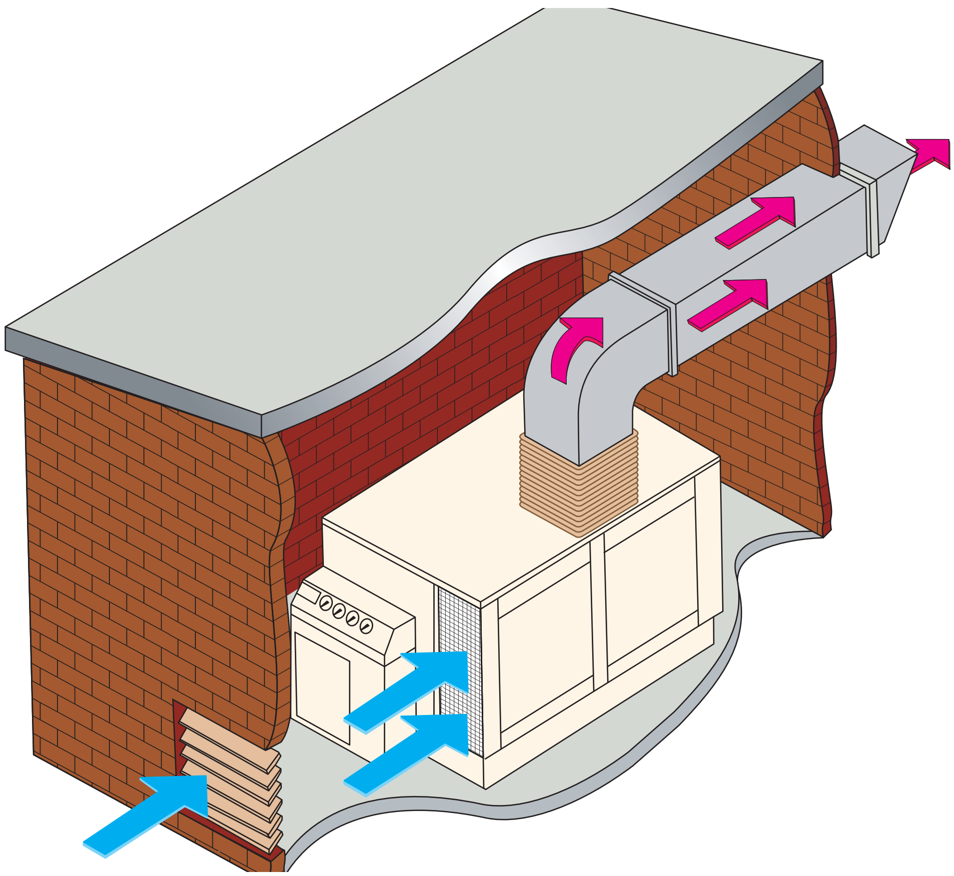
Installation Manual

Installation Requirements
for Air Cooled
Medium and High Pressure Air Compressor Units



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⚠ WARNING

This Installation Manual contains safety information and instructions for installing Medium and High Pressure Air Compressor Units.
You must read, understand and follow all safety precautions and instructions.

Editions, Revisions and Changes

- An Edition is the original or a complete rewriting of the entire Manual.
- A Revision occurs whenever a complete Section or Appendix is rewritten or added.
- A Change occurs when individual pages, drawings or tables are changed.

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0	0	Aug. 29, 2005		JD
0	1	July 11, 2006	Updates and Changes after Review	JD
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0	3	June 16, 2009	Update Warnings	SS
0	4	August 6, 2009	Corrected Temperatures available	SS

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CHAPTER 1: INTRODUCTION

1.1 Preface

Correct installation influences, to a large extent, the reliability and efficiency of a compressor unit. Special consideration should be given to proper ventilation in order to ensure sufficient dissipation of heat.

This manual provides suggestions and directions for the installation of Bauer air cooled high and medium pressure compressor units. These suggestions and directions cover two stage through five stage compressor units with outputs in the range of 3.5 to 250 scfm (6 to 420 Nm^3/hr) and pressures of 370 to 7,500 psi (25 to 500 bar).

All EPA, NEC and OSHA installation codes must be followed.

The enclosed installation instructions are specifically for the Bauer air cooled reciprocating compressor units. The explanation and much of the technical data are of a general nature and can be applied to all Bauer high and medium pressure compressors. For specific applications, corresponding data is included in a table as part of the appendix which can be applied to special proposal drawings.

The best possible installation will in the end be dependent on the operating conditions

While every effort is made to ensure the accuracy of the information contained in this manual, Bauer Compressors, Inc. will not, under any circumstances be held accountable for any inaccuracies or the consequences thereof.

1.2 Manual Safety Notices

Important instructions concerning the endangerment of personnel, technical safety or operator safety will be specially emphasized in this manual by placing the information in the following types of safety notices.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This is limited to the most extreme situations.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

NOTICE

NOTE advise of technical requirements that require particular attention by the operator or the maintenance technician for proper maintenance and utilization of the equipment.

CHAPTER 2: VENTILATION REQUIREMENTS

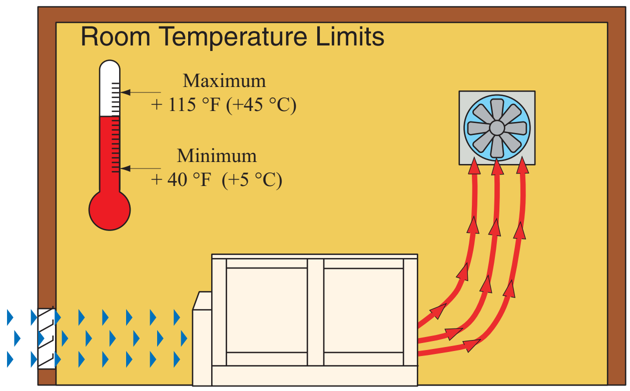
2.1 Installation Prerequisites

2.1.1 Compressor Room/Building

The following should be observed, even if there is no special room available.

- The room should be clean, free of dust, dry and cool.
- Direct sunlight should be avoided, possibly by picking the north side of the building.
- Additional heat generating equipment or piping should be avoided or must be well insulated.
- The room temperature must not fall below 40 °F due to the danger of frost or corrosion damage resulting from condensate accumulation.
- To prevent overheating of the compressor, the room temperature should not exceed 115 °F under any circumstances.

Figure 2-1 Temperature Limits



- Seasonal temperature changes should be evened out if possible.
- For different set-up temperatures, please ask for a special quotation. Temperatures down to 35 °F (1.6 °C) or up to 125 °F (52 °C) may well be possible with modifications.
- Good access and lighting should be provided for service and maintenance.
- For the larger compressor sizes, it is recommended to have accessibility to the compressor unit by a forklift or a crane for easier service and maintenance.

2.1.2 Space Requirement

1. If a special set-up is required, reference special set-up drawings for necessary spacing of the compressor unit.
2. Otherwise, a space of 30 to 40 inches (75 to 100 cm) should be maintained on all sides, for maintenance on the compressor.
3. The applicable NEC and local government regulations for switch box access should be followed.
4. Check the width of any necessary doorways to ensure that the compressor can be brought into the room and/or building.

2.1.3 Foundation

Each Bauer compressor unit is optimally balanced and is, additionally, vibration isolated through the use of vibration mounts. A special foundation or connection is therefore not necessary, however, the floor should be solid and level.

2.1.4 Floor Load

The floor should be able to support the compressor weight. If uncertain about the weight of the compressor unit, refer to the compressor unit manual or confer with our Product Support Department.

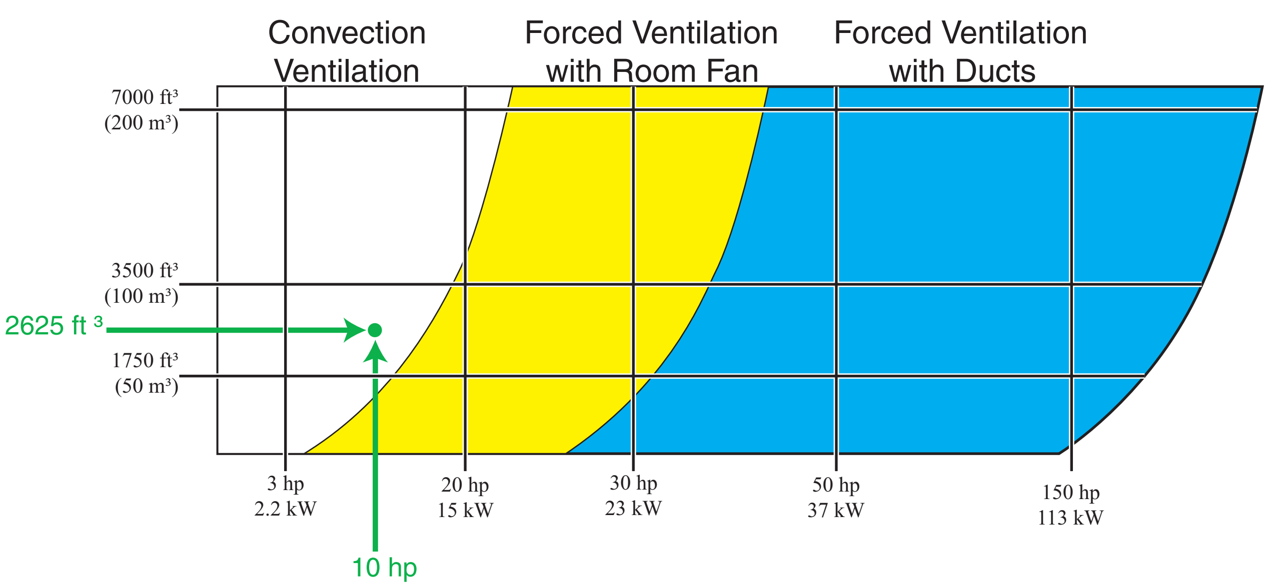
2.1.5 Extreme Temperature Conditions

If the compressor unit is to be installed in extreme temperature conditions, the compressor unit can be adapted for correct operation. Temperatures down to -35 °F (37 °C) or up to 125 °F (52 °C) may well be possible with modifications. The necessary technical modifications should be defined during the proposal stage, please ask for a special quotation.

2.2 Heat Flow - Choice of Proper Ventilation

Sufficient heat dissipation must be provided by proper ventilation as part of correct installation. It is necessary to dissipate this heat by ventilation. The heat generated in the compressor increases with more compression. Approximately 70% of the heat generated during compression is in the compressor, the additional heat is generated by the compressor drive.The necessary ventilation may be attained by natural or artificial means. The graph in Figure 2-2 illustrates how the room volume and drive power determine the necessity for natural or forced ventilation. An example of 2,625 ft³ room with a 10 Hp compressor is indicated in green.

Figure 2-2 Determining the Method of Ventilation



In determining the necessary type of ventilation the following factors should also be considered:

- Ambient temperature of the set-up room
- Length of a possible ventilation ducts
- Back pressure of the ventilation ducts
- Size of the intake and exhaust openings
- Additional heat sources in the set-up room

2.2.1 Cooling Air Flow Requirements

The minimum amount of cooling air required may be approximated by the following formulas.

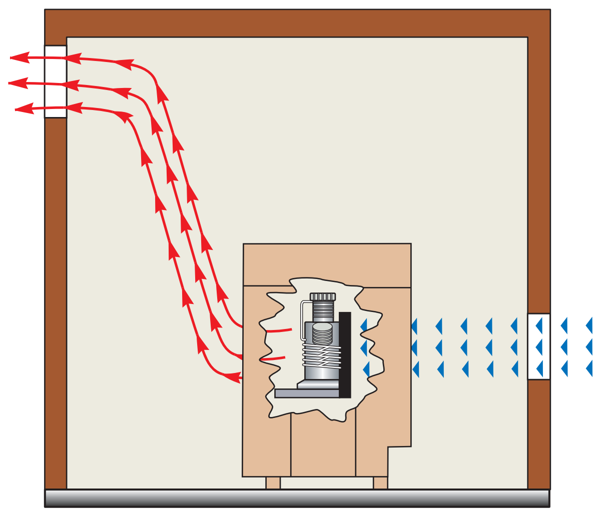
Cooling Air Flow (cfm) = 132 x Drive Power (Hp)

A table has been included in the appendix for more precise requirements.

2.3 Ventilation by Convection

Ventilation by convection is the simplest type of ventilation. In operation, the compressor draws in cool air and exhausts warm air. Warm air rises and is automatically circulated with no additional requirements, such as fans.

Figure 2-3 Convection Ventilation



To maximize the effect of convection, the following should be considered:

- The compressor drive should be 20 Hp (15 kW) or less.
- The compressor unit must be set up such that the air current between room air intake and room air exhaust flows through the compressor.
- The cooling air intake should be as close as possible to the ground.
- The compressor should be placed close to the air intake.
- Cooling air suction should occur directly from the air intake
- The heat exhaust should be placed as high in the room as possible.
- An intake baffle to prevent overcooling is used when the intake air temperature is below 40 °F (5 °C).
- Recirculation, the intake of warm exhaust air back into the compressor should be avoided.

2.3.1 Size of the Required Intake and Exhaust Openings for Convection

The intake opening for cooling air should be approximately 20% larger than the exhaust opening to compensate for the effect of dirty louvers or gratings. These openings may be of the same size only if they both use the larger area.

The required approximate sizes are tabulated below.

- V is the volume of the room
- Δh is the height difference between the air intake and exhaust openings

Table 2-1: Required Intake &Exhaust Opening Sizes for Ventilation by Convection; Standard

V	1,750 ft^3		3,500 ft^3		7,000 ft^3	
Δh	**6.5 ft**		**10 ft**		**13 ft**	
Power, Hp	**Inlet, ft^2**	**Outlet, ft^2**	**Inlet, ft^2**	**Outlet, ft^2**	**Inlet, ft^2**	**Outlet, ft^2**
5.0	1.3	1.1	1.6	1.3	—	—
7.5	2.2	1.8	2.4	2.0	—	—
10	3.2	2.7	3.2	2.7	2.1	1.7
15	4.3	3.6	4.8	4.0	3.1	2.6
20	6.5	5.4	6.5	5.4	4.1	3.4

The values above define the necessary size of air intake and exhaust openings in ft^2 should these values not be possible, because of construction reasons, forced ventilation will be necessary.

2.3.1.1 Example

The drive power is 10 Hp, the room size is approximately V = 1750 ft^3, the height difference between air intake and exhaust is **Δh** = 6.5 ft:

by using Table 2-1:

Exhaust opening is approximately 2.7 ft^2

Intake opening is approximately 3.2 ft^2

Table 2-2: Required Intake & Exhaust Opening Sizes for Ventilation by Convection; Metric

V	**50 m³**		**100 m³**		**200 m³**	
∆h	**2 m**		**3 m**		**4 m**	
Power, kW	**Inlet, m²**	**Outlet, m²**	**Inlet, m²**	**Outlet, m²**	**Inlet, m²**	**Outlet, m²**
2.2	0.12	0.10	—	—	—	—
3.0	0.24	0..20	0.12	0.10	—	—
4.0	0.30	0.25	0.12	0.10	—	—
5.5	0.42	0.35	0.24	0.20	0.12	0.10
7.5	0.90	0.75	0.60	0.50	0.24	0.20
11.0	1.38	1.15	0.90	0.75	0.54	0.45
15.0	1.92	1.60	1.45	1.20	0.90	0.75

The values above define the necessary size of air intake and exhaust openings in ft² should these values not be possible, because of construction reasons, forced ventilation will be necessary.

2.3.1.2 Example

The drive power is 7.5 kW, the room size is approximately V = 40 ft³, the height difference between air intake and exhaust is ∆**h** = 2 m:

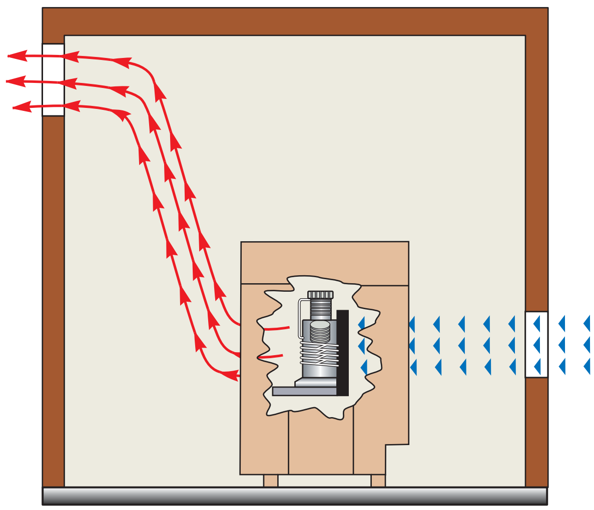
by using Table 2-2:

Exhaust opening is approximately 0.75 m²

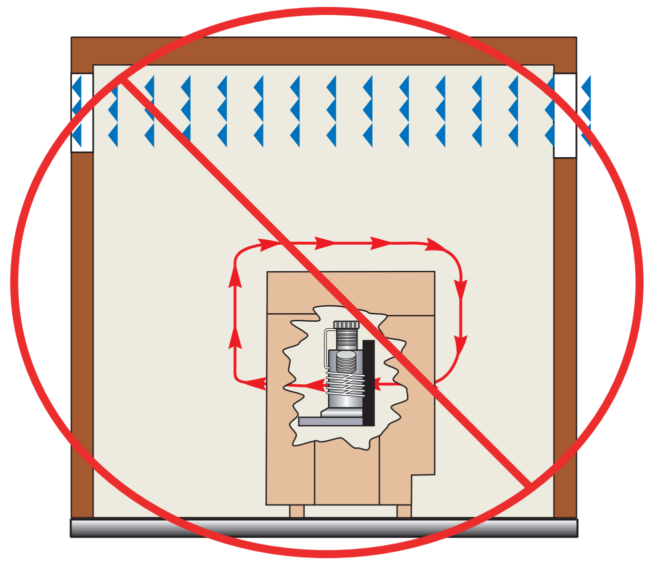
Intake opening is approximately 0.9 m²

2.3.2 Installation Examples for Ventilation by Convection

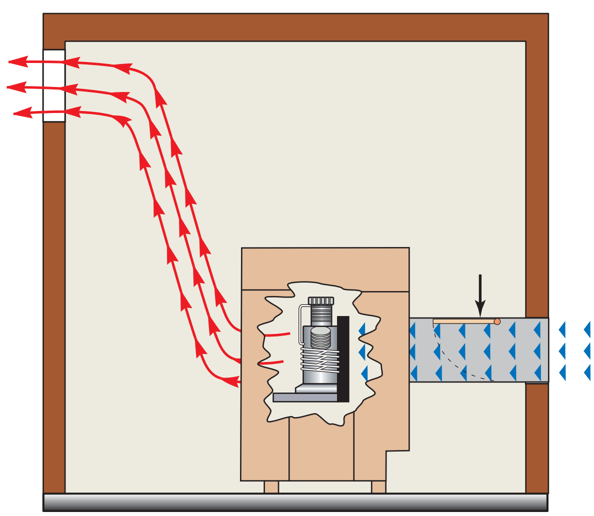
Figure 2-4 Convection Ventilation Examples, up to 20 Hp



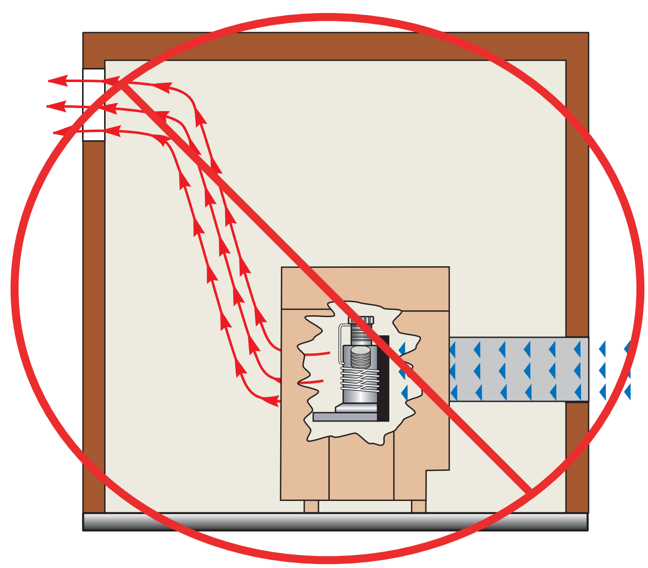
Correct
Air intake is near the ground;
Cooling Air flows through the unit.



Incorrect
Air Intake to high:
Air rushes through the room without cooling.

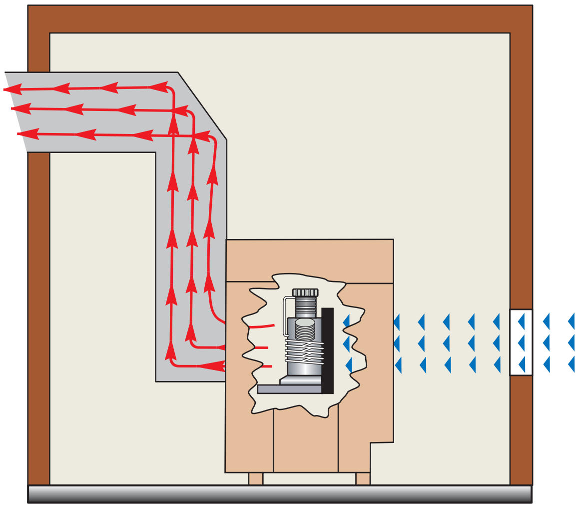


Correct
Channeled air intake includes a baffle;
for temperatures below 40 °F the
baffle closes the opening to the outside.

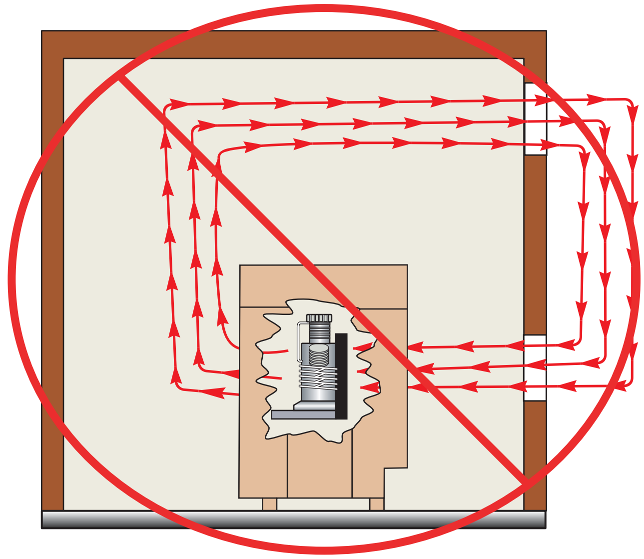


Incorrect
Air Intake is channeled; however
there is no baffle to shutting off outside air
below 40° F.

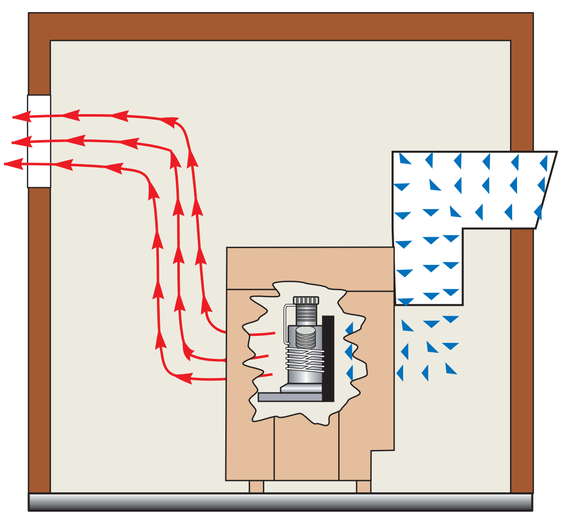
Figure 2-5 Convection Ventilation Examples, continued



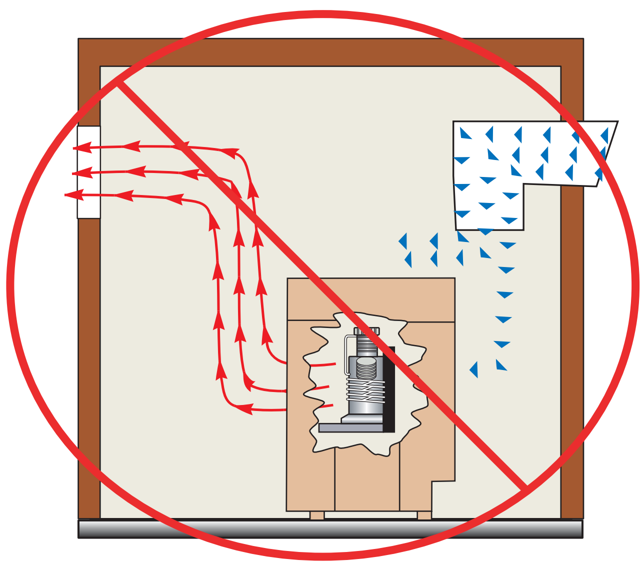
Correct
Warm air is channeled upward;
a cooling air loop is not possible



Incorrect
Warm air is not channeled;
the cooling air circulates in a loop.



Correct
The cooling air is channeled
directly into the unit;
proper cooling is assured



Incorrect
The cooling air is not channeled
into the unit;
proper cooling is not assured.

2.4 Forced Ventilation

Forced ventilation is a requirement for compressors with a 20 hp or greater drive. Compressors with a drive power less than 20 hp natural ventilation may not be sufficient under the following unfavorable conditions.

- The compressor room is very small.
- The ventilation openings cannot be adequately sized.
- There are additional heat sources in the room, including multiple compressor installations.
- When other unfavorable conditions make forced ventilation necessary.

2.4.1 Types of Forced Ventilation

- Exhaust with a room fan
- Ventilation through ducts without an additional fan
- Ventilation through ducts with an additional fan
- Ventilation through ducts with baffle and an additional fan
- Ventilation through ducts with use of exhaust as source of auxiliary heat.

2.4.2 Forced Ventilation Using a Room Fan

This is the simplest type of forced ventilation. It functions principally in the same manner as natural ventilation, except that the warm exhaust is blown out through an room exhaust fan. Ducts for the intake and exhaust are not required.

- The room fan should be mounted near the compressor exhaust and mounted as high as possible.
- The air intake should be installed so that the compressor suction is not impeded.
- The room fan must be sized appropriately. See the Appendix for required air flow.

Figure 2-6 Forced Ventilation Using a Room Fan

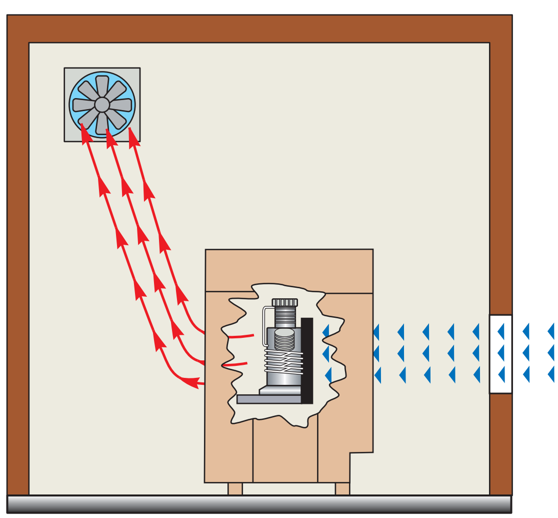
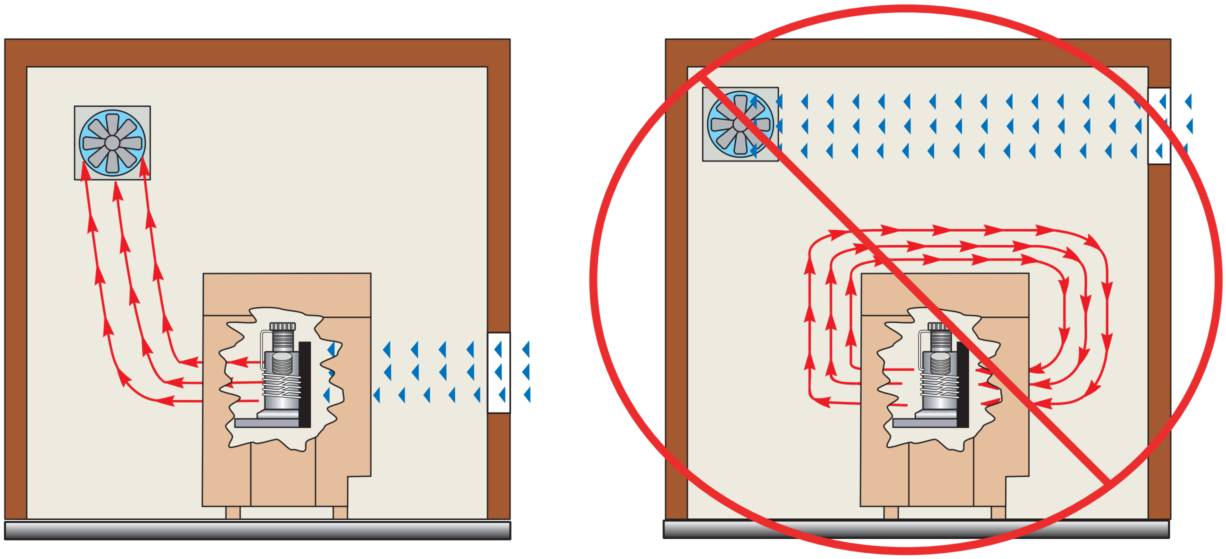
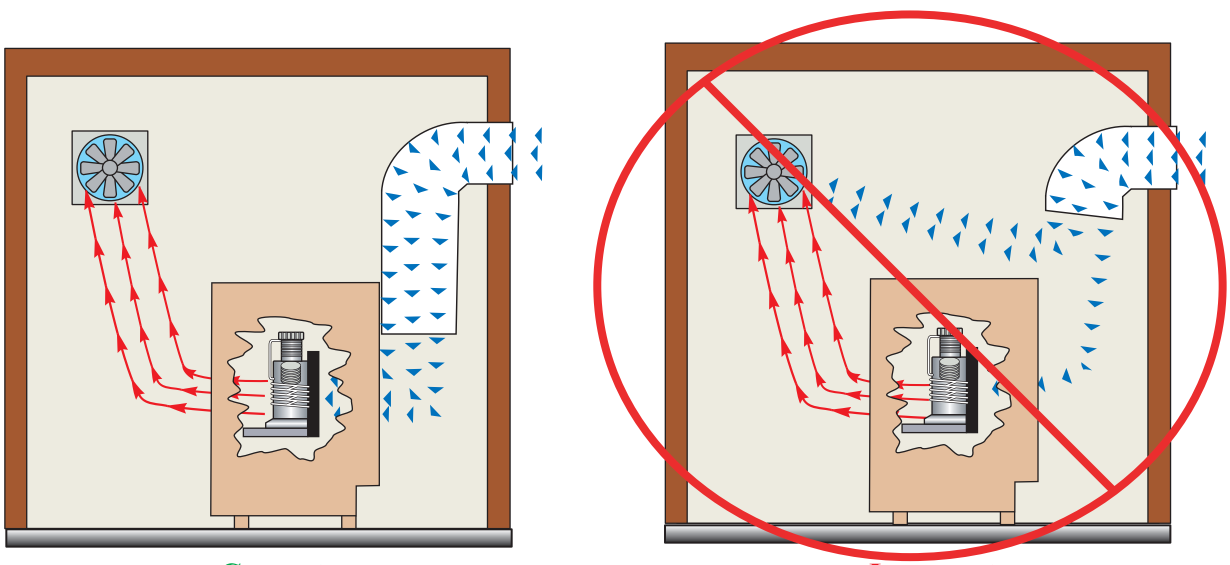


Figure 2-7 Examples of Forced Ventilation Using a Room Fan



Correct
Air intake is near the ground;
Cooling Air flows through the unit.

Incorrect
Air Intake to high:
Cooling Air rushes through the room.



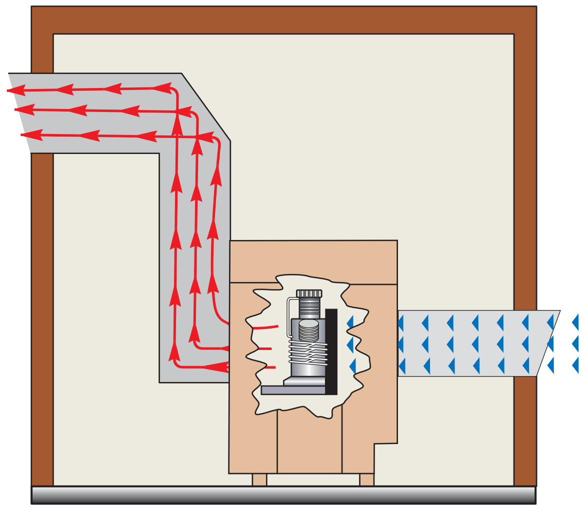
Correct
The cooling air is channeled
directly into the unit;
proper cooling is assured

Incorrect
The cooling air is not channeled
into the unit;
proper cooling is not assured.

2.4.3 Forced Ventilation by Using Ducts

A ventilation duct can be directly attached to the exhaust of the compressor unit. For longer ducts, an exhaust fan mounted in the duct will become necessary. This type of ventilation is recommended for greater drive power and in unfavorable set-up conditions. The heat dissipation is optimized.

Figure 2-8 Forced Ventilation by Using Ducts



NOTICE

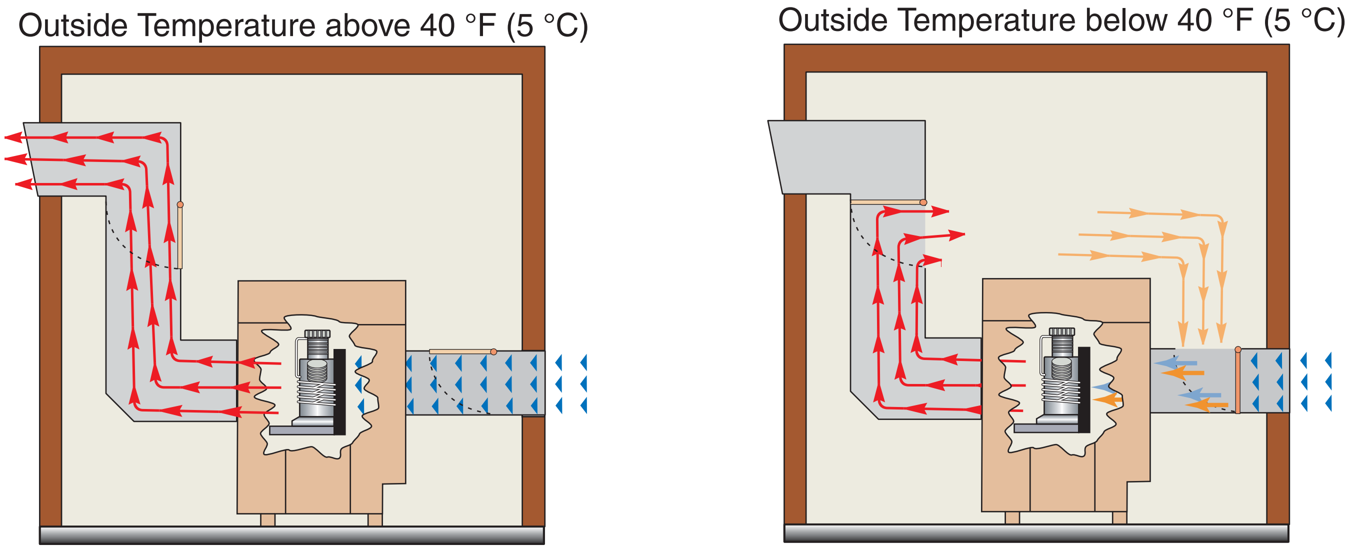
The duct area and length cannot be chosen at random, but must be adapted to the conditions.

2.4.4 Forced Ventilation Using Ducts and a Baffle

(See Figure 2-9) This type of ventilation for the most part is similar to the simple duct ventilation, with the exception of an installed baffle. This is absolutely necessary if the outside temperature falls below 40°F. The cool air from outside is mixed with the warm exhaust by means of the baffle, producing the necessary cooling air temperature. The baffle can be controlled either manually or by thermostat. This provides optimal ventilation; therefore, we recommend this type of ventilation for all Bauer compressors operating under the following conditions:

- Drive power exceeding 50 hp
- Extended run time
- Outside temperature at times below 40°F
- Multiple installations.

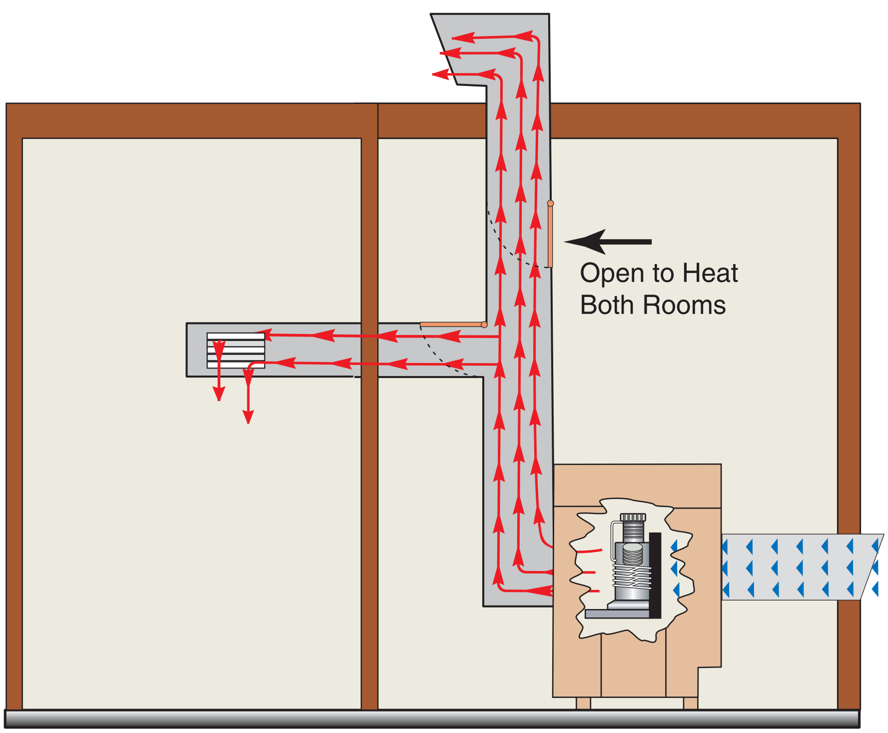
Figure 2-9 Forced Ventilation Using Ducts and a Baffle



2.4.5 Forced Ventilation Using Ducts with the Exhaust Used as Heating Air

(See Figure 2-10) This version is also an extension of the previous version, therefore the same operating condition requirements apply. The use of the warm compressor exhaust for room heating (i.e. storeroom) is possible; however, it is seldom used because of the noise level produced and the relatively short run times of the compressor unit.

Figure 2-10 Forced Ventilation Using Ducts with the Exhaust Used as Heating Air



2.5 Planning Assistance for Forced Ventilation

2.5.1 Calculation of the Duct Area; in Feet & Horsepower

The recommended cooling air velocity within the duct is 600 to 1000 ft/min. The maximum velocity is 1,575 ft/min.

The necessary cooling air flow can be approximated by means of the following formula or can chosen more accurately from the tables in the Appendix.

Required Cooling Air Flow (cfm) = 132 x Drive Power (Hp)

The required duct area can be calculated based on the velocity and the required flow of the cooling air using the following formulas.

$$\text{DuctArea}[\text{ft}^2] = \frac{\text{CoolingAirFlow}[\text{ft}^3/\text{min}]}{\text{Velocity}[m/\text{s}]}$$

Example:

- Compressor Model: B25.4 - 50
- Drive Power: 50 Hp
- Cooling Air Flow: 132 x 50 = 6,600 cfm
- Velocity: 600 ft/min

$$\text{DuctArea} = \frac{6,600[\text{ft}^3/\text{min}]}{600[\text{ft}/\text{min}]} = 11\text{ft}^2$$

2.5.2 Calculation of the Duct Area; in Meters & Kilowatts

The recommended cooling air velocity within the duct is 3 meters/sec. to 5 meters/sec. The maximum velocity is 7- 8 meters/sec.

The necessary cooling air flow can be approximated by means of the following formula or can chosen more accurately from the tables in the Appendix.

Required Cooling Air Flow (m^3/h) = 300 x Drive Power (kW)

The required duct area can be calculated based on the velocity and the required flow of the cooling air using the following formulas.

$$\text{DuctArea}[m^2] = \frac{\text{CoolingAirFlow}[\text{m}^3/\text{h}]}{\text{Velocity[m /s] x 3,600 [s/h]}}$$

Example:

- Compressor Model: B25.4 - 50 Hp
- Drive Power: 50 Hp = 37 kW (approx.)
- Cooling Air Flow: 300 x 37 = 11,100 m^3/h
- Velocity: 5 m/s

$$\text{uctArea} = \frac{(11,100[\text{m}^3/\text{h}])}{5[m/\text{s}]x3,600[\text{s}/h]} = 0.62\text{m}^2$$

2.5.3 Duct Backpressure

(See Figure 2-11) The maximum static pressure created by the cooling fans on Bauer compressors is 0.31” water. The inlet and outlet openings on the enclosure are sized for a maximum back pressure of 0.20” water, measured at 40” from the start of the duct. Should the back pressure exceed this limit, an additional fan must be mounted in the ventilation duct.

As a rule of thumb, the back pressure is as follows:

1 ft. duct ≅ 0.01” water or 1 m duct = 0.1 mbar

one 90^{o} Bend ≅ 0.16” water or one 90° bend = 0.4 mbar

This means that the maximum value allowed of 0.20” water (5 mmWs) is attained with a duct length of 4 ft. (1 m) and with one 90° bend. Should the duct length be greater or include multiple bends, an additional fan must be installed.

Figure 2-11 Duct Backpressure

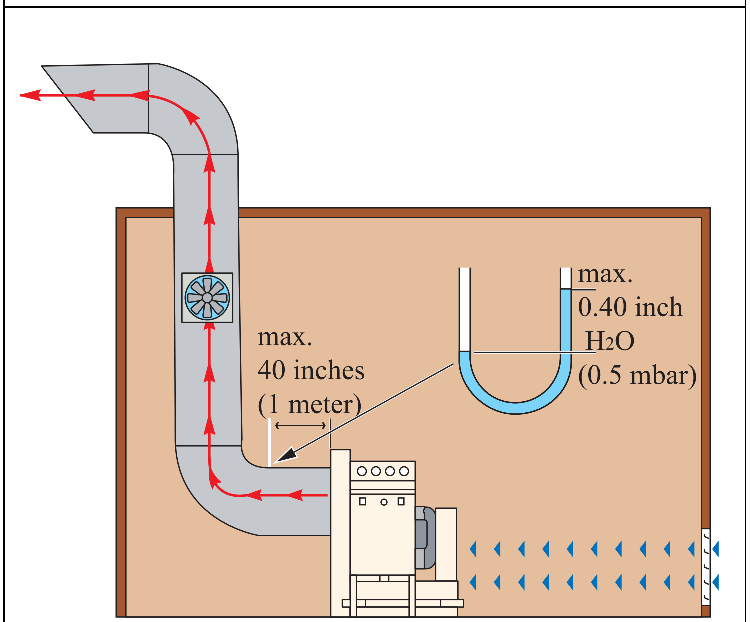
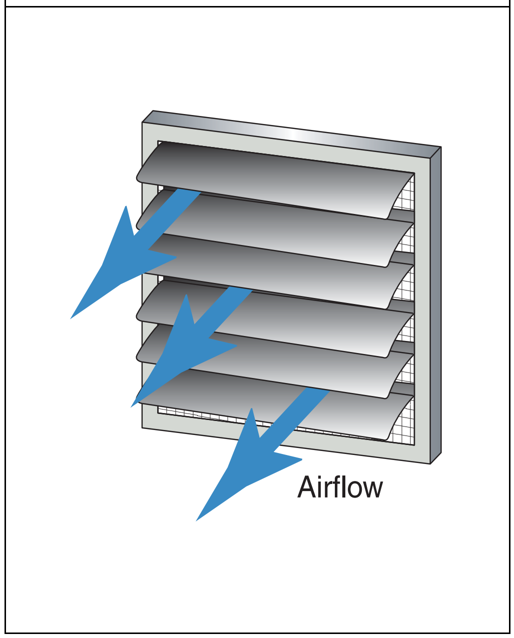


Figure 2-12 Air Intake Opening



2.6 Connection ventilation frames

Upon request, certain models of Bauer compressors can be delivered with a connection frame. To avoid the transfer of vibration, any connection between the compressor and the ventilation duct should be flexible.

2.6.1 Air Intake Opening

(See Figure 2-12) A built in screened louver is recommended with the screen preventing entry of contaminates and the louvers preventing entry by precipitation. Some form of cold weather protection should also be installed, i.e. baffles which can be closed if necessary. This louver in the air intake opening should be inspected for cleanliness on a regular basis and should be cleaned if necessary.

CHAPTER 3: ELECTRICAL AND CONDENSATE COLLECTION

3.1 Electrical Data

In the below tables, all values are based on 2005 NEC. These values are provided as a general guide; however, the information given on the motor nameplate supersedes the above information.

Wiring should be done by a certified electrician who is familiar with national, state and local codes.

The applicable NEC regulations for switch box access should be followed.

Table 3-1: Single Phase Motor Data

1 PHASE									
Motor Hp	Full Load Amps			Fuse Amps[a]			Minimum Wire Size[b]		
	120V	208V	230V	120V	208V	230V	120V	208V	230V
5	56	31	28	80	50	40	4	8	8
7.5	80	44	40	125	70	60	3	8	8
10	---	55	50	---	90	80	---	6	6

a. dual element time delay fuse amps

b. normal copper wire with THW, THWN or XHHW insulation

Table 3-2: Three Phase Motor Data

3 PHASE									
Motor Hp	**Full Load Amps**			**Fuse Amps**[a]			**Minimum Wire Size**[b]		
	208V	**230V**	**460V**	**208V**	**230V**	**460V**	**208V**	**230V**	**460V**
5	16.7	15.2	7.6	25	25	12	12	14	14
7.5	24.2	22	11	40	30	20	10	10	14
10	30.4	28	14	50	40	20	8	10	14
15	46.2	42	21	60	60	30	6	6	10
20	59.4	54	27	90	80	40	4	4	10
25	74.8	68	34	100	100	50	3	4	8
30	88.0	80	40	125	100	60	2	3	8
40	114	104	52	175	150	80	1/0	1	6
50	143	130	65	200	200	100	3/0	2/0	4
60	169	154	77	250	200	100	4/0	3/0	3
75	211	192	96	300	300	150	300 mcm	250	1
100	273	248	124	400	350	175	500 mcm	350	2/0
125	343	312	156	500	400	200	2 @ 4/0	2 @ 3/0	3/0
150	396	360	180	600	500	250	2 @ 300 mcm	2 @ 4/0	3/0

a. dual element time delay fuse amps

b. normal copper wire with THW, THWN or XHHW insulation

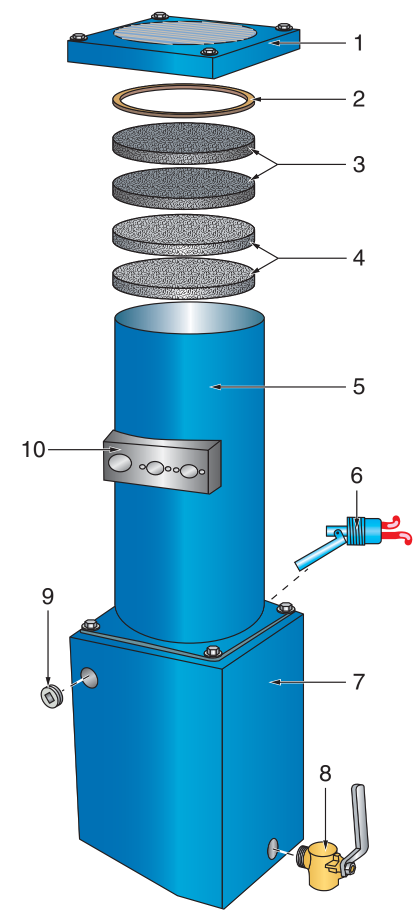
3.2 Condensate Removal

During compression the water content of the air is also compressed. The resulting water is removed after each compression stage and is collected through the automatic condensate drain. This water, additionally, has a small oil content. The separation of oil and water is not possible through simple methods; therefore the condensate has to be completely removed. It is most practical to collect this condensate in special containers and dispose of it entirely.

3.2.1 Compressor Units up to 20 Hp (15kW)

For these compressor units a housing and tank assembly is used. A float level switch is also included. The discharged air is passed through an activated carbon filter to free the air of oil particles. The condensate is drained from the tank assembly by the manual drain valve into a separate container for proper disposal.

Figure 3-1 Condensate Collector for Small Units

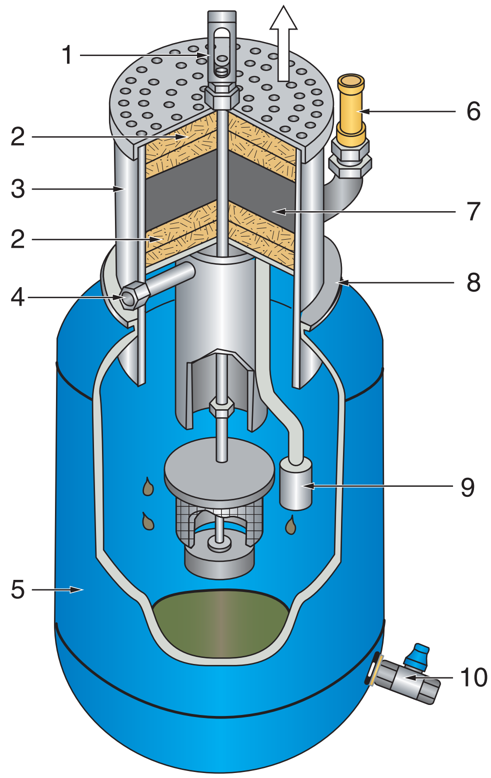


1.	Cover	6.	Float Switch
2.	Gasket	7.	Collection Tank
3.	Fine Filter Elements	8.	Drain Valve
4.	Coarse Filter Elements	9.	Plug
5.	Separator Tank	10.	ACD Manifold

3.2.2 Compressor Units Greater than 20 Hp (15 kW)

There is a specially developed condensate container for these units. This container is equipped with a level indicator to prevent overflows. This container is especially environmentally friendly as it is also sound insulated and, the discharged air is passed through an activated carbon filter to completely free the air of oil particles.

Figure 3-2 Condensate Collection for Large Units



1. Level Indicator	6. Relief Valve
2. Condensate Filter Mats	7. Activated Charcoal
3. Filter Head	8. Clamp
4. Condensate Inlet	9. Float Switch
5. Condensate Tank	10. Drain Tap

3.2.3 Condensate Collection for Multiple Installations

For multiple installations several condensate drains can be concentrated together, however, it is crucial that one pays close attention that the diameter of the collection pipe is of sufficient size. Otherwise, there is the possibility of condensate stagnation in the pipe.

CHAPTER 4: APPENDIX

4.1 Required Intake and Exhaust Openings for Convection

Table 4-1: Convection Cooling Intake & Exhaust Openings

Convection Cooling Intake and Exhaust Openings; in Feet² and Horsepower						
V[a] =	**1,750 ft³**		**3,500 ft³**		**7,000 ft³**	
Δh[b] =	**6.5 ft**		**10 ft**		**13 ft**	
Power Hp	**Inlet, ft²**	**Outlet, ft²**	**Inlet, ft²**	**Outlet, ft²**	**Inlet, ft²**	**Outlet, ft²**
5	1.3	1.1	1.6	1.3	—	—
7.5	2.2	1.8	2.4	2.0	—	—
10	3.2	2.7	3.2	2.7	2.1	1.7
15	4.3	3.6	4.8	4.0	3.1	2.6
20	6.5	5.4	6.5	5.4	4.1	3.4

a.V = volume of the room

b.Dh = the height difference between the air intake and the exhaust openings

Convection Cooling Intake and Exhaust Openings; in Meters² and Kilowatts						
V[a]	**50 m³**		**100 m³**		**200 m³**	
Δh[b]	**2 m**		**3 m**		**4 m**	
Power Hp	**Inlet, m²**	**Outlet, m²**	**Inlet, m²**	**Outlet, m²**	**Inlet, m²**	**Outlet, m²**
2.2	0.12	0.10	—	—	—	—
3.0	0.24	0..20	0.12	0.10	—	—
4.0	0.30	0.25	0.12	0.10	—	—
5.5	0.42	0.35	0.24	0.20	0.12	0.10
7.5	0.90	0.75	0.60	0.50	0.24	0.20
11.0	1.38	1.15	0.90	0.75	0.54	0.45
15.0	1.92	1.60	1.45	1.20	0.90	0.75

a.V = volume of the room

b.Dh = the height difference between the air intake and the exhaust openings

4.2 Cooling Air Flow Required for Convection Cooling

Table 4-2: Cooling Air Flow Required for Convection Cooling

Cooling Air Flow Required for Convection Cooling; in Feet³ and Horespower				
		Wall Material		
Room Volume Ceiling Height	Motor Hp	Concrete cfm	Brick cfm	Cinder Block cfm
V = 900 ft³ Δh = 8 ft	5	37	110	183
	7.5	55	165	274
	10	73	219	365
	15	110	329	548
	20	146	439	731
V = 1750 ft³ Δh = 8 ft	5	156	259	359
	7.5	239	389	538
	10	117	468	702
	15	176	702	1,053
	20	234	936	1,404
V = 3500 ft³ Δh = 10 ft	5	59	234	351
	7.5	88	351	526
	10	117	468	702
	15	176	702	1,053
	20	234	936	1,404
V = 5,300 ft³ Δh = 11.5 ft	5	80	249	351
	7.5	120	374	526
	10	160	499	702
	15	239	748	1,053
	20	319	997	1,404

Cooling Air Flow Required for Convection Cooling; in Meters³ and Kilowatts				
		Wall Material		
Room Volume Ceiling Height	Motor kW	Concrete m^3/hr	Brick m^3/hr	Cinder Block m^3/hr
V = 25 m^3 Δh = 2.5 m	5	5	—	—
	7.5	7.5	120	220
	10	10	410	510
	15	15	650	770
	20	20	1,060	1,180
	25	25	1,590	1,770
	30	30	1,940	2,120
V = 50 m^3 Δh = 2.5 m	3	50	150	250
	4	200	370	400
	5.5	700	870	1,000
	7.5	1,100	1,300	1,500
	11	1,800	2,000	2,200
	15	2,700	3,000	3,100
	18.5	3,300	3,600	3,700
	22	4,000	4,200	4,300
V = 100 m^3 Δh = 3 m	3	—	25	200
	4	—	180	350
	5.5	400	650	900
	7.5	800	1,100	1,350
	11	1,400	1,800	2,100
	15	2,400	2,700	3,000
	18.5	3,000	3,300	3,600
	22	3,700	4,000	4,250

Cooling Air Flow Required for Convection Cooling; in Meters³ and Kilowatts				
		Wall Material		
Room Volume Ceiling Height	Motor kW	Concrete m³/hr	Brick m³/hr	Cinder Block m³/hr
V = 150 m³ Δh = 3.5 m	3	—	—	—
	4	—	—	170
	5.5	—	50	600
	7.5	—	500	1,000
	11	400	1,250	1,800
	15	1,800	2,100	2,600
	18.5	1,900	2,700	3,200
	22	2,600	3,400	3,900
V = 200 m³ Δh = 4 m	3	—	—	—
	4	—	—	50
	5.5	—	—	400
	7.5	—	200	900
	11	—	1,000	1,600
	15	900	1,800	2,500
	18.5	1,500	2,500	3,100
	22	2,200	3,200	3,800

4.3 Cooling Air Flow Required for Forced Ventilation

Table 4-3: Cooling Air Flow Required for Forced Ventilation

Cooling Air Flow Required for Forced Ventilation; in Feet³ and Horsepower				
		Wall Material		
Room Volume Ceiling Height	Motor Hp	Concrete cfm	Brick cfm	Cinder Block cfm
$V = 1{,}750\ ft^3$ $\Delta h = 8\ ft$	25	3,144	3,290	3,363
	30	3,772	3,948	4,036
	40	5,030	5,264	5,381
	60	7,545	7,896	8,071
	100	12,575	13,159	13,452
$3{,}500\ ft^3$ $\Delta h = 10\ ft$	25	2,924	3,144	3,290
	30	3,509	3,772	3,948
	40	4,679	5,030	5,264
	60	7,018	7,545	7,896
	100	11,697	12,575	13,159
$7{,}000\ ft^3$ $\Delta h = 13\ ft$	25	2,632	2,961	3,217
	30	3,158	3,553	3,860
	40	4,211	4,737	5,147
	60	6,317	7,106	7,720
	100	10,528	11,844	12,667
$17{,}700\ ft^3$ $\Delta h = 16.5\ ft$	25	1,791	2,449	2,924
	30	2,149	2,939	3,509
	40	2,866	3,919	46,79
	60	4,299	5,878	7,018
	100	7,165	9,797	11,697

Cooling Air Flow Required for Forced Ventilation, in Meters³ and Kilowatts				
		Wall Material		
Room Volume Ceiling Height	**Motor kW**	**Concrete**	**Brick**	**Cinder Block**
		m^3/hr	**m^3/hr**	**m^3/hr**
V= 50 m^3 Δh = 2.5m	18	5000	5300	5600
	22	6100	6400	6700
	30	8600	9000	9200
	37	10800	11200	11400
	45	13400	13700	14000
	55	16500	16900	17100
	75	22800	23200	23400
	90	27600	28000	28200
	110	33900	34300	34500
V = 100 m^3 Δh =2 m	18	4400	5000	5400
	22	5500	6100	6500
	30	8000	8600	9000
	37	10300	10800	11200
	45	12800	13400	13800
	55	15900	16500	16900
	75	22300	22850	23200
	90	27000	27600	28000
	110	33300	34000	34300
V = 200 m^3 Δh =4 m	18	3600	4500	5100
	22	4600	5600	6200
	30	7200	8100	8800
	37	9400	10300	11000
	45	12000	12900	13500
	55	15100	16000	16700
	75	21400	22300	23000
	90	26200	27100	27700
	110	32500	33500	374100

Cooling Air Flow Required for Forced Ventilation, in Meters³ and Kilowatts				
		Wall Material		
Room Volume Ceiling Height	**Motor kW**	**Concrete**	**Brick**	**Cinder Block**
		m^3/hr	**m^3/hr**	**m^3/hr**
V = 500 m^3 ∆h = 5m	18	1,300	3,100	4,300
	22	2,400	4,200	5,500
	30	4,900	6,700	8,000
	37	7,100	8,900	10,200
	45	9,600	11,500	12,800
	55	12,800	14,600	15,900
	75	19,900	20,900	22,200
	90	23,900	25,600	27,000
	110	30,200	32,000	33,300

4.4 Required Air Intake Opening for Forced Ventilation

Table 4-4: Required Air Intake Opening for Forced Ventilation

Intake Opening Area, in Feet²		
Cooling Air Flow	**590 ft/min**	**985 ft/min**
cfm	**ft²**	**ft²**
2,942.5	5.4	3.2
5,885.0	9.7	6.5
8,827.5	15.1	9.7
11,770.0	20.5	11.8
14,712.5	24.8	15.1
17,655.0	30.1	18.3
20,597.5	34.4	21.5
23,540.0	39.8	23.7
26,482.5	45.2	26.9
29,425.0	49.5	30.1

Intake Opening Area, in Meters²		
Cooling Air Flow	**3 m/s**	**5 m/s**
m³	**m²**	**m²**
5,000	0.5	0.3
10,000	0.9	0.6
15,000	1.4	0.9
20,000	1.9	1.1
25,000	2.3	1.4
30,000	2.8	1.7
35,000	3.2	2.0
40,000	3.7	2.2
45,000	4.2	2.5
50,000	4.6	2.8