Your step-by-step compressor installation check list

1. Space
2. Ventilation
3. Air Intake
4. Cooling Water
5. Electrical System
6. Pipe Dimensions, Air Receiver Volume

Atlas Copco

Customer: ....

Address: ....

Contact Person: ....

Contact Details: ....

Atlas Copco Services Middle East

Address: ....

Contact Person: ....

Contact Details: ....

For Service Enquiries: ....

For Parts Enquiries: ....

Unit Model: ....

Unit Serial: ....

Dryer Serial: ....

Motor Serial: ....

How to use this document

You have made a wise decision to install an Atlas Copco stationary air compressor to give you the right quality of air when and where you need it. The purpose of this check list is to make sure you get the performance you have paid for by ensuring that your compressor installation, your air treatment package, and your air distribution network are assembled correctly. **A correct compressed air system will keep your maintenance costs down and put your productivity up.**

This document contains all the necessary information required for a good installation. This is followed by a check list to ensure that all the relevant points related to installation are covered. Ideally you should be able to answer YES to each questions. Read each question carefully. If you cannot answer YES, then you need to take action so that you can finally answer YES. If you're not a hundred percent certain of your YES, then you should contact your Atlas Copco Engineer and ask for advice. Don’t hesitate to ask for this sort of advice. It's part of the service you're entitled to as a user of Atlas Copco products. Remember it's never too far for Atlas Copco.

So take your time, read the check list questions carefully, and take the necessary steps to make your answers YES and you'll have an effective, economical and easy-to-operate compressed air system helping you to do a better job.

This INSTALLATION CHECK LIST is for the use with Atlas Copco stationary screw compressors.

While you should find all you need in this check list, it's not possible to cover every local condition. You can help improve the check list by sending details of your installation to Atlas Copco.

How can a good installation save energy?

The greatest waste of electrical energy is caused by compression inefficiency. However, good engineering and a little imagination can reduce energy losses to a minimum.

Three common sources of energy losses are:

Inadequate supply of cooling water or air to the intercooler.

Poorly dimensioned pipework and filters excessive pressure drops the compressor.

Badly assembled pipework and fittings causing air leakage; the compressor must work longer. Each additional 0.1 bar required to overcome pressure drops increases the compressor's power requirement by ± 0.7%. The effect of air line leakage is even more dramatic.

Hole diameter					
True size					
mm		1	3	5	10
in		3/64	1/8	3/16	3/8
Air leakage at					
6 bar	l/s	1	10	27	105
85 psi	cfm	2	21	57	220
Power required for compression					
hp		0.4	4.2	11.2	44
kW		0.3	3.1	8.3	33

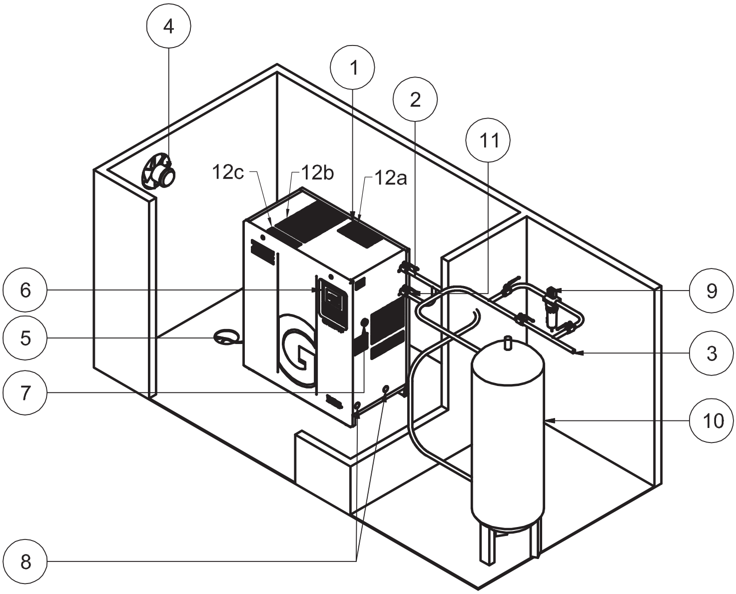
Fortunately, almost all the energy used by the compressor is recoverable in the form of warmed cooling air or hot water, which may be recycled for space heating, boiler feed water, shower and wash water, etc.

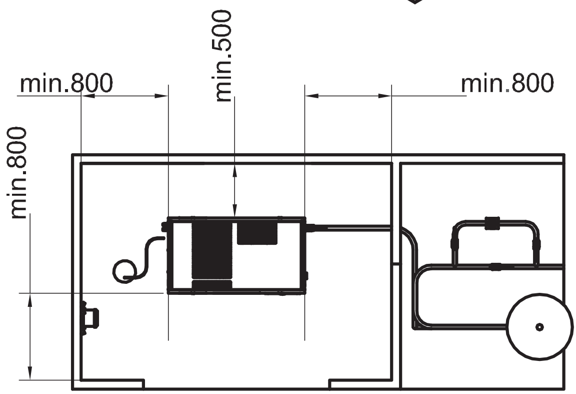
How does the design of an installation affect maintenance?

High maintenance cost on a compressor are often the result of a poor installation, inadequate water treatment and filtration can cause the coolers to become fouled and overheat; incorrectly locating the air intake increases the burden on filters.

- Attention to details is the key to efficient, maintenance friendly operation.
- Check every component of the proposed installation against the manufacturer's maintenance instructions.
- Allow adequate clearance around the installation for doors to be opened, motors and coolers to be removed and oil to be drained.
- Use differential pressure gauges across filters to monitor their performance. Bypass pipework around filters and dryers to permit isolation and maintenance.
- isolation valves on all compressor discharges, water lines etc.
- Provide for connection of compressor between the plant compressor and aftercooler (if provided) which comes handy should there be a need.
- Install a monorail and hoist for lifting heavy components.
- Provide a large-dimension door to the compressor room to allow entry of fork lift and future units.

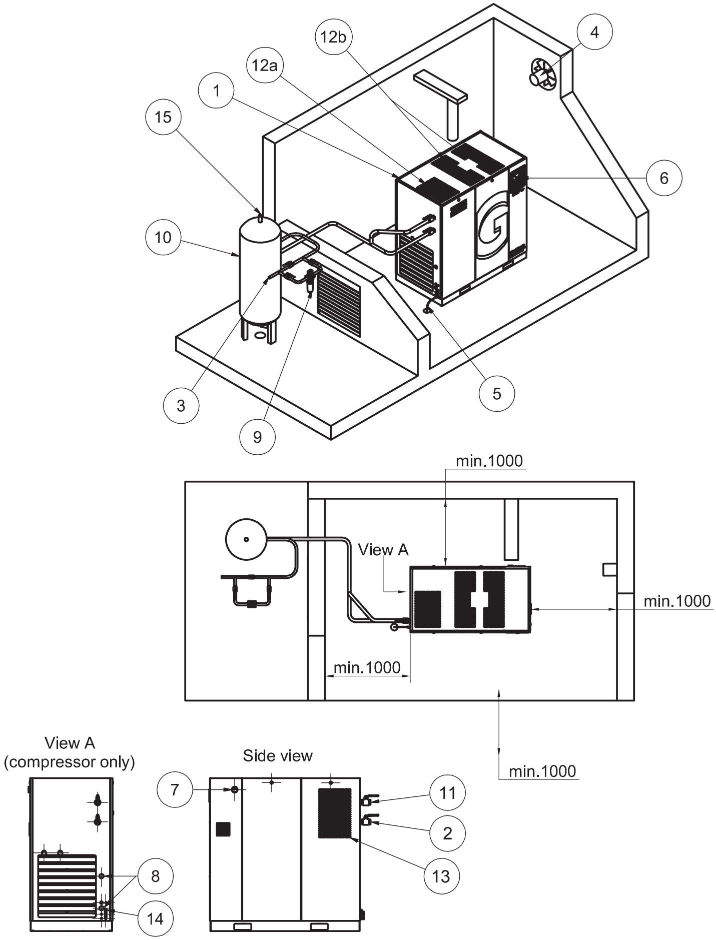
Installation proposal
GA 11+ to 30



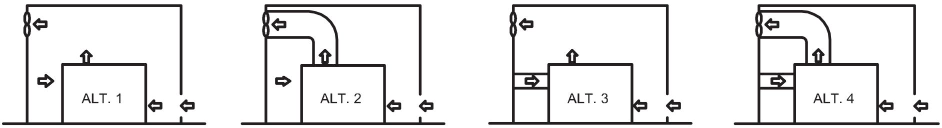


The direction of the cooling flows may never be inverted.

Installation proposal GA 30+ to 45

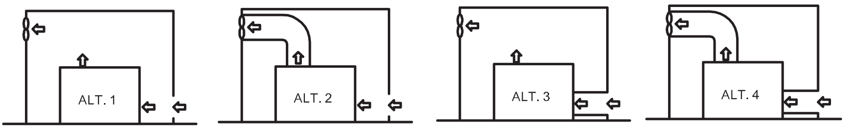


Installation proposal
GA 11+ to 45



GA 11+ to 30

The direction of the cooling flows may never be inverted



GA 30+ to 45

Main components

1 Compressor unit: The unit should be installed on a level floor capable of taking the weight of the compressor.

2 Compressed air outlet valve (not in scope of supply)

3 Delivery pipe:
The maximum total pipe length (including interconnecting piping between compressor and receiver) can be calculated as follows:

$$L = \frac{\Delta P \times d^5 \times P}{450 \times Qc^{1.85}}$$

where,
- L = length of the pipe (m)
- Δp = pressure drop (recommended maximum = 0.1 bar / 1.5 psi)
- d = inner diameter of the pipe (mm)
- p = absolute pressure at compressor outlet- bar (a)
- Qc = free air delivery of the compressor (l/s)

4 Ventillation :
The inlet grid(s) and ventillation fan should be installed in such a way that any recirculation of cooling air to the inlet grating of the compressor/dryer is avoided.
The air velocity to the grid(s) has to be limited to 5m/s. The maximum air temperature at compressor intake opening is 46 °C (115 °F), (minimum 0°C/32 °F).

Installation proposal GA 11+ to 45

Ventilation alternative 1 and 3: The required ventilation to limit compressor room temperature can be calculated from :

$$Qv = 1.06\ N / \Delta T \quad \text{for Pack unit}$$

$$Qv = \frac{(1.06N+1.2\ D)}{\Delta T} \quad \text{for Full-Feature unit}$$

where,

- Qv = required cooling air flow (m^3/s)
- N = nominal motor power of compressor (kW)
- ΔT = temperature increase in compressor room (°C)
- D = electric power dryer

Ventilation alternative 2 and 4: The fan capacity should match the compressor – fan capacity at a pressure head equal to the pressure drop caused by cooling air ducts.
The ducting for the air outlet of the dryer (12a) should be separated from the ducting for the cooling air outlet of AIR/OIL coolers and cooling air outlet of the compressor compartement.(12b)
Maximum allowable pressure drop in ducting before or after the compressor = 30 Pa.

5 Drain pipes to drain collector must not dip into the water. For draining of pure condensate water, install an oil /water separator. Consult Atlas Copco. Drain pipes of different compressors may not be interconnected before the (atmospheric) collector. Interconnecting drain pipes of different compressors can damage the electronic drains of the compressor.
6 Control cubicle with monitoring panel.
7 Power supply cable to be sized and installed by a qualified electrician. In case of IT network, consult Atlas Copco. To preserve the protection degree of the electric cubicle and to protect its components from dust from the environment, it is absolutely necessary to use a proper cable gland when connecting the supply cable to the compressor.
8 Provision for energy recovery system.

Installation proposal
GA 11+ to 45

9 Filter type DD for general purpose filtration (particle removal down to 1 micron with a maximum oil carry over of 0.5 ppm). In case of FULL FEATURE variants (dryer included), this filter can be integrated in the compressor. A high efficiency PD filter may be installed downstream the DD filter (particle removal down to 0.01 micron and maximum oil carry over of 0.01ppm). Should oil vapors and odors be undesirable, a QD active carbon filter should be installed after the PD filter. It is recommended to install by-pass pipes over each filter together with ball valves in order to isolate the filters service operations, without interrupting the compressed air delivery.

10 The air receiver (optional) should be installed in a frost-free room on a solid level floor. For normal air consumption, the volume of the air net (receiver and piping) cane calculated as follows:

$$V=(0.25 \times Qc \times P1 \times TO)/(fmax \times \Delta P \times T1)$$

V	= volume of the air net in l
Qc	= free air delivery of the compressor in l/s
P1	= compressor air inlet pressure in bar absolute
fmax	= cycle frequency=1 cycle/30s
ΔP	= Punload - Pload in bar
T1	= compressor air inlet temperature in K
T0	= air receiver temperature K

11 By-pass systems: to be installed to by-pass the dryer during service operations. (Available as option: consult Atlas Copco)

12 To prevent feadback of exhaust air to the cooling inlet, sufficient space should be foreseen above the unit to evacuate the exhaust air. Otherwise a ducting for the exhaust air should be foreseen. See ALT.1 to ALT.4

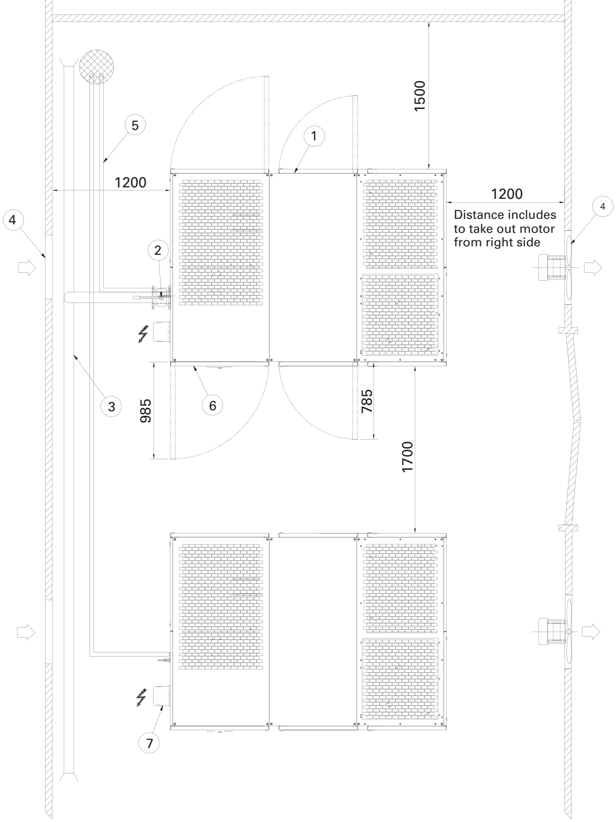
13 Cooling air grating dryer.

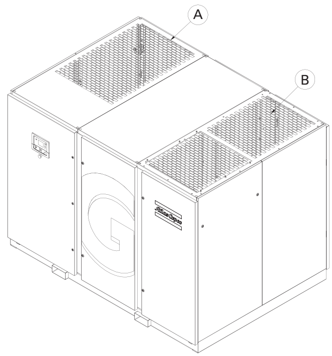
14 When ducting is foreseen on the inlet air then the ambient temperature sensor need to be repositioned in such a way that the inlet temperature is monitored.

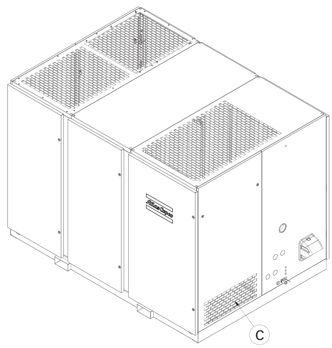
15 Safety valve.

Installation proposal GA 90+ to 160

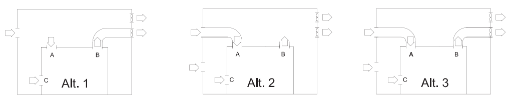
Minimum free area to be reserved for the compressor installation.







Ventilation Proposals



Notations :

- (A) :Compressor air inlet & Cooling air inlet
- (B) :Cooling air & motor ventilation outlet
- (C) :Motor cooling air inlet

Main components

1 Compressor unit:
The unit should be installed on a level floor capable of taking the weight of the compressor.

2 Compressed air outlet valve (not in scope of supply).

3 Delivery pipe:
The maximum total pipe length can be calculated from:

$$L = \frac{\Delta P \times d^5 \times P}{450 \times Qc^{1.85}}$$

L is the length of the pipe (m)
P is the max. allowable pressure drop (recommended 0.1 bar)
d is the inner diameter of the pipe (mm)
P is the absolute pressure at the compressor outlet (bar)
Qc is the compressor FAD (l/s)

The connection of the compressor air delivery pipe should be made on top of the main air net pipe to minimize carry-over of possible remainder of condensate.

4 Ventilation:
The inlet grid(s) and ventilation fan should be installed in such a way that any recirculation of cooling air to the compressor is avoided. The air velocity to the grid(s) has to be limited to 5 m/s. The maximum allowable pressure drop over all cooling air ducts together is 30 Pa.
The maximum air temperature at the compressor intake opening is 46°C (55°C for HAT version), minimum 0°C. The required ventilation to limit the compressor room temperature can be calculated from:

$$Qv = 0.92\ N / \Delta T$$

Qv is the required ventilation capacity (m/s)
N is the shaft input of the compressor (kW)
ΔT is the compressor room temperature over the outdoor temperature (°C)

5 Drain pipes to condensate collector: The drain pipes may not enter in the collector. Individual drain pipes may not be interconnected, to avoid interference. Compressor condensate contains oil. Depending on local legislation it is recommended to install an oil/water separator, consult Atlas Copco.

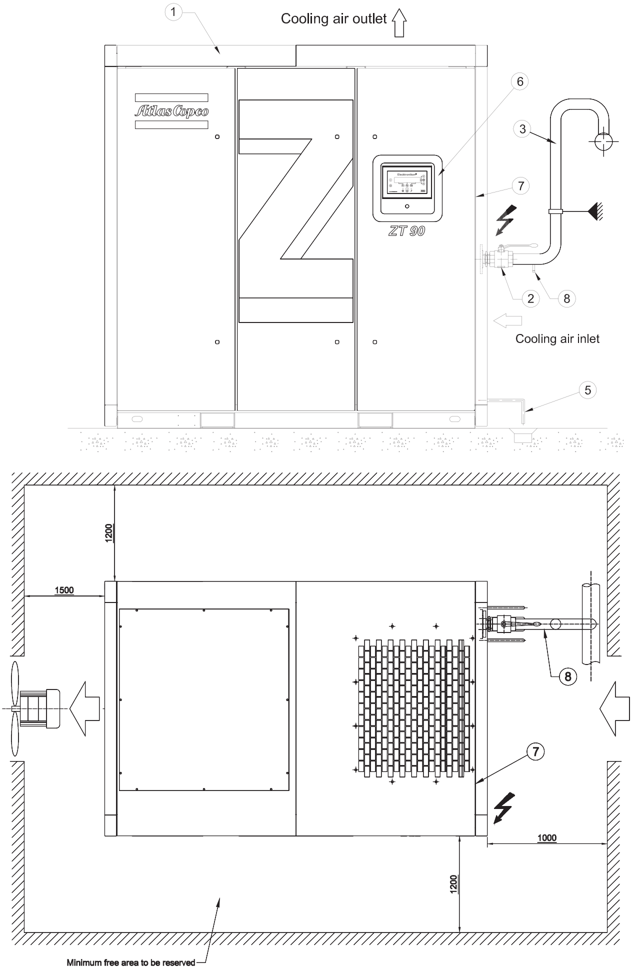
6 Control cubicle with monitoring panel.

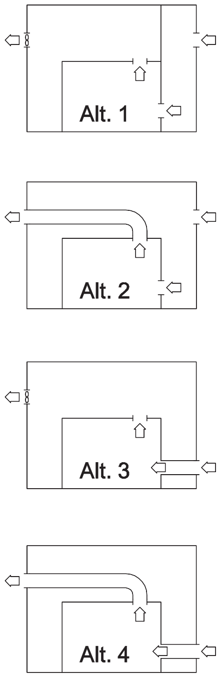
7 Main cable entry.

Notes:

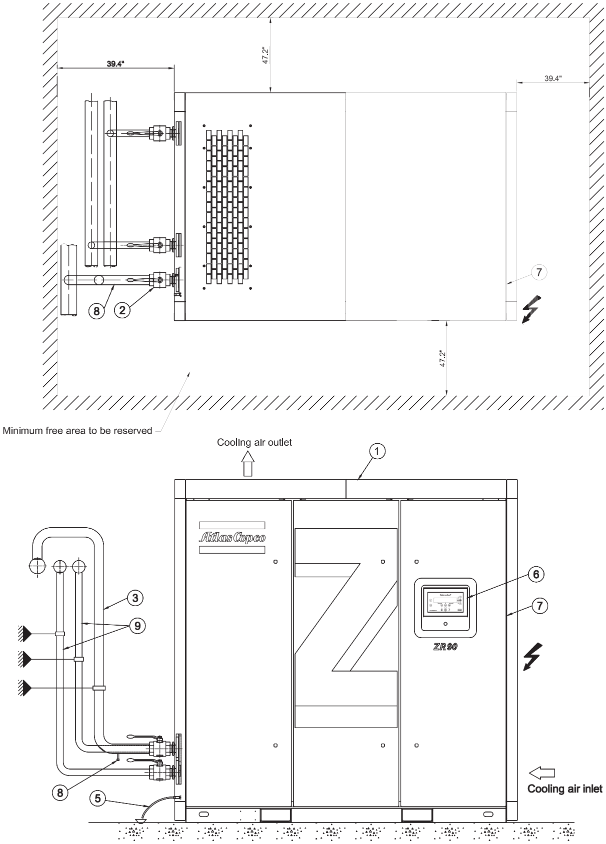
- For more information concerning air nets, cooling systems, etc refer to the compressor installation manual.
- All pipes should be installed stress-free to the compressor unit.
- For dimensions and air flow directions refer to the dimension drawing.
- Calculate air receiver volume acc. compressor installation manual for a max cycle frequency of 1/30s.

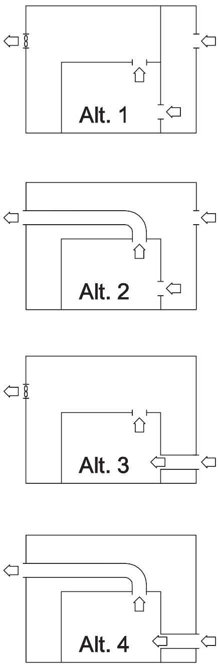
Installation proposal ZT 55 to 90





Installation proposal ZR 55 to 90 (FF)





Common ducting for multiple units is not allowed

Installation proposal
ZT 55 to 90 / ZR 55 to 90 (FF)

Main components

1 Compressor unit:
The unit should be installed on a level floor capable of taking the weight of the compressor (Max allowable deviation: 3 mm on 1 meter). Recommended minimum distance between top of unit and ceiling is 1200 mm for ventilation. (ventilation proposal 2-3-4 excepted) Distances between unit and walls stated are minimum.

2 Compressed air outlet valve (not in scope of supply)

3 Delivery pipe:
The max. total pipe length can be calculated from:

$$L = \frac{\Delta P \times d^5 \times P}{450 \times Qc^{1.85}}$$

L is the length of the pipe (m)
ΔP is the maximum allowable pressure drop (recommended 0.1 bar)
d is the inner diameter of the pipe (mm)
P is the absolute pressure at the compressor outlet (bar)
Qc is the compressor FAD (l/s)

(The connection of the compressor air delivery pipe should be made on top of the main air net pipe to minimize carry-over of possible remainder of condensate).

4 Ventilation proposal:
Common ducting for multiple units is not allowed

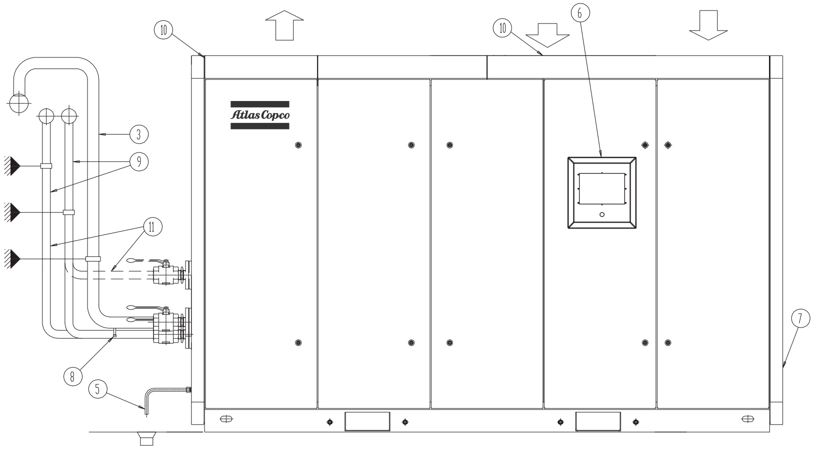
The inlet grid(s) and ventilation fan should be installed in such a way that any recirculation of cooling air to the compressor is avoided.
The air velocity to the grid(s) has to be limited to 5 m/s.
For alternatives 2,3 and 4 the maximum allowable pressure drop over cooling air duct is 30Pa.
The maximum air temperature to the compressor intake opening is 40°C (For HAT version 50°C), minimum 0°C.

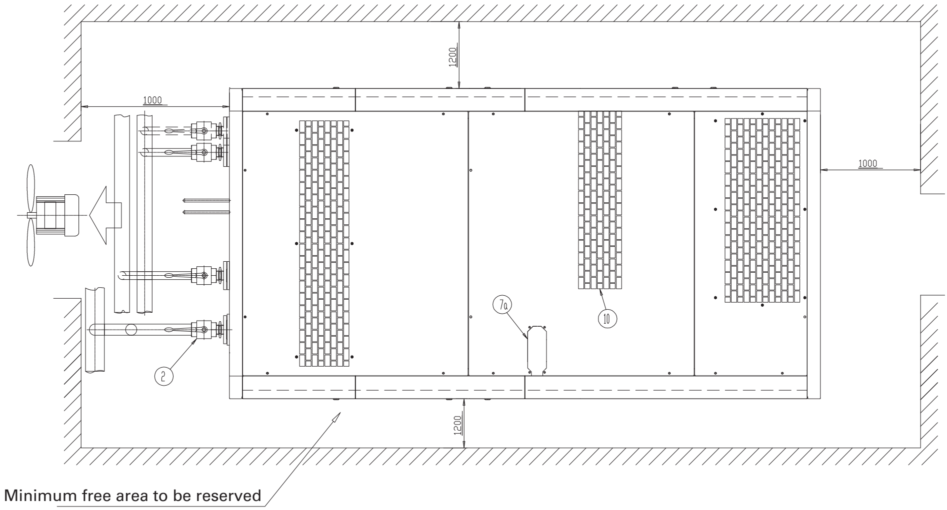
Alternative 1 & 3:
The required ventilation to limit the compressor room temperature can be calculated from:
$Qv=0.92\ N / \Delta T$
Qv is the required ventilation capacity (m^3/s)
N is the shaft input of the compressor (kW)
ΔT is the compressor room temperature over the outdoor temperature (°C)

5 Drain pipes to open condensate collector. The drain pipes must not enter in the collector.
6 Control cubicle with monitoring panel.
7 Power supply cable entry.
8 Drain valve

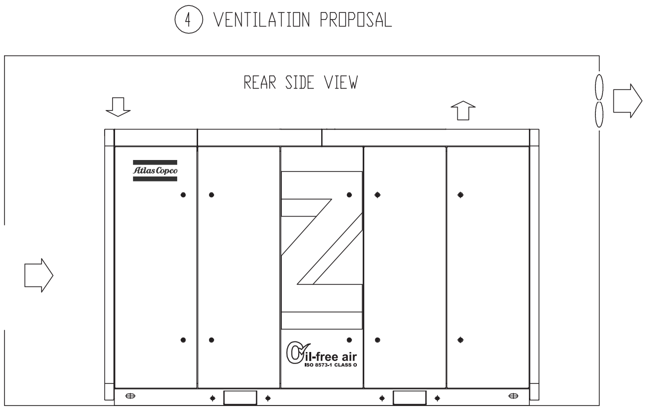
Notes:
- All pipes should be installed stress free to the compressor unit.
- For dimensions and air flow directions refer to the dimension drawings.

Installation proposal
ZR 160 to 275





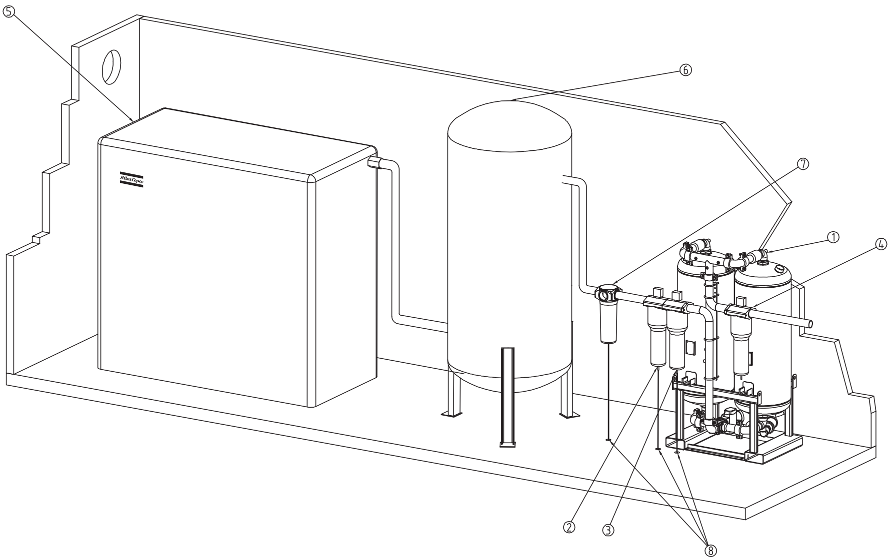
Installation proposal
ZR 160 to 275



Main components
1 Air Compressor
2 Compressed air outlet valve (not in scope of supply)
3 Delivery pipe
4 Ventilation proposal
5. Drain pipes
6 Control cubicle with monitoring panel.
7 Cable power entry
7a Second possibility only for VSD units
8 Drain valve
9 Cooling water supply
10 Extra inlet grating only for units not in scope of supply prefilter min. temprature -20°C.
11 OPTION ENERGY RECOVERY Cooling water supply

Notes:
- For more information concerning air nets, cooling systems, etc refer to the compressor installation manual.
- All pipes should be installed stress free to the compressor unit.

Installation proposal
CD Air Dryer



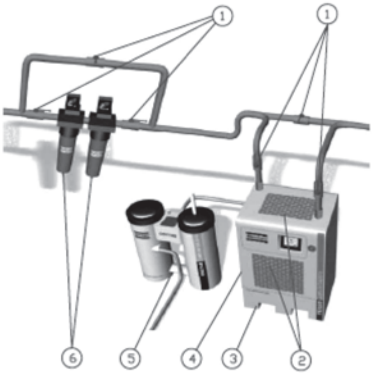
Installation proposal
CD Air Dryer

The air dryer unit must be installed on a level floor suitable for taking the weight of the dryer. There must be a free space of 800 mm around the dryer.

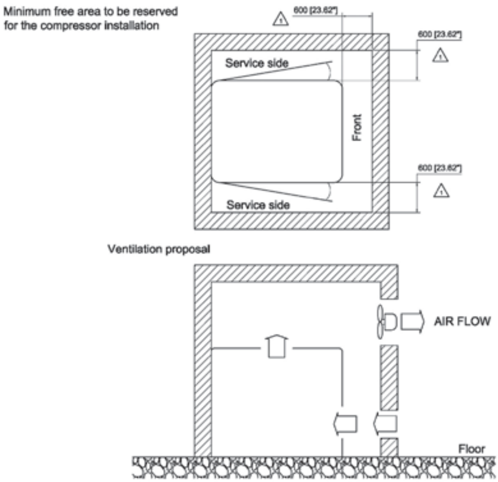
On both inlet filters a drain tube must be installed. The drain pipes to the drain collector must not dip into the water. For draining of pure condensate water, install an oil/water separator (Consult Atlas Copco).

The DD inlet filter for general-purpose filtration (particle removal down to 1 micron with a maximum oil carry-over of 0.5 ppm). A high efficiency PD-filter(3) installed downstream the DD- filter (particle removal down to 0.01 micron and max. oil carry- over of 0.01 ppm).

Installation proposal
FD Air Dryer



Dryer without integrated options:



Installation proposal FD Air Dryer

1 It is recommended to install by-pass pipes over each filter and air dryer together with ball valves in order to isolate the filters and/or dryer during service operations, without disturbing the compressed air delivery.

2 Ventilation:
The installation grid(s) and ventilation fan should be installed in such a way that any recirculation of cooling air to the inlet gratings of the dryer is avoided.

The air velocity to the grid(s) has to be limited to 5m/s.

Maximum allowable pressure drop over the cooling air ducts is 30 Pa. When 30 Pa is exceeded, a ventilation fan is needed at the outlet of the cooling air ducts.

3 The refrigerant air dryer should be installed on a level floor suitable for taking the weight of the dryer.

4 Power supply cable to be sized and installed by a qualified electrician.

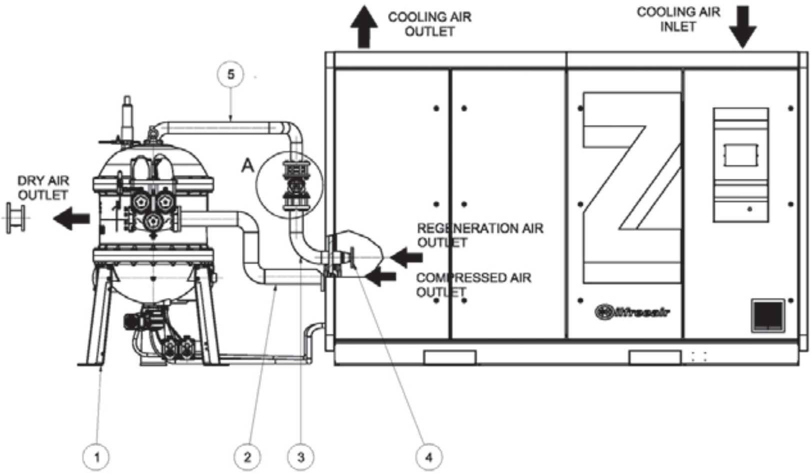
5 The condensate drain pipes from the dryer to the collection point must not submerge in the collected condensate.
Do not allow untreated condensate to enter the draining system. An OSC can be added to separate oil from the water that is coming from the drain of the dryer. As an option you can get Integrated OSD to do this.

6 Filter type DD for general-purpose filtration (particle removal down to 1 micron with a maximum oil carry-over of 0.5 ppm). A high efficiency PD-filter (3) installed downstream the DD- filter (particle removal down to 0.01 micron and max. oil carry- over of 0.01 ppm).
Should oil vapour and odors be undesirable, a QD active carbon filter should be installed after the PD filter.

As an option you can get integrated filters in the dryer.

Notes:
- All pipes should be installed stress free to the dryer.
- For dimensions and air flow directions refer to the dimension drawing.

Installation proposal MD Air Dryer



Installation proposal MD Air Dryer

Before installation of the MD air dryer to the compressor, be sure that the compressor is de-pressurized and disconnected from the mains.

All the pipes and valves for the connection between air dryer and air compressor are delivered with the unit. The unit should be installed on a level floor capable of taking the weight of the dryer.

Connect the compressed air lines to the inlet and outlet pipes of the dryer.

Connect the regeneration airline to the regeneration air inlet of the dryer. The dryer can be serviced while by-passing the dryer.

Each drain pipe must be individually connected to the waste pipe. Lay out the condensate drain pipes via a funnel towards the waste pipe to allow visual inspection. The pipes must slope downwards.

If the condensate drain pipes have been fitted outside the compressor room where they may be exposed to freezing temperatures, it must be insulated.

For water cooled units connect the water cooling pipes to the inlet and outlet connections. It is recommended to fit a manual shut-off valve and drain in the water inlet and outlet (customer's installation).

Install the safety valve(s).
Connect the supply cable for gear motor and fan motor (only air-cooled versions) via the compressor panel and frame into the compressor cubicle to the correct terminals.

Guidelines for cooling water requirements

Knowing your total cooling water requirement and its allowed temperature increase you can calculate the heat amount that has cooled away in the cooling tower.

D^t X Q^v in kcal/second

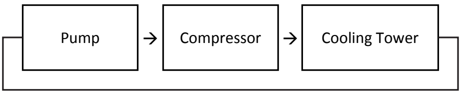
where D^t is increase of cooling water temp. in °C
Q^v is cooling water flow in litres/second.

Calculate with a cooling water temperature increase of 15°C. Should a lower temperature increase than 15°C be required, please contact your Atlas Copco Engineer for advice.

The water pressure in G or Z compressor must not exceed 5 bar. You must therefore limit the water pressure drop through the compressor to approximately 2 bar. If you install a cooling water pump close to and before the compressor, the pump must overcome the following resistance:

Compressor	2.0 bar
Static water height	0.3 bar
Cooling tower nozzle	0.4 bar
Pipes, bends and valves	0.3 bar
Totally	3.0 bar

In countries with a temperate climate you can reduce water temperature by 15°C in a cooling tower. You can use a simple single-circuit cooling system with this water flow:



In tropical countries with high temperature and high humidity it is difficult to obtain a better temperature reduction than 10°C in a cooling tower. To get this you will need a double-circuit cooling system with two water pumps, a separate water basin, and individual water circuits for tower and compressor. This gives a sophisticated and efficient solution but investment needed is high. The alternative is to use a modified single-circuit system. Your investment costs will be lower. But you must dimension your cooling tower for a water flow 50% higher than the flow through the compressor. 50% of the water flow should be by-passed around the compressor and be mixed with the warm compressor water before entering the cooling tower.

You'll need to balance and adjust the by-passed water flow in accordance with your actual compressor running conditions.

You can cool the water in a cooling tower to a temperature approximately 5°C above the wet bulb temperature. If you still need better cooling you will have to make a large increase in the size of your cooling tower.

Even, in the warmest countries, wet bulb temperature seldom exceeds 28°C. This fact makes cooling water temperature of 33°C possible & 35°C practical.

You must regularly check you cooling water quality. Cooling water should be soft, clean and free from mineral salts. Your cooling tower must have a chemical dosage system to prevent algae growth, line crustation and corrosion.

A cooling tower always uses up a certain amount of water. The three main reasons are:

Evaporation Splashing Dilution

You can work out the water amount lost by evaporation with this formula:

$$\frac{\text{Heat quantity kcal/hour}}{580} = \text{water loss in liters/hour}$$

580 is evaporation coefficient for water

Splash losses are negligible

You need to add water dilution to avoid increased concentration of mineral salts. The amount of water to be added is approximately 50% of the evaporation without chemical dosage at favourable conditions.

If you have a chemical dosage system, then your dilution needs can be reduced to 25% of the evaporation.

The total water amount you need to add equals evaporation amount plus 25% or 50%.

Cooling water requirements

Recommendations

The cooling water quality must meet certain minimum requirements.

No general recommendation can encompass the effects of all combinations of the various compounds, solids and gases typically found in cooling water in interaction with different materials.

This recommendation is a general guide line for acceptable coolant quality.

Type of system

First, it is important to consider whether you are dealing with a closed system or an open system. In a closed system, the same cooling water circulates through a system without contact with air.

An open system is a pass-through system, or a circulating system with a cooling tower. In the latter case, the composition of the water that enters the cooler must be considered, and not the composition of the make-up water. Due to the evaporative effect in the cooling tower, much higher concentrations of ions can be obtained in the circulating water than in the make-up water.

Ryznar stability index (RSI)

The Ryznar Stability Index (RSI) is a parameter for predicting whether water will tend to dissolve or precipitate calcium carbonate. The adhesion of scaling deposits and their effect are different on different materials, but the equilibrium of the water (scaling or corrosive) is only determined by its actual pH value and by the saturation pH value (pH_S).

The saturation pH value is determined by the relationship between the calcium hardness, the total alkalinity, the total solids concentration and the temperature.

The Ryznar Index is calculated as follows:
$RSI = 2 * pH_S - pH$

Symbol	Explanation
pH	Measured pH (at room temperature) of water sample
pH_S	pH at saturation

The pH_S is calculated by using : $pH_S = (9.3 + A + B) - (C + D)$

Symbol	Explanation
A	Depends on the total solids concentration (mg/l)
B	Depends on the highest cooling water temperature (°C/°F), (T=65 °C/149 °F)
C	Depends on the calcium hardness (ppm $CaCO_3$)
D	Depends on the HCO_3 - concentration or M-alkalinity (mval/l)

Cooling water requirements

The values of A, B, C and D can be found in the following table.

Total dissolved	A	Temperature (°C)	B	Ca-hardness (ppm CaCO3)	C	-alkalinity	D
50 - 300	0.1	0 – 1	2.6	10 - 11	0.6	0.20 - 0.22	1.0
400-1000	0.2	2 - 6	2.5	12 - 13	0.7	0.24 - 0.26	1.1
		7 - 9	2.4	14 - 17	0.8	0.28 - 0.34	1.2
		10 - 13	2.3	18 - 22	0.9	0.36 - 0.44	1.3
		14 - 17	2.2	23 - 27	1.0	0.46 - 0.54	1.4
		18 - 21	2.1	28 - 34	1.1	0.56 - 0.70	1.5
		22 - 27	2.0	35 - 43	1.2	0.72 - 0.88	1.6
		28 - 31	1.9	44 - 55	1.3	0.90 - 1.10	1.7
		32 - 37	1.8	56 - 69	1.4	1.12 - 1.38	1.8
		38 - 44	1.7	70 - 87	1.5	1.40 - 1.76	1.9
		45 - 50	1.6	88 - 110	1.6	1.78 - 2.20	2.0
		51 - 56	1.5	111 - 138	1.7	2.22 - 2.78	2.1
		57 - 63	1.4	138 - 174	1.8	2.80 - 3.54	2.2
		64 - 71	1.3	175 - 220	1.9	3.54 - 4.40	2.3
		72 - 80	1.2	230 - 270	2.0	4.6 - 5.4	2.4
				280 - 340	2.1	5.6 - 7.0	2.5
				350 - 430	2.2	7.2 - 8.8	2.6
				440 - 550	2.3	9.0 - 11.0	2.7
				560 - 690	2.4	11.2 - 13.8	2.8
				700 - 870	2.5	14.0 - 17.6	2.9
				880 - 1000	2.6	17.8 - 20.0	3.0

Interpretation of the value obtained

RSI	Water condition	Action
RSI<3.9	Very high scale formation	Water cannot be used.
4.0<RSI<5.5	High boiler scale formation	Regular inspection and descaling operation necessary.
5.6<RSI<6.2	Slight boiler scale formation	Water treatment not necessary. Occasional inspection recommended.
6.3<RSI<6.8	Neutral water	Water treatment not necessary. Occasional inspection recommended.
6.9<RSI<7.5	Slight corrosion at higher temperature	Water treatment not necessary. Occasional inspection recommended.
7.6<RSI<9.0	Strong corrosion	Regular inspection necessary, use of corrosion inhibitor recommended.
9.1<RSI<11	Very strong corrosion in complete water system	Regular inspection necessary, use of corrosion inhibitor required.
RSI>11	Very strong corrosion	Water should not be used.

Cooling water requirements

The table indicates that distilled or demineralized water should never be used, as their RSI is > 11.
The RSI only indicates the equilibrium of scaling - descaling. A cooling water showing good RSI conditions can still be unsuitable due to other factors.
From the table above, the RSI index should be between 5.6 and 7.5; otherwise, contact a specialist.

pH

The effect of pH is already calculated in the Ryznar index, but the pH itself has some additional limitations: 6.8 < pH < 8.5

Total dissolved solids (TDS)

This is the sum of all the ions in the water. It can be derived from the dry residue after evaporation (but not including suspended solids), or it can be estimated from the electrical conductivity.
In a closed system, the following limits apply: TDS < 3000 mg/l (< 3800 microS/cm) For an open system, the following limits apply: TDS < 750 mg/l (< 960 microS/cm)

Chlorides (Cl -)

Chloride ions will create pitting corrosion on stainless steel. Their concentration should be limited: Closed cooling system: chlorides < 500 ppm
Open cooling system: chlorides < 150 ppm
However, if the water is scaling, lower limits should be used.
(See The Ryznar stability index (RSI)).

Free chlorine (Cl2)

A level of 0.5 ppm should not be exceeded for long periods.
For shock treatments, a maximum limit of 2 ppm for maximum 30 minutes/day applies.

Sulphates (SO4 --)

Closed cooling system: sulphates < 400 ppm
Open cooling system : sulphates < 150 ppm

Ammonia

< 0.5 ppm

Copper

< 1 ppm

Iron and manganese

< 1 ppm

Organics

No algae
No oil

Suspended solids

Non-soluble particles, size < 1 mm.
< 10 ppm

Storage instructions for GA compressors

The storage procedures are implemented in the factory when the machine leaves the production line. It will protect the machine against corrosion during shipping and transport, and during a subsequent period of some three months in storage. Water-cooled units are drained prior to packing/shipment ex-factory.

One should always inspect the entire machine on arrival. This instruction applies, regardless of whether the unit is on its way to the end user or whether it will go into further storage.

All machine components contained in the canopy are protected against corrosion by placing of a number of "VCI plates" (volatile corrosion inhibitor) plates inside the canopy & cubicle of the unit. These are white felt-like paper plates having volatile chemical product. This releases a harmless vapor which acts as a corrosion inhibitor within the enclosed air space of the compressor canopy.

Note: for the corrosion protection to remain effective, all canopy doors must be closed and the unit sealed off airtight with e.g. plastic sheeting which is shipped ex-factory inside the sturdy wooden crate.

Packaging during transport and storage are designed to keep out immediate rainfall etc. These machines should not be stored out in the open air. Keep the protective packaging in place for as long as the unit is kept in storage.

All GA units delivered are *filled with our house brand of lubricating oil:*

All GA units undergo a short test run prior to leaving the production line. This ensures that an oil film will remain behind on all moving parts during subsequent transport and storage.

During storage periods > 3 months: turn the main motor coupling 10 turns by hand, once every 2 weeks, to redistribute the oil film on all moving parts. (Note: be sure to turn the coupling in the direction of the arrow cast in the coupling housing.)
Note: never mix different kinds of oil, e.g. when topping up.

Storage instructions for GA compressors

Storing your GA unit locally (valid for max. duration of 3 months)

- Store the compressor, preferably indoors, in a clean dry place.
- Cover up the unit with tight fitting plastic or canvas, so as to avoid ingression of dust and moisture.
- Place the unit on a clean and level floor which should be free from vibrations or pulsations emanating from nearby machinery (to avoid 'brinelling' of bearings). The storage room should be well ventilated.
- Water-cooled units: be sure all coolant is drained and all connections closed off.
- Avoid extreme ambient conditions (temperature and moisture) Min/max ambient temperature during storage: 0°C/50°C. Min/max ambient relative humidity during storage: 10%-70% (at amb.temp.25°C)
- Once every 2 weeks: turn the motor/compressor coupling 10 turns by hand, in order to redistribute the oil (or grease) film on all moving parts.

  Note: If the compressor is to be stored outdoors, then it must be placed under a shelter or roof, never out in the open.

Precautions for electric motor(s) in storage

- Electric motors must always be protected against humidity. As a rule, GA units are fitted with TEFC motors which prevent ingression of dirt and humidity.

- This applies to the main drive motor as well as to the fan motor(s) if / when fitted.

- After a longer storage period (> 6 months), check the insulation of the motor windings using a megger. Refer to the motor manufacturer for minimum acceptable values (MΩ). If there is a significant deviation from the normal value check with the nearest service outlet of the motor manufacturer for remedial action.

Storage and shipping instructions for Z-compressors

Special procedures are followed at factory when packaging equipment. The aim is to prevent corrosion during shipment. The action taken in the factory protects the compressor for a period of at six months.

- All compressor units are test-run with Roto-Z oil, a film of which remains behind on the shafts, gears and bearings.
- Five silica gel bags, tied together, are placed inside the housing of the intercooler water separator of ZR compressors which absorbs any traces of moisture. The compartments are closed off airtight using the original flange of the machine.

NOTE: *One of the strings of the bags is made to stick out of the flange and a sticker is glued to the flange in order to draw your attention to the presence of the silica gel bags and as a reminder to remove before start up.*

- The vent holes are closed off with moisture repellent adhesive tape.
- The complete compressor unit is enclosed in a plastic cover and placed on a pallet or in a crate. Lifting marks are painted on the crates.
- VCI-paper (Volatile Corrosion Inhibitor) is placed inside the compressor canopy and converter compartment ex-factory to protect the electronic devices to keep it as dry as possible. This protects the converter against a possible high humidity

It is important to carry out the following action which is due for further storage. Store the unit in a clean, dry, well ventilated warehouse. Be sure there is no source of vibrations nearby e.g: vibrations coming up through the floor can have a detrimental effect on the bearings in long-term.

Renew the silica gel bags

- Remove the plate and take the silica gel bags out of the intercooler moisture drain compartment of ZR units. Replace or regenerate the silica gel

Renewing the preservative oil-film

- ZR units are normally delivered ex-factory with Roto Z oil as first fill which is also having preservative qualities. The duration of the protective period is six months.
- Turn the main drive coupling by hand, in correct direction, a few minutes in order to re new the oil film on bearings balls, rollers and drive gears.

Repeat this procedure once every month

NOTE: *Take care to close off the opening really airtight, using moisture repellent adhesive tape. Moisture present in the intercooler compartment during storage will be detrimental to the condition of the compressor stages.*

The compressor unit is now ready for storage for maximum 6 months. The storage period remains valid provided that the ambient conditions remain normal (meaning no excesses of heat, cold or high humidity). If the unit is to be stored for a period longer than six months then repeat the storage maintenance procedures every subsequent six months.

If the unit will not be started again for a period of:
Several hours to several days

- Open or purge manual drains of intercooler and after cooler drain receivers or EWDs, in loaded condition just before stopping.
- Check if the drain pipes are free from water. Close the valves after the condensate is drained.
- Inspect the unit once a month. Turn the main coupling a few turns by hand, to change the position of balls and rollers in the bearings and redistribute the oil-film.

Several months to 6 months

- Proceed as above.
- Close off compressor air intake and compressor element vent holes.
- Close air outlet valve.
- Place five (5) Silica gel bags in the intercooler and aftercooler moister drain compartment. It is best to immobilize the bags, e.g. by tying them together and then tying one string to a flange hole.

NOTE: *Take care to close off the opening really airtight, using moisture repellent adhesive tape. Moisture present in the intercooler/ after cooler compartment during storage will be detrimental to the condition of the compressor stages.*

- Put VCI-plates (Volatile Corrosion Inhibitor) inside the canopy and compressor cubicle. These can be ordered from Atlas Copco.
- Close the doors of the unit. Cover the roof with plastic sheeting to reach down just over the doors.
- Put a warning label on the start cubicle, indicating to remove Silica gel bags, open compressor air intake and compressor element vent holes.
- The compressor unit is now ready for storage for maximum six (6) months. The storage period remains valid provided that the ambient conditions remain normal (meaning no excesses of heat, cold or high humidity). If the unit is to be stored for a period longer than 6 months then repeat the storage maintenance procedures once, every subsequent 6 months.
- Follow installation checklist before starting.

1. Do you have enough SPACE in your compressor room?

Read each question carefully.
If you can answer YES, put X in the box.

1 Is entrance to your compressor room high enough and wide enough to get your compressor(s) IN & OUT? ☐

2 Is room large enough to give you adequate free space around your compressor(s) for installation, for ventilation, for inspection, for maintenance, and for service? ☐

3 Do you have sufficient space above and around your compressor(s) for you to remove the electric motor and place it on the floor? ☐

4 Have you enough space in your compressor room to allow you to install a second compressor in the future? ☐

5 Does your compressor room have overhead lifting to facilitate major overhauls? ☐

6 If no overhead hoist is available, are you able to use a mobile crane, or fork lift truck in your compressor room? To lift and move heavy parts like motor, compressor elements, air coolers and air dryer. ☐

7 Is the floor area, where you will place compressor(s), made of smoothed, level concrete?
Not more than 6 mm (1/4") unevenness allowed. ☐

8 Will your floor be splashed frequently with water while cleaning?
If YES, you should place your compressor on a raised concrete plinth 100-150 mm (4-6 in.) high. ☐

9 Will your floor support the static load imposed on it by your compressor? ☐

10 Do you have Atlas Copco drawings showing compressor dimensions, maintenance space, installation proposals and foundation needs? ☐

Have you been able to answer YES and put an X in all the boxes?
If YES, go on to check list 2.
If NO, take necessary steps to get correct space in your compressor room.

Customer Atlas Copco

2. Do you have sufficient VENTILATION in your compressor room?

Read each question carefully.
If you can answer YES, put X in the box.

1 Are you aware that nearly all the electric energy to your compressor motor is converted into heat? And are you aware that this heat must be removed from the compressor room either by ventilation air or cooling water? ☐

2 Do you have sufficient fan capacity to limit compressor room temperature increase to 7°C (13°F)? ☐
Required ventilation fan capacity in m^3/second = Air Cooled compressor shaft input in kW divided by 7.5. If the heated ventilation air is led out of the compressor room by duct then ventilation air need = air compressor shaft input in kW divided by 20.

3 If you use ventilation ducts, have you checked that pressure drop in these is less than 30 Pa (3 mm of water column) per duct? ☐

4 Do you take in your ventilation air from the coldest and cleanest location outside your compressor room? ☐

5 If your compressor operates in dusty surroundings have you fitted a ventilation air INLET PANEL FILTER to reduce dust, sand and other particles to a minimum? ☐

6 Is your ventilation air outlet at opposite end of compressor room to inlet? ☐

7 Does outlet opening have a wall louvre to prevent ingress of dust? ☐

8 Is the grid dimensioned for a maximum velocity of 5 m/s? ☐

Have you been able to answer YES and put an X in all the boxes?
If YES, go on to check list 3.
If NO, take necessary steps to get correct ventilation in your compressor room.

Customer Atlas Copco

3. Is the INTAKE of suction air to your compressor adequate?

Read each question carefully.
If you can answer YES, put X in the box.

1 Will you take the suction air for the compressor room:
   a) your compressor room itself? ☐
   or
   b) outside your compressor room via an air intake pipe duct? ☐
   If your answer to question 1 a) is YES, go straight to question 4.
   If your answer to question 1 b) is YES, go on from question 2.

2 Is your outside air intake:
   a) at least 3m (10 ft) above ground level? ☐
   b) raised above the roof level? ☐

3 Have you fitted your outside air intake with:
   a) a rain cover? ☐
   b) a protective net or screen? ☐
   c) a prefilter to reduce high air pollutant levels? ☐
   While the standard paper filter in the compressor is adequate, you will be able to reduce the number of paper filter replacements, if you fit a prefilter.

4 Does your air intake pipe duct:
   a) have a circular cross section? ☐
   b) have at least the same diameter as the suction pipe connection to the standard suction filter? ☐
   c) have more than two bends in it? ☐
   If YES, to c), then you must increase pipe duct diameter by 50% to avoid flow restrictions caused by more than two bends.

5 Is your air intake pipe duct:
   a) properly supported? ☐
   b) anti-corrosion treated on the inside? ☐
   c) more than 10m (30ft) in length? ☐
   If YES to c), then you must increase pipe duct diameter by 50% to avoid flow restrictions caused by the pipe length.

Have you been able to answer YES and put an X in all the boxes?
If YES, go on to check list 4.
If NO, take necessary steps to get correct air intake conditions for your compressor.

Customer　　　　　　　　　　　　　　　　　　　　Atlas Copco

4. Is the WATER you use to cool your compressor acceptable?

Read each question carefully.
If you can answer YES, put X in the box.

1 Is your cooling water free from sand and other particles? ☐

2 Is the hardness of your cooling water less than 50 ppm? ☐
If the hardness is above 50 ppm you may get scale forming in cooling jackets and coolers.

3 Are you satisfied with the quality of your cooling water? ☐
If you are uncertain, get a local chemist to make an analysis and send a copy of your cooling water analysis to Atlas Copco.

4 Is the pressure in your cooling water system about, but not above, 3 bar (43 psig)? ☐

5 Is the water inlet temperature between 20-35°C (68-95°F)? ☐

6 Is the cooling water outlet temperature less than 50°C (122°F)? ☐
Temperature above 50°C (122°F) increase the risk of scale forming in cooling jackets and coolers.

7 Have you installed water shut-off valve in cooloing water outlet? (only for Z series) ☐

8 Is the cooling water flow / pressure as per instruction? ☐

Have you been able to answer YES and put an X in all the boxes?
If YES, go on to check list 5.
If NO, take necessary steps to get correct cooling water conditions.

Customer Atlas Copco

5. Do you have the correct ELECTRICAL SYSTEM for your compressor(s)?

Read each question carefully.
If you can answer YES, put X in the box.

1 Is the voltage and frequency of your electricity supply at your connection point the same as that required by the motor fitted in your compressor? ☐

2 Do you have 110 / 220 V AC available for use as control voltage? ☐

3 Does your electricity supply have enough capacity for your compressor motor during starting? ☐
Direct-on-Line (DOL) starters need 6 - 10 times the rated motor current while starting, Star-delta (Y/D) starters need up to 5 times the rated motor current at start.

4 Have you provided an isolator switch in the electricity supply line to your compressor? ☐
This gives you possibilities to do maintenance on electrical equipment without stopping more than one compressor.

5 Does your electricity supply have sufficient capacity to allow you to install a second compressor at a later date? ☐

6 Are your electric power cables to be carried on cable ladders? ☐
Floor conduits for power cables make inspection / access difficult; they are generally more expensive and less flexible. If you have two or more compressors installed:

7 Have you fitted an ENERGY SAVING SYSTEM (ES) to equalize the running hours between the compressors? ☐

8 If the machine is IT classification then install separate earth pit for VSD units. ☐

Have you been able to answer YES and put an X in all the boxes?
If YES, go on to check list 6.
If NO, take necessary steps to get the correct electrical system.

6. Do you have the correct PIPE DIMENSIONS & AIR RECEIVER VOLUME in your air distribution network?

Read each question carefully.
If you can answer YES, put X in the box.

Remember that dimensions (inner diameter) of delivery pipes and hoses in your air distribution network must be chosen with respect to:

a) how much air you will use at each outlet?
b) what your future consumption will be?
c) working pressure, air flow, pipe length and the maximum allowable pressure drop between compressor room and work station outlet.

Use of the smallest pipe diameter, although initially cheaper, is often a false economy. The savings you make are small compared to the cost of a later change to bigger diameters. So make sure you get right pipe dimensions from the start. It would a good idea to consider the future expansion also into account

1 Have you estimated the total air flow capacity you'll need? ☐

2 Have you made allowances for future air needs? ☐

3 Have you made a plan drawing of your pipe network that shows lengths of different sections and numbers of bends, joints & valves? ☐

4 Have you selected the pipe inner diameter that will give you the correct working pressure and airflow at each work station outlet? ☐
Pipe inner diameters suitable for small and medium size air distribution networks are listed on page 10

5 Are your delivery pipes:
a) galvanized? ☐
or
b) anti-corrosive treated on the inside? ☐

6 Will your delivery pipes be hung from the wall or ceiling brackets? ☐
Floor conduits for delivery pipes make inspection / access difficult; they are generally more expensive and less flexible.

7 Have you fitted membrane, ball or butterfly shut-off valves in your network? ☐
Only these three types of shut-off valve give low resistance to air flow.

Customer Atlas Copco

Do you have the correct PIPE DIMENSIONS & AIR RECEIVER VOLUME in your air distribution network?

8 If you have NOT installed an AIR DRYER after your compressor, have you made sure that:

a) your main delivery pipes slope down towards water separator installed in your air distribution network? ☐

b) your branch pipes are taken out from the upper side of the main pipe? ☐

The *"Swan-neck" take-out eliminates risk of water condensate running down branch pipe.*

9 Do your pipes end above the level of the floor drain so that you can see the actual condensate flow? ☐

10 Is your air receiver volume adequate for your compressor and for the size of your air distribution network? ☐

For small and medium size compressors the total air volume in the network, including the air receiver, should not be less than:

A. Total volume m^3 = FAD in l/s divided by 80
Total volume cu.ft. = FAD in cfm divided by 0.9

For large compressors the total volume in the network, including air receiver, should not be less than:

B. Total Volume m^3 = FAD in l/s divided by (130 x Δ p bar)
Total volume cu.ft = FAD in cfm divided by (0.55 x Δ p psi)

Δ p = difference between loading and unloading pressure

The air receiver should preferably be placed outdoors in the shade on a concrete foundation, duly insulated externally, If a dryer is used down stream of the air receiver.

Your delivery PIPE DIMENSIONS

1 Your main delivery pipe (ring main) should preferably be a closed loop. It should have an inner pipe diameter of 25 mm (1 in.) or larger.

2 For small or medium size compressors, where the working pressure is 7 bar (102 psig) and where the maximum pressure drop between compressor room (downstream from after cooler and air dryer) and work station is to be maximum 0.1 bar (1.45 psig).

SI (metric) units			Imperial units	
Your pipe inner diameter should be	When your free air delivery (FAD) is		Your pipe inner diameter should be	When your free air delivery (FAD) is
mm	l/s	m^3/min	inch	cfm
10	3	0.2	3/8	7
13	5	0.3	1/2	11
19	10	0.6	3/4	21
25	17	1	1	35
32	34	2	1 1/4	70
40	50	3	1 1/2	110
50	115	7	2	250
65	200	12	2 1/2	425
80	330	20	3	700
100	500	30	4	1100
125	900	54	5	1900
150	1500	90	6	3200
200	2000	120	8	4200

Use these pipe dimensions when your compressor is close to where the air is being consumed. If your main delivery pipe is more than 100m (300 ft) long, use a pipe diameter that is one size bigger than that listed in the table.

Some useful conversion factors

LENGTH

m	in. (inch)	ft (foot)	mile
1	39.3701	3.28084	$0.621371 \cdot 10^{-3}$
$25.4 \cdot 10^{-3}$	1	$83.3333 \cdot 10^{-3}$	$15.7828 \cdot 10^{-6}$
0.3048	12	1	$0.189394 \cdot 10^{-3}$
$1.60934 \cdot 10^{3}$	$63.360 \cdot 10^{3}$	$5.280 \cdot 10^{3}$	1

SPPED

m/s	m/min	ft/s	ft/min	km/h	mile/h
1	60	3.28084	195.85	3.6	2.23694
$16.667 \cdot 10^{-3}$	1	$54.6807 \cdot 10^{-3}$	3.28084	$60 \cdot 10^{-3}$	$37.282 \cdot 10^{-3}$
0.3048	18.2867	1	60	1.0972	0.68177
$5.08 \cdot 10^{-3}$	0.3048	$16.6667 \cdot 10^{-3}$	1	$18.288 \cdot 10^{-3}$	$11.3636 \cdot 10^{-3}$
0.27778	16.6667	0.91134	54.6806	1	0.62137
0.44704	26.8224	1.46667	88	1.60934	1

AREA

m^2	in^2	ft^2	yd^2
1	$1.550 \cdot 10^{3}$	10.7639	1.19599
$0.64516 \cdot 10^{-3}$	1	$6.94444 \cdot 10^{-3}$	$0.771605 \cdot 10^{-3}$
$92.903 \cdot 10^{-3}$	144	1	0.111111
0.836127	$1.296 \cdot 10^{3}$	9	1

VOLUME

m^3	in^3	ft^3	yd	gallon (US)
1	$61.0237 \cdot 10^{3}$	35.3147	1.30795	264.172
$16.3871 \cdot 10^{-6}$	1	$0.578704 \cdot 10^{-3}$	$21.4335 \cdot 10^{-3}$	$4.329 \cdot 10^{-3}$
$28.3168 \cdot 10^{-3}$	$1.728 \cdot 10^{3}$	1	$37.037 \cdot 10^{-3}$	7.48052
0.764555	$46.656 \cdot 10^{3}$	27	1	201.974
$3.78541 \cdot 10^{-3}$		0.133681	$4.95113 \cdot 10^{-3}$	1

VOLUME FLOW,
CAPACITY

l/s	m^3/min	m^3/h	ft^3/min	yd^3/h	gal (US)/min
1	60.10^{-3}	3.6	2.11888	4.70862	15.8503
16.6667	1	60	35.3147	78.477	264.172
0.27778	$16.6667 \cdot 10^{-3}$	1	0.58858	1.30795	4.40287
0.47195	$28.3168 \cdot 10^{-3}$	1.699	1	2.22222	7.48052
0.21238	$12.7426 \cdot 10^{-3}$	0.76456	0.45	1	3.36623
$63.0902 \cdot 10^{-3}$	$3.78541 \cdot 10^{-3}$	0.22712	0.13368	0.29707	1

Some useful conversion factors

FORCE

n (NEWTON)	kp (kilo-pound)	lbf (pound-force)
1	0.101972	0.224809
9.80665	1	2.20462
4.44822	0.453592	1

TORQUE

Nm	kpm	in-lbf	ft-lbf
1	0.101972	8.85075	0.737562
9.80665	1	86.7962	7.23301
0.112985	$11.5212 \cdot 10^{-3}$	1	$83.3333 \cdot 10^{-3}$
1.35582	0.138255	12	1

PRESSURE, STRAIN

Pa; N/m^2	bar	kp/cm^2	lbf/in^2; psi
1	10 · 10-6	$10.1972 \cdot 10^{-6}$	$0.145038 \cdot 10^{-3}$
0.1 · 106	1	1.01972	14.5038
$98.0665 \cdot 10^{3}$	0.980665	1	14.2233
$101.325 \cdot 10^{3}$	1.01325	1.03323	14.6959
$6.89476 \cdot 10^{3}$	$68.9476 \cdot 10^{-3}$	$70.307 \cdot 10^{-3}$	1

MASS

kg	lb (pound)	sh cwt (short hundred weight US)v	sh ton (short ton US)
1	2.20462	$22.0462 \cdot 10^{-3}$	$1.10231 \cdot 10^{-3}$
0.453592	1	$10 \cdot 10^{-3}$	$0.5 \cdot 10^{-3}$
45.3592	100	1	$50 \cdot 10^{-3}$
907.185	$2 \cdot 10^{3}$	20	1

DENSITY

kg/m^3	g/cm^3	lb/in^3	ib/ft^3
1	$'10^{-3}$	$36.1273 \cdot 10^{-6}$	$62.428 \cdot 10^{-3}$
$'10^{3}$	1	$36.1273 \cdot 10^{-3}$	62.428
$27.6799 \cdot 10^{3}$	27.6799	1	$1.728 \cdot 10^{3}$
16.0185	$16.0185 \cdot 10^{-3}$	$0.578704 \cdot 10^{3}$	1

Some useful conversion factors

	J; Nm; Ws	kWh	kpm	ft-lbf (foot · pound-force)	BTU (British thermal Unit)
ENERGY, WORK	1	$0.277778 \cdot 10^{-6}$	0.101972		$0.947817 \cdot 10^{-3}$
	$3.6 \cdot 10^{6}$	1	$367.098 \cdot 10^{6}$	0.737562	$3.241214 \cdot 10^{3}$
	9.80665	$2.72407 \cdot 10^{-6}$	1	$2.65522 \cdot 10^{6}$	$9.29491 \cdot 10^{-3}$
	1.35582	$0.376616 \cdot 10^{-6}$	0.138255	7.23301	$1.2857 \cdot 10^{-3}$
	$1.05506 \cdot 10^{3}$	$0.293071 \cdot 10^{-3}$	107.586	1	1
				778.169	

	J/l; kJ/m^3	kWh/m^3	hp (US) min/ft^3
SPECIFIC ENERGY	1	$0.277778 \cdot 10^{-3}$	$0.632891 \cdot 10^{-3}$
	$3.6 \cdot 10^{3}$	1	2.27841
	$1.58005 \cdot 10^{3}$	0.438903	1

	W; Nm/s: J/s	kpm/s		ft-lbf/s
POWER	1	0.101972	hp(US)	0.737562
	9.80665	1	$1.34102 \cdot 10^{-3}$	7.23301
	745.7	76.0402	$13.1509 \cdot 10^{-3}$	550
	1.35582	0.138255	1	1
			$1.81818 \cdot 10^{-3}$	

	Kelvin	Celsius	Rankine	Fahrenhiet	Remarks
TEMPERATURE	0 K	-273.15^{0}C	0^{0}R	-459.67^{0}F	absolute zero
	255.37 K	-17.78^{0}C	459.6^{0}R	0^{0}F	
	273.15 K	0^{0}C	491.67^{0}R	32^{0}F	melting point of ice
	273.16 K	0.01^{0}C	491.69^{0}R	32.02^{0}F	triplepoint of water

TEMPERATURE CONVERSION

$t^0c =$ $(t^0F-32.0)/1.8$

$T_K =$ $(t^0F+459.7)/1.8$

where t^0c

where t^0f

where T_K

Notes:

Notes:

Notes:

Notes:

Committed to sustainable productivity

We stand by our responsibilities towards our customers, towards the environment and the people around us. We make performance stand the test of time. This is what we call — Sustainable Productivity.

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