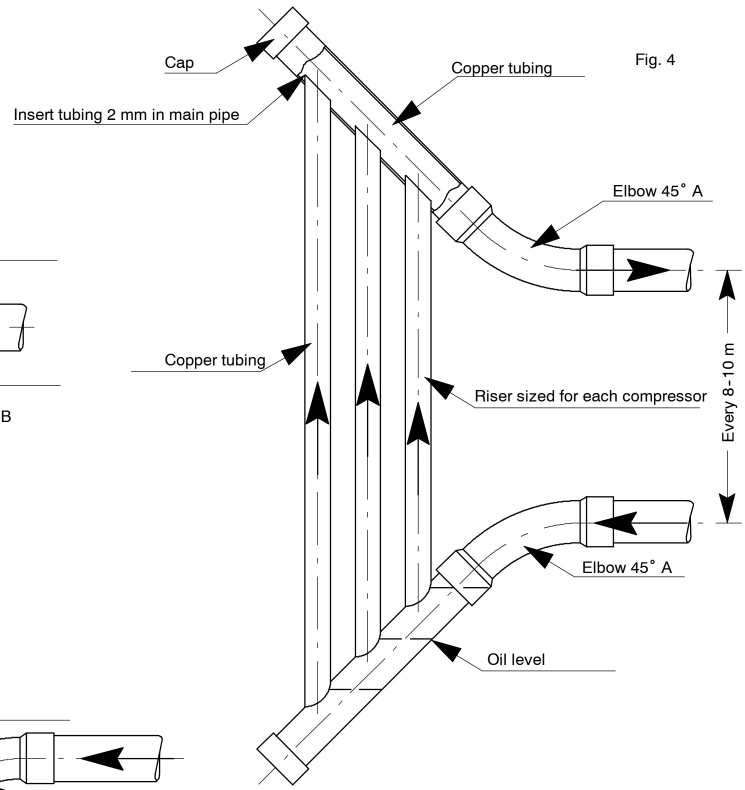


Fig. 4

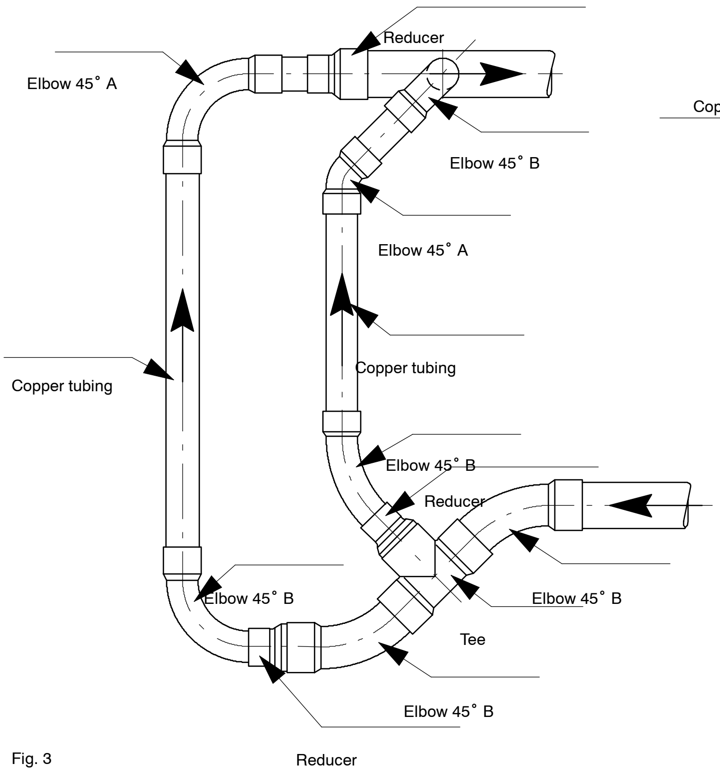


Fig. 3

Rising lines are frequently **split** into several lines of different diameter. Connect the largest-bore riser to the horizontal main line with an oil trap (siphon). In part load conditions this branch of the line will be closed by an accumulating seal of oil. The quantity of oil contained in these traps on suction lines should be maintained as small as possible, because the oil drains in a sudden surge to the multicompressor unit when compressors are loaded.

Owing to the limited capacity of the suction receiver into which the suction line opens on single-stage multicompressor refrigeration units, surplus oil will pass directly into the compressor, where it might cause damage to the cylinder head gaskets and valve plates.

On two-stage multicompressor refrigeration units the suction line is connected to a *suction distributor* rather than to the suction receiver. This is even less capable than the suction receiver of accommodating a large surge of oil. Due to the motor and compressor compartment being at interstage pressure, the LP suction lines are connected directly to the cylinder heads. Any liquid, refrigerant or oil, reaching this point would be taken directly into the cylinders.

Figs. 3 and 4 on page 20 illustrate layouts which ensure that the volume of oil that can accumulate in the split suction lines is suitably limited.

1.6.5 Connecting the refrigerant lines

Prior to delivery, all multicompressor refrigeration units are put through factory leak test, after which they are filled with inert gas at 10 bar. This pressure must be released before connecting the piping. When opening a valve, the internal pressure must be distinctly heard and felt to escape. If not, there is a leak at some point of the unit, which must be localized and repaired at the latest when making leak test on the complete refrigeration system. When using ester oil, leaks can result in premature spoilage of the oil (see 1.8, page 25).

Pipes at least larger than 22 mm diameter on multicompressor refrigeration units installed on antivibration mounts must be connected to the site piping by flexible corrugated pipe sections and not by rigid joints. These flexible pipes must not be installed in the (normally advantageous) vertical position on the suction side. Only horizontal runs (parallel to the compressors) are permissible so as to avoid icing and with it risk of damage to the transition between flexible pipe and soldering nozzle.

On two-stage multicompressor units, branchoff from liquid refrigerant lines to thermostatic expansion valves for subcooler and LP discharge vapor desuperheater must always be made at the bottom of a horizontal run of pipe so as to ensure priority supply of refrigerant to these expansion valves when liquid level is low.

1.6.6 Cleanness in piping installation

Care is taken to ensure cleanness during factory assembly of the multicompressor unit. It is essential to maintain the same cleanness during installation of the refrigeration system piping for protection of the compressors and other components sensitive to dirt. Many malfunctions, for instance failure of thermostatic expansion valves and leaking solenoid valves, are wholly attributable to dirt in the system. The damage caused thereby is usually far in excess of the value of the failed component (spoilage of merchandise in refrigerated display cases, production losses). Moreover, replacement and cleaning of components necessitates opening the refrigerant circuit, which entails renewed risk of dirt and moisture entering.

Piping stock must therefore be kept in dry storage. Caps fitted on the ends of pipes protect the interior from dirt. Lengths of pipe must be recapped if not used fully. The same care must be exercised when installing valves, filter-dryers, strainers, vessels and other piping equipment.

Brazed joints must be made in a reducing atmosphere or with equivalent protection.

Caution is required when installing copper piping in floor ducts, pits and so on, where foul gases may occur in certain circumenstances. Hydrogen sulphide, H_2S, present in these gases causes selective corrosion of phosphours-containing brazing fillers, resulting in leaks at brazed joints.

To avoid damage to such copper piping, brazed joints made with phosphorus-containing filler must be painted with a coating adhering to metal. Alternatively, phosphours-free brazing filler, e.g. Degussa 4579 (L-Ag45Sn), may be used together with a flux such as Degussa H.

1.6.7 Testing for leaks

Leak test is made on the multicompressor unit at the factory. Even so, new leaks can occur during shipment, siting and installation. Therefore the multicompressor unit installed in a refrigeration system must be included in leak testing performed on the system when completed (this also includes evaporators in refrigerated display cases, coldrooms, etc.).

German regulations stipulate mandatory leak test on the refrigeration system in accordance with VBG Safety Codes prior to commissioning. Reference is made to DIN 8975 for the procedures to be observed. National and local regulations may apply in other countries. Within the European Union, Tentative Standard EN 378 may be applicable.

Leak test must be made at minimum 1 bar (gauge) pressure, not exceeding the allowable working pressure (which requires attention to the differences in allowable working pressure for the LP and HP sides). Test should preferably be made at allowable working pressure for detection of leaks by foaming agents, leak detector lamp or electronic leak detector.

When testing with leak detectors, approx. 10 %vol refrigerant must be added to the test gas (dry nitrogen), using exclusively the refrigerant stipulated for the system concerned. First fill in the refrigerant and then the nitrogen. Leak detector lamps are not usable with refrigerants R134a and R404A (or other chlorine-free refrigerants). The D-Tek or TEK-Made electronic leak detector made by Leybold/Inficon is an approved testing device.

DIN 8975 permits alternative vacuum leak testing. To do so, evacuate the complete system to at least 1.0 m bar (Caution: not all devices connected are vacuum-tight, e.g., pressure switches and bursting disks). Then make pressure hold test for 24 hours. Pressure rise during this period must not exceed 0.3 mbar.

Successful vacuum test also verifies dry condition of the system.

Leak test procedures are described in **Installation Notes for Pressure Testing** (section 6.3, page 48)

Before multicompressor refrigeration systems are commissioned in Germany, a ***Certificate of Test on Refrigeration System or Heat Pump*** must be completed (see Installation Circular MS/05/90).

1.7 Refrigerant

1.7.1 Notes on refrigerants

The most important requirement on a refrigerant with regard to satisfactory working of the system is minimum moisture content (less than 40 ppm water). As supplied, refrigerants contain 6 to 7 ppm moisture. To prevent any increase in this moisture level as far as possible, the system must be installed in dry state. Entry of moisture must be avoided during service work (do not open system components while still cold, thoroughly evacuate before restarting). Moist refrigerant is detrimental to system operation by effects both physical (icing) and chemical (coppering, decomposition of oil).

1.7.2 Working with refrigerants (FCs, HCFCs)

The following notes are adapted from the most recent version of the bulletin issued by the German Chemical Workers Compensation Society on working with fluorocarbons (FCs) and are applicable also to HCFCs.

A Properties

A 1 Some FCs have a low boiling point and therefore are highly volatile. They are marketed in the form of liquefied gases or colorless liquids.

A 2 FC vapors are perceptible by smell only in concentrations of about 20 %vol or higher in air.
Weaker concentrations are hardly or not at all perceptible.

A 3 Some FCs are potentially harmful to health.

Note by Hoechst AG:

The toxicologic properties of R134a have been investigated under a global cooperation program involving leading manufacturers of refrigerants. Tests have meanwhile been completed and show R134a to possess at least the same safety in toxicologic respects as R22. This enables recommendations for the workplace concentration of R134a to be set at 1000 ppm on an 8-hour weighted average.

A 4 Like other halocarbons, FCs are decomposed in the presence of open flames, hot or incandescent surfaces, ultraviolet light and electric arcs (welding arcs).
The products of decomposition thereby formed are toxic and even small concentrations will develop a strong irritating and alerting action.

A 5 Most FCs are incombustible and will not form explosive mixtures of vapor and air. FCs can enter into explosive reactions with alkaline and alkaline-earth metals.

Note by Hoechst AG:

R134a does not form ignitable mixtures with air under normal conditions, meaning at atmospheric pressure. Ignitable mixtures can form at pressures above atmospheric and in mixtures containing more than 60 % air. When conducting leak tests or pressure tests, R134a must never be employed together with air or oxygen.

B **Health hazards**

B 1 Some FCs are potentially harmful to health.

B 2 All FCs must be regarded as asphyxiating gases. They are hazardous when they displace the oxygen in air to less than the level necessary for respiration, namely less than 15 %vol.

B 3 Vapors of some liquid FCs produce a benumbing action in high concentrations.

B 4 FCs absorb lubricants from the skin, causing the skin to become dry and chapped, making it vulnerable to disease and infection. FCs must therefore not be used to clean skin.

B 5 Like all liquefied gases, liquid FCs can cause frostbite in contact with skin.

B 6 Smoking in an atmosphere containing FCs can lead to formation of toxic products of decomposition.

B 7 Even small concentrations of products of decomposition cause irritation of mucosa.

C **Storage**

C 1 FCs must be stored in a cool place. Vessels containing FCs must not be exposed to heat from the sun, hot piping and the like.

C 2 Storerooms must be well ventilated and the ventilation must be effective particularly at floor level, because FC vapors are heavier than air. When FCs are stored below ground level, a system must be installed to ensure adequate forced ventilation of the space prior to being entered and while occupied.

D **General precautions**

D 1 Good ventilation must be provided in all rooms and areas in which FCs are used.

D 2 FCs must not be filled into or stored in beverage bottles.

D 3 Liquid FCs which are not subject to codes and regulations pertaining to compressed gases are best stored in screw-capped metal containers. Galvanized containers are not suitable.

D 4 All containers must be legibly marked with the symbol identifying their contents (e.g., R134a).

D 5 FCs must not be discharged into drains or sewers.

E **Personal safety measures**

E 1 Suitable gloves must be worn when working with liquid FCs as a precaution against loss of skin lubricants and frostbite. A face shield must be worn for protection against possible splashes when filling and emptying equipment.

E 2 If contact of the skin with FCs is not avoidable in special circumstances, due care of the skin must be exercised both prior to and after contact.

E 3 Owing to the risk of asphyxiation, entering vessels and tight spaces where FCs and their vapors may be present entails life-threatening danger. Such vessels or spaces may only be entered with written permit of the company owner or duly authorized officer and while observing all prescribed safety measures.

E 4 Use of filter-type gasmasks is not permissible when entering vessels and tight spaces and when high concentrations of vapors are present. In all such instances, self-contained respiratory protection devices (e.g., hose masks, oxygen breathing apparatus or air-line masks) must be worn.

E 5 Rooms or spaces must be vacated immediately if a pungent odor is detected or if irritation of eyes and airways is experienced.

E 6 Consumption of alcohol and tobacco are prohibited when working with FCs.

F First aid

F 1 Consult a physician if ill effects are experienced during or after working with FCs. Notify the physician that the victim has been working with FCs.

F 2 In any acute distress, immediately remove the victim to the open air or a well ventilated area. Strip all items of clothing contaminated with FCs from the victim and remove them from the area. Lay the victim on an insulating surface and wrap in blankets to prevent loss of body heat. Always lay unconscious victims on their side so that saliva and vomit can drain from their mouth. The victim should hold still as well as possible and avoid all exertion. Immediately notify a physician.

F 3 Never leave the victim unsupervised.

F 4 If the victim's breathing has stopped, immediately begin artificial respiration (mouth-to-mouth or mouth-to-nose resuscitation). Continue resuscitation with an oxygen breathing apparatus if available. In cardiac arrest, artificial respiration must be combined with heart massage (external cardiac compression). Cardiac compression may however only be administered by persons specifically trained in the method. First aid measures must always be continued until a physician takes charge of the victim.

F 5 Do not give liquid to unconscious or seriously dazed victims.

F 6 If the victim is suspected of having swallowed liquid FCs, immediately induce vomiting to force out the FC provided the victim is fully conscious. Do not give castor oil or milk.

F 7 Administration of a suspension of medicinal charcoal in water is recommended to combine FCs remaining in the stomach.

F 8 Splashes of FCs entering the eyes can be blown out by a helper or fanned out by the victim himself. Then flush with liberal quantities of water. Do not wipe with a cloth.

G Physician's notes

G 1 Owing to the risk of ventricular fibrillation, do not use preparations of the adrenaline-ephedrine group (also no noradrenaline or norepinephrine) to treat shock.

G 2 Information for treatment of FC injuries or poisoning can be obtained from poison centers and major clinics.

1.7.3 Disposal

Disposal of refrigerants (R22, R134a, R402A and R404A) is handled by the supplier or special-line trade.

The used refrigerant must be removed from the system by means of an exhauster and filled into special recycling cylinders (identified by "R" mark).

In Germany a permit issued under German Pressure Vessel Code, Section 26, is required. In other countries, observance of pertinent national and local laws and regulations will be required.

The refrigerant cylinders may only be filled to a weight of 75 % of their capacity (in kg). A suitable weighing scale is therefore required for filling.

1.8 Refrigerating Machine Oil

It is not possible to use the same refrigerating machine oil with all of the refrigerants named.

The refrigerating machine oil currently employed by Linde for compressors of R22 and R404A multicompressor refrigeration units is **SHELL 22-12 Oil** (international designation **SHELL SD Refrigerator Oil**). This same oil was used earlier in R502 multicompressor units, meaning that when these are converted to R402A it is only necessary to make oil change but the make and grade of oil can be retained.

Multicompressor refrigeration units (Mini units) equipped with hermetic compressors are an exception, since they require oil of special temperature resistance. Exclusively **SHELL Frigo 2786** oil may be used in **MANEUROP** compressors.

New **chlorine-free refrigerants**, e.g., R134a and R404A, will not dissolve in SHELL SD Refrigerator Oil or other customary refrigerating machine oils used previously.

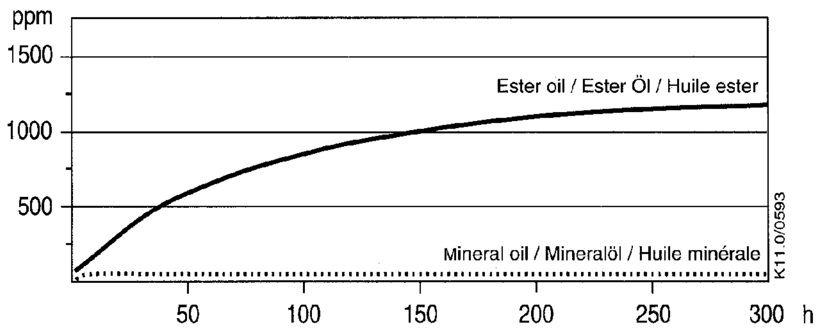
In refrigeration systems working with dry-expansion evaporators - as almost all multicompressor systems do - solubility of the refrigerant in the oil is however essential to good heat transfer in the evaporator and troublefree oil return to the compressors.

Multicompressor refrigeration units working with refrigerants like R134a and R404A are therefore lubricated with ester oils (usually polyol ester), in which these refrigerants are soluble. Two basic rules must definitely be observed when working with ester oils:

Ester oils must never be left standing in open containers.

These oils are extremely hygroscopic, which means they rapidly and liberally take up moisture from the atmosphere and are difficult to dry. The maximum permissible moisture content of around 200 ppm will be exceeded within at most two hours if the oil is left in an open container and exposed to air of 25 °C and 50 % relative humidity.

Fig. 5



Hygroscopicity of oils

Absorption of water by ester oil compared to mineral oil, in ppm by weight at 25 °C and 50 % relative humidity (time in hours).

Ester oils differ from previous refrigerating machine oils in that different makes and grades must not be mixed.

No two ester oils are alike. Some contain additives that can interreact, possibly causing precipitation and clogging. Our major compressor suppliers specify approved types of ester oil for their machines. When refilling, make certain that only the grade of oil specified on the label affixed to the compressor is used.

1.9 Commissioning

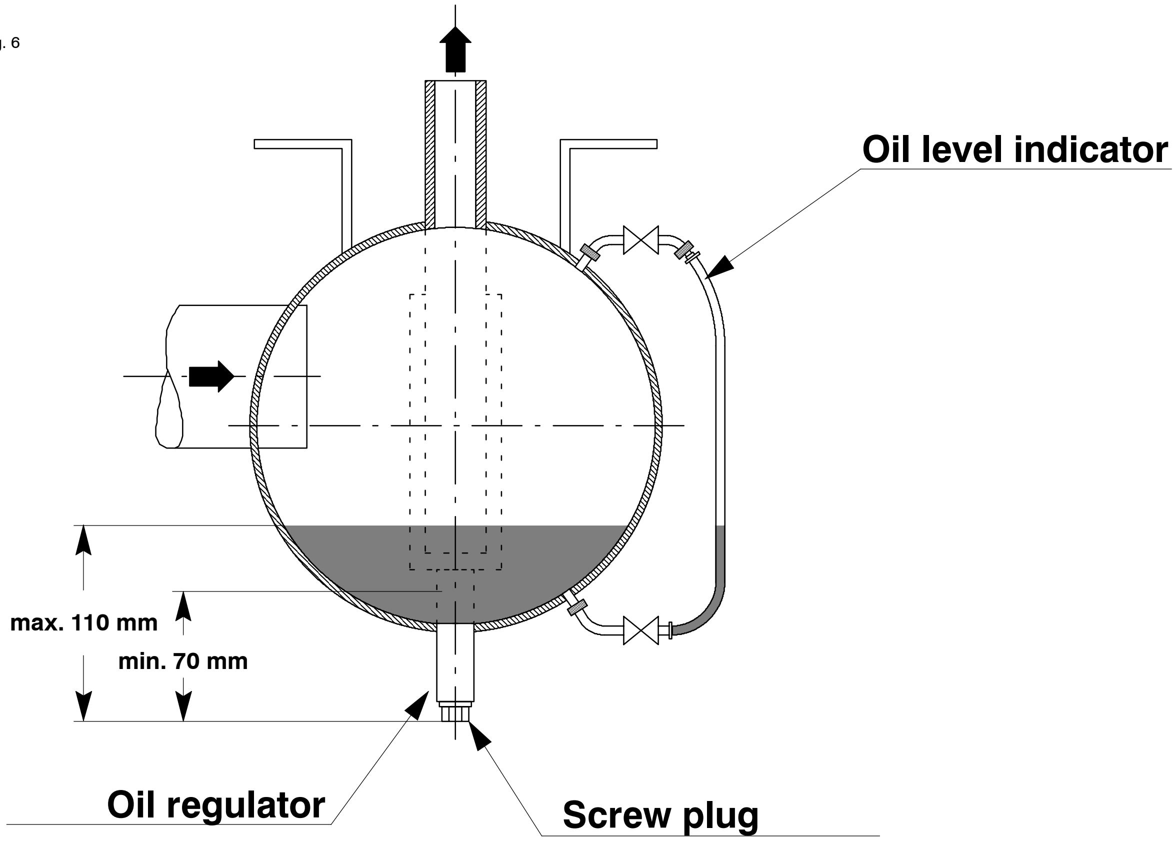
1.9.1 Filling the suction receiver

Conditions for ensuring satisfactory working of the suction receiver are:

a) Oil must be filled in to the level specified for the respective type of multicompressor unit.

b) The regulating screws for oil supply to the separate compressors must be adjusted in accordance with the tables listed in the following sections.

Fig. 6



Connections containing isolating valves (6 mm diameter) are provided at the highest and lowest points of the suction receiver and mounted on the machine frame. A transparent hose line can be connected to these fittings to serve as an oil level indicator.

Note: ***The transparent hose is not suitable for permanent installation, as it will gradually become corroded by the refrigerant!***

As supplied, the suction receiver is not filled with refrigerating machine oil. Filling is best undertaken by utilizing the vacuum in the system prior to charging with refrigerant.

Caution: Do not allow air to enter the system when filling in oil!

Differences need to be observed between multicompressor units equipped with semihermetic and hermetic compressors. On units with semihermetic compressors, either single-stage or two-stage, the suction receiver can be filled to 110 mm above the bottom edge of the screw plug as illustrated in *Fig. 6 , page 26*. With hermetic compressors, the maximum oil level for the first fill is only 70 mm. Fill in oil through the top connection on the suction receiver, which requires the transparent oil level hose to be detached temporarily. If the quantity of oil to be filled into the suction receiver is not known, proceed in steps, checking the level after each step. Do not overfill the suction receiver!

This first fill is often inadequate for normal operation, requiring oil to be refilled after commissioning the system.

Excess pressure will then exist in the system, resulting in risk of oil or refrigerant squirting out when refilling oil and handling the oil level hose. **Protective goggles must be worn!**

The total quantity of oil needing to be filled depends above all on the size of the refrigerant piping system. Other facts affecting oil filling quantity are differences in elevation between refrigeration points, multicompressor unit and condenser and the care taken during installation, for instance to ensure that horizontal lines slope gently in the direction of flow, rising lines are split and oil traps are not oversize. The required quantity above that filled into the suction receiver will normally be approximately 3 to 5 % of the quantity of refrigerant charged. Normally refill this amount while the system is **running**.

Three methods of refilling oil can be used:

a) Use of an oil filling pump

b) Use of an oil filling tank

c) Temporary creation of a vacuum in the suction receiver

As previously mentioned, two 6 x 1 mm pipes terminating in isolating valves are connected to the top and bottom of the suction receiver on the multicompressor unit. An oil filling pump can be connected to the upper of these.

The control panel contains two Schrader valves connected to the LP and HP sides. When using an oil filling tank, connect its top nozzle to the HP Schrader valve and bottom nozzle to the LP Schrader valve. Oil will then be forced into the suction receiver or suction distributor by the condenser pressure.

Slight vacuum (0.2 – 0.3 bar) can be created in the **suction receiver of single-stage multicompressor units** by throttling the suction line stop valve. Start only one compressor and watch the LP gauge. Oil can then be filled in by suction through a 6 x 1 mm copper pipe connected to the LP Schrader valve or the top connection on the suction receiver.

Alternatively oil can be refilled while the unit is shut down. To do so, close all stop valves in the inlet and outlet lines connected to the suction receiver and then generate slight vacuum in the suction receiver using an exhauster. Connect the exhauster to the top connection. Oil can be filled in simultaneously by suction at the bottom connection.

Caution: Do not overfill the suction receiver and never fill the suction distributor by the same method! Do not fill oil via the suction line filter! Exercise special care when working with ester oils!

Record the quantity of oil filled in the commissioning report. This will enable the correct quantity of oil to be filled in immediately during later oil changes.

1.9.2 Charging the refrigerant circuit

Proceed with charging the multicompressor refrigeration system with refrigerant after successful completion of leak test. Use exclusively the refrigerant specified on the nameplate. Any other refrigerant than that specified will cause serious trouble. If conversion is made to a different refrigerant, the nameplate must be amended accordingly.

The refrigerant charging procedure is as follows:

Utilizing the existing vacuum in the piping system, vessels and compressors, first fill refrigerating machine oil into the suction receiver as described above.

Then break vacuum with gaseous refrigerant. To do so, connect a refrigerant cylinder to the charge/drain valve via a suitable refrigerant-resistant hose or 6 x 1 mm copper pipe. Liquid refrigerant (including mixtures such as R402A or R404A) must never be filled in to break vacuum, because inadmissibly low temperatures can occur at such low pressure. Pressure in the system must first rise to 1.0 bar before liquid refrigerant can be filled in. This requires the solenoid valve in the liquid refrigerant line upstream of the thermostatic expansion valve to be de-energized, i.e., closed. First fill in no more than 70 % of the specified charge weight (see P&I Diagram). The remaining refrigerant can then be filled in the gaseous state via the service connection on the compressor suction stop valve with the compressor running. Recharge refrigerant mixtures such as R402A and R404A always in the liquid state, but filling them through the liquid line and never through the compressor suction side.

2. Single-Stage Multicompressor Refrigeration Units

2.1 Application Range

The application range for single-stage multicompressor refrigeration units is governed by these factors:

- Type of compressor, e.g., reciprocating (with or without suction gas cooling) or Scroll
- Equipment level of the compressors, e.g., auxiliary cooling fan, CIC system (Bitzer), demand cooling (Copeland)
- Refrigerant used

Multicompressor refrigeration units working with R404A refrigerant are designed for normal-temperature (NT) and low-temperature (LT) cooling.

NT Standard range	t_o = -10 °C		t_c = 45 °C

Refrigeration capacity range:

R404A	Q_o = 7.7 kW	to	475.2 kW
R134a	Q_o = 6.6 kW	to	274.4 kW
R22	Q_o = 7.3 kW	to	460.4 kW

The application range for these multicompressor refrigeration units covers evaporating temperatures as follows at a condensing temperature of t_c = 45°C:

R404A	t_o = 5 °C	to	t_o = -20 °C
R134a	t_o = 10 °C	to	t_o = -15 °C
R22	t_o = 5 °C	to	t_o = -20 °C

LT Standard range	t_o = -40 °C		t_c = 40 °C

Refrigeration capacity range:

R404A	Q_o = 5.6 kW	to	233.4 kW
R22	Q_o = 4.6 kW	to	170.1 kW

The application range for these multicompressor refrigeration units covers evaporating temperatures as follows at a condensing temperature of t_c = 40°C:

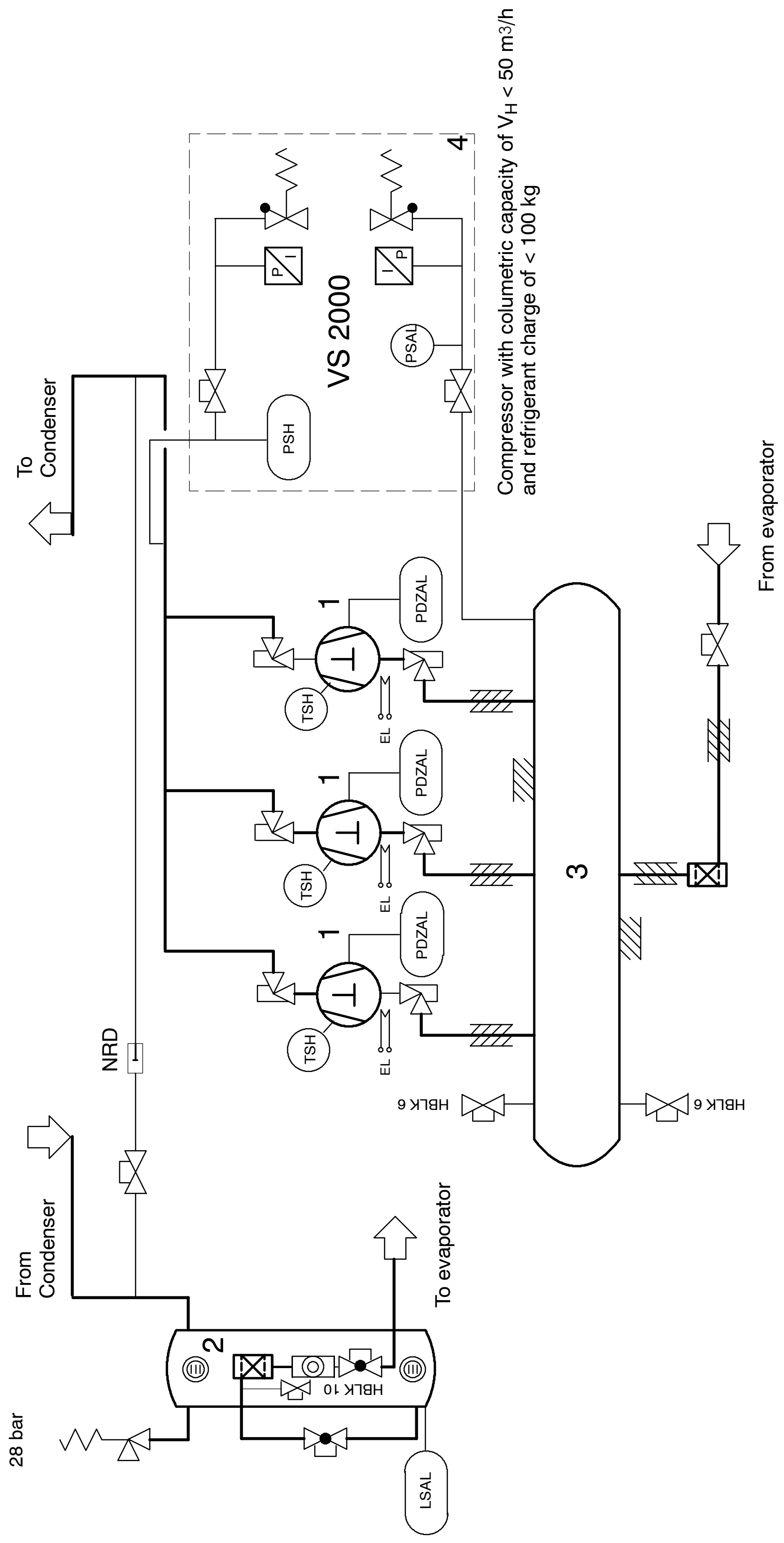
R404A	t_o = -25 °C	to	t_o = -50 °C
R22	t_o = -25 °C	to	t_o = -45 °C

2.2 Refrigeration Section

Single-stage multicompressor refrigeration units are used in refrigeration systems usually comprising a number of evaporators controlled by thermostatic or electronic expansion valves, an air-cooled condenser and a refrigerant receiver. In many instances a heat recovery exchanger is installed in the discharge line upstream of the condenser.

The compressors draw the slightly superheated refrigerant vapor from the evaporators and compress it to *condensing pressure*. The given condensing pressure and with it the condensing temperature (reading in temperature scale of pressure gauge) is high enough to enable the heat of condensation to be dissipated to the ambient air. Pressures occurring during condensation are dependent on the temperature of the ambient air, design and condition of the condenser, and the type of refrigerant used.

Fig. 7



Single-stage multicompressor refrigeration unit equipped with reciprocating compressors

1	Compressor
2	Liquid receiver
3	Suction receiver
4	Control panel

PSH	High-pressure switch
PSAL	Low-pressure cutout
P/I	Pressure transducer
LSAL	Niveauwächter
TSH	Discharge gas temp. sensor
PDZAL	Low oil pressure cutout

Similarly, *pressure in the evaporator* must be low enough for the respective evaporating temperature to permit transfer of heat from the product being cooled to the refrigerant in the evaporator. Removal of heat in this manner results in cooling of the product or maintaining its temperature at a desired low level. Heat entering the evaporator causes the liquid refrigerant inside it to evaporate. The refrigerant vapor is then drawn in by the compressors as described at the beginning.

In other words, the purpose of the compressors in a multicompressor refrigeration unit is to produce a refrigerant pressure in the evaporator which results in the refrigerant boiling point being low enough in the evaporator to remove heat from the air flowing through it and high enough in the condenser for this heat to be transferred to the surroundings. If a heat recovery exchanger is installed in the refrigerant circuit, the superheat and heat of condensation is utilized wholly or partly for space heating purposes or to produce hot service water. With an installation of this type, special attention must be paid to suitable piping runs.

2.2.1 Multicompressor refrigeration units with satellite compressors

A common configuration that offers advantages at times is to install a so-called *satellite compressor* in the machine frame of a multicompressor unit.

Satellite compressors are machines that have a suction line separate from the multicompressor unit, through which they draw refrigerant vapor at low evaporating pressure from one or more evaporators but discharge the compressed refrigerant into a common condenser.

2.3 Starting

Where necessary, set the safety valve on the refrigerant receiver to a blowoff pressure of **28 bar gauge**, in special instances to 25 bar (U.K., Denmark).

2.3.1 Settings for pressure cutouts and pressure switches, in bar gauge

Safety relief valve Refrigerant receiver (Blow-off valve)	28 bar (Standard) or 25 bar (only U.K. and Denmark)

Design pressure of plant HP side 25 bar

Table 18

Gerät		**R404A**				**R22**		**R134a**		**R402A**			
		Off	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**
Safety relief valve Refrigerant receiver	bar	**25 (GB / DK)**		**28 (Standard)**		**25 / 28**				**25 (GB / DK)**		**28 (Standard)**	
Safety high pressure cutout	°C bar	51,1 22,5	Reset manu.	55,6 25,0	Reset manu.	55,5 21,0	Reset manu.	55,2 14,0	Reset manu.	49,0 22,5	Reset manu.	53,5 25,0	Reset manu.
High-pressure cutout	°C bar	50,1 22,0	Reset manu.	54,7 24,5	Reset manu.	54,5 20,5	Reset manu.	53,9 13,5	Reset manu.	48,1 22,0	Reset manu.	52,6 24,5	Reset manu.
High-pressure switch	°C bar	49,2 21,5	40,8 17,5	53,8 24,0	46,2 20,0	53,4 20,0	44,3 16,0	52,4 13,0	39,4 9,0	47,1 21,5	38,8 17,5	51,8 24,0	44,2 20,0
Low oil pessure cutout	bar	0.7 (Unit set value) Please observe compressor data of manufacturer											
Time delay oil pressure monitoring	s	after 120 s max. Please observe compressor data of manufacturer											

Table 19

Gerät		**NT**		**LT**		**NT**		**LT**		**NT**		**LT**	
		Off	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**
Low-pressure cutout *	°C bar	-20,0 2,0	-16,0 2,5	-45,0 0,05	-40,0 0,35	-20,0 1,42	-16,0 1,85	-45,0 −0,2	-39,0 0,1	-20,0 0,32	-15,0 0,65	-45,0 0,1	-40,0 0,4

*) (at t_c = +45°C)

2.3.2 Setting the suction pressure control switch with neutral zone

Set the suction pressure control switch as specified by the project department or for refrigerated display cases as specified in Manual C1.

2.3.3 Settings for oil regulating valves on suction receiver of multicompressor refrigeration units equipped with reciprocating compressors

The oil regulating valves are mounted on the underside of the suction receiver. After removing the screw plug, the valve can be adjusted with a screwdriver. Use a screwdriver of correct bit size (6 mm) to prevent deforming the screw slot and risk of the valve plug binding in the screw thread.

The oil regulating valves on the compressors are factory-set according to compressor type. Settings are listed in Tables 19 and 20 below.

Individual readjustment of the oil regulating valves may be necessary if oil level differs in the compressor crankcases after the multicompressor unit has been commissioned.

Allocation of suction receivers to compressors and oil regulating valve settings for evaporating temperatures t_o (in °C)

Table 20 : NT range, R22 / R134a, R404A, t_c = 45 °C

Compressor Type	Suction receiver	Valve stem turns *					
Copeland	Type	5	±0	-5	-10	-15	-20
DKJ - 100 DKSJ - 150	A01	– –	5 –	9 6	9 7	11 9	12 10
DLE - 201 DLF - 301 DLJ - 301	A02	11 10 4	12 10 4	13 12 5	13 12 7	14 13 10	14 14 11
DLJ - 301 DLL - 401	A 1	7 4	9 6	12 10	12 11	14 13	14 14
D2DD - 500 D2DL - 400 D2DB - 750 D3DA - 750 D3DC - 1000	A 2	11 – 4 7 4	12 – 4 9 4	14 10 8 12 6	14 11 10 12 7	15 13 12 14 10	15 13 13 14 12
D3DS - 1500 D4DA - 2000	B 1	6 4	7 6	11 10	12 11	13 13	14 13
D4DH - 2500 D4DJ - 3000 D6DH - 3500 D6DJ - 4000	B 2	10 9 7 6	11 10 9 8	13 13 12 11	14 13 12 12	14 14 14 13	15 15 14 14

* Opening turns from closed position.

Table 21: **NT range,** R22, 134a, R404A, t_c = 45 °C

Compressor Type Bitzer	Suction receiver Type	Valve stem turns * 5	±0	-5	-10	-15	-20
2HC - 1.2 (2HL-1.2) 2FC - 2.2 (2FL-2.2)	A01			4 4	4 4	4 4	4 4
2DC - 2.2 (2DL-2.2) 2CC - 3.2 (2CL-3.2) 2U - 3.2 (4FC-3.2)	A02			4 4 4	4 4 4	5 4 4	8 6 4
2Q - 4.2 (4EC-4.2)	A 03			4	4	8	10
2Q - 4.2 (4EC-4.2)	A 1			4	4	8	10
2N - 5.2 (4DC-5.2)	A 03			4	4	6	8
2N - 5.2 (4DC-5.2) 4V - 6.2 (4CC-6.2) 4Z - 5.2	A 1			4 4 7	4 4 8	6 5 11	8 8 12
4T - 8.2 4P - 10.2	A 2			5 4	7 6	11 10	12 11
4N - 12.2 4J - 13.2 4H - 15.2	B 1			11 10 9	11 11 10	13 13 12	14 13 13
4G - 20.2 6J - 22.2 6H - 25.2 6G - 30.2 6F - 40.2	B 2			13 12 12 11 10	13 13 13 12 11	14 14 14 13 13	15 15 14 14 14

* Opening turns from closed position.

Table 22: **LT range,** R22, R 134a, R404A; t_c = 40 °C

Compressor Type Copeland	Suction receiver Type	Valve stem turns * -25	-30	-35	-40	-45
DKL - 150 DLF - 201	A01	7 4	9 6	10 8	11 10	12 –
DLJ - 201 DLL - 301	A02	12 11	13 11	14 12	15 13	– 15
DLSG - 401	A 1	14	14	15	15	15
D2DL - 400 D2DB - 500 D3DA - 500 D3DC - 750 D3DS -1000	A 2	14 13 13 13 11	14 14 14 13 12	15 14 14 14 13	15 15 14 14 13	15 15 15 14 14
D4DF -1000 D4DL -1500	B 1	14 13	14 14	14 14	15 14	15 15
D4DT -2200 D6DL -2700 D6DT -3000	B 2	15 15 14	15 15 15	15 15 15	15 15 15	15 15 15

* Opening turns from closed position.

Tabelle 23: **LT range**, R22, R 402A, R404A; t_c = 40 °C

Compressor Type Bitzer	Suction receiver Type	Valve stem turns *				
		-25	-30	-35	-40	-45
2HC - 1.2 (2HL-1.2) 2GC - 2.2 (2GL-2.2) 2FC - 2.2 (2FL-2.2)	A01	4 4 4	5 4 4	8 6 4	9 8 5	11 10 8
2DC - 2.2 (2DL-2.2) 2CC - 3.2 (2CL-3.2) 2U - 3.2 (4FC-3.2) 2Q - 4.2 (4EC-4.2)	A02	9 8 6 4	11 10 8 6	12 11 10 8	13 12 11 9	14 13 12 11
2U - 3.2 (4FC-3.2) 2Q - 4.2 (4EC-4.2) 2N - 5.2 (4DC-5.2) 4V - 6.2 (4DC-6.2)	A 1	12 11 10 9	13 12 11 11	14 13 12 12	14 13 12 12	14 14 13 13
4T - 8.2 4P - 10.2	A 2	12 12	13 13	14 13	14 14	14 14
4N - 12.2 4J - 13.2 4N - 15.2	B 1	14 14 14	14 14 14	15 15 14	15 15 15	15 15 15
4G - 20.2 6J - 22.2 6H - 25.2 6G - 30.2 6F - 40.2	B 2	15 15 15 15 14	15 15 15 15 14	15 15 15 15 15	15 15 15 15 15	15 15 15 15 15

* Opening turns from closed position.

Suction receivers A 03 and A 1 have identical compressor suction line connections, as do suction receivers A 04 and A 2. This means that the number of valve stem turns is identical on receivers having identical compressor suction line connections.

2.3.4 First startup

When first starting the system it is essential to remember that the refrigeration points are still warm, which means that refrigerant pressure on the LP side of the circuit can be considerably higher than design pressure.

This results in higher load on compressors and motors, which may even be higher than the permissible load, causing safety devices to actuate. It is also possible for refrigerant to migrate into the compressors. Malfunctions and damage, for example to the cylinder head gaskets, are not uncommon occurrences under these conditions.

Therefore it is essential to check prior to first startup that oil in the compressors is at a visible level and the compressors are at least at ambient temperature. If suction pressure is high, start the first compressor with tightly throttled suction stop valve. Then gradually open the suction stop valve as suction pressure decreases.

3. Multicompressor Refrigeration Units with Scroll Compressors

3.1 Application Range

NT Standard range to = -10°C tc = 45°C

Refrigeration capacity range

R 404A Qo = 10.2 kW bis 43.6 kW

LT Standard range to = -35°C tc = 45°C

Refrigeration capacity range

R 404A Qo = 2.07 kW bis 12.66 kW

3.2 Description

3.2.1 Operation

The working concept of a scroll compressor consists in crescent-shaped gas pockets being formed by two meshing scrolls, one stationary and one orbiting. As the one scroll orbits, the gas pockets are gradually forced toward the center of the two, reducing their volume and compressing the gas trapped in them. When each pocket aligns with the center of the scrolls, the highly compressed gas it contains is forced through the central discharge port. Since gas is compressed simultaneously in a multiple number of pockets and two pockets containing gas at the same pressure are aligned opposite at all times, compression takes place very evenly and almost continuously.

The main advantages of this type of compressor are:

- A low level of vibration and noise due to the continuous compression process and reduced number of moving parts.
- Resistance of the compressor to liquid slugging and foreign particles.
- Reduced space requirement and weight compared to semihermetic reciprocating compressors.

At the present time, exclusively Copeland scroll compressors of the following types are used:

ZS models, suitable for air conditioning and normal-temperature refrigeration applications.

ZF model, suitable for air conditioning and normal- and low-temperature refrigeration applications.

The difference between the ZS and ZF models is that ZF compressors used for LT refrigeration are additionally cooled during compression by injecting a small amount of refrigerant through a capillary tube in the center of the scrolls.

This method of injection is highly efficient and does not affect volumetric efficiency of the compressor. ZF models used for LT refrigeration are moreover fitted with a discharge gas thermostat which trips the compressor at high discharge temperature of about 100°C and restarts it automatically when temperature drops to about 70°C. The discharge gas thermostat should be installed about 120 mm downstream of the discharge valve outlet.

In order to avoid high starting moments, refrigerant that has entered the casing during compressor standstill must first be expelled.
This is accomplished by a casing heater which is switched on during standstill.

3.2.2 Oil supply to scroll compressors

Multicompressor refrigeration units equipped with maximum four compressors working in the same temperature range

Oil equalization takes place through a 15 mm diameter equalizing line connected to the compressor sightglass nozzles of each compressor.
Due to differing pressure in the LP section of the compressors - caused by variations in the oil entrained from the compressors or the amount of oil returning to the separate compressors with the suction gas - oil level in the compressors may differ.
So as to equalize oil level between the compressors, the unit is shut down for 2 minutes when one or more compressors have been operating longer than 3 hours.
During this brief shutdown, pressure equalizes in the full complement of compressors and with it the oil level.

<u>Multicompressor refrigeration units equipped with satellite scroll compressors</u>

In satellite operation, oil level is similarly equalized via an equalizing line connected to the compressor sightglass nozzles during the time the LT refrigeration points are being defrosted.
Oil equalizing lines of the LT and NT sections are interconnected by a directly operated solenoid valve. All LT refrigeration points must be defrosted at the same time for this method of oil regulation. When defrosting commences, the solenoid valve is opened. Due to the different pressures in the LP sections of the NT and LT compressors, surplus oil is initially forced from the NT compressors to the LT compressors. At the end of the defrosting cycle, when pressure is higher in the LT compressors than in the NT compressors, surplus oil is conversely forced from the LT compressors to the NT compressors.
On completion of defrosting, the solenoid valve is re-closed. It must be installed to provide tight sealing in the direction from the NT to the LT sections (direction of flow to LT section).
If it is not possible for all LT refrigeration points to be defrosted at the same time, pressure is increased in the LT compressors through a bypass from the HP to the LP side of these compressors. A check valve must be installed to prevent equalization of gas into the rest of the LT suction line. The bypass is re-closed after maximum 3 minutes.

<u>Multicompressor refrigeration units equipped with more than four scroll compressors</u>

When more than four compressors are working in the same temperature stage and when the compressors are tiered in the machine frame, use is made of oil separators, oil receivers and electronic oil level regulators.
Electronic oil level regulators (Linde uses Trax-Oil made by Sporlan) serve a safety function in addition to controlling oil supply to the compressors. They are electrically connected in the control circuit or safety loop. Power supply is 24 V.
When oil level falls below the setpoint, a solenoid valve opens to admit oil. After reaching the setpoint, the solenoid valve remains open for another 10 seconds. If oil level still remains below the setpoint after about 120 seconds, however, the internal relay actuates to trip the compressor and signal alarm. The solenoid valve remains energized when the internal relay actuates. The electronic oil level regulator will automatically restart the compressor when oil level returns to the setpoint.

3.3 Starting

Like some other types, scroll compressors can only compress gas in one direction of rotation.
Compressors operating on three-phase AC power may however rotate in either direction according to how the terminals are wired.
To check correct wiring connections, observe the compressor after switching it on to see whether pressure decreases on the suction side and increases on the discharge side. The wrong direction of rotation is indicated by a much higher noise level than when running correctly and the motor power input is very much lower than in normal operation (which may be checked against the performance tables).
Brief running in the wrong direction of rotation is not detrimental to the life of scroll compressors. However the internal motor cutout will actuate if allowed to run in this state for several minutes.

Scroll compressors do not need suction or discharge valves and therefore do not require functional check-out with the suction line closed to verify suction capacity. In fact, a scroll compressor might sustain damage if tested in this manner, as incidentally other types of compressor might.

When the suction side is closed off or blocked, a high vacuum develops in scroll compressors. This can lead to arcing on the internal contacts, resulting in compressor damage or failure.

In exceptional cases, scroll compressors may generate high running noise on startup. The cause may be jamming of the "floating seal ring" above the stationary scroll, which separates the HP and LP sections during normal operation.
This can be remedied by briefly increasing the condensing pressure (e.g., by throttling the HP shutoff valve), which will force the seal ring back into place.

Use the following check-out procedure to verify satisfactory working of scroll compressors:

1. Check that the power line connection is correct.
2. Make the usual tests for continuity on the motor coil and leakage current to determine whether the internal motor cutout has actuated or earthing has occurred. If the motor cutout (inside the compressor) has opened, let the compressor cool down for it to re-close.
3. Connect suction and discharge pressure gauges and start the compressor. If suction pressure falls below the normal level, either the system refrigerant charge is inadequate or the refrigerant circuit is blocked.
4. If suction pressure does not decrease and discharge pressure does not increase to the normal level, change the direction of rotation. To do so, switch off the power supply, change around two phases of the power cable at the terminals, and switch power supply back on. This will indicate whether the compressor was running in the wrong direction due to crossed phases. If normal pressures are still not obtained, the compressor is defective.
5. Compare power input of the compressor with the data listed for the respective operating conditions (pressures and voltages). Marked variation from the listed data (more than 15% up or down) may indicate a compressor defect.

Servicing

As supplied, the scroll compressors in multicompressor refrigeration units are filled with oil. This oil charge will usually not be adequate for normal operation, requiring oil to be refilled when the compressor is first commissioned. The required system oil charge depends mainly on the size of the refrigerant piping system.
When using ester oils, the oil charge should normally be about *2% to 4%* of the refrigerant charge.
Overfilling the refrigeration system with refrigerating machine oil is detrimental both to the compressors and to the heat exchange components (e.g., condenser, subcooler, evaporators) and should definitely be avoided.

Compressors delivered by Copeland are filled with the following ester oils:

Mobil EAL Arctic 22 CC

ICI Emkarate RL 32 CF

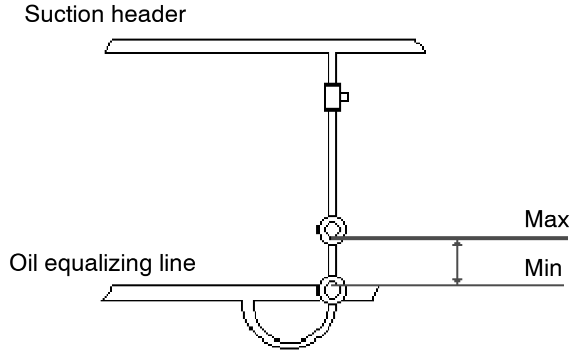
According to Copeland, these oils may be mixed.

Ester oil is extremely hygroscopic (absorbs water from the atmosphere), which affects stability of the oil.
When refilling ester oil, it should be taken from new and small containers so as to minimize the absorption of water to the extent possible.
Do not use oil from containers that have been open for longer than two hours.

When the refrigerant charge is removed from a scroll compressor system by evacuating the HP side alone, the scrolls may close, resulting in pressure not being able to equalize across the compressor. This will leave the LP section of the casing and the suction line still pressurized.
To prevent his happening, both the HP and the LP side must be evacuated.

Two sightglasses are installed between the suction line and oil equalizing line for visual check of oil level. A shutoff valve is installed above these sightglasses and connected to the system LP side (see Fig. 8).

Fig. 8



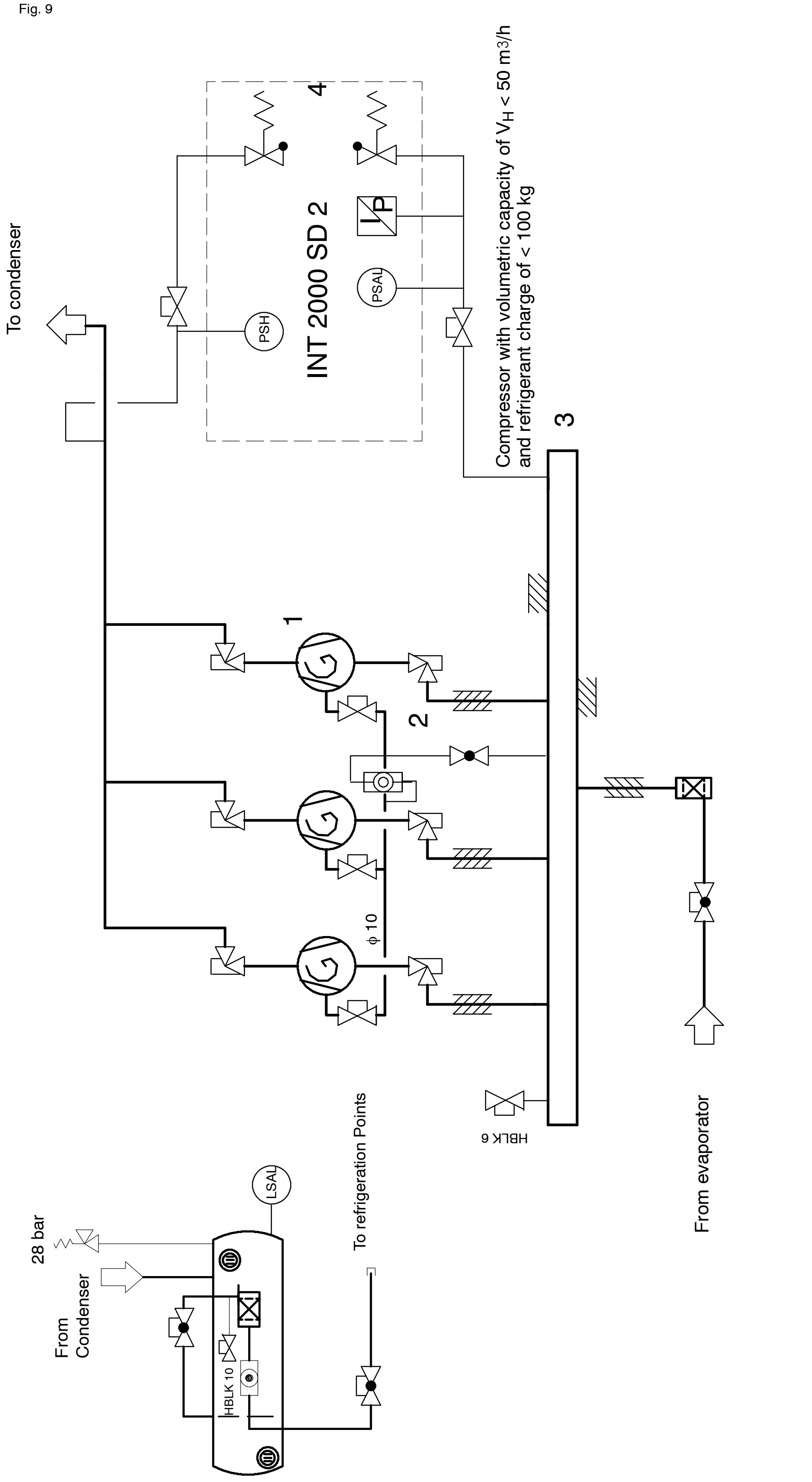
This arrangement is used for a maximum of four compressors each pressure stage.
The compressors must be mounted on the same plane.

The sightglasses serve only to check oil level at standstill.
To check oil level, all compressors of the same pressure stage must be stopped and the above-mentioned shutoff valve must be opened.
A meaningful reading of oil level can be made after the compressors have been stopped for about 5 minutes, allowing pressure to equalize.
Oil level is correct when between ¾ and top of the lower sightglass. The upper sightglass is provided as a precaution against overfilling with oil and no oil should be visible in this sightglass when the system is correctly charged. Refill or drain oil as and if necessary.

C A U T I O N

Make sure to re-close the stop valve after checking oil level and before restarting the compressors.

Fig. 9

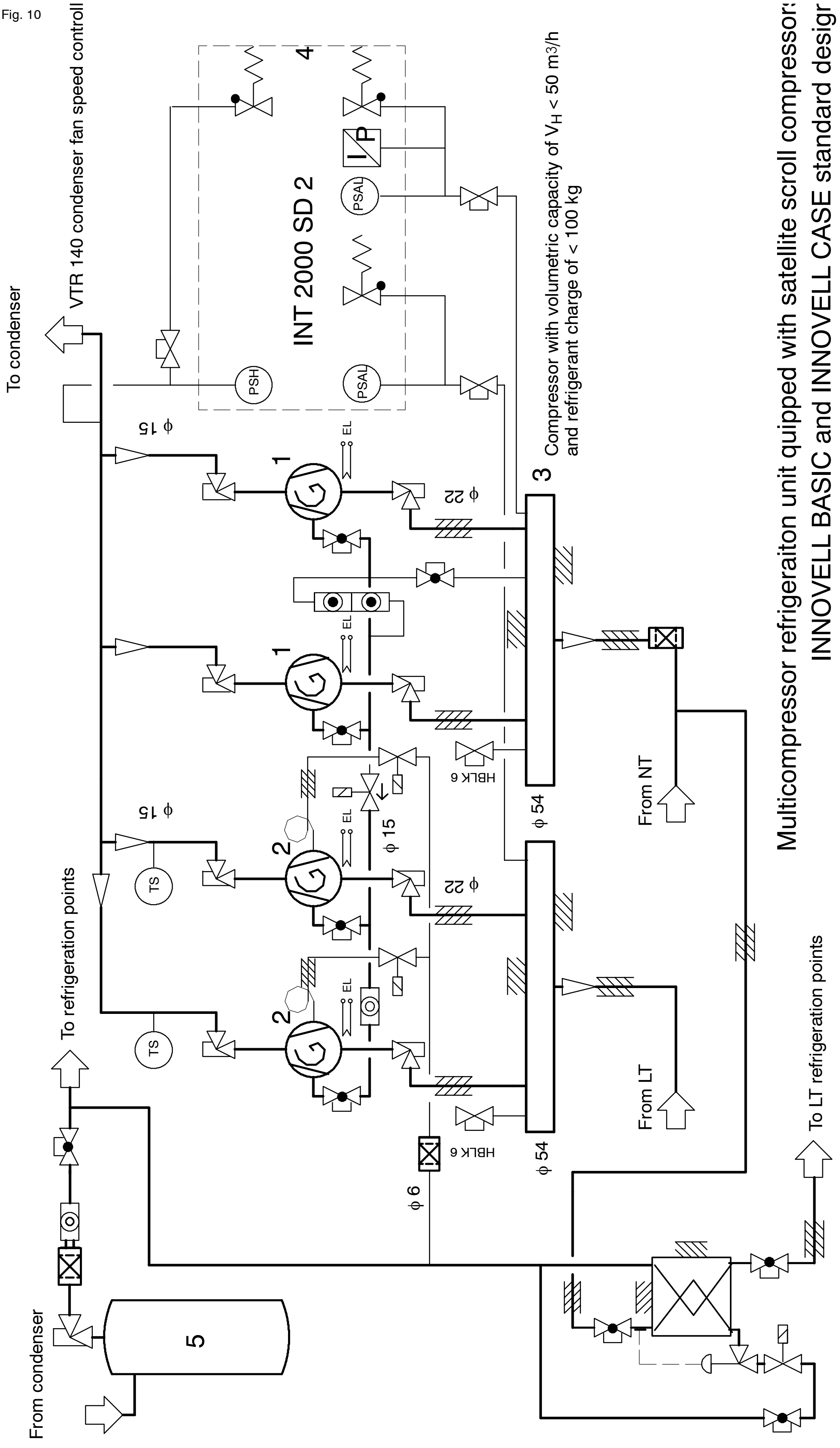


1	Scroll compressor
2	Oil level sightglass
3	Suction distributor
4	control panel

PSAL	Low-pressure cutout
PSH	High-pressure switch
P/I	Pressure transducer
LS	Low liquid level cutout

Singel-stage multicompressor refrigeration unit equipped with scroll compressors

Fig. 10



Multicompressor refrigeraiton unit quipped with satellite scroll compressor:
INNOVELL BASIC and INNOVELL CASE standard desigr

1	ZS Scroll compressor
2	ZF
3	Suction distributor, 54 mm dia.
4	Control panel
5	Liquid receiver, 8 litres

PSAL	Low-pressure cutout
PSH	High-pressure cutout
P/I	Pressure transducer
TS	High temperature switch

4. Multicompressor Refrigeration Units with Booster Compressors

4.1 Application Range

For the NT section see under 2.1, page 28.

LT Standard range		t_o = −35 °C	t_c = −10 °C
Refrigeration capacity range:			
	R22		Q_o = 1.4 kW to 5.2 kW

The application range for this multicompressor unit stage covers the following evaluating temperatures
R22 t_o = −25 °C to t_o = −45 °C

4.2 Description

4.2.1 Refrigeration section

Booster compressors enable low-temperature applications to be realized with comparative convenience when using refrigerant R22 and the multicompressor unit is required for normal-temperature cooling.

As shown in the diagram of Fig. LEERER MERKER on page LEERER MERKER, one or more compressors are installed upstream of the NT compressors. The compressors draw refrigerant vapor at correspondingly low pressure from LT evaporators and discharge the compressed refrigerant into the NT suction line. To reduce discharge temperature prior to mixing with the NT suction vapor, liquid refrigerant is injected into the booster compressor discharge line via a thermostatic expansion valve.

So as to be able to control oil return to the booster compressors they are fitted with oil level regulators. The oil is taken from the NT compressor suction receiver. Setting of the oil regulating valves is the same as for single-stage multicompressor refrigeration units.

Distribution of the return oil among the compressors of multicompressor units equipped with boosters and hermetic compressors takes place differently. As noted under 2.2 on page 28, these multicompressor units do not have a suction receiver. The intake NT suction line opens into a distributor pipe, to which the separate compressors are connected. The NT compressors are mounted at the same level in the machine frame and equipped with oil equalizing lines. Return oil flow is not preferentially fed to the compressors via the suction lines; instead it passes from the bottom of the distributor pipe into the oil equalizing line. Oil is supplied to the booster compressor in the same manner as for stellite scroll compressors.

4.2.2 Control

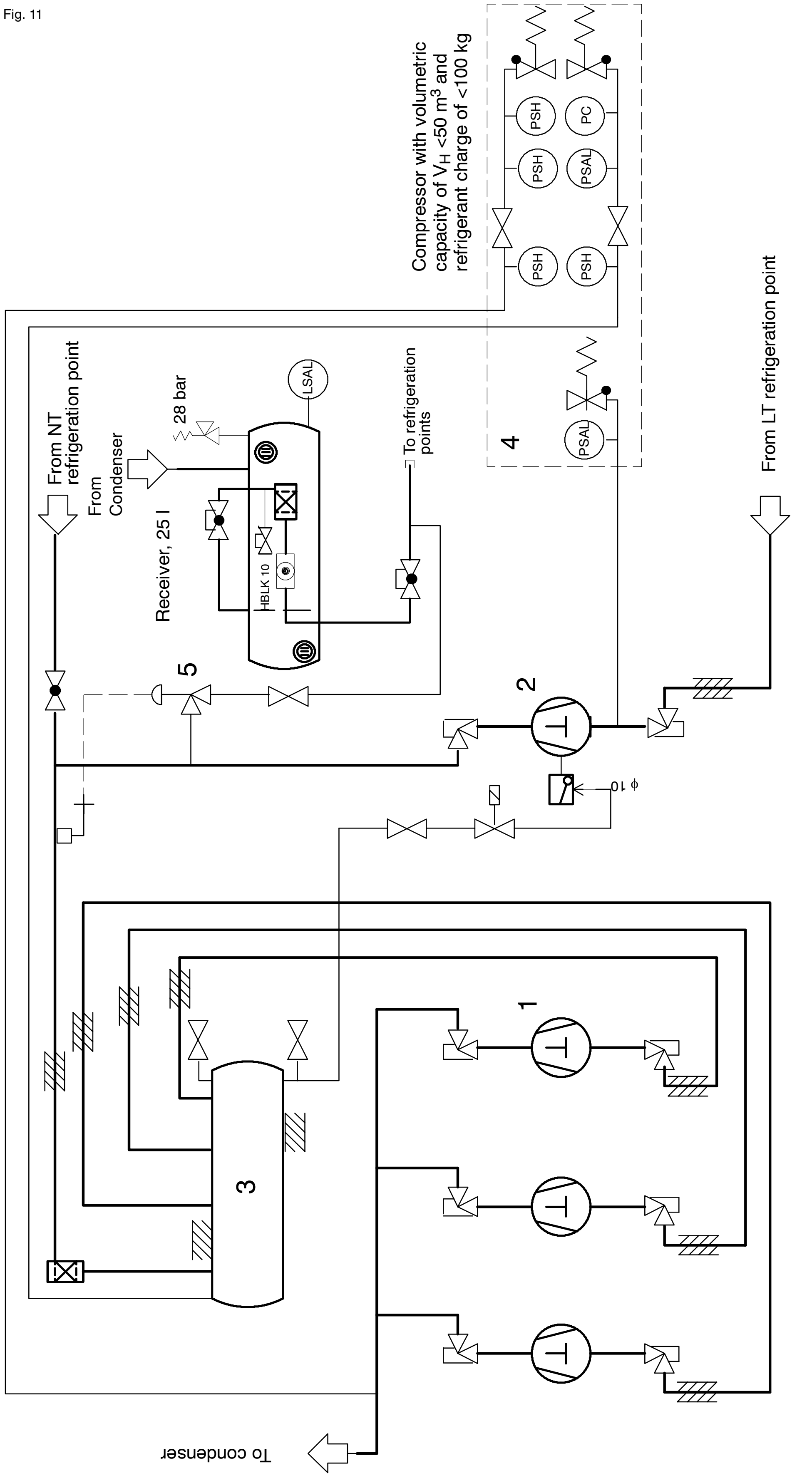
Control of the booster(s) cannot be made with the multicompressor unit controller for the NT compressors. Controllers with this capability are as yet not available. Booster compressors are therefore loaded and unloaded independently of the NT section. Depending on the number of refrigeration points, this can be done as a function of refrigeration temperature or suction pressure. In specific instances a second electronic multicompressor unit controller is installed to control the booster compressors.

When there is no refrigeration load in the NT section and a booster compressor starts, loading of a NT compressor does not take place immediately but in response to pressure rise in the NT suction line. The time delay for loading must therefore not be set appreciably longer than 60 seconds.

The other safety devices (e.g., high-pressure switches) are no different from those for other compressors.

Enabling of the solenoid valve upstream of the thermostatic expansion valve for desuperheating the LT discharge vapor is made via a thermostat which has its sensor in contact with the NT discharge pipe.

Fig. 11



Standard multicompressor unit equipped with booster compressor

1	NT compressors
2	Booster compressor
3	Suction receiver
4	Control panel
5	Discharge gas desuperheating

PSAL	Low-pressure cutout
PSH	High-pressure cutout
PC	Pressure controller
LS	Low liquid-level cutout

4.3 Starting

4.3.1 Settings for pressure and temperature switches

Booster compressor, R22

Table 24

Device		Switch-on	Switch-off
High-pressure switch	°C bar	-5 3,2	5 4,8
Low-pressure cutout 1	°C bar	-33 0,4	-37 0,2
Low-pressure cutout 2	°C bar	-30 0,6	-40 0,0
High-temperature switch Desuperheating	°C	85	95

Refer to the associate circuit diagram for the differing switch-on criteria.

4.3.2 First startup

Before first starting the multicompressor refrigeration system the oil quantity and distribution must be balanced carefully.

5. Two-Stage Multicompressor Refrigeration Units

5.1 Operation of Two-stage Compressors

When evaporating temperatures are low, the compression ratio resulting from condensing and evaporating temperature which has to be overcome by the compressor will become too high at some point as the temperature gradient between condenser and evaporator increases. Factors affecting this are the **discharge temperature** - especially when working with R22 - and vol**umetric efficiency** of the compressor. Limits for both vary with the type of refrigerant.

Two-stage compressors are necessary to overcome these limits of single-stage machines.

A two-stage compressor has LP and HP cylinders arranged in line in the one casing. Swept volume of the LP cylinders (LP stage) must be greater than that of the HP cylinders (HP stage). Cylinder ratios of 2:1 and 3:1 are common. This may mean two or three LP cylinders and one HP cylinder of equal diameter and thus equal displacement or, as in the case of Bitzer four-cylinder compressor units for example, two LP cylinders of larger and two HP cylinders of smaller displacement.

For compressor units a cylinder ratio (or ratio of swept volume) of 2:1 is normally selected.

Interstage pressure, which is the LP stage discharge pressure or the HP suction pressure, is obtained automatically as a state of equilibrium depending on the cylinder ratio and the LP stage suction pressure (such as evaporating pressure) and HP stage discharge pressure (such as condensing pressure). This equilibrium is achieved when the LP stage has sufficiently compressed the refrigerant vapor drawn from the evaporator for it to be taken in by the HP stage and further compressed to condensing pressure.

5.2 Application Range

Linde LT multicompressor refrigeration units working with R404A are equipped with two-stage compressor units of Bitzer or Copeland manufacture.

LT Standard design conditions:	t_0 = -40 °C		t_c = +40 °C
Refrigeration capacity range:	Q_0 = 15.21	to	155.22 kW

So as to prevent entry of moist air into the refrigerant circuit, operation in the negative pressure range, meaning at evaporating temperatures below -46 °C (corresponding to 0 bar on the pressure gauge) should be avoided where possible.

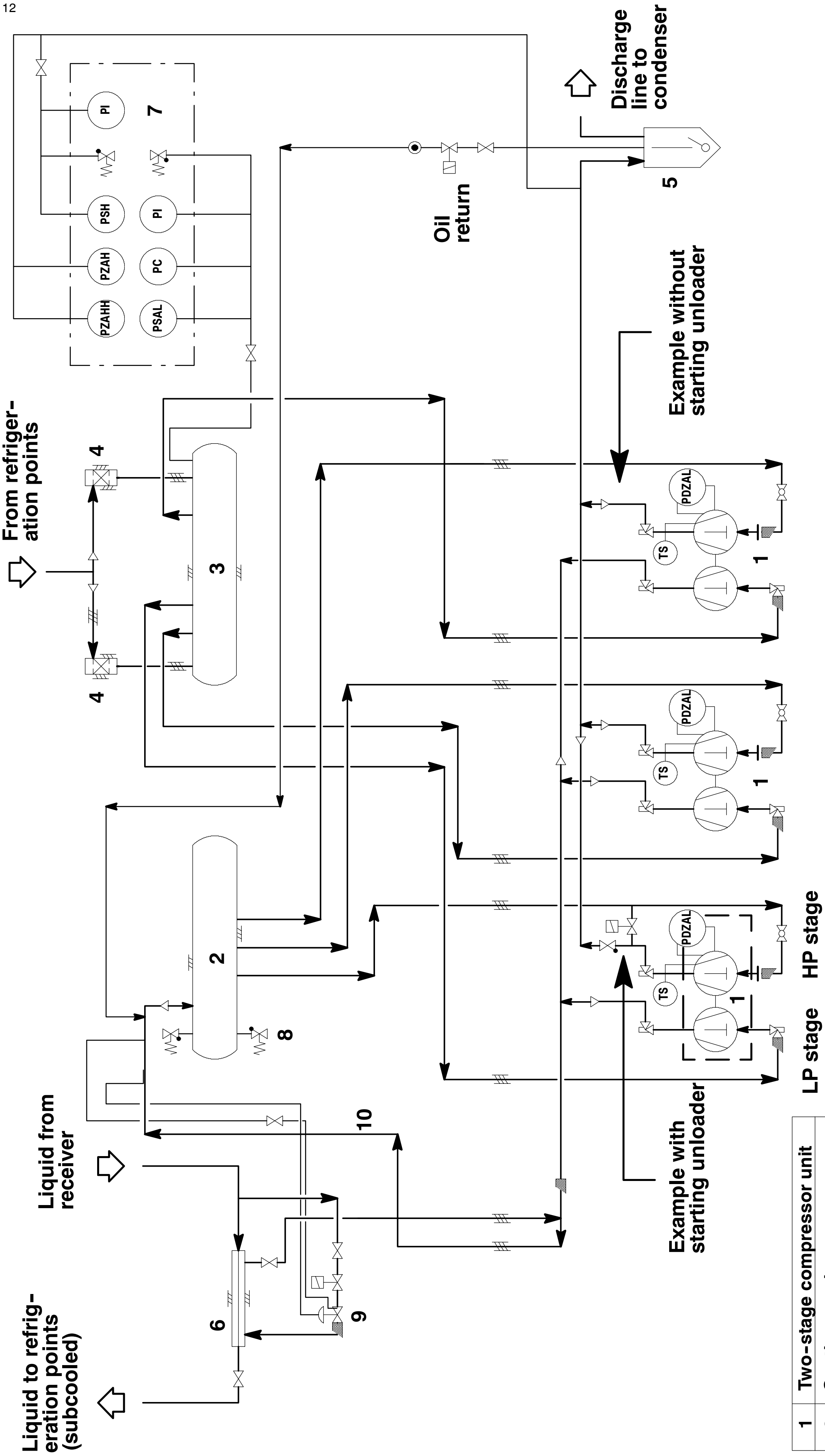
5.3 Refrigeration Section
(See Fig. 12, page 44)

The LP stage cylinders of the compressors ***1*** draw R404A vapor from the refrigeration points via the filter-dryers (installed while running in) and suction distributor ***3***. The LP suction lines entering this suction distributor are arranged so as to achieve preliminary distribution of the entrained oil.

The R404A vapor compressed to interstage pressure passes into the suction receiver ***2*** after previously being desuperheated by mixing with saturated vapor from the subcooler ***6***, this vapor still containing some liquid.

The subcoolers used for the liquid R404A are standard plate-type dry-expansion evaporators working at evaporating pressure equal to the **interstage pressure** of the multicompressor unit.

Fig. 12



1	Two-stage compressor unit
2	Suction receiver
3	Suction distributor D1/3/42
4	Filter-dryer
5	Oil separator
6	Subcooler
7	Control panel
8	Schrader valve
9	Thermostatic expansion valve
10	Desuperheater

PDZAL	Low oil pressure cutout
PSAL	Low-pressure cutout
PZAH	High-pressure cutout
PZAHH	Safety high-pressure cutout
PSH	High-pressure switch
PC	Suction pressure control switch
PI	Pressure gauge
TS	High-temperature switch

The thermostatic expansion valve ***9*** of the subcooler ***6*** controls the amount of R404A necessary for desuperheating the LP discharge vapor as well as supplying liquid to the subcooler.

Accordingly the sensor of the thermostatic expansion valve ***9*** is not located directly on the suction line of the subcooler ***6*** but on the desuperheater ***10*** ahead of entry to the suction receiver ***2***. In this way, only one thermostatic expansion valve is required for both subcooling and desuperheating.

Two thermostatic expansion valves are provided on the subcooler of multicompressor units equipped with more than four compressors so as to achieve good control at part load.

The cylinders of the HP stages of the compressors draw refrigerant vapor from the suction receiver ***2***. In this suction receiver the oil is distributed among the separate compressors as previously described. Since the compressor crankcases are loaded by interstage pressure due to the suction ports of the HP cylinders connecting to the crankcase, it is necessary for the suction receiver to be relocated from the LP stage to the HP stage on two-stage multicompressor refrigeration units. The benefit of this approved system consists in avoiding the need for mechanical oil level regulators and corresponding adapters.

In the HP stage the refrigerant vapor is compressed to condensing pressure. Entrained oil is substantially separated in the oil separator ***5*** and routed to the suction receiver ***2*** by an internal float valve.

The oil return line contains a solenoid valve and a sight glass. The sight glass affords a visual check on operation of the float valve and oil return.

A small amount of oil still enters the condenser and passes with the liquid refrigerant to the refrigeration points.

A temperature sensor is mounted on the cylinder heads of the HP stage of all two-stage compressors so as to trip the compressor at high discharge vapor temperature. This is performed by microprocessor control in systems equipped with the VS2000 controller and by the motor overload trip when using conventional control. This prevents possible compressor damage due to high discharge temperature caused by a defective thermostatic expansion valve or solenoid valve in the liquid line or defective float valve in the oil separator.

Each compressor has four stop valves. This enables a compressor to be replaced without shutting down the multicompressor unit altogether.

Where fitted on two-stage compressors, starting unload is active only on the HP stage.

The control panel and VS2000 controller are the same as for single-stage multicompressor refrigeration units.

5.4 Starting

5.4.1 Settings for pressure cutouts and pressure/temperature switches

Table 25

Device	Switch-on	Switch-off
Safety high-pressure cutout	Internal manual reset	54 °C 25.1 bar*
High-pressure cutout	Manual reset	53 °C 24.55 bar*
High-pressure switch	40 °C 17.5 bar*	51 °C 22.5 bar*
Low-pressure cutout	-41 °C 0.3 bar*	-46 °C 0.0 bar*
High-temperature switch Desuperheating **	85 °C	95 °C
Low oil pressure cutout	Fixed setting max. 120 s delay	0.7 bar

* R404A gauge pressure
** Multicompressor refrigeration units with more than four compressors in LT cold stores

5.4.2 Setting the suction pressure control switch with neutral zone

Set the suction pressure control switch as specified by the project department or for refrigerated display cases as specified in Manual C1.

5.4.3 Settings for oil regulating valves on suction receiver

The oil regulating valves are mounted on the underside of the suction receiver. After removing the screw plug, the valve can be adjusted with a screwdriver. Use a screwdriver of correct bit size (6 mm) to prevent deforming the screw slot and risk of the valve plug binding in the screw thread.

The oil regulating valves on the compressors are factory-set according to compressor type. Settings are listed in Table 23 following.

Individual readjustment of the oil regulating valves may be necessary if oil level differs in the compressor crankcases after the multicompressor unit has been commissioned.

Table 26

LT range, R404A, R22

Allocation of suction receivers to compressors and oil regulating valve settings for evaporating temperatures t_o in °C (t_c = 40 °C)

Compressor Type		Interstage suction receiver	Valve stem turns[1])				
Bitzer	**Copeland**	**Type**	**-25**	**-30**	**-35**	**-40**	**-45**
S4T- 5.2		A1	6	8	10	12	13
S4N- 8.2		A1	4	4	8	10	11
S4G-12.2		A1	4	4	4	7	9
	D6TA-1500	A1	4	4	4	4	6
	D6TH-2000	A1	4	4	4	4	4
	D6TJ-2500	A1	4	4	4	4	4
S6J-16.2		A2	4	5	8	10	12
S6H-20.2		A2	4	4	7	9	11
S6G-25.2		A2	4	4	5	8	10
S6F-30.2		A2	4	4	4	7	9

[1])Opening turns from closed position

5.4.4 First startup

After being evacuated, the refrigerant receiver must be filled as far as possible with *liquid* refrigerant (see 1.9.2., page 27) to ensure immediate supply of liquid refrigerant to the thermostatic expansion valve(s) of the subcooler and desuperheater. Otherwise the compressors might be tripped due to *high cylinder temperature* (max. 150 °C).

If system pressure exceeds 2.5 bar (reading on suction pressure gauge) with the compressors at standstill, two-stage compressors must be started in *Manual* mode with tightly throttled suction stop valve on the LP stage. All other compressor stop valves (LP discharge side, HP suction and discharge side) must be open. Connect a pressure gauge (service instrument) to the LP suction stop valve so that suction pressure of the selected compressor can be measured. When pressure indicated by the **system suction pressure gauge** has dropped to 1.5 bar, the suction stop valve can be fully opened.

Damage is even more likely on multicompressor units equipped with two-stage compressors than those with single-stage machines if the compressors are started in automatic mode at high system pressure (see 2.3.4, page 32).

Make sure to check satisfactory working of the thermostatic expansion valve (item 9 of Fig. 12, page 44) and desuperheater. Do so for all capacity stages of the multicompressor unit.

Interstage pressure, meaning evaporating pressure of the subcooler (measurable at the top instrument connection, item 8 of Fig. 8, page 37) should be

t_o = -30°C t_c = 40°C t_m = ca. 2°C
t_o = -40°C t_c = 40°C t_m = ca.-10°C

Temperature on the sensor of the thermostatic expansion valve should therefore be about 10°C or 0°C respectively (figures applicable to R404A).

6. Maintenance Instructions

6.1 Block and Filter Elements

Remove the block and filter elements and their supports after about 200 operating hours, particularly after first commissioning the system, so as to cancel the temporary pressure drop they cause in the suction line.

If heavy fouling of filter elements is determined, new elements must be installed for an additional 200 operating hours.

6.2 Oil Inspection / Oil Change

Inspection of the oil (acid test) should be made at least **once a year**. If results show oil change to be necessary, replace the block elements of the filter-dryer at the same time.

Oil change is recommended not later than **20,000 to 25,000** operating hours.

The procedure for oil change is as follows:

Stop the compressors and secure against unintentional restarting. Drain the spent oil from the suction receiver, oil separator (on two-stage multicompressor units) and compressors. This is best done utilizing slight excess pressure in the system.

Fill in fresh oil in accordance with the instructions under 1.9.1, page 26.

6.3 Leak Test

A simple and effective method of testing a refrigeration system for leaks is to make frequent check of liquid level in the refrigerant receiver. The measurements should preferably be recorded in a logbook so that they can be reviewed for any possible indication of leaks. If the charge level remains constant, there will be no need for time-consuming routine inspection of the system for leaks.

Inspection for leaks must be made on the system whenever charge level in the refrigerant receiver is found to vary, either by viewing level through the sight glass on the refrigerant receiver or by actuation of the low liquid level cutout or by observing bubbles in the liquid line sight glass. In every instance, inspection for leaks must be made **once a year**.

When inspecting for leaks, first test critical locations such as screwed joints. Major leaks can be localized with a foaming agent. Use exclusively suitable electronic leak detectors (see 1.6.7, page 22).

6.4 Troubleshooting

Causes and correction of trouble in operation

Defects or malfunctions can either be caused by external influences or arise within the refrigeration system.

Possible faults, their symptoms and notes on correcting them are listed in the following table, which covers major and typical faults without however being complete in scope.

Table 27

Symptom	Possible cause	Correction
1. High condensing pressure	Fans not operative.	Check, adjust or repair control. Check fuses.
	Condenser fouled.	Clean condenser
	High liquid level in condenser.	Check thermostatic expansion valve.
	Filter-dryer fouled.	Replace dryer element.
	Air in system.	Vent syste.
2. Low condensing pressure	Fan control failure.	Check control.
	Low refrigerant charge.	Refill refrigerant.
	Compressor cylinder valves defective.	Check cylinder valves.
	Leak on compressor bypass valve.	Check bypass valve, replace if necessary.
3. High evaporator pressure	Inadequate refrigeration capacity of compressor.	Check cylinder valves, replace if necessary.
	Evaporator pressure controller failure.	Check controller.
4. Low evaporator pressure	Low refrigerant level in evaporator.	Refill refrigerant. Check termostatic expansion valve.
	Low refrigeration load.	Check capacity control.
	Liquid-line filter-dryer fouled.	Replace dryer element.
5. Refrigerant or oil slugging in compressor	Liquid-line solenoid valve leak.	Check solenoid valve, replace if necessary.
	Defective or incorrectly set thermostatic expansion valve.	Check working and setting of thermostatic expansion valve.
6. Low oil pressure in compressor	Low oil level in crankcase.	Refill oil, determine cause of low level.
	Oil filter fouled.	Clean oil filter.
	Foaming of oil due to excessive refrigerant content.	Determine and correct cause of refrigerant migration.
7. Actuation of safety device:		
High-pressure cutout/ safety high-pressure cutout	High compressor discharge pressure/High condensing pressure.	See 1. above.
Low pressure cutout	Low evaporating pressure.	See 4. above.
Low oil pressure cutout	Low oil pressure cutout.	See 6. above.
High cylinder head temperature cutout	High discharge pipe/compressor discharge temperature.	Check compressor cylinder valves and bypass valve. Correct low refrigerant level.
8. Overcurrent relay / thermistor trip	Electric motor overload.	High evaporating/condensing pressure. Compressor failure.
	Power line phase failure.	Check line phases.
	Low power line voltage.	Check line voltage.

7. Components

7.1 Electronic Refrigerant Level Monitor

Part No. 345 790 (Fig. LEERER MERKER, page LEERER MERKER)

The electronic refrigerant level monitor is factory-installed on the refrigerant receiver, level with the lower sight glass.

The purpose of this monitor is to ensure a minimum level of refrigerant. If level drops below the set minimum, alarm is actuated through a time delay device.

A second G1 screw mount may be provided on the receiver for maximum level monitoring where required.

7.1.1 Operation

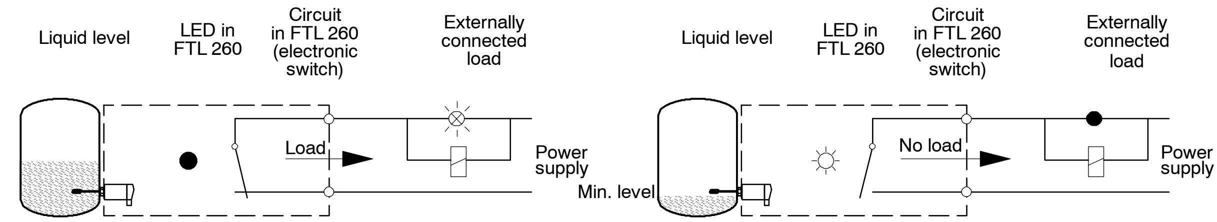
A vibrating reed is set in resonant vibration by a piezoelectronic oscillator. When the reed immerses in refrigerant, the electronic circuit actuates a contactless switch and the load relay in the control cabinet is energized.

When the reed vibrates free of refrigerant, the load relay is de-energized and the internal signal lamp lights.

7.1.2 Operation as function of filling level and mode switch setting

Low level monitoring

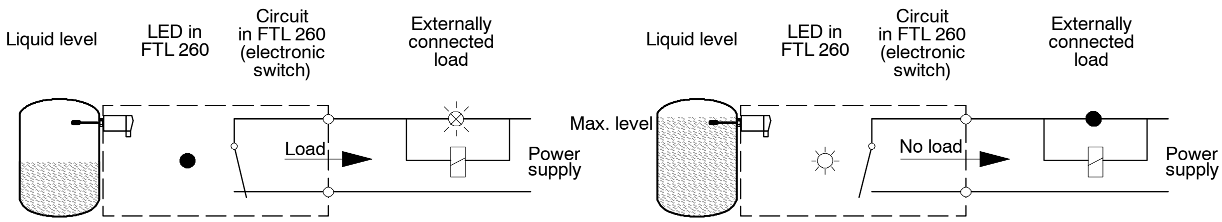
Fig. 13



If high filling level is to be monitored, the bottom switch must be set to MAX.

High level monitoring

Fig. 14



7.1.3 Electrical connection

Make electrical connection as illustrated in Fig. 15.

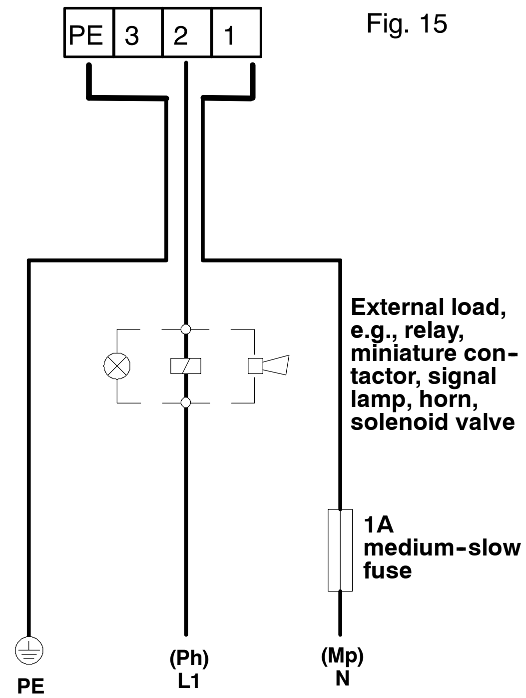
Caution! The level monitor must not be connected without the load relay.

Direct connection to line power will destroy the electronic circuitry.

Before switching on line power supply, check the limit values (see Specifications).

Also note that a no-load current of approx. 4 mA flows or respectively must flow when the load is switched off.

Fig. 15



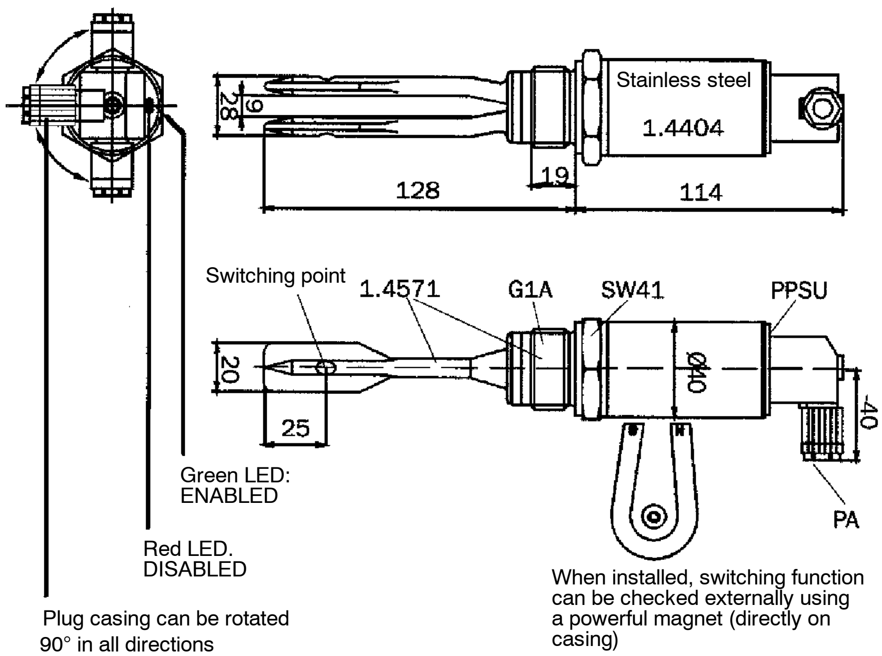
7.1.4 Installation

The cable entry should face downwards. Position of the cable entry can be adjusted after undoing the two terminal screws.

Factory-installed seal is:
Form A, 33 x 39 x 2 mm, aluminum to DIN 7603, conforming to Works Standard SN 909.00.2, Part No. 101 091.

Fig. 16

Measurements and materials



Install in accordance with operating instructions.

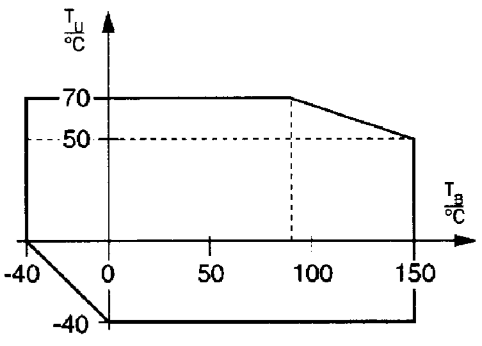
7.1.5 Specifications

Power supply:	19 to 253 V, 50/60 Hz disabled
Electrical loading:	4 mA max.
Connectable load:	Temporarily (40 ms): max. 1.5 A, max. 375 VA on 250 V or max. 36 VA on 24 V (not short circuit proof) Continuous max. 87 VA on 250 V, max. 8.4 VA on 24 V min. 2.5 VA on 250 V (10 mA), min. 0.5 VA on 24 V (20 mA)
Voltage drop:	12 V max. via DTL
Residual current:	4 mA max. with disabled output

General

Safety circuit:	Minimum or maximum NC, depending on load connection, never operate **FTL 260/AC without load (contactor, relay, etc.)**
Failure signal:	Output disabled
Switching time:	Approx. 0.5 s disabling, Approx. 1.5 s enabling
Hysteresis:	Approx. 4 mm with upright mounting position
Mounting position:	Random
Ambient temperature:	-40 °C to +70 °C
Measured fluid temperature:	-40 °C to +150 °C
Working pressure:	-1 bar to +40 bar
Storage temprature:	-40 °C to +85 °C
Climate Class:	Climate protection to IEC 68, Part 2-38
Electrical enclosure:	IP 67
Measured fluid density:	Min. 0.7 g/cm^3
Measured fluid viscosity:	Max. 10,000 mm^2/s (cSt)
Weight:	Approx. 0.45 kg
Electrical connection:	4-pin plug to DIN 43650-A, ISO 4400 PG 9 cable gland, for cable 6 to 8 mm dia., max. 1 mm^2 lead cross-section

Fig 17



Allowable ambient temperature T_U on casing as function of working temperature T_B in tank