Palestine Polytechnic University

College of Engineering & Technology

Mechanical Engineering Department

Design Building And Operating Of Simple Vapor Compression Refrigeration System For Laboratory Demonstration

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Hebron – Palestine

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Project Name

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بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الميكانيكية ، وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة التكييف والتبريد .

توقيع المشرف

توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

Dedication

To our Families ……………………. For their support

To our Teachers ……........... For help us until the end

To our friends ………………. Who give us Positive sentiment

To oppressed people throughout the world and their struggle for social justice and egalitarianism

To our great Palestine

To our supervisor Dr. Ishaq Sider

To all who made this work possible

Mohammad Taha Abu Srour

ACKNOWLEDGEMENT

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Finally , our ultimate thanks go to great edifice of science (Palestine Polytechnic University) for their endless support and their huge effort in providing us with all what we need to build this project .

ABSTRACT

Design building and operating of simple vapor compression refrigeration system for laboratory demonstration .

In this project we will design and build an educational device which works on the principles of the simple refrigeration cycle so as simplified the understanding through learning the refrigeration subject .

This device will check refrigerant case, itstemperature , pressure in each stage in the cycle ,and sense the factor affecting the behavior of refrigerant ,the device which we are looking to build is related the theoretical learning and experimentally on the refrigeration cycle .

يهدف هذا المشروع الى تصميم وبناء جهاز تعليمي يعمل على مبدأ دورة التبريد البسيطة التي تعتبر المكون الرئيسي للعديد من أجهزة التبريد (الثلاجات) ، كما ونهدف من خلال النموذج توضيح المكونات الرئيسية لدورة التبريد والتوصيلات الميكانيكية والكهربائية المكونة للدورة ، والعوامل المؤثرة على سلوك الغاز حيث يمكننا من خلال الجهاز تتبع سلوكه في كل مرحلة من مراحل الدورة .

وأخذت فكرة الجهاز من نماذج تقوم العديد من الشركات العالمية بتصنيعها ويمكن تجميع الجهاز محليا وبتكلفة اقل .

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CHAPTER 1

INTRODUCTION

1.1 Introduction

1.2 Objective

1.3 Scope

1.4 Time Table

1.5 The budget of the project

CHAPTER ONE

INTRODUCTION

1.1. Introduction

This kit is specifically designed for educational aims and it includes all the components of the hydraulic of a beverage cooler . it enables students to deal with the issues concerning the assembling of the hydraulic circuit , the connection of electric components , besides the calibration of the controller for an optimum operation of the system . the kit also includes the pipes that can be used together with the standard tools for refrigerator technicians to assemble the hydraulic circuit . this kit can easily be disassembled for a repeateduse.

1.2. Objectives

The project objective are:

1- The building and designs of educational models help students to understand the basic of simple refrigeration cycle .
2- Applied the theoretical education for design and building device .
3- Enrich the refrigeration lab by the devices to interest education .
4- simplify the student's learning process by integrating concrete elements into the theory learned in the classroom and textbooks.
5- simplify the teacher's work by demonstrating how the theory of the topic studied is applied in practice.

1.3. Scope

1) Select one of the devices that are present in the catalogue .
2) Select and design the appropriate loading to achieve the objective of the work device .
3) Calculate the cooling loading .
4) Select the components of project.
5) Search for the components .

6) Make complete drawing design .
7) Buy the components and begin building thedevice.
8) Make tests one the device and read the measurement .
9) Attach instruction sheet on the device to illustrate how to use.

1.4. Time Plan

Table 1.1: Timetable for the second semester time (week)

Task\week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project selection And proposal																
Information Gathering																
Writing introduction																
Cooling load Calculation																
Selection the cycle components																

Table 1.2: Timetable for the first semester time (week)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Drawing															
Search for the components															
Build The Project															
The Results of Project															

1.5. The Budget Of The Project

Table (1.3):The budget of the project:

	Component name	**Price (NIS)**
1	**Compressor**	300
2	**Condenser**	200
3	**Evaporator**	250
4	**Connecting pipes**	250
5	**2-Pressure Gauges**	100
6	**Frame**	700
7	**Refrigerant**	200
8	**Control Equipment's** **(Thermostat** **Filter** **Sight glass** **Capillary tube** **Switches** **Wires** **Valves)**	800
	Total price	**2800 (NIS)**

CHAPTER 2

Cycle components and market review

2.1. Name of companies

2.2.Simple refrigeration cycle

2.3.Components of assembly kit of beverage cooler

CHAPTER TWO

Cycle components and market review

In this chapter we will review the name of some companies which designs and manufactures the educationaldevice in the field of technical refrigeration also we will review some models that we make and design , we chose one of these of these models and we will make design and implementation in practice**.**

2.1 Name of companies:

2.1.1Elettronica venta:

It is an Italian company recognised as a world leader in technical training equipment.

These are some of the technical equipment produced by this company[Reference11] .

Figure 2.1:Assembly kit of beverage cooler

Figure 2.2:Preassembled kit for refrigeration and air conditioning

2.1.2Edibonfor technical teaching equipment：

The American company experienced provider of design to manufacturing solutions and teaching labs to educators and students for over 25 years based in concord.[Reference10]

These are some of the technical equipment produced by this company.

Figure 2.3:Refrigeration cycle demonstration unit

Figure 2.4:Refrigeration unit with refrigeration and freezing chamber

Figure 2.5:Computer controlled absorption refrigeration unit

Figure 2.6:One condenser (water)and one evaporator

Figure 2.7:One condenser (water)and one evaporator(water)

The device will design and build like to the device in Figure 2.1(assembly kit of beverage cooler) that we will design and build .

2.2.Simple refrigeration cycle

Simple refrigeration cycle is a simple vapor compression refrigeration system , in which suitable working substance termed as refrigerant . It condenses and evaporates at a temperature and pressure close to atmospheric condition . It can be used ordinary application of refrigeration and it gives a high coefficient of performance , but the single stage refrigeration cycle is limited in the lower evaporation temperature and the lower vapor pressure in the evaporator , and the compressor sucks less refrigerant per stroke so it has a lower volumetric efficiency . This problem caused reducing capacity to the point where load and capacity are in balance [Reference1] .

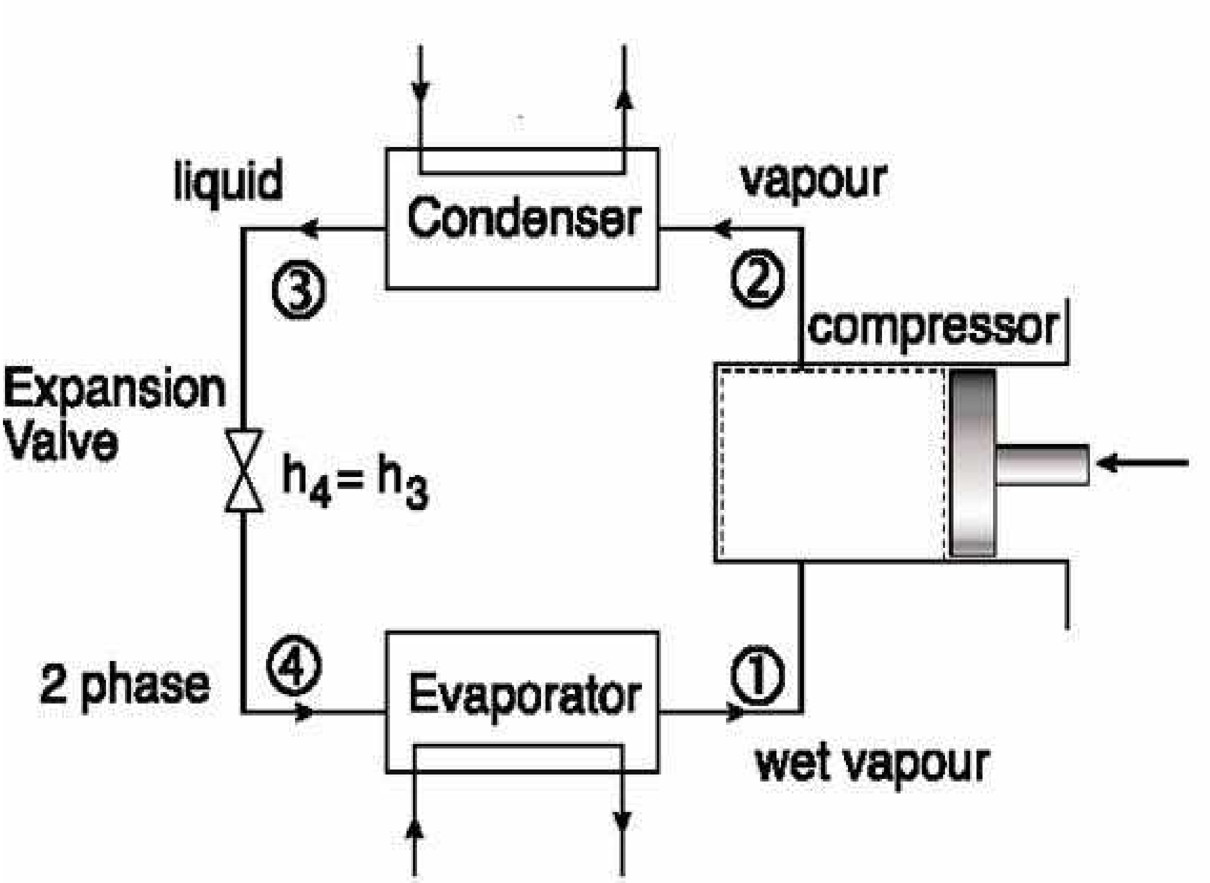

Fig.2.8:Simple vapor compression refrigeration system .

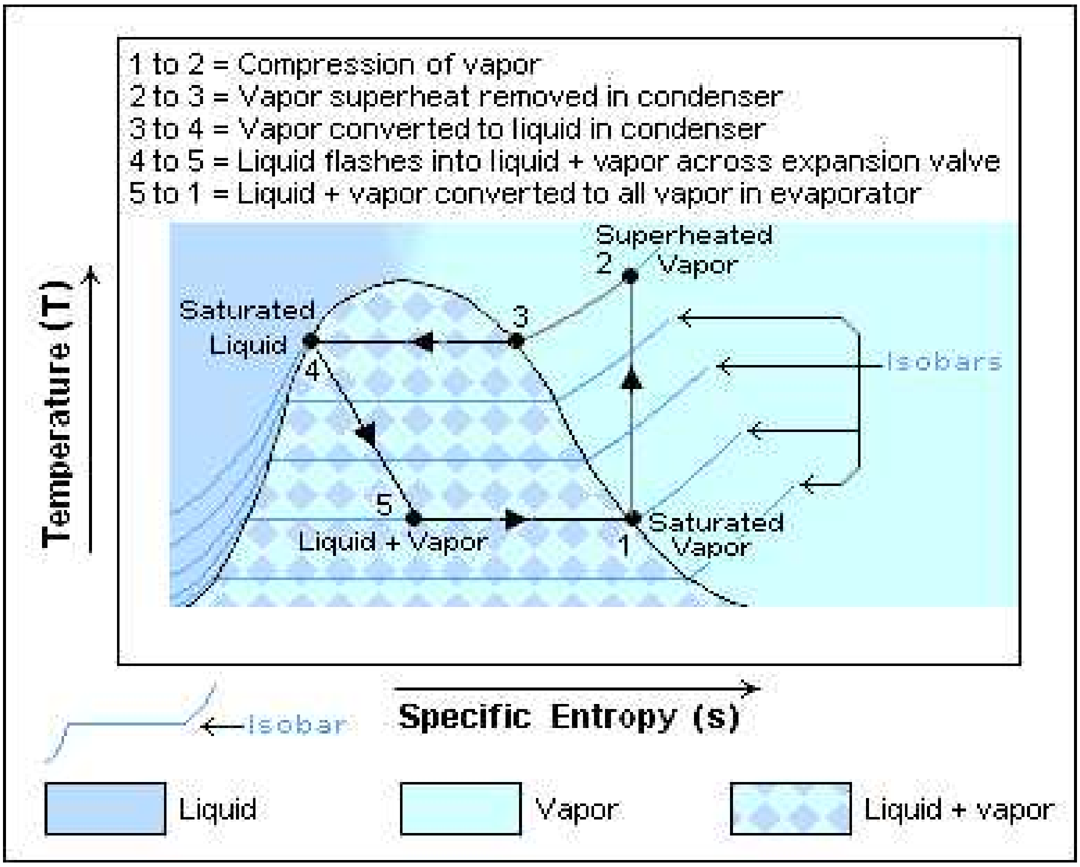

Fig.2.9: T-S diagram .

Sometimes the vapor refrigerant is required to be delivered at a very high pressure as in the case of low temperature refrigeration systems , in such cases the vapor refrigerant must be compressed by employing two or more compressors placed in series . The compression carried by this case is called multistage compression .

2.3.Components of simple refrigeration cycle

There are several mechanical components required in simple refrigeration cycle system . This part of project discuss the four major components of the system and some auxiliary equipment's working with these major components [reference 5].

The major components of the simple refrigeration cycle are as follows :

- Compressor .
- Condenser .
- Evaporator .
- Thermostatic expansion valve.

2.3.1. Compressor

In refrigeration cycle , the compressor has two main functions within the refrigeration cycle. One of this function is to pump the refrigerant vapor from the evaporator so that the desired temperature and pressure can be maintained in the evaporator . The second function is to increase the pressure of refrigerant vapor through the process of compression, and simultaneously increase the temperature of the refrigerant vapor . By this change in pressure the superheated refrigerant flows through the system. Refrigerant compressors, which are knows as the heart of the refrigeration system, can be divided into three main categories : [reference 5]

- Hermetic compressor
- Simihermetic compressor
- Open compressor

In this project we will use hermetic compressor .

Hermetic Compressor

These compressors, are available for small capacities, motor and drive are sealed in compact welded housing. The refrigerant and lubricating oil are contained in this housing. Almost all small motor-compressor pairs used in domestic refrigerator, freezers, and air conditioners are of the hermetic type . Their revolutions per minute are either 1450 or 2800 rpm . Hermetic compressors can work for a long time in small capacity refrigeration system without any maintenance requirement and without any gas leakage , but they are sensitive to electric voltage fluctuations, which may make the copper coils of the motor burn . The cost of these compressors is very low [reference 5].

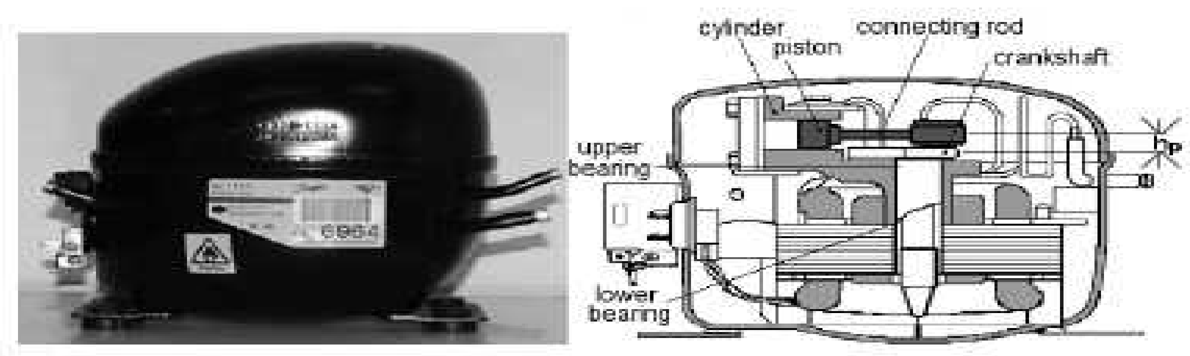

Figure 2.10: Hermetic Compressor

Expectations From The refrigerant compressors are expected to meet the following requirements high reliability, long service life, easy maintenance, quiet operation, compactness, and low cost .

2.3.2 Condensers

A condenser is a major system component of refrigeration system. It also an indirect contact heat exchanger in which the total heat rejected from the refrigerant is removed by cooling medium, usually air or water. As a result, the gaseous refrigerant is cooled and condensed to liquid at the condensing pressure [reference 2].

Air cooled condensers

The air cooled condensers find application in domestic, commercial, and industrial refrigerating, chilling, freezing, and air conditioning systems, the centrifugal fan are used in the condenser particularly for heat recovery and auxiliary ventilation applications. In fact, they employ outside air as cooling medium [reference 6].

Fans draw air past the refrigerant coil and the latent heat of the refrigerant is removed as sensible heat by the air stream[reference 6].

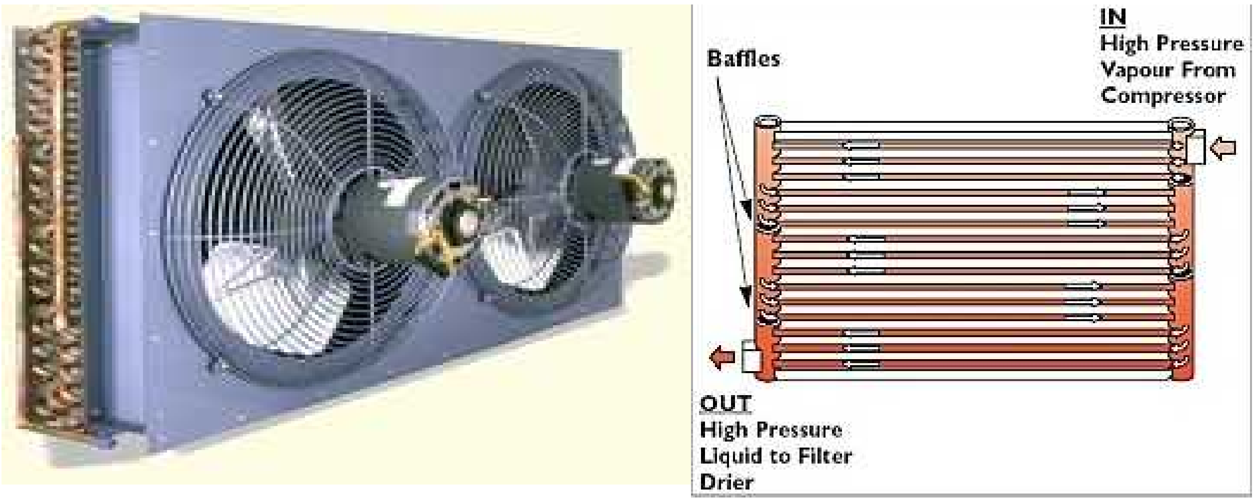

Figure 2.11: Air Cooled Condenser

2.3.3 Evaporator

Evaporator is an important device used in the low pressure side of a refrigeration system . The liquid refrigerant from the expansion valve enters into the evaporator where it boils and changes into vapor . The function of an evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by means of refrigerant . The temperature of the boiling refrigerant in the evaporator must always be less than the temperature of the surrounding medium so that the heat flows to the refrigerant [reference 6] .

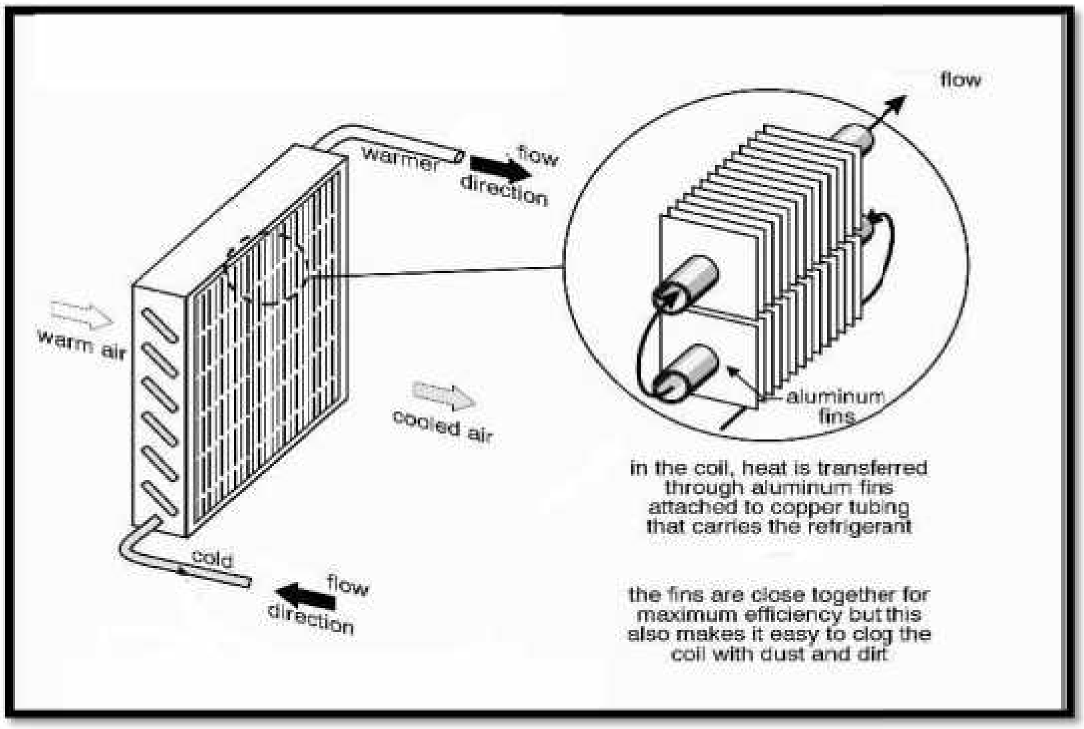

Figure 2.12: Evaporator

Bare Tube Coil Evaporator

The simplest type of evaporator is the bare tube coil evaporator, as shown in figure 3.3. The bare tube coil evaporator are also known as prime surface evaporators. Because of its simple construction, the bare tube coil is easy to clean and defrost. A little consideration will show that this type of evaporator, offers relatively little surface contact area as compared to other types of coils. The amount of surface area may be increased by simply extending the length of the tube, but there are disadvantages of excessive tube length. The effective length of the tube is limited by the capacity of expansion valve. If the tube is too long for the valve's capacity, the liquid refrigerant will tend to completely vaporize early in its progress through the tube, thus leading to excessive superheating at the outlet. The long tubes will also cause considerably greater pressure drop between the inlet and outlet of the evaporator . This results in reduced suction line pressure.

The diameter of the tube in relation to tube length may also be critical. If the tube diameter is too large, the refrigerant velocity will be too low and the volume of refrigerant will be too great in relation to the surface area of the tube to allow complete vaporization. This, in turn, may allow liquid refrigerant to enter the suction line with possible damage to the compressor (slugging). One the other hand, if the diameter is too small, the pressure drop due to friction may be too high and will reduce the system efficiency. The bare tube coil evaporators may be used for any type refrigeration requirement [reference 6].

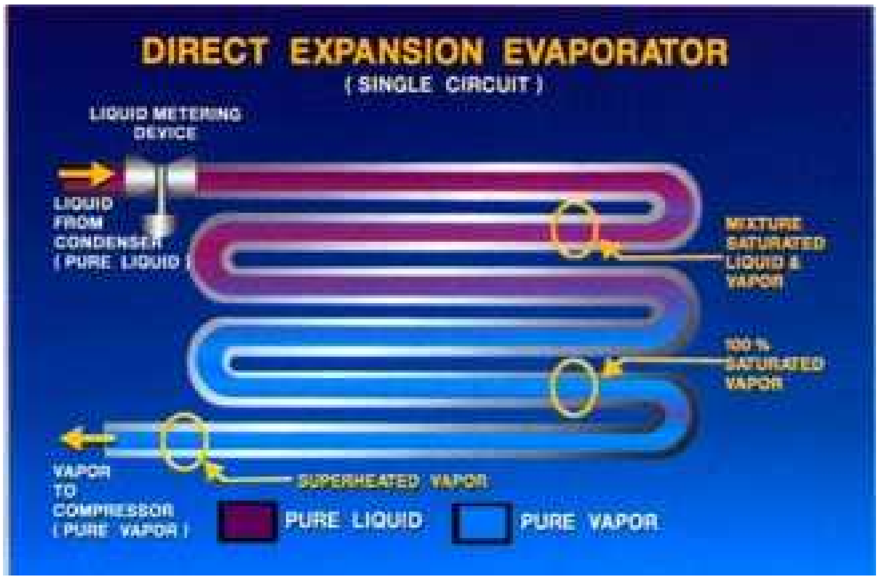

Figure 2.13: Bare Tube Coil Evaporator

2.3.4 Throttling Devices

In practice, throttling devices, called either expansion valves or throttling valves, are used to reduce the refrigerant condensing pressure (high pressure) to the evaporating pressure (low pressure) by a throttling operation and regulate the liquid refrigerant flow to the evaporator to match the equipment and load characteristics. These devices are designed to proportion the rate at which the refrigerant enters the cooling coil to the rate of evaporation of the liquid refrigerant in the coil , the amount depends – of course – on the amount of heat being removed from the refrigerated space [reference 6] .

The most common throttling devices are as follows :

- Thermostatic expansion valves .
- Constant pressure expansion valves .
- Float valves .
- Capillary tubes .

Note that a practical refrigeration system may consist of large range of mechanical and electronic expansion valves and other flow control devices for small and large scale refrigeration system, comprising thermostatic expansion valves, solenoid valves and thermostats, modulating pressure regulators, filter driers, liquid indicators, non-return valves and water valves, and furthermore, decentralized electronic systems for full regulation and control.

Capillary Tubes

The capillary tube is the simplest type of refrigerant flow control device and its shown is figure 2.14 and may be used in place of an expansion valve. The capillary tubes are small diameter tubes through which the refrigerant flows into the evaporator. These devices, reduce the condensing pressure to the evaporating pressure in a copper tube of small internal diameter (0.4 – 3 mm diameter and 1.5 – 5 m length), maintaining a constant evaporating pressure independently of the refrigeration load change. A capillary tube may also be constructed as a part of a heat exchanger, particularly in household refrigerators .

With capillary tubes, the length of the tube is adjusted to match the compressor capacity. Other consideration in determining capillary tube size include condenser efficiency and evaporator size. Capillary tubes are most effective when used in small capacity systems .

Figure 2.14:Capillary Tube

2.3.5. Auxiliary Component

The auxiliary components are very important in the refrigeration system, their working together with main components allowing system works very well, and we will discuss some auxiliaries in the following sections.

2.3.5.a FilterDrier

Filter-driers are used to protect the compressor from contamination, particularly moistureleft in the system at the time of installation and keeps the system free of impurities duringoperation, such as motor burn byproducts[reference 6].

Figure 2.15:FilterDrier

2.3.5.b Sight Glass

The Sight Glass was designed to provide an accurate method of determining the moisture content of a system’s refrigerant , Unique 3% high accuracy moisture indicator , Refrigerant level indicator[reference 6].

Figure 2.16:Sight Glass

2.3.5.cThermostat

+

A thermostat is a component of a control system which senses the temperature of a system so that the system’s temperature is maintained near a desired set point. The thermostat does this by switching heating or cooling devices on or off, or regulating the flow of a heat transfer fluid as needed, to maintain the correct temperature. The name is derived from the Greek words thermos "hot" and status "a standing".

Thermostat used in refrigeration system to senses the evaporating temperature. If this temperature reach the required temperature, the thermostat shut off the compressor, and when this temperature increase again it turn on the compressor [reference 1].

Figure 2.17: Thermostat

CHAPTER 3

COOLING LOAD

3.1 Introduction

3.2 load sources

3.3 Total cooling load

CHAPTER THREE

COOLING LOAD

3.1 Introduction

The total heat required to be removed from refrigerated space in order to bring it at the desired temperature and maintain it by the refrigeration equipment is known as cooling load . The purpose of a load estimation is to determine the size of the refrigeration equipment that is required to maintain inside design conditions during periods of maximum outside temperatures . The design load is based on inside and outside design conditions and its refrigeration equipment capacity to produce and satisfactory inside conditions . [reference 2].

3.2 load sources

The cooling load seldom results from any one single source of heat .Rather , it is the summation of the heat which usually evolves from several different sources . some of the more common sources of heat that impose the load on refrigerating equipment are : [Reference 3].

1) The wall heat gain .
2) Defrosts heater heat gain.
3) Fan motor heat gain.

Overview about the Chamber :

Storage temperature is -5 ℃ .
Surrounding Temperature is 35 ℃ .
Chamber Dimensions (0 .6 , 0.5 , 0.3) meter .
Length = 0.6 mWidth = 0.5 mHigh = 0.3 m

Chamber size = 0.6 * 0.5* 0.3 = 0.09m^3= 90 liter .

3.2.1 The wall heat gain

The wall heat gain load , sometimes called the leakage load , is a measure of the heat flow rate by conduction through the walls of the refrigerated space from the outside to the inside . since there is no perfect insulation , there is always a certain amount of heat passing from the outside to the inside whenever the inside temperature is below than the outside . the wall gain load is common to all refrigeration application and is ordinary a considerable part of the total cooling load , commercial storage coolers and residential air conditioning applications are both examples of applications where in the wall gain load often accounts for the greater portion of the total load . [reference 3].

$$Q_{wall} = U * A * \Delta T \quad \text{..(3.1)}$$

Where :-

A : Outside Surface Area of The Wall [m^2] .

U : the overall heat transfer coefficient [$W \quad {}^{\circ}C * m^2$] .

ΔT: the temperature differences across the walls [°C] .

$\Delta T = T_{out} - T_{in}$

Where :

T_{in} : -5 °C

T_{out} : 35 °C

Overall heat transfer coefficient is computed by the following :

$$U = \frac{1}{\frac{1}{h_i}+\frac{\Delta x1}{k_1}+\frac{\Delta x2}{k_2}+\cdots+\frac{1}{h_o}} \quad \text{..(3.2)}$$

Where :

Δx : the thickness of the layer of the wall [m] .

k : the thermal conductivity of the material [$W \quad m.{}^{\circ}C$] .

h_i: the convection heat transfer coefficient of inside air [$\frac{W}{°C.m^2}$] .

Forced convection by using fan (30 – 100) , taken 50[$\frac{W}{°C.m^2}$] .

h_o : the convection heat transfer coefficient of outside air [$\frac{W}{°C.m^2}$] .

Free convection inside the room (5- 20) , taken 10 [$\frac{W}{°C.m^2}$] .

All walls are constructed of three layers as shown in Figure 3.1 .

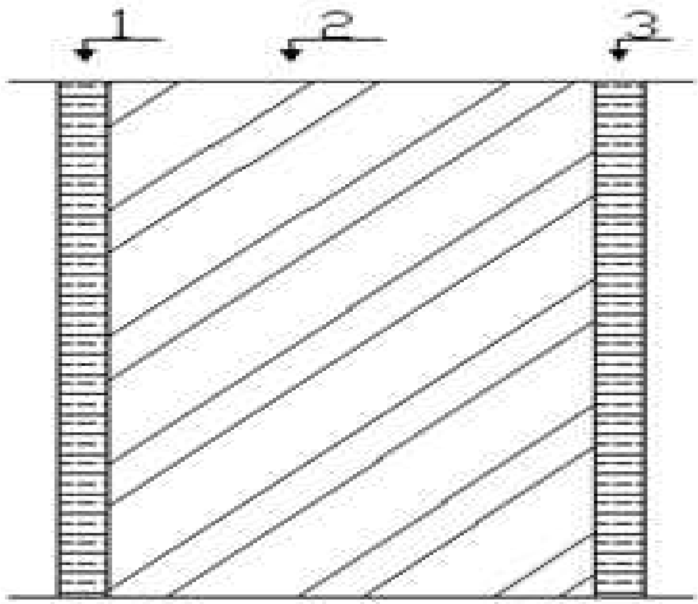

Figure 3.1: Chamber wall layer

1) Galvanized steel 0.1 [cm] , k = 15.60 [$\frac{W}{m.°C}$] . From Table A-1 .
2) polyethylene 5 [cm] , k = 0.036 [$\frac{W}{m.°C}$] . From Table A-1 .
3) Galvanized steel 0.1 [cm] , k = 15.60 [$\frac{W}{m.°C}$] . From Table A-1 .

$$U_{wall} = \frac{1}{\frac{1}{50}+\frac{0.002}{15.6}+\frac{0.05}{0.036}+\frac{1}{10}} = 0.662 \ [\frac{W}{°C.m^2}] .$$

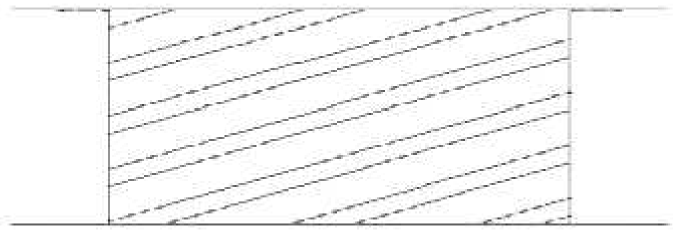

Figure 3.2: Chamber door layer

1) Glass single layer 1 [cm] , k = 6.42 [$\frac{W}{m.\,°C}$] . From Table A-1 .

$U_{door} = \frac{1}{\frac{1}{50}+\frac{0.01}{6.42}+\frac{1}{10}}$ = 8.226 [$\frac{W}{°C.\,m^2}$] .

$Q_{floor\,\&\,roof}$ = 0.662 * (0.6 * 0.5) * (35 - -5) = 7.944 W .

$Q_{two\ sides}$ = 0.662 * (0.5 * 0.3) * (35 - -5) = 3.972 W .

Q_{behind} = 0.662 * (0.6 * 0.3) * (35 - -5) = 4.766 W .

Q_{front} = 8.226 * (0.6 * 0.3) * (35 - -5) = 59.227 W .

$Q_{all\ walls}$ = 2 * ($Q_{floor\,\&\,roof}$ + Q_{sides}) + Q_{front} + Q_{behind} .

$Q_{all\ walls}$ = 2 * (7.944 + 3.972) + 59.227 + 4.766 = 87.825 [W] .

3.2.2 Defrosts heater heat gain

The process of removing frost from the evaporator and around the door is called defrosting .

3.2.2.a Defrosts heater heat gain of the evaporator

If the surface temperature of the evaporator coil is (0 ℃) and lower , frost accumulates on the coil surface . Because frost impedes air passage and reduces the rate of heat transfer of the coil , it must be removed periodically . An electric heating element is used as a simple and effective way to defrost the coil . [reference 1] .

$Q_{defrosts}$ = φ * P ………………………………………………………….……………..(3.3)

Where :

P : Power of heater , taken 500 [W]

φ : heater usage factor (0.1 – 0.5) , taken 0.2

$Q_{defrosts}$ = P * φ = 0.2 * 500 = 100 [W]

3.2.3 Fan motor heat gain

The evaporator fan motor release a heat , this heat relatively equal the power of the motor :

Q_{motor} = power of motor = 25 [W]

3.3 Total cooling load

The total cooling load is the summation of the heat gains:

Q_T = Q_{wall} + $Q_{defrost}$ + Q_{motor}…………………………….……………………….(3.4)

Q_T = 87.825+100+25

Q_T = 212.825 [W]

Add 20 % as safety of factor .

Total cooling load = Q_T * 1.2 ……………………………………………..………….(3.5)

Total cooling load = 212.825 * 1.2 = 255.39 [W]

CHAPTER 4

CYCLE ANALYSIS

4.1 Refrigerant Selection

4.2 Cycle Analysis

4.4 Calculation for cycle using R-134a

4.5 Calculation of the coefficient of performance (COP)

CHAPTER FOUR

CYCLE ANALYSIS

4.1 Refrigerant selection

In the selection of an appropriate refrigerant for use in a refrigeration or heat pump system, there are many criteria to be considered . Briefly, the refrigerant are expected to meet the following condition .

- Low boiling point .
- High critical temperature .
- High latent heat of vaporization .
- Low specific volume of vapor .
- Non corrosive to metal .
- Nonflammable and non-explosive .
- Nontoxic.
- Low cost.
- Easy to liquefy at moderate pressure and temperature .
- Easy of locating leaks by suitable indicator .
- Mixes well with oil .

To select refrigerants successfully we must consider the above properties . We made a comparison between various refrigerants and found that , the best refrigerants could be used is R-134a. In addition to above properties in selection process of R-134a we have to determine the compressor type that works perfectly with R-134a, and it has to be cheap and available . The pressure inside cycle must be a little greater than atmospheric pressure . If the atmospheric pressure became greater than inside cycle pressure will destroy the cycle, so we select R-134a . Refrigerant 134a has low temperature at 0.5 atm. , so R134a is suitable for our system[reference 1].

4.2 Cycle Analysis

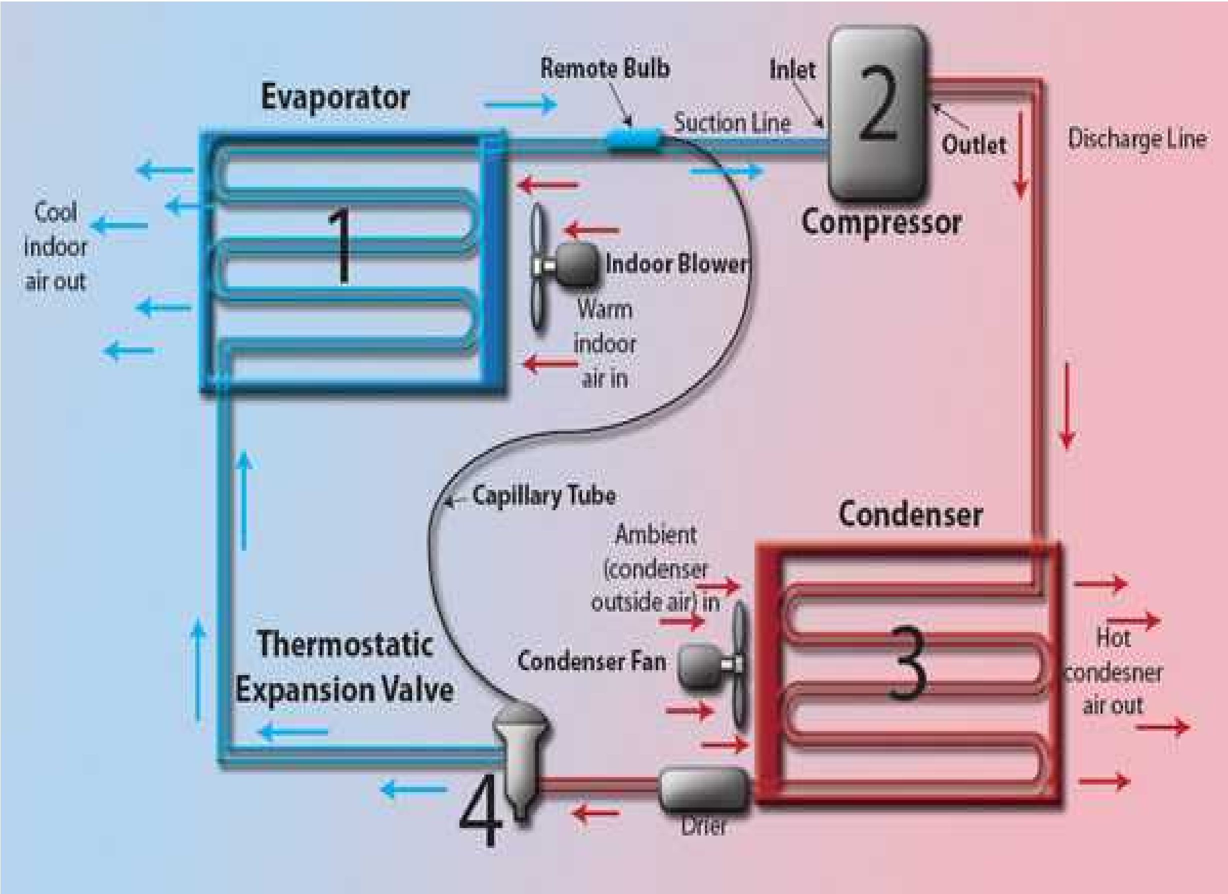

Figure 4.1: Simple Refrigeration Cycle

4.3Calculation For cycle Using R-134a

Figure 4.2 Shows P-h chart for R-134a [reference 7] .

$Q_e = \dot{m} \times q_e$ ……………………………………………………………………………..(4.1)

$Q_e = \dot{m} \times (h_1 - h_4)$ ……………………………………………………………………..(4.2)

$\dot{m} = \frac{Qe}{(h1-h4)}$……………………………………………………………………………….....(4.3)

where :

$\dot{m}$: mass flow rate [kg/s]

Q_e : Heat transfer rate in evaporator (cooling effect) [W]

q_e : Refrigeration effect [kJ/kg]

h_1 : Enthalpy at point before compressor [kJ/kg]

h_4 : Enthalpy at point before evaporator [kJ/kg]

$\dot{m} = \frac{0.255}{394.284-256.160}$ = 0.00184 [kg/s]

$Q_c = \dot{m} \times (h_2 - h_3)$ ……………………………………………………………...…...…..(4.4)

h_2 : Enthalpy at point after compressor [kJ/kg]

h_3 : Enthalpy at point after condenser [kJ/kg]

Q_c : Heat transfer rate in condenser (condenser load) [W]

$Q_c = 0.00184 \times (423.835 - 256.160)$

Q_c = 0.3085 [KW] = 308.82[W]

$W_c = \dot{m} \times (h_2 - h_1)$ ………………………………………………………………………..(4.5)

W_c : Compressor Work [W]

$W_c = 0.00184 \times (423.835 - 394.284)$

W_c = 0.05437[KW] = 54.37 [W]

In horse Power = 142.7/746 = 0.0728 HP

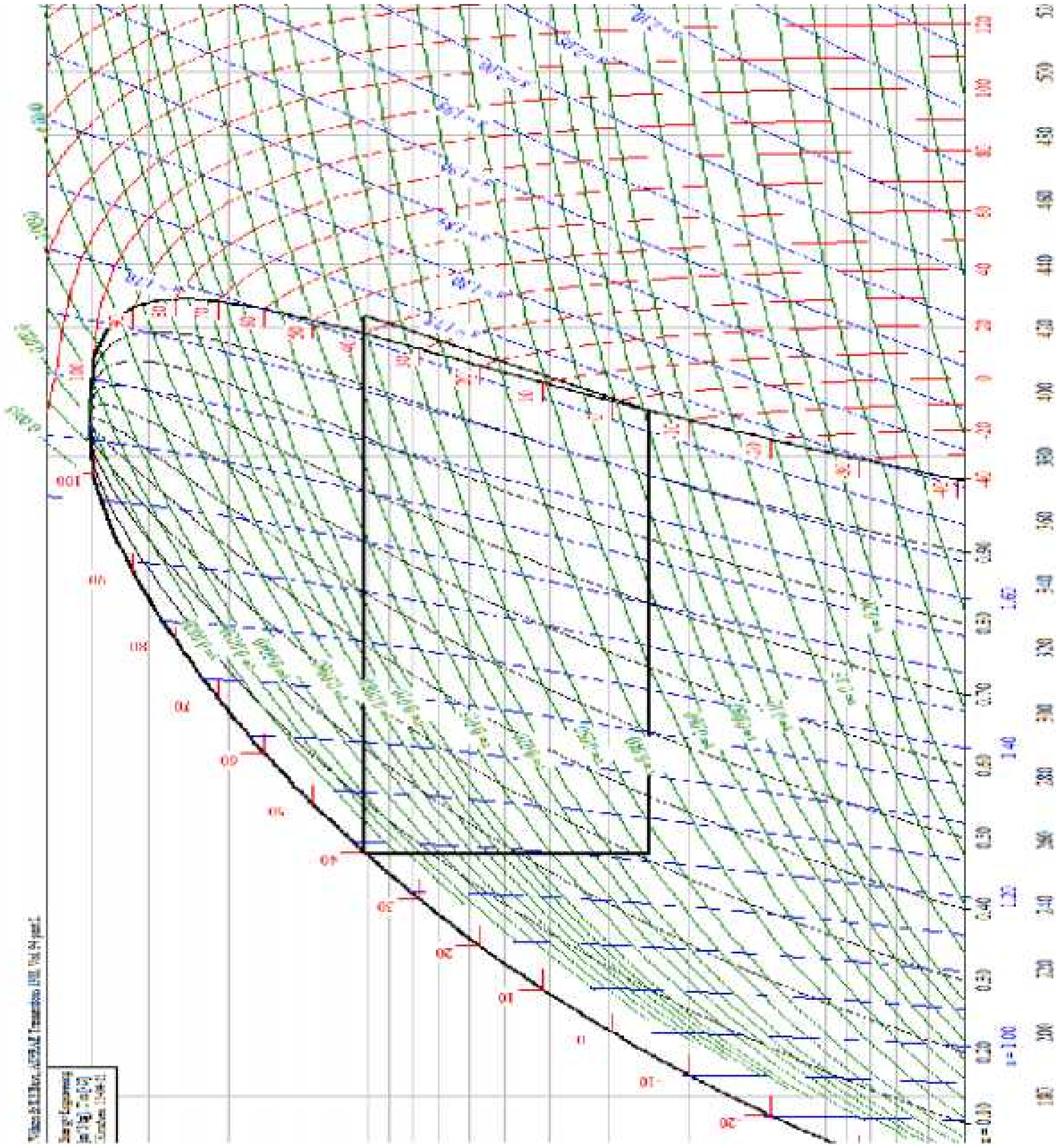

Figure 4.2: P-h chart for R-134a

Values at points 1-6,15 for the selected one stage cycle

Point	T	P	v	h	s
	[°C]	[bar]	[m^3/kg]	[kJ/kg]	[kJ/(kg K)]
1	-5.000	2.434	0.082302	394.284	1.7249
2	44.802	10.164	0.020555	423.835	1.7249
3	44.802	10.164	0.020555	423.835	1.7249
4	40.000	10.164	N/A	256.160	N/A
5	N/A	2.434	N/A	256.160	N/A
6	-5.000	2.434	0.082299	394.284	1.7249
15	N/A	10.164	N/A	256.160	N/A

Figure 4.3:properties of cycle

4.4 Calculation Of Coefficient Of Performance (COP)

W_c = 54.37 [W]

COP = $\frac{Qe}{Wc}$……………………………………………………………….……………………..(4.6)

COP = $\frac{255.39}{54.37}$ = 4.69

4.5 Compressor Calculation And Selection

To determine the volumetric efficiency for the compressor can be used the equation (4.7) .

$\eta_v = \eta_c * \eta_h$……………………..……………………………………………………….. (4.7)

where :

η_v : volumetric efficiency .

η_c : volumetric efficiency due to clearance volume in compressor .

η_h : volumetric efficiency due to heating occurs in compressor .

The volumetric efficiency due the clearance volume in compressor calculated by equation (4.8) , [reference 8]

$\eta_c = 1 - c\,[(\frac{PH}{PL})^{1/n} - 1\,]$ …………………………..………………………………………………. (4.8)

where :

c : clearance volume (ratio between volumetric clearance and volume of cylinder of the compressor , c = 0.04 for low pressure , c = 0.02 for high pressure, [reference 9]

n : exponential coefficient of expansion for refrigerant , n = 1 , [reference 4]

PH : High pressure of the cycle .

PL : Low pressure of the cycle .

$\eta_c = 1 - 0.02\,[(\frac{10.164}{2.434})^{1/1} - 1\,] = 93\%$

The volumetric efficiency due to the heating in compressor is get from equation (4.9), [reference 3]

$\eta_h = \frac{Tevap.}{Tcond.}$…………………………………………………………..……………………......... (4.9)

where :

$T_{evap.}$: evaporator temperature [°K]

$T_{cond.}$: condenser temperature [°K]

$\eta_h = \frac{268}{313} = 85.6\%$

$\eta_v = 93\% * 85.6\% = 79.6\%$

The theoretical volume flow rate (V) of the compressor can be calculated in equation(4.10), [reference 8]

$\dot{V}_{theo} = \dot{m} * v$ …………..…………………………………………………………...……... (4.10)

Where :

$\dot{V}_{theo}$: theoretical volume flow rate of the compressor [m^3/s]

$\dot{m}$: mass flow rate of refrigerant [Kg/s]

v : specific volume at the inlet of compressor [m^3/s].

$\dot{V}_{theo}$ = 0.00184* 0.082302 = 1.514 * 10^{-4} [m^3/s]

To determine the actual volume flow rate , using equation (4.),[reference 3]

$$\dot{V}_{act} = \frac{\dot{V}_{the.}}{\eta v} \quad \text{……………………………………………………..………………………….. (4.11)}$$

Where :

$\dot{V}_{act}$: actual volumetric flow rate [m^3/s]

$$\dot{V}_{act} = \frac{0.0001514}{0.795} = 1.9 * 10^{-4} \ [m^3/s]$$

The main consider to select the compressor is the actual volumetric flow rate , so we will chose a compressor that satisfy it in the next semester .

CHAPTER 5

Drawing

References

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Appendix A

TABLE A-1 Thermal Conductivity Of Materials

TABLE A-2 Maximum And Minimum Temperature For Hebron City

TABLE A-1 Thermal Conductivity Of Materials

Material	Description	Thermal Conductivity (k) W/m K	Thermal Conductance (C) W/m² K
Masonry	Brick, common	0.72	
	Brick, face	1.30	
	Concrete, mortar or plaster	0.72	
	Concrete, sand aggregate	1.73	
	Concrete block		
	Sand aggregate 100 mm		7.95
	Sand aggregate 200 mm		5.11
	Sand aggregate 300 mm		4.43
Woods			
	Maple, oak, similar hardwoods	0.16	
	Fir, pine, similar softwoods	0.12	
	Plywood 13 mm		9.09
	Plywood 1.9mm		6.08
Roofing	Asphalt roll roofing		36.91
	Built-up roofing 9 mm		17.03
Insulating materials	Blanket or batt, mineral or Polythane	0.039	
	Board or slab		
	Cellular glass	0.058	
	Corkboard	0.043	
	Glass fiber	0.036	
	Expanded polystyrene (smooth)	0.029	
	Expanded polystyrene (cut cell)	0.036	
	Expanded polyurethane	0.025	
Loose fill			
	Milled paper or wood pulp	0.039	
	Sawdust or shavings	0.065	
	Mineral wool (rock, glass, slag)	0.039	
	Redwood bark	0.037	
	Wood fiber (soft woods)	0.043	
Glass	Single pane		6.42
	Two pane		2.61
	Three pane		1.65
	Four pane		1.19
Metal	Galvanized steel	15.6	
	Aluminum	202	
	cooper	386	

TABLE A-2 Maximum And Minimum Temperature For Hebron City

Month	Max. Temp. C°	Min. Temp. C°
Jan	10.3	3
Fep	11.5	4.7
Mar	14.6	6.5
Apri	19.6	9.9
May	25.6	13.2
Jun	26	15.8
Jul	28	17
Aug	38	18
Sep	29	15
Oct	28	14
Nov	22	9.9
Dec	12	5.6

Appendix B

Catalogues

embraco

PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE																						
-15		-5		0		+5		CHECK POINT DATA [illegible]						+10		+15		MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
								CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
1074	212	1640	480	1581	381	2340	452	2303	747	367	1.83	6.95	2.04	2775	814	3338	946	LST / RSIR-CSIR	513516000	NRT30AAN-5590	-	189-227
1077	210	1758	507	1808	513	2467	722	2503	767	368	1.82	7.22	2.12	2855	836	3530	752	LST / RSIR-CSIR	513516508	4TM/436/ARY-53	-	64-77
1776	295	1885	553	1734	525	2796	819	4083	987	425	1.48	7.88	2.14	4964	987	4080	1.131	LST / RSIR-CSIR	513516249	NRT17AAN-5590	-	198-240
1340	381	1983	549	2364	589	2052	836	4083	987	417	2.42	7.39	2.17	3405	998	4032	1.185	LST / RSIR-CSIR	513516250	4TM437LHRY-53	-	88-108
1744	562	2093	549	2485	728	2986	877	3083	958	481	3.07	6.76	1.98	3582	1052	4555	1.343	LST / RSIR-CSIR	513516249	NRT30AAN-5590	-	440-532
1344	562	2093	549	2482	728	2986	877	3083	958	481	3.61	6.74	1.98	3582	1052	4555	1.343	LST / RSIR-CSIR	513516025	NRT30AAN-5590	-	130-156
1666	488	2573	754	2128	716	3721	1.098	4003	1.173	584	5.20	6.85	2.01	4073	1.280	5061	1.483	LST / RSIR-CSIR	513516053	NST22AAN-5590		440-532
1666	488	2573	754	2128	716	3721	1.098	4003	1.173	578	3.15	6.92	2.03	4073	1.280	5061	1.483	LST / RSIR-CSIR	513516450	NRT30AAN-5590	-	130-156
2040	598	3077	901	3682	1.123	4627	1.354	5033	1.468	582	5.45	7.28	2.13	5437	1.593	6003	1.849	LST / RSIR-CSIR	513516163	NRT30AAN-5590	-	440-532
1881	551	3077	901	3842	1.123	4627	1.354	5033	1.468	553	3.48	7.77	2.08	5437	1.593	6003	1.849	HST / CSIR	513516403	NST26AAN-5590	-	124-149
2040	598	3077	901	3682	1.123	4627	1.354	5033	1.468	577	5.80	8.67	2.54	5437	1.593	6003	1.849	HST / CSIR	513516021	NRT16AAN-5590	-	200-380

PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE														MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
-35		-25		CHECK POINT DATA -23.3						-15		-5						
				CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
513	150	830	232	947	278	202	2.54	4.69	1.37	1078	375	1821	546	HST / CSIR	513503292	NSP94AJC-5590	-	189-227
708	207	1057	308	1267	371	257	3.47	4.39	1.29	1380	398	2021	677	HST / CSIR	513516445	4TM250PRAY-53	-	145-175
1080	293	1509	471	1675	491	318	4.47	5.25	1.54	2425	710	2588	1085	HST / CSIR	513516051	NSG76AJC-5590	-	378-456

PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE														MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
-35		-25		CHECK POINT DATA -23.3						-15		-5						
				CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
57	17	144	42	172	50	39	0.59	2.92	0.86	325	48	440	129	LST / RSIR-CSIR	513514402	4TM118NFRY-53	-	78-94
98	28	314	64	245	72	63	0.56	3.85	1.13	405	119	-	-	LST / RSIR-CSIR	513514807	4TM109NFRY-53	-	72-88
98	28	314	67	245	72	64	0.56	3.88	1.13	438	126	-	-	LST / RSIR-CSIR	513514807	4TM109NFRY-53	-	72-88
108	32	245	72	268	76	76	0.68	3.03	0.88	435	128	797	236	LST / RSIR-CSIR	513514809	4TM109NFRY-53	-	30-50
108	32	243	73	275	81	65	0.55	4.28	1.28	445	130	-	-	LST / RSIR-CSIR	513514814	4TM116NFRY-53	-	-
116	34	281	82	303	89	83	0.70	3.73	1.08	515	150			LST / RSIR-CSIR	513514144	4TM116NFRY-53		55-64
142	42	306	91	330	97	96	0.81	3.46	1.00	544	160			LST / RSIR-CSIR	513514138	4TM118NFRY-53	-	38-46
148	43	320	95	348	100	82	0.72	4.24	1.20	551	160	-	-	LST / RSIR-CSIR	513514814	4TM116NFRY-53	-	50-60
145	43	294	86	348	102	99	0.81	3.50	1.00	538	155	875	256	LST / RSIR-CSIR	513514138	4TM118NFRY-53	-	38-46
155	48	314	93	352	105	84	1.20	4.17	1.20	583	170	-	-	LST / RSIR	7M4R2MK	4TM107NFRY-53	-	-
171	50	339	99	365	107	83	0.74	4.40	1.29	544	160	-	-	LST / RSIR-CSIR	513514814	4TM116NFRY-53	-	50-60
188	54	335	96	372	109	79	0.82	5.29	1.55	595	175	-	[illegible]	LST / RSIR [illegible]	[illegible] 220V	[illegible]	3	-
156	46	348	100	373	109	78	0.84	4.78	1.40	597	166	-	[illegible]	[illegible]	[illegible]	[illegible]	5	-
175	51	355	103	438	122	115	1.00	3.65	1.07	645	190	-	[illegible]	[illegible]	[illegible]	[illegible] NFRY-53	-	50-60
199	58	380	111	438	123	100	0.71	4.33	1.28	673	197			LST / RSIR-CSIR	513514814	4TM118NFRY-53		106-130
152	45	365	108	431	123	106	0.82	4.02	1.18	665	195			LST / RSIR-PSCR	8EA5003	4TM109NFRY-53	3	-

R-134a - L/MBP - 50Hz

MODEL	VOLTAGE / FREQUENCY	APPLICATION	DISPLACEMENT cm³	OPERATING VOLTAGE RANGE V	COOLING TYPE*	OIL VISCOSITY	CHECKPOINT DATA (CECOMAF CALCULATED) CAPACITY W	COP W/W
EMI 60HER	220V 50-60Hz	LBP	4.39	187 - 245	S	ISO22	107	0.90
EM 60HNR	220-240V 50Hz	LBP	5.54	198 - 255	S	ISO22	105	0.95
EMU 50HSR	100V 50-60Hz	LBP	4.77	85 - 132	S	ISO10	105	0.99
EMT 50HLC	220-240V 50Hz	LBP	4.77	198 - 255	S	ISO10	116	1.29
EM 65HNR	220V 50Hz	LBP	5.54	187 - 245	S	ISO22	117	0.92
EGAS 70HLR	220-240V 50-60Hz	LBP	5.56	198 - 255	S	ISO10	121	1.16
EGZS 70HLC	220-240V 50-60Hz	LBP	5.56	198 - 255	S	507	121	1.30
FG 65HAK	220-240V 50Hz	LBP	6.76	198 - 255	S/F	ISO22	121	0.92
EMI 70HER	220V 50Hz	LBP	5.59	187 - 245	S/F	ISO22	125	0.95
FF 6HAK	220V 50-60Hz	LBP	6.23	187 - 255	S	ISO10	124	1.00
FF 6HAK	220V 50-60Hz	L/MBP	6.23	187 - 245	S	ISO22	126	0.91
FGS 70HAK	220-240V 50-60Hz	LBP	6.36	198 - 255	S	ISO10	130	1.19
FFU 70HAK	220-240V 50-60Hz	L/MBP	6.36	187 - 255	S/F	ISO10	137	1.13
EMT 55HLC	220-240V 50Hz	LBP	4.94	187 - 255	S	ISO10	137	1.26
FF 7.5HAK	220-240V 50-60Hz	L/MBP	6.76	187 - 255	S	ISO22	141	1.00
FFV 7.5HAK	220-240V 50-60Hz	L/MBP	6.76	187 - 255	S	ISO10	141	1.11
EG 70HLR	220-240V 50Hz	LBP	6.76	170 - 255	S	ISO22	142	1.10
FG 75HAK	220-240V 50Hz	LBP	7.95	198 - 255	S/F	ISO22	143	0.90
FF 8.5HBK	220-240V 50Hz	L/MBP	7.72	187 - 255	S/F	ISO22	[illegible]	1.27
EGAS 80HLR	220-240V 50-60Hz	LBP	6.56	198 - 255	S	ISO10	144	1.20
EGZS 80HLC	220-240V 50-60Hz	LBP	6.56	198 - 255	S	ISO10	144	1.30
FFI 80HAK	220-240V 50-60Hz	LBP	6.76	187 - 255	S	ISO10	147	1.22
FFU 80HAK	220-240V 50-60Hz	L/MBP	6.76	187 - 255	S/F	ISO10	147	1.11
FGS 80HAK	220-240V 50-60Hz	LBP	7.11	198 - 255	S	ISO10	151	1.22
EG 80HLR	220-240V 50Hz	LBP	7.15	170 - 255	S	ISO22	152	1.09
FFI 8.5HAK	220-240V 50-60Hz	L/MBP	7.15	187 - 255	S/F	ISO10	152	1.07
FFV 8.5HAK	220-240V 50-60Hz	L/MBP	7.15	187 - 255	S	ISO10	152	1.09
EGYS 90HLP	220-240V 50Hz	LBP	7.15	198 - 255	S	ISO10	167	1.32
EGZS 90HLC	220-240V 50-60Hz	LBP	7.15	198 - 255	S	ISO10	167	1.38
FG 85HAK	220-240V 50Hz	LBP	9.04	198 - 255	S/F	ISO22	168	0.95
FGS 90HAK	220-240V 50-60Hz	LBP	7.76	198 - 255	S	ISO10	173	1.22
FFU 100HAK	220-240V 50-60Hz	L/MBP	7.76	198 - 255	S	ISO10	177	1.06
FGS 100HAK	220-240V 50-60Hz	LBP	9.04	198 - 255	S	ISO22	184	1.11
FFI 10HAK	220-240V 50-60Hz	L/MBP	9.04	187 - 254	S	ISO22	184	1.00
EGAS 100HLR	220-240V 50-60Hz	LBP	7.76	198 - 255	S	ISO10	186	1.20
EGYS 100HLP	220-240V 50Hz	LBP	7.75	198 - 255	S	ISO10	186	1.32
EGZS 100HLC	220-240V 50-60Hz	LBP	7.75	198 - 255	S	ISO10	186	1.37
EG 100HLC	220-240V 50Hz	LBP	9.04	170 - 255	S	ISO22	[illegible]	1.11
FG 95HAK	220-240V 50Hz	LBP	10.61	198 - 255	S/F	ISO22	[illegible]	0.95
FFU 130HAK	220-240V 50Hz	L/MBP	10.61	187 - 255	F	ISO10	229	1.09
FGS 130HAK	220-240V 50Hz	LBP	11.14	198 - 255	S	ISO22	235	1.15
FFI 12HBX	220-240V 50Hz	L/MBP	11.14	198 - 255	F	ISO22	274	2.05

Note: Condensing Temperature 54.4°C (129.9°F)

*Static Cooling (S) / Fan Cooling (F)

R-134a - M/HBP - 50Hz

MODEL	VOLTAGE / FREQUENCY	APPLICATION	DISPLACEMENT cm^3	OPERATING VOLTAGE RANGE V	COOLING TYPE*	OIL VISCOSITY	CHECK POINT DATA CECOMAF (CALCULATED) CAPACITY W	COP W/W
SA30HBR	220-240V 50-60Hz	L/M HBP	3.27	187 - 255	S,F	ISO22	331	1.00
SA30HBR	220-240V 50-60Hz	L/M HBP	3.80	187 - 255	S,F	ISO22	301	1.18
SA45HBR	220-240V 50Hz	L/M HBP	3.77	198 - 255	S,F	ISO22	75	0.83
EMT 45HCR	220-240V 50Hz	L/M HBP	3.97	187 - 255	F	ISO10	354	1.34
SA55HBR	220-240V 50-60Hz	HBP	4.60	198 - 255	F	ISO22	394	1.13
SA65HBR	220-240V 50Hz	HBP	5.54	198 - 255	F	ISO22	475	1.16
SA65HBR	220V 50-60Hz	M/HBP	5.54	187 - 242	F	ISO22	477	1.09
FF 8.5HBK	220-240V 50Hz	L/M HBP	7.95	187 - 255	S,F	ISO22	685	1.37
FFI 12HBX	220-240V 50Hz	M/HBP	11.14	198 - 255	F	ISO22	909	1.63
FFI 12HBX	220-240V 50Hz	L/M HBP	11.14	198 - 255	F	ISO22	926	1.56

Notes: Condensing Temperature 54.4ºC (130.0ºF)

*Static Cooling (S) / Fan Cooling (F)

R-600a - L/MBP - 50Hz

MODEL	VOLTAGE / FREQUENCY	APPLICATION	DISPLACEMENT cm^3	OPERATING VOLTAGE RANGE V	COOLING TYPE*	OIL VISCOSITY	CHECK POINT DATA CECOMAF (CALCULATED) CAPACITY W	COP W/W
EMT 17CLP	220-240V 50Hz	LBP	2.40	187 - 255	S	ISO7	38	0.97
EMX 20CLC	220-240V 50Hz	LBP	2.97	198 - 254	S	ISO5	46	1.24
EMY 20CLC	220-240V 50Hz	LBP	2.97	198 - 254	S	ISO5	46	1.35
EMZ 20CLC	220-240V 50Hz	LBP	2.97	187 - 255	S	ISO5	38	1.30
EMT 25CLP	220-240V 50Hz	LBP	4.50	187 - 255	S	ISO7	38	1.08
EMT 25CLP	115V 60Hz	LBP	4.50	85 - 118	S	ISO7	58	1.05
EMY 26CLC	220-240V 50Hz	LBP	5.19	198 - 254	S	ISO5	62	1.32
EMZ 26CLC	220-240V 50Hz	LBP	5.19	198 - 254	S	ISO5	62	1.38
EMX 26CLC	220-240V 50Hz	LBP	5.19	187 - 255	S	ISO5	63	1.24
EMT 26CLP	220-240V 50Hz	L/MBP	5.19	187 - 255	S	ISO7	64	0.98
EMU 26CLC	220-240V 50Hz	L/MBP	5.19	198 - 254	S	ISO7	64	1.17
EMT 30CLP	220-240V 50Hz	L/MBP	5.96	198 - 254	S	ISO7	73	1.00
EMU 30CLC	220-240V 50Hz	L/MBP	5.96	198 - 254	S	ISO7	73	1.08
EMY 30CLC	220-240V 50Hz	LBP	5.96	198 - 254	S	ISO5	73	1.35
EMZ 30CLC	220-240V 50Hz	LBP	5.96	198 - 254	S	ISO5	73	1.29
EMX 30CLC	220-240V 50Hz	LBP	5.96	187 - 255	S	ISO5	74	1.26
EMU 45CLP	115V 60Hz	LBP	5.96	85 - 118	S	ISO10	76	1.17
EMY 40CLC	220-240V 50Hz	LBP	7.50	198 - 254	S	ISO5	89	1.35
EMZ 40CLC	220-240V 50Hz	LBP	7.50	198 - 254	S	ISO5	89	1.30
EMT 40CLP	220-240V 50Hz	L/MBP	7.50	198 - 254	S	ISO7	89	1.03
EMU 40CLC	220-240V 50Hz	L/MBP	7.50	198 - 254	S	ISO7	91	1.10
EMY 46CLP	220-240V 50Hz	L/MBP	7.96	198 - 254	S	ISO7	101	1.15
EMT 46CLP	220-240V 50Hz	L/MBP	7.96	198 - 254	S	ISO7	102	1.05
EMU 46CLC	220-240V 50Hz	L/MBP	7.96	198 - 254	S	ISO7	102	1.10
EMZ 46CLC	220-240V 50Hz	LBP	[illegible]	[illegible]	S	[illegible]	106	1.34
EMY 46CLC	220-240V 50Hz	LBP	[illegible]	[illegible]	S	[illegible]	106	1.37
EMT 56CLP	220-240V 50Hz	LBP	[illegible]	[illegible]	[illegible]	[illegible]	116	1.06
EMY 56CLC	220-240V 50Hz	LBP	[illegible]	[illegible]	[illegible]	ISO5	137	1.31

Notes: Condensing Temperature 54.4ºC (130.0ºF)

*Static Cooling (S) / Fan Cooling (F)

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PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE														MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
-35		-25		CHECK POINT DATA - 23.3						-15		-5						
				CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
262	77	487	143	536	157	91	0.42	5.90	1.73	818	240	-	-	LST / RSCR	TSD-220V	[illegible]	5	-
311	91	553	165	646	189	106	0.49	5.91	1.73	947	277	-	-	LST / RSCR	TSD-220V	[illegible]	5	-
359	105	592	174	653	191	111	0.55	5.87	1.73	966	283	-	-	LST / RSCR	TSD-220V	4TM275RDEYY-53	5	-
365	107	624	183	679	199	107	0.49	6.33	1.86	1003	294	-	-	LST / RSCR	TSD-220V	4TM181NFDYY-53	5	-
386	113	639	187	696	204	118	0.57	5.87	1.73	1027	302	-	-	LST / RSCR	TSD-220V	[illegible]	5	-
397	116	679	199	731	214	115	0.53	6.41	1.88	1085	318			LST / RSCR	TSD-220V	4TM181NFDYY-53	4	
436	128	736	217	788	231	136	0.57	5.81	1.73	1098	322	-	-	LST / RSCR	[illegible]	[illegible]	5	-

PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE														MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
-35		-25		CHECK POINT DATA - 23.3						-15		-5						
				CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
132	39	219	64	235	73	48	0.33	[illegible]	[illegible]	415	115			LST / RSIR-RSCR	8EA583	[illegible]	4	
216	64	417	122	464	135	108	0.84	4.29	1.25	728	213	-	-	LST / RSIR-CSIR	21351859	[illegible]	-	88-108
247	71	415	125	478	138	126	0.73	3.77	1.09	709	208	-	-	LST / RSIR-RSCR	8EA583	4TM181NEHYY-53	-	-
258	79	474	146	545	160	140	0.82	3.91	1.14	816	237	-	-	LST / RSIR-RSCR	8EA583	4TM181NEHYY-53	6	-
337	99	630	177	627	184	158	0.67	3.97	1.16	754	280	1437	421	LST / RSIR-CSIR	21351616	[illegible]	-	88-108
379	109	647	189	700	205	146	1.14	4.80	1.41	1005	304	1573	461	LST / RSIR-CSIR	21351655	[illegible]	-	64-77
415	122	659	193	715	210	185	1.16	3.84	1.13	1058	310	1625	476	LST / RSIR-CSIR	21351619	[illegible]	-	88-108
421	123	693	203	758	220	158	1.24	4.79	1.39	1105	324	1720	504	LST / RSIR-CSIR	21351486	[illegible]	-	88-108
454	133	731	215	795	233	263	1.40	3.02	[illegible]	1165	342	1771	519	LST / RSIR-CSIR	21351678	MSP57AMK-2590	-	58-64
810	237	1360	373	1120	337	275	2.10	[illegible]	1.22	1703	499	2647	775	LST / RSIR-CSIR	21351485	MBP40APN-2590	-	88-108

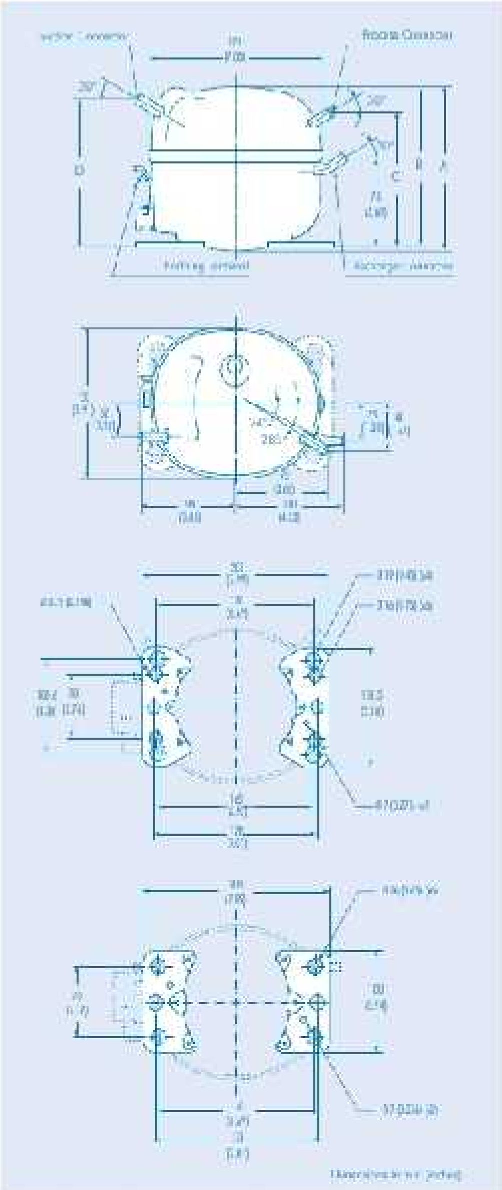
PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE																		MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
[illegible]		[illegible]		[illegible]		[illegible]		CHECK POINT DATA + 7.2						[illegible]		[illegible]						
								CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
956	280	1437	421	1738	509	2206	[illegible]	2135	626	298	1.50	[illegible]	2.14	2465	722	2942	862	LST / RSIR-CSIR	[illegible]	[illegible]	-	88-108
1058	310	1625	476	1977	579	2575	754	2567	752	352	1.94	7.29	2.14	2822	827	3310	970	LST / RSIR-CSIR	[illegible]	[illegible]		108-130
1166	342	1772	519	2151	630	2587	758	2800	820	381	2.10	7.35	2.15	3065	898	3649	1069	LST / RSIR-CSIR	21351678	MSP57AMK-2590		58-64
1700	498	2647	776	[illegible]	949	[illegible]	1128	[illegible]	[illegible]	558	[illegible]	[illegible]	[illegible]	4583	1320	5252	1539	LST / RSIR-CSIR	[illegible]	MBP40APN-2590	-	88-108

PERFORMANCE / EVAPORATING TEMPERATURE °C - ASHRAE														MOTOR TYPE	STARTING RELAY SUBASSEMBLY CODE	OVERLOAD PROTECTOR	RUN CAPACITOR	STARTING CAPACITOR
-35		-25		CHECK POINT DATA - 23.3						-15		[illegible]						
				CAPACITY		POWER CONSUMPTION	CURRENT CONSUMPTION	EFFICIENCY										
Btu/h	W	Btu/h	W	Btu/h	W	W	A	Btu/Wh	W/W	Btu/h	W	Btu/h	W				µF	µF
621	182	981	288	1090	320	216	1.65	5.10	1.49	1587	466	2422	709	[illegible]	21351843	[illegible]	-	[illegible]
776	228	1285	377	1368	399	271	2.26	4.99	1.47	1941	569	2847	[illegible]	HST / CSIR	[illegible]	[illegible]	-	88-108

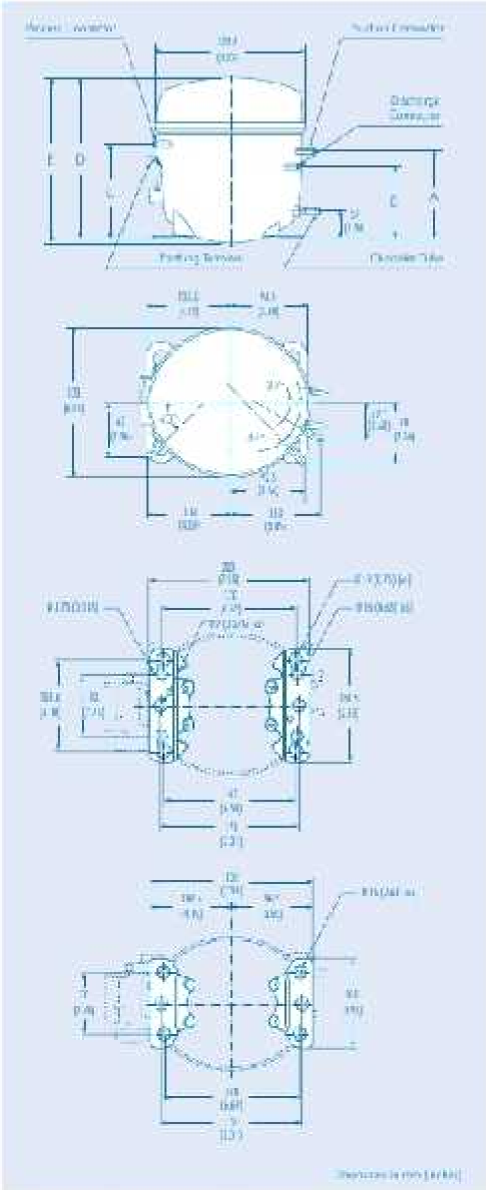
R-600a - R-134a - Blends - R-290

10) - COMPRESSOR HOUSING

EM



EG / F

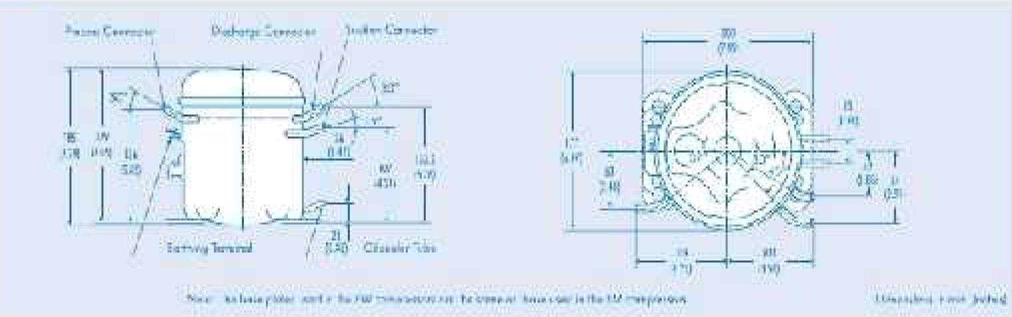


COMPRESSORS	A	B	C	D
EM (tall)	168 (6.61)	166 (6.54)	150 (5.91)	155 (6.10)
EM (short)	157 (6.18)	155 (6.10)	139 (5.47)	144 (5.67)

COMPRESSORS	A	B	C	D	E
EG / [illegible]	109 [illegible]	90 (2.54)	138 [illegible]	201 (7.91)	207 (8.15)
E[illegible]	[illegible]	[illegible]68	[illegible]	195 (7.68)	20[illegible] (7.[illegible]1)

Compressors may be supplied with either of the above plates. Please make sure you indicate which base should be supplied.

PW



CONNECTORS INTERNAL DIAMETERS - mm (inches)														
COMPRESSORS / CONNECTORS	EM								PW					
MATERIAL	COOPER					COOPER PLATED STEEL			COOPER			COOPER PLATED STEEL		
SUCTION	6.50 (0.256)	6.50 (0.256)	8.20 (0.323)	8.20 (0.323)	6.50 (0.256)	6.10 (0.240)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	8.20 (0.323)	8.20 (0.323)	6.50 (0.256)	8.20 (0.323)	6.10 (0.240)
DISCHARGE	4.94 (0.194)	6.50 (0.256)	4.94 (0.194)	6.50 (0.256)	5.10 (0.201)	5.00 (0.197)	5.00 (0.197)	6.50 (0.256)	4.94 (0.194)	6.50 (0.256)	6.50 (0.256)	5.00 (0.197)	6.50 (0.256)	5.00 (0.197)
PROCESS	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.10 (0.240)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	8.20 (0.323)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.10 (0.240)
OIL COOLER TUBE	-	-	-	-	-	-	-	-	-	-	-	4.77 (0.188)	-	-

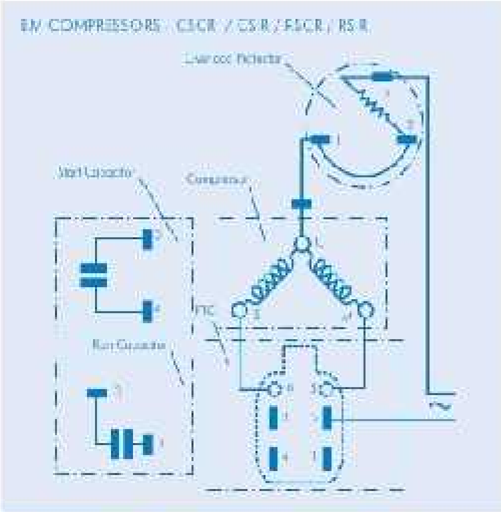
CONNECTORS INTERNAL DIAMETERS - mm (inches)																
COMPRESSORS / CONNECTORS	F / FG															
MATERIAL	COOPER							COOPER PLATED STEEL								
SUCTION	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	8.20 (0.323)	8.20 (0.323)	6.10 (0.240)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	8.20 (0.323)	8.20 (0.323)	6.50 (0.256)	6.50 (0.256)
DISCHARGE	4.94 (0.194)	4.94 (0.194)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	4.94 (0.194)	5.00 (0.197)	5.00 (0.197)	5.00 (0.197)	5.00 (0.197)	6.50 (0.256)	6.50 (0.256)	5.00 (0.197)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)
PROCESS	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.10 (0.240)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)	6.50 (0.256)
OIL COOLER TUBE	4.90 (0.193)	5.10 (0.201)	4.90 (0.193)	6.50 (0.256)	6.50 (0.256)	-	-	4.90 (0.193)	5.10 (0.201)	6.50 (0.256)	6.50 (0.256)	5.10 (0.201)	5.10 (0.201)	6.50 (0.256)	4.77 (0.188)	4.90 (0.193)

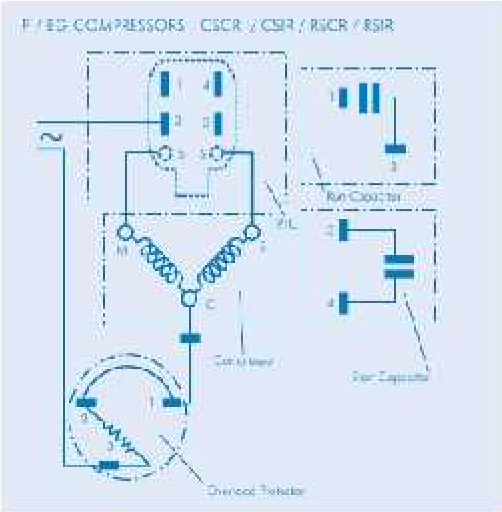
For other connectors configurations, please contact our sales division.

TOLERANCE								
MATERIAL	COOPER				COOPER PLATED STEEL			
CONNECTORS	4.94 +0.08 -0.08 (0.194 [illegible])	5.10 +0.10 -0.10 (0.201 +0.004 0.000)	6.50 +0.12 -0.08 (0.256 [illegible])	8.20 +0.12 0.08 (0.323 [illegible])	5.00 +0.18 +0.06 (0.197 +0.007 +0.002)	6.10 +0.10 0.00 (0.240 +0.004 0.000)	6.50 +0.12 0.08 (0.256 [illegible])	8.20 +0.12 -0.08 (0.323 [illegible])
OIL COOLER TUBE	4.77 +0.17 -0.17 (0.188 [illegible] 0.007)	4.90 +0.02 -0.05 (0.193 [illegible] 0.002)	5.10 +0.10 -0.10 (0.201 [illegible] 0.003)	6.50 +0.09 0.09 (0.256 +0.004 0.004)				

R-600a - R-134a - Blends - R-290

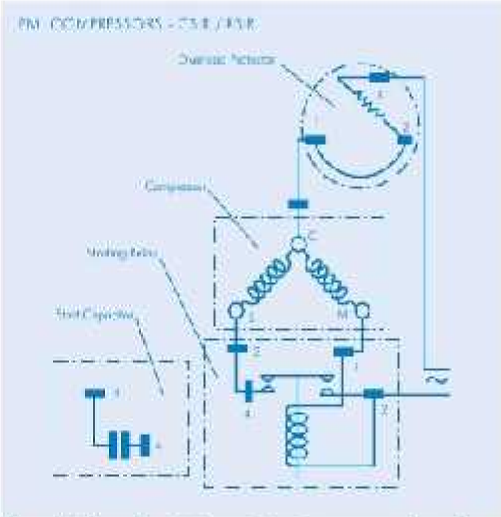
11) - ELECTRICAL DIAGRAMS



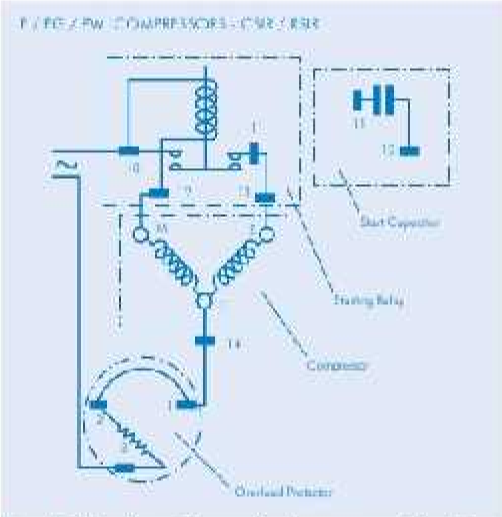


Compressors with a run capacitor must use PTC with 3 terminals.

Compressors without run capacitor use PTC with 1 terminal.

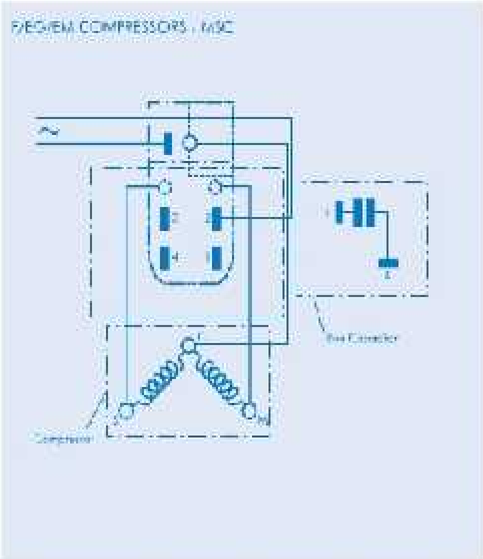


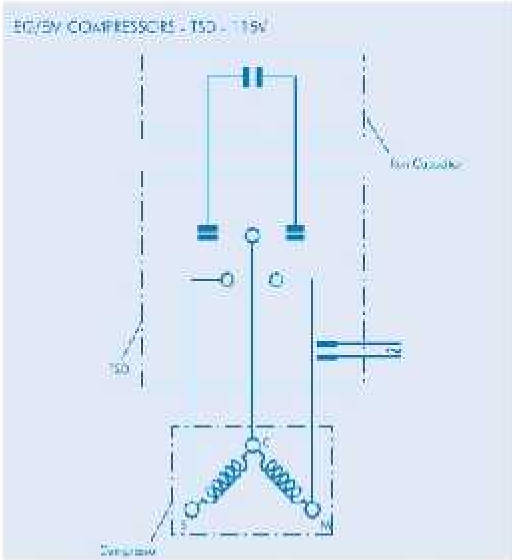
If application of a start capacitor is necessary, then it must be connected between terminals 3 and 4. To achieve this, just rupture this bridge.

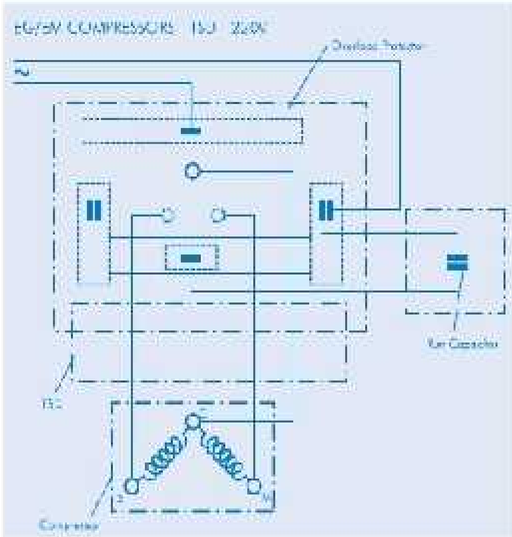


If application of a start capacitor is necessary, then it must be connected between terminals 11 and 13. This requires a specific relay, with fast on terminals for better start capacitor installation, which can be supplied upon request.

11) - ELECTRICAL DIAGRAMS







Notice: In order to increase the safety of our product, Embraco proposes the connection of the overload protector to the phase wire (Power Supply). The neutral wire must be connected to the starting relay.

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13) - EM COMPRESSOR DENOMINATION

EM X S 60 H E R

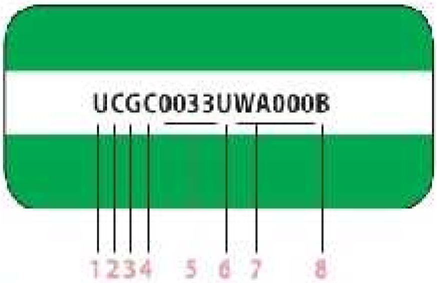
- **EM** – Basic type
  - Embraco mini compressor
- **X** – Product Generation
  - □ - Standard Generation
  - I - 1st Generation
  - T - 2nd Generation
  - U - 3rd Generation
  - Y - 4th Generation
  - Z - 5th Generation
  - X - 6th Generation
- **S** – Mechanical Kit (Embraco Internal Use)
  - S - Standard Mechanical Kit
- **60** – Compressor capacity in Btu/h - 60Hz - Check point divided by 10
- **H** – Refrigerant
  - H - R-134a
  - C - R-600a
  - U - R-290
  - E - Blends
- **E** – Efficiency level
  - N - Standard efficiency (LBP)
  - J - Intermediate efficiency (LBP)
  - E - Improved efficiency 1st generation (LBP)
  - S - Improved efficiency 2nd generation (LBP)
  - H - Standard efficiency (L/M/HBP)
  - D - Standard efficiency (HBP)
  - B - Standard efficiency (M/HBP)
- **R** – Electrical Equipment
  - LST:
    - P - PTC – Run Capacitor (optional)
    - R - Relay
    - C - PTC – Run Capacitor (mandatory)
    - S - PTC – Run Capacitor + Start Capacitor
    - V - PTC – Run Capacitor + Start Capacitor (optional)
  - HST:
    - X - Relay – Start Capacitor (mandatory)

Introduction and Overview

Optyma™ is the widest range of hermetic condensing units on the market.
Optyma™ condensing unit is available with high capacity models of reciprocating and scroll compressors so to cover a large range of commercial refrigeration applications, reducing costs and complexity of the systems.
All Optyma™ condensing units are extremely efficient and reliable. That means less energy consumption and less running costs, less cost for service and maintenance.

Nomenclature / Model No.

1 Application
2 Design
3 Refrigerant
4 Condenser size
5 hp rating
6 Certification
7 Version
8 Electrical code



1

Low	L
Medium/High	H
Universal Low/Med/High	U

2

C: Air cooled condenser, single fan, hermetic compressor
G: Air cooled condenser, dual fan, hermetic compressor

3

R-12 replacement	B
R-134a	G
R-404A/R-507	H
R-22	M
R-404A/R-134a/R-507/R-407C	Z

4

Condenser size - sized for 110°F ambient

5

hp rating in hundredths of hp
i.e. 0033 = 1/3 hp
1000 = 10 hp

6

R: UL Recognized
U: UL Listed

7

W	=	Wholesale model
A	=	Power cord
B	=	Power cord, receiver
C	=	Electrical box, power cord, receiver
D	=	Electrical box, receiver, low pressure control, cartridge fan cycling
E	=	Electrical box, receiver, dual pressure control, cartridge fan cycling control, larger then 3 hp dual fan units use KPU fan cycling control
F	=	WE + filter drier, sight glass, solenoid valve with coil
Fan Motor Version		
000	=	Standard unit
300	=	Complies with California standards

8

B: Compressor & fan(s) 115V, 1 ph, 60 Hz
N: Compressor & fan(s) 230V, 1 ph, 60 Hz
Q: Compressor 208-230V, 3 ph, 60 Hz; Fan(s) 230V, 1 ph, 60 Hz
R: Compressor 460V 3 ph, 60 Hz; Fan(s) 460V, 1 ph, 60 Hz
K: Compressor 575V 3 ph, 60 Hz; Fan(s) 575V, 1 ph, 60 Hz

Rating Conditions (ARI)		
Application	LBP	MBP/HBP
Ambient Temp	90°F	90°F
Return Gas	40°F	65°F
SubCooling	5°F	5°F

Product Selection

*Ambient temperature = 90°F
Return gas = 65°F
Subcooling = 5°F

R-134a MBP			Ambient temperature (°F)	Capacity Btu/h ASHRAE* at evaporating temperature (°F)									
Competitor Model Nos.	Danfoss Model No.	Code No.		0	5	10	15	20	25	30	35	40	45
AEA3425 M2FH0020 M2FH0024	UCGC0020RWA000B	**114N2017**	90	1052	1196	1339	1505	1671	1853	2046	2260	2472	2696
			95	1033	1148	1287	1447	1607	1793	1972	2176	2383	2601
			100	966	1100	1234	1388	1543	1719	1855	2092	2289	2502
			110	880	1004	1128	1271	1415	1577	1740	1923	2105	2304
AEA4430 M2FH0026	UCGC0025RWD000B	**114N2019**	90	1193	1351	1514	1669	1884	2095	2306	2541	2775	3025
			95	1151	1306	1451	1629	1818	2022	2225	2452	2680	2924
			100	1109	1258	1407	1580	1752	1945	2144	2364	2583	2815
			110	1024	1162	1301	1461	1620	1802	1983	2186	2389	
AEA4440 AEA4448 M2FHA033	HCGC0033UWC000B	**114N2022**	90		1709	1927	2179	2431	2717	3004	3324	3644	3988
			95		1648	1858	2101	2345	2622	2908	3208	3517	3846
			100		1586	1789	2024	2259	2525	2753	3091	3390	3706
			110		1462	1651	1869	2087	2335	2582	2859	3136	3432
AKA4460 AKA7437 M2FH0049	UCGC0050UWC000B	**114N2024**	90	2339	2662	3026	3420	3815	4254	4713	5210	5713	6246
			95	2245	2579	2913	3255	3678	4139	4541	5020	5499	6011
			100	2150	2476	2801	3171	3540	3954	4366	4827	5285	5774
			110	1961	2250	2578	2852	3265	3645	4034	4441	4857	5296
AJA4482 AJA7455 FTAH-A074 FTAH-A075 FTAH-B074 FTAMA074 FTAMA075	HCGC0075UWC000B HCGC0075UWC000N	**114N2027 114N2028**	90		4596	5079	5774	6470	7325	8180	9129	10077	11032
			95		4276	4771	5453	6135	6952	7765	8660	9551	10458
			100		3956	4463	5131	5800	6578	7357	8190	9024	9853
			110				4562	5234	5986	6640	7383	8119	
AJA4512 FTAH-A100 FTAH-A101	HCGC0100UWD000N	**114N2029**	90		6529	7090	7794	8491	9273	10055	10385	11715	12555
			95		6003	6556	7242	7918	8673	9421	10211	11001	11792
			100			6094	5690	7346	8067	8788	5538	10288	11038
			110				5566	6202	6861	7520			

BC SERIES BULLET® RESTRICTO CAPTUBING

Fits **ANY** domestic and commercial refrigerator or room air conditioner from 1/8 H.P. to 5 H.P.

FEATURES

- Precision Bore, Plus or Minus .001
- The Bullet Restricto Cap is consolidated into a five-pak replacement kit. It's guaranteed to provide you with uniformity on all applications.
- The five "Restricto Cap" sizes cover hundreds of applications (see chart below).

Our Soft Copper Capillary Tubing is precision plug drawn with the internal diameter held to a tolerance of +/- .001. It has been thoroughly dehydrated, sealed and individually packaged.

PART NO.	SIZE	LENGTH
BC1	.061 O.D. x .031 I.D.	10 FT. COIL
BC2	.093 O.D. x .040 I.D.	12 FT. COIL
BC3	.093 O.D. x .052 I.D.	12 FT. COIL
BC4	.125 O.D. x .064 I.D.	12 FT. COIL
BC5	.071 O.D. x .028 I.D.	10 FT. COIL
BC1-100 (NEW!)	.081 O.D. x .031 I.D.	100 FT. COIL
BC2-100 (NEW!)	.093 O.D. x .040 I.D.	100 FT. COIL
BC3-100 (NEW!)	.093 O.D. x .052 I.D.	100 FT. COIL
BC4-100 (NEW!)	.125 O.D. x .064 I.D.	100 FT. COIL
BC5-100 (NEW!)	.071 O.D. x .028 I.D.	100 FT. COIL
5 PAK	Five pack replacement kit.	

REFERENCE CHART FOR BULLET® "RESTRICTO" CAPILLARY TUBING FOR ALL REFRIGERANTS IN LOW, MEDIUM AND HIGH APPLICATIONS

NOTE: This chart is average measurements for average conditions, and may have to be "fine tuned" for exact replacement. These charts are for Fan Cooled units only. Add 10% to the length of the cap tubing for Static Cooled Units.

SINGLE FEED

REF	HP	LOW	MED	HIGH
R12/R416A	1/8 HP	110" # 5	84" # 5	48" # 5
	1/6 HP	71" # 3	96" # 1	72" # 1
	1/5 HP	54" # 1	36" # 1	24" # 1
	1/4 HP	43" # 1	90" # 2	60" # 2
	1/3 HP	33" # 2	72" # 2	36" # 2
	1/2 HP	36" # 3	48" # 3	90" # 4
	3/4 HP	30" # 3	92" # 4	72" # 4
	1 HP	33" # 3	84" # 4	54" # 4
	1-1/2 HP	34" # 4	60" # 4	43" # 4
	2 HP	35" # 4	40" # 4	26" # 4
R134A / R401A R401B/R406A R409A/R500	1/8 HP	121" # 5	92" #5	53" # 5
	1/6 HP	79" # 3	103" # 1	79" # 1
	1/5 HP	53" # 1	39" #1	26" # 1
	1/4 HP	47" # 1	99" #2	66" # 2
	1/3 HP	132" # 2	79" #2	39" # 2
	1/2 HP	105" # 3	52" # 3	99" # 4
	3/4 HP	33" # 3	101" #4	79" # 4
	1 HP	39" # 3	92" #1	59" # 4
	1-1/2 HP	32" # 4	66" #4	47" # 4
	2 HP	31" # 4	44" #4	29" # 4
R22	1/8 HP	132" # 5	101" # 5	58" # 5
	1/6 HP	33" # 5	115" # 1	86" # 1
	1/5 HP	34" # 1	42" # 1	28" # 1
	1/4 HP	31" # 1	109" # 2	72" # 2
	1/3 HP	112" # 2	87" # 2	43" # 2
	1/2 HP	115" # 3	57" # 3	109" # 4
	3/4 HP	72" # 3	111" # 4	87" # 4
	1 HP	42" # 3	101" # 4	65" # 4
	1-1/2 HP	101" # 4	72" # 4	51" # 4
	2 HP	57" # 4	48" # 4	32" # 4

REF	HP	LOW	MED	HIGH
R402B/R403B R404A/R407C R408A/R502	1/8 HP	144" # 5	111" # 5	63" # 5
	1/6 HP	95" # 5	78" # 5	95" # 1
	1/5 HP	70" # 1	46" # 1	31" # 1
	1/4 HP	56" # 1	31" # 1	79" # 2
	1/3 HP	30" # 1	90" # 2	47" # 2
	1/2 HP	29" # 2	63" # 3	32" # 3
	3/4 HP	79" # 3	32" # 3	96" # 4
	1 HP	46" # 3	111" # 4	72" # 4
	1-1/2 HP	111" # 4	79" # 4	56" # 4
	2 HP	74" # 4	52" # 4	34" # 4
R402A/R407A R407B/R507	1/8 HP	N/A	127" # 5	69" # 5
	1/6 HP	104" # 5	133" # 1	105" # 1
	1/5 HP	77" # 1	50" # 1	34" # 1
	1/4 HP	52" # 1	34" # 1	86" # 2
	1/3 HP	33" # 1	105" # 2	52" # 2
	1/2 HP	31" # 2	69" # 3	35" # 3
	3/4 HP	57" # 3	37" # 3	106" # 4
	1 HP	52" # 3	30" # 3	79" # 4
	1-1/2 HP	32" # 3	86" # 4	62" # 4
	2 HP	32" # 4	58" # 4	37" # 4
R410A	1/8 HP	N/A	144" # 5	81" # 5
	1/6 HP	122" # 5	100" # 5	78" # 5
	1/5 HP	90" # 1	60" # 1	41" # 1
	1/4 HP	73" # 1	40" # 1	101" # 2
	1/3 HP	38" # 1	30" # 1	62" # 2
	1/2 HP	37" # 2	84" # 3	42" # 3
	3/4 HP	104" # 3	44" # 3	34" # 3
	1HP	52" # 3	36" # 3	94" # 4
	1-1/2 HP	38" # 3	[illegible]	74" # 4
	2 HP	30" # 4	69" # 4	45" # 4

Reach-In Unit Coolers

Thin Profile Air Defrost Unit Coolers

Model TA reach-in evaporators are thin units that mount in the top of a refrigerator, making the entire top shelf area usable. The attractive low silhouette makes this unit particularly desirable for display-type refrigerators. It can also be used in back bars, under counter cabinets or wherever space is at a premium.

Drain fitting at 45° angle so drain can be run through the back or bottom of refrigerator. Room for expansion valve inside so that it is out of sight. Model TA is available with optional coated coil for corrosion protection (use model designation TAK). Also features sweat inlet connection to reduce leaks.

TA (K) Model	Capacity (BTUH)	Fan		Motor (Total FLA)		Dimensions (in.)			Connections (in.)			Approx. Net Wt. (lbs.)
	10°F TD +25 SST	Qty.	CFM	Shaded Pole 115/1/60	Shaded Pole 208-230/1/60	L	H	D	Liquid OD	Suction ID	Drain OD	
TA10	1,000	1	120	0.8	0.4	16-1/2	4-1/2	13-1/2	3/8	3/8	1/2	10
TA13	1,300	2	170	1.6	0.8	20-1/2	4-1/2	13-1/2	3/8	3/8	1/2	13
TA17	1,700	2	210	1.6	0.8	24	4-1/2	14-1/2	3/8	3/8	1/2	17
TA23	2,300	3	330	2.4	1.2	31-5/8	4-1/2	14-1/2	3/8	3/8	1/2	23
TA30	3,000	3	360	2.4	1.2	40	4-1/2	14-1/2	3/8	1/2	1/2	26
TA45*	4,500	4	340	3.2	1.6	53-3/8	4-1/2	14-1/2	1/2	5/8	1/2	36
TA55*	5,500	5	650	4.0	2.0	53-3/8	6-3/4	14-1/2	1/2	5/8	1/2	45

*These models use external equalized expansion valve

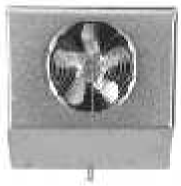
Thin Profile Electric Defrost Unit Coolers

Model TL low temperature reach-in evaporators have an automatic defrost system. Mounted in the top of a refrigerator, its extremely compact cabinet makes it possible to utilize the entire top shelf area for storage. With a normal operating range of 15°F to -20°F, this unit is ideally suited for such applications as commercial freezers, ice cream boxes, bakery freezers and dual-temp reach-in boxes. Mechanical contact is provided between the heater elements and the drain pan ensuring a warm pan during the defrost cycle. Sufficient space is provided to mount the expansion valve within the cabinet. Systems for both 115 volt and 208-230 volt operation are available. Also features sweat inlet connection to reduce leaks. Some models available with EC motors, contact your sales representative for availability.

TL Model	Capacity (BTUH)	Fan		Motor (Total FLA)		Defrost Heater			Dimensions (in.)			Connections (in.)			Approx. Net Wt. (lbs.)
	10°F TD -10°F SST	Qty.	CFM	Shaded Pole 115/1/60	Shaded Pole 208-230/1/60	Watts	115/1/60 Amps	230/1/60 Amps	L	H	D	Liquid OD	Suction ID	Drain OD	
TL09	900	1	110	0.3	0.4	475	4.1	2.1	16-1/2	4-1/2	13-1/2	3/8	3/8	1/2	10
TL12	1,200	2	210	1.5	0.8	500	5.2	2.6	20-1/2	4-1/2	13-1/2	3/8	1/2	1/2	15
TL16	1,600	2	210	1.5	0.8	700	6.1	3.0	24	4-1/2	14-1/2	3/8	1/2	1/2	19
TL21	2,100	1	240	1.3	0.5	1,100	9.6	4.8	24	6-3/4	16-1/2	3/8	1/2	1/2	19
TL28	2,800	3	335	-	1.2	1,430	-	5.7	31-5/8	6-3/4	14-1/2	3/8	1/2	1/2	22
TL35*	3,500	3	420	-	1.0	1,600	-	7.0	38-3/8	6-3/4	16-1/2	1/2	5/8	1/2	31
TL53*	5,300	3	595	-	1.5	1,950	-	6.5	49-1/8	6-3/4	16-1/2	1/2	7/8	1/2	45

*These models use external equalized expansion valve

High Profile Air Defrost Unit Coolers



Model C unit coolers are ideal for refrigerated reach-ins. It mounts to the top of the refrigerator and discharges cold air against the back wall. With this air flow pattern, the air is not blasted on the product, but is diffused along the back wall and then gently drawn across the product as it returns to the unit. Thus, uniform temperatures are maintained throughout the refrigerator. In addition, door sweating and refrigeration loss due to door opening is greatly reduced because the air is not discharged against the doors. Mounting is easy with aluminum hangers that automatically space the unit the correct distance from the back wall. The expansion valve fits inside, out of sight. Model C is available with an optional coated coil (designated as model CK) for corrosion protection. Also features sweat inlet connection to reduce leaks. Some models available with EC motors, contact your sales representative for availability.

C (K) Model	Capacity (BTUH)	Fan		Motor (Total FLA)		Dimensions (in.)			Connections (in.)			Approx. Net Wt. (lbs.)
	10°F TD +25 SST	Qty.	CFM	Shaded Pole 115/1/60	Shaded Pole 208-230/1/60	L	H	D	Liquid OD	Suction ID	Drain OD	
C13	1,300	1	235	1.0	0.5	14-1/4	8-7/8	13-3/4	[illegible]	[illegible]	1/2	[illegible]
C17	1,700	1	250	1.0	0.5	17-1/4	8-7/8	13-3/4	3/8	1/2	1/2	[illegible]
C23	2,300	1	265	1.0	0.5	22-3/4	8-7/8	13-3/4	3/8	[illegible]	1/2	[illegible]
C30	3,000	2	480	2.0	1.0	27-3/4	8-7/8	13-3/4	3/8	1/2	1/2	21
C43*	4,300	2	520	2.0	1.0	33	8-7/8	13-3/4	1/2	1/2	1/2	30

*Size 43 uses external equalized expansion valve

Introduction and Overview

Danfoss DCL/DCB filter driers offer industry leading system protection. These driers use a mixture of molecular sieve and activated alumina to both adsorb system moisture and capture acid and prevent solid contaminants from entering the system. Moisture can clog an expansion device with ice, reducing system efficiency, or can form acids which damage the compressor and other components. Solid contaminants can clog expansion devices and wear compressors prematurely. For aftermarket service, most contractors choose this blend of molecular sieve and activated alumina for both high moisture capacity and acid adsorption capacity. Type DAS are used in the suction line to clean up refrigeration and AC systems with fluorinated refrigerants after a compressor burn-out. The solid core adsorbs harmful acids as well as moisture to protect the compressor from premature failure.

Danfoss filter driers function as simple drop-in replacements for most driers sold in the aftermarket or installed on equipment by manufacturers. All Danfoss filter driers are constructed with a solid core design to maximize moisture removal while minimizing pressure drop. Other product features and benefits are depicted in the picture below.

Nomenclature

D C L 03 2 s VV

D – Filter drier

C – Solid Core
- **A:** Core with 70% molecular sieve/ 30% activated alumina (burn-out)
- **C:** Core with 80% molecular sieve / 20% activated alumina
- **M:** Core with 100% molecular sieve

L – Application
- **B:** Bi-flow
- **L:** Liquid line
- **S:** Suction line

03 – **Size (volume)**
- **03:** 3 in³
- **05:** 5 in³
- **08:** 8 in³
- **16:** 16 in³
- **30:** 30 in³
- **41:** 41 in³
- **60:** 60 in³
- **75:** 75 in³

2 – Connection (filter connection in 1/8 of an inch increments)
- **2:** 1/4 in
- **2.5:** 5/16 in
- **3:** 3/8 in
- **4:** 1/2 in
- **5:** 5/8 in
- **6:** 3/4 in
- **7:** 7/8 in
- **9:** 1 1/8 in

s – Connection type
- **(blank):** Flare connection
- **s:** Solder connection

VV – Access valves

	Inlet	Outlet
(blank)	blank	none
V	Schrader valve	
VV	Schrader valve	Schrader valve

Quick Select Guide — Filter Driers, Types DCL/DCB/DAS

Type	Connection solder (in.)	Weight (lbs)	Code No.
DCL 032s	1/4	0.39	**023Z5013***
DCL 033s	3/8	0.42	**023Z5015**
DCL 052s	1/4	0.61	**023Z5018**
DCL 053s	3/8	0.64	**023Z5019**
DCL 082s	1/4	0.64	**023Z5022**
DCL 083s	3/8	0.66	**023Z5023**
DCL 084s	1/2	0.88	**023Z5026**
DCL 162s	1/4	1.69	**023Z5028**
DCL 163s	3/8	1.72	**023Z5029**
DCL 164s	1/2	1.74	**023Z5032**
DCL 165s	5/8	1.76	**023Z5033**
DCL 167s	7/8	1.85	**023Z5034**
DCL 303s	3/8	2.64	**023Z0030**
DCL 304s	1/2	2.66	**023Z0031**
DCL 305s	5/8	2.68	**023Z0032**
DCL 307s	7/8	2.57	**023Z0034**
DCL 309s	1 1/8	2.59	**023Z0035**
DCL 414s	1/2	4.47	**023Z0104**
DCL 415s	5/8	4.49	**023Z0105**
DCL 417s	7/8	4.58	**023Z0106**
DCL 419s	1 1/8	4.60	**023Z0107**
DCL 607s	7/8	5.26	**023Z0016**
DCL 609s	1 1/8	5.28	**023Z0037**
DCL 757s	7/8	7.44	**023Z0115**
DCB 082s	1/4	1.1	**023Z1434**
DCB 083s	3/8	1.1	**023Z1433**
DCB 084s	1/2	1.3	**023Z1432**
DCB 163s	3/8	1.8	**023Z1437**
DCB 164s	1/2	1.8	**023Z1436**
DCB 165s	5/8	2.0	**023Z1435**
DCB 304s	1/2	2.2	**023Z1440**
DCB 305s	5/8	2.4	**023Z1439**
DCB 307s	7/8	2.4	**023Z1438**
DAS 083sVV	3/8	1.0	**023Z1003**
DAS 084sVV	1/2	1.1	**023Z1004**
DAS 085sVV	5/8	1.1	**023Z1005**
DAS 086sVV	3/4	1.1	**023Z1006**
DAS 164sVV	1/2	2.03	**023Z1009**
DAS 165sVV	5/8	1.9	**023Z1010**
DAS 166sVV	3/4	1.9	**023Z1011**
DAS 167sVV	7/8	1.9	**023Z1012**
DAS 305sVV	5/8	2.9	**023Z1013**
DAS 306sVV	3/4	2.9	**023Z1014**
DAS 307sVV	7/8	3.0	**023Z1015**
DAS 309sVV	1 1/8	3.0	**023Z1016**
DAS 417sVV	7/8	4.6	**023Z1017**
DAS 419sVV	1 1/8	4.6	**023Z1018**
DAS 607sVV	7/8	5.3	**023Z1019**
DAS 609sVV	1 1/8	5.3	**023Z1020**

Type	Connection flare (in.)	Weight (lbs)	Code No.
DCL 032	1/4	0.44	**023Z5000***
DCL 032	1/4	0.44	**023Z5075**
DCL 033	3/8	0.51	**023Z5001***
DCL 033	3/8	0.51	**023Z5085**
DCL 052	1/4	0.86	**023Z5002**
DCL 053	3/8	0.92	**023Z5003**
DCL 082	1/4	0.88	**023Z5004**
DCL 083	3/8	0.97	**023Z5005**
DCL 084	1/2	1.06	**023Z5006**
DCL 162	1/4	1.74	**023Z5007**
DCL 163	3/8	1.80	**023Z5008**
DCL 164	1/2	1.91	**023Z5009**
DCL 165	5/8	2.00	**023Z5010**
DCL 303	3/8	2.93	**023Z0012**
DCL 304	1/2	3.04	**023Z0013**
DCL 305	5/8	3.12	**023Z0014**
DCL 306	3/4	3.28	**023Z0156**
DCL 413	1 1/8	4.09	**023Z0101**
DCL 414	1/2	4.20	**023Z0102**
DCL 415	5/8	4.29	**023Z0103**
DCB 082	1/4	1.1	**023Z1402**
DCB 083	3/8	1.1	**023Z1401**
DCB 084	1/2	1.3	**023Z1400**
DCB162	1/4	1.8	**023Z1406**
DCB 163	3/8	1.8	**023Z1405**
DCB 164	1/2	2.0	**023Z1404**
DCB 165	5/8	2.0	**023Z1403**
DAS 083VV	3/8	1.12	**023Z1001**
DAS 084VV	1/2	1.37	**023Z1002**
DAS 164VV	1/2	2.01	**023Z1007**
DAS 165VV	5/8	2.09	**023Z1008**

* Wire mesh in filter drier outlet

Type	Material	Code No.
DCB core insert, type 48-DC solid core	80% molecular sieve & 20% activated alumina	**023U4381**
DCB core insert, type 48-DA solid core	30% molecular sieve & 70% activated alumina	**023U5381**

Quick Select Guide	Sight Glasses, Types SGN/SGRN

Introduction and Overview

Danfoss sight glasses are designed to accurately indicate the presence of moisture in refrigeration and air-conditioning systems. When system moisture content rises above permissible levels, the "dry/green" indicator will change to yellow indicating a "wet" system. The indication of dangerous moisture levels is essential in helping prevent the formation of harmful acids which are detrimental to the system.

Danfoss offers two types of sight glasses; inline and vessel mount. Inline sight glass, type SGN is used in the system's liquid line to indicate both the condition and moisture content of the refrigerant. They incorporate an indicator which changes color dependent on the moisture content. Type SGN is recommended for all HCFC and HFC refrigerants. Vessel sight glasses, type SGRN are specially designed to be mounted directly on either a receiver or the compressor crankcase to indicate liquid level. Type SGRN are available with a refrigerant moisture indicator which can be used with all fluorinated refrigerants.

Product Selection

Type	Version	Connection (in.)	Ambient Temperature (°F)	Maximum working pressure (psig)	Weight (lbs)	Code No.
SGN 6	Flare (int. x ext.)[1]	1/4 x 1/4	-50 to 175	500	0.22	**014-0137**
SGN 10		3/8 x 3/8		500	0.44	**014-0138**
SGN 12		1/2 x 1/2		500	0.66	**014-0139**
SGN 6s	ODF x ODF solder	1/4 x 1/4		500	0.22	**014-0142**
SGN 10s		3/8 x 3/8		500	0.22	**014-0143**
SGN 12s		1/2 x 1/2		500	0.44	**014-0144**
SGN 16s		5/8 x 5/8		500	0.44	**014-0145**
SGN 22s		7/8 x 7/8		400	0.44	**014-0142**
SGRN	NPT	1/2		500	0.22	**014-0006**

[1] can be screwed directly onto Danfoss filter drier.

REFRIGERATION GAUGE
25W100

ASHCROFT

DESCRIPTION

The **Ashcroft Model 25W100 Refrigeration Gauges** are ideal for installation on refrigeration manifolds for testing air conditioning units. The compound scale is designed specifically for R134A refrigerant testing. FlutterGuard™, a standard feature of these gauges, eliminates pointer flutter.

25W100

SPECIFICATIONS	
Dial Size	2 1/2" (6.4 cm)
Accuracy	1%-2%-5%
Measurement Range	30" Hg vac to 120 psi (retard to 250 psi)
Wetted Parts	Brass socket, phosphor bronze bourdon tube
Process Connection	1/8" NPT, lower
Enclosure	Window: Polycarbonate
Case	ABS plastic
Warranty	1 year

ORDERING INFORMATION

MODEL	DESCRIPTION
25W1007PH01L-R134A	Refrigeration gauge for R134A

PRESSURE GAUGES
PG SERIES

DESCRIPTION

The **PG Series Pressure Gauges** are durable, cost-effective, general-purpose gauges for use in a wide variety of HVAC controls applications. All gauges are compatible with air, oil, and water and have a bronze bourdon tube, acrylic lens, and dual unit psi/kPa scale. The **PG Series** (except model **PG-05**) has a recalibrator screw. A wide variety of models, options, and accessories are available, including panel-mount models, specialty gauges, and diaphragm seals.

PG Series

SPECIFICATIONS			
Overpressure	125% of FS value	**Process Connection**	1/8" NPT or 1/4" NPT, depending on model (LM = lower mount, CBM = center back mount, PM = panel mount)
Operating Temperature	-40° to 150°F (-40° to 65°C)		
Wetted Parts	Brass socket, phosphor bronze bourdon tube		
Window Material	Acrylic	**Warranty**	1 year

ORDERING INFORMATION

GAUGE TYPE	ECONOMY				QUALITY				CONTRACTOR
DIAL SIZE	1-1/2"	1-1/2"	1-1/2"	2"	2"	2"	2-1/2"	2-1/2"	4-1/2"
CONNECTION	1/8" CBM	1/8" LM	1/8" CBM	1/4" CBM	1/4" LM	1/4" PM	1/4" LM	1/4" PM	1/4" LM
ACCURACY	3-2-3%	2-1-2%	2-1-2%	2-1-2%	2-1-2%	2-1-2%	2-1-2%	2-1-2%	1%
CASE MATERIAL	BLACK STEEL	BLACK STEEL	BLACK STEEL	BLACK STEEL	BLACK STEEL	BLACK STEEL	BLACK STEEL	BLACK STEEL	STAINLESS STEEL
PRESSURE RANGE									
30" Hg VAC/kPa	N/A	PG-15-30-0-8L	PG-15-30-0-8C	PG-20-30-0-4C	PG-20-30-0-4L	PG-20-30-0-4P	PG-25-30-0-4L	PG-25-30-0-4P	PG-45-30-0-4L
30" Hg VAC-30 psig	N/A	N/A	N/A	N/A	N/A	N/A	PG-25-30-30-4L	N/A	PG-45-30-30-4L
0-15 psig/kPa	N/A	PG-15-0-15-8L	PG-15-0-15-8C	PG-20-0-15-4C	PG-20-0-15-4L	PG-20-0-15-4P	PG-25-0-15-4L	PG-25-0-15-4P	PG-45-0-15-4L
0-30 psig/kPa	PG-05	PG-15-0-30-8L	PG-15-0-30-8C	PG-20-0-30-4C	PG-20-0-30-4L	PG-20-0-30-4P	PG-25-0-30-4L	PG-25-0-30-4P	PG-45-0-30-4L
0-60 psig/kPa	N/A	PG-15-0-60-8L	PG-15-0-30-8C	PG-20-0-60-4C	PG-20-0-60-4L	PG-20-0-60-4P	PG-25-0-60-4L	PG-25-0-60-4P	PG-45-0-60-4L
0-100 psig/kPa	N/A	PG-15-0-100-8L	PG-15-0-100-8C	PG-20-0-100-4C	[illegible]	[illegible]	[illegible]	[illegible]	PG-45-0-100-4L
0-160 psig/kPa	N/A	PG-15-0-160-8L	PG-15-0-160-8C	PG-20-0-160-4C	[illegible]	[illegible]	[illegible]	[illegible]	PG-45-0-160-4L
0-200 psig/kPa	N/A	PG-15-0-200-8L	PG-15-0-200-8C	PG-20-0-200-4C	[illegible]	[illegible]	[illegible]	[illegible]	PG-45-0-200-4L
0-300 psig/kPa	N/A	PG-15-0-300-8L	PG-15-0-300-8C	PG-20-0-300-4C	PG-20-0-300-4L	[illegible]	N/A	N/A	N/A
0-400 psig/kPa	N/A	PG-15-0-400-8L	PG-15-0-400-8C	PG-20-0-400-4C	PG-20-0-400-4L	[illegible]	N/A	N/A	N/A
0-600 psig/kPa	N/A	PG-15-0-600-8L	PG-15-0-300-8C	PG-20-0-600-4C	PG-20-0-600-4L	[illegible]	N/A	N/A	N/A

PRESSURE

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