Selection
& Application Guidelines

Performer® scroll compressors in parallel installation

R22 - R407C - R134a

REFRIGERATION AND
AIR CONDITIONING

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GENERAL OVERVIEW

Benefits

A parallel compressor installation refers to a system of interconnected compressors with a common suction line and common discharge line. The technique of mounting compressors in parallel, also called manifolding, has several benefits.

The main reason is reduced operating cost through greater control of capacity and power consumption. This is achieved by staggering compressor switch-on sequences that allow the parallel system to match its power with the capacity needed.

A second reason for manifolding is improved part load efficiency. In a parallel installation the individual compressor(s) can be switched off while the other compressor(s) keep operating at 100% load. Therefore the part load efficiency is very near the full load efficiency. Conventional fixed speed compressor unloading methods impose a serious penalty for part load efficiency, mainly at low load operation.

Third, working with parallel systems allows for standardisation of compressors. As an example, the capacity range 10, 15, 20, 25 and 30 Tons can be covered with 5 individual compressors. But the same needs can be covered with only a 10 Tons and a 15 Tons model mounted in parallel, thus reducing the number of different compressors from 5 to 2.

Scope

These application guidelines describe the operating characteristics, design features, and application requirements for the Performer scroll compressor (SM, SY, SZ) in air conditioning and heat pump applications. The guidelines are not valid for refrigeration applications, which require dedicated compressors and more specific installations precautions.

To ensure proper parallel installation and running conditions, the following recommendations must be followed:

- It is essential to respect all instructions given in these guidelines, the instruction leaflet delivered with each compressor, and the Selection & Application Guidelines for single compressors.
- For additional system components related to specific application requirements, the supplier recommendations must always be respected.

Design challenge

Parallel systems have to ensure correct compressor operation, oil management and reliability, which requires evaluation and testing.

Oil equalisation

Contrary to semi hermetic compressors, suction gas in a hermetic compressor flows via the oil sump which makes it more difficult to maintain equal pressure in the sumps of parallel compressors. Since oil equalisation usually depends on equal sump pressures this is a point of special attention. Danfoss Commercial Compressors has developed specially adapted oil equalisation systems which ensure proper oil balancing between the compressors .

Interconnecting piping design

This is an area where the manufacturer can use its research and testing capabilities to the users benefits. All factory designed parallel systems pass the critical 500 hours run test to qualify the piping configuration. This is not easily achieved with “field” erected systems which are often affected by infancy problems such as pipe vibrations, noise or ultimately pipe ruptures.

Using factory designed and tested parallel systems guarantees predictable reliability.

GENERAL OVERVIEW

Compressor sequence

The operating sequence should be arranged in such way that the running time of the compressors is equalized as much as possible. It will be explained later in these guidelines how this can be achieved with a system of two compressors and why a fixed sequence of loading and unloading may be required in trio and quadro systems with 3 or 4 Performer® scroll compressors.

Cycling

As a part of the design and development process at Danfoss Commercial Compressors it is verified that oil management and piping resistance meet engineering specifications at any cycling frequency.
The system must be designed in a way that guarantees a minimum compressor running time of 2 minutes to provide sufficient motor cooling after its start and a proper oil return. Note that the oil return may vary as it is a function of the system design.

Cost effectiveness and serviceability

In today's business climate, machine simplicity and low cost are main requirements. Performer® scroll tandem, trio and quadro configurations are compact designs but they ensure easy maintenance and service because refrigeration circuit connections, oil change, compressor wiring and compressor replacement are taken into account from the earliest design stage.

Application envelope

The domain of application, the types of refrigerant are evaluated to meet the requirements of the intended applications.

Oil return

There is one last challenge which falls under the responsibility of the system designers and end users; proper oil return from the circuit.

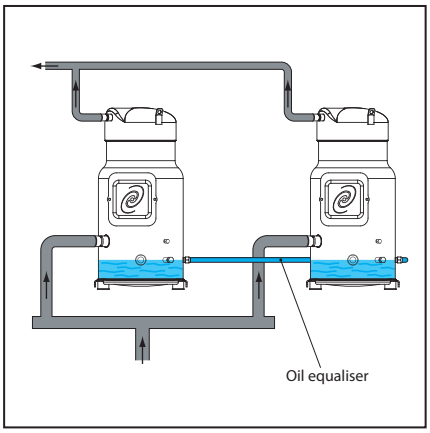
Whatever the design of the parallel compressor system, good oil return from the circuit is prerequisite for the success of the equipment.

As mentioned before, one of the challenges of manifolding is oil management. To ensure suitable oil distribution, different systems can be used.

Static systems

This is one of the most simple, and cheapest ways of manifolding compressors. Compressor sumps and low pressure shells are interconnected. A small interconnecting pipe, on the lower part of the compressor (below the oil level), ensures oil balancing. The suction header design is critical, as it ensures a pressure drop balancing and equal distribution of oil returning from the system when all compressors are running.
The success of such a system relies very much on the sizing of the pipe work, small differences in sump pressure can result in significant oil level variations.

This system is limited to three compressors in parallel, and needs perfect suction tube balancing.



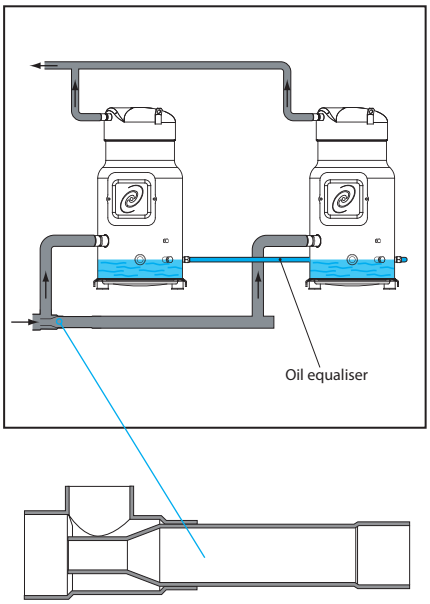
Dynamic systems

The dynamic system provides truly positive oil management, uniting the advantages of both a mechanical and a static system, i.e. flexible oil management allowing a large number of compressors, simplicity and cost effectiveness.

The suction connections of the two individual compressors are interconnected by a suction oil separator / gas restrictor (suction Tee). The compressor which appears first on the suction line is called the “upstream compressor” while the second one will be referred to as the “downstream compressor”.

The oil which clings back along the main suction line is separated by the suction Tee which returns 80 to 100% of the oil in the suction gas to the upstream compressor. The Tee creates a slight pressure drop in the suction line of the downstream compressor, which therefore has a slightly lower sump pressure. Driven by the sump pressure difference, the excess oil from the upstream compressor runs into the downstream compressor sump. To avoid the migration of the normal oil charge from one compressor to the other, the oil equalisation line protrudes into each compressor shell, thereby ensuring a real overflow function.

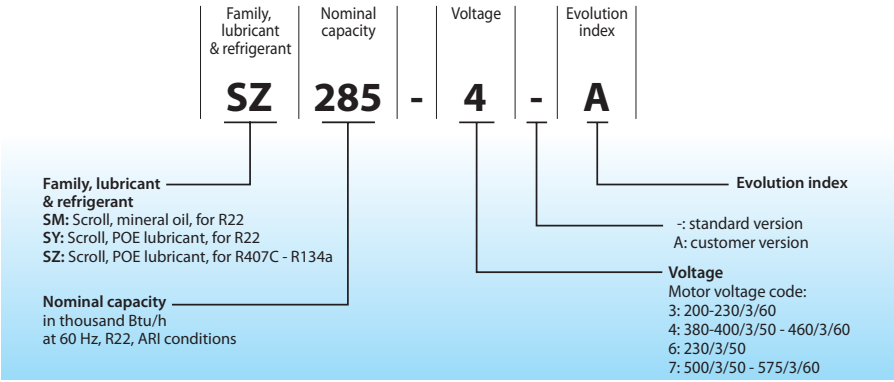
Suitable oil management, with no mechanical components or pressure equalisation line is created. This system allows up to four compressors in parallel with minimum costs. The active components in this oil balancing system are calibrated and qualified by Danfoss Commercial Compressors.



suction oil separator / gas restrictor

COMPRESSOR PARALLEL ASSEMBLY NOMENCLATURE

Performer® scroll tandem models SM/SZ 170 to 370 are available as factory assembled units. The code number and technical reference of these units is explained in the below example. The larger tandems as well as the trio and quadro units can only be achieved by "field-assembly" of individual compressors.



Performer® scroll tandem

Model		Composition
SM / SZ 170	●	**S084 + S084**
SM / SZ 180	●	**S090 + S090**
SM / SZ 200	●	**S100 + S100**
SM / SZ 220	●	**S110 + S110**
SM / SZ 230	●	**S115 + S115**
SM / SZ 242	●	**S120 + S120**
SM / SZ 250	●	**S125 + S125**
SM / SZ 268	●	**S120 + S148**
SM / SZ 271	●	**S110 + S161**
SM / SZ 281	●	**S120 + S161**
SM / SZ 285	●	**S160 + S125**
SM / SZ 290	●	**S175 + S115**
SM / SZ 296	●	**S148 + S148**
SM / SZ 310	●	**S185 + S125**
SM / SZ 320	●	**S160 + S160**
SM / SZ 322	●	**S161 + S161**
SM / SZ 350	●	**S175 + S175**
SM / SZ 370	●	**S185 + S185**
SZ 425	○	**S240 + S185**
SY / SZ 482	○	**S240 + S240**
SZ 485	○	**S300 + S185**
SY / SZ 540	○	**S300 + S240**
SY / SZ 600	○	**S300 + S300**
SY / SZ 680	○	**S300 + S 380**
SY / SZ 760	○	**S380 + S380**

● = Factory built or field assembly with kits

○ = Field assembly

Performer® scroll trio

Model		Composition
SM / SZ 480	○	**S160 + S160 + S160**
SM / SZ 550	○	**S185 + S185 + S185**

Performer® scroll quadro

Model		Composition
SM / SZ 640	○	**S160 + S160 + S160 + S160**
SM / SZ 740	○	**S185 + S185 + S185 + S185**

TECHNICAL SPECIFICATIONS

50 Hz data

	Model		Nominal tons 60 Hz TR	Nominal cooling capacity W	Nominal cooling capacity Btu/h	Power input kW	Efficiency COP W/W	Efficiency E.E.R. Btu/h /W	Sound power dB(A)	Swept volume m³/h	Net weight kg
R22	Tandem	SM170	13.5	40 100	137 000	12.23	3.28	11.2	73.0	39.85	150
		SM180	15	42 900	146 500	13.08	3.28	11.2	73.0	41.93	150
		SM200	16	45 600	155 600	13.91	3.28	11.2	73.0	44.27	150
		SM220	18	51 100	174 400	15.63	3.27	11.1	78.0	50.18	170
		SM230	19	55 200	188 300	16.61	3.32	11.3	79.0	53.94	170
		SM242	20	59 300	202 500	17.90	3.31	11.3	78.0	57.98	170
		SM250	20	59 300	202 500	17.86	3.32	11.3	79.0	57.98	170
		SM268	22	65 200	222 700	19.76	3.30	11,3	77,0	63.60	160
		SM271	22	64 000	218 500	19.41	3.30	11,3	77,5	62.80	180
		SM281	23	68 100	232 600	20.54	3.31	11,3	77,5	66.70	180
		SM285	23	68 200	232 700	20.54	3.32	11.3	81.0	66.68	200
		SM290	23.5	69 000	235 400	20.77	3.32	11.3	81.5	67.51	200
		SM296	24	71 100	242 700	21.59	3.29	11,2	82,0	69,30	192
		SM310	25	74 500	254 200	22.56	3.30	11.3	81.5	72.47	200
		SM320	26	77 000	263 000	23.19	3.32	11.3	82.5	75.38	210
		SM322	26	76 800	262 400	23.17	3.32	11.3	82.5	75.38	192
		SM350	28	82 700	282 500	24.91	3.32	11.3	83.0	81.08	225
		SM370	30	89 600	306 000	27.23	3.29	11.2	83.0	86.97	225
		SY482	40	120 500	411 100	36.40	3.31	11.3	86.0	121.00	320
		SY540	45	137 300	468 500	41.00	3.35	11.4	86.0	136.60	320
		SY600	50	154 130	525 900	45.60	3.38	11.5	86.0	152.30	320
		SY680	55	167 700	572 100	49.58	3.38	11.5	83,5	168.50	323
		SY760	60	184 000	618 300	53.57	3.43	11.5	88,0	184.80	326
	Trio	SM480	39	113 800	388 200	34.80	3.27	11.2	84.3	113.07	-
		SM550	45	132 400	451 800	40.90	3.24	11.1	84.8	130.44	-
	Quadro	SM640	52	151 700	517 700	46.42	3.27	11.2	85.5	150.76	-
		SM740	60	176 500	602 400	54.49	3.24	11.1	86.0	173.92	-
R407C	Tandem	SZ170	13.5	38 100	129 900	12.26	3.10	10.6	76.0	39.85	150
		SZ180	15	40 200	137 100	12.88	3.12	10.6	76.0	41.93	150
		SZ200	16	42 500	145 100	13.67	3.11	10.6	76.0	44.27	150
		SZ220	18	48 500	165 400	15.52	3.12	10.6	80.0	50.18	170
		SZ230	19	52 900	180 600	16.97	3.12	10.6	81.0	53.94	170
		SZ242	20	56 300	192 100	17.95	3.14	10.7	80.0	57.98	170
		SZ250	20	56 300	192 100	17.89	3.15	10.7	81.0	57.98	170
		SZ268	22	62 700	214 100	19.99	3.14	10,7	79,0	63.60	160
		SZ271	22	61 600	210 200	19.59	3.14	10,7	79,5	62.80	180
		SZ281	23	65 500	223 800	20.83	3.15	10,8	79,5	66.70	180
		SZ285	23	65 100	222 300	20.53	3.17	10.8	82.5	66.68	200
		SZ290	23.5	66 000	225 100	21.16	3.12	10.6	83.0	67.51	200
		SZ296	24	69 100	236 100	21.97	3.15	10,8	83,5	69,30	192
		SZ310	25	70 600	240 900	22.57	3.13	10.7	83.0	72.47	200
		SZ320	26	74 000	252 600	23.15	3.20	10.9	83.5	75.38	210
		SZ322	26	74 600	255 200	23.65	3.17	10.7	83.5	75.38	192
		SZ350	28	79 000	269 700	25.32	3.12	10.6	84.0	81.08	225
		SZ370	30	84 900	289 800	27.22	3.12	10.6	84.0	86.97	225
		SZ425	35	100 700	343 700	32.17	3.13	10,7	85.5	105,10	263
		SZ482	40	116 500	397 500	37.10	3.14	10.7	86.5	121.00	320
		SZ485	39	114 100	389 500	36.35	3.14	10,7	85.5	119,60	263
		SZ540	45	129 900	443 400	41.30	3.14	10.7	86.7	136.60	320
		SZ600	50	143 300	489 200	45.50	3.15	10.8	87.0	152.30	320
		SZ680	55	160 000	545 800	50.24	3.19	10.9	85,5	168.50	323
		SZ760	60	176 600	602 500	55.13	3.20	10.9	89,5	184.80	326
	Trio	SZ480	39	109 300	372 900	34.75	3.15	10.7	85.3	113.07	-
		SZ550	45	125 400	427 900	40.86	3.07	10.5	85.7	130.44	-
	Quadro	SZ640	52	145 700	497 300	46.33	3.15	10.7	86.5	150.76	-
		SZ740	60	167 200	570 500	54.48	3.07	10.5	87.0	173.92	-

Rating conditions:	**SM compressors**	**SZ compressors**
Refrigerant	R22	R407C
Frequency	50 Hz	50 Hz
Standard rating conditions	ARI standard conditions	ARI standard conditions
Evaporating temperature	7.2 °C	7.2 °C (dew point)
Condensing temperature	54.4 °C	54.4 °C (dew point)
Sub-cooling	8.3 K	8.3 K
Superheat	11.1 K	11.1 K

TECHNICAL SPECIFICATIONS

60 Hz data

	Model		Nominal tons 60 Hz TR	Nominal cooling capacity		Power input kW	Efficiency		Sound power dB(A)	Swept volume m³/h	Net weight kg
				W	Btu/h		COP W/W	E.E.R. Btu/h /W			
R22	Tandem	SM170	13.5	48 500	165 500	14.74	3.29	11.2	78.0	48.09	150
		SM180	15	51 900	177 300	15.63	3.32	11.3	78.0	50.61	150
		SM200	16	54 300	185 200	16.28	3.33	11.4	78.0	53.42	150
		SM220	18	62 200	212 400	18.69	3.33	11.4	81.0	60.56	170
		SM230	19	66 500	226 900	20.14	3.30	11.3	82.0	65.10	170
		SM242	20	72 300	246 900	21.60	3.35	11.4	81.0	69.97	170
		SM250	20	72 900	249 000	21.96	3.32	11.3	82.0	69.97	170
		SM268	22	79 300	270 900	23.82	3.33	11.4	81,0	76.80	160
		SM271	22	78 000	266 400	23.41	3.33	11.4	81,0	75.80	180
		SM281	23	83 100	283 700	36.86	3.34	11.4	81,0	80.50	180
		SM285	23	83 500	285 000	25.21	3.31	11.3	85.0	80.47	200
		SM290	23.5	83 500	285 100	25.35	3.29	11.2	84.0	81.48	200
		SM296	24	86 200	294 500	26.00	3.32	11.3	86,0	83.60	192
		SM310	25	90 000	307 100	27.21	3.31	11.3	84.0	87.47	200
		SM320	26	94 000	321 000	28.42	3.31	11.3	87.0	90.97	210
		SM322	26	93 800	320 200	28.12	3.34	11.3	87.0	90.97	192
		SM350	28	100 600	343 400	30.53	3.29	11.2	85.5	97.86	225
		SM370	30	107 000	365 300	32.42	3.30	11.3	85.5	104.96	225
		SY482	40	145 900	497 800	22.10	3.30	11.3	87.7	146.10	320
		SY540	45	166 000	566 500	27.50	3.34	11.4	88.4	164.90	320
		SY600	50	186 200	635 300	44.20	3.38	11.5	88.9	183.80	320
		SY680	55	201 500	687 200	60.96	3.31	11.3	87,0	203.50	323
		SY760	60	216 800	739 200	66.99	3.24	11.0	91,0	223.20	326
	Trio	SM480	39	138 900	474 000	42.66	3.26	11.1	88.8	136.47	-
		SM550	45	158 100	539 300	48.66	3.25	11.1	87.3	157.44	-
	Quadro	SM640	52	185 200	632 000	56.88	3.26	11.1	90.0	181.96	-
		SM740	60	210 700	719 100	64.88	3.25	11.1	88.5	209.92	-
R407C	Tandem	SZ170	13.5	44 400	151 500	14.11	3.15	10.7	81,0	48.09	150
		SZ180	15	48 100	164 100	15.26	3.15	10.7	81.0	50.61	150
		SZ200	16	52 200	178 300	16.35	3.19	10.9	81.0	53.42	150
		SZ220	18	59 300	202 400	18.56	3.19	10.9	84.0	60.56	170
		SZ230	19	64 600	220 700	20.43	3.16	10.8	84.0	65.10	170
		SZ242	20	68 600	234 300	21.48	3.20	10.9	84.0	69.97	170
		SZ250	20	68 800	234 700	21.77	3.16	10.8	84.0	69.97	170
		SZ268	22	76 300	260 500	24.09	3.17	10.8	83,0	76.80	160
		SZ271	22	75 000	255 900	23.61	3.17	10.8	83,0	75.80	180
		SZ281	23	79 600	271 800	25.07	3.17	10.8	83,0	80.50	180
		SZ285	23	79 200	270 400	24.97	3.17	10.8	86.5	80.47	200
		SZ290	23.5	80 300	274 000	25.50	3.15	10.7	86.0	81.48	200
		SZ296	24	83 900	286 600	26.68	3.15	10.8	88,0	83.60	192
		SZ310	25	85 400	291 500	27.32	3.13	10.7	86.0	87.47	200
		SZ320	26	89 700	306 100	28.14	3.19	10.9	88.0	90.97	210
		SZ322	26	90 700	309 100	28.62	3.17	10.8	88.0	90.97	192
		SZ350	28	95 900	327 300	30.54	3.14	10.7	87.0	97.86	225
		SZ370	30	102 000	348 200	32.84	3.11	10.6	87.0	104.96	225
		SZ425	35	121 100	413 300	39.09	3.10	10.6	89,0	126,90	263
		SZ482	40	140 200	478 300	45.30	3.09	10.6	90.0	146.10	320
		SZ485	39	137 600	469 600	43.92	3.13	10.7	89,0	-	263
		SZ540	45	156 700	534 700	50.20	3.12	10.7	90.3	164.90	320
		SZ600	50	173 200	591 000	55.00	3.15	10.7	90.5	183.80	320
		SZ680	55	193 600	658 400	60.81	3.18	10.8	88,5	203.50	323
		SZ760	60	213 900	725 800	66.71	3.21	10.9	92,5	223.20	326
	Trio	SZ480	39	132 500	452 000	42.24	3.14	10.7	89.8	136.47	-
		SZ550	45	150 700	514 200	49.28	3.06	10.4	88.8	157.44	-
	Quadro	SZ640	52	176 600	602 700	56.31	3.14	10.7	91.0	181.96	-
		SZ740	60	200 900	685 600	65.71	3.06	10.4	90.0	209.92	-

Rating conditions:	**SM compressors**	**SZ compressors**
Refrigerant	R22	R407C
Frequency	60 Hz	60 Hz
Standard rating conditions	ARI standard conditions	ARI standard conditions
Evaporating temperature	7.2 °C	7.2 °C (dew point)
Condensing temperature	54.4 °C	54.4 °C (dew point)
Sub-cooling	8.3 K	8.3 K
Superheat	11.1 K	11.1 K

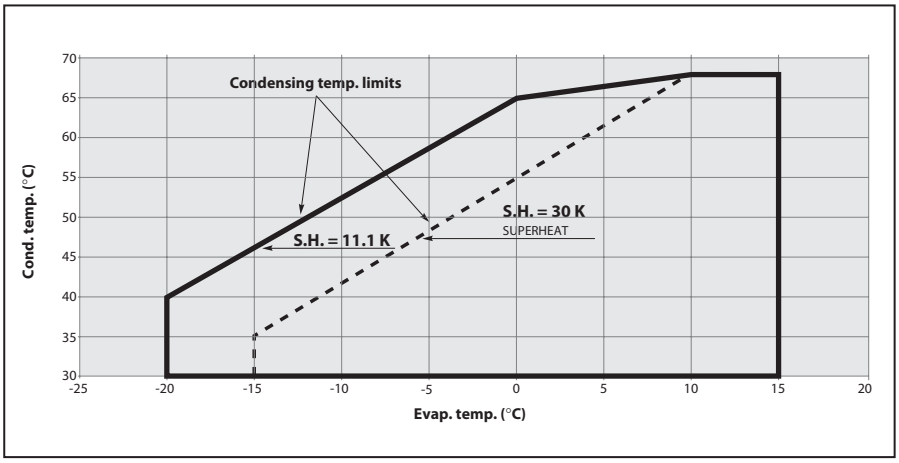
OPERATING ENVELOPES

The parallel assemblies recommended design from Danfoss Commercial Compressors have been qualified to ensure there is no impact on the compressor operating envelopes. Consequently, the Performer® scroll tandem, trio and quadro assemblies have the operating limits as shown below.

More details can be found in the Selection and Application Guidelines for Performer® scroll compressors (FRCC. PC.003).

R22

Tandem: **SM 170 to SM 370**
SY 482 to SY 600
Trio : **SM 480 - SM 550**
Quadro : **SM 640 - SM 740**



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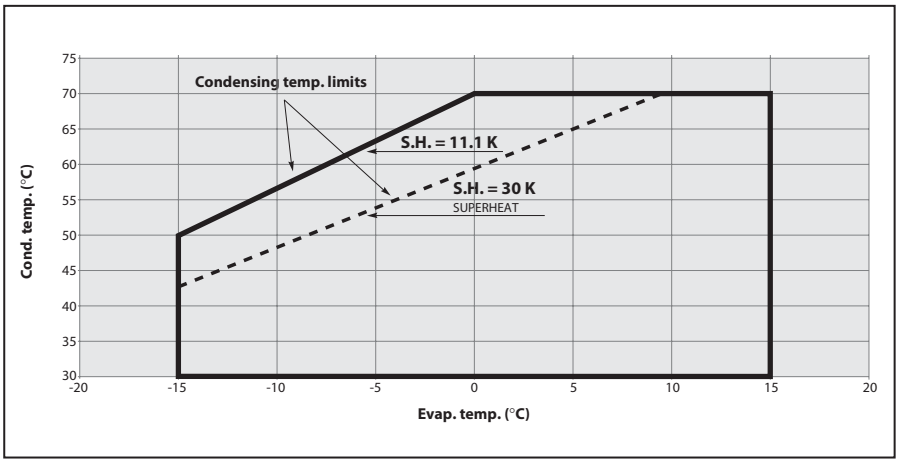
Tandem: **SZ 170 to SZ 370**
Trio : **SZ 480 - SZ 550**
Quadro : **SZ 640 - SZ 740**



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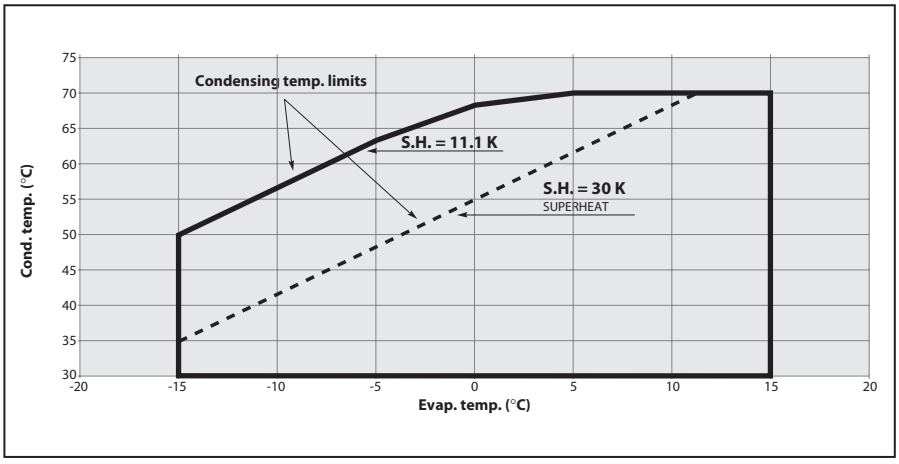
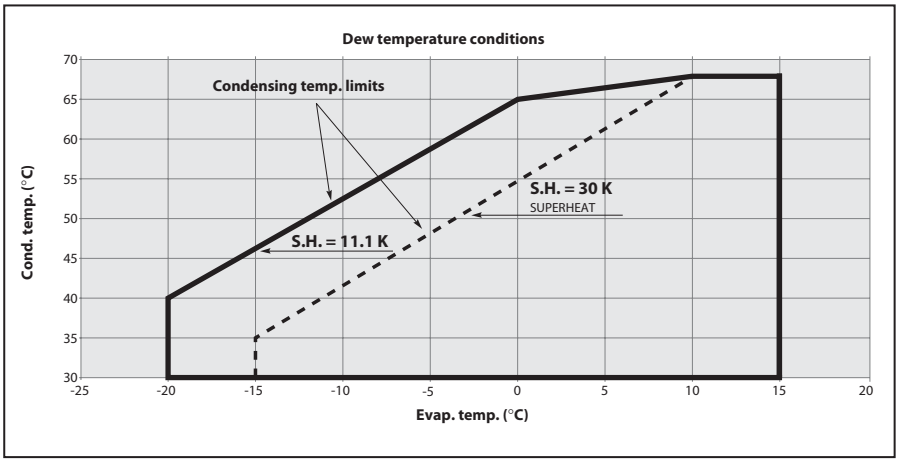
Tandem: **SZ 482 to SZ 600**

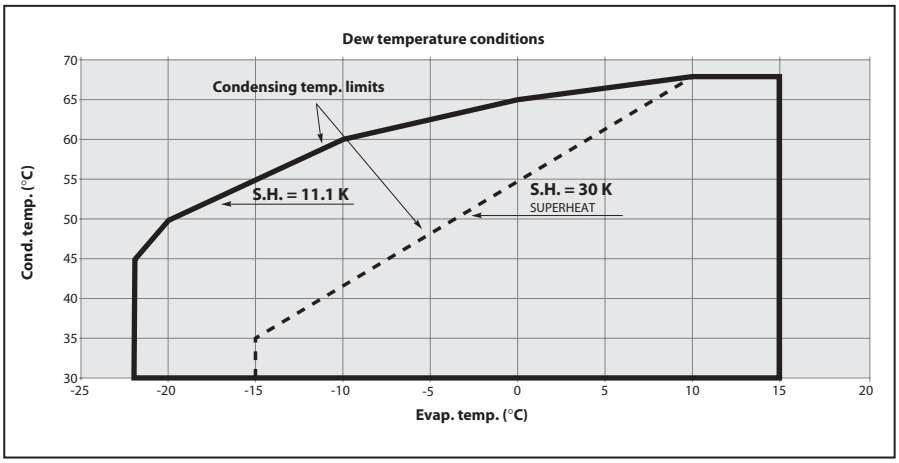


OPERATING ENVELOPES

R407C
At DEW temperature
Tandem: **SZ 170 to SZ 370**
SZ 425 - SZ 485
Trio : **SZ 480 - SZ 550**
Quadro : **SZ 640 - SZ 740**



R407C
At DEW temperature
Tandem: **SZ 482 & SZ 540 to SZ 760**



Please refer to the Selection and Application Guidelines for Performer® scroll compressors for general system design recommendations that are valid for single compressors as well as for parallel systems.

Typical system requirements and recommendations for parallel installations are listed below.

Thermostatic expansion valve

When the parallel installation is serving a single evaporator system the dimensioning of the thermostatic expansion valve (TXV) becomes critical and must be made in relation to both minimum and maximum capacity. This will ensure correct superheat control in all situations, with the minimum of 5K superheat at the compressor suction. The superheat setting of the expansion device should be sufficient to ensure proper superheat levels during low loading periods. A minimum of 5K stable superheat is required. In addition, the refrigerant charge should be sufficient to ensure proper subcooling within the condenser so as to avoid the risk of flashing in the liquid line before the expansion device. The expansion device should be sized to ensure proper control of the refrigerant flow into the evaporator. An oversized valve may result in erratic control. This consideration is especially important in manifolded units where low load conditions may require the frequent cycling of compressors. This can lead to liquid refrigerant entering the compressor if the expansion valve does not provide stable refrigerant superheat control under varying loads.

Refrigerant charge limits

	Tandem Units										Trio Units		Quadro Units	
Compressor models	S170 S180 S200	S220 S242	S230 S250	S268 S271 S281	S285 S290	S296 S310 S320 S322	S350 S370	S482	S540	S600 S680 S760	S480	S550	S640	S740
Refrigerant charge limit (kg)	10	12	14.5	15	15.5	16.5	17.5	21	23.5	26	21.5	23	28	30

Pressure switch settings

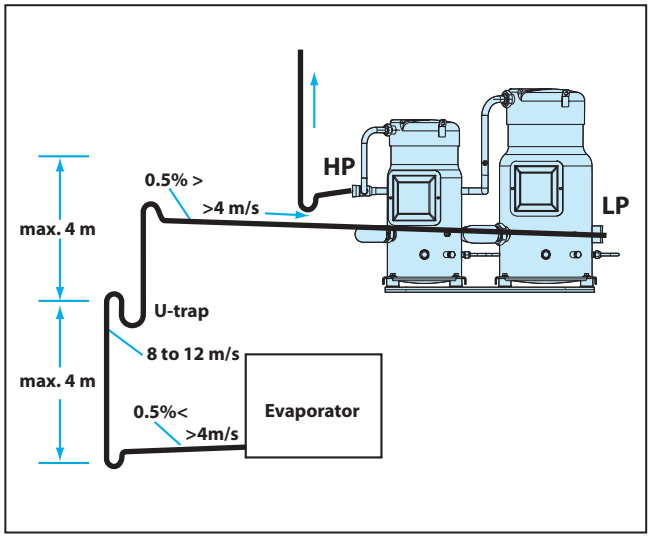
The pump down pressure switch must have a set point slightly higher than the lowest compressor safety pressure switch set point. The high-pressure safety pressure switch shall stop all compressors. Please refer to Performer® scroll compressors single application guidelines for recommended settings.

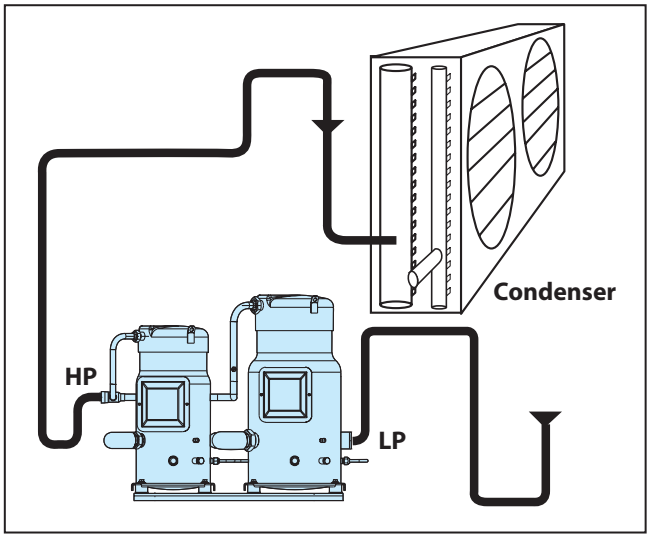
External check valve

Tandem, trio and quadro assemblies do not require the installation of an external check valve as each compressor comes equipped with a factory mounted internal check valve, which prevents the compressor running backwards when stopped while others are in operation.

Essential piping design considerations

Proper piping practices should be employed to ensure adequate oil return, even under minimum load conditions with special consideration given to the size and slope of the tubing coming from the evaporator. Tubing returns from the evaporator should be designed so as to not trap oil and to prevent oil and refrigerant migration back to the compressor during off cycles. A double suction riser may be required for low load operation if suction gas velocity is not sufficient to ensure proper oil return.





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

If the evaporator was situated below the compressors, the suction riser must be trapped so as to prevent liquid refrigerant from collecting at the thermal bulb location.

When the condenser is mounted at a higher position than the compressors, a suitably sized “U”-shaped trap close to the compressors is necessary to prevent oil leaving the compressor from draining back to the discharge side of the compressors during off cycle. The upper loop also helps avoid liquid refrigerant from draining back to the compressor when stopped.

Piping should be designed with adequate three-dimensional flexibility. It should not be in contact with the surrounding structure, unless a proper tubing mount has been installed. This protection proves necessary to avoid excess vibration, which can ultimately result in connection or tube failure due to fatigue or wear from abrasion. Aside from tubing and connection damage, excess vibration may be transmitted to the surrounding structure and generate an unacceptable noise level within that structure as well (for more information on noise and vibration, see section "Sound and vibration management" in Performer® scroll compressors application guidelines).

Cycle rate limit

The system must be designed in a way that guarantees a minimum compressor running time of 2 minutes so as to provide for sufficient motor cooling after start-up along with proper oil return. Note that the oil return may vary since it depends upon system design.

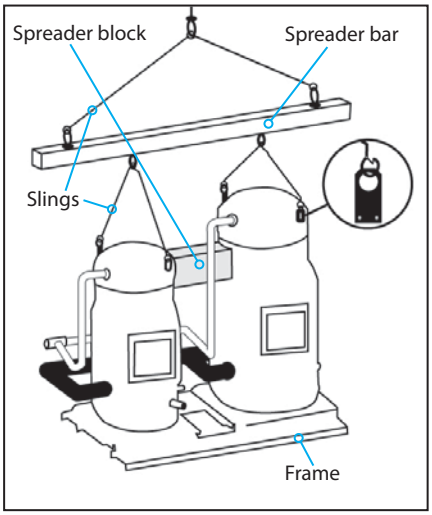
There must be no more than 12 starts per hour (6 when a resistor soft-start accessory is introduced); a number higher than 12 reduces the service life of the motor-compressor unit. If necessary, place an anti-short-cycle timer in the control circuit, then connected as shown in the wiring diagram in the P erformer® scroll compressors application guidelines. A three-minute (180-sec) timeout is recommended.

Installation and service procedures for a parallel system are similar to basic system installations. The selection of additional system components for parallel installations follows the basic system common rules. Please refer to the Selection and Application Guidelines for Performer® scroll compressors (FRCC.PC.003) for detailed installation and service procedures.

Handling

When a factory made tandem unit is applied (SM/SZ 170 to 370) special precautions and tools are required to put the unit into position. Handling must be smooth and gentle. Danfoss Commercial Compressors recommends using the lift and handling devices as shown in picture beside, and that the following procedure be used to prevent damage.

- Two lift rings are provided on each compressor. Use all four rings.
- Maximum loads authorized per sling and for the hoist hook must not be lower than the weight of the assembly.
- The minimum spreader bar length must be at least equal to the centre distance between the two compressors to prevent bending the frame.
- When lifting, use a spreader block between the compressors to prevent any unit frame damage.
- When the tandem unit is already mounted into an installation, never lift the complete installation by using the lift rings on the compressors.



Compressor mounting

Individual compressors must always be mounted using the provided mounting grommets and metal sleeves that isolates the compressor from the base plate. If this is not done the system will transmit vibration and in turn reduce compressor life. The rubber grommets must be compressed until contact between the flat washer and the steel-mounting sleeve is made.

A common base frame, rigid enough to support the weight of the compressors, must be used for installation. The common frame may be mounted on grommets to reduce transmission of vibration to the floor. It is recommended to install all control and safety devices on an independent frame. These devices should be connected to the common frame using flexible tubing.

Suction and discharge lines must have adequate three dimensional flexibility. For parallel systems the simplest means of acquiring this is by the use of vibration absorbers.

Tandem, trio & quadro piping design

For each tandem, trio and quadro configuration specific outline drawings are available as indicated on the following pages. These drawings must always be respected.

No changes shall be made to the indicated tubing diameter and fitting types.

The oil equalisation line shall be made of 3/8 and 1/2 inch refrigerant grade copper tube and assembled in such a way that it does not extend above the connection height and must be horizontal so as not to trap oil.

Wiring and rotation direction

All compressors in a tandem, trio and quadro unit must be electrically wired individually.
Compressors should run with the correct rotation direction. This can be achieved by having the correct phase sequence on each compressor motor terminal (L1-T1, L2-T2, L3-T3).

Oil level

The oil must be checked before commissioning (1/2 to full of the oil sight glass). Check the oil level again after a minimum of 2 hours operation at nominal conditions. In most installations the initial compressor oil charge will be sufficient. In installations with line runs exceeding 20 m or with many oil traps, additional oil may be required. Normally the quantity of oil added should be no more than 2% of the total refrigerant charge (this percentage does not take into account oil contained in accessories such as suction accumulators, liquid receiver, or oil traps). If this amount has already been added and the oil level in the compressors keeps decreasing, the oil return in the installation is insufficient. A piping design checking is required.

During operation, the oil level in the sight glass of the compressors may fluctuate. The oil level can be checked directly after the system has stopped. In this case the level must be at about 1/3 minimum in the oil sight glass.

Failure analysis

When one compressor in a parallel system fails, the chance of foreign particles entering other compressors is greatly increased. Therefore a failure analysis must be done quickly to insure further proper running conditions for the overall installation (i.e. : oil analysis).

Oil equalisation connection

Danfoss Commercial Compressors has developed specially adapted oil equalisation systems which ensure proper oil balancing between the compressors.
Hence, Performer® scroll compressors are equipped with flare connections:

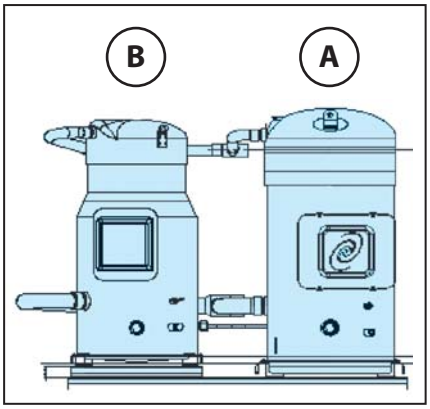
- S 084 to 185: 3/8" flare SAE – tightening torque 50 Nm.
- S 240 to 380: 1/2" flare SAE – tightening torque 65 Nm.

Operation principle

Tandem units SM/SZ 170 to SZ 425 & SZ 485 use the dynamic system for oil equalisation. This allows both the upstream compressor and the downstream compressor to run alone and provide for part load operation.

When the upstream compressor A runs alone, all suction gas and returned oil goes to this compressor. The sump of the downstream compressor B is at a higher pressure than compressor A. Should there be an excess of oil in the downstream compressor, which normally does not occur, the pressure difference will force the excess oil towards the upstream compressor.

When the downstream compressor B runs alone, all suction gas and a portion of oil goes to compressor B. The majority of returned oil goes to A under the effect of gravity. The sump of compressor A is at a higher pressure than compressor B, which allows any excess of oil to overflow to compressor B



Tandem assembly kits

Depending on the tandem model either factory made units or different tandem assembly kits are available:

1. Factory made tandem unit (only for models SM/SZ 170 to 370)
2. A kit containing the full suction and discharge piping, suction and discharge Tees and the suction oil separator / gas restrictor (only for models SM/SZ 170 to 370).
3. A kit containing the suction and discharge Tees and the suction oil separator / gas restrictor (only for models SM/SZ 170 to 370).
4. The suction oil separator / gas restrictor only (all models).

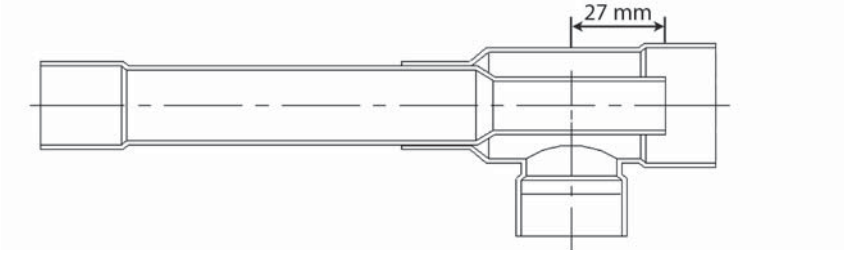
TANDEM UNITS S170 to S425 & S485

Tandem model	Composition	Suction	Discharge	Tandem assembly kit code no.			Outline drawing number
				Full piping	Restrictor +suc. & dis. Tees	Suction header restrictor	
SM/SZ 170	S084 + S084	1" 5/8	1" 1/8	**7777018**	**7703251**	**7765012**	8552021
SM/SZ 180	S090 + S090	1" 5/8"	1" 1/8	**7777018**	**7703251**	**7765012**	8552021
SM/SZ 200	S100 + S100	1" 5/8	1" 1/8	**7777018**	**7703251**	**7765012**	8552021
SM/SZ 220	S110 + S110	1" 5/8	1" 3/8	**7777014**	**7703384**	**7765025**	8552027
SM/SZ 230	S115 + S115	1" 5/8	1" 1/8	**7777019**	**7703251**	**7765012**	8551016
SM/SZ 242	S120 + S120	1" 5/8	1" 3/8	**7777014**	**7703384**	**7765025**	8552027
SM/SZ 250	S125 + S125	1" 5/8	1" 1/8	**7777019**	**7703251**	**7765012**	8551016
SM/SZ 268	S148 + S120	2" 1/8	1" 3/8	**7777031**	**7703390**	**7765025**	8552044 (8552051*)
SM/SZ 271	S161 + S110	2" 1/8	1" 3/8	**7777031**	**7703390**	**7765025**	8552044 (8552051*)
SM/SZ 281	S161 + S120	2" 1/8	1" 3/8	**7777031**	**7703390**	**7765025**	8552044 (8552051*)
SM/SZ 285	S160 + S125	2" 1/8	1" 3/8	**7777022**	**7703311**	**7765014**	8551095
SM/SZ 290	S175 + S115	2" 1/8	1" 3/8	**7777021**	**7703311**	**7765014**	8551017
SM/SZ 296	S148 + S148	2" 1/8	1" 3/8	**7777031**	**7703390**	**7765025**	8552045 (5252050*)
SM/SZ 310	S185 + S125	2" 1/8	1" 3/8	**7777021**	**7703311**	**7765014**	8551017
SM/SZ 320	S160 + S160	2" 1/8	1" 3/8	**7777020**	**7703372**	**7765013**	8551047
SM/SZ 322	S161 + S161	2" 1/8	1" 3/8	**7777031**	**7703390**	**7765025**	8552045 (5252050*)
SM/SZ 350	S175 + S175	2" 1/8	1" 3/8	**7777015**	**7703371**	**7765013**	8551018
SM/SZ 370	S185 + S185	2" 1/8	1" 3/8	**7777015**	**7703371**	**7765013**	8551018
SZ 425	S300 + S125	2" 1/8	1" 3/8	-	-	**7765027**	8556015
SZ 485	S300 + S185	2" 1/8	1" 3/8	-	-	**7765027**	8556016

*Drawings for models with motor voltage code 3 are different due to different electrical box model.

Restrictor assembly

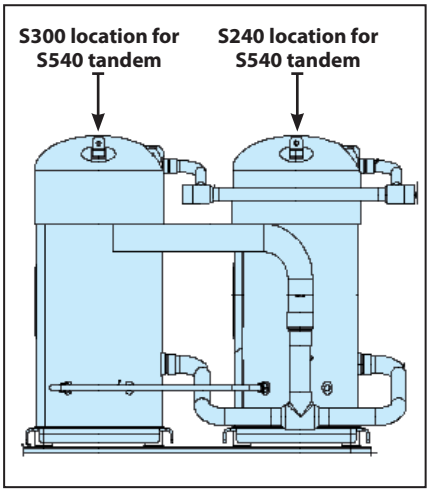
Special attention is required when mounting the restrictor tube into the suction tee. The extremity of the restrictor tube must be located as shown below.



Operation principle

SY/SZ 482-540-600-680-760 tandems use the static system to balance the oil level between the compressors. Each of the compressors may run alone to provide for part load operation. The system has been designed to ensure a precise pressure balancing between the sumps, facilitating the oil equalisation by gravity. The discharge line is shown with two tees, to indicate that both left and right side discharge header are possible.

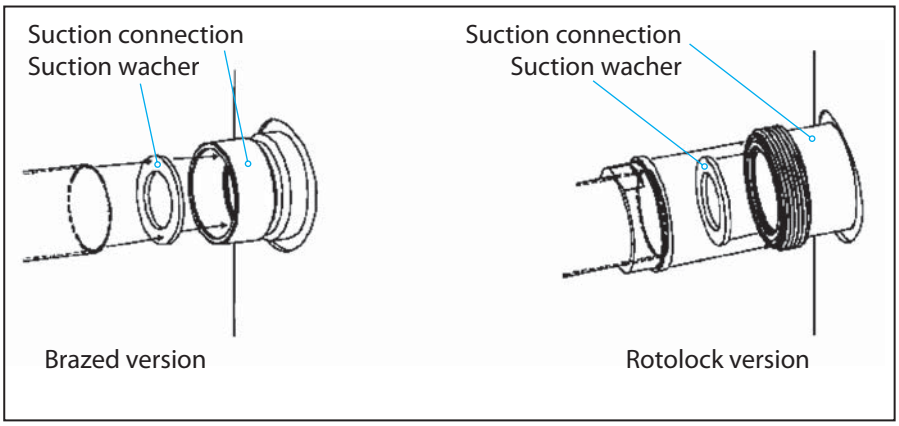
Note: the compressor position has to be respected for SY / SZ 540 tandem, as shown beside.



Suction washer

Tandem must be assembled according to the drawings as listed in below table. Some essential design elements from these drawings that must absolutely be followed are:

- The manifold assembly extending from the common suction connection to each compressor must be symmetrical, which means that they must utilize identical components and lengths.
- All elbows must be of the long radius type.
- The discharge and suction lines from each compressor must have a slope as indicated.
- A suction washer must be placed in the S240 compressor suction, on S540 tandems as shown below.
- A suction washer must be placed in the S380 compressor suction, on S680 tandems as shown below.



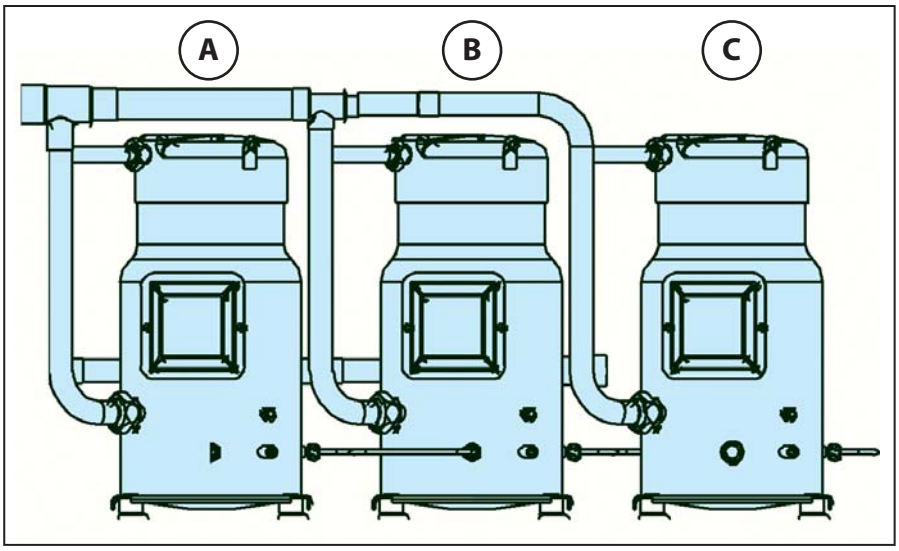
TANDEM UNITS SY/SZ 482-540-600-680-760

Tandem model	Composition	Suction	Discharge	Suction washer Code no.	Outline drawing number
SY/SZ 482	S240 + S240	2" 5/8	1" 5/8	-	8556013
SY/SZ 540	S300 + S240	2" 5/8	1" 5/8	**7777023**	8556034
SY/SZ 600	S300 + S300	2" 5/8	1" 5/8	-	8556013
SZ 620	S380 + S240	2" 5/8	2" 1/8	-	8556036
SY/SZ 680 left suction	S380 + S300	2" 5/8	2" 1/8	**7777036**	8556032
SY/SZ 680 right suction	S380 + S300	2" 5/8	2" 1/8	**7777032**	8556032
SY/SZ 760	S380 + S380	2" 5/8	2" 1/8	-	8556029

Operation principle

Trio units SM/SZ 480 and 550 use the dynamic system for oil equalisation, based on preferred oil return to the upstream compressor A. Oil sump pressure differences are created, so that when all compressors are running sump pressure $p_A > p_B > p_C$, which allows oil transfer from A to B to C.

A 1/2" oil equalisation line is fitted from the oil equalisation connector of compressor A to the oil equalisation connector of compressor B and from the sight glass connector of compressor B to the oil equalisation connector of compressor C.



A fixed loading sequence must be respected to ensure reliable operation (see table).
This applies to continuous operation. For transient situations other sequences are possible. For example when starting the unit at 66 % it is acceptable to start directly C and a few seconds later B. The above loading sequence ensures good oil distribution in the whole application envelope, even when rapid cycling occurs.

Load	A	B	C
33 %	On	Off	Off
66 %	Off	On	On
100 %	On	On	On

Trio assembly kits

Due to their volume and weight, trio assemblies are not available as factory made units. Three different assembly kits are available for field assembly;

1. A suction oil separator/gas restrictor, discharge header T connector, sleeves, gaskets, oil adapters and oil fittings.
2. A suction oil separator/gas restrictor, sleeves, gaskets, oil adapters and oil fittings.
3. gaskets, oil adapters and oil fittings.

TRIO UNITS SM / SZ 480 - 550

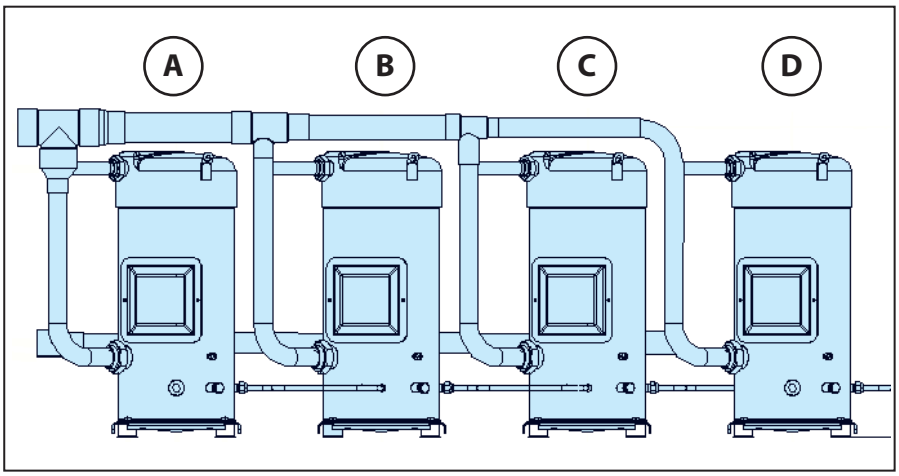
Trio model	Composition	Suction	Discharge	Trio assembly kit code no.			Trio drawing number
				Restrictors + Tees + sleeves + gaskets + oil fittings	Restrictors + sleeves + gaskets + oil fittings	Adapters + gaskets + oil fittings	
SM/SZ 480	3 x S160	2" 5/8	2" 1/8	**7777012**	**7777016**	**7773112**	8551093* 8551094**
SM/SZ 550	3 x S185	2" 5/8	2" 1/8	**7777012**	**7777016**	**7773112**	8551084* 8551081**

* Left suction connection
** Right suction connection

Operation principle

Quadro units SM/SZ 640 and 740 use the dynamic system for oil equalisation, based on preferred oil return to the upstream compressor A. Oil sump pressure differences are created, so that when all compressors are running sump pressure $p_A > p_B > p_C > p_D$ which allows oil transfer from A to B to C to D.

A 1/2" oil equalisation line is fitted from the oil equalisation connector of compressor A to the sight glass connector of compressor B, from the oil equalisation connector of compressor B to the sight glass connector of compressor C and from the oil equalisation connector of compressor C to the oil equalisation connector of compressor D.



A fixed loading sequences must be respected to ensure reliable operation (see table).
This applies to continuous operation. For transient situations other sequences are possible. For example when starting the unit at 50 % it is acceptable to start directly D and a few seconds later C or for 75 % start D, then C, then B. The above loading sequence ensures good oil distribution in the whole application envelope, even when rapid cycling occurs.

Load	A	B	C	D
25 %	On	Off	Off	Off
50 %	Off	Off	On	On
75 %	Off	On	On	On
100 %	On	On	On	On

Quadro assembly kits

Due to their volume and weight, quadro assemblies are not available as factory made units. Two different assembly kits are available for field assembly;

1. A suction oil separator/gas restrictor, discharge header T connector, sleeves, gaskets, oil adapters and oil fittings.
2. A suction oil separator/gas restrictor, sleeves, gaskets, oil adapters and oil fittings.

QUADRO UNITS SM / SZ 640 - 740

Quadro model	Composition	Suction	Discharge	Quadro assembly kit code no.			Quadro drawing number
				Restrictors + Tees + sleeves + gaskets + oil fittings	Restrictors + sleeves + gaskets + oil fittings	Adapters + gaskets + oil fittings	
SM/SZ 640	4 x S160	3" 1/8	2" 1/8	**7777011**	**7777017**	-	8551088* 8551089**
SM/SZ 740	4 x S185	3" 1/8	2" 1/8	**7777011**	**7777017**	-	8551078* 8551080**

* Left suction connection
** Right suction connection

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